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TETRA TECH NUS

Comprehensive Long-term Environmental Action Navy

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Remedial Design
for
Site 10 – Parade Field Ditch

Naval Construction
Battalion Center Gulfport
Gulfport, Mississippi

Contract Task Order 0288

July 2007

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

TETRA TECH NUS, Inc.

REMEDIAL DESIGN
FOR
SITE 10 – PARADE FIELD DITCH

NAVAL CONSTRUCTION BATTALION CENTER GULFPORT
GULFPORT, MISSISSIPPI

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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This document, *Remedial Design for Site 10, Parade Field Ditch, Naval Construction Battalion Center, Gulfport, Mississippi*, has been prepared under the direction of a Registered Professional Engineer in the State of Mississippi. The work and professional opinions rendered in this report were conducted or developed in accordance with commonly accepted procedures consistent with applicable standards of practice. This document was prepared for Site 10 at the Naval Construction Battalion Center, Gulfport, Mississippi, and should not be construed to apply to any other site.

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TABLE OF CONTENTS

SECTION **PAGE**

PROFESSIONAL ENGINEER CERTIFICATION iii

ACRONYMS vi

1.0 INTRODUCTION 1-1
1.1 SCOPE AND PURPOSE 1-1
1.2 REPORT ORGANIZATION 1-1

2.0 EXISTING SITE CHARACTERISTICS 2-1
2.1 SITE DESCRIPTION 2-1
2.2 SITE HISTORY 2-1
2.3 PREVIOUS INVESTIGATIONS 2-2
2.4 SURFACE WATER HYDROLOGY 2-3
2.5 GEOLOGY 2-3
2.5.1 Regional Geology 2-4
2.6 SOILS 2-4
2.6.1 Soil Classification 2-4
2.7 HYDROGEOLOGY 2-5
2.7.1 Groundwater Flow Direction 2-5
2.7.2 Water Table Gradient 2-5
2.7.3 Hydraulic Conductivity 2-6
2.7.4 Groundwater Flow Velocity 2-6
2.7.5 Regional Hydrogeology 2-6
2.8 LAND USE 2-7
2.9 NATURE AND EXTENT OF CONTAMINATION 2-7
2.10 CONTAMINANT SOURCES 2-8
2.11 SOILS AND VADOSE ZONE 2-8
2.11.1 Summary of Soil Analytical Results 2-8
2.12 GROUNDWATER 2-9
2.12.1 Summary of Groundwater Analytical Results 2-9
2.13 SURFACE WATER AND SEDIMENTS 2-10
2.13.1 Summary of Surface Water and Sediment Analytical Results 2-10

3.0 DESIGN REQUIREMENTS 3-1
3.1 DESCRIPTION OF THE SELECTED REMEDY 3-1
3.2 PERFORMANCE STANDARDS 3-4
3.2.1 Erosion, Surface Water, and Sediment Control 3-4
3.2.2 Excavation 3-4
3.2.3 Additional Performance Standards 3-5
3.3 OTHER DESIGN REQUIREMENTS 3-6
3.3.1 Utilities 3-6
3.4 POST-REMEDIAL ACTION VERIFICATION SAMPLING 3-6
3.5 IMPLEMENTATION 3-7

TABLE OF CONTENTS (Continued)

SECTION **PAGE**

4.0 EROSION, SEDIMENT, AND STORMWATER CONTROL PLAN 4-1
4.1 SCOPE AND PURPOSE 4-1
4.2 EROSION, SEDIMENT, AND STORMWATER CONTROL MEASURES 4-1
4.2.1 Structural Practices 4-2
4.2.2 Management Strategies 4-2
4.3 INSPECTION AND MAINTENANCE 4-3
4.4 SITE RESTORATION/PERMANENT STABILIZATION 4-3

5.0 VERIFICATION SAMPLING 5-1
5.1 SCOPE AND PURPOSE 5-1
5.2 SAMPLE OBJECTIVES 5-1
5.3 TECHNICAL AND ADMINISTRATIVE REQUIREMENTS 5-1
5.4 SAMPLING LOCATIONS AND FREQUENCY 5-2
5.5 ANALYTICAL PROGRAM 5-2
5.6 SAMPLING AND ANALYSIS PLAN 5-3

REFERENCES R-1

FIGURES

NUMBER
1-1 Vicinity Map
1-2 Site Location Map
2-1 Site Plan
2-2 Site Features
2-3 Site 10 Source Removal Area
2-4 Results of Previous PCB Samples
2-5 Soil Boring Locations
2-6 Monitoring Well Locations
2-7 Groundwater Potentiometric Surface
2-8 Soil PCB PRG Exceedances
2-9 Groundwater TRG Exceedances
2-10 Surface Water/Sediment Criteria Exceedances
3-1 Surface Water Controls and Excavation Area Layout
3-2 Site Conceptual Model

APPENDICES

A RI/FS (CD) A-1
B EXCAVATION VOLUME CALCULATIONS B-1
C VERIFICATION SAMPLING INFORMATION (CD) C-1

ACRONYMS

ABB-ES	ABB Environmental Services, Inc.
ARAR	Applicable or Relevant and Appropriate Requirement
bls	below land surface
CCI	CH2MHill Constructors, Inc.
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Chemical of concern
CTO	Contract Task Order
DD	Decision Document
DDT	1,1,1-Trichloro-2,2-bis(p-chlorophenyl)ethane
DI	deionized
DPT	Direct-push technology
EDB	Ethylene dibromide
ESSCP	Erosion, Sediment, and Stormwater Control Plan
FOL	Field Operations Lead
ft	feet/foot
FS	Feasibility Study
HASP	Health and Safety Plan
HxCDF	Hexachlorinated-dibenzo-furan
µg/kg	micrograms per kilogram
mg/kg	milligram per kilogram
MDEQ	Mississippi Department of Environmental Quality
MPDMCESS	Mississippi Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater
MSWCC	Mississippi Soil and Water Conservation Commission
NAVFAC SE	Naval Facilities Engineering Command, Southeast
NCBC	Naval Construction Battalion Center
NCF	Naval Construction Force
NRCS	Natural Resources Conservation Service
OCBE	Octachlorinated-biphenyl ether
OPC	Office of Pollution Control
PCB	polychlorinated biphenyl
PPE	Personal protective equipment
ppm	part per million
PRG	Preliminary Remediation Goal
PRSE	Post-Removal Site Evaluation

ACRONYMS (Continued)

QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Remedial Action
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI	Remedial Investigation
ROICC	Resident Officer in Charge of Construction
S3TM	Sampling Strategies and Statistics Training Materials
SAP	Sampling and Analysis Plan
SVOC	Semivolatile organic compound
TAL	Target Analyte List
TBC	To Be Considered
TCL	Target Compound List
TRG	Target Risk Goal
TSCA	Toxic Substances Control Act
TSDF	Treatment Storage or Disposal Facility
TtNUS	Tetra Tech NUS, Inc.
UCL	Upper confidence limit
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
VSAP	Verification Sampling and Analysis plan
VOC	Volatile organic compound
yd^3	cubic yards

1.0 INTRODUCTION

1.1 SCOPE AND PURPOSE

This report provides the basis for the Remedial Design (RD) at Site 10 - Parade Field Ditch at the Naval Construction Battalion Center (NCBC) or "base" in Gulfport, Mississippi. The RD was prepared under Contract Task Order (CTO) 0288 under Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N62467-94-D-0888. Under this CTO, Tetra Tech NUS, Inc. (TtNUS) is performing engineering and design services for the subsequent Remedial Action (RA) at Site 10.

NCBC Gulfport is located in the southeastern portion of Mississippi, approximately 2 miles north of the Gulf of Mexico. The base is located in the western part of the City of Gulfport in Harrison County. Figure 1-1 shows the location of the base in relation to the City of Gulfport and the Gulf of Mexico. The base occupies 1,100 acres with an average elevation of approximately 30 feet (ft) above sea level. An installation map of NCBC Gulfport is provided as Figure 1-2.

This report summarizes the design for the selected remedial alternative in the Remedial Investigation (RI)/Feasibility Study (FS) for Site 10 (TtNUS, 2007). The selected alternative, detailed in Section 3.0, was selected to protect public health, welfare, and the environment from exposure to the polychlorinated biphenyl (PCB) Aroclor-1260 at Site 10.

1.2 REPORT ORGANIZATION

The following information is contained in each section of this RD:

- Section 1.0 – Outlines the scope and purpose of the RD and provides this introduction and summary of the Basis for the Conceptual Design.
- Section 2.0 – Provides site background and history and summarizes the existing site characteristics including site history, soils, geology, hydrogeology, surface water hydrology, and a description and extent of contamination.
- Section 3.0 - Details the design requirements of the selected remedy.
- Section 4.0 – Provides the Erosion, Sediment, and Stormwater Control Plan (ESSCP).
- Section 5.0 – Provides the details for final verification/post-remedial confirmation sampling.

2.0 EXISTING SITE CHARACTERISTICS

2.1 SITE DESCRIPTION

Site 10 includes a short section of a primary drainage ditch located in the south-central section of NCBC Gulfport adjacent to the Parade Field (Figure 2-1). The drainage ditch at Site 10 is approximately 2.5 ft deep and 10 ft wide at the base and approximately 25 ft wide at the top of the banks. The site is bordered to the north by a parking area associated with Building 295 and to the south by the Parade Field. Large trees are present on the northern side of the ditch, although several trees were destroyed during Hurricane Katrina in 2005. The site topography is relatively flat. A sidewalk, leading south from the former location of Building 295, crosses the ditch via a concrete footbridge and continues south to the Parade Field. Current Site 10 features are shown on Figure 2-2.

Stormwater runoff from the paved areas surrounding Site 10 flows into various tributary ditches that feed into the larger primary ditch. Surface water runoff in the primary ditch is conveyed to the west into Canal No. 1, which collects runoff from Drainage Area 5. Surface water in Canal No. 1 flows to the north and eventually leaves NCBC Gulfport at Outfall 1, located at 28th Street.

NCBC is located in the Gulf Coast Flatwoods physiographic division, which extends along the southern coast of Harrison County. Topography in this area is a series of wet, poorly drained depressions between better drained areas of slightly higher elevation.

2.2 SITE HISTORY

Contamination was first detected at the area designated as Site 10 during the dioxin delineation activities for on- and off-site surface water drainage features conducted in 1997 [ABB Environmental Services, Inc. (ABB-ES), 1997]. Samples collected at Drainage Area 5 (southwestern corner of NCBC) for this investigation had high levels of dioxins and furans, particularly hexachlorinated-dibenzo-furans (HxCDFs) in the drainage ditch south of Building 369. Further evaluation of the laboratory data indicated that the responses interpreted as elevated HxCDFs were actually caused by octachlorinated-biphenyl ethers (OCBEs), which are commonly found in transformer oils manufactured in the 1940s and 1950s. Two of the samples collected during this study were analyzed for PCBs. Aroclor-1260 was detected at concentrations exceeding screening levels in these samples. Analysis of sediment samples for volatile organic compounds (VOCs) also indicated elevated levels of chlorobenzene, another common ingredient in transformer oil.

The detections of OCBE, chlorobenzene, and Aroclor-1260 indicate the probable release or releases of electrical transformer oil adjacent to or directly into the drainage ditch near the footbridge as the source of contamination at Site 10.

2.3 PREVIOUS INVESTIGATIONS

As discussed below, the following environmental investigations and remedial activities have been conducted at Site 10:

- Initial field investigation (ABB-ES, 1997)
- Source removal and associated sampling [Ch2MHill Constructors, Inc.(CCI), 2000]
- Post-Removal Site Evaluation (PRSE) (TtNUS, 2002)

Initial Field Investigation

Following the discovery of the site in April 1997, further delineation studies were conducted at Site 10 in July 1997 (ABB-ES, 1997). Field screening and sediment sample analysis indicated an area of PCB exceedances of approximately 100 ft along the length of the ditch. The source removal area is shown on Figure 2-3. The vertical extent of contamination appeared to be confined to the upper 3 ft of sediment and soil below the base of the ditch. This delineation was based on a PCB screening level of 1 part per million (ppm), a level established by the Toxic Substances Control Act (TSCA) standards [United States Environmental Protection Agency (USEPA), 1985 and 1986]. The highest contaminant levels were found within a 15-ft area near the footbridge. The maximum PCB concentration measured during this event was 140 ppm. Screening level exceedances continued, at decreasing concentrations, for almost 80 ft downstream of the footbridge. The RI Report (ABB-ES, 1997) summarized the results of the investigation and provided recommendations for soil removal strategies.

Source Removal

The levels of PCB and chlorobenzene contamination in sediments in the ditch at Site 10 prompted a source removal excavation in August 1999. Approximately 80 cubic yards (yd^3) (120 tons) of sediment and soil with PCB concentrations exceeding the Mississippi Department of Environmental Quality (MDEQ) unrestricted Tier 1 Target Risk Goal (TRG) of 1 ppm were removed from the source area (Figure 2-4) during this excavation (Phase I excavation). Confirmation sampling from the bottom of the excavation indicated that PCB concentrations up to 1,240 ppm remained in the soil below the area of excavation. Therefore, an additional 1.5-ft layer of sediment was removed, and additional confirmation samples were collected (Phase II

excavation). Results of the Phase II confirmation sampling identified PCB concentrations up to 16,300 ppm. Excavation activities were suspended and further delineation sampling was conducted using direct-push technology (DPT) sampling methods. Results showed that PCB concentrations exceeding the Tier 1 TRG continued to a depth of 22 ft, with PCB concentrations decreasing with depth. Based on these results, a Phase III excavation was conducted. An additional 3 to 6 ft of soil were removed from the entire excavation area, resulting in a maximum excavation depth of 14.5 ft in the vicinity of the footbridge. PCB concentrations in confirmation samples collected from three locations at the bottom of the Phase III excavation still exceeded the TRG screening level.

Post-Removal Site Evaluation

Following the source removal excavations and site restoration, additional samples were collected to evaluate the effectiveness of the RA (TtNUS, 2002). The samples from the various media were analyzed for VOCs, pesticides and PCBs, and ethylene dibromide (EDB). The continued presence of PCB concentrations exceeding screening level in subsurface soil samples prompted the Navy to conduct a more comprehensive RI and to use these data for evaluation of remedial alternatives. The complete nature and extent of contamination is described in Section 2.9.

2.4 SURFACE WATER HYDROLOGY

NCBC Gulfport is located in the coastal plain physiographic province of southern Mississippi. This area is typically drained by small streams flowing southeast toward the coast. Surface water in the vicinity of NCBC Gulfport is abundant. Stormwater runoff is collected in a series of ditches and canals and directed off base. Large precipitation events tend to produce small stream and ditch flooding due to relatively high stream flow velocities.

Stormwater runoff from the paved areas surrounding Site 10 flows into various tributary ditches that feed into the larger primary ditch. Surface water runoff in the primary ditch is conveyed to the west into Canal No. 1, which collects runoff from Drainage Area 5. Surface water in Canal No. 1 flows to the north and eventually leaves NCBC Gulfport at Outfall 1, located at 28th Street.

2.5 GEOLOGY

Data collected from soil borings advanced at Site 10 were used to evaluate the lithologic and stratigraphic conditions that may influence contaminant fate and transport at the site.

2.5.1 Regional Geology

NCBC Gulfport is located in the coastal plain of southern Mississippi, which is underlain by a series of estuarine or deltaic sediments that dip southwestward toward the delta of the Mississippi River. These sediments range in age from Miocene to Recent and are not readily separated into stratigraphic units. The uppermost beds are Pleistocene and Recent terrace and stream valley deposits. The uppermost stratigraphic formation in the coastal plain area is the Pamlico Sand, which is approximately 60 to 70 ft thick and is composed of fine sands and shale or clay. The Pamlico Sand is underlain by the following older formations:

- Citronelle Formation, sand approximately 100 ft thick
- Graham Ferry Formation, alternating layers of sand, shale, and clay ranging from 125 to 250 ft thick.
- Upper and Lower Pascagoula Formations, alternating layers of sand, shale, and clay with shell and boulders approximately 1,100 ft thick.

2.6 SOILS

Surface and shallow subsurface soils from soil borings (Figure 2-5) at Site 10 were identified as primarily sand and sandy loam with minor clay horizons.

2.6.1 Soil Classification

The Soil Survey of Harrison County [United States Department of Agriculture (USDA), 1975] identifies two soil types at Site 10. Soils in the eastern part of Site 10 are Ocilla loamy sand, a somewhat poorly drained soil commonly found on broad topographic flats. This soil type is typically comprised of a thick sandy surface layer over loamy material and is strongly or very strongly acidic. Permeability is moderate throughout the soil. Available water capacity is low to medium, and runoff is slow. Soil blowing is a hazard on bare and unprotected soil during dry periods.

Soils in the western part of Site 10 are similar and categorized as Atmore silt loam, a poorly drained soil developed in loamy material and commonly found on broad flats and in drainageways. This soil type is typically silt loam and clay loam and is strongly to extremely acidic. Permeability is moderate in the upper part of the soil horizon and slow in the lower part.

Available water capacity is medium to high. The water table is at the surface during wet periods, and runoff is slow.

2.7 HYDROGEOLOGY

Hydrogeologic data were collected to evaluate the movement of groundwater in the shallow surficial aquifer at the site. Depth-to-groundwater and groundwater elevation data collected from all Site 10 monitoring wells (Figure 2-6) were used to determine the site-specific groundwater flow direction and water table gradient. Groundwater flow velocity at the site was estimated using hydraulic conductivity values determined for Site 6 and Site 10 water table gradient data.

2.7.1 Groundwater Flow Direction

To evaluate the direction of groundwater flow at the site, groundwater elevations from site monitoring wells were plotted on a site map (Figures 2-7), and groundwater elevation isocontours were drawn from the plotted data. Interpretation of data from the gauging events at Site 10 indicates that groundwater flow in the shallow surficial aquifer is to the northwest.

2.7.2 Water Table Gradient

The highest and lowest groundwater elevation values measured in shallow monitoring wells were used to determine the difference in groundwater elevation across the site. The horizontal distance between the high and low groundwater elevation points was measured parallel to the estimated groundwater flow direction.

In February 2002, the groundwater elevation in GPT-10-05, 26.24 ft, was the highest value and the groundwater elevation in GPT-10-02, 26.00 ft, was the lowest value in shallow monitoring wells. The horizontal distance between these two wells parallel to groundwater flow is approximately 124 ft. These data indicate an average hydraulic gradient of 0.0019 for the shallow surficial aquifer at the site.

In December 2003, GPT-10-05 again had the highest groundwater elevation value, 26.49 ft, and GPT-10-02 had the lowest value, 26.17 ft. These data indicate an average hydraulic gradient of 0.0026.

2.7.3 Hydraulic Conductivity

Hydraulic conductivity values for Site 10 were estimated from slug test data from monitoring wells at Site 6 (ABB-ES, 1994). Site 6 is located approximately 2,000 ft west-northwest of Site 10 and has similar lithologies and a similar hydrogeologic setting. The geometric mean of the hydraulic conductivity values reported for the shallow wells at Site 6 is approximately 0.0057 ft/minute (2.9×10^{-3} centimeters/second) or 8.2 ft/day (ABB-ES, 1994). The slug test data indicate an order of magnitude variation in hydraulic conductivity in the shallow surficial aquifer (ABB-ES, 1994).

2.7.4 Groundwater Flow Velocity

Data from soil borings advanced during the DPT investigation indicate that fine-grained sand and silty or clayey sand are the typical lithologies at the site. Review of standard literature suggests that a representative effective porosity for this lithology is approximately 30 percent (Heath, 1983).

Using an average hydraulic conductivity of 8.2 ft/day, an average hydraulic gradient of 0.002, and an effective porosity value of 30 percent, the estimated average groundwater velocity for the shallow zone at the site was calculated to be 0.055 ft/day.

2.7.5 Regional Hydrogeology

In the Gulfport area, geologic units containing fresh water are of Miocene to recent age. Aquifers are composed predominantly of sand beds that are irregular in thickness and horizontal extent. There are no thick, consistently traceable confining units between aquifers.

The uppermost aquifer is the surficial aquifer. The surficial aquifer sediments are composed of undifferentiated alluvium and Pamlico Sand terrace deposits (recent to Pleistocene in age). The Pamlico Sand formation is approximately 60 to 70 ft thick and is composed of fine sands and shale or clay. Depth to ground water in the surficial aquifer is variable, depending on local topography and precipitation, but generally ranges from 4 to 7 ft. Locally, shallow groundwater flow in the surficial aquifer is northwest toward Turkey Creek, which empties into Bernard Bayou and eventually into the Gulf of Mexico via the Mississippi Sound. Generally, this aquifer is not used for potable water supply.

Beneath the surficial aquifer are hydrogeologic units referred to collectively as the Miocene aquifers. The Miocene aquifers include the Citronelle Formation and the Graham Ferry Formation (Pliocene), and the Pascagoula, Hattiesburg, and Catahoula Formations (Micoene). Boundaries between the aquifers are vaguely defined, if at all. These aquifers are composed of sands and discontinuous clays. The Miocene aquifers are a major source of potable water in the Gulfport area.

The water wells in the Citronelle Formation are used for both domestic and industrial water supply. Supply wells in the Upper and Lower Pascagoula Formations provide the majority of fresh water used in the coastal plain. The Hattiesburg Formation becomes increasingly brackish with depth, and salt water is encountered near the base of this unit (approximately 2,000 ft below sea level).

2.8 LAND USE

NCBC Gulfport is located in the western part of the City of Gulfport, Mississippi, in southeastern Harrison County. Biloxi, the largest city in Harrison County is located 7 miles east of Gulfport, and Pass Christian is located 7 miles to the west.

NCBC Gulfport is an active military facility. The primary mission is the support of battalions of the Naval Construction Force (NCF) and the storage and maintenance of pre-positioned War Reserve Material Stock. NCF support consists of both homeport services and deployed support. Additional missions include tenant support and services to other activities in the region.

Land uses on base include training, equipment and materials storage, maintenance, recreational facilities, and residential housing for military personnel. Land use in the off-base areas adjacent to NCBC Gulfport is primarily residential.

2.9 NATURE AND EXTENT OF CONTAMINATION

Analytical data from the Phase I, Phase II, and Phase III investigations were used to evaluate the nature and extent of contamination at Site 10. The nature of contamination was determined by the types of contaminants detected in the sampled media and the concentrations of these contaminants compared to MDEQ screening criteria. Soil and sediment sample results were compared to Tier 1 restricted and unrestricted soil TRGs. Groundwater and surface water

sample results were compared to Tier 1 groundwater TRGs. Surface water sample results were also compared to MDEQ surface water criteria when available.

Much of the Phase I and Phase II sampling analysis focused on PCB-related contaminants. Samples from all media collected during the Phase III investigation were analyzed for a wider range of contaminants to verify that environmental impact at Site 10 was limited to the suspected release area and contaminants.

2.10 CONTAMINANT SOURCES

The detections of OCBE, chlorobenzene, and Aroclor-1260 at Site 10 indicate the probable release of electrical transformer oil as the source of contamination. The distribution of contaminants in the drainage ditch adjacent to the footbridge suggests that the release occurred in this area (Figure 2-3).

2.11 SOILS AND VADOSE ZONE

Soil samples were collected from 29 soil boring locations at Site 10. Due to the shallow water table at Site 10, the majority of the samples were collected from the saturated zone below the water table. Soil samples collected during the Phase I and Phase II sampling events were analyzed for pesticides and PCBs, Target Compound List (TCL) VOCs, and EDB. Soil samples collected during the Phase III sampling event were analyzed for a full suite of analytes [TCL VOCs, TCL semivolatile organic compounds (SVOCs), pesticides and PCBs, herbicides, Target Analyte List (TAL) metals, and cyanide]. The soil boring locations are shown on Figure 2-5.

2.11.1 Summary of Soil Analytical Results

The following summarizes Phase I, II, and III soil analytical results:

- Detected VOC concentrations in soil samples were less than Tier 1 unrestricted TRGs.

- Aroclor-1260 was detected in three soil samples at concentrations greater than the unrestricted TRG and in two samples at concentrations greater than the restricted TRG (Figure 2-8). The dieldrin concentration in one soil sample was greater than the unrestricted TRG but less than the restricted TRG. Other pesticides and PCBs were detected at concentrations less than Tier 1 unrestricted TRGs.

- Detected SVOC concentrations in soil samples were less than Tier 1 unrestricted TRGs.

- Herbicide concentrations in soil samples were less than standard laboratory detection limits.

- Arsenic was detected in five of the six soil samples at concentrations greater than the Tier 1 unrestricted TRG but less than the restricted TRG. Other metals were detected at concentrations less than Tier 1 unrestricted TRGs.

- Cyanide concentrations in soil samples were less than standard laboratory detection limits.

2.12 GROUNDWATER

Groundwater samples were collected during the Phase II and Phase III sampling events from the five monitoring wells installed at Site 10 (Figure 2-7). Groundwater samples collected during the Phase II sampling event were analyzed for pesticides and PCBs, TCL VOCs, and EDB. Groundwater samples collected during the Phase III sampling event were analyzed for a full suite of analytes (TCL VOCs, TCL SVOCs, pesticides and PCBs, herbicides, TAL metals, and cyanide).

2.12.1 Summary of Groundwater Analytical Results

The following summarizes Phase I, II, and III groundwater analytical results:

- Detected VOC concentrations in groundwater samples were less than Tier 1 TRGs.

- Pesticides were detected in groundwater samples from two monitoring wells (Figure 2-9). The dieldrin concentration in one Phase III groundwater sample was greater than the Tier 1 TRG. DDT was detected in one monitoring well at a concentration greater than the Tier 1 TRG. Other pesticides were detected at concentrations less than Tier 1 TRGs. PCB concentrations in groundwater samples were less than standard laboratory detection limits.

- Detected benzo(k)fluoranthene concentrations in two groundwater samples were greater than the Tier 1 TRG (Figure 2-9). Concentrations of other SVOCs in groundwater samples were less than standard laboratory detection limits

- Herbicide concentrations in groundwater samples were less than standard laboratory detection limits.

- Metals were detected in groundwater samples at concentrations less than Tier 1 TRGs.

- Detected cyanide concentrations in groundwater samples were less than Tier 1 TRG.

2.13 SURFACE WATER AND SEDIMENTS

Surface water samples were collected during the Phase I and Phase III sampling events (Figure 2-10). Sediment samples were collected during Phase I, Phase II, and Phase III sampling events (Figure 2-10). Surface water and sediment samples collected during the Phase I and Phase II sampling events were analyzed for pesticides and PCBs, TCL VOCs, and EDB. Surface water and sediment samples collected during the Phase III sampling event were analyzed for a full suite of analytes (TCL VOCs, TCL SVOCs, pesticides and PCBs, herbicides, TAL metals, and cyanide).

2.13.1 Summary of Surface Water and Sediment Analytical Results

The following summarizes Phase I, II, and III surface water and sediment analytical results:

- Detected VOC concentrations in surface water and sediment samples were less than Tier 1 TRGs.

- Pesticides were detected in Phase I surface water samples. The dieldrin concentration in one Phase I surface water sample was greater than the human health surface water criteria, but less than the Tier 1 TRG and the aquatic life surface water criteria. Aroclor-1260 was detected in a Phase I surface water sample at a concentration exceeding the Tier 1 TRG and the acute and chronic criteria for fresh water aquatic life. Both of these samples were collected following the RA at the site. Pesticides were not detected in the Phase III surface water samples collected approximately 1 year later. Pesticide and PCB concentrations in sediment samples were less than Tier 1 TRGs.

- Indeno(1,2,3-cd)pyrene was detected in a Phase III surface water sample at a concentration greater than the Tier 1 TRG. Concentrations of other SVOCs in surface water samples were less than Tier 1 TRGs. Benzo(a)pyrene was detected in a Phase III sediment sample at a concentration greater than the unrestricted TRG of 0.426 milligrams per kilograms (mg/kg) but less than the restricted TRG of 3.82 mg/kg. Concentrations of other SVOCs in sediment samples were less than Tier 1 TRGs.

- Herbicide concentrations in surface water and sediment samples were less than standard laboratory detection limits.

- Copper was detected in surface water samples at concentrations less than the Tier 1 TRG and the human health surface water criteria but greater than the acute and chronic aquatic life criteria. Concentrations of other metals in surface water samples were less than screening criteria. Arsenic concentrations in four of the sediment samples were greater than the Tier 1 unrestricted TRG but less than the restricted TRG. Concentrations of other metals detected in sediment samples were less than Tier 1 TRGs.

- Cyanide concentrations in surface water and sediment samples were less than standard laboratory detection limits.

3.0 DESIGN REQUIREMENTS

3.1 DESCRIPTION OF THE SELECTED REMEDY

The selected remedy will address contaminated soil and sediment at Site 10, Parade Field Ditch, at NCBC Gulfport, Mississippi. The selected remedy for Site 10 consists of surface water controls, excavation, dewatering, and off-site treatment and disposal (TtNUS, 2007).

The Remedial Action Objectives (RAOs) identified in the FS were based on the chemical of concern (COC), Aroclor-1260, for Site 10 and are as follows:

RAO 1: Prevent direct exposure to soil with concentrations of Aroclor-1260 greater than 1,000 micrograms per kilograms (µg/kg).

RAO 2: Prevent the erosional transport of Aroclor-1260 through the drainage channel system.

RAO 3: Comply with federal and state Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) guidance criteria in accordance with accepted USEPA and MDEQ guidelines.

The Preliminary Remediation Goals (PRGs) for Site 10 soil and sediment is 1,000 µg/kg. Due to the relatively small volume of media to be addressed at Site 10, soil and sediment will be addressed as one combined medium.

The selected remedy consists of excavating approximately 450 yd^3 of contaminated soil and sediment containing approximately 33 pounds of Aroclor-1260. Assumptions and calculations used in deriving this estimate are provided in Appendix B

The selected remedy at Site 10, with some additions/modifications to Alternative 4, will consist of the following components: (1) surface water controls, (2) dewatering, (3) soil/sediment excavation, (4) off-site treatment and disposal, (5) verification sampling, and (6) backfilling and site restoration.

<u>Component 1: Surface Water Controls</u>

Within the drainage channel, surface water controls will be used to divert water from work areas. Steel sheet piling will be used to section off portions of the drainage channel, and pumps (e.g., bladder-type mud pumps) will be used to remove water from within the cordoned-off sections.

In addition, a temporary drainage channel (approximately 4 ft deep) running from just east of the excavation area to the western side is recommended to divert any overflow from the nearby channels that occurs during excavation. Soil/sediment removed to create the temporary drainage channel will be used to construct a temporary berm on the southern side of the excavation near the Parade Field to prevent any stormwater runoff from infiltrating the excavation area during implementation of the selected remedy.

Component 2: Dewatering

If necessary (depending on site water levels at the time of remedy implementation), a subsurface well point dewatering system may be implemented prior to excavation activities to improve the ease and efficiency of excavation activities. This system would include several temporary well points installed to approximately 16 ft below land surface (bls) and require the use of steel sheet piling installed to depths of 20 ft bls, but would replace the need for construction of dewatering cells originally included in Alternative 4 in the FS.

Component 3: Soil/Sediment Excavation

Soil containing PCBs (Aroclor-1260) at concentrations greater than 1,000 µg/kg will be excavated from the area indicated on Figure 3-1. The area to be excavated will be cleared and grubbed as needed, and the pedestrian bridge will be removed. Approximately 450 yd^3 of soil/sediment will be excavated. Excavation of the contaminated material will be accomplished with a Gradall-type excavator, backhoe, or similar type of equipment. The sidewalls of the excavation will be shored to minimize the amount of soil/sediment requiring excavation to reach soils at depth (approximate total depth of 15 ft bls).

Excavated material will be stockpiled in materials handling/staging cells constructed on site. The cells will be constructed on the Parade Field just south of the drainage channel as indicated on Figure 3-1. It is assumed that two handling/staging cells will be constructed and operated at Site 10. The staging cells will measure approximately 50 ft by 50 ft and be designed to stage approximately 250 yd^3 of soil/sediment each. After stockpiling, soil/sediment will be placed in a roll-off dumpster for transport off site.

Component 4: Off-Site Treatment and Disposal

Excavated soil/sediment will be transported and disposed at a permitted off-site TSDF (e.g., Pecan Grove Landfill, Mississippi). The pre-treatment requirements will be dictated by the characteristics of the excavated material as determined by pre-excavation/characterization sampling.

As part of pre-excavation sampling, samples will be collected to further refine the extent of soil that contains PCBs (Aroclor-1260) at concentrations greater than 50,000 µg/kg. For costing purposes, it is assumed that approximately 100 yd^3 of excavated material contains Aroclor-1260 concentrations greater than 50,000 µg/kg and will require disposal at the TSCA-certified TSDF. Prior to ultimate disposal by landfilling, the TSDF will pre-treat that entire fraction of the excavated material by chemical fixation/solidification to meet disposal requirements. It is assumed that the remaining 350 yd^3 will be classified as Resource Conservation and Recovery Act (RCRA) non-hazardous waste and will be disposed by landfilling at a permitted off-site RCRA Subtitle D TSDF. This component will also include the manifesting of soil/sediment waste materials.

It is estimated that approximately 28 truckloads (16 yd^3) will be required to remove all contaminated soil/sediment material from Site 10. The RAOs and PRGs will be achieved immediately upon completion of the RA. It is expected that the selected remedy will be completed in approximately 13 days.

Removal of contaminated soil/sediment from its present location and off-base treatment and disposal of this soil will eliminate risk from exposure of human receptors to PCBs. These remedial activities, when completed, will protect human health and the environment by removing the potential for future migration of PCBs. Short-term risks may be incurred by workers from exposure to contamination during the implementation of this RA. Potential for exposure will be minimized by the wearing of appropriate personnel protective equipment (PPE) and compliance with site-specific health and safety procedures.

Component 5: Verification Sampling

Verification samples will be collected from the bottom (at total depth) and sides of the excavation area to ensure that all soil containing PCB concentrations that greater than the PRG is removed. Additional excavation may or may not be required based on the results of the verification sampling. Verification sampling and analysis procedures are described in Section 5.0.

Component 6: Backfilling and Site Restoration

After verification sampling activities have verified the removal of all contaminated soil/sediment, the excavated areas will be backfilled with imported clean soil. The excavated areas will also be restored to original grade, and native vegetation will be planted. Additionally, a replacement pedestrian bridge will be constructed across the drainage channel.

3.2 PERFORMANCE STANDARDS

The Decision Document (DD) for Site 10 stipulates that the remedy be capable of managing residuals and achieving RAOs within the boundaries of Site 10 and meet all ARARs. The performance standards specific to the activities proposed for this RA are presented in the following sections.

3.2.1 Erosion, Surface Water, and Sediment Control

Before excavation activities begin on site, erosion, sediment, and stormwater controls will be established to prevent impacts to areas adjacent to and downgradient of the excavation limits. The erosion, sediment, and stormwater controls will be regularly inspected and maintained during excavation and backfilling operations and until vegetation is established. These controls will include the temporary drainage channel running from just east of the excavation to the western side to divert any overflow from the nearby channels and the temporary berm on the southern side of the excavation area near the Parade Field area to control any stormwater runoff from infiltrating the excavation area (Figure 3-2).

Erosion, sediment, and stormwater control regulations of the Mississippi Commission on Environmental Quality Regulation WPC-1 will be complied with during these activities.

3.2.2 Excavation

Contaminated soil/sediment will be excavated and transported to the materials staging area where it will be stored prior to off-site transportation and disposal. Prior to excavating the soil/sediment, the area of excavation will be cleared, grubbed, and dewatered as needed.

Excavation of contaminated soil/sediment will continue until verification samples indicate that all contaminated material has been removed or that concentrations of PCBs are less than the PRG as indicated in the Verification Sampling and Analysis Plan (VSAP) (see Section 5.0).

The area may not be excavated until erosion and sediment controls are in place (see Section 4.0). Sediment removed from the erosion and sediment control areas prior to verification that all of the contaminated soil/sediment has been removed will be conservatively handled as contaminated and will be transported to the materials staging area. Sediment removed from the erosion and sediment control areas can be used as backfill material after verification that contaminated sediment has been removed from the excavation area.

Excavation will be performed in accordance with Specification Section 02315N, “Excavation and Fill.”

3.2.3 Additional Performance Standards

Additional activities associated with the selected remedy that were not specifically identified in the FS/DD are required to satisfy ARARs. These activities and performance standards are presented below.

Clearing and Grubbing

Clearing and grubbing will be conducted as needed within the limits of the excavation area. Grubbed material from within contaminated soil/sediment areas will be stored in the materials staging area. Clean soil excavated during grubbing activities will be stockpiled for reuse during backfill and restoration activities.

Decontamination Pad

A decontamination pad will be used to clean site and construction equipment used to haul and excavate contaminated soil/sediment. The pad will be constructed at the location indicated on Figure 3-1. No earthen cut or fill is required for construction of the decontamination pad.

Materials and Soils Staging/Handling Area

The materials staging/handling area will be used to stockpile excavated soil/sediment and miscellaneous soils resulting from over excavation. The materials staging/handling area will be located on the paved area at the northern edge of the Parade Field as indicated on Figure 3-1.

The general material/soils management requirements associated with this RD are the installation of erosion (surface water), sediment, and stormwater control features and clearing and grubbing within the limits of disturbance. The erosion, sediment, and stormwater control features include construction entrances/exits, silt fencing, the temporary drainage channel, the temporary berm, and sheet piling. The locations of these features are shown on Figure 3-2.

Backfilling and Site Restoration

Backfilling of the excavation area will be performed when the appropriate PRGs are achieved. Backfilling activities may be staged to minimize impacts to the Site 10 area. Following backfilling of the excavation area, the area will be restored to pre-excavation conditions. The drainage channel will be vegetated using a specified (Section 4.4) permanent seed mixture.

The excavation within the drainage channel will be backfilled with clean fill and 6 inches of topsoil to establish final grades. The upper 6 inches of fill soil will consist of clean, medium-texture topsoil with a minimum organic matter content of 5 percent and a maximum of 8 percent. The topsoil will be obtained from locations free of invasive plant species.

Following installation of the topsoil, the soil surface in the drainage channel will be hydroseeded with a commercially available wetland seed mixture appropriate for nontidal marshes in the Coastal Plain of Mississippi. Seeding will be timed to coincide with periods when the soil surface is saturated but not inundated.

Backfilling will be performed in accordance with Specification Section 02315N, "Excavation and Fill." Restoration will be performed in accordance with Specification Section 02953, "Mitigated Wetland Area, Trees, Herbs, and Grasses." The restoration will be conducted in accordance with the Mississippi Department of Marine Resources' Coastal Zone Consistency Determination and relevant portions of the Clean Water Act (Sections 404 and 401).

3.3 OTHER DESIGN REQUIREMENTS

3.3.1 Utilities

Underground utilities exist near Site 10 along the drainage channel and may exist elsewhere within the site boundaries. The RA Contractor will be obligated through specification to verify all utility locations and adequately protect the utilities before any excavation activities commence.

3.4 POST-REMEDIAL ACTION VERIFICATION SAMPLING

Verification samples will be collected from the excavated areas to ensure that all PCB-contaminated soil/sediment has been removed from the site. Additional excavation may or may not be required based on the results of the verification sampling.

Verification sampling will be performed to confirm that RA activities sufficiently achieve the remedial objectives. The VSAP (Section 5.0) for the Site 10 RA presents the plan to confirm that PCB-contaminated soil/sediment excavated from the Site 10 drainage channel is successfully removed to levels less than the PRG of 1,000 ug/kg.

In the event that additional excavation is required, it will be followed by additional verification sampling. Verification activities contained within the VSAP were prepared using the Michigan Department of Environmental Quality guidance document entitled "Verification of Soil Remediation" (MDEQ, 2001).

3.5 IMPLEMENTATION

The RA Contractor will coordinate field work through the Base Environmental and Safety office and the Resident Officer in Charge of Construction (ROICC) for specific requirements related to Site 10.

The time to perform the required construction activities is estimated to be approximately 13 days. The following sequence of construction assumes that all of the work will be performed in one construction period. Upon approval of the ROICC, sequence items may be conducted concurrently. The generalized sequence of construction activities is as follows:

1. Hold pre-construction meeting with the ROICC.

2. Inspect the site prior to construction to verify existing site conditions and underground utility locations.

3. Establish horizontal and vertical controls for construction. Stake the location of all areas to be excavated or disturbed prior to actual work.

4. Install perimeter controls for the construction entrance(s)/exit(s). All perimeter controls will conform to MDEQ standards, unless otherwise specified. The perimeter controls to be installed include, but are not limited to, the following:

   - Placement of silt fencing around the construction entrance(s)/exits(s), materials staging/handling pad, decontamination pad, and excavation areas.

   - Additional controls as may be required by the ROICC and/or warranted by site conditions and best construction practices.

5. Clear and grub areas for the materials staging/handling pad and decontamination pad, unless indicated otherwise. Clear but do not grub all areas where excavation will occur.

6. Construct materials staging/handling pad and decontamination pad.

7. Excavate contaminated soil/sediments from the Site 10 Parade Field Ditch and transport soil/sediment to the materials staging/handling area. Verification sampling and analysis will follow visual confirmation that all contaminated material has been excavated. If verification results indicate that contaminants are either completely removed or at levels less than the PRG for PCBs (Aroclor-1260), excavation of contaminated soil/sediment is complete. If the initial verification results indicate

that soil/sediment remains on site with PCB concentrations greater than the PRG, continue excavation in accordance with the VSAP, and the Navy will conduct additional verification sampling and analysis. Continue the excavation process until contaminants are removed and the PRG is achieved.

8. Following completion of the excavation, remove the materials staging/handling pad and decontamination pad. Transport and dispose off site all required materials from these temporary features. The Navy will collect verification samples from the soil below the materials handling pad and decontamination pad in accordance with the VSAP and as outlined in Sequence Item 7.

9. Stabilize all remaining areas of disturbance with the selected permanent seed mixture indicated in Section 4.0.

10. When the Site 10 area has been stabilized and approval of stabilization has been received from the ROICC and MDEQ, remove all remaining temporary perimeter controls and all remaining on-site controls.

4.0 EROSION, SEDIMENT, AND STORMWATER CONTROL PLAN

This ESSCP was prepared for the RA at Site 10, Parade Field Ditch at the NCBC in Gulfport, Mississippi.

4.1 SCOPE AND PURPOSE

The objective of this section is to present the ESSCP describing the measures that will be taken to minimize and/or eliminate potential erosion, sedimentation, and stormwater runoff during implementation of the RA at Site 10. Runoff quality during the RA is addressed via erosion, sediment, and stormwater controls located around the perimeter of the excavation area. The ESSCP was prepared in accordance with State of Mississippi regulations as set forth in the Mississippi Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater (MPDMCESS) (USDA, 1994).

This section also presents the State of Mississippi's narrative checklist requirements for erosion, sediment, and stormwater control plans, a response to the narrative requirements, and a generalized sequence of remedial/construction activities. A copy of the completed Mississippi Checklist for Erosion, Sediment, and Stormwater Control Plans is presented in Appendix B.

4.2 EROSION, SEDIMENT, AND STORMWATER CONTROL MEASURES

Unless otherwise noted in this ESSCP or in the design requirements, erosion, sediment, and stormwater control measures will be implemented, installed, and maintained according to the standards and specifications of the April 1994 MPDMCESS. The MPDMCESS was produced with the cooperation of the USDA Natural Resources Conservation Service, MDEQ, and Mississippi Soil and Water Conservation Commission (MSWCC) (USDA, 1994). The required erosion, sediment, and stormwater control measures are shown on Figure 3-2 and summarized as follows:

- Construction entrance(s)/exit(s) will be installed to provide ingress and egress to Site 10 and the Parade Field and will be protected with silt fencing.

- Silt fencing will be placed along the downslope sides of construction entrance(s)/exit(s), support facilities [i.e., the decontamination pad, staging area(s), and materials handling pad], and around identified excavation areas.

- Temporary diversions will be constructed along the excavation area (temporary ditch) and near the Parade Field (temporary berm). The diversions will be used to divert stormwater runoff from the Parade Field and convey excess water around the excavation.

- Sheet piling will be placed within the drainage channels. After insertion of the sheet piles, dewatering will take place and contaminated soil/sediment will be excavated.

4.2.1 Structural Practices

The following structural practices will be used during and/or following RA activities at Site 10 to control erosion and sedimentation:

1. Sediment Tank - A sediment tank will be available on site for use during the dewatering of excavation areas and for collecting decontamination water. Water from excavations may be collected in a temporary holding tank, tested, and disposed at an appropriate off-site facility, if necessary. In the event that a determination is made to allow discharge of the collected water onto the ground surface, water will first be cleaned of sediment and then broadcast over an approved vegetated area or designated drainage channel. Water from the decontamination pad will be collected in a temporary holding tank, tested, and disposed at an appropriate off-site facility, if necessary.

2. Temporary Seeding - All regraded areas that will be left dormant for extended periods of time will be seeded with fast-germinating temporarily vegetation immediately following grading. Seeding will be performed dependent on the time of year, in accordance with the Seeding Chart in the Mississippi Stormwater Pollution Prevention Plan Guidance Manual for Construction Activities published by the General Permits Branch of the Office of Pollution Control (OPC) of the MDEQ (OPC, 2000).

3. Permanent Seeding - All regraded areas will be permanently seeded with a seed mixture that will minimize erosion and provide suitable food and cover for wildlife. The permanent seed mixture for this RA is presented in Section 4.4.

4. Mulching - All areas receiving permanent seeding will be mulched with an organic material that prevents erosion by protecting the soil surface from raindrop impact and reducing the velocity of overland flow.

4.2.2 Management Strategies

The following management strategies will be utilized during the RA:

1. Seeding or other stabilization measures will immediately follow grading.

2. Areas that are not to be disturbed will be clearly marked by flags, signs, etc.

3. The construction superintendent will be responsible for ensuring the installation and maintenance of all erosion, sediment, and stormwater control practices.

5. Erosion, sediment, and stormwater control structures will be installed and/or constructed before the start of any earth-disturbance activities.

6. Temporary erosion, sediment, and stormwater control features will remain in place until permanent vegetation is established over disturbed surfaces.

4.3 INSPECTION AND MAINTENANCE

During the RA, all erosion, sediment, and stormwater control measures will be checked daily and after each runoff-producing rainfall event. Any required repairs will be made immediately. The following items will be checked:

- Construction entrance(s)/exit(s) will be checked to ensure that they are being maintained in a condition that will minimize tracking soil/sediment onto roads, including the addition of stone or other repairs.

- Silt fencing will be checked regularly for undermining or deterioration of the fabric. Sediment will be removed when the level of sediment deposition causes “bulging” or reaches one-half of the fabric height.

- Seeded areas will be checked regularly to ensure that a good stand of vegetation is maintained. Areas will be fertilized and reseeded as needed. The Contractor is responsible for maintenance until formal acceptance of the RA by the ROICC.

4.4 SITE RESTORATION/PERMANENT STABILIZATION

Because existing conditions at Site 10 consist of stabilized soil with light vegetation, Site 10 will be restored to grassy or natural conditions following completion of the RA.

All areas disturbed by RA activities will be stabilized with permanent seeding as soon as possible following final grading, but no later than 14 calendar days after establishment of final grade. Permanent seeding will be conducted in accordance with the MPDMCESS (USDA, 1994). The seed mixture to be selected is recommended in the Mississippi SWPPP Guidance Manual for Construction Activities for

Mississippi's Southern Zone (OPC, 2000). The seed mixture should consist of common Bermuda grass and/or annual rye grass.

5.0 VERIFICATION SAMPLING

5.1 SCOPE AND PURPOSE

During the upcoming RA, PCB-contaminated soil/sediment from areas impacted by the past activities at Site 10 will be excavated and disposed off site at an approved landfill. Verification of the RA is required under MDEQ regulations. A site-specific VSAP will be prepared and executed by the Contractor to demonstrate that the PRGs have been achieved. This chapter presents the technical and administrative requirements for RA verification.

5.2 SAMPLING OBJECTIVES

The objectives for verification sampling are as follows:

- Determine if excavation activities met PRGs.
- Provide sufficient data to demonstrate that PRGs have been achieved and to support site closure reporting.
- If the RA has not been successful, the sampling data should be sufficient to define additional remedial alternatives.

The following sub-sections describe the technical and administrative requirements in detail.

5.3 TECHNICAL AND ADMINISTRATIVE REQUIREMENTS

Verification of the RA will be confirmed by a random grid node sampling strategy as described below. The RA will be considered successful when the 95 percent upper confidence limit (UCL) of the arithmetic mean is equal to or less than the PRG of 1,000 ug/kg.

The Tier I TRG table is included in Appendix C, VSAP Documentation.

The number and locations of samples required for verification will be determined using the Sampling Strategies and Statistics Training Materials (S3TM) for Part 201 Cleanup Criteria (MDEQ Remedial and Redevelopment Division, 2002), also provided in Appendix C.

For characterizing human exposure potential to hazardous substances, MDEQ and USEPA recommend that a 95 percent UCL of the arithmetic mean be used to estimate reasonable maximum exposure concentrations. The IR program at NCBC Gulfport uses ProUCL (Version 3.00.02) as published by the USEPA to calculate 95 percent UCLs.

5.4 SAMPLING LOCATIONS AND FREQUENCY

Based on the S3TM guidance, the general strategy for verification at Site 10 includes the following:

- Determine if a statistical approach is applicable.
- Determine the size of the site and the appropriate formula for developing a grid interval.
- Establish the sample grid.
- Randomly select 25 percent of the grid nodes for sampling, with a minimum of nine samples for the excavation floor and nine samples for side wall samples.

Based on the contaminant type and media, a statistical approach is considered applicable.

Site 10 is considered a “small”, defined by the S3TM guidance as less than ¼ acre; therefore, the formula for establishing the grid interval is as follows:

$$GI = \frac{\sqrt{A/\pi}}{2}$$

Where,
GI = Grid interval
A = Area of grid (ft^2)
π = 3.14

The grid interval will be specific to the actual size of the excavation, but for planning purposes, a site the size of Site 10 would have a grid interval of approximately 10 feet.

A sampling frequency of 25 percent of the nodes should be completed if the minimum number of samples is satisfied as discussed above.

5.5 ANALYTICAL PROGRAM

The PCB Aroclor-1260 was retained as the only COC for both sediment and subsurface soil at Site 10. All verification samples will be sent to a Navy-approved laboratory for PCB analysis by Method SW-846 8082.

5.6 SAMPLING AND ANALYSIS PLAN

Before verification sampling, a sampling and analysis plan (SAP) will be submitted to and approved by Naval Facilities Engineering Command, Southeast (NAVFAC SE). The SAP will include the following information:

- Sampling objectives, approach, and activities.
- Detailed field procedures including equipment, decontamination procedures, utility clearance, and field documentation.
- Analytical program including the calculation for the total number of samples, Quality Assurance Project Plan (QAPP), and data management procedures.
- Health and Safety Plan

It is anticipated that the SAP will be issued as a draft prior to the initiation of remediation activities.

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FIGURES

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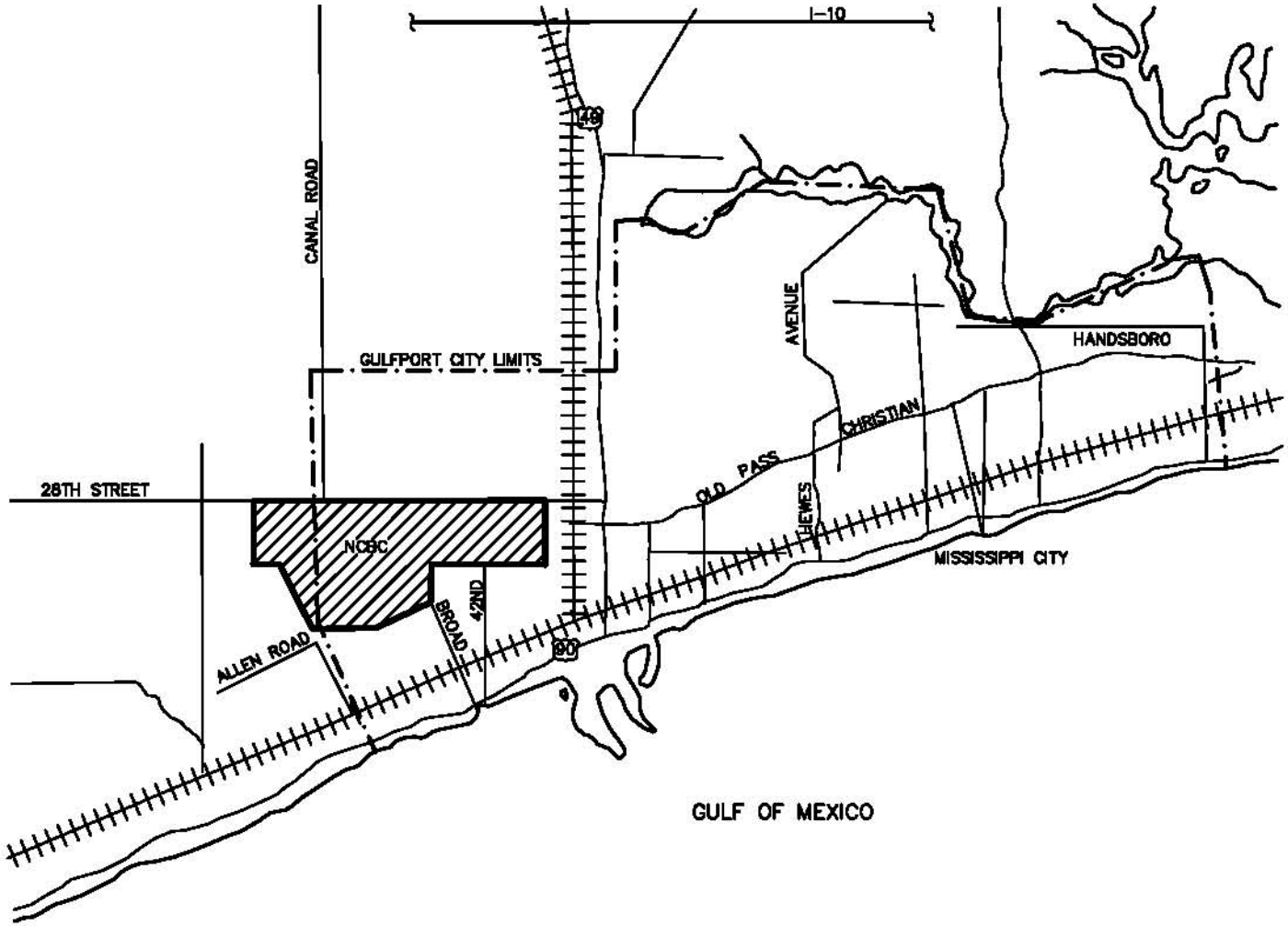

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CHECKED BY	DATE		OWNER NO.
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-1 / REV. 0

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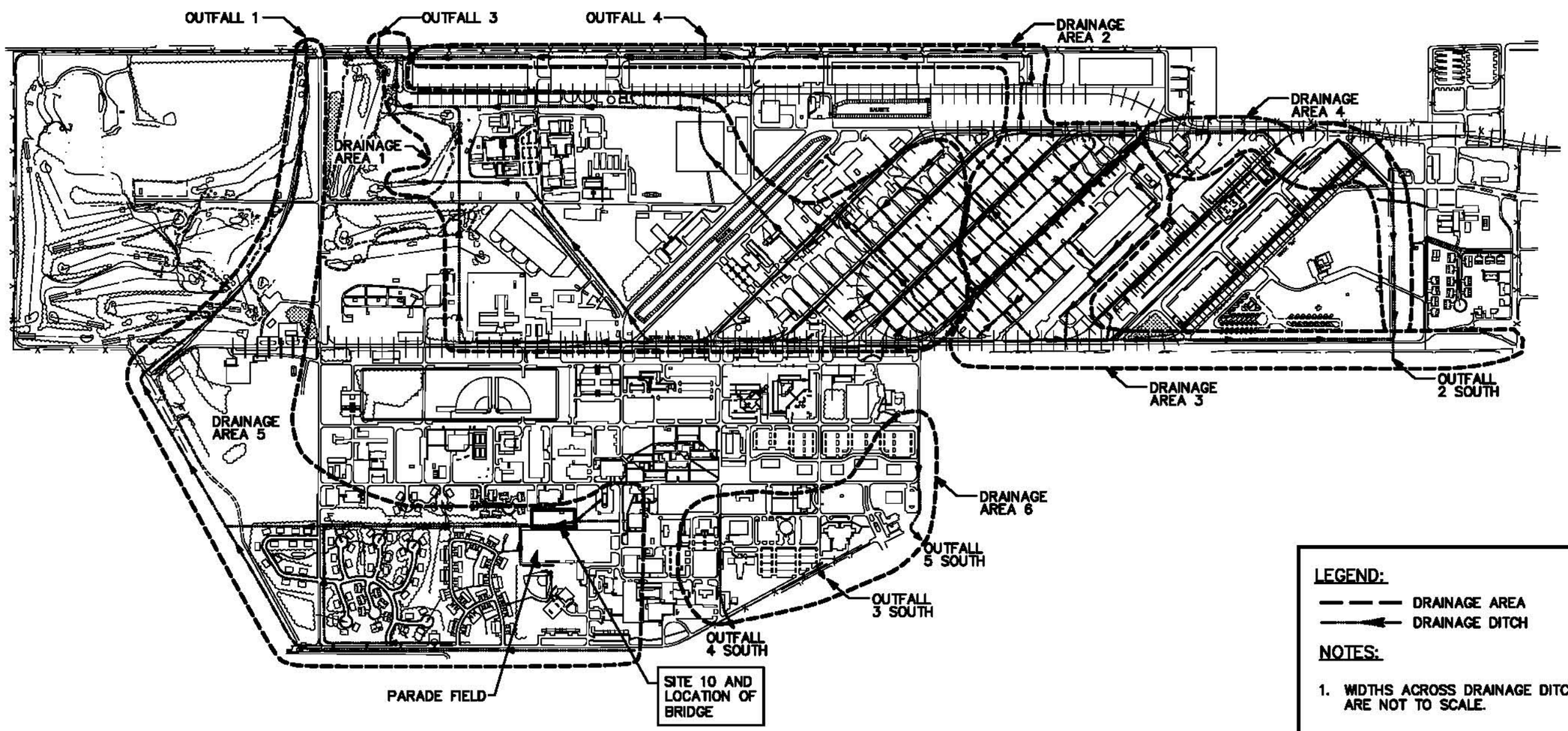

LEGEND:

— — — DRAINAGE AREA

—◄— DRAINAGE DITCH

NOTES:

1. WIDTHS ACROSS DRAINAGE DITCHES ARE NOT TO SCALE.

0 1000 2000

GRAPHIC SCALE IN FEET

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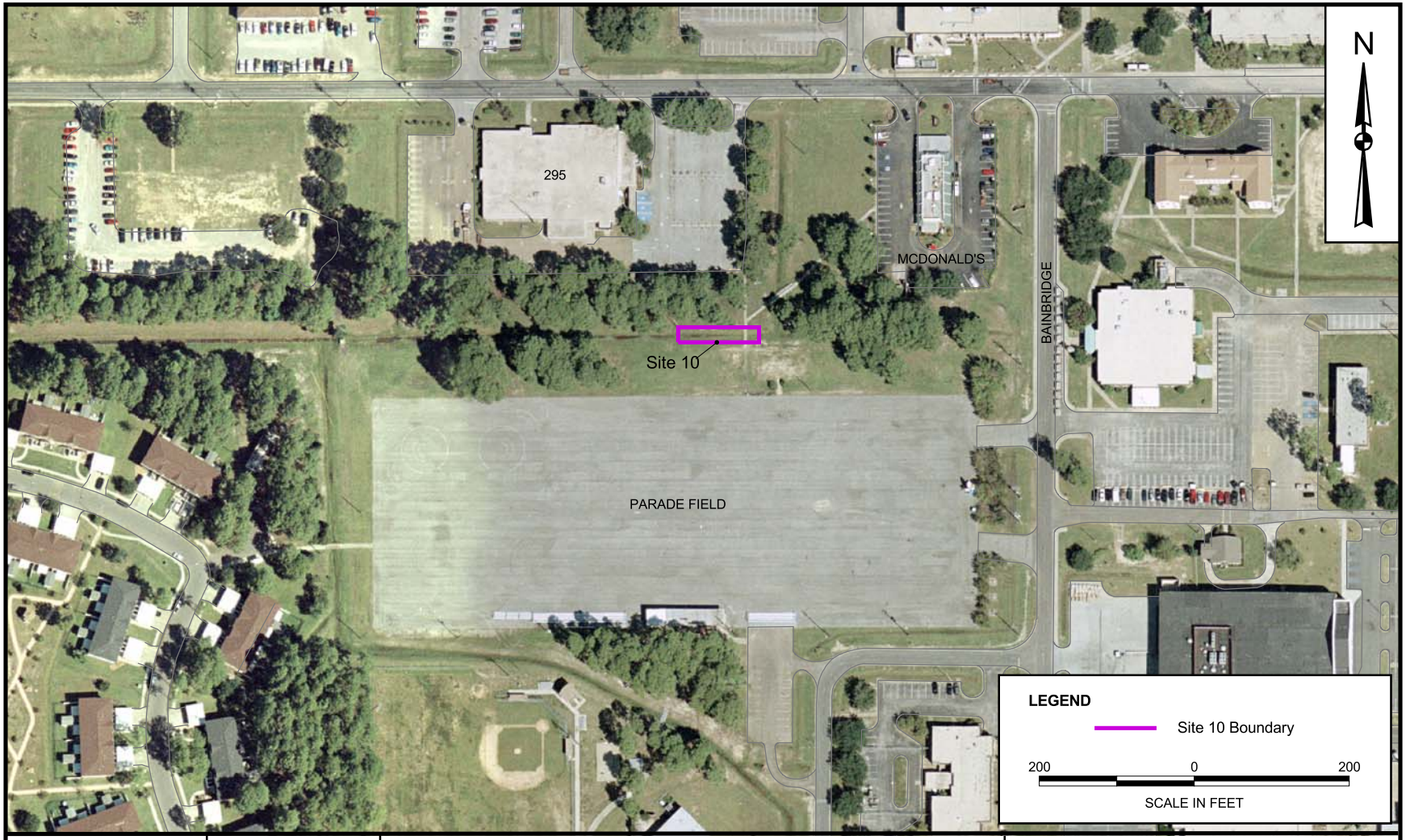

DRAWN BY	DATE
A. JANOCHA	2/25/04
CHECKED BY	DATE
M. JAYNES	4/19/07

COST/SCHEDULE-AREA

SCALE
AS NOTED

NAVFAC

SITE PLAN
SITE 10 REMEDIAL DESIGN
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER
1831

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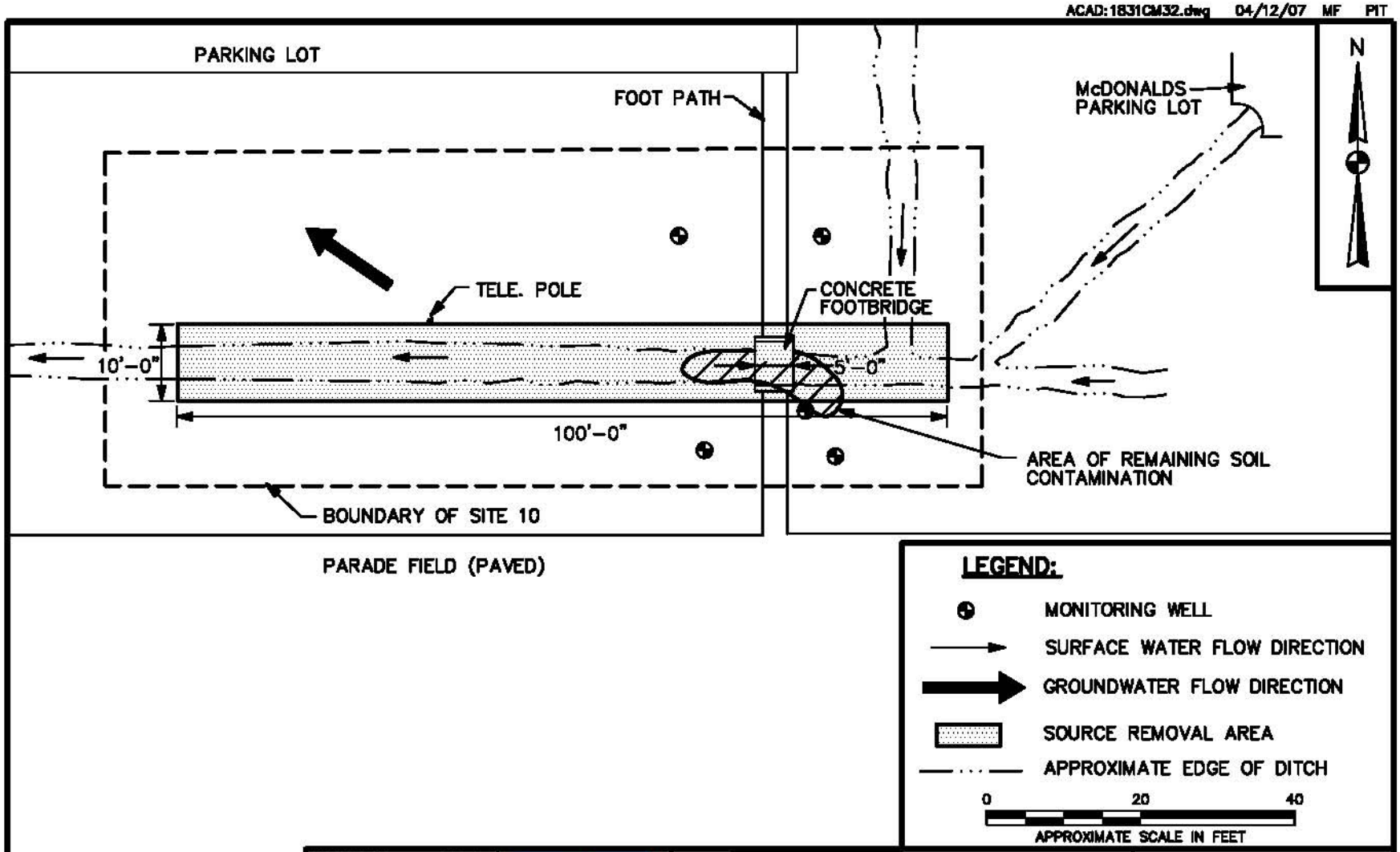

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COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

NAVFAC

AERIAL EXTENT OF CONTAMINATION

SITE 10 REMEDIAL DESIGN

FEASIBILITY STUDY REPORT

NAVAL CONSTRUCTION BATTALION CENTER

GULFPORT, MISSISSIPPI

CONTRACT NUMBER		
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FIGURE 2-3		0

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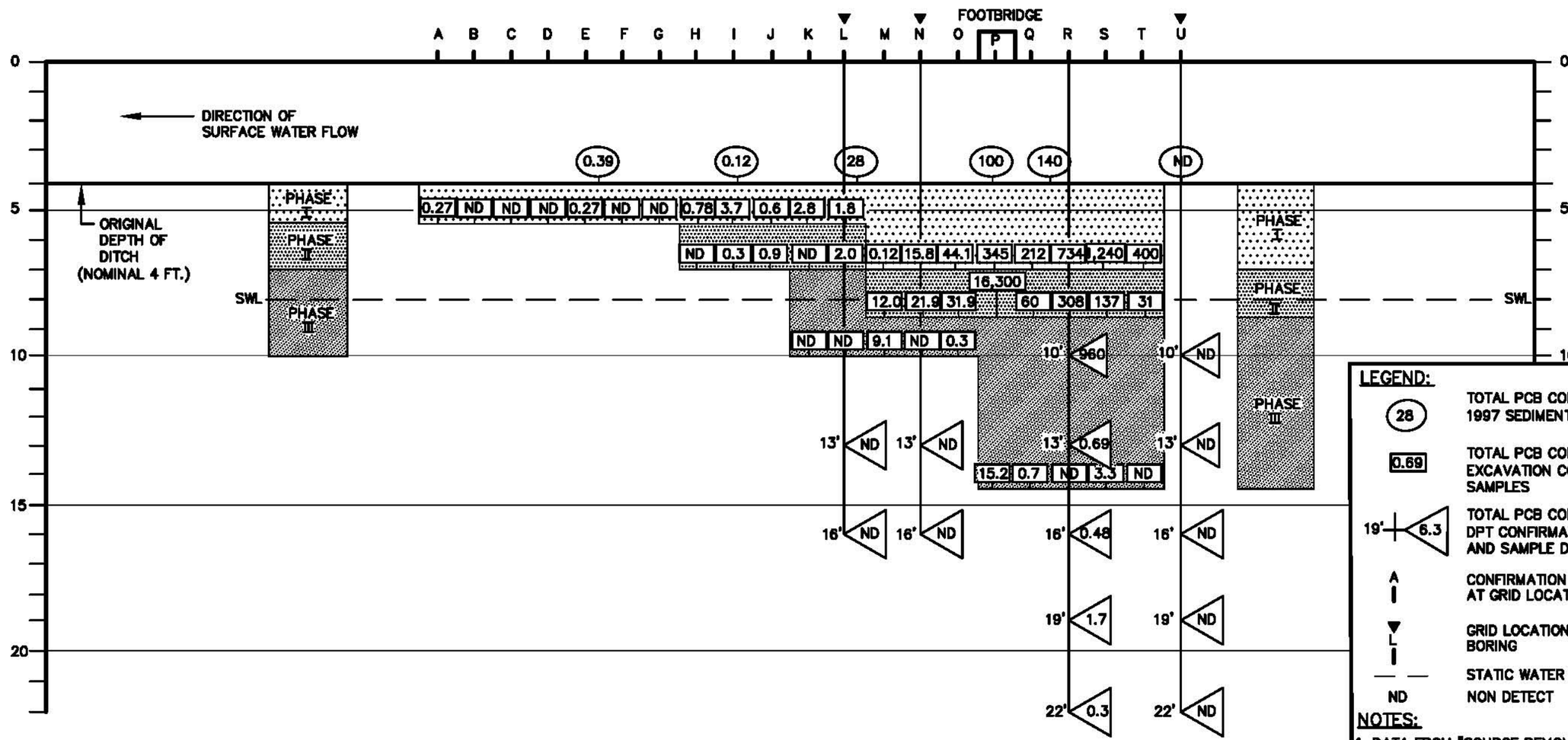

LEGEND:

(28)	TOTAL PCB CONCENTRATION 1997 SEDIMENT SAMPLES
[0.69]	TOTAL PCB CONCENTRATION EXCAVATION CONFIRMATION SAMPLES
19' 6.3	TOTAL PCB CONCENTRATION DPT CONFIRMATION SAMPLES AND SAMPLE DEPTH
A	CONFIRMATION SAMPLING AT GRID LOCATION
L	GRID LOCATION WITH SOIL BORING
— —	STATIC WATER LEVEL
ND	NON DETECT

NOTES:

1. DATA FROM "SOURCE REMOVAL REPORT FOR THE EXCAVATION OF PCB CONTAMINATED SOIL FROM THE DRAINAGE DITCH ADJACENT TO THE PARADE FIELD, NAVAL CONSTRUCTION BATTALION CENTER GULFPORT," CCI 2000
2. CONCENTRATIONS IN PARTS PER MILLION

0 10 20
HORIZONTAL SCALE IN FEET
0 5 10
VERTICAL SCALE IN FEET

DRAWN BY MF	DATE 12/14/06	RESULTS OF PREVIOUS PCB SAMPLES SITE 10 REMEDIAL DESIGN NAVAL CONSTRUCTION BATTALION CENTER GULFPORT GULFPORT, MISSISSIPPI
CHECKED BY	DATE	
REVISED BY	DATE	
SCALE AS NOTED		

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OWNER NO.	
APPROVED BY	DATE
DRAWING NO. FIGURE 2-4	REV. 0

FORM CADD NO. SDIV-IN.DWG - REV 1 - 9/10/98

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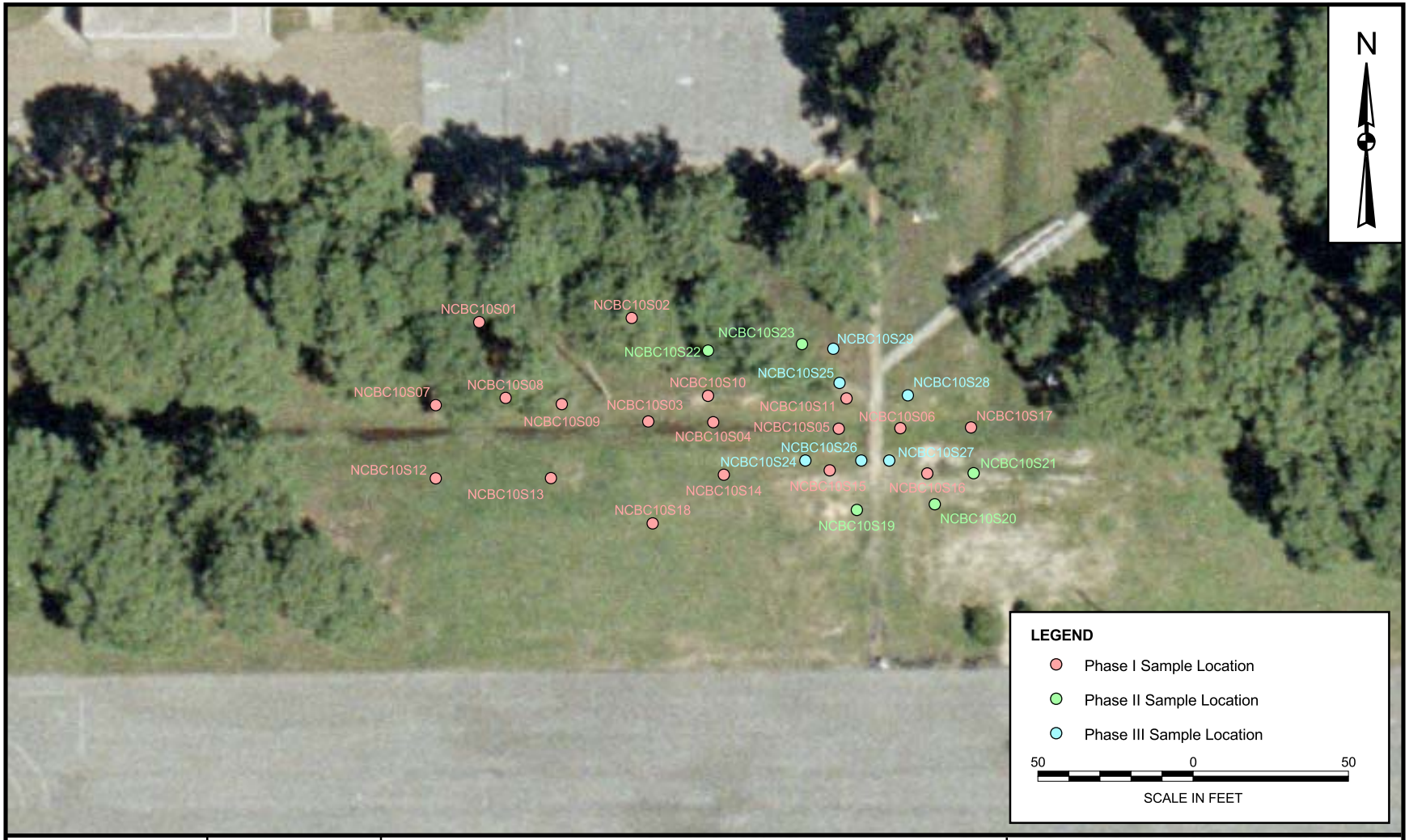

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A. JANOCHA	2/25/04
CHECKED BY	DATE
M. JAYNES	4/19/07
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

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SOIL BORING LOCATIONS

SITE 10 REMEDIAL DESIGN

NAVAL CONSTRUCTION BATTALION CENTER

GULFPORT, MISSISSIPPI

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APPROVED BY	DATE
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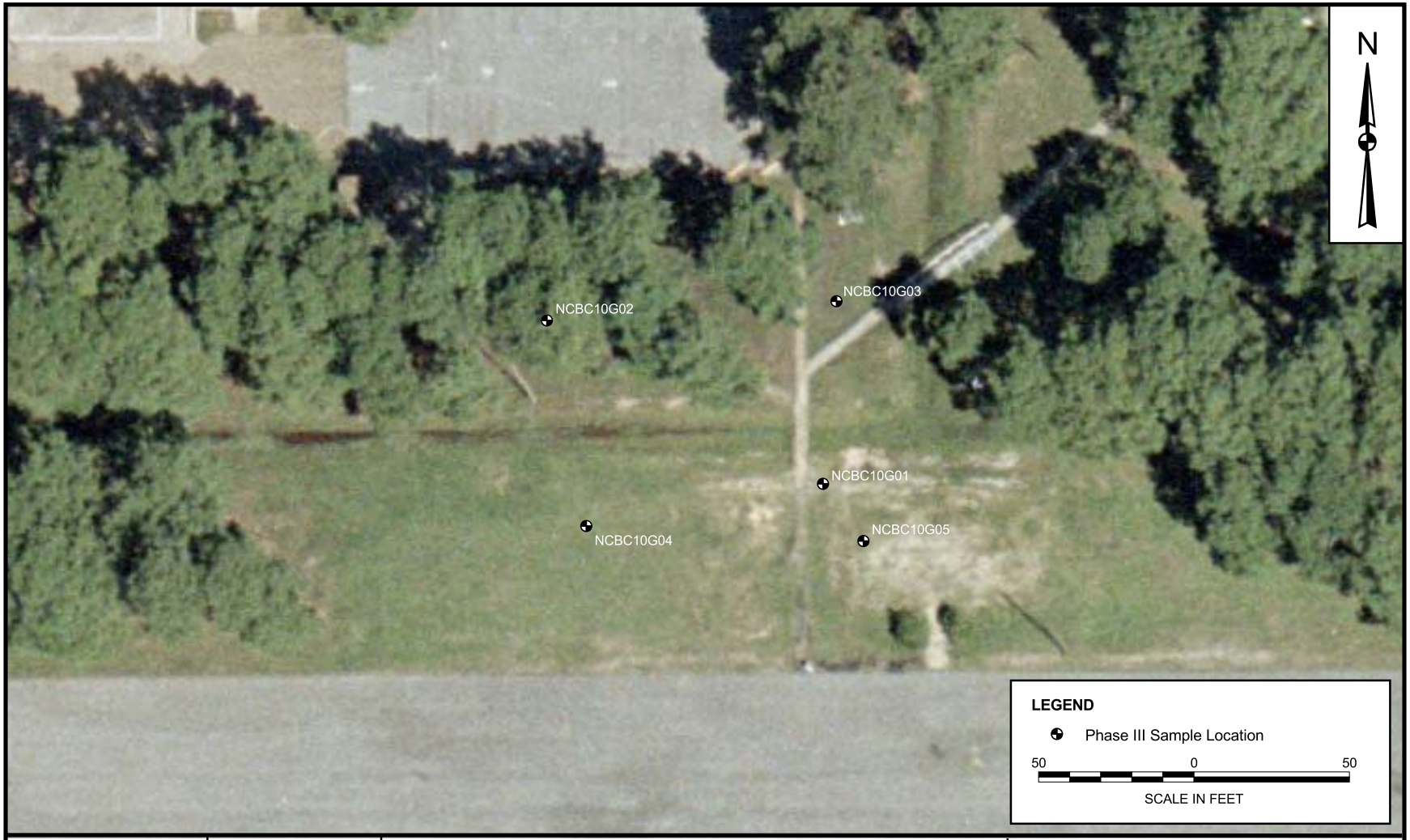
FIGURE 2-5	0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 2-2 SB LOCATION LAYOUT 4/19/07 KM



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CHECKED BY	DATE
M. JAYNES	4/19/07

COST/SCHEDULE-AREA

SCALE
AS NOTED

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MONITORING WELL LOCATIONS
SITE 10 REMEDIAL DESIGN
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER
1831

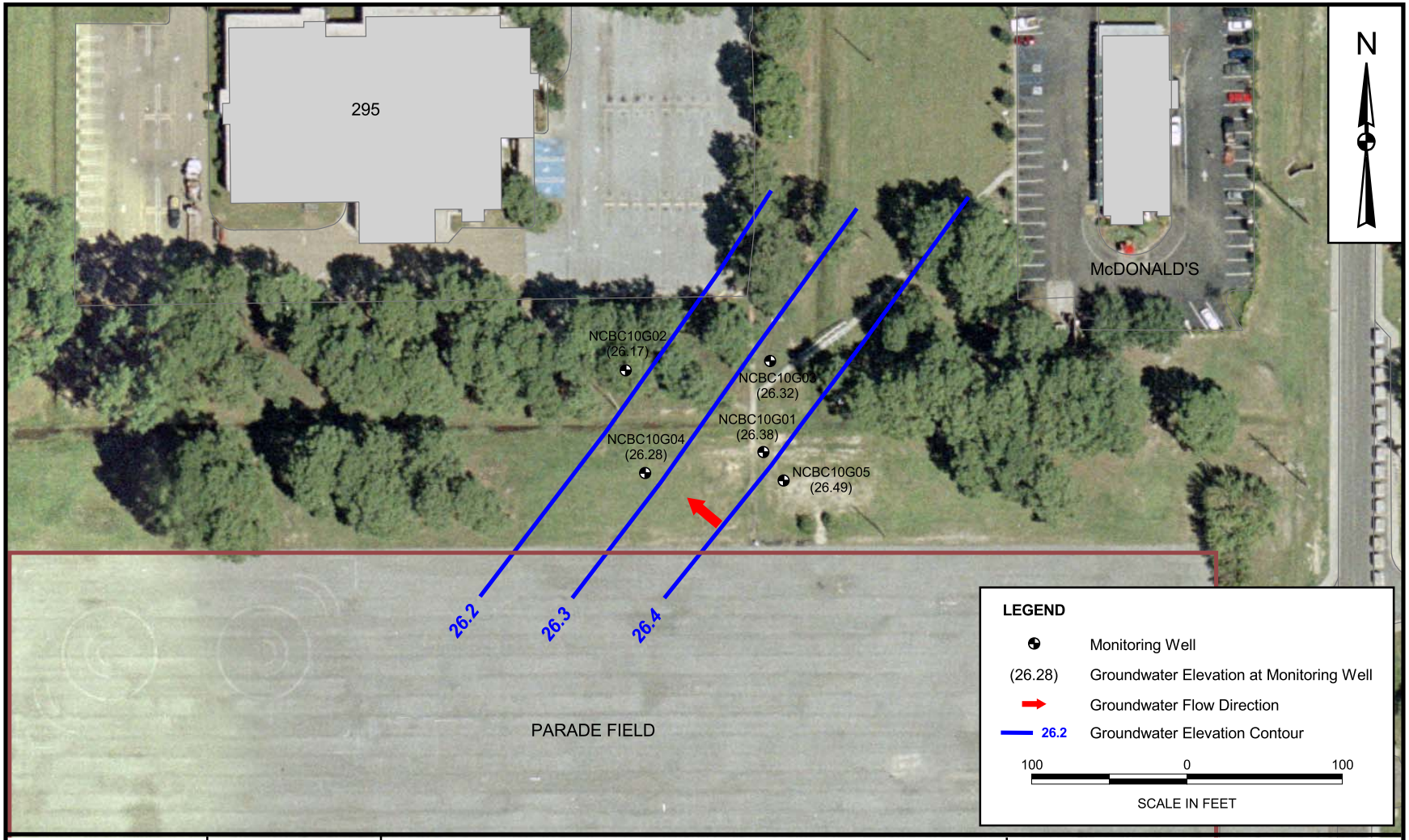
APPROVED BY — DATE —

APPROVED BY — DATE —

DRAWING NO. FIGURE 2-6

REV 0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 2-3 MW LOCATION LAYOUT 4/19/07 KM



DRAWN BY	DATE
A. JANOCHA	4/29/04
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M. JAYNES	4/19/07

COST/SCHEDULE-AREA

SCALE
AS NOTED

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GROUNDWATER POTENTIOMETRIC SURFACE
SITE 10 REMEDIAL DESIGN
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER
1831

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APPROVED BY — DATE —

DRAWING NO. FIGURE 2-7

REV 0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 3-7 POTENTIOMETRIC CONTOUR DECEMBER 2003 LAYOUT 4/19/07 KM

DRAWN BY	DATE
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M. JAYNES	4/19/07
COST/SCHEDULE-AREA	
SCALE	AS NOTED

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SOIL PCB PRG EXCEEDANCES
SITE 10 REMEDIAL DESIGN
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

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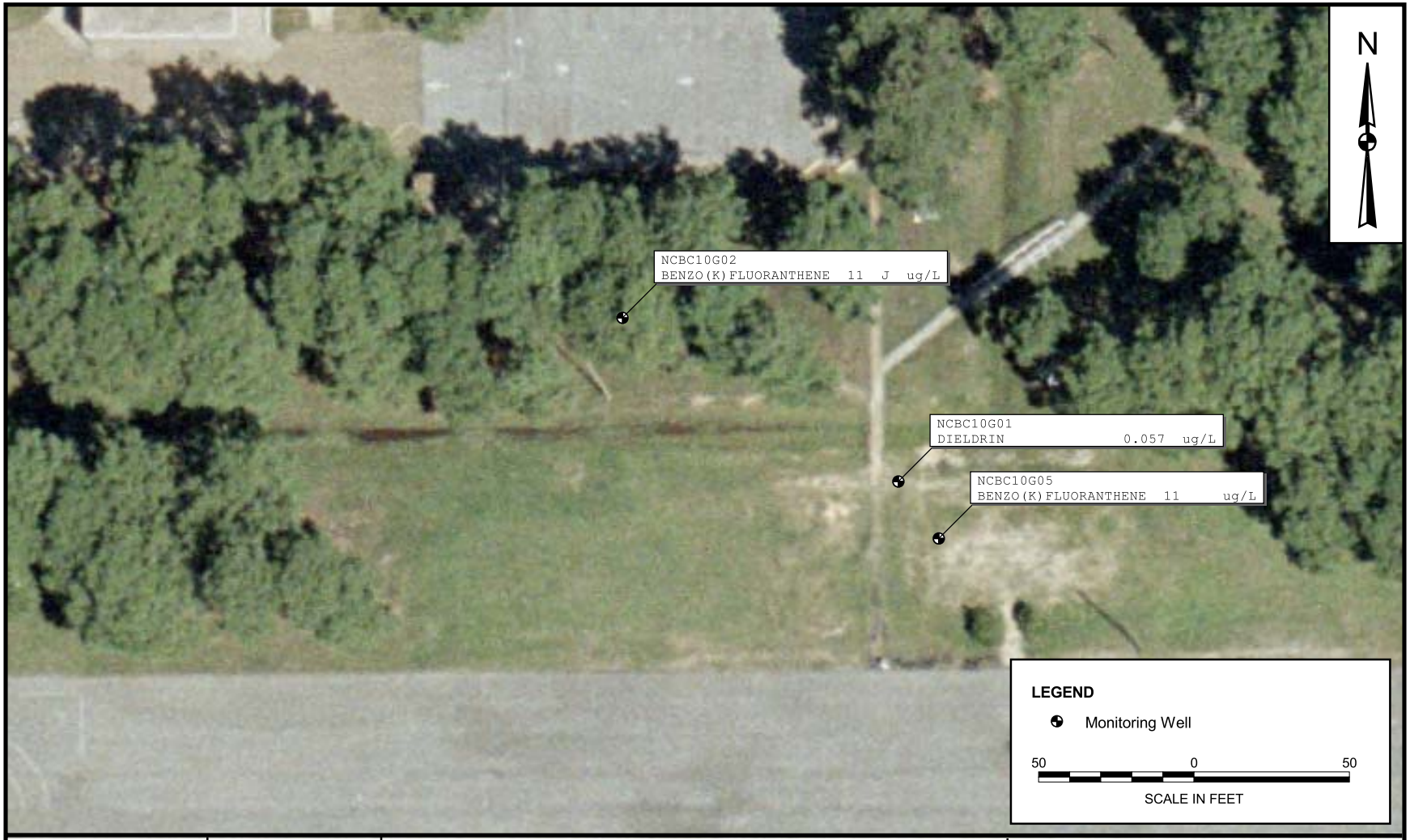
DRAWING NO.	REV
FIGURE 2-8	0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 4-2 SOIL ORGANIC TAG LAYOUT 4/19/07 KM



DRAWN BY	DATE
A. JANOCHA	4/30/04
CHECKED BY	DATE
M. JAYNES	4/19/07

COST/SCHEDULE-AREA

SCALE
AS NOTED

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GROUNDWATER TRG EXCEEDANCES
SITE 10 REMEDIAL DESIGN
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER
1831

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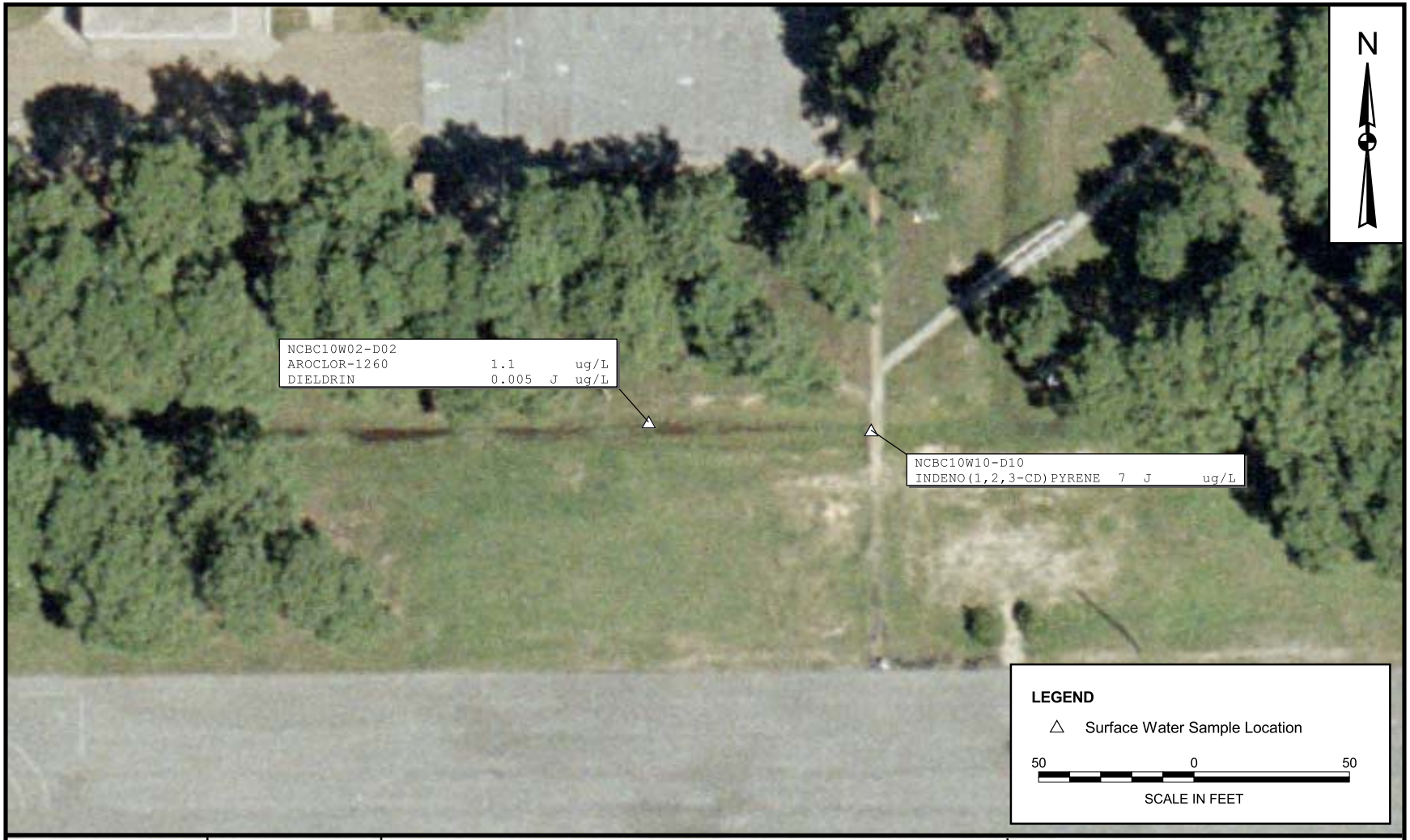
APPROVED BY — DATE —

DRAWING NO. FIGURE 2-9

REV 0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 4-4 GROUNDWATER TAG LAYOUT 4/19/07 KM



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A. JANOCHA	4/30/04
CHECKED BY	DATE
M. JAYNES	4/19/07

COST/SCHEDULE-AREA

SCALE
AS NOTED

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SURFACE WATER CRITERIA EXCEEDANCES
SITE 10 REMEDIAL DESIGN
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER
1831

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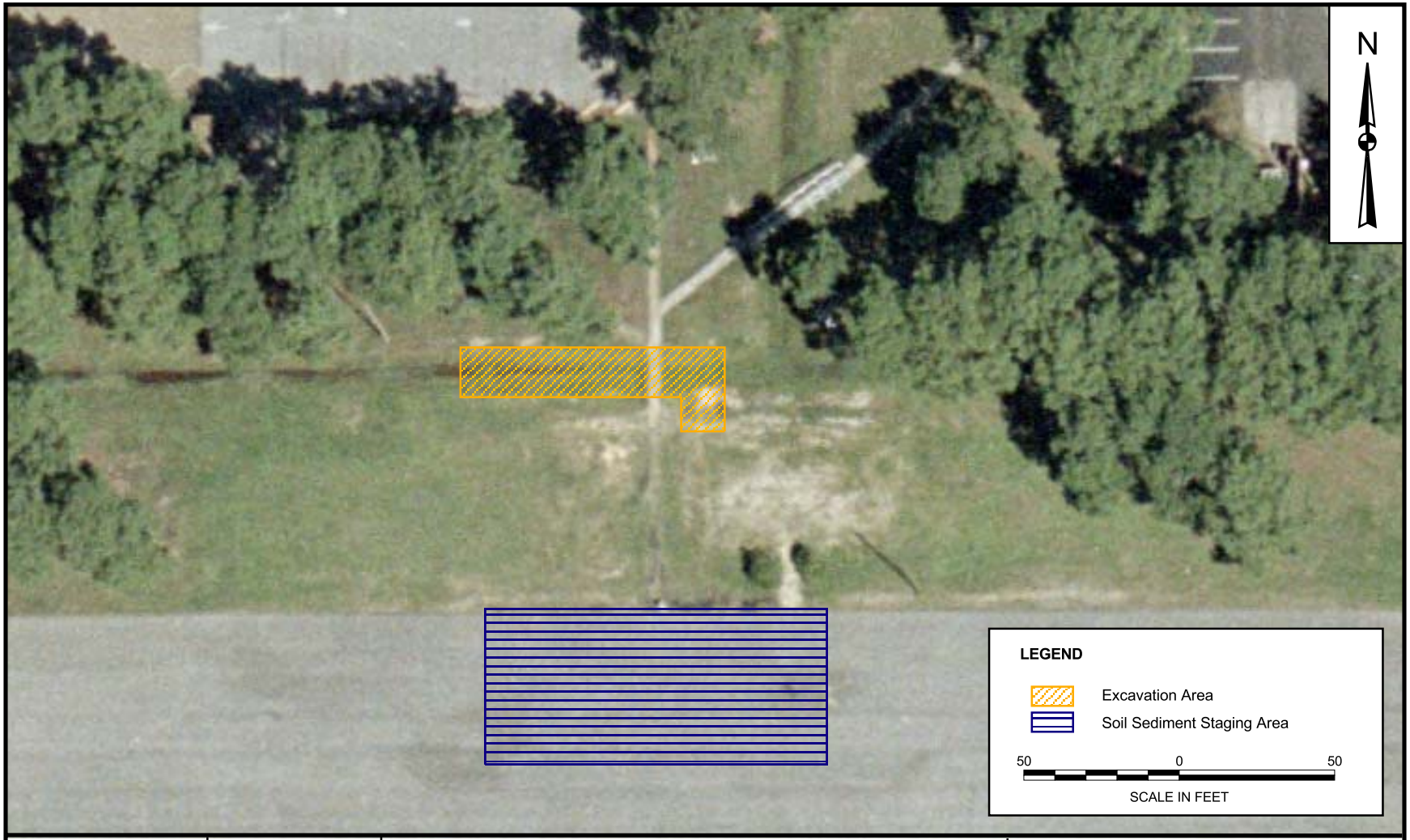
APPROVED BY — DATE —

DRAWING NO. FIGURE 2-10

REV 0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 4-5 SURFACE WATER TAG LAYOUT 4/19/07 KM



DRAWN BY	DATE
C. FOSTER	12/08/04
CHECKED BY	DATE
M. JAYNES	4/19/07

COST/SCHEDULE-AREA

SCALE
AS NOTED

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SURFACE WATER CONTROLS AND EXCAVATION AREA LAYOUT
SITE 10 REMEDIAL DESIGN
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER
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DRAWING NO. FIGURE 3-1

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P:\GIS\GULFPORT_CBC\MAPDOCS\APR\SITE10.APR ALTERNATIVE 4 LAYOUT 4/19/07 KM

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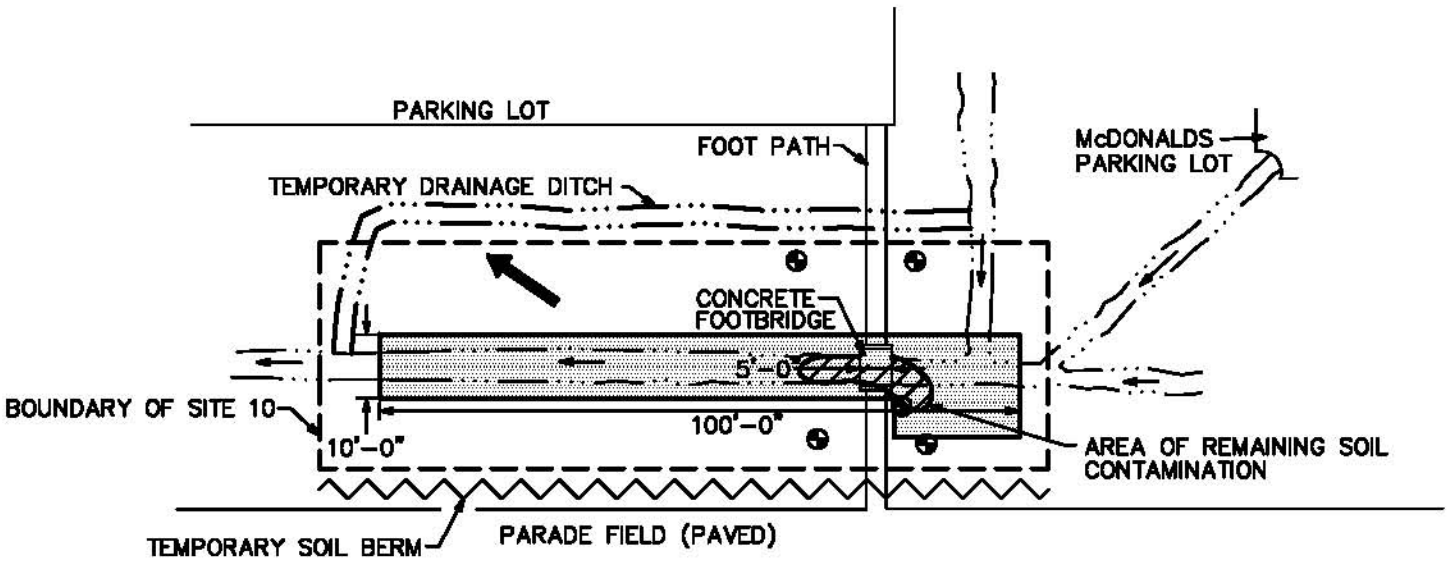

LEGEND:

- MONITORING WELL
- SURFACE WATER FLOW DIRECTION
- GROUNDWATER FLOW DIRECTION
- SOURCE REMOVAL AREA
- APPROXIMATE EDGE OF DITCH

0 30 60

APPROXIMATE SCALE IN FEET

DRAWN BY MF	DATE 4/12/07	SITE CONCEPTUAL MODEL SITE 10 REMEDIAL DESIGN NCBC GULFPORT GULFPORT, MISSISSIPPI	CONTRACT NO. 1831
CHECKED BY	DATE		OWNER NO. 0000
REVIEWED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 3-2 / REV. 0

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FORM CADD NCL SDIV-AH.DWG - REV 1 - 9/10/98

APPENDIX A

RI/FS (CD)

Comprehensive Long-term Environmental Action Navy

CONTRACT NUMBER N62467-94-D-0888

Rev. 1
02/02/07

Remedial Investigation and Feasibility Study

at

Site 10 – Parade Field Ditch

at

Naval Construction Battalion Center

Gulfport, Mississippi

Contract Task Order 0288

February 2007

Naval Facilities Engineering Command
Southeast
2155 Eagle Drive
North Charleston, South Carolina 29406

TETRA TECH NUS, Inc.

Rev. 1
02/02/07

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY AT SITE 10 – PARADE FIELD DITCH

NAVAL CONSTRUCTION BATTALION CENTER GULFPORT, MISSISSIPPI

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Naval Facilities Engineering Command
Southeast
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 0288

FEBRUARY 2007

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TABLE OF CONTENTS

SECTION **PAGE NO.**

LIST OF ACRONYMS AND ABBREVIATIONS viii

EXECUTIVE SUMMARY ES-1

REMEDIAL INVESTIGATION

1.0 INTRODUCTION 1-1
1.1 PURPOSE OF REPORT 1-1
1.2 SITE BACKGROUND 1-1
1.2.1 Site Description 1-1
1.2.2 Site History 1-2
1.2.3 Previous Investigations 1-2
1.3 REPORT ORGANIZATION 1-3

2.0 STUDY AREA INVESTIGATION 2-1
2.1 SURFACE WATER AND SEDIMENT INVESTIGATIONS 2-2
2.1.1 Phase I Surface Water and Sediment Sampling 2-2
2.1.2 Phase II Sediment Sampling 2-2
2.1.3 Phase III Surface Water and Sediment Sampling 2-2
2.2 SOIL AND VADOSE ZONE INVESTIGATIONS 2-3
2.2.1 Phase I Soil Sampling 2-3
2.2.2 Phase II Soil Sampling 2-4
2.2.3 Phase III Soil Sampling 2-4
2.3 GROUNDWATER INVESTIGATIONS 2-4
2.3.1 Monitoring Well Installation 2-5
2.3.2 Phase II Groundwater Sampling 2-5
2.3.3 Phase III Groundwater Sampling 2-5

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA 3-1
3.1 SURFACE FEATURES 3-1
3.2 METEOROLOGY 3-1
3.3 SURFACE WATER HYDROLOGY 3-1
3.4 GEOLOGY 3-2
3.4.1 Stratigraphy 3-2
3.4.2 Regional Geology 3-2
3.5 SOILS 3-2
3.5.1 Soil Classification 3-3
3.6 HYDROGEOLOGY 3-3
3.6.1 Static Water Levels and Groundwater Elevations 3-3
3.6.2 Groundwater Flow Direction 3-4
3.6.3 Hydraulic Gradient 3-4
3.6.4 Hydraulic Conductivity 3-5
3.6.5 Groundwater Flow Velocity 3-5
3.6.6 Regional Hydrogeology 3-5
3.7 DEMOGRAPHY AND LAND USE 3-6
3.8 ECOLOGY 3-6
3.8.1 Aquatic Habitats 3-7
3.8.2 Terrestrial Habitats 3-7
3.8.3 Species of Concern 3-7

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

4.0 NATURE AND EXTENT OF CONTAMINATION 4-1
4.1 CONTAMINANT SOURCES 4-1
4.2 SOILS AND VADOSE ZONE 4-1
4.2.1 Volatile Organics 4-1
4.2.2 Pesticides/PCBs 4-2
4.2.3 Semivolatile Organics 4-3
4.2.4 Herbicides 4-3
4.2.5 Inorganics 4-3
4.2.6 Summary of Soil Analytical Results 4-4
4.3 GROUNDWATER 4-4
4.3.1 Volatile Organics 4-4
4.3.2 Pesticides/PCBs 4-5
4.3.3 Semivolatile Organics 4-5
4.3.4 Herbicides 4-5
4.3.5 Inorganics 4-5
4.3.6 Summary of Groundwater Analytical Results 4-6
4.4 SURFACE WATER AND SEDIMENTS 4-6
4.4.1 Volatile Organics 4-6
4.4.2 Pesticides/PCBs 4-7
4.4.3 Semivolatile Organics 4-7
4.4.4 Herbicides 4-8
4.4.5 Inorganics 4-8
4.4.6 Summary of Surface Water and Sediment Analytical Results 4-9
4.5 AIR 4-10

5.0 CONTAMINANT FATE AND TRANSPORT 5-1
5.1 POTENTIAL ROUTES OF MIGRATION 5-1
5.1.1 Physical and Chemical Factors Affecting Contaminant Mobility 5-1
5.1.2 Potential Pathways for Contaminant Migration 5-4
5.2 CONTAMINANT PERSISTENCE 5-6
5.2.1 SVOCs 5-6
5.2.2 Pesticides 5-7
5.2.3 PCBs 5-7
5.2.4 Metals 5-8
5.3 CONTAMINANT MIGRATION 5-8
5.3.1 SVOCs 5-8
5.3.2 Pesticides 5-8
5.3.3 PCBs 5-9
5.3.4 Metals 5-9

6.0 BASELINE RISK EVALUATION 6-1
6.1 EXPOSURE ASSESSMENT 6-1
6.1.1 Sources of Contamination 6-1
6.1.2 Transport Mechanisms 6-1
6.1.3 Exposure Routes/Pathways 6-2
6.1.4 Receptors 6-3
6.1.5 Baseline SCEM 6-3

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

6.2 TIER 1 RISK EVALUATION 6-3
6.2.1 Soil 6-4
6.2.2 Sediment 6-4
6.2.3 Groundwater 6-4
6.2.4 Surface Water 6-5
6.3 TIER 2 RISK EVALUATION 6-5
6.3.1 Statistical Methods 6-5
6.3.2 Site Background 6-6
6.3.3 Regionally Prevalent Chemicals 6-6
6.3.4 Site-Specific Variables 6-7
6.3.5 Eliminate/Minimize Exposure Routes 6-7
6.4 ECOLOGICAL EVALUATION 6-7
6.4.1 Ecotoxicity 6-7
6.4.2 Complete Exposure Pathway 6-9
6.4.3 Preliminary Assessment and Measurement Endpoints 6-10
6.5 SCREENING-LEVEL ECOLOGICAL EFFECTS EVALUATION 6-11
6.6 SCREENING-LEVEL EXPOSURE ESTIMATE 6-11
6.7 SCREENING-LEVEL RISK CALCULATION 6-12
6.7.1 Sediment 6-12
6.7.2 Surface Water 6-12
6.8 SUMMARY AND CONCLUSIONS 6-12

7.0 REMEDIAL INVESTIGATION SUMMARY AND CONCLUSIONS 7-1
7.1 SITE CONDITIONS 7-1
7.1.1 Land Use and Topography 7-1
7.1.2 Surface Water 7-1
7.1.3 Geology 7-2
7.1.4 Hydrogeology 7-2
7.1.5 Ecology 7-2
7.2 NATURE AND EXTENT OF CONTAMINATION 7-2
7.2.1 Soil 7-3
7.2.2 Groundwater 7-3
7.2.3 Surface Water and Sediment 7-3
7.3 SUMMARY OF RISK EVALUATION/CHEMICAL OF CONCERN SELECTION 7-4
7.4 CONCLUSIONS 7-5

FEASIBILITY STUDY

8.0 REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS 8-1
8.1 REMEDIAL ACTION OBJECTIVES 8-1
8.1.1 ARARs and To Be Considered Criteria 8-1
8.1.2 Chemicals and Media of Concern 8-3
8.1.3 Preliminary Remedial Goals 8-3
8.1.4 Statement of Remedial Action Objectives 8-4
8.2 GENERAL RESPONSE ACTIONS 8-4
8.3 ESTIMATED VOLUMES OF CONTAMINATED MEDIA 8-5

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

9.0 SCREENING OF TECHNOLOGIES AND DEVELOPMENT OF ALTERNATIVES 9-1
9.1 PRELIMINARY SCREENING OF SOIL AND SEDIMENT TECHNOLOGIES AND PROCESS OPTIONS 9-2
9.2 SCREENING OF REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS 9-2
9.2.1 No Action 9-2
9.2.2 Limited Action 9-3
9.2.3 Containment 9-3
9.2.4 Removal 9-4
9.2.5 Ex-Situ Treatment 9-4
9.2.6 Disposal 9-6
9.3 SELECTION OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS 9-6
9.4 DEVELOPMENT OF ALTERNATIVES 9-6

10.0 ASSEMBLY AND DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES 10-1
10.1 INTRODUCTION 10-1
10.1.1 Evaluation Criteria 10-1
10.1.2 Relative Importance of Criteria 10-5
10.1.3 Selection of Remedy 10-6
10.2 ASSEMBLY OF REMEDIAL ALTERNATIVES 10-6
10.3 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES 10-7
10.3.1 Alternative 1: No Action 10-7
10.3.2 Alternative 2: Institutional Controls and Monitoring 10-8
10.3.3 Alternative 3: Surface Water Controls, Excavation, Surface Protection, Institutional Controls, and Monitoring 10-11
10.3.4 Alternative 4: Surface Water Controls, Excavation, Dewatering, Off-Site Treatment and Disposal 10-15

11.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES 11-1
11.1 COMPARISON OF REMEDIAL ALTERNATIVES BY CRITERIA 11-1
11.1.1 Overall Protection of Human Health and the Environment 11-1
11.1.2 Compliance with ARARs and TBCs 11-2
11.1.3 Long-Term Effectiveness and Permanence 11-2
11.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment 11-2
11.1.5 Short-Term Effectiveness 11-3
11.1.6 Implementability 11-4
11.1.7 Cost 11-4
11.2 SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES 11-5

REFERENCES R-1

APPENDICES

A FIELD DATA FORMS
B REMEDIAL INVESTIGATION ANALYTICAL DATA
C BASELINE SCEM WORKSHEET
D 95-PERCENT UCL CALCULATIONS AND TIER 2 RISK EVALUATION SUPPORT

TABLE OF CONTENTS (Continued)

DATA
E USEPA AND MDEQ DECISION ON SITE 10
F CALCULATIONS
G COST ESTIMATE

TABLES

NUMBER

2-1 Remedial Investigation and Feasibility Study Sampling and Analysis Summary
2-2 Phase I Soil Sampling Summary
2-3 Monitoring Well Installation Details
3-1 Groundwater Elevation Data
4-1 Phases I and II Soil Detection Summary
4-2 Phase III Soil Detection Summary
4-3 Phase II Groundwater Detection Summary
4-4 Phase III Groundwater Detection Summary
4-5 Phase I Surface Water Detection Summary
4-6 Phase III Surface Water Detection Summary
4-7 Phases I and II Sediment Detection Summary
4-8 Phase III Sediment Detection Summary
5-1 Environmental Fate and Transport Parameters for Organic Chemicals
5-2 Relative Mobilities of Metals as a Function of Environmental Conditions (Eh, pH)
6-1 Human Health Exposure Scenarios
6-2 Summary of Exceedances of Human health Screening Criteria
6-3 Occurrence, Distribution, and Selection of Chemicals of Potential Concern-Sediment
6-4 Occurrence, Distribution, and Selection of Chemicals of Potential Concern – Surface Water
8-1 ARARs and TBC Criteria
9-1 Preliminary Screening of Soil and Sediment Remediation Technologies and Process Options
11-1 Comparative Analysis of Remedial Alternatives

FIGURES

NUMBER

1-1 Vicinity Map
1-2 Site Location Map
1-3 Site Plan
1-4 1997 PCB Detections in Sediment, Parade Field Ditch
1-5 Results of Previous PCB Samples
2-1 Surface Water and Sediment Sample Locations
2-2 Soil Boring Locations
2-3 Monitoring Wells Locations
3-1 Surface Features of Study Area
3-2 Site Plan for Cross Section
3-3 East/West Cross Section

3-4 Groundwater Potentiometric Surface - February 2002
3-5 Groundwater Potentiometric Surface - December 2003

TABLE OF CONTENTS (Continued)

NUMBER

4-1 Soil TRG Exceedances - Organics
4-2 Soil TRG Exceedances - Inorganics
4-3 Groundwater TRG Exceedances
4-4 Surface Water Criteria Exceedances
4-5 Sediment TRG Exceedances
8-1 Areal Extent of Contamination
10-1 Alternative 2 - Institutional Controls and Monitoring
10-2 Alternative 3 - Surface Water Controls, Excavation, Surface Protection, Institutional Controls, and Monitoring
10-3 Alternative 4 - Surface Water controls, Excavation, Dewatering, Off-Site Treatment and Disposal of Excavated Soil

LIST OF ACRONYMS AND ABBREVIATIONS

ABB-ES	ABB Environmental Services, Inc.
ARAR	Applicable or Relevant and Appropriate Requirement
ATSDR	Agency for Toxic Substance and Disease Registry
BCF	Bioconcentration factor
bgs	Below ground surface
BTOC	Below top of casing
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Chemical of concern
ComQAP	Compresensive Quality Assurance Plan
COPC	Chemical of Potential Concern
°F	Degree Farenheit
DPT	Direct push technology
DQO	Data Quality Objective
EDB	Ethylene dibromide
ESV	Ecological Screening Value
FID	Flame ionization detector
FS	Feasibility Study
GAC	Granular activated carbon
GRA	General Response Action
HSA	Hollow-stem auger
HQ	Hazard Quotient
HxCDF	Hexachlorinated-dibenzo-furan
IAS	Initial Assessment Study
IDW	Investigation derived waste
K_d	Distribution coefficient
K_{oc}	Organic carbon partition coefficient
K_{ow}	Octanol/water partition coefficient
LTTD	Low-temperature thermal desorption
LUC	Land use control
LUCIP	Land Use Control Implementation Plan
µg/kg	microgam(s) per kilogram
mg/kg	milligram per kilogram

mg/L	milligram per liter
MDEQ	Mississippi Department of Environmental Quality
MI	Mobility index
msl	Mean sea level
NAVFAC EFD South	Naval Facilities Engineering Field Division South
NCBC	Naval Construction Battalion Center
NCF	Naval Construction Force
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPW	Net present worth
OCBE	Octachlorinated-biphenly ether
O&M	Operation and maintenance
OSHA	Occupational Safety and Health Act
PAH	Polynuclear aromatic hydrocarbon
PCB	polychlorinted biphenyl
PPE	Personal protective equipment
ppm	Part per million
PRG	Preliminary Remedial Goal
PRSE	Post Removal Site Evaluation
PVC	Polyvinyl chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments Reauthorization Act
SCEM	Site Concenptual Exposure Model
SLERA	Screening level ecological risk assessment
SOP	Standard Operating Procedure
SVOC	Semivolatile organic compound
SWL	Static water level
TAL	Target Analyte List
TBC	To Be Considered (criterion)
TCL	Target Compound List
TCLP	Toxicity Characteristics Leaching Procedure (USEPA's)
TOC	Top of casing

TRG	Target Risk Goal (MDEQ's)
TSCA	Toxic Substance Control Act
TSDF	Treatment Storage or Disposal Facility
TtNUS	Tetra Tech NUS, Inc.
UCL	Upper confidence limit
USC	United States Code
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound
yd^2	square yard(s)
yd^3	cubic yard(s)

EXECUTIVE SUMMARY

E.1 PURPOSE OF THE REPORT

The purpose of this Remedial Investigation (RI) and Feasibility Study (FS) Report is to summarize environmental conditions and to develop and evaluate options for the remediation of contaminated soil and sediment of Site 10 – Parade Field Ditch at the Naval Construction Battalion Center (NCBC) in Gulfport, Mississippi.

E.2 SITE DESCRIPTION AND HISTORY

Site 10 is a short section of primary drainage ditch located in the south-central section of NCBC Gulfport adjacent to the Parade Field. The site is bordered to the north by a parking area (the former location of the Building 295) and to the south by the Parade Field. The site topography is relatively flat. A sidewalk leading south from the former location of Building 295 crosses the ditch via a footbridge and continues south to the Parade Field.

The drainage ditch at Site 10 is approximately 10 feet wide and 4 feet deep. Storm water runoff from the paved areas surrounding Site 10 flows into various tributary ditches that feed into the larger primary ditch. Surface water runoff in the primary ditch is conveyed to the west into Canal No. 1, which collects the runoff from Drainage Area 5. Surface water in Canal No. 1 flows north and eventually leaves NCBC Gulfport at Outfall 1, located at 28th Street.

Several environmental investigations were performed at Site 10, starting with the dioxin delineation studies for on-and off-site surface water drainage features conducted in 1997 (ABB-ES, 1997). These investigations showed that areas of surface soil and sediment at Site 10 and associated surface drainage systems were contaminated with octachlorinated-biphenyl ethers (OCBEs), chlorobenzene, and Aroclor-1260. The detections of OCBE, chlorobenzene, and Aroclor-1260 indicate the probable release or releases of electrical transformer oil adjacent to or directly into the drainage ditch near the footbridge as the source of contamination at Site 10.

The levels of polychlorinated biphenyls (PCBs) and chlorobenzene contamination in the sediments in the ditch at Site 10 prompted a source removal excavation in August 1999. Approximately 80 cubic yards (yd^3) (120 tons) of sediment and soil with PCB concentrations exceeding the Mississippi Department of Environmental Quality (MDEQ) unrestricted Tier 1 Target Risk Goal (TRG) of 1 part per million (ppm) were removed from the source area during this excavation (Phase I). Confirmation sampling from the bottom of the excavation indicated that PCB concentrations up to 1,240 ppm remained in the soil below

the area of excavation. Therefore, an additional 1.5-foot layer of sediment was removed and additional confirmation samples were collected (the Phase II excavation). Results of the Phase II confirmation sampling identified PCB concentrations up to 16,300 ppm. Excavation activities were suspended and further delineation sampling was conducted using direct push technology (DPT) sampling methods. Results showed that PCB concentrations exceeding the Tier 1 TRG of 1,000 ppm continued to a depth of 22 feet, with PCB concentrations declining with depth. Based on these results, the Phase III excavation was conducted. An additional 3 to 6 feet of soil was removed from the excavation area, with a maximum excavation depth of 14.5 feet in the vicinity of the footbridge. Confirmation samples collected from three locations at the bottom of the Phase III excavation had PCB concentrations exceeding the screening level.

Following the source removal excavations and site restoration, additional samples were collected to evaluate the effectiveness of the remedial action (TtNUS, 2002). The samples from the various media were analyzed for volatile organic compounds (VOCs), pesticides and PCBs, and ethylene dibromide (EDB). The continued presence of PCB concentrations exceeding the screening level in subsurface soil samples prompted the Navy to conduct a more comprehensive RI/FS and to use these data for evaluation of remedial alternatives.

E.3 SUMMARY OF REMEDIAL INVESTIGATION

The overall goal of the investigative work at Site 10 is to characterize environmental contamination and to determine whether there is a risk to human health and the environment and therefore to (1) determine whether further action is required, (2) determine whether further investigation and characterization is needed, and/or (3) develop and design appropriate remedial actions. The overall purpose of this investigation was to address potential risks associated with Site 10 and develop and evaluate options for the remediation of contaminated soil and sediment of Site 10.

Three phases of fieldwork associated with the post-removal site evaluation (PRSE) and RI/FS were conducted at Site 10:

- Phase I PRSE – January 7 through January 13, 2002
- Phase II PRSE – February 11 through February 15, 2002
- Phase III RI – December 2003

Surface water and sediment samples were collected from the ditch at Site 10 to evaluate conditions within the bed of the ditch. Surface water samples were collected during Phase I and Phase III of the investigation. Sediment samples were collected during Phases I, II, and III of the investigation.

Soil samples were collected during Phase I, Phase II, and Phase III of the investigation at Site 10 to evaluate the horizontal and vertical extent of soil contamination. The soil investigation was conducted utilizing DPT methods to allow for collection of soil samples from discrete vertical intervals and to reduce the amount of investigation derived waste (IDW) produced during the investigation.

Based on the results of the soil sampling conducted during Phase I, five permanent monitoring wells were installed at Site 10, allowing for the characterization and delineation of potential groundwater contamination. Groundwater in the vicinity of Site 10 was anticipated to flow to the west-northwest; therefore, the monitoring wells were installed in the following locations:

- NCBC10G01 Source area well (in area of the highest detected PCB concentrations)
- NCBC10G02 Downgradient well
- NCBC10G03 Sidegradient well
- NCBC10G04 Sidegradient well
- NCBC10G05 Upgradient well

Groundwater samples were collected from the monitoring wells during Phase II and Phase III of the investigation.

E.4 NATURE AND EXTENT OF CONTAMINATION

VOC and semivolatile organic compound (SVOC) concentrations in soil samples were less than Tier 1 unrestricted TRGs. Herbicide concentrations in soil samples were less than standard laboratory detection limits. Aroclor-1260 was detected in three soil samples at concentrations greater than the unrestricted TRG and in two samples at concentrations greater than the restricted TRG. The dieldrin concentration in one soil sample was greater than the unrestricted TRG but less than the restricted TRG. Other pesticides and PCBs were detected at concentrations less than Tier 1 unrestricted TRGs. Arsenic was detected in five of the six soil samples at concentrations greater than the Tier 1 unrestricted TRG but less than the restricted TRG. Other metals were detected at concentrations less than Tier 1 unrestricted TRGs. Cyanide concentrations in the soil samples were less than standard laboratory detection limits.

Detected VOC concentrations in groundwater samples were less than Tier 1 TRGs. Detected benzo(k)fluoranthene concentrations in two groundwater samples were greater than the Tier 1 TRG. Concentrations of other SVOCs in groundwater samples were less than standard laboratory detection limits. Pesticides were detected in groundwater samples from two monitoring wells. The dieldrin concentration in one Phase III groundwater sample was greater than Tier 1 TRG. Other pesticides were detected at concentrations less than Tier 1 TRGs. PCB concentrations in groundwater samples were less than standard laboratory detection limits. Herbicide concentrations in groundwater samples were

less than standard laboratory detection limits. Metals and cyanide concentrations in groundwater were less than the Tier 1 TRGs.

Detected VOC concentrations in surface water and sediment samples were less than Tier 1 TRGs. Indeno(1,2,3-CD)pyrene was detected in a Phase III surface water sample at a concentration greater than the Tier 1 TRG. Concentrations of other SVOCs in surface water samples were less than Tier 1 TRGs. Benzo(a)pyrene was detected in a Phase III sediment sample at a concentration greater than the unrestricted TRG of 0.426 milligrams per kilogram (mg/kg) but less than the restricted TRG of 3.82 mg/kg. Concentrations of other SVOCs in sediment samples were less than Tier 1 TRGs. Pesticides were detected in Phase I surface water samples. The dieldrin concentration in one Phase I surface water sample was greater than the human health surface water criteria but less than the Tier 1 TRG and the aquatic life surface water criteria. Aroclor-1260 was detected in a Phase I surface water sample at a concentration exceeding the Tier 1 TRG and the acute and chronic criteria for fresh water aquatic life. Both samples were collected following the remedial action at the site. Pesticides were not detected in the Phase III surface water samples collected approximately 1 year later. Pesticide and PCB concentrations in sediment samples were less than Tier 1 TRGs. Herbicide concentrations in surface water and sediment samples were less than standard laboratory detection limits. Copper was detected in surface water samples at concentrations less than the Tier 1 TRG and the human health surface water criteria but greater than the acute and chronic aquatic life criteria. Concentrations of other metals in surface water samples were less than screening criteria. Arsenic concentrations in four sediment samples were greater than the Tier 1 unrestricted TRG but less than the restricted TRG. Concentrations of other metals detected in sediment samples were less than Tier 1 TRGs. Cyanide concentrations in surface water and sediment samples were less than standard laboratory detection limits.

E.5 BASELINE RISK EVALUATION

Baseline Risk Evaluation was conducted for both Human and Ecological Receptors.

HUMAN HEALTH

The baseline Site Conceptual Exposure Model (SCEM) identified completed pathways in soil, surface water, and sediment and potentially completed pathways to unrestricted receptor populations.

The following analytes were identified in the Baseline Risk Evaluation as having concentrations exceeding Tier 1 TRGs in one or more samples:

Subsurface soil	Aroclor-1260, arsenic, and dieldrin
Sediment	Arsenic and benzo(a)pyrene

Groundwater	Benzo(k)fluoranthene and dieldrin
Surface water	Aroclor-1260, dieldrin, and indeno(1,2,3-CD)pyrene

However, polynuclear aromatic hydrocarbons (PAHs) and pesticides will not be retained as chemicals of concern (COCs) due to infrequent detections and because their presence is likely a result of urban runoff. Similarly, arsenic will not be retained because it was detected within the lower range of naturally occurring concentrations.

Only Aroclor-1260 will be retained as a COC for protection of human health. An FS was prepared to present alternatives to eliminate or minimize human exposure to Aroclor-1260 in soil, sediment, and surface water by active cleanup, engineering controls, and/or institutional controls.

ECOLOGICAL

The potential risk posed to ecological receptors was evaluated following EPA Screening Level Ecological Risk Assessment criteria.

Based on an evaluation of site-specific data with respect to EPA Region IV screening criteria, Aroclor-1260 was also retained as a COC for ecological receptors. Potential ecological risks from Aroclor-1260 were identified at the majority of sediment sampling locations. Potential ecological risks from other contaminants were low and only found in isolated locations.

E.6 REMEDIAL ACTION OBJECTIVES, PRELIMINARY REMEDIAL ACTION GOALS, AND VOLUME OF CONTAMINATED SOIL AND SEDIMENT

The Remedial Action Objectives (RAOs) identified in this section are based on the one COC (Aroclor-1260) retained for Site 10 and consist of the following.

RAO 1: Prevent direct exposure to soil with concentrations of Aroclor-1260 greater than 1,000 micrograms per kilogram (µg/kg).

RAO 2: Prevent the erosional transport of Aroclor-1260 through the drainage channel system.

RAO 3: Comply with federal and State Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) guidance criteria in accordance with accepted United States Environmental Protection Agency (USEPA) and MDEQ guidelines.

Based on discussions between the Navy, MDEQ, and USEPA, it was agreed that the Preliminary Remediation Goals (PRGs) for the project would be based on the State of Mississippi TRGs. As a result, TRGs will serve as the basis for remedial action.

Per Mississippi Code Section 49-35-21, TRGs are based on either (1) a $1x10^{-6}$ target incremental cancer risk level for each carcinogenic chemical, (2) a hazard index not to exceed 1.0 for each systemic toxicant, or (3) constituent TRG concentrations established through federal/State programs (e.g., the Safe Drinking Water Act). The State of Mississippi lists TRGs for both restricted (industrial) and unrestricted (residential) land use. Site 10 is located due south of the base mess hall and to the southwest of McDonald's. Because of Site 10's proximity to these public locations, unrestricted (residential) TRGs are deemed appropriate for remedial consideration. The State of Mississippi unrestricted TRG for Aroclor-1260 in soil is 1,000 µg/kg, and this value is selected as the PRG for soil and sediment at Site 10.

Although concentrations of Aroclor-1260 detected in sediment are less than the unrestricted TRG, sediment is retained as a medium of concern. It is believed that sediment concentrations of Aroclor-1260 are responsible for the surface water detection of Aroclor-1260 observed during the RI/FS. By addressing sediment, surface water concerns will also be addressed.

Due to the relatively small volume of media identified at Site 10, soil and sediment will be addressed as one combined medium. Moreover, soil is assumed to be similar to sediment because subsurface soil is saturated. Lastly, any actions conducted to address contaminated soil would require movement of sediment.

In all, an estimated 450 yd^3 of contaminated soil/sediment containing 33 pounds of Aroclor-1260 is present at Site 10.

E.7 SCREENING OF GENERAL RESPONSE ACTIONS, REMEDIATION TECHNOLOGIES, AND PROCESS OPTIONS

General Response Actions (GRAs) and associated technologies and processes were screened for effectiveness, implementability, and cost. Technologies that were determined to be ineffective or too difficult to implement were eliminated from further consideration. The following GRAs, remediation technologies, and process options were retained to develop soil and sediment remedial alternatives for Site 10:

General Response Action	Remediation Technology	Process Option
No Action	None	Not Applicable
Limited Action	Institutional Controls	Active and Passive Controls

	Monitoring	Sampling and Analysis
Containment	Surface Protection	Concrete/Rip-Rap Cover/Asphalt
	Surface Water Controls	Vertical Barriers
Removal	Excavation	Excavation
Ex-Situ Treatment	Physical/Chemical	Dewatering
		Chemical Fixation/Solidification
Disposal	Landfill	Off-Site Disposal

E.8 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The following remedial alternatives were developed for Site 10:

Alternative 1: No Action. No action would be taken. Retained as a baseline for comparison with other alternatives.

Alternative 2: Institutional Controls and Monitoring. Institutional controls would consist of restricting access to soil with concentrations of Aroclor-1260 greater than 1,000 µg/kg and controlling future land use. Existing fencing at Site 10 would be expanded. Site controls would be developed and implemented to prevent residential development of Site 10. Signs would be posted to warn against unauthorized digging activities.

Monitoring would consist of annually collecting samples of sediment and surface water and analyzing these samples for PCBs. Two surface water and two sediment samples would be collected within the area of known contamination. Additionally, two surface water and two sediment samples would be collected immediately downgradient of the fenced area to detect potential migration of PCBs.

Every 5 years, the status of the site would be formally reviewed and evaluated to determine the continued effectiveness of this alternative.

Alternative 3: Surface Water Controls, Excavation, Surface Protection, Institutional Controls, and Monitoring. Within the drainage channel, surface water controls would be used to divert water from work areas. Marine-grade polyvinyl chloride (PVC) sheet piling would be used to section off portions of the drainage channel, and pumps (e.g., bladder-type mud pumps) would be used to remove water from within the cordoned-off sections.

Excavation would be performed within the area designated for surface protection and would be limited to the top 1 foot of soil or sediment. This limited excavation would be conducted to allow the surface protection to be placed at grade with the existing ground surface. The area to be excavated would first be

cleared and grubbed, and the pedestrian bridge would be removed. Next, approximately 45 yd^3 of vegetation, soil, and sediment would be removed and disposed at an approved off-site facility. Based on data collected during the RI/FS, it is assumed that the excavated material would be characterized as non-hazardous waste. It is also anticipated that excavated material would not need to be dewatered.

Surface protection would be installed at Site 10 to prevent direct contact with PCB-contaminated media and to prevent erosional transport of PCBs in the shallow sediment. As part of this component, approximately 85 linear feet of the drainage channel would be lined with a 9-inch-thick layer of concrete and/or rip rap and approximately 27 square yards (yd^2) of soil would be paved (consisting of a 6-inch stone base, a 2-inch binder course layer, and a 1-inch wearing course layer). Because direct contact with contaminated media would be prevented by installing surface protection, existing fencing present at Site 10 would not be needed and would be removed. Additionally, a new pedestrian bridge would be constructed across the drainage channel to replace the one removed to facilitate excavation activities.

Site controls would be developed and implemented to prevent residential development of Site 10. Signs would be posted to warn against unauthorized digging activities. Periodic inspections would be required to ensure that the integrity of the surface protection is not compromised and to determine whether maintenance to the surface protection is required.

Monitoring would consist of annually collecting samples of sediment and surface water and analyzing these samples for PCBs. Two surface water and two sediment samples would be collected immediately downgradient of the surface protection to detect potential migration of PCBs. Every 5 years, the status of the site would be formally reviewed and evaluated to determine the continued effectiveness of this alternative.

Alternative 4: Surface Water Controls, Excavation, Dewatering, Off-Site Treatment and Disposal. Within the drainage channel, surface water controls would be used to divert water from work areas. In addition, a temporary drainage channel (approx. 4 ft deep) running from just east of the excavation area to the west side is recommended to divert any overflow from the nearby channels that occurs during the excavation. And the soil/sediment that is removed to create the temporary drainage channel will be used to construct a temporary berm on the south side of the excavation near the Parade Field to control and divert any stormwater runoff from infiltrating the excavation area

In order to allow for effective excavation of the soil/sediment to the required depths, steel sheet piling would be used to section off the portion of the drainage channel that encompasses the entire excavation area, and prior to commencing with excavation activities, a subsurface well point mechanical dewatering system would be utilized to remove water down to 15 feet bls from within the area to be excavated.

Approximately 450 yd^3 of soil with concentrations of PCBs greater than 1,000 µg/kg would be excavated. The area to be excavated would be cleared and grubbed and the pedestrian bridge would be removed. Excavation of the contaminated material would be accomplished with a Gradall-type excavator, backhoe, or similar type of equipment. The sidewalls of the excavation would be shored to minimize the amount of soil required to be excavated to reach soils at depth. Pre-excavation sampling would be conducted to verify the depth of excavation. After sampling activities have verified the removal of contaminated material, the excavated areas would be backfilled with imported clean soil. The excavated areas would also be graded to original grade and native vegetation would be planted. Additionally, a new pedestrian bridge would be constructed across the drainage channel.
Excavated soil would be transported and disposed at a permitted off-site Treatment Storage or Disposal Facility (TSDF). The type of TSDF and pre-treatment requirements prior to ultimate disposal by landfilling would be dictated by the anticipated characteristics of the excavated material.

As part of pre-excavation sampling, samples would be collected to further refine the extent of soil that contains PCBs at concentrations greater than 50,000 µg/kg. It is assumed that approximately 100 yd^3 of excavated material would contain PCB concentrations greater than 50,000 µg/kg and would require disposal at a Toxic Substance Control Act (TSCA)-certified TSDF. It is also assumed that prior to ultimate disposal by landfilling, the TSDF would pre-treat that entire fraction of the excavated material by chemical fixation/solidification to meet disposal requirements. Lastly, it is assumed that the remaining 350 yd^3 would be classified as Resource Conservation and Recovery Act (RCRA) non-hazardous and would be disposed by landfilling at a permitted off-site RCRA Subtitle D TSDF.

E.9 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The remedial alternatives were analyzed in detail using the nine criteria provided in the USEPA's National Oil and Hazardous Substance Pollution Contingency Plan (NCP) and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). These criteria are as follows:

- Overall Protection of Human Health and the Environment,
- Compliance with ARARs and TBCs guidance criteria,
- Long-term Effectiveness and Permanence,
- Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment,
- Short-term Effectiveness,
- Implementability, and
- Cost
- State Acceptance

The last criteria, Community Acceptance, will be evaluated after the Proposed Plan has been developed, the public comment period has taken place, and public comments are available.

E.10 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

The remedial alternatives were compared to each other using the same criteria that were used for detailed analysis. The following is a summary of these comparisons:

Overall Protection of Human Health and Environment

Alternative 1 would not be protective of human health and the environment because Arocor-1260 would remain at concentrations in soil in excess of its PRG. As a result, exposure to these concentrations could result. Also, under this alternative, no monitoring would occur; therefore, no warning would be provided if Arocor-1260 concentrations were to migrate through the drainage channel system.

Although Alternative 2 would allow Arocor-1260 concentrations to remain in soil and to possibly continue to migrate from contaminated areas, it would provide some protection by restricting access to contaminated media through fencing and site restrictions and would provide warning of potential contaminant migration through monitoring.

Alternative 3 would be more protective than Alternative 2 because it would essentially eliminate the potential for exposure to PCBs. Surface protection in conjunction with site controls would eliminate direct contact with contaminated media. Moreover, the surface protection would prevent the potential migration of contaminants through the drainage channel system via erosion.

Alternative 4 would provide the highest level of protection because contaminated soil would be removed from its present location and would be transported to an approved TSDF.

Compliance with ARARs and TBCs

Alternative 1 would not comply with chemical-specific ARARs. Action-specific ARARs or TBCs would not apply.

Alternatives 2 and 3 would not comply with chemical-specific ARARs and TBCs due to the pervasiveness of PCBs through the environment. Alternatives 2 and 3 would comply with action-specific ARARs and TBCs.

Alternative 4 would comply with chemical- and action-specific ARARs and TBCs.

There are no location-specific ARARs identified for Site 10.

Long-term Effectiveness and Permanence

Alternative 1 would have very limited long-term effectiveness and permanence because no contaminant removal or reduction would occur. Because there would be no site controls to restrict access to Site 10, the potential would also exist for direct exposure to PCB-contaminated media. Because there would be no monitoring, potential PCBs migration would remain undetected.

Alternative 2 would provide some long-term effectiveness and permanence because fencing and site controls would reduce exposure to contaminated soil, and monitoring would provide indication of PCBs migration.

Alternative 3 would be more effective and permanent than Alternative 2 in the long term. Surface protection would be more effective and permanent than fencing in preventing direct contact with contaminants and preventing the erosional transport of PCBs through the drainage channel system. Inspection, maintenance, and repair of the surface protection would need to be conducted to ensure its continued structural integrity and effectiveness.

Alternative 4 would be the most long-term effective and permanent remedy. Under this alternative, contaminated soil would be removed from its present location and treated, as required, for ultimate disposal at a TSDF.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 1 and 2 would not achieve any reduction of toxicity, mobility, or volume of PCB-contaminated media through treatment. Both alternatives might eventually achieve reduction of contaminant toxicity and volume through natural attenuation; however, under Alternative 1, this reduction would neither be verified or quantified. There would be no treatment residuals associated with Alternative 2.

Alternative 3 would not achieve any reduction of toxicity or volume of PCB-contaminated media through treatment. However, Alternative 3 would significantly reduce PCB mobility because Arocor-1260 concentrations would be contained under the surface protection. There would be construction debris associated with this alternative.

Similarly, Alternative 4 would not achieve any reduction of toxicity or volume of PCB-contaminated media through treatment. However, Alternative 4 would reduce PCB mobility through off-site chemical stabilization. A wastewater residual might be generated by the sediment dewatering step, but it is anticipated that this wastewater could be discharged to surface water without treatment. There would be construction debris associated with this alternative.

Short-term Effectiveness

Implementation of Alternative 1 would not result in risks to site workers or adversely impact the surrounding community or environment because no remedial activities would be performed. Alternative 1 would never achieve the RAOs, and although the Arocor-1260 PRG might eventually be attained through natural attenuation processes in the very long term, this occurrence would not be verified.

Implementation of Alternative 2 would result in a slight possibility of exposing site workers to PCB contamination during long-term monitoring activities. However, the risk of exposure would be effectively controlled through compliance with proper site-specific health and safety procedures. Implementation of Alternative 2 would not adversely impact the surrounding community or environment. Alternative 2 would be expected to achieve the RAOs immediately upon implementation of institutional controls and monitoring.

Implementation of Alternatives 3 and 4 would result in the possibility of exposing construction workers to PCB contamination during remedial activities. However, the risk of exposure would be effectively controlled by the implementation of engineering controls (e.g., dust suppression) and compliance with applicable OSHA regulations and proper site-specific health and safety procedures. Implementation of Alternative 4 would potentially impact the surrounding community because approximately 28 truckloads of PCB-contaminated material would be transported over public roads. However, the potential for adverse impact would be effectively addressed through implementation of such appropriate measures as decontamination of transport vehicles, traffic control, and spill prevention and emergency response. Alternatives 3 and 4 would be expected to achieve the RAOs immediately upon removal of the contaminated soil. Alternative 4 would also achieve PRGs upon implementation.

It is anticipated that Alternatives 2, 3, and 4 can be implemented in 1 day, 3 days, and 13 days, respectively.

Implementability

Alternative 1 would be extremely simple to implement because no action would occur.

The technical implementability of Alternative 2 would also be very simple because it would only require implementation of site controls and monitoring.

The technical implementability of Alternative 3 would be somewhat more difficult than that of Alternative 2. In addition to site controls and long-term monitoring, this alternative would require the use of surface water controls, excavation, and surface protection. However, these activities would be technically implementable. Resources, equipment, and materials are readily available to perform the tasks associated with Alternative 3. Alternative 4 would be somewhat harder to implement, although resources, equipment, and materials are readily available to perform the excavation, dewatering, and transportation activities.

Administratively, Alternatives 2 and 3 would require the development and implementation of land use controls (LUCs) and the performance of long-term monitoring and 5-year site reviews. Under Alternatives 3 and 4, off-site transportation of the excavated soil may require the preparation and implementation of a traffic control plan and would require the completion of waste manifests. Off-site treatment and disposal of the excavated soil would require prior securing of waste acceptance from the TSDF. Alternatives 3 and 4 would require a base permit to conduct remedial activities, manifesting of the material to be transported off base, and formal acceptance of this material by the off-base disposal facility. These administrative requirements could readily be met. Alternative 4 would not require site controls, long-term monitoring, or 5-year reviews because all soil with concentrations greater than the Arocor-1260 PRG would be removed from Site 10.

Cost

The capital and operation and maintenance (O&M) costs and net present worth (NPW) of the remedial alternatives were estimated to be as follows:

Alternative	Capital ($)	NPW of O&M ($)		NPW ($)	
1	0	0		0	
2	22,000	78,000	(30 Year)	100,000	(30 Year)
3	42,000	69,000	(30 Year)	111,000	(30 Year)
4	421,000	0	(1 Year)	421,000	(1 Year)

The above cost figures have been rounded to the nearest $1,000 to reflect the preliminary nature of these estimates.

1.0 INTRODUCTION

Tetra Tech NUS (TtNUS) under contract to the United States Department of the Navy, Naval Facilities Engineering Field Division South (NAVFAC EFD South), has conducted a Remedial Investigation and Feasibility Study (RI/FS) at Site 10, Naval Construction Battalion Center (NCBC), Gulfport, Mississippi. This RI/FS report was prepared under the Comprehensive Long-Term Environmental Action Navy (CLEAN) III, Contract No. N62467-94-D-0888.

1.1 PURPOSE OF REPORT

The primary objective of the RI/FS was to provide environmental data and the basis of the selection of a remedy for contamination at Site 10 that is protective of human health and the environment. In order to achieve this objective, samples from various media were collected and analyzed to fill data gaps from previous investigations. Previous investigations and removal actions at the site focused on polychlorinated biphenyl (PCB) and transformer oil-related contaminants; therefore, additional samples were collected and analyzed during the RI/FS to evaluate the nature and extent of other contaminants that may have been released at the site. Samples from various media were used to confirm the extent of PCB-related contamination previously documented at the site and to evaluate the effect remedial actions have had on site conditions.

1.2 SITE BACKGROUND

NCBC Gulfport is located in the western part of Gulfport, Mississippi, in the southeastern part of Harrison County, about 2 miles north of the Gulf of Mexico (Figure 1-1). Originally, nine sites at NCBC Gulfport were identified in the Initial Assessment Study (IAS) as potential threats to human health or the environment (Naval Energy and Environmental Support Activity, 1985). Contamination was first detected at the area later designated as Site 10 during the dioxin delineation activities for on- and off-site surface water drainage features conducted in 1997 (ABB-ES, 1997).

1.2.1 Site Description

Site 10 is a short section of primary drainage ditch located in the south-central section of NCBC Gulfport adjacent to the Parade Field (Figure 1-2). The site is bordered to the north by a parking area (the former location of the Building 295) and to the south by the Parade Field (Figure 1-3). The site topography is relatively flat. A sidewalk leading south from the former location of Building 295 crosses the ditch via a footbridge and continues south to the Parade Field.

The drainage ditch at Site 10 is approximately 10 feet wide and 4 feet deep. Storm water runoff from the paved areas surrounding Site 10 flows into various tributary ditches that feed into the larger primary ditch. Surface water runoff in the primary ditch is conveyed to the west into Canal No. 1, which collects the runoff from Drainage Area 5 (Figure 1-2). Surface water in Canal No. 1 flows north and eventually leaves NCBC Gulfport at Outfall 1, located at 28th Street.

1.2.2 Site History

Contamination was first detected at the area designated as Site 10 during the dioxin delineation activities for on- and off-site surface water drainage features conducted in 1997 (ABB-ES, 1997). Analytical results from the samples collected at Drainage Area 5 (in the southwestern corner of NCBC) for this investigation indicated high levels of dioxins and furans, particularly hexachlorinated-dibenzo-furans (HxCDFs). Further evaluation of the laboratory data indicated that the responses interpreted as elevated HxCDFs were actually caused by octachlorinated-biphenyl ethers (OCBEs), which are commonly found in transformer oils manufactured in the 1940s and 1950s. Two of the samples collected during this study were analyzed for PCBs. Aroclor-1260 was detected at concentrations exceeding screening levels in these samples (Figure 1-4). Analysis of sediment samples for volatile organic compounds (VOCs) also detected elevated levels of chlorobenzene, another common ingredient in transformer oil.

The detections of OCBE, chlorobenzene, and Aroclor-1260 indicate the probable release or releases of electrical transformer oil adjacent to or directly into the drainage ditch near the footbridge as the source of contamination at Site 10.

1.2.3 Previous Investigations

Previous environmental investigations and remedial activities conducted at Site 10, as discussed below, are as follows:

- The initial field investigation (ABB-ES, 1997)
- The source removal and associated sampling (CCI, 2000)
- The post-removal site evaluation (PRSE) (TtNUS, 2002)

Initial Field Investigation

Delineation studies were conducted at Site 10 in July 1997 (ABB-ES, 1997). The field screening and sediment sample analysis indicated an area of PCB exceedances approximately 100 feet along the length of the ditch (the source area shown on Figure 1-4). The vertical extent of contamination appeared to be confined to the upper 3 feet of sediment and soil below the base of the ditch. This delineation was

based on a PCB screening level of 1 part per million (ppm), a level based on the Toxic Substances Control Act (TSCA) (USEPA, 1976). The highest contaminant levels were found within a 15-foot area near the footbridge. The maximum level of PCB contamination measured during this event was 140 ppm. Screening level exceedances continued, at decreasing concentrations, for almost 80 feet downstream of the footbridge. The Investigation Report (ABB-ES, 1997) summarized the results of the investigation and provided recommendations for soil removal strategies.

Source Removal

The levels of PCB and chlorobenzene contamination in the sediments in the ditch at Site 10 prompted a source removal excavation in August 1999. Approximately 80 cubic yards (yd^3) (120 tons) of sediment and soil with PCB concentrations exceeding the Mississippi Department of Environmental Quality (MDEQ) unrestricted Tier 1 Target Risk Goal (TRG) of 1 ppm were removed from the source area (Figure 1-4) during this excavation (Phase I). Confirmation sampling from the bottom of the excavation indicated that PCB concentrations up to 1,240 ppm remained in the soil below the area of excavation (Figure 1-5). Therefore, an additional 1.5-foot layer of sediment was removed and additional confirmation samples were collected (the Phase II excavation). Results of the Phase II confirmation sampling identified PCB concentrations up to 16,300 ppm. Excavation activities were suspended and further delineation sampling was conducted using direct push technology (DPT) sampling methods. Results showed that PCB concentrations exceeding the Tier 1 TRG continued to a depth of 22 feet (Figure 1-5), with PCB concentrations declining with depth. Based on these results, the Phase III excavation was conducted (Figure 1-5). An additional 3 to 6 feet of soil was removed from the excavation area, with a maximum excavation depth of 14.5 feet in the vicinity of the footbridge. Confirmation samples collected from three locations at the bottom of the Phase III excavation had PCB concentrations exceeding the screening level.

Post-Removal Site Evaluation

Following the source removal excavations and site restoration, additional samples were collected to evaluate the effectiveness of the remedial action (TtNUS, 2002). The samples from the various media were analyzed for VOCs, pesticides and PCBs, and ethylene dibromide (EDB). The continued presence of PCB concentrations exceeding the screening level in subsurface soil samples prompted the Navy to conduct a more comprehensive RI/FS and to use these data for evaluation of remedial alternatives.

1.3 REPORT ORGANIZATION

This report incorporates the results of the PRSE sampling activities and the RI/FS sampling events and is organized into the following chapters:

- Section 1.0 – Introduction
- Section 2.0 – Study Area Investigation
- Section 3.0 – Physical Characteristics of the Study Area
- Section 4.0 – Nature and Extent of Contamination
- Section 5.0 – Contaminant Fate and Transport
- Section 6.0 – Screening Risk Assessment
- Section 7.0 – Remedial Investigation Summary and Conclusions
- Section 8.0 – Remedial Action Objectives and General Response Actions
- Section 9.0 – Screening Of Technologies and Development of Alternatives
- Section 10.0 – Assembly and Detailed Analysis of Remedial Alternatives
- Section 11.0 – Comparative Analysis of Remedial Alternatives

The following appendices are included with this report:

- Appendix A – Field Data Forms
- Appendix B – Remedial Investigation Analytical Data
- Appendix C – Baseline SCEM Worksheet
- Appendix D – 95-Percent UCL Calculations and Tier 2 Risk Evaluation Support Data
- Appendix E – USEPA and MDEQ Decision on Site 10
- Appendix F – Calculations
- Appendix G – Cost Estimate

2.0 STUDY AREA INVESTIGATION

Three phases of fieldwork associated with the PRSE and RI/FS were conducted at Site 10:

- Phase I PRSE – January 7 through January 13, 2002
- Phase II PRSE – February 11 through February 15, 2002
- Phase III RI – December 2003

The data from the Phase I event were used to select the Phase II sampling locations and the monitoring well locations. The analytical results from the Phase I and Phase II sampling efforts were screened against the appropriate MDEQ Tier 1 (unrestricted) TRGs. PCB concentrations exceeding screening levels were reported for subsurface soil samples collected in the vicinity of the footbridge following the removal action. Groundwater, sediment, and surface water sample results were less than screening criteria.

The presence of PCBs at concentrations exceeding the screening level in these subsurface soil samples prompted the Navy to conduct a more comprehensive RI/FS, including the Phase III sampling event and an evaluation of remedial alternatives. Previous investigations and the removal actions at the site focused on PCB and transformer oil-related contaminants; therefore, additional samples were collected and analyzed for an expanded list of analyses to evaluate the nature and extent of other contaminants that may have been released at the site. Samples from various media were collected to confirm the extent of PCB-related contamination previously documented at the site and to evaluate the effect remedial actions have had on site conditions

Field investigation techniques used during the PRSE and RI/FS are described in the PRSE Work Plan (TtNUS, 2001) and the RI Work Plan (TtNUS, 2003). The Work Plans provide descriptions of standard operating procedures (SOPs), field personnel responsibilities, mobilization, sampling methods, monitoring well installation, decontamination procedures, groundwater level measurements, sample management, procedures for changes in field methods, waste management, project documentation, and other general information.

Laboratory and data quality assurance and quality control (QA/QC) requirements for the investigation activities were consistent with the Data Quality Objectives (DQOs) of the appropriate Work Plans. Samples collected were handled in accordance with the Quality Assurance Project Plan (QAPP) of the appropriate Work Plan and the TtNUS corporate comprehensive Quality Assurance Plan (ComQAP). At the end of each sampling day, the samples were submitted to the off-site laboratory under proper chain-of-custody protocol.

2.1 SURFACE WATER AND SEDIMENT INVESTIGATIONS

Surface water and sediment samples were collected from the ditch at Site 10 to evaluate conditions within the bed of the ditch. Surface water samples were collected during Phase I and Phase III of the investigation (Table 2-1). Sediment samples were collected during Phases I, II, and III of the investigation (Table 2-1).

2.1.1 Phase I Surface Water and Sediment Sampling

Three surface water samples were collected at Site 10 during Phase I (Figure 2-1). The surface water samples were analyzed for pesticides and PCBs, Target Compound List (TCL) VOCs, and EDB. Water quality parameters including pH, conductivity, temperature, dissolved oxygen, and turbidity were measured with field instruments at each surface water sampling location at the time of sample collection.

Three sediment samples were collected at Site 10 during Phase I (Figure 2-1), co-located with surface water samples. Sediment samples only were collected at the other three locations. The sediment samples were collected from depths of 0 to 6 inches and were analyzed for pesticides and PCBs, TCL VOCs, and EDB.

2.1.2 Phase II Sediment Sampling

Three sediment samples were collected at Site 10 during Phase II (Figure 2-1). No surface water samples were collected during Phase II. The sediment samples were collected from depths of 0 to 6 inches. The sediment samples were analyzed for pesticides and PCBs, TCL VOCs, and EDB.

2.1.3 Phase III Surface Water and Sediment Sampling

Two additional surface water samples were collected at Site 10 during Phase III and analyzed for a wider range of analytical parameters (Figure 2-1). The Phase III surface water samples were analyzed for pesticides and PCBs, TCL VOCs and semivolatile organic compounds (SVOCs), herbicides, Target Analyte List (TAL) metals, and cyanide. Water quality parameters including pH, conductivity, temperature, dissolved oxygen, and turbidity were measured with field instruments at each surface water sampling location at the time of sample collection.

Five sediment samples were collected at Site 10 during Phase III (Figure 2-1), two co-located with surface water samples and three at other locations. The sediment samples were collected from depths of 0 to 6 inches. The Phase III sediment samples were analyzed for pesticides and PCBs, TCL VOCs and SVOCs, herbicides, TAL metals, and cyanide.

The sediment samples collected at two of the Phase III locations were analyzed for grain size and Atterburg Limits to provide preliminary engineering data for use in the initial screening of remedial alternatives in the FS.

2.2 SOIL AND VADOSE ZONE INVESTIGATIONS

Soil samples were collected during Phase I, Phase II, and Phase III of the investigation at Site 10 to evaluate the horizontal and vertical extent of soil contamination (Table 2-1). The subsurface soil investigation was conducted utilizing DPT methods to allow for collection of soil samples from discrete vertical intervals and to reduce the amount of investigation derived waste (IDW) produced during the investigation.

2.2.1 Phase I Soil Sampling

The Phase I soil investigation included 18 soil boring locations (Figure 2-2). Soil samples were collected from five soil boring locations within the ditch (NCBC10S03, NCBC10S04, NCBC10S05, NCBC10S06, and NCBC10S17). Temporary bridges were constructed to allow sampling at the locations within the ditch. The 13 remaining soil boring locations (NCBC10S01, NCBC10S02, NCBC10S07 through NCBC10S16, and NCBC10S18) were collected outside of the ditch.

Soil samples were collected from three intervals at each Phase I soil boring location. The soil sample intervals specified in the PRSE Work Plan (TtNUS, 2001) were (1) 5 feet, (2) 15 feet, and (3) 35 feet below ground surface (bgs) based on the predicted occurrence a confining clay layer at approximately 40 feet bgs. The confining layer, composed of gray marine clay, was actually encountered at approximately 23 feet bgs at Site 10; therefore, the sampling intervals were changed to reflect site conditions.

Sample intervals for each soil boring were selected based on site stratigraphy and field flame ionization detector (FID) screening results. FID headspace readings were collected at 1-foot intervals, and the screening data were used to select sample intervals for laboratory analysis. The shallow soil samples collected from soil borings located in the ditch (NCBC10S03, NCBC10S04, NCBC10S05, NCBC10S06, and NCBC10S17) were collected from 1 to 2 feet below the bottom of the ditch. The shallow soil samples at the other soil boring locations were collected from 5 feet bgs, which roughly corresponds to the same vertical horizon as the shallow samples collected from the ditch. The intermediate soil samples collected from soil borings in the ditch were collected from 8 to 11 feet bgs, based on the FID field screening results. The intermediate soil samples collected from outside of the ditch were collected from 10 feet bgs. The majority of deep samples were collected from the interval just above the confining clay,

approximately 20 feet below the bottom of the ditch or 23 feet bgs. The sample intervals and FID readings for the Phase I soil borings are summarized in Table 2-2.

The soil samples collected from 14 of the borings (NCBC10S03 through NCBC10S16) were analyzed for pesticides and PCBs, TCL VOCs, and EDB. Soil samples from the remaining four borings (NCBC10S01, NCBC10S02, NCBC10S17, NCBC10S18) were analyzed for pesticides and PCBs only. The sample analyses for the Phase I soil borings are summarized in Table 2-2.

2.2.2 Phase II Soil Sampling

Five additional soil boring locations were sampled during the Phase II investigation to fill data gaps identified in Phase I (Figure 2-2). The Phase II soil samples were collected from depths of 5 feet. The five additional soil samples were collected to delineate contaminants detected in Phase I samples. Three of the samples (NCBC10S19, NCBC10S20, and NCBC10S21) were collected in the vicinity of NCBC10S 6 and were analyzed for pesticides and PCBs. Two of the additional samples (NCBC10S22 and NCBC10S23) were collected north of the ditch in the vicinity of NCBC10S11 and were analyzed for TCL VOCs and EDB.

2.2.3 Phase III Soil Sampling

Six soil samples were collected at six soil boring locations during Phase III. Shallow soil samples were collected at five of the soil boring locations, NCBC10S24, NCBC10S25, NCBC10S27, NCBC10S28, and NCBC10S29. These shallow samples were collected from a depth of 7 or 8 feet. One intermediate soil sample was collected at NCBC10S26 from a depth of 19 feet. These soil boring locations were selected to provide additional information on non-PCB and transformer oil-related contaminants that may have been released in the previously identified area of soil contamination. The Phase III soil samples were analyzed for pesticides and PCBs, TCL VOCs and SVOCs, herbicides, TAL metals, and cyanide.

2.3 GROUNDWATER INVESTIGATIONS

Based on the results of the soil sampling conducted during Phase I, five permanent monitoring wells were installed at Site 10, allowing for the characterization and delineation of potential groundwater contamination. Groundwater in the vicinity of Site 10 was anticipated to flow to the west-northwest; therefore, the monitoring wells were installed in the following locations:

- NCBC10G01 Source area well (in area of the highest detected PCB concentrations)
- NCBC10G02 Downgradient well
- NCBC10G03 Sidegradient well

- NCBC10G04 Sidegradient well
- NCBC10G05 Upgradient well

The locations of the five monitoring wells are shown in Figure 2-3. Groundwater samples were collected from the monitoring wells during Phase II and Phase III of the investigation (Table 2-1).

2.3.1 Monitoring Well Installation

The monitoring wells at Site 10 were installed using hollow-stem auger (HSA) drilling techniques. The wells were constructed of 2-inch-diameter, Schedule 40 polyvinyl chloride (PVC), flush-threaded casing with 15-foot, 0.01-inch slotted PVC screens. The shallow monitoring wells were installed to a total depth of approximately 17 feet so that the screened interval corresponded with the vertical extent of detected soil contamination. A filter pack of clean, 20/40, silica sand was installed from the bottom of the borehole to 2 feet above the top of the screen. A bentonite pellet seal or fine sand seal approximately 4 feet thick was installed above the 20/40 sand filter pack. The remainder of the annulus of the borehole was grouted with cement/bentonite slurry. The monitoring wells were completed at ground surface with flush mount vaults, as specified in the Southern Division Specifications for Monitoring Well Completion and Abandonment (NFESO, 1999). The horizontal location and top of casing elevation for each of the monitoring wells was surveyed by a Mississippi-licensed professional land surveyor. The details of the monitoring well installations are summarized in Table 2-3.

2.3.2 Phase II Groundwater Sampling

In February, 2002, TtNUS conducted groundwater sampling associated with Phase II of the investigation at Site 10. Groundwater samples were collected from the five monitoring wells installed at the site and submitted for laboratory analysis. The groundwater sample log sheets are included in Appendix A. The Phase II groundwater samples were analyzed for pesticides and PCBs, TCL VOCs, and EDB. Groundwater quality parameters including pH, conductivity, temperature, dissolved oxygen, and turbidity were measured with field instruments at each monitoring well during the sampling activities.

2.3.3 Phase III Groundwater Sampling

In December 2003, TtNUS conducted groundwater sampling associated with Phase III of the investigation at Site 10. Groundwater samples were collected from the five monitoring wells installed at the site and submitted for laboratory analysis. The groundwater sample log sheets are included in Appendix A. The Phase III groundwater samples were analyzed for pesticides and PCBs, TCL VOCs and SVOCs, herbicides, TAL metals and cyanide. Groundwater quality parameters including pH, conductivity,

temperature, dissolved oxygen, and turbidity were measured with field instruments at each monitoring well during the sampling activities.

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

NCBC Gulfport is located in the western part of the City of Gulfport, Mississippi, in southeastern Harrison County, about 2 miles north of the Gulf of Mexico (Figure 1-1). NCBC Gulfport occupies approximately 1,100 acres and has an elevation averaging approximately 30 feet above sea level.

3.1 SURFACE FEATURES

Site 10 includes a short section of primary drainage ditch located in the south-central section of NCBC Gulfport adjacent to the Parade Field (Figure 3-1). The drainage ditch at Site 10 is approximately 2.5 feet deep and 10 feet wide at the base and approximately 25 feet wide at the top of the banks. The site is bordered to the north by a parking area associated with Building 295 and to the south by the Parade Field. Large trees are present on the northern side of the ditch. The site topography is relatively flat. A sidewalk leading south from the former location of Building 295 crosses the ditch via a footbridge and continues south to the Parade Field.

NCBC is located in the Gulf Coast Flatwoods physiographic division, which extends along the southern coast of Harrison County. Topography in this area is a series of wet, poorly drained depressions between better drained areas of slightly higher elevation.

3.2 METEOROLOGY

The Gulfport area has a mild climate with warm and humid summers (average temperature of 82° F) and mild winters (average temperature of 52°F). The mean annual precipitation is 63.5 inches, and individual storms are often intense and may produce large 24-hour precipitation totals. The Mississippi coast is subject to hurricanes between June 1st and November 30th.

3.3 SURFACE WATER HYDROLOGY

NCBC Gulfport is located in the Coastal Plain physiographic province of southern Mississippi. This area is typically drained by small streams flowing southeastward toward the coast. Surface water in the vicinity of NCBC Gulfport is abundant. Storm water runoff is collected in a series of ditches and canals and directed off base. Large precipitation events tend to produce small stream and ditch flooding due to relatively high stream flow velocities.

Stormwater runoff from the paved areas surrounding Site 10 flows into various tributary ditches that feed into the larger primary ditch. Surface water runoff in the primary ditch is conveyed to the west into

Canal No. 1, which collects the runoff from Drainage Area 5 (Figure 1-2). Surface water in Canal No. 1 flows to the north and eventually leaves the NCBC Gulfport at Outfall 1, located at 28th Street.

3.4 GEOLOGY

Data collected from soil borings advanced at Site 10 were used to evaluate the lithologic and stratigraphic conditions that may influence contaminant fate and transport at the site.

3.4.1 Stratigraphy

Surface and shallow subsurface soils in this area are primarily gray and brown sand to sandy clay with varying amounts of gravel and minor clay horizons. The top of the local confining clay layer was encountered at a depth of approximately 23 feet at Site 10. Figure 3-2 is a site plan showing the line of cross section for Figure 3-3, an east/west-oriented cross section of Site 10.

3.4.2 Regional Geology

NCBC Gulfport is located in the coastal plain of southern Mississippi, which is underlain by a series of estuarine or deltaic sediments that dip southwestward toward the delta of the Mississippi River. These sediments range in age from Miocene to Recent and are not readily separated into stratigraphic units. The uppermost beds are Pleistocene and Recent terrace and stream valley deposits. The uppermost stratigraphic formation in the coastal plain area is the Pamlico Sand. The Pamlico Sand formation is approximately 60 to 70 feet thick and is composed of fine sands and shale or clay. The Pamlico Sand is underlain by the following formations:

- Citronelle Formation, sand approximately 100 feet thick.
- Graham Ferry Formation, alternating layers of sand, shale, and clay ranging from 125 to 250 feet thick.
- Upper and Lower Pascagoula Formations, alternating layers of sand, shale, and clay with shell and boulders approximately 1,100 feet thick.

3.5 SOILS

Surface and shallow subsurface soils identified from soil borings at Site 10 are primarily sand and sandy loam with minor clay horizons.

3.5.1 Soil Classification

The Soil Survey of Harrison County (USDA, 1975) identifies two soil types at Site 10. Soils in the eastern part of Site 10 are Ocilla loamy sand, a somewhat poorly drained soil commonly found on broad topographic flats. This soil type is typically comprised of a thick sandy surface layer over loamy material and is strongly acidic or very strongly acidic. Permeability is moderate throughout the soil. Available water capacity is low to medium, and runoff is slow. Soil blowing is a hazard on bare and unprotected soil during dry periods.

Soils in the western part of Site 10 are Atmore silt loam, a poorly drained soil developed in loamy material and commonly found on broad flats and in drainage ways. This soil type is typically silt loam and clay loam and is strongly acidic to extremely acidic. Permeability is moderate in the upper part of the soil horizon and slow in the lower part. Available water capacity is medium to high. The water table is near the surface during wet periods, and runoff is slow.

3.6 HYDROGEOLOGY

Hydrogeologic data were collected to evaluate movement of groundwater in the shallow surficial aquifer at the site. Depths to groundwater and groundwater elevations were used to determine the site-specific groundwater flow direction and hydraulic gradient. Groundwater flow velocity at the site was estimated using the hydraulic conductivity values determined for Site 6 and the Site 10 gradient data.

3.6.1 Static Water Levels and Groundwater Elevations

The depth to groundwater at NCBC Gulfport ranges from approximately 2 to 10 feet and is controlled primarily by surface topography. Static water level (SWL) measurement data were recorded from Site 10 monitoring wells in February 2002 and December 2003 (Table 3-1). The top of casing (TOC) elevations of the monitoring wells were surveyed by a professional land surveyor on February 21, 2002. The SWL measurement data and the elevations from the well TOC survey were used to determine relative groundwater elevations at each well.

In February 2002, the SWL measurements in the shallow wells ranged from 1.46 feet below TOC (BTOC) in NCBC10G04 to 2.15 feet BTOC in NCBC10G01. The groundwater elevations in the shallow wells ranged from 26.00 feet above mean sea level (msl) in NCBC10G02 to 26.24 feet above msl in NCBC10G05.

In December 2003, the SWL measurements in the shallow wells ranged from 1.26 feet BTOC in NCBC10G04 to 1.91 feet BTOC in NCBC10G01. The groundwater elevations in the shallow wells ranged from 26.17 feet above msl in NCBC10G02 to 26.49 feet above msl in NCBC10G05.

3.6.2 Groundwater Flow Direction

To evaluate the direction of groundwater flow at the site, the groundwater elevations from the site monitoring wells were plotted on a site map (Figures 3-4 and 3-5). Groundwater elevation isocontours were drawn from the plotted data; groundwater flow direction is perpendicular to the elevation isocontours. Interpretation of data from the gauging events at Site 10 indicates that flow in the shallow groundwater interval is to the northwest.

3.6.3 Hydraulic Gradient

The average horizontal groundwater gradient across the site was calculated from the groundwater elevations measured in shallow monitoring wells and the estimated groundwater flow direction.

The groundwater flow gradient was determined using the following equation:

$$I = \frac{h_1 - h_2}{d}$$

Where:

I = the hydraulic gradient
h_1 = the water elevation at point 1, the highest value
h_2 = the water elevation at point 2, the lowest value
d = the horizontal distance between point 1 and point 2 parallel to the direction of groundwater flow

The highest and lowest groundwater elevation values measured in the shallow monitoring wells were used to determine the difference in groundwater elevation across the site. The horizontal distance between the high and low groundwater elevation points was measured parallel to the estimated groundwater flow direction.

In February 2002, the groundwater elevation in NCBC10G05, 26.24 feet above msl, was the highest value and the groundwater elevation in NCBC10G02, 26.00 feet above msl, was the lowest value in the shallow monitoring wells. The horizontal distance between these two wells parallel to groundwater flow is approximately 124 feet. These data indicate the average hydraulic gradient of 0.0019 foot per foot for the shallow wells.

In December 2003, NCBC10G05 again had the highest groundwater elevation value, 26.49 feet above msl, and NCBC10G02 had the lowest value, 26.17 feet above msl. These data indicate the average hydraulic gradient of 0.0026 foot per foot for the shallow wells.

3.6.4 Hydraulic Conductivity

Hydraulic conductivity values for Site 10 were estimated from the slug test data from monitoring wells at Site 6 (ABB-ES, 1994). Site 6 is located approximately 2,000 feet to the west-northwest of Site 10 and has similar lithologies and a similar hydrogeologic setting. The geometric mean of the hydraulic conductivity values reported for the shallow wells at Site 6 is approximately 0.0057 foot per minute ($2.9X10^{-3}$ centimeters per second) or 8.2 feet per day (ABB-ES, 1994). The slug test data indicate an order of magnitude variation in hydraulic conductivity in the shallow surficial aquifer (ABB-ES, 1994).

3.6.5 Groundwater Flow Velocity

Potential movement of groundwater at the site may be described by Darcy's Law which is expressed as:

$$V = \frac{(Kxl)}{n}$$

Where:

V = average velocity
K = hydraulic conductivity
n = effective porosity
I = average hydraulic gradient

Data from soil borings advanced during the DPT investigation indicate that fine-grained sand and silty or clayey sand are the typical lithologies at the site. Review of standard literature suggests that a representative effective porosity for this lithology is approximately 30 percent (Heath, 1983).

Using an average hydraulic conductivity of 8.2 feet per day, an average hydraulic gradient of 0.002 foot per foot, and an effective porosity value of 30 percent, the estimated average groundwater velocity for the shallow zone at the site was calculated at 0.055 foot/day.

3.6.6 Regional Hydrogeology

In the Gulfport area, geologic units containing fresh water are of Miocene to Recent age. Aquifers are composed predominantly of sand beds that are irregular in thickness and horizontal extent. In the coastal area of southern Mississippi, the surficial aquifer is typically separated from the Miocene aquifer by a widespread clay aquitard.

The uppermost aquifer is the surficial aquifer. The surficial aquifer sediments are composed of undifferentiated alluvium and the Pamlico sand terrace deposits (Recent to Pleistocene in age). The Pamlico Sand formation is approximately 60 to 70 feet thick and is composed of fine sands and shale or clay. Depth to ground water in the surficial aquifer is variable, depending on local topography and precipitation, but generally ranges from 4 to 7 feet. Locally, shallow groundwater flow in the surficial aquifer is northwest toward Turkey Creek, which empties into Bernard Bayou and eventually into the Gulf of Mexico via the Mississippi Sound. Generally, this aquifer is not used for potable water supply.

Beneath the surficial aquifer are hydrogeologic units referred to collectively as the Miocene aquifers. The Miocene aquifers include the Citronelle Formation and the Graham Ferry Formation (Pliocene), and the Pascagoula, Hattiesburg, and Catahoula Formations (Micoene). Boundaries between the aquifers are vaguely, if at all, defined. These aquifers are composed of sands and discontinuous clays. The Miocene aquifers are a major source of potable water in the Gulfport area.

The water wells in the Citronelle Formation are used for both domestic and industrial water supply. Supply wells in the Upper and Lower Pascagoula Formations provide the majority of fresh water used in the Coastal Plain. The Hattiesburg Formation becomes increasingly brackish with depth, and salt water is encountered near the base of this unit (approximately 2,000 feet below sea level).

3.7 DEMOGRAPHY AND LAND USE

NCBC Gulfport is located in the western part of the City of Gulfport, Mississippi, in southeastern Harrison County. Biloxi, the largest city in Harrison County is located 7 miles east of Gulfport and Pass Christian is located 7 miles to the west.

NCBC Gulfport is an active military facility. The primary mission is the support of battalions of the Naval Construction Force (NCF) and the storage and maintenance of pre-positioned War Reserve Material Stock. NCF support consists of both homeport services and deployed support. Additional missions include tenant support and services to other activities in the region.

Land uses on base include training activities, equipment and materials storage, maintenance areas, recreational facilities, and residential housing for military personnel. Land use in the off-base areas adjacent to NCBC Gulfport is primarily residential.

3.8 ECOLOGY

Site 10 is located in a developed area of the base and includes part of a man-made ditch and the adjacent paved parade ground area.

3.8.1 Aquatic Habitats

The ditch at Site 10 is part of the network of interconnected ditches and canals that convey storm water on the base. The on-base ditches at NCBC Gulfport are generally straight and uniform in width, lacking the morphological properties of natural streams. Aquatic plants may grow in stable sand and gravel banks near and below water levels. The steep slopes on both sides of the ditches limit over bank flooding. Wading birds, fish, and benthic organisms have been observed in the ditches and canals on the base.

Based on the criteria established in Mississippi Commission on Environmental Quality Regulation WPC-2, the ditch at Site 10 would be classified as an ephemeral stream. As defined in Regulation WPC-2, ephemeral streams:

- Do not support a fisheries resource.
- Are not useable for human consumption or aquatic life.
- Include manmade drainage ditches that flow only in direct response to precipitation with channels that are normally above the groundwater table.

Regulation WPC-2 further states the following:

"These streams may contain a transient population of aquatic life during the portion of the year when there is suitable habitat for fish survival. Normally aquatic habitat in these streams is not adequate to support a reproductive cycle for fish and other aquatic life."

3.8.2 Terrestrial Habitats

Site 10 is located in a developed part of the base. Ground cover at the site is predominantly pavement and maintained lawn. Large trees are present on the northern side of the ditch, but native understory is absent. Vegetation along the sides of the ditch is periodically cut to control tree growth. No wetlands are located adjacent to the ditch in the vicinity of Site 10. On-site wildlife may temporarily use Site 10 but, due to lack of suitable cover, wildlife use is assumed to be infrequent.

3.8.3 Species of Concern

A request for a listing of species of concern was sent to the Heritage Program of the Mississippi Museum of Natural Science. A response from the Heritage Program dated February 24, 2003 cited no occurrences of State or federal listed or proposed endangered or threatened plants or animals on NCBC Gulfport.

4.0 NATURE AND EXTENT OF CONTAMINATION

Analytical data from the Phase I, Phase II, and Phase III investigations were used to evaluate the nature and extent of contamination at Site 10 including the types of contaminants detected in the sampled media and the concentrations of these contaminants compared to MDEQ screening criteria. The analytical data gathered during the RI can be found in Appendix B. Soil and sediment sample results were compared to Tier 1 restricted and unrestricted soil TRGs. Groundwater and surface water sample results were compared to Tier 1 groundwater TRGs. Surface water sample results were also compared to MDEQ surface water criteria when available.

Much of the Phase I and Phase II sampling analysis focused on PCB-related contaminants. Samples from all media collected during the Phase III investigation were analyzed for a wider range of contaminants to verify that the environmental impact at Site 10 was limited to the suspected release area and contaminants.

4.1 CONTAMINANT SOURCES

The detections of OCBE, chlorobenzene, and Aroclor-1260 at Site 10 indicate the release of electrical transformer oil as the probable source of contamination. The distribution of contaminants in the drainage ditch adjacent to the footbridge suggests that the release occurred in this area (Figure 3-1).

4.2 SOILS AND VADOSE ZONE

Soil samples were collected from 29 soil boring locations at Site 10. Due to the shallow water table at Site 10, the majority of the samples were collected from the saturated zone below the water table. Soil samples collected during the Phase I and Phase II sampling events were analyzed for pesticides and PCBs, TCL VOCs and EDB. Soil samples collected during the Phase III sampling event were analyzed for a full suite of analytes (TCL VOCs and SVOCs, pesticides and PCBs, herbicides, TAL metals and cyanide). The soil boring locations are shown on Figure 2-2. Analytes detected in the Phase I and Phase II soil samples are summarized in Table 4-1. Analytes detected in the Phase III soil samples are summarized in Table 4-2

4.2.1 <u>Volatile Organics</u>

Several VOCs were detected in Phase I and Phase II soil samples (Table 4-1). The reported concentrations of 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, acetone, benzene, carbon disulfide, and chlorobenzene were less than unrestricted Tier 1 TRGs. Additional VOCs reported from Phase III soil samples, also at concentrations less than unrestricted TRGs, included

1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, toluene, and trichlorofluoromethane (Table 4-2). The frequent occurrence of chlorobenzene compounds in the VOC analyses suggests a transformer oil source.

4.2.2 Pesticides/PCBs

Several pesticides and PCBs were detected in Phase I and Phase II soil samples (Table 4-1). The reported concentrations of alpha-BHC, Aroclor-1254, delta-BHC, DDD, DDE, DDT, endosulfan II, endrin, and endrin aldehyde were less than unrestricted Tier 1 TRGs. Aroclor-1260 and dieldrin were detected in one or more of the soil samples at concentrations exceeding Tier 1 TRGs (Figure 4-1).

Aroclor-1260 was detected in 10 of the 57 Phase I and Phase II soil samples submitted for laboratory analysis. Aroclor-1260 concentrations in five of these samples were less than the unrestricted Tier 1 TRG of 1,000 micrograms per kilogram (µg/kg). The following three soil samples had Aroclor-1260 concentrations greater than the unrestricted TRG but less than the restricted TRG of 10,000 µg/kg:

Location	Depth (ft bgs)	Concentration (µg/kg)
NCBC10S04	1	6,000
NCBC10S05	2	5,200
NCBC10S16	5	1,800

Aroclor-1260 concentrations were greater than the restricted Tier 1 TRG of 10,000 µg/kg in the following two soil samples:

Location	Depth (ft bgs)	Concentration (µg/kg)
NCBC10S06	2	83,000
NCBC10S06	8	19,000

PCB concentrations reported for the six Phase III soil samples submitted for laboratory analysis were less than the unrestricted Tier 1 TRGs (Table 4-2). An Aroclor-1260 detection was reported from one soil sample. Other PCB concentrations were less than standard laboratory detection limits.

Dieldrin was detected in 4 of the 51 Phase I and Phase II soil samples submitted for pesticide analysis (Table 4-1). Dieldrin concentrations in three of these samples were less than the unrestricted Tier 1 TRG of 39.9 µg/kg. One of the soil samples, NCBC10S16 (5 feet bgs), had a dieldrin concentration of 46 µg/kg, which is greater than the unrestricted TRG but less than the restricted TRG of 358 µg/kg. The reported dieldrin concentration for soil samples NCBC10S06 (2 feet bgs) (240 µg/kg) and NCBC10S06

(8 feet bgs) (60 µg/kg) were rejected in data validation due to interference from the high levels of PCBs present in these samples. Pesticide concentrations reported for the six Phase III soil samples submitted for laboratory analysis were less than standard laboratory detection limits.

4.2.3 Semivolatile Organics

SVOC concentrations reported for the six Phase III soil samples submitted for laboratory analysis were less than unrestricted Tier 1 TRGs (Table 4-2). Acenaphthene detections were reported from two of the soil samples and di-N-butyl phthalate was reported from four of the soil samples. Phase I and Phase II soil samples were not analyzed for SVOCs.

4.2.4 Herbicides

Herbicide concentrations in the six Phase III soil samples submitted for laboratory analysis were less than standard laboratory detection limits. Phase I and Phase II soil samples were not analyzed for herbicides.

4.2.5 Inorganics

Metals were frequently detected in the six Phase III soil samples submitted for inorganic analyses (Table 4-2). Aluminum, barium, calcium, chromium, copper, iron, magnesium, sodium, vanadium, and zinc were detected in all of the Phase III samples at concentrations less than Tier 1 unrestricted TRGs (TRGs are not established for calcium, magnesium, or sodium). Cobalt, manganese, nickel, potassium, and selenium were detected in one or more of the Phase III soil samples at concentrations less than TRGs (a TRG has not been established for potassium). Cyanide was not detected in the Phase III soil samples.

Arsenic was detected in the six Phase III soil samples submitted for inorganic analyses (Table 4-2). Arsenic concentrations in the following five samples (Figure 4-2) were greater than the Tier 1 unrestricted TRG of 0.426 milligram per kilogram (mg/kg) but less than the restricted TRG of 3.82 mg/kg:

Location	Depth (ft bgs)	Concentration mg/kg)
NCBC10S24	6	1.5
NCBC10S25	7	0.5
NCBC10S26	18	0.6
NCBC10S28	6	0.44
NCBC10S29	6	0.45

The arsenic concentration reported for NCBC10S27 (6 feet bgs), 0.21 mg/kg, was less than the unrestricted TRG. The detected concentrations of arsenic in the Phase III soil samples are typical for coastal plain soils in Mississippi and are not attributable to a release of electrical transformer oil.

4.2.6 Summary of Soil Analytical Results

- Detected VOC concentrations in soil samples were less than Tier 1 unrestricted TRGs.

- Aroclor-1260 was detected in three soil samples at concentrations greater than the unrestricted TRG and in two samples at concentrations greater than the restricted TRG (Figure 4-1). The dieldrin concentration in one soil sample was greater than the unrestricted TRG but less than the restricted TRG. Other pesticides and PCBs were detected at concentrations less than Tier 1 unrestricted TRGs.

- Detected SVOC concentrations in soil samples were less than Tier 1 unrestricted TRGs.

- Herbicide concentrations in soil samples were less than standard laboratory detection limits.

- Arsenic was detected in five of the six soil samples at concentrations greater than the Tier 1 unrestricted TRG but less than the restricted TRG (Figure 4-2). Other metals were detected at concentrations less than Tier 1 unrestricted TRGs.

- Cyanide concentrations in the soil samples were less than standard laboratory detection limits.

4.3 GROUNDWATER

Groundwater samples were collected during the Phase II and Phase III sampling events from the five monitoring wells installed at Site 10. Groundwater samples collected during the Phase II sampling event were analyzed for pesticides and PCBs, TCL VOCs, and EDB. Groundwater samples collected during the Phase III sampling event were analyzed for a full suite of analytes (TCL VOCs and SVOCs, pesticides and PCBs, herbicides, TAL metals and cyanide). Analytes detected in Phase II groundwater samples are summarized in Table 4-3. Analytes detected in Phase III groundwater samples are summarized in Table 4-4.

4.3.1 Volatile Organics

Two VOCs, 1,3-dichlorobenzene and 1,4-dichlorobenzene, were reported in groundwater samples collected during Phase II (Table 4-3). Both detections were from MW-02 and at concentrations less than

the Tier 1 TRG. Additional VOCs reported from Phase III groundwater samples included 1,2-dichlorobenzene, 1,2,4-trichlorobenzene, chlorobenzene, and benzene. Most of the Phase III detections were from MW-02 and were again at concentrations less than TRGs. Chlorobenzene was detected in the Phase III groundwater sample from MW-01 at a concentration less than the TRG (Table 4-4).

4.3.2 Pesticides/PCBs

The pesticide and PCB concentrations reported for the five Phase II groundwater samples submitted for laboratory analysis were less than standard laboratory detection limits (Table 4-3).

Several pesticides were detected in Phase III groundwater samples (Table 4-4). The reported concentrations of DDD and DDT (NCBC10G05) and delta-BHC (NCBC10G01) were less than unrestricted Tier 1 TRGs. The delta-BHC concentration was compared to the TRG for technical BHC because a TRG for delta-BHC has not been established. Dieldrin was detected in the groundwater sample from NCBC10G01 at a concentration of 0.057 µg/L, exceeding the Tier 1 TRG of 0.00419 µg/L (Figure 4-3). The detected concentrations of pesticides in the Phase III groundwater samples may be due to pesticide applications at NCBC Gulfport and are not attributable to a release of electrical transformer oil.

4.3.3 Semivolatile Organics

One SVOC, benzo(k)fluoranthene, was detected in Phase III groundwater samples (Table 4-4). The reported benzo(k)fluoranthene concentrations in NCBC10G02, an estimated 11 µg/L, and NCBC10G05, 11 µg/L, were greater than the Tier 1 TRG of 0.917 µg/L (Figure 4-3). Concentrations of other SVOCs in Phase III groundwater samples were less than standard laboratory detection limits.

4.3.4 Herbicides

Herbicide concentrations in the five Phase III groundwater samples submitted for laboratory analysis were less than standard laboratory detection limits. Phase II groundwater samples were not analyzed for herbicides.

4.3.5 Inorganics

Metals were frequently detected in the five Phase III groundwater samples submitted for inorganic analyses (Table 4-4). Barium, calcium, iron, manganese, magnesium, and sodium were detected in all of the Phase III samples at concentrations less than the TRGs (TRGs are not established for calcium, magnesium, or sodium). Chromium, copper, vanadium, zinc, and cyanide were detected in one or more

of the Phase III groundwater samples at concentrations less than the TRGs (a TRG has not been established for potassium).

4.3.6 Summary of Groundwater Analytical Results

- Detected VOC concentrations in groundwater samples were less than Tier 1 TRGs.

- Pesticides were detected in groundwater samples from two monitoring wells. The dieldrin concentration in one Phase III groundwater sample was greater than Tier 1 TRG (Figure 4-3). Other pesticides were detected at concentrations less than Tier 1 TRGs. PCB concentrations in groundwater samples were less than standard laboratory detection limits.

- Detected benzo(k)fluoranthene concentrations in two groundwater samples were greater than the Tier 1 TRG (Figure 4-3). Concentrations of other SVOCs in groundwater samples were less than standard laboratory detection limits.

- Herbicide concentrations in groundwater samples were less than standard laboratory detection limits.

- Metals were detected in groundwater samples at concentrations less than Tier 1 TRGs.

- Detected cyanide concentrations in groundwater samples were less than the Tier 1 TRG.

4.4 SURFACE WATER AND SEDIMENTS

Surface water samples were collected during the Phase I and Phase III sampling events. Sediment samples were collected during Phase I, Phase II, and Phase III sampling events. Surface water and sediment samples collected during the Phase I and Phase II sampling event were analyzed for pesticides and PCBs, TCL VOCs, and EDB. The surface water and sediment samples collected during the Phase III sampling event were analyzed for a full suite of analytes (TCL VOCs and SVOCs, pesticides and PCBs, herbicides, TAL metals and cyanide). Analytes detected in Phase I surface water samples are summarized in Table 4-5. Analytes detected in Phase III surface water samples are summarized in Table 4-6. Analytes detected in Phase I and Phase II sediment samples are summarized in Table 4-7. Analytes detected in Phase III sediment samples are summarized in Table 4-8.

4.4.1 Volatile Organics

VOC concentrations in surface water samples collected during Phase I were less than standard laboratory detection limits. Chlorobenzene was detected in one of the Phase III surface water samples at

a concentration less than the Tier 1 TRG (Table 4-6). Neither aquatic life nor human health standards for chlorobenzene in surface water have been established by the State of Mississippi.

Several VOCs were detected in Phase I and Phase II sediment samples (Table 4-7). The reported concentrations of 2-butanone, acetone, and toluene were less than unrestricted Tier 1 TRGs. The VOCs reported from Phase III sediment samples, also at concentrations less than unrestricted TRGs, included acetone, methylene chloride, and trichlorofluoromethane (Table 4-8).

4.4.2 Pesticides/PCBs

Several pesticides were detected in Phase I surface water samples (Table 4-4). The reported concentrations of endosulfan II and endrin aldehyde were less than Tier 1 TRGs and MDEQ surface water criteria. Dieldrin was detected in surface water sample NCBC10W02-D02 at an estimated concentration of 0.005 µg/L, which is less than the TRG and fresh water aquatic life criteria but greater than the human health criteria of 0.000144 µg/L for consumption of organisms and the consumption of organisms and water criteria of 0.000135 µg/L (Figure 4-5).

Aroclor-1260 was also detected in surface water sample NCBC10W02-D02 at a concentration of 1.1 µg/L, exceeding the Tier 1 TRG of 0.0335 µg/L and the acute (0.2 µg/L) and chronic (0.014 µg/L) criteria for fresh water aquatic life (Figure 4-4).

The pesticide and PCB concentrations reported for Phase III surface water samples submitted for laboratory analysis were less than standard laboratory detection limits (Table 4-6). The detected concentrations of pesticides in Phase I surface water samples may be due pesticide applications at NCBC Gulfport and are not attributable to a release of electrical transformer oil.

Several pesticides and Aroclor-1260 were detected in Phase I and Phase II sediment samples (Table 4-7). The reported concentrations of alpha-BHC, dieldrin, endosulfan II, gamma-BHC, heptachlor, and Aroclor-1260 were less than unrestricted Tier 1 TRGs. Aroclor-1260 and the pesticide delta-BHC were detected in Phase III sediment samples at concentrations less than unrestricted TRGs (Table 4-8).

4.4.3 Semivolatile Organics

Indeno(1,2,3-CD)pyrene was detected in sample NCBC10W10-D10 at an estimated concentration of 7 µg/L, exceeding the Tier 1 TRG of 0.917 µg/L. Surface water criteria have not been established for this SVOC by the State of Mississippi. Other SVOCs, fluoranthene and phenanthrene, were detected in both Phase III surface water samples at concentrations less than TRGs.

Several SVOCs were detected in Phase III sediment samples (Table 4-8). The reported concentrations of di-n-butyl phthalate, diethyl phthalate, fluoranthene, and phenanthrene were less than the unrestricted Tier 1 TRGs. Benzo(a)pyrene was detected in sediment sample NCBC10D07, at an estimated concentration of 170 mg/kg, which is greater than the unrestricted TRG of 0.426 mg/kg but less than the restricted TRG of 3.82 mg/kg (Figure 4-5). The detected concentration of benzo(a)pyrene in this sediment sample may be due to storm water runoff from paved areas and roads that is collected by the drainage system and is not attributable to a release of electrical transformer oil.

4.4.4 Herbicides

Herbicide concentrations in the Phase III surface water and sediment samples submitted for laboratory analysis were less than standard laboratory detection limits. Phase I and Phase II samples were not analyzed for herbicides.

4.4.5 Inorganics

Metals were frequently detected in Phase III surface water samples (Table 4-6). Barium, calcium, chromium, iron, manganese, magnesium, sodium, and vanadium were detected in both Phase III samples at concentrations less than TRGs (TRGs are not established for calcium, magnesium, or sodium). Chromium concentrations were also less than the aquatic life and human health surface water criteria. Aluminum was detected in one of the Phase III surface water samples at a concentration less than the TRG.

Copper was detected in both surface water samples at concentrations less than the TRG of 1,300 µg/L and the human health surface water criteria of 1,000 µg/L but greater than the acute (7 µg/L) and chronic (5 µg/L) aquatic life criteria (Table 4-6).

Metals were frequently detected in the five Phase III sediment samples submitted for inorganic analyses (Table 4-8). Aluminum, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, selenium, sodium, vanadium, and zinc were detected in all of the Phase III samples at concentrations less than Tier 1 unrestricted TRGs (TRGs are not established for calcium, magnesium, or sodium). Cobalt, nickel, and potassium were detected in one or more of the Phase III sediment samples at concentrations less than TRGs (a TRG has not been established for potassium). Cyanide was not detected in Phase III sediment samples.

Arsenic was detected in the five Phase III sediment samples submitted for inorganic analyses (Figure 4-5). Arsenic concentrations in the following four samples (Table 4-8) were greater than the Tier 1 unrestricted TRG of 0.426 mg/kg but less than the restricted TRG of 3.82 mg/kg:

Location	Concentration (mg/kg)
NCBC10D08	2.1
NCBC10D09	1.8
NCBC10W10-D10	1.7
NCBC10W11-D11	1.4

The arsenic concentration reported for NCBC10D07, 0.35 mg/kg, was less than the unrestricted TRG. The detected concentrations of arsenic in Phase III sediment samples are typical for sediments derived from coastal plain soils in Mississippi and are not attributable to a release of electrical transformer oil.

4.4.6 Summary of Surface Water and Sediment Analytical Results

- Detected VOC concentrations in surface water and sediment samples were less than Tier 1 TRGs.

- Pesticides were detected in Phase I surface water samples. The dieldrin concentration in one Phase I surface water sample was greater than the human health surface water criteria but less than the Tier 1 TRG and the aquatic life surface water criteria. Aroclor-1260 was detected in a Phase I surface water sample at a concentration exceeding the Tier 1 TRG and the acute and chronic criteria for fresh water aquatic life (Figure 4-4). Both samples were collected following the remedial action at the site. Pesticides were not detected in the Phase III surface water samples collected approximately 1 year later. Pesticide and PCB concentrations in sediment samples were less than Tier 1 TRGs.

- Indeno(1,2,3-CD)pyrene was detected in a Phase III surface water sample at a concentration greater than the Tier 1 TRG (Figure 4-4). Concentrations of other SVOCs in surface water samples were less than Tier 1 TRGs. Benzo(a)pyrene was detected in a Phase III sediment sample at a concentration greater than the unrestricted TRG of 0.426 mg/kg but less than the restricted TRG of 3.82 mg/kg. Concentrations of other SVOCs in sediment samples were less than Tier 1 TRGs.

- Herbicide concentrations in surface water and sediment samples were less than standard laboratory detection limits.

- Copper was detected in surface water samples at concentrations less than the Tier 1 TRG and the human health surface water criteria but greater than the acute and chronic aquatic life criteria. Concentrations of other metals in surface water samples were less than screening criteria. Arsenic concentrations in four sediment samples were greater than the Tier 1 unrestricted TRG but less than

the restricted TRG (Figure 4-5). Concentrations of other metals detected in sediment samples were less than Tier 1 TRGs.

- Cyanide concentrations in surface water and sediment samples were less than standard laboratory detection limits.

4.5 AIR

Air samples were not collected at Site 10 during the RI/FS.

5.0 CONTAMINANT FATE AND TRANSPORT

The behavior of contaminants released into the environment, particularly the potential for a contaminant to migrate from the release area and persist in an environmental medium, can influence whether the release will result in an adverse human health or ecological effect. The fate and transport discussion for this RI/FS report is limited to the groups of chemicals that were detected during the Phase I, Phase II, and Phase III sampling events at concentrations greater than Tier 1 TRGs established by the State of Mississippi.

5.1 POTENTIAL ROUTES OF MIGRATION

The movement of contaminants in the environment will be controlled by certain properties of the contaminants and the availability of suitable pathways for contaminant movement.

5.1.1 Physical and Chemical Factors Affecting Contaminant Mobility

The following properties can be used to evaluate the potential environmental mobility and fate of site contaminants:

- Specific gravity
- Vapor pressure
- Water solubility
- Octanol/water partition coefficient (K_{ow})
- Organic carbon partition coefficient (K_{oc})
- Henry's Law constant
- Bioconcentration factor (BCF)
- Mobility index (MI)

Table 5-1 presents the physical and chemical properties of the organic compounds detected at Site 10. The relative mobilities of metals as a function of environmental conditions are provided in Table 5-2.

Specific Gravity

Specific gravity is the ratio of the weight of a given volume of pure chemical at a specified temperature to the weight of the same volume of water at a given temperature. Specific gravity is used to determine whether a chemical will have a tendency to float or sink in water if present as a pure chemical or at very high concentrations. Non-aqueous-phase chemicals with a specific gravity greater than 1 will tend to

sink, and chemicals with a specific gravity less than 1 will tend to float. Of the groups of chemicals detected at Site 10, polynuclear aromatic hydrocarbons (PAHs), PCBs, and pesticides generally have a specific gravity greater than 1.

Vapor Pressure

Vapor pressure provides an indication of the rate at which a chemical volatilizes from both soil and water. Chemicals with higher vapor pressures are expected to enter the atmosphere much more readily than chemicals with lower vapor pressures. Volatilization is a significant loss process for VOCs in surface water or surface soil and is of primary importance at environmental interfaces such as surface soil/air and surface water/air. Volatilization is not as important when evaluating contaminated groundwater and subsurface soils that are not exposed to the atmosphere. Vapor pressures for pesticides and PCBs are very low, and volatilization is not significant for inorganics.

Water Solubility

The rate at which a chemical may be leached from a solid matrix (e.g., soil, waste deposit) by infiltrating precipitation is proportional to its water solubility. More soluble chemicals are more readily leached than less soluble chemicals.

The solubility of inorganics is strongly influenced by their valence state(s) and forms (hydroxides, oxides, carbonates, etc.). The solubility is also dependent on pH, Eh (redox potential), temperature, and other ionic species in solution (the Debye-Huckel theory). The solubility products reported in the literature vary with the type of complex formed, but generally it can be noted that, for example, cadmium and copper complexes are more soluble than lead and nickel complexes.

Octanol/Water Partition Coefficient

K_{ow} is a measure of the equilibrium partitioning of chemicals between octanol and water. A linear relationship between K_{ow} and the uptake of chemicals by fatty tissues of animal and human receptors (the BCF) has been established. It is also useful in characterizing the sorption of compounds by organic soils where experimental values are not available. PAHs, pesticides, and PCBs are several orders of magnitude more likely to partition to fatty tissues than the more soluble VOCs. K_{ow} is also used to estimate BCFs in aquatic organisms.

Organic Carbon Partition Coefficient

K_{oc} indicates the tendency of a chemical to adhere to soil particles containing organic carbon. Chemicals with high K_{oc} values generally have low water solubilities and vice versa. This parameter may be used to

infer the relative rates at which the more mobile chemicals (ketones, monocyclic aromatics, and halogenated aliphatics) partition to groundwater. Most pesticides, PAHs, and PCBs are relatively immobile in the soil and are preferentially bound to the soil. These compounds are not as likely to be transported in the dissolved phase by groundwater to the same extent as compounds with higher water solubilities. However, these preferentially bound chemicals are easily transported by erosional processes when they are present in surface soils and the soil particles to which they have adsorbed are mobilized.

Henry's Law Constant

Both vapor pressure and water solubility are of use in determining volatilization rates from surface water bodies and from groundwater. The ratio of these two parameters, the Henry's Law constant, is used to calculate the equilibrium chemical concentrations in the vapor (air) phase versus the liquid (water) phase for the dilute solutions commonly encountered in environmental settings. In general, chemicals having a Henry's Law constant of less than 1×10^{-5} atm-m^3/mole, such as pesticides and PCBs, should volatilize very little and be present only in minute amounts in the atmosphere or soil gas. For chemicals with a Henry's Law constant greater than 5×10^{-3} atm-m^3/mole, such as many of the halogenated aliphatics, volatilization and diffusion in soil gas could be significant.

Bioconcentration Factor

The BCF represents the ratio of aquatic-animal-tissue concentration to water concentration. The ratio is both contaminant and species specific. When site-specific values are not measured, literature values are used or the BCF is derived from the K_{ow}. Many of the pesticides, PCBs, and PAHs will bioconcentrate at levels three to five orders of magnitude greater than those concentrations found in water.

Distribution Coefficient

The distribution coefficient (K_d) is a measure of the equilibrium distribution of a chemical or ion in soil/water systems. The distribution of organic chemicals is a function of both K_{oc} and the amount of organic carbon in the soil. For ions (e.g., metals), K_d is the ratio of the concentration adsorbed on soil surfaces to the concentration in water. Distribution coefficients for metals vary over several orders of magnitude because K_d is dependent on the size and charge of the ion and the soil properties governing exchange sites on soil surfaces. Coulomb's Law predicts that the ion with the smallest hydrated radius and the largest charge will be preferentially accumulated over ions with larger radii and smaller charges.

Mobility Index

MI is a quantitative assessment of chemical mobility in the environment based on the water solubility (S), vapor pressure (VP), and K_{oc} of a given material (Laskowski, 1983):

$$MI = \log ((S*VP)/K_{oc})$$

The MI for a given chemical is evaluated using the following scale (Ford and Gurba, 1984):

Relative MI	Mobility Description
> 5	extremely mobile
0 to 5	very mobile
-5 to 0	slightly mobile
-10 to -5	immobile
< -10	very immobile

Lighter molecular weight PAHs, such as naphthalene, have MIs ranging from -5 to 0 and are considered slightly mobile, and the heavier molecular weight PAHs [e.g., benzo(a)pyrene] are classified as very immobile, having MIs less than -10 (Table 5-1). The MIs of pesticides detected at Site 10 range from -3.55 (endosulfan sulfate) to -15.8 (DDT); most of the pesticides have MIs less than -10 and are generally considered to be very immobile in soil. The MIs of PCBs are less than -10, and these chemicals are classified as very immobile.

5.1.2 Potential Pathways for Contaminant Migration

Based on the evaluation of existing conditions at Site 10, the following potential contaminant transport pathways may exist at the site:

- Leaching of soil contaminants to groundwater
- Migration of groundwater contaminants
- Migration of contaminants in surface water and sediment
- Volatilization from soil or groundwater

Leaching of Soil Contaminants to Groundwater

Contaminants that adhere to soil particles or have accumulated in soil pore spaces can be remobilized and transported to groundwater as a result of infiltration or precipitation. The rate and extent of this leaching are influenced by the following:

- Depth of the water table
- Amount of precipitation
- Rate of infiltration

- Physical and chemical properties of the soil
- Physical and chemical properties of the contaminant

The mobility of chemicals at Site 10 will influenced by the shallow water table, potentially high rates of precipitation, and the sandy soil in the area that may allow a higher rate of infiltration.

Migration of Groundwater Contaminants

Contaminants can migrate in either a dissolved phase or as an immiscible liquid. A contaminant that is present in water at a level greater than its solubility concentration will form an immiscible liquid. Based on the specific gravity of the contaminant, it will either float or sink in the water. In the case of chlorinated solvents (e.g., chloroform), the contaminant will sink in water because it has a higher specific gravity than water. Subsurface transport of immiscible contaminants is governed by a set of factors different than those of dissolved contaminants.

The groundwater data at Site 10 do not provide evidence of immiscible contaminants at concentrations exceeding water solubility levels. Solvents were detected at concentrations less than their water solubilities. Therefore, the migration of groundwater contaminants, for the most part, is likely governed by factors that govern the movement of dissolved contaminants. Three general processes govern the migration of dissolved constituents in groundwater: advection, dispersion, and retardation. Advection is a process by which solutes are carried by groundwater movement. Dispersion is a mixing of contaminated and uncontaminated water during advection. Retardation is a slowing of contaminant migration caused by the reaction of the solute with the aquifer soil.

Contaminant concentrations may be affected by one or more mechanisms during transport. Volatilization or precipitation may physically transform contaminants. Contaminants may be chemically transformed through photolysis, hydrolysis, or oxidation/reduction. Contaminants may also be biologically transformed by biodegradation.

Migration of Contaminants in Surface Water and Sediment

The dissolved contaminants in groundwater may migrate downgradient with the natural flow of groundwater. Contaminants can migrate as dissolved constituents in surface water or bound to sediment particles that are moved in direction of surface water flow. Three general processes govern the migration of dissolved contaminants caused by the flow of surface water: movement caused by the flow of surface water, movement caused by the irregular mixing of water, and chemical mechanisms occurring during the movement of surface water. Sediment particles can disassociate from the sediment into surface water and migrate by one of the aforementioned methods. At Site 10, contaminants in the drainage ditches

may be transported northwest to Canal No. 1. Storm events are of particular concern at Site 10 because the greater flow velocities can mobilize bedload sediments that are usually not disturbed under normal flow conditions.

Volatilization from Soil or Groundwater

Chemicals in soil can migrate into ambient air either as vapors or by adhering to particulate matter (dusts). Chemicals that have a significant volatility are likely to enter ambient air as vapors. These chemicals are generally considered to be compounds with Henry's Law Constants greater than 1.0×10^{-5} and molecular weights less than 200. Chemicals with lower Henry's Law Constants and higher molecular weights are more likely to enter ambient air on particulate matter carried by winds. This pathway may not be significant for Site 10 because the contamination is mainly in subsurface media, thereby limiting emissions from soil.

Once in groundwater, volatile chemicals may migrate or they may volatilize through the capillary zone and overlying soil layers into ambient air or inside buildings. Chemicals in the vapor phase may migrate horizontally or vertically and can enter buildings through cracks in the foundation or through foundation walls. Once inside buildings, the air concentrations in buildings are subject to various factors such as building dimensions and ventilation rates. Upon entering ambient air, the vapors are not expected to persist for long periods of time, having half-lives in the atmosphere typically measured in hours or a few days. The air concentrations of vapors in ambient air are likely to be quickly diluted by the action of winds. Vapors may also be released directly to ambient air from soil or groundwater during excavation activities.

5.2 CONTAMINANT PERSISTENCE

The life span of contaminants after they are released to the environment is controlled by the susceptibility of the contaminants to certain chemical and biological processes that may degrade the contaminants and reduce their remaining mass.

5.2.1 SVOCs

SVOCs as a class of compounds, and PAHs in particular, are considered to be persistent in the environment. SVOCs in soil are much more likely to bind to soil and be transported via mass transport mechanisms than to go into solution. PAHs are subject to degradation via aerobic bacteria but may be relatively persistent in the absence of microbial populations or macronutrients such as phosphorus and nitrogen. Landspreading applications have indicated that PAHs are highly amenable to microbial degradation in soil. The rate of degradation is influenced by temperature, pH, oxygen concentrations,

initial chemical concentrations, and moisture. Photolysis, hydrolysis, and oxidation are not important fate processes for the degradation of PAHs in soil.

The most important degradation processes for PAHs in aqueous matrices are photo-oxidation, chemical oxidation, and biodegradation. PAHs do not contain functional groups that are susceptible to hydrolytic action, and hydrolysis is considered to be an insignificant degradation mechanism. The rate of photodegradation is influenced by water depth, turbidity, and temperature. Benzo(a)pyrene and chrysene are reported to be resistant to photodegradation. PAHs may also be oxidized by chlorination and ozonation and may be metabolized by microbes under oxygenated conditions. Bioconcentration of PAHs in aquatic organisms is greater for the higher-molecular-weight compounds than the lower-molecular-weight compounds. PAHs can be bioaccumulated from water, sediments, or lower organisms in the food chain.

5.2.2 Pesticides

Pesticides as a class of compounds are considered to be persistent in the environment. Hydrolysis, oxidation, and photolysis are not generally important degradation mechanisms for pesticides in soil or water. Hydrolysis half-lives for several pesticides are reported in periods of months to years. Bioconcentration of pesticides in the food chain is an important fate.

DDT and its metabolites are considered to be persistent chemicals. Biodegradation may occur under both aerobic and anaerobic conditions in the presence of certain soil microorganisms. Under aerobic conditions, DDT may be transformed to DDE and, under anaerobic conditions, DDD may result. These compounds are, however, somewhat volatile, with a reported half-life of 100 days for DDT. These compounds are highly lipophilic and therefore readily bioaccumulate.

Aldrin is readily converted to dieldrin, which is a particularly persistent pesticide. In soil, dieldrin will persist for long periods of time (more than 7 years) and may slowly evaporate. It does not readily leach to groundwater. Once in surface waters (via runoff), dieldrin adsorbs strongly to sediments and bioconcentrates and slowly photodegrades. Biodegradation and hydrolysis are not significant degradation mechanisms.

5.2.3 PCBs

PCBs are considered to be very persistent organic chemicals. Biodegradation is the only process known to transform PCBs under environmental conditions, and only the lighter compounds are measurably biodegraded. Although some microorganisms (e.g., *Phanaerochaete chrysosporium*) may biodegrade PCBs, such fungi may not exist in local soil. There is experimental evidence to suggest that heavier

PCBs (five or more chlorines per molecule) can undergo photolytic degradation, but there are no data to suggest that this process operates under environmental conditions. Base-, acid-, and neutral-promoted hydrolysis are considered to be inconsequential degradation mechanisms for PCBs.

5.2.4 Metals

Metals are highly persistent environmental contaminants. They do not biodegrade, photolyze, or hydrolyze. Metals released to the environment generally adsorb to the soil matrix (as opposed to being part of the soil structure) and bioaccumulate. Because metals are frequently incorporated into the soil matrix and remain bound to particulate matter, they also migrate from source areas via bulk movement processes (erosion).

5.3 CONTAMINANT MIGRATION

The mobility of contaminants after they are released to the environment is controlled by the physical properties of the contaminants that determine whether a contaminant partitions to more mobile media (air or groundwater) or less mobile media (soil or sediment particles).

5.3.1 SVOCs

SVOCs are generally considered to be fairly immobile chemicals in the environment because they are large molecules with high K_{oc} values and low solubilities when compared to the volatile organics. However, some of the lighter molecular weight PAHs such as naphthalene are more water soluble and environmentally mobile. SVOC compounds in soil generally do not migrate vertically to a great extent and are more likely to adhere to soil particles and be removed from the site via surface runoff and erosional processes. Detections of SVOCs in groundwater and surface water samples collected at Site 10 may be the result of higher turbidity readings (particulate matter) in the samples.

PAHs generally have very low solubilities, vapor pressures, and Henry's Law constants and high K_{oc}s and K_{ow}s. The low molecular weight PAHs (e.g., acenaphthene, anthracene, fluorene, phenanthrene) may volatilize from surface waters, and the high-molecular-weight PAHs [e.g., benzo(a)pyrene, benz(a)anthracene, chrysene, etc.] are less likely to volatilize. PAHs in soil are much more likely to bind to soil and be transported via mass transport mechanisms than to go into solution.

5.3.2 Pesticides

Pesticides were detected in soil, groundwater, surface water, and sediment samples at Site 10. Pesticides can enter the environment by spraying, dusting, or direct application to the soil. Many of the compounds detected at Site 10 are no longer licensed for general sale and use in the United States.

Pesticides as a class of compounds are not considered to be very mobile in the environment. These chemicals, upon application or disposal, tend to remain affixed to soil particles. Migration of pesticides generally occurs primarily by erosion via the action of wind or water. Surface soil runoff may carry pesticides to adjacent surface water bodies.

5.3.3 PCBs

PCBs were detected in soil, sediment, and surface water samples at Site 10. The presence of PCBs in soil and sediment samples and their absence in all but one of the aqueous samples reflects their low water solubility and their tendency to adhere to particulate matter. Their presence in the surface water sample may be the result of turbidity (particulate matter) in the sample.

5.3.4 Metals

The mobility of metals is influenced primarily by their physical and chemical properties, in combination with the physical and chemical characteristics of the soil matrix. Factors that assist in predicting the mobility of inorganic species are soil/pore water pH, soil/pore water Eh, and cation exchange capacity. The mobility of metals generally increases with decreasing soil pH and cation exchange capacity (Table 5-2).

Because inorganics are frequently incorporated into the soil matrix and remain bound to particulate matter, they also migrate from the source areas via bulk movement processes (erosion). The larger, non-colloidal soil particles (greater than 0.45 micron) are not generally considered to be mobile in groundwater. Metals are also more mobile under acidic conditions. In these cases, it is possible for metals to migrate vertically through the soil column and reach groundwater.

6.0 BASELINE RISK EVALUATION

The risk evaluation for this RI/FS is based on the assumption that despite remedial actions already conducted at Site 10, risk may still remain for human health and the environment. The objectives of the risk evaluation are:

- to identify potential exposure pathways to receptor populations (exposure assessment)
- to identify the contaminants at the site that exceed default human health risk-based criteria (Tier 1 and Tier 2 risk evaluation)
- to evaluate the potential for risk to ecological receptors from site contaminants (ecological evaluation)

6.1 EXPOSURE ASSESSMENT

The exposure assessment evaluates the physical characteristics of the site, exposed populations, sources of contamination, and contaminant mobility to identify potential exposure routes and receptors. The following factors are evaluated in the exposure assessment:

- Sources of contamination
- Transport mechanisms
- Exposure routes/pathways
- Actual or potential receptors

The data from the exposure assessment were incorporated into the baseline Site Conceptual Exposure Model (SCEM).

6.1.1 Sources of Contamination

The source of contamination at Site 10 appears to be limited to a past release or releases of PCB-containing waste from electrical transformers into or adjacent to the ditch near the footbridge (Figure 3-1).

6.1.2 Transport Mechanisms

Potential contaminant migration mechanisms at Site 10 include the release of contaminants from soil to groundwater by infiltration of precipitation and dissolution of soluble contaminants. The dissolved contaminants in groundwater may migrate downgradient with the natural flow of groundwater and discharge as seeps to drainage ditches. Contaminants in drainage ditches may then be transported

northwest to Canal No. 1. Storm events are of particular concern because of greater flow velocities that mobilize bedload sediments that are usually not disturbed under normal flow conditions.

6.1.3 Exposure Routes/Pathways

Soil

Exposure to contaminated soil at the site under current land use is expected to be limited to surface soil. Under future land use, exposure to chemicals in subsurface soil could occur if the soil were to be uncovered (e.g., during excavation). A receptor may be exposed to soil by inadvertent ingestion of a small amount of soil, by dermal absorption of contaminants from the soil, or by inhalation of vapors or particulates emitted from soil.

Groundwater

Available information indicates that no domestic groundwater wells have been installed at or immediately downgradient of Site 10. Therefore, exposure to groundwater is not expected to occur under current land usage. Dermal contact with groundwater by construction workers may occur if workers contact groundwater during future excavation activities. Future on-site residents are assumed to use local groundwater as a source of domestic water and to be exposed to groundwater via ingestion and dermal contact.

Surface Water/Sediment

Exposure to contaminated surface water and sediment in the drainage ditch at Site 10 could occur under current or future land use. Potential receptors are assumed to come into direct contact with surface water and sediment while wading. Individuals may be exposed primarily via dermal contact and incidental ingestion, but the frequency of exposure is expected to be less than typical residential or industrial exposures to soil.

Air

This exposure pathway is based on the assumption that a receptor inhales air that contains suspended particulates and/or volatile organic vapors originating from soil. Exposure to fugitive dust and vapors would be an applicable exposure pathway mainly if soil or sediment at the site were to be uncovered in future construction or excavation activities. However, the contaminants exceeding Tier 1 TRGs in samples collected from other media do not have inhalation-based TRGs, indicating that the potential for migration to air is low.

6.1.4 Receptors

NCBC Gulfport is an active military facility and is anticipated to remain active for the foreseeable future. The paved area south of Site 10 is currently used as a parade field and is expected to be used for this purpose in the future. The area north of the ditch currently includes an office building and a parking lot. A footbridge crosses the contaminated portion of the ditch and allows pedestrians to walk from the parking lot to the parade field. Access to the site is not restricted, although access to the ditch is controlled by a fence. Table 6-1 summarizes the potential receptors that may be exposed to contaminated environmental media within the study area based on current and potential future land use.

6.1.5 Baseline SCEM

The baseline SCEM is used to identify the exposure pathways by which site contaminants can reach receptor populations. Because land use at Site 10 could potentially change in the future, the more conservative unrestricted potential receptor populations were considered applicable. The baseline SCEM worksheet is included in Appendix C.

Based on the baseline SCEM, the soil (including sediment) and surface water pathways are considered complete. The groundwater pathway is potentially complete under future land use, and the air pathway is considered incomplete.

Completed pathways indicate that if site contaminants are present at concentrations exceeding risk-based screening criteria, risk to receptors could occur. Risk to receptor populations can be controlled or eliminated by active cleanup, engineering controls, and/or institutional controls.

6.2 TIER 1 RISK EVALUATION

The Tier 1 risk evaluation is a comparison of site-specific analytical results to risk-based TRGs established to be protective of human health and the environment. The TRGs are based on the following:

- A 1 X 10^{-6} target cancer risk level for each carcinogenic chemical
- A non-carcinogenic hazard index not to exceed 1 for each systemic toxicant, or
- Constituent concentrations established through federal or state programs

Because of the lack of toxicity criteria, MDEQ Tier 1 TRGs are not available for calcium, magnesium, sodium, and potassium. These inorganics are essential nutrients and are commonly detected in environmental media.

Sediment sample analytical results are compared to soil TRGs. Surface water sample analytical results are compared to groundwater TRGs and criteria established by other applicable regulations. Analytes detected at concentrations exceeding Tier 1 TRGs are summarized by medium in the following sections.

6.2.1 Soil

Arsenic was detected at concentrations greater than the unrestricted Tier 1 TRG in five of the six soil samples analyzed for metals. The detected arsenic concentrations were less than the Tier 1 restricted TRG.

Aroclor-1260 was detected at concentrations greater than the unrestricted Tier 1 TRG but less than the restricted TRG in 3 of the 63 surface and subsurface soil samples collected during the RI ad in previous investigations. Aroclor-1260 concentrations in two additional samples were greater than the restricted Tier 1 TRG.

Dieldrin was detected at a concentration exceeding the unrestricted Tier 1 TRG in one of the 57 soil samples analyzed for pesticides. The detected dieldrin concentration was less than the Tier 1 restricted TRG.

6.2.2 Sediment

Arsenic was detected in four of the five sediment samples analyzed for metals at concentrations greater than the unrestricted Tier 1 TRG. The detected arsenic concentrations were less than the Tier 1 restricted TRG.

Benzo(a)pyrene was detected at a concentration exceeding the unrestricted Tier 1 TRG in one of the five sediment samples analyzed for SVOCs. The detected benzo(a)pyrene concentration was less than the Tier 1 restricted TRG.

6.2.3 Groundwater

Benzo(k)fluoranthene was detected at concentrations exceeding the groundwater Tier 1 TRG in two of the five groundwater samples analyzed for SVOCs.

Dieldrin was detected at a concentration exceeding the groundwater Tier 1 TRG in one of the 10 groundwater samples collected at Site 10.

6.2.4 Surface Water

Indeno(1,2,3-CD)pyrene was detected at a concentration exceeding the groundwater Tier 1 TRG in one of the two surface water samples analyzed for SVOCs.

Aroclor-1260 was detected at a concentration exceeding the groundwater Tier 1 TRG in one of the five surface water samples analyzed for PCBs.

Dieldrin was detected at a concentration exceeding the groundwater Tier 1 TRG and the human health criteria established in the Mississippi Water Quality Criteria for Intrastate, Interstate and Coastal Waters WPC-2 in one of the five surface water samples analyzed for pesticides.

6.3 TIER 2 RISK EVALUATION

Contaminants detected at concentrations exceeding Tier 1 TRGs are included in the Tier 2 risk evaluation. A Tier 2 risk evaluation is a more in-depth evaluation of site-specific conditions beyond the default values and assumptions of the Tier 1 evaluation. A Tier 2 risk evaluation is required by MDEQ at sites where PCB concentrations exceed the Tier 1 restricted TRG. The Tier 2 risk evaluation provides various methods to use site-specific data to evaluate risk.

6.3.1 Statistical Methods

The 95-percent upper confidence limit (UCL) of the mean detected concentrations can be used as the exposure concentration for comparison to the appropriate Tier 1 TRGs. The methodology to determine the UCL of the mean was conducted in accordance with USEPA guidance (USEPA, 1992). The 95-percent UCL can be calculated from populations of 10 or more samples. The 95-percent UCL calculations for the selected parameters are included in Appendix D.

The 95-percent UCL calculated for dieldrin in surface soil (less than 6 feet in depth) and sediment is 3.83 µg/kg, which is less than the unrestricted Tier 1 TRG of 39.9 µg/kg.

The 95-percent UCL calculated for dieldrin in groundwater, 0.033 µg/L is less than the maximum detected dieldrin concentration but is still greater than the TRG of 0.00419 µg/L.

The 95-percent UCL calculated for arsenic in surface soil and sediment, 2.42 mg/kg, is greater than the maximum arsenic concentration detected, 2.10 mg/kg, and the Tier 1 TRG, 0.426 mg/kg.

The 95-percent UCL calculated for Aroclor-1260, 2,777 µg/kg, is greater than the Tier 1 TRG of 1,000 µg/kg.

6.3.2 Site Background

Several groups of organic chemicals detected at Site 10, particularly pesticides and PAHs, are typically found in developed areas like NCBC Gulfport. The presence of these chemicals is more likely attributable to urban runoff than a past release of PCB-containing waste. Moreover, as shown below, the frequency of detection of these chemicals and the number of observed exceedances of TRGs indicate that the presence of PAHs and pesticides are not widespread. Based on these data, PAHs and pesticides will not be retained as chemicals of concern (COCs) for Site 10.

Solid Samples

Medium	Chemical	Maximum Conc. (µg/kg)	Freq. of Detection	Unrestricted TRG (µg/kg)	Unrestricted TRG Exceedances	Restricted TRG (µg/kg)	Restricted TRG Exceendances
Soil	Dieldrin	46	4/57	39.9	1/57	358	0/57
Sediment	Benzo(a) pyrene	170 J	1/5	87.5	1/5	784	0/5

Aqueous Samples

Medium	Chemical	Frequency of Detection	Maximum Conc. (µg/L)	TRG (µg/kg)	TRG Exceedances
Groundwater	Benzo(k)fluoranthene	2/5	11	0.917	2/5
	Dieldrin	1/10	0.057	0.00419	1/10
Surface Water	Indeno(1,2,3-CD)pyrene	1/2	7 J	0.0917	1/2
	Dieldrin	1/5	0.005 J	0.00419	1/5

6.3.3 Regionally Prevalent Chemicals

The detected concentrations of arsenic in soil and sediment at Site 10 is likely attributed to naturally occurring conditions. Pettry and Switzer (2001) evaluated arsenic concentrations in soil in Mississippi and reported data from five sample locations in the coastal flatwoods in Jackson County and one from Hancock County. The reported concentrations of arsenic in the coastal flatwoods samples ranged from 0.38 to 14.78 mg/kg. Twelve of the 13 reported results were greater than the unrestricted TRG for arsenic, with five of these results greater than the restricted TRG. The detected concentrations of arsenic in soil and sediment at Site 10 ranged from 0.21 to 2.4 mg/kg, within the lower end of the range reported by Pettry and Switzer. As a result, arsenic will not be retained as a COC.

6.3.4 Site-Specific Variables

Certain default values used to calculate the Tier 1 TRGs, such as exposure duration, exposure frequency, and moisture content, can be replaced with site-specific variables to calculate a site-specific TRG. Aroclor-1260 was detected in at least one soil sample at a concentration greater than the restricted Tier 1 TRG; therefore, it is unlikely that a TRG calculated from the site-specific variables would be protective of human health.

6.3.5 Eliminate/Minimize Exposure Routes

Risk to receptor populations can be controlled or eliminated by active cleanup, engineering controls, and/or institutional controls that eliminate or minimize routes of exposure. Active remediation by excavation of soil and sediment from the ditch at Site 10 in August 1999 failed to reduce PCB concentrations to less than TRGs. An FS was conducted for Site 10 to provide a detailed evaluation of alternatives to achieve protection of human health and the environment.

6.4 ECOLOGICAL EVALUATION

The screening-level risk assessment was conducted in accordance with USEPA Ecological Risk Assessment Guidance for Superfund (USEPA, 1997), USEPA Amended Guidance on Ecological Risk Assessment at Military Bases (USEPA, 2000), and the Navy Policy for Conducting Ecological Risk Assessments (DON, 1999). The risk assessment for Site 10 consists of Steps 1 and 2 of USEPA's 8-step ecological risk assessment process:

Step 1 Screening-Level Problem Formulation and Ecological Effects Evaluation
Step 2 Screening-Level Exposure Estimate and Risk Calculation

The ecotoxicity of site contaminants and potential ecological receptors are described in below in Section 6.4.1. Section 6.4.2 describes complete exposure pathways and preliminary assessment and measurement endpoints are discussed in Section 6.4.3. Sections 6.5, 6.6, and 6.7 describe the screening level ecological effects evaluation, exposure estimates, and risk characterization, respectively. The summary and conclusions of this ecological risk assessment are provided in Section 6.8.

6.4.1 Ecotoxicity

Pesticides, PCBs, VOCs, SVOCs, and metals were detected in either sediment or surface water samples collected from the ditch at Site 10. The following abstracts from the literature provide general discussions of each group's ecotoxicity.

6.4.1.1 VOCs

VOCs readily volatilize, are poorly adsorbed to soil and sediment particles, and are typically detected in surface water, surface soil, and sediment only at low concentrations. VOCs do not bioaccumulate in ecological receptors, and their toxicity to ecological receptors is relatively low.

6.4.1.2 SVOCs

Few generalizations can be made about the ecotoxicity of PAHs because of the extreme variability in toxicity and physiochemical properties of PAHs. Adverse impacts to plants from PAHs, however, are rare (Eisler, 2000). In most animal species, PAHs are metabolized by a mixed-function oxidase enzyme system into intermediates that may be toxic, mutagenic, or carcinogenic to the host. Some invertebrate species cannot efficiently metabolize PAHs (Eisler, 2000), and PAHs can be chronically toxic to invertebrates, but overall, very little is known about the toxicological mechanisms of PAHs in invertebrates (Erstfield and Snow-Ashbrook, 1999). PAHs can bind to cellular macromolecules and thereby disrupt their function in higher level organisms such as mammals and birds. Biological macromolecules include polymers of carbohydrates (e.g., starch), amino acids (proteins), and nucleotides (e.g., DNA). The cellular functions of these polymers include structure, energy storage, energy transfer, material transport, and the storage and transmittal of genetic information. PAHs show little tendency to biomagnify in the food web (Eisler, 2000). USEPA Region 4 considers the potential toxicity of PAHs via the terrestrial food web to be generally negligible unless PAHs are present at extremely high concentrations (i.e., percent levels: 10,000 mg/kg) in soil. Microbial metabolism is the major process for degradation of PAHs in soil (ATSDR, 1997).

Chronic oral exposure to phthalates can result in liver toxicity in mammals. Ingested phthalates metabolize to monoesters in the gut and are subsequently absorbed. Following absorption, phthalates distribute primarily to the liver and kidneys and may, in some species, concentrate in the testes (Rhodes et al., 1986). Liver carcinogenesis has been observed (ATSDR, 1997). Many receptors are able to metabolize and excrete phthalate esters, so their ability to bioaccumulate varies among species.

6.4.1.3 Pesticides

Organochlorine pesticides are reproductive and nervous system toxins. Although these compounds were used as insecticides, they are toxic to other animals as well. The target organ for acute exposures is the nervous system, while chronic exposures can affect the liver and endocrine systems of higher animals. Organochlorine pesticides are lipophilic and can be stored in the fat tissue of organisms such as birds and mammals. They can cause reproductive failure in birds of prey through eggshell thinning and

disruption of egg-laying and nesting cycles (Amdur et al., 1991). These pesticides were developed to control insects on crops, and as a result, they are practically non-toxic toxic to plants.

6.4.1.4 PCBs

PCBs are highly lipophilic, and can bioaccumulate in animals. PCBs can accumulate in offspring through placental transfer in mammals and accumulation in bird eggs, and can accumulate in upper trophic level animals such as piscivorous birds and mammals that feed on contaminated prey items (Eisler, 2000). Toxicity to aquatic organisms can occur through chronic exposures to PCBs at the parts per billion level. In animals, the primary effect associated with PCB exposure is the induction of liver enzyme systems. These enzymes are associated with detoxification mechanisms and with the metabolism of hormones. Adverse reproductive effects observed with PCB exposure are associated with induction of the enzyme systems. The toxicity of PCBs to mammals and birds varies, depending on the particular PCB and the animal species. Mink, for example, are highly sensitive to PCBs. Impacts to mink include anorexia, weight loss, lethargy, reproductive effects, and death (Eisler, 2000). Among sensitive avian species, PCBs disrupt the normal pattern of growth, reproduction, metabolism, and behavior. PCBs are not water soluble and accumulate to a much greater degree in animals than in plants. Nevertheless, plant-related effects of PCB exposure can include slower growth, reduced chlorophyll content, and diminished photosynthesis (USEPA, 1999).

6.4.1.5 Metals

It is difficult to make generalizations about the toxic actions of metals because of diverse affinities for organic molecules in biological structures, a wide array of biological effects, and a multiplicity of target organs and systems (Amdur et al., 1991). At the molecular level, metals can manifest toxicity in many ways, including selectively accumulating in target organs (such as the kidneys), substituting for essential metals, and mimicking essential substrates (Clarkson, 1983). At the molecular level, metal toxicity typically affects enzyme systems, leading to disruption of cellular transport, cellular respiration, cell division, and other physiological processes. Metal toxicity to aquatic organisms is marked by a broad spectrum of effects that can range from reduced growth to death. Aquatic organisms are most sensitive to metal toxicity in the embryonic and larval stages of the life cycle.

6.4.2 <u>Complete Exposure Pathways</u>

Based on the criteria established in Mississippi Commission on Environmental Quality Regulation WPC-2, the ditch at Site 10 would be classified as an ephemeral stream that does not support a fisheries resource and is not useable for human consumption or aquatic life. Site 10 is located in a developed part of the base. Ground cover at the site is predominantly pavement and maintained lawn. Large trees are present

on the northern side of the ditch, but native understory is absent. Vegetation along the sides of the ditch is periodically cut. No wetlands are located adjacent to the ditch in the vicinity of Site 10. Local wildlife may temporarily use Site 10 but, due to lack of suitable cover, wildlife use is assumed to be infrequent. No occurrences have been reported of State or federal listed or proposed endangered or threatened plants or animals on NCBC Gulfport.

Due to the ephemeral nature of the ditch and the limited amount of use by wildlife, sediment invertebrates are possibly the only organisms that may be exposed to sediment and surface water contaminants through ingestion and direct contact.

Actual or potential exposures of ecological receptors are determined by identifying the most likely pathways of contaminant release and transport. A complete exposure pathway has three components: (1) a source of chemicals that can be released to the environment, (2) a route of contaminant transport through an environmental medium, and (3) an exposure or contact point for an ecological receptor. As explained in Step 1 of USEPA's ecological risk assessment guidance (USEPA, 1997), if an exposure pathway is not complete, that exposure pathway does not need to be evaluated. Amphibians have a potentially complete pathway, but toxicological data regarding oral doses are not sufficient for their inclusion in the analyses. In summary, complete exposure pathways and routes of entry into aquatic biota at Site 10 consist of:

- Direct contact with sediment
- Ingestion of sediment
- Direct contact with surface water
- Ingestion of surface water

6.4.3 Preliminary Assessment and Measurement Endpoints

USEPA Region IV has specified that assessment endpoints for the screening-level assessment should be broad and generic. For the screening level assessment, the preliminary assessment endpoint is the protection of benthic invertebrates from adverse effects of chemicals on their growth, survival, and reproduction. Measurement endpoints represent the assessment endpoints chosen for a site, and are measures of biological effects (USEPA, 1997). The preliminary measurement endpoints were chemical concentrations in sediment and surface water that are associated with no adverse effects on growth, survival, and reproduction of aquatic organisms. The measurement endpoints are represented by EPA Region IV ecological screening values (ESVs) for sediment and surface water.

The USEPA Region IV ESVs for sediment and surface water are based on conservative endpoints and sensitive ecological effects data, and thus, the screening values represent chemical concentrations

associated with a low probability of unacceptable risks to ecological receptors. For this reason, USEPA Region IV considers their ESVs to be protective of aquatic invertebrates, fish, and plants.

6.5 SCREENING-LEVEL ECOLOGICAL EFFECTS EVALUATION

For the screening level ecological risk assessment, maximum concentrations of chemicals detected in sediment and surface water were compared to USEPA Region IV ESVs (USEPA, 2001). If the maximum concentration was less than the ESV, the chemical was eliminated from further consideration. If the maximum concentration equaled or exceeded the ESV, or if an ESV was not available, the chemical was then considered to be an ecological chemical of potential concern (COPC) and was retained for further study in the ecological risk assessment.

The surface water ESV for copper was derived using equations provided by USEPA (2004) for hardness-dependent metals. The surface water hardness (30.4 mg/L) was calculated using the average calcium and magnesium concentrations from all three surface water samples.

6.6 SCREENING-LEVEL EXPOSURE ESTIMATE

Exposure point chemical concentrations were obtained from sediment and surface water samples collected from the ditch at Site 10. The full data set are presented in Tables 4-5 through 4-8 in Section 4.

The sediment data base consisted of eleven samples (and two duplicate samples) collected from the ditch at Site 10 in January and February 2002 and December 2003. Figure 2-1 in Section 2 illustrates where sediment samples were collected.

The surface water data base consisted of five samples (and one duplicate sample) collected from the ditch at Site 10 in January 2002 and December 2003. Figure 2-1 in Section 2 illustrates the locations of the surface water samples.

All analytes (except calcium, magnesium, potassium, and sodium) detected in sediment and surface water samples were assessed in this investigation. Calcium, magnesium, potassium, and sodium were excluded because they are essential nutrients that are toxic only at extremely high concentrations. Due to the scarcity of data for these essential nutrients, it was not possible to develop ranges of toxicity for them even at high concentrations.

6.7 SCREENING-LEVEL RISK CALCULATION

The preliminary risk calculation step compared maximum concentrations of chemicals in sediment and surface water to USEPA Region IV ESVs. The ratio of the maximum concentration to the ESV is called the screening hazard quotient (HQ). Analytes whose maximum concentrations did not exceed ESVs (i.e., HQ < 1.0) were dropped from further consideration, and those that equaled or exceeded ESVs (i.e., HQ $\geq$ 1.0), or did not have ESVs, were retained as ecological COPCs.

6.7.1 Sediment

In sediment, five VOCs (2-Butanone, acetone, toluene, trichlorofluoromethane, and methylene chloride) were retained as COPCs because ESVs were not available (Table 6-3). One PAH (phenanthrene) was retained as a COPC because its maximum concentration slightly exceeded its ESV. Phenanthrene was detected in only one of six sample locations. Two phthalates (Di-N-butyl phthalate, diethylphthalate) were retained as COPCs because ESVs were not available. One pesticide (dieldrin) was retained as a COPC because its maximum concentration slightly exceeded its ESV. Dieldrin was detected in only one of four sample locations. Two pesticides (Endosulfan II, heptachlor) were retained as COPCs because ESVs were not available. The PCB Aroclor 1260 was retained as a COPC because its maximum concentration exceeded its screening value. Eight of thirteen sediment samples had Aroclor 1260 concentrations greater than the ESV indicating a large affected area.

Seven metals (aluminum, barium, cobalt, iron, manganese, selenium, vanadium) were retained as COPCs because ESVs were not available.

6.7.2 Surface Water

In surface water, two SVOCs (Ideno(1,2,3-CD)Pyrene, phenanthrene) were retained as COPCs because ESVs were not available (Table 6-4). Two pesticides (dieldrin, endrin aldehyde) were retained as COPCs because their maximum concentrations exceeded their screening value. The PCB Aroclor 1260 was retained as a COPC because its maximum concentration (one detection) exceeded its screening value. Three metals (aluminum, copper, and iron) were retained as COPCs because their maximum concentrations exceeded screening values. Aluminum and iron exceeded their ESVs in one of two samples while copper exceeded its ESV in two of two samples. Three metals (barium, manganese, and vanadium) were retained as COPCs because ESVs were not available.

6.8 SUMMARY AND CONCLUSIONS

The baseline SCEM identified completed pathways in soil, surface water, and sediment and potentially completed pathways to unrestricted receptor populations.

The following analytes were identified in the Tier 1 risk evaluation for human receptors as having concentrations exceeding Tier 1 TRGs in one or more samples:

Subsurface soil	Aroclor-1260, arsenic, and dieldrin
Sediment	Arsenic and benzo(a)pyrene
Groundwater	Benzo(k)fluoranthene and dieldrin
Surface water	Aroclor-1260, dieldrin, and indeno(1,2,3-CD)pyrene

However, PAHs and pesticides were not retained as COCs due to infrequent detections and because their presence is likely a result of urban runoff. Similarly, arsenic was not retained because it was detected within the lower range of naturally occurring concentrations.

Only Aroclor-1260 was retained as a COC for protection of human health. An FS was prepared to present alternatives to eliminate or minimize human exposure to Aroclor-1260 in subsurface soil and surface water by active cleanup, engineering controls, and/or institutional controls.

The ecological screening identified potential risks to ecological receptors from contaminants in sediment and surface water. The results of the sediment screening indicated a low level of potential risk from the pesticide dieldrin and the PAH phenanthrene. An elevated level of potential risk was found for Aroclor-1260. The results of the surface water screening for ecological risk indicated a low level of potential risk from the pesticides dieldrin and endrin aldehyde, and the metals aluminum and copper. An elevated level of potential risk was found for Aroclor-1260. There is uncertainty regarding potential ecological risk associated with chemicals for which no ESVs are available.

The results of the ecological screening indicate that the highest level of ecological risk is associated with Aroclor-1260. Potential ecological risks from Aroclor-1260 were identified at the majority of sediment sampling locations. Potential ecological risks from other contaminants were only found in isolated locations. Any steps taken to address the potential risk from Aroclor-1260 will also address potential risks from other contaminants.

7.0 REMEDIAL INVESTIGATION SUMMARY AND CONCLUSIONS

The primary objective of the RI was to provide data to guide the selection of a remedy for contamination at Site 10 that is protective of human health and the environment. In order to achieve this primary objective, samples from various media were collected and analyzed to fill data gaps from previous investigations. Previous investigations and removal actions at the site focused on PCB and transformer oil-related contaminants; therefore, additional samples were collected and analyzed to evaluate the nature and extent of other contaminants that may have been released at the site. Samples from various media were used to confirm the extent of PCB-related contamination previously documented at the site and to evaluate the effect remedial actions have had on site conditions.

7.1 SITE CONDITIONS

NCBC Gulfport is located in the western part of the City of Gulfport, Mississippi, in southeastern Harrison County, about 2 miles north of the Gulf of Mexico. NCBC Gulfport occupies approximately 1,100 acres and has an elevation averaging approximately 30 feet above msl.

7.1.1 Land Use and Topography

Land uses on base include training activities, equipment and materials storage, maintenance areas, recreational facilities, and residential housing for military personnel. Land use in the off-base areas adjacent to NCBC Gulfport is primarily residential.

Site 10 includes a short section of primary drainage ditch located in the south-central section of NCBC Gulfport adjacent to the Parade Field. The drainage ditch at Site 10 is approximately 2.5 feet deep and 10 feet wide at the base and approximately 25 feet wide at the top of the banks. The site is bordered to the north by a parking area associated with Building 295 and to the south by the Parade Field. Large trees are present on the northern side of the ditch. Except for the drainage ditch itself, the site topography is relatively flat.

7.1.2 Surface Water

Surface water in the vicinity of NCBC Gulfport is abundant. Storm water runoff is collected in a series of ditches and canals and directed off base. Large precipitation events tend to produce small stream and ditch flooding due to relatively high stream flow velocities. Storm water runoff from the paved areas surrounding Site 10 flows into various tributary ditches that feed into the larger primary ditch. Surface water runoff in the primary ditch is conveyed to the west into Canal No. 1, which collects the runoff from

Drainage Area 5. Surface water in Canal No. 1 flows north and eventually leaves the NCBC Gulfport at Outfall 1, located at 28th Street.

7.1.3 Geology

Surface and shallow subsurface soils in this area are primarily gray and brown sand to sandy clay with varying amounts of gravel and minor clay horizons. The top of the local confining clay layer was encountered at a depth of approximately 23 feet at Site 10.

7.1.4 Hydrogeology

The depth to groundwater at NCBC Gulfport ranges from approximately 2 to 10 feet bgs and is controlled primarily by surface topography. Depth to groundwater at Site 10 ranged from 1.26 to 2.15 feet bgs. Groundwater elevations in shallow wells ranged from 26.00 to 26.49 feet above msl. Groundwater flow direction in shallow groundwater is to the northwest. The estimated average groundwater velocity for the shallow zone at the site was calculated at 0.055 feet per day

7.1.5 Ecology

The ditch at Site 10 is part of the network of interconnected ditches and canals that collect on base storm water runoff and convey it off base. The on-base ditches at NCBC Gulfport are generally straight and uniform in width, lacking the morphological properties of natural streams. Aquatic plants may grow in stable sand and gravel banks near and below water levels. The steep slopes on either side of the ditch limit over bank flooding. Wading birds, fish, and benthic organisms have been observed in the ditches and canals on the base.

Site 10 is located in a developed part of the base. Ground cover at the site is predominantly pavement and maintained lawn. Large trees are present on the northern side of the ditch, but native understory is absent. Vegetation along the sides of the ditch is periodically cut to control tree growth. No wetlands are located adjacent to the ditch in the vicinity of Site 10. Local wildlife may temporarily use Site 10 but, due to lack of suitable cover, wildlife use is assumed to be infrequent. No occurrences have been reported of State or federal listed or proposed endangered or threatened plants or animals on NCBC Gulfport.

7.2 NATURE AND EXTENT OF CONTAMINATION

The detections of OCBE, chlorobenzene, and Aroclor-1260 at Site 10 indicate the probable release of electrical transformer oil as the source of contamination. The distribution of contaminants in the drainage ditch adjacent to the footbridge suggests that the release occurred in this area.

7.2.1 Soil

Detected VOC, SVOC, herbicide, and cyanide concentrations in soil samples were less than Tier 1 unrestricted TRGs.

Aroclor-1260 was detected in three soil samples at concentrations greater than the unrestricted TRG and in two samples at concentrations greater than the restricted TRG. The dieldrin concentration in one soil sample was greater than the unrestricted TRG but less than the restricted TRG. Other pesticides and PCBs were detected at concentrations less than Tier 1 unrestricted TRGs.

Arsenic was detected in five of the six soil samples at concentrations greater than the Tier 1 unrestricted TRG but less than the restricted TRG. Other metals were detected at concentrations less than Tier 1 unrestricted TRGs.

7.2.2 Groundwater

Detected VOC, herbicide, metals, and cyanide concentrations in the groundwater samples were less than Tier 1 TRGs.

Pesticides were detected in one Phase III groundwater sample from one monitoring well. The dieldrin concentration detected in that groundwater sample was greater than the Tier 1 TRG, but other pesticides were detected at concentrations less than Tier 1 TRGs. PCB concentrations in groundwater samples were less than standard laboratory detection limits.

Detected benzo(k)fluoranthene concentrations in two groundwater samples were greater than the Tier 1 TRG. Concentrations of other SVOCs in groundwater samples were less than standard laboratory detection limits

7.2.3 Surface Water and Sediment

Detected VOC, herbicide, and cyanide concentrations in the surface water and sediment samples were less than Tier 1 TRGs.

Pesticides were detected in two Phase I surface water samples. The dieldrin concentration detected in one of these samples was greater than the human health surface water criteria, but less than the Tier 1 TRG and the aquatic life surface water criteria. Aroclor-1260 was detected in the other Phase I surface water sample at a concentration exceeding the Tier 1 TRG and the acute and chronic criteria for fresh water aquatic life. Both of the Phase I surface water samples were collected following the remedial action

at the site. Pesticides were not detected in the Phase III surface water samples collected approximately 1 year later. Pesticide and PCB concentrations in sediment samples were less than Tier 1 TRGs.

Indeno(1,2,3-CD)pyrene was detected in one Phase III surface water sample at a concentration greater than the Tier 1 TRG. Concentrations of other SVOCs in surface water samples were less than Tier 1 TRGs. Benzo(a)pyrene was detected in a Phase III sediment sample at a concentration greater than the unrestricted TRG of 0.426 mg/kg but less than the restricted TRG of 3.82 mg/kg. Concentrations of other SVOCs in sediment samples were less than Tier 1 TRGs.

Copper was detected in surface water samples at concentrations less than the Tier 1 TRG and the human health surface water criteria but greater than the acute and chronic aquatic life criteria. Concentrations of other metals in surface water samples were less than screening criteria. Arsenic concentrations in four of the sediment samples were greater than the Tier 1 unrestricted TRG but less than the restricted TRG. Concentrations of other metals detected in sediment samples were less than Tier 1 TRGs.

7.3 SUMMARY OF RISK EVALUATION/CHEMICAL OF CONCERN SELECTION

The baseline SCEM identified completed pathways in soil, surface water, and sediment and potentially completed pathway to unrestricted receptor populations.

The following analytes were identified in the Tier 1 risk evaluation as having concentrations exceeding Tier 1 TRGs in one or more samples:

Subsurface soil	Aroclor-1260, arsenic, and dieldrin
Sediment	Arsenic and benzo(a)pyrene
Groundwater	Benzo(k)fluoranthene and dieldrin
Surface water	Aroclor-1260, dieldrin, and indeno(1,2,3-CD)pyrene

However, PAHs and pesticides were not retained as COCs due to infrequent detections and because they are likely a result of urban runoff. Similarly, arsenic was not retained as a COC because it was detected within the lower range of naturally occurring concentrations. As a result, only Aroclor-1260 was retained as a COC for protection of human health following the Tier 2 risk evaluation.

Based on an evaluation of site-specific data with respect to EPA Region IV screening criteria, Aroclor-1260 was also retained as a COC for ecological receptors. Potential ecological risks from Aroclor-1260 were identified at the majority of sediment sampling locations. Potential ecological risks from other contaminants were low and only found in isolated locations.

7.4 CONCLUSIONS

An FS was prepared to present alternatives to eliminate or minimize potential human and ecological receptor exposure to Aroclor-1260 in affected media including subsurface soil, sediment, and surface water by active cleanup, engineering controls, and/or institutional controls. The FS is included in the following sections.

8.0 REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS

The objectives and goals for a remedial action at Site 10 provide the basis for selecting Remedial Action Objectives (RAOs) and identifying remedial technologies to address unacceptable exposure scenarios that may be encountered with Site 10 contaminated media.

This section presents the development of RAOs. As part of this development, regulatory requirements, or Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered criteria (TBCs), are identified. Next, media of concern are identified based on the one COC (Aroclor-1260) selected for Site 10. Preliminary action levels, or Preliminary Remedial Goals (PRGs), for each medium of concern are then identified. Taking into consideration this information, RAOs are then defined.

This section also presents General Response Actions (GRAs) for Site 10 contaminated media. GRAs are categories of actions that could be implemented to satisfy or address a component of the RAOs for the site. Lastly, this section provides an estimate of the volumes of contaminated media to be addressed at Site 10.

8.1 REMEDIAL ACTION OBJECTIVES

8.1.1 ARARs and To Be Considered Criteria

ARARs for this FS are the federal and State environmental requirements used to define the appropriate extent of site cleanup, to identity sensitive land areas or land uses, to develop remedial alternatives, and to direct site remediation. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) require remedial actions to comply with State ARARs when they are more stringent than federal ARARs.

The NCP defines two ARAR components: (1) applicable requirements and (2) relevant and appropriate requirements. Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal or State environmental or facility siting laws specifically addressing a hazardous substance, pollutant, contaminant, remedial action, or other circumstance found at a CERCLA site. Applicable State standards are only those (1) identified by the State in a timely manner, (2) consistently enforced, and (3) more stringent than federal requirements.

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements under federal and State environmental and facility siting laws that, while not

"applicable" to a hazardous substance, pollutant, contaminant, or remedial action, address situations sufficiently similar to those encountered at the CERCLA site so their use is well suited to the particular site. Only those State standards (1) identified in a timely manner and (2) more stringent than federal requirements may be relevant and appropriate.

"Applicability" is a legal determination of jurisdiction of existing statutes and regulations, whereas "relevant and appropriate" is a site-specific determination of the appropriateness of existing statutes and regulations. Therefore, relevant and appropriate requirements allow flexibility not provided by applicable requirements in the final determination of cleanup levels. After a requirement is identified as an ARAR, the selected remedy must comply with or be waived from compliance with the ARAR, even if the ARAR is not required to assure protectiveness. Applicable requirements apply to both on- and off-site remedial actions.

TBC guidance criteria are federal and State non-promulgated advisories or guidance that are not legally binding and do not have the status of potential ARARs. However, if there are no specific ARARs for a chemical or site condition, or if ARARs are not deemed sufficiently protective, then guidance or advisory criteria should be identified and used to ensure the protection of human health and the environment.

Under the description of ARARs set forth in the NCP and the Superfund Amendments Reauthorization Act (SARA), State and federal ARARs are categorized as follows:

- Chemical-specific: Controlling the extent of site remediation with regard to specific contaminants and pollutants.

- Location-specific: Governing site features such as wetlands, floodplains, and sensitive ecosystems (including features of historical significance).

- Action-specific: Pertaining to the proposed site remedies and governing the implementation of the selected site remedy.

During the detailed analysis of remedial alternatives presented in Section 10.0, each alternative will be analyzed to determine its compliance with ARARs. Chemical-, location-, and action-specific ARARs for Site 10 are presented in Table 8-1.

8.1.2 Chemicals and Media of Concern

As determined in Section 6.0, one chemical, Aroclor-1260 (a PCB), is retained as a COC in this FS. As explained in the following paragraphs, Site 10 soil, sediment, and surface water are retained as media of concern. Remedial alternatives were developed to address Aroclor-1260 concentrations in these media.

Aroclor-1260 was detected throughout the soil of Site 10 with concentrations ranging from 11 to 83,000 µg/kg and detections at depths up to 8 feet bgs. As a result, soil is retained as a medium of concern. Similarly, Aroclor-1260 was detected in sediment at concentrations ranging from 65 to 710 µg/kg. Accordingly, sediment is retained as a medium of concern.

Surface water is also retained as a medium of concern. Aroclor-1260 was detected in one Site 10 surface water sample at a concentration of 1.1 µg/L. PCBs may be mobilized into the surface water of the site when erosion of sediment and/or shallow soil occurs. However, remedial alternatives were not developed to directly address impacts to surface water. Instead, it is assumed that remedial actions taken to address soil and sediment will indirectly address PCB impacts to surface water.

Groundwater is not retained as a medium of concern. The mobility of PCBs via the groundwater pathway is not considered significant at Site 10 because PCBs have a great affinity for particulates. Moreover, PCBs were not detected in Site 10 groundwater.

8.1.3 Preliminary Remedial Goals

Based on discussions between the Navy, MDEQ, and United States Environmental Protection Agency (USEPA), it was agreed that the State of Mississippi would be the regulatory lead agency at Site 10 (see Appendix E) and that PRGs for the project would be based on the State of Mississippi TRGs. As a result, the MDEQ TRG will serve as the basis for remedial action.

Per Mississippi Code Section 49-35-21, TRGs are based on either (1) a $1x10^{-6}$ target incremental cancer risk level for each carcinogenic chemical, (2) a hazard index not to exceed 1.0 for each systemic toxicant, or (3) constituent TRG concentrations established through federal/State programs (e.g., the Safe Drinking Water Act). The State of Mississippi lists TRGs for both restricted (industrial) and unrestricted (residential) land use. Site 10 is located due south of the base mess hall and to the southwest of McDonald's. Because of Site 10's proximity to these public locations, unrestricted (residential) TRGs are deemed appropriate for remedial consideration. The State of Mississippi unrestricted TRG for Aroclor-1260 in soil is 1,000 µg/kg, and this value is selected as the PRG for soil and sediment at Site 10.

Although concentrations of Aroclor-1260 detected in sediment are less than the unrestricted TRG, sediment is retained as a medium of concern. It is believed that sediment concentrations of Aroclor-1260 are responsible for the surface water detection of Aroclor-1260 observed during the RI/FS. By addressing sediment, surface water concerns will also be addressed.

As part of the CERCLA process, PRGs are periodically revised because of new guidance requirements and promulgated or updated ARARs. Final remediation goals will not be formally established until the approval of the Record of Decision (ROD).

8.1.4 Statement of Remedial Action Objectives

RAOs are the medium-specific goals established to protect human health and the environment (USEPA, 1988). The RAOs identified in this section are based on the one COC (Aroclor-1260) retained for Site 10 and consist of the following.

RAO 1: Prevent direct exposure to soil with concentrations of Aroclor-1260 greater than 1,000 µg/kg.

RAO 2: Prevent the erosional transport of Aroclor-1260 through the drainage channel system.

RAO 3: Comply with federal and State ARARs and TBC guidance criteria in accordance with accepted USEPA and MDEQ guidelines.

8.2 GENERAL RESPONSE ACTIONS

GRAs describe categories of actions that could be implemented to satisfy or address a component of the RAOs for the site. Remedial alternatives will be developed using one or more GRAs to meet the RAOs. These remedial alternatives will be capable of achieving the RAOs for each contaminated medium at the site. The following GRAs will be considered for soil and sediment at Site 10:

- No Action
- Limited Action (e.g., Monitored Natural Attenuation, Institutional Controls, Monitoring)
- Containment
- Removal
- In-Situ Treatment
- Ex-Situ (On-Site) Treatment
- Disposal

8.3 ESTIMATED VOLUMES OF CONTAMINATED MEDIA

Due to the relatively small volume of media identified at Site 10, soil and sediment will be addressed as one combined medium. Moreover, soil is assumed to be similar to sediment because subsurface soil is saturated. Lastly, any actions conducted to address contaminated soil would require movement of sediment.

Based on an Aroclor-1260 PRG of 1,000 µg/kg, the approximate areal extent of contamination is presented in Figure 8-1. In all, an estimated 450 yd^3 of contaminated soil/sediment containing 33 pounds of Aroclor-1260 is present at Site 10. Assumptions and calculations used in deriving this estimate are provided in Appendix F.

9.0 SCREENING OF TECHNOLOGIES AND DEVELOPMENT OF ALTERNATIVES

This section identifies, screens, and evaluates the potential technologies and process options that may be applicable to assemble remedial alternatives for Site 10 at NCBC Gulfport. The primary objective of this phase of the FS is to develop an appropriate range of remedial technologies and process options that will be used for developing remedial alternatives. Technologies for soil and sediment remediation are discussed in Sections 9.1 through 9.3. Remedial alternatives are assembled and developed in Section 9.4 using the technologies and process options that were retained following preliminary evaluation.

The basis for remediation technology identification and screening began in Section 8.0 with a series of discussions that included the following:

- Identification of ARARs
- Development of RAOs
- Identification of GRAs
    1) No Action
    2) Limited Action (e.g., Monitored Natural Attenuation, Institutional Controls, Monitoring)
    3) Containment
    4) Removal
    5) In-Situ Treatment
    6) Ex-Situ (On-Site) Treatment
    7) Disposal

Remediation technology screening is performed in this section with the completion of the following analytical steps:

- Identification and screening of remediation technologies and process options
- Evaluation and selection of representative process options

In this section, soil and sediment remediation technologies and process options are first identified for each of the GRAs and then screened.

The selection of remediation technologies and process options for initial screening is based on the Guidance for Conducting Remedial Investigations/Feasibility Studies under CERCLA (USEPA, 1988). The screening is first conducted at a preliminary level to focus on relevant remediation technologies and process options, then the screening is conducted at a more detailed level based on the evaluation criteria.

Finally, process options are selected to represent the remediation technologies that have passed the entire evaluation and screening process.

Due to the relatively small volume of contaminated media identified at Site 10, soil and sediment will be addressed as one combined medium. Moreover, soil is assumed to be similar to sediment because soils at depth are saturated. Lastly, any actions conducted to address contaminated soil would require movement of sediment.

9.1 PRELIMINARY SCREENING OF SOIL AND SEDIMENT TECHNOLOGIES AND PROCESS OPTIONS

This section identifies and screens remediation technologies and process options for soil and sediment at a preliminary stage based on implementation with respect to site conditions and COCs. Table 9-1 summarizes the preliminary screening of technologies and process options. It presents the GRAs, identifies the technologies and process options, and provides a brief description of each process option followed by the screening comments. The following are the technologies and process options were retained for screening:

General Response Action	Remediation Technology	Process Option
No Action	None	Not Applicable
Limited Action	Institutional Controls	Active and Passive Controls
	Monitoring	Sampling and Analysis
Containment	Surface Protection	Concrete/Rip-Rap Cover/Asphalt
	Surface Water Controls	Vertical Barriers
Removal	Excavation	Excavation
Ex-Situ Treatment	Physical/Chemical	Dewatering
		Chemical Fixation/Solidification
Disposal	Landfill	Off-Site Disposal

9.2 SCREENING OF REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

9.2.1 No Action

No action consists of maintaining the status quo at the site. As required under CERCLA regulations, the No Action alternative is carried through the FS to provide a baseline for comparison of alternatives and their effectiveness in mitigating risks posed by site contaminants. Because no remedial actions are conducted under this alternative, there are no costs associated with “walking away from” the site and no reduction in risk through exposure control or treatment. No action is retained for comparison to other options.

9.2.2 Limited Action

9.2.2.1 Institutional Controls

Institutional controls would consist of access restrictions and land use controls (LUCs). Access restrictions would consist of expanding and maintaining existing fencing at the site to prevent access by trespassers. LUCs would consist of preparing and implementing a Land-Use Control Implementation Plan (LUCIP), that would prohibit current site users from being exposed to contaminants and deed restrictions to prevent the site from being used in the future for residential purposes.

Institutional controls are retained in combination with other process options for the development of remedial alternatives.

9.2.2.2 Monitoring

Monitoring would consist of regularly collecting and analyzing samples of media (e.g., sediment) from the site to evaluate trends in concentrations and check for potential migration. Monitoring may be considered when contaminated media are left in place without treatment.

Monitoring is retained in combination with other process options for the development of remedial alternatives.

9.2.3 Containment

9.2.3.1 Surface Protection

Surface protection would consist of providing a barrier to prevent direct exposure to contaminated soil and sediment. Additionally, this technology would minimize potential off-site migration of contaminated soil and sediment via erosion. The impacted drainage channel could be lined with concrete and/or rip rap, and impacted soil could be covered with an asphalt pavement.
Surface protection is retained in combination with other process options for the development of remedial alternatives.

9.2.3.2 Surface Water Controls

Surface water controls would consist of using vertical barriers to contain or divert surface or storm water in order to minimize the potential for infiltration and/or migration of contaminated soil and sediment.

Vertical barriers would consist of sheet piling and silt curtains. Sheet piling consists of an impervious barrier that would be installed around remediation work areas to divert surface water. Silt curtains are permeable barriers that would be installed immediately downstream/downgradient from areas of concern to prevent migration of contaminated soil or sediment from these areas.

Surface water controls, including sheet piling and silt curtains, are retained in conjunction with other remedial technologies for the formulation of remedial alternatives for Site 10.

9.2.4 Removal

The only technology considered under this GRA is excavation. Excavation can be performed by a variety of equipment such as tractor shovels (front-end loaders), backhoes, grade-alls, etc. The type of equipment selected must take into consideration several factors such as the type of material to be removed, the load-bearing capacity of the ground surrounding the removal area, the depth and areal extent of removal, the required rate of removal, and the elevation of the groundwater table. Excavation is the technology of choice for the removal of well-consolidated material such as soil to depths of up to 30 feet and from well-defined areas of ground with significant load-bearing capacity (i.e., greater than 1,500 pounds per square foot).

The logistics of excavation must take into account the available space for operating the equipment, loading/unloading to transport the removed material, location of the site, etc. After excavation is completed, the location would be filled and graded with clean fill material or treated soils, and the area would be restored to pre-excavation conditions.

Excavation is retained in combination with other process options for the development of remedial alternatives.

9.2.5 Ex-Situ Treatment

The following technologies were retained under this GRA: dewatering and chemical fixation/solidification.

9.2.5.1 Dewatering

Dewatering is a process for reducing the free water content of solid wastes. Dewatering would likely be required to reduce free water present in contaminated sediment removed from certain sections of the Site 10 drainage ditch and deeper soils to improve handling and reduce volumes/weights prior to additional treatment and disposal.

Dewatering can be achieved either through passive (gravity-aided) decantation, such as drainage of free water from stockpiled material, or by mechanical expression. Depending on the physical characteristics of the material to be dewatered, specialized mechanical equipment such as belt filter presses, plate-and-frame filter presses, vacuum filters, and centrifuges may be used.

Stockpiling of wet sediment on a lined pad would allow the free water to decant from the sediment due to gravity and to some extent to mechanical compression of the lower layers of stockpiled sediment by the weight of the upper layers. The separated water could then be collected into a sump. If necessary, the removed free water would be treated on site using such technologies as granular activated carbon (GAC) adsorption prior to discharge to local surface water or sewage treatment system.

Stockpiling is eliminated from further consideration because it would not be effective in achieving the preferred conditions for the excavation. The excavation area will need to be dewatered prior to commencement of the excavation activities, particularly at depths below the normal water level and up to 15 feet bls in the area of Site 10.

Mechanical dewatering techniques would utilize pressure, vacuum, or centrifugal forces to force the liquid phase through semipermeable membranes or to separate free water from sediment. As with stockpiling, the released water would be treated if required and discharged to local surface water or sewage treatment system.

Mechanical dewatering is retained in conjunction with other remedial technologies for the formulation of remedial alternatives for soil and sediment. Mechanical dewatering will be more effective than stockpiling and allow the area to be dewatered prior to the excavation activities.

9.2.5.2 Chemical Fixation/Solidification

Chemical fixation/solidification consists of mixing the contaminated material to be treated, typically a soil or sludge, with chemical reagents that bind the COCs within the matrix of the material being treated. The most common fixation/solidification reagents are pozzolanic-based materials such as Portland Cement, cement kiln dust, and fly ash. Chemicals such as quick lime or proprietary reagents (e.g., organophilic compounds) are also often added to the fixation/solidification reagents to increase their effectiveness of treatment, especially if organic contaminants are present that may not readily respond to pozzolanic-based binding.

The mixing of the material to be treated with the chemical reagents is normally accomplished in the presence of a controlled amount of water with specialized mechanical blending equipment such as a pug mill. After the material is mixed with the chemical reagents, it is allowed to cure for a specified time

period. The duration of curing is dependent on the strength required before handling or disposal. The solidified material can be formed into monolithic blocks or can be made into a granular material that would have the consistency of a soil-cement.

Chemical fixation/solidification is retained in combination with other technologies and process options for the development of remedial alternatives for off-site disposal.

9.2.6 Disposal

The only technology considered under this GRA is off-site disposal. Off-site disposal consists of transporting the excavated material for burial in a permitted off-site TSDF. Resource Conservation and Recovery Act (RCRA) non-hazardous waste may be disposed in a RCRA Subtitle D, or solid waste, landfill. RCRA hazardous waste must be disposed in a RCRA Subtitle C, or hazardous waste, landfill. It is anticipated that the portion of the excavated Site 10 soil that does not contain PCBs would be classified as RCRA non-hazardous while the portion that does would be classified as RCRA hazardous.

Off-site disposal is retained in combination with other process options for the development of remedial alternatives.

9.3 SELECTION OF SOIL REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS

The following technologies and process options are retained to develop soil remedial alternatives:

- No Action
- Institutional Controls
- Monitoring
- Surface Protection
- Surface Water Controls
- Excavation
- Dewatering
- Chemical Fixation/Solidification
- Off-Site Disposal

9.4 DEVELOPMENT OF ALTERNATIVES

Alternatives have been developed based on an assembly of the technologies selected under each of the GRAs. The assembly of alternatives follows the assembly of GRAs discussed in Section 8.0. Alternatives are developed to provide an appropriate range of options. Sufficient information is included

to adequately evaluate and compare alternatives and to determine the most appropriate alternative. Alternatives are developed around USEPA's expectations pertaining to remediation of CERCLA sites The following discusses the assembly of alternatives.

Alternative 1: No Action

The No Action alternative is used as the baseline to use for comparison with other alternatives.

Alternative 2: Institutional Controls and Monitoring

Institutional controls would consist of restricting access to soil with concentrations of Aroclor-1260 greater than 1,000 µg/kg and controlling future land use. Existing fencing at Site 10 would be expanded. Site controls would be developed and implemented to prevent residential development of Site 10. Signs would be posted to warn against unauthorized digging activities.

Monitoring would consist of annually collecting samples of sediment and surface water and analyzing these samples for PCBs. Two surface water and two sediment samples would be collected within the area of known contamination. Additionally, two surface water and two sediment samples would be collected immediately downgradient of the fenced area to detect potential migration of PCBs.

Every 5 years, the status of the site would be formally reviewed and evaluated to determine the continued effectiveness of this alternative.

Alternative 3: Surface Water Controls, Excavation, Surface Protection, Institutional Controls, and Monitoring

Within the drainage channel, surface water controls would be used to divert water from work areas. Marine-grade PVC sheet piling would be used to section off portions of the drainage channel, and pumps (e.g., bladder-type mud pumps) would be used to remove water from within the cordoned-off sections.

Excavation would be performed within the area designated for surface protection and would be limited to the top 9 inches of soil or sediment. This limited excavation would be conducted to allow the surface protection to be placed at grade with the existing ground surface. The area to be excavated would first be cleared and grubbed, and the pedestrian bridge would be removed. Next, approximately 45 yd^3 of vegetation, soil, and sediment would be removed and disposed at an approved off-site facility. Based on data collected during the RI/FS, it is assumed that the excavated material would be characterized as non-hazardous waste. It is also anticipated that excavated material would not need to be dewatered.

Surface protection would be installed at Site 10 to prevent direct contact with PCB-contaminated media and to prevent erosional transport of PCBs in the shallow sediment. As part of this component, approximately 85 linear feet of the drainage channel would be lined with a 9-inch -thick layer of concrete and/or rip rap and approximately 27 square yards (yd^2) of soil would be paved (consisting of a 6-inch stone base, a 2-inch binder course layer, and a 1-inch wearing course layer). Because direct contact with contaminated media would be prevented by installing surface protection, existing fencing present at Site 10 would not be needed and would be removed. Additionally, a new pedestrian bridge would be constructed across the drainage channel to replace the one removed to facilitate remedial activities.

Site controls would be developed and implemented to prevent residential development of Site 10. Signs would be posted to warn against unauthorized digging activities. Periodic inspections would be required to ensure that the integrity of the surface protection is not compromised and to determine whether maintenance to the surface protection is required.

Monitoring would consist of annually collecting samples of sediment and surface water and analyzing these samples for PCBs. Two surface water and two sediment samples would be collected immediately downgradient of the surface protection to detect potential migration of PCBs. Every 5 years, the status of the site would be formally reviewed and evaluated to determine the continued effectiveness of this alternative.

Alternative 4: Surface Water Controls, Dewatering, Excavation, Off-Site Treatment and Disposal

Within the drainage channel, surface water controls would be used to divert water from work areas. Steel sheet piling would be used to section off a portion of the drainage channel that encompasses the entire excavation area, and prior to commencing with excavation activities a subsurface well point mechanical dewatering system would be utilized to remove water down to 15 feet bls from within the area to be excavated. In addition, a temporary drainage channel (approx. 4 ft deep) running from just east of the excavation area to the west side is recommended to divert any overflow from the nearby channels that occurs during the excavation. And the soil/sediment that is removed to create the temporary drainage channel will be used to construct a temporary berm on the south side of the excavation near the Parade Field to control and divert any stormwater runoff from infiltrating the excavation area during implementation of the RA.

Following dewatering, approximately 450 yd^3 of soil with concentrations of PCBs greater than 1,000 µg/kg would be excavated. The area to be excavated would be cleared and grubbed and the pedestrian bridge would be removed. Excavation of the contaminated material would be accomplished with a Gradall-type excavator, backhoe, or similar type of equipment. The sidewalls of the excavation would be shored as needed to minimize the amount of soil required to be excavated to reach soils at depth. Pre-excavation

sampling would be conducted to verify the depth of excavation. After sampling activities have verified the removal of contaminated material, the excavated areas would be backfilled with imported clean soil. The excavated areas would also be graded to original grade and native vegetation would be planted. Additionally, a new pedestrian bridge would be constructed across the drainage channel.

Excavated soil would be transported and disposed at a permitted off-site TSDF. The type of TSDF and pre-treatment requirements prior to ultimate disposal by landfilling would be dictated by the anticipated characteristics of the excavated material.

As part of pre-excavation sampling, samples would be collected to further refine the extent of soil that contains PCBs at concentrations greater than 50,000 µg/kg. It is assumed that approximately 100 yd^3 of excavated material would contain PCB concentrations greater than 50,000 µg/kg and would require disposal at a TSCA-certified TSDF. It is also assumed that prior to ultimate disposal by landfilling, the TSDF would pre-treat that entire fraction of the excavated material by chemical fixation/solidification to meet disposal requirements. Lastly, it is assumed that the remaining 350 yd^3 would be classified as RCRA non-hazardous and would be disposed by landfilling at a permitted off-site RCRA Subtitle D TSDF.

10.0 ASSEMBLY AND DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

In this section, the remedial technologies retained from the technology screening process conducted in Section 9.0 are assembled into multiple remedial alternatives. The following sections contain descriptions of these alternatives and provide a detailed analysis of these alternatives in accordance with the CERCLA evaluation criteria.

10.1 INTRODUCTION

This section presents an evaluation of each remedial alternative with respect to the criteria of the NCP of 40 Code of Federal Regulations (CFR) Part 300, as revised in 1990. The criteria as required by the NCP and the relative importance of these criteria are described in the following subsections.

10.1.1 Evaluation Criteria

In accordance with the NCP (40 CFR 300.430), the following nine criteria are used for the evaluation of remedial alternatives:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs
- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, and Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost
- State Acceptance
- Community Acceptance

10.1.1.1 Overall Protection of Human Health and the Environment

Alternatives must be assessed for adequate protection of human health and the environment, in both the short and long term, from unacceptable risks posed by hazardous substances or contaminants present at the site. For this purpose, alternatives should eliminate, reduce, or control exposure to levels of contaminants exceeding remediation goals. Overall protection draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

10.1.1.2 Compliance with ARARs

Alternatives must be assessed to determine whether they attain ARARs under federal and State environmental or facility siting regulations. If one or more regulations that are applicable cannot be complied with, a waiver must be invoked by the appropriate regulatory body for the alternative to be considered acceptable. Grounds for invoking a waiver would depend on the following circumstances:

- The alternative is an interim measure and will become part of a total remedial action that will attain the ARAR.
- Compliance will result in greater risk to human health and the environment.
- Compliance is technically impracticable from an engineering perspective.
- The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limit through use of another method or approach.
- A state requirement has not been consistently applied, or the state has not demonstrated the intention to consistently apply the promulgated requirement in similar circumstances at other remedial actions within the state.
- For CERCLA-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of CERCLA monies to respond to other sites that may present a threat to human health and the environment.

10.1.1.3 Long-Term Effectiveness and Permanence

Alternatives must be assessed for the long-term effectiveness and permanence they offer, along with the degree of certainty that the alternative will prove successful. Factors that shall be considered as appropriate include the following:

- Magnitude of Residual Risk - Residual risk is posed by untreated waste or treatment residuals at the conclusion of remedial activities. The characteristics of residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

- Adequacy and Reliability of Controls - Controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste must be shown to be reliable. In particular, the following should be addressed: the uncertainties associated with land disposal for providing long-term protection from residuals; the potential need to replace technical components of an alternative such as a cap, slurry wall, or treatment system; and the potential exposure pathways and risks posed should the remedial action need replacement.

10.1.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The degree to which the alternative employs recycling or treatment that reduces the toxicity, mobility, or volume shall be assessed, including how treatment is used to address the principal threats posed by the site. Factors that shall be considered, as appropriate, include the following:

- The treatment or recycling processes the alternative employs and the materials that they will treat.

- The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled.

- The degree of expected reduction in toxicity, mobility, or volume of waste due to treatment or recycling and the specification of which reductions are occurring.

- The degree to which the treatment is irreversible.

- The type and quantity of residuals that will remain following treatment considering the persistence, toxicity, mobility, and propensity to bioaccumulate of hazardous substances and their constituents.

- The degree to which treatment reduces the inherent hazards posed by principal threats at the site.

10.1.1.5 Short-Term Effectiveness

The short-term impacts of the alternative shall be assessed considering the following:

- Short-term risks that might be posed to the community during implementation.

- Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures.

- Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation.

- Time until protection is achieved.

10.1.1.6 Implementability

The ease or difficulty of implementing the alternatives shall be assessed by considering the following types of factors, as appropriate:

- Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy.

- Administrative feasibility, including activities needed to coordinate with other offices and agencies, and the ability and time required to obtain any necessary approvals and permits from other agencies.

- Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists and provisions to ensure necessary additional resources; the availability of services and materials; and the availability of prospective technologies.

10.1.1.7 Cost

Capital costs shall include both direct and indirect costs. Annual O&M costs shall be provided. A net present value of the capital and O&M costs shall also be provided. Typically, the cost estimate accuracy range is plus 50 percent to minus 30 percent.

10.1.1.8 State Acceptance

The State's concerns that must be assessed include the following:

- The State's position and key concerns related to the preferred alternative and other alternatives.
- State comments on ARARs or the proposed use of waivers.

The State (MDEQ)) has reviewed and commented on the FS. The State's concerns were evaluated and addressed via a Response to Comments (RTC) based on the State's review of the Draft FS (Appendix E).

These concerns will be incorporated and discussed, to the extent possible, in the Proposed Plan to be issued for public comment.

10.1.1.9 Community Acceptance

This assessment consists of responses of the community to the Proposed Plan. This assessment includes determining which components of the alternative interested persons in the community support, have reservations about, or oppose. This assessment can be done after comments on the Proposed Plan are received from the public.

10.1.2 Relative Importance of Criteria

Among the nine criteria, the threshold criteria are considered to be the following:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs (excluding those that may be waived)

The threshold criteria must be satisfied for an alternative to be eligible for selection.

Among the remaining criteria, the following five criteria are considered to be the primary balancing criteria:

- Long-Term Effectiveness and Permanence
- Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment
- Short-Term Effectiveness
- Implementability
- Cost

The balancing criteria are used to weigh the relative merits of alternatives.

The remaining two of the nine criteria, State Acceptance and Community Acceptance, are considered to be modifying criteria that must be considered during remedy selection. State Acceptance has been addressed via an RTC based on the Draft FS (Section 10.1.1.8 and Appendix E). The last criteria, Community Acceptance, cannot be completely evaluated until the Proposed Plan has been discussed in a public meeting. Therefore, this Section addresses only seven of the nine criteria for each alternative.

10.1.3 Selection of Remedy

The selection of a remedy is a two-step process. The first step consists of identification of a preferred alternative and presentation of the alternative in a Proposed Plan to the community for review and comment. The preferred alternative must meet the following criteria:

- Protection of human health and the environment.
- Compliance with ARARs unless a waiver is justified.
- Cost effectiveness in protecting human health and the environment and in complying with ARARs.
- Utilization of permanent solutions and alternate treatment technologies or resource recovery technologies to the maximum extent practicable.

The second step consists of the review of the public comments and the determination, in consultation with MDEQ, as to whether or not the preferred alternative continues to be the most appropriate remedial action for the site.

10.2 ASSEMBLY OF REMEDIAL ALTERNATIVES

Based on the technology screening presented in Section 9.0, the following four remedial alternatives were developed.

- Alternative 1: No Action
- Alternative 2: Institutional Controls and Monitoring
- Alternative 3: Surface Water Controls, Excavation, Surface Protection, Institutional Controls, and Monitoring
- Alternative 4: Surface Water Controls, Dewatering, Excavation, Off-Site Treatment and Disposal

Alternative 1 was developed and analyzed to serve as a baseline for other alternatives, as required by CERCLA and the NCP. Alternative 2 was formulated and analyzed to evaluate the adequacy of minimal action. Alternatives 3 and 4 were formulated and analyzed to evaluate active remediation. Descriptions and detailed analyses of these alternatives are presented in the following sections.

10.3 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

10.3.1 Alternative 1: No Action

10.3.1.1 Description

The no action alternative maintains the site as is. This alternative does not address site contamination and is only retained to provide a baseline for comparison to other alternatives. There would be no reduction in toxicity, mobility, or volume of PCBs other than what might result from natural dispersion, dilution, and other attenuating factors. Existing monitoring programs and institutional controls would be discontinued, and the site would be available for unrestricted use.

10.3.1.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative 1 would not provide protection of human health and the environment. Under the current land-use scenario (industrial/military), the potential for human contact with PCB concentrations in soil would remain. The primary exposure route would be through construction activities because controls would not be in place to prevent unauthorized digging activities from occurring. If unauthorized digging occurred, construction workers could be exposed to contaminated material primarily through dermal contact and to a lesser extent through ingestion of soil. Additionally, this alternative would not be protective of potential future residents because soil could erode over time and humans could be exposed to elevated PCB concentrations found in deeper soil. Moreover, these exposed soils could migrate through the drainage channel system via erosion.

PCB concentrations in soil are not expected to migrate into the groundwater of Site 10 based on the low leaching potential of PCBs. As a result, this alternative would be protective of humans who would consume or come into contact with Site 10 groundwater in the future.

Compliance with ARARs and TBCs

Alternative 1 would not comply with chemical-specific ARARs or TBCs because no action would be taken to reduce contaminant concentrations. There are no location-specific ARARs identified for Site 10. Action-specific ARARs or TBCs are not applicable because no action would be taken.

Long-Term Effectiveness and Permanence

Alternative 1 would have no long-term effectiveness and permanence because soil with Aroclor-1260 concentrations greater than the Mississippi unrestricted TRG would remain on site. Since there would be

no institutional controls to control land use, the potential would exist for human exposure to PCB concentrations (primarily construction workers). Because there would be no monitoring, potential PCB migration would not be detected. Although PCB concentrations might eventually decrease to acceptable levels through natural attenuation in the very long term, monitoring would not be in place to verify this condition.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 would not reduce toxicity, mobility, or volume of PCBs through treatment because no treatment would occur. Some reduction of PCB toxicity and volume might occur through natural dispersion, dilution, or other attenuation process in the very long term, but no monitoring would be performed to verify this condition.

Short-Term Effectiveness

Because no action would occur, implementation of Alternative 1 would not pose any risks to on-site workers or result in short-term adverse impact to the local community and the environment. Alternative 1 would never achieve the RAOs and, although the Aroclor-1260 PRG might eventually be achieved through natural attenuation in the very long term, monitoring would not be in place to verify this condition.

Implementability

Because no action would occur, Alternative 1 would be readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable. Implementability of administrative measures is not applicable because no such measures would be taken.

Cost

There would be no costs associated with the no action alternative.

10.3.2 Alternative 2: Institutional Controls and Monitoring

10.3.2.1 Description

Alternative 2 consists of institutional controls and monitoring.

Component 1: Institutional Controls

Institutional controls would consist of restricting access to soil with concentrations of Arocor-1260 greater than 1,000 µg/kg and controlling future land use. Fencing at Site 10 would be expanded as indicated on

Figure 10-1. LUCs would be developed and implemented to prevent residential development of Site 10. Signs would be posted to warn against unauthorized digging activities.

Component 2: Monitoring

Monitoring would consist of regularly collecting samples of sediment and surface water and analyzing these samples for PCBs. Samples would be collected within the drainage channel system as shown on Figure 10-1. Two surface water and two sediment samples would be collected within the area of known contamination. Additionally, two surface water and two sediment samples would be collected immediately downgradient of the fenced area to detect potential migration of PCBs.

For costing purposes, monitoring would consist of annual sampling for a period of 30 years. Every 5 years, the status of the site would be formally reviewed and evaluated to determine the continued effectiveness of this alternative.

10.3.2.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative 2 would provide some protection of human health. Under the current land-use scenario, the potential for human contact with PCB concentrations in soil would be diminished because fencing would restrict human access to impacted areas. Other controls such as digging restrictions and prohibiting future residential development of the area would be protective of human health by preventing exposure to contaminated soil. However, activities under Alternative 2 would not prevent erosional transport of PCB-contaminated shallow soil and sediment from occurring. As a result, minor impacts to surface water (such as observed in the RI/FS surface water data) could occur.

PCBs in soil are not expected to migrate into the groundwater of Site 10 based on the low leaching potential of PCBs. As a result, this alternative is assumed to be protective of humans who would consume or come into contact with Site 10 groundwater in the future.

Monitoring not would be protective of the environment. Attenuation of PCB concentrations would likely occur through erosional processes rather than biodegradation based on the fate and transport properties of PCBs. If the results of monitoring conducted as part of this alternative indicate that contaminants are migrating and that migration could have a negative environmental impact, contingency remedies (e.g., implementation of a sediment recovery trap) would be implemented to prevent such an occurrence.

Compliance with ARARs and TBCs

Alternative 2 would comply with action-specific ARARs and TBCs. This alternative would not comply with chemical-specific ARARs due to the pervasiveness of PCBs in the environment. There are no location-specific ARARs identified for Site 10.

Long-Term Effectiveness and Permanence

Alternative 2 would provide long-term effectiveness and permanence. Although no removal or treatment of contaminated soil would occur, human exposure to contaminants would be controlled and monitored. Site access restrictions and controls would effectively prevent human exposure to contaminated soils until PRGs have been achieved. Long-term monitoring would be an effective means to assess the occurrence of natural attenuation and to detect the potential migration of contamination.

Reduction of Toxicity, Mobility, or Volume through Treatment

Although no active treatment is included in Alternative 2, PCB volume and toxicity might eventually be reduced in the very long term through natural degradation processes. Alternative 2 would also not provide an immediate reduction in PCB mobility because no containment, removal, or treatment of soil is proposed. Human health toxicity posed by exposure to Arocor-1260 in soil would remain until concentrations have been sufficiently reduced by natural processes. No treatment residuals would be produced if Alternative 2 was implemented.

Short-Term Effectiveness

Alternative 2 would have minimal short-term effectiveness concerns. Exposure of workers to contamination during monitoring activities would be minimized by compliance with site-specific health and safety procedures, including the wearing of appropriate PPE. Alternative 2 would also not adversely impact the surrounding community or the environment. The RAOs would be achieved immediately upon implementation of institutional controls and monitoring. It is expected that the RAOs could be achieved within the construction duration of 1 day.

Implementability

Alternative 2 would be readily implementable. Installation and maintenance of site access restrictions, development and implementation of site controls, sampling and analysis of surface water and sediment, and performance of 5-year site reviews could readily be accomplished. The resources, equipment, and materials required to implement these activities are readily available.

The administrative aspects of Alternative 2 would be relatively simple to implement. No construction permits would be required for this alternative. Deed restrictions would ensure continued implementation of LUCs in case of change of ownership of any of the contaminated areas. However, continued implementation of LUCs under private ownership could be more difficult.

Cost

The estimated costs for Alternative 2 are:

- Capital cost: $22,000
- 30-Year net present worth (NPW) of O&M costs: $78,000
- 30-Year NPW: $100,000

These estimates have been rounded to the nearest $1,000 to reflect their preliminary nature. A detailed breakdown of the cost estimate for this alternative is provided in Appendix G.

10.3.3 Alternative 3: Surface Water Controls, Excavation, Surface Protection, Institutional Controls, and Monitoring

10.3.3.1 Description

Alternative 3 consists of the following components: (1) surface water controls, (2) excavation, (3) surface protection, (4) institutional controls, and (5) monitoring.

Component 1: Surface Water Controls

Within the drainage channel, surface water controls would be used to divert water from work areas. Marine-grade PVC sheet piling would be used to section off portions of the drainage channel, and pumps (e.g., bladder-type mud pumps) would be used to remove water from within the cordoned-off sections.

Component 2: Excavation

Excavation would be performed within the area designated for surface protection as shown on Figure 10-2 and would be limited to the top 9 inches of soil or sediment. This limited excavation would be conducted to allow the surface protection to be placed at grade with the existing ground surface. The area to be excavated would be cleared and grubbed and the pedestrian bridge would be removed. Next, approximately 45 yd^3 of vegetation, soil, and sediment would be removed and disposed at an approved off-site facility. Based on data collected during the RI/FS, it is assumed that the excavated material would

be characterized as non-hazardous waste. It is anticipated that excavated material would not need to be dewatered.

Component 3: Surface Protection

Surface protection would be installed at Site 10 to prevent direct contact with PCB-contaminated media and to prevent erosional transport of PCBs in shallow sediment. As part of this component, approximately 85 linear feet of the drainage channel would be lined with 9 inches of concrete and/or rip rap and approximately 27 yd^2 of soil would be paved (consisting of a 6-inch stone base, a 2-inch binder course layer, and a 1-inch wearing course layer) as illustrated in Figure 10-2. Because direct contact with contaminated media would be prevented by installing surface protection, existing fencing present at Site 10 would not be needed and would be removed. Additionally, a new pedestrian bridge would be constructed across the drainage channel.

Component 4: Institutional Controls

LUCs would be developed and implemented to prevent residential development of Site 10. Signs would be posted to warn against unauthorized digging activities. Periodic inspections would be required to ensure that the integrity of the surface protection is not compromised and to determine whether maintenance of the surface protection is required.

Component 5: Monitoring

Monitoring would consist of regularly collecting samples of sediment and surface water and analyzing these samples for PCBs. Two surface water and two sediment samples would be collected immediately downgradient of the surface protection to detect potential migration of PCBs.

For costing purposes, monitoring would consist of annual sampling for a period of 30 years. Every 5 years, the status of the site would be formally reviewed and evaluated to determine the continued effectiveness of this alternative.

10.3.3.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative 3 would be protective of human health and the environment.

Surface protection would be protective of human health and the environment because it would prevent direct contact with contaminated media. Moreover, this alternative would be protective because potential

erosional transport of PCBs through the drainage channel system would be prevented by the surface protection, and potential impacts to surface water would be mitigated. PCBs in soil are not expected to migrate into the groundwater of Site 10 because of the low leaching potential of PCBs. As a result, this alternative is expected to be protective of humans who would consume or come into contact with Site 10 groundwater in the future. Site controls such as digging restrictions and prohibiting future residential development of the area would be protective of human health by preventing exposure to contaminated soil.

Monitoring would also be protective of human health and the environment. Attenuation of PCB concentrations in shallow soil would likely occur through erosional processes rather than biodegradation, based on the fate and transport properties of PCBs. If the results of the monitoring conducted as part of this alternative indicate that contaminants are migrating and that migration could have a negative environmental impact, contingency remedies (e.g., implementation of a sediment recovery trap) would be implemented to prevent such an occurrence.

Compliance with ARARs and TBCs

Alternative 3 would comply with action-specific ARARs and TBCs. This alternative would not comply with chemical-specific ARARs due to the pervasiveness of PCBs in the environment. There are no location-specific ARARs identified for Site 10.

Long-Term Effectiveness and Permanence

Alternative 3 would provide long-term effectiveness and permanence. Although treatment would not be used to reduce PCB concentrations, contaminated soil would be effectively contained to prevent exposure through direct contact and to reduce the potential for migration. Inspection, maintenance, and repair of the surface protection would ensure its continued structural integrity and effectiveness. Monitoring would be an effective means to verify that PCB concentrations are not migrating through the drainage channel system.

Reduction of Toxicity, Mobility, or Volume through Treatment

Although no active treatment is included in Alternative 3, PCB volume and toxicity might eventually be reduced over the very long term through natural degradation processes. In the short term, no reduction in volume would be realized. Alternative 3 would provide an immediate reduction in PCB mobility because the surface protection would prevent erosional transport of PCB concentrations through the drainage channel system. Human health toxicity posed by exposure to Arocor-1260 in soil would be reduced because surface protection would be in place to prevent human exposure. No treatment residuals would

be produced if Alternative 3 was implemented. However, there would be construction debris from site clearing that would have to be disposed.

Short-Term Effectiveness

Alternative 3 would be effective in the short term. Exposure of workers to contamination during remediation and monitoring activities would be minimized by implementing engineering controls, complying with the requirements of OSHA, and adhering to site-specific health and safety procedures, including the wearing of appropriate PPE. Alternative 3 would not result in a significant destruction of ecological habitat. Removal of the existing fencing at Site 10 would also aesthetically improve the setting of the area. The transportation of contaminated soil from Site 10 to the off-base TSDF would have minimal impact on the surrounding community. It would take approximately four truckloads (16 yd^3 each) to remove all contaminated material from the base.

The RAOs are expected to be achieved immediately upon completion of remedial activities and implementation of institutional controls and monitoring. Although the RAOs would be achieved, PCB soil contamination would remain at the site. It is expected that the RAOs could be achieved within a construction duration of three days.

Implementability

Alternative 3 would be readily implementable.

Use of surface water controls, implementation of excavation methods and surface protection, installation and maintenance of site controls, sampling and analysis of surface water and sediment, and performance of 5-year site reviews could readily be accomplished. The resources, equipment, and materials required to implement these activities are readily available.

The administrative aspects of Alternative 3 would be relatively simple to implement. Deed restrictions would ensure continued implementation of LUCs in case NCBC Gulfport changes from military to civilian ownership.

Cost

The estimated costs for Alternative 3 are:

- Capital cost: $42,000
- 30-Year NPW of O&M cost: $69,000
- 30-Year NPW: $111,000

A detailed breakdown of the cost estimate for this alternative is provided in Appendix G.

10.3.4 Alternative 4: Surface Water Controls, Excavation, Dewatering, Off-Site Treatment and Disposal

Alternative 4 consists the following components: (1) surface water controls, (2) dewatering, (3) excavation, and (4) off-site treatment and disposal.

Component 1: Surface Water Controls

Within the drainage channel, surface water controls would be used to divert water from work areas. In addition, a temporary drainage channel (approx. 4 ft deep) running from just east of the excavation area to the west side is recommended to divert any overflow from the nearby channels that occurs during the excavation. And the soil/sediment that is removed to create the temporary drainage channel will be used to construct a temporary berm on the south side of the excavation near the Parade Field to control and divert any stormwater runoff from infiltrating the excavation area

Component 2: Dewatering

In order to allow for effective excavation of the soil/sediment to the required depths, steel sheet piling would be used to section off the portion of the drainage channel that encompasses the entire excavation area, and prior to commencing with excavation activities, a subsurface well point mechanical dewatering system would be utilized to remove water down to 15 feet bls from within the area to be excavated.

Component 3: Excavation

Soil with concentrations of PCBs greater than 1,000 µg/kg would be excavated from the area shown on Figure 10-3. The area to be excavated would be cleared and grubbed, and the pedestrian bridge would be removed. Approximately 450 yd^3 of soil would be excavated. Excavation of the contaminated material would be accomplished with a Gradall-type excavator, backhoe, or similar type of equipment. The sidewalls of the excavation would be shored to minimize the amount of soil required to be excavated to reach soils at depth. Pre-excavation sampling would be conducted to refine the depth of excavation. After sampling activities have verified the removal of contaminated material, the excavated areas would be backfilled with imported clean soil. The excavated areas would also be graded to original grade and

native vegetation would be planted. Additionally, a new pedestrian bridge would be constructed across the drainage channel.

Component 4: Off-Site Treatment and Disposal

Excavated soil would be transported and disposed at a permitted off-site TSDF. The type of TSDF and pre-treatment requirements prior to ultimate disposal by landfilling would be dictated by the anticipated characteristics of the excavated material.

As part of pre-excavation sampling, samples would be collected to further refine the extent of soil that contains PCBs at concentrations greater than 50,000 µg/kg. For costing purposes, it is assumed that approximately 100 yd^3 of excavated material would contain PCB concentrations greater than 50,000 µg/kg and would require disposal at a TSCA-certified TSDF. It is assumed that prior to ultimate disposal by landfilling, the TSDF would pre-treat that entire fraction of the excavated material by chemical fixation/solidification to meet disposal requirements. It is also assumed that the remaining 350 yd^3 would be classified as RCRA non-hazardous waste and would be disposed by landfilling at a permitted off-site RCRA Subtitle D TSDF. This component would also include the manifesting of the waste materials to be transported.

10.3.4.2 Detailed Analysis

Overall Protection of Human Health and the Environment

Alternative 4 would be protective of human health and the environment.

Removal of contaminated soil from its present location and off-base treatment and disposal of this soil would eliminate risk from exposure of human receptors to PCBs. These remedial activities would also protect human health and the environment by removing the potential for future migration of PCBs. Some short-term risks could be incurred by workers from exposure to contamination during the implementation of this alternative. However, the potential for this exposure would be minimized by the wearing of appropriate PPE and compliance with site-specific health and safety procedures.

Compliance with ARARs and TBCs

Alternative 4 would comply with chemical- and action-specific ARARs and TBCs. There are no location-specific ARARs identified for Site 10.

Long-Term Effectiveness and Permanence

Alternative 4 would provide long-term effectiveness and permanence. Excavation of soil with off-site treatment and disposal (followed by backfilling with clean soil) are technologies that would offer effective and permanent solutions for the removal of contaminants to meet PRGs on site. Treatment/disposal of excavated material would effectively minimize the adverse impact from contaminated soil on human health and the environment.

Reduction of Toxicity, Mobility, or Volume through Treatment

Under Alternative 4, contaminated soil containing approximately 33 pounds of PCBs would be permanently and irreversibly removed from the site. Human health toxicity posed to base personnel by exposure to Arocor-1260 in soil would be reduced because contaminated soil would be removed from the site. Alternative 4 would also both achieve a permanent and irreversible reduction in the mobility of the COCs through off-site treatment with chemical fixation/solidification to the extent necessary to meet disposal requirements. Although contaminated soil is removed from the site, its volume would not be reduced under this alternative.

Short-term Effectiveness

Alternative 4 would have some short-term effectiveness concerns. Exposure of workers to contamination during remediation activities would be minimized by implementing engineering controls (e.g., dust suppression) and complying with site-specific health and safety procedures, including the wearing of appropriate PPE. Alternative 4 would not result in a significant destruction of ecological habitat. The transportation of contaminated soil from Site 10 to the off-base TSDF could have some impact on the surrounding community. It would take approximately 28 truckloads (16 yd^3) to remove all contaminated material from the base. This impact would be minimized through the implementation of truck decontamination, spill prevention, and traffic control measures.

The RAOs and PRGs would be achieved immediately upon completion of remedial activities. It is expected that the RAOs could be achieved within a construction duration of 13 days.

Implementability

Alternative 4 would be readily implementable.

Implementation of surface water controls, dewatering, excavation of contaminated soil, and off-base transportation, treatment, and disposal of excavated material could readily be accomplished. The resources, equipment, and materials required to implement these activities are readily available.

The excavation component of this alternative could be performed with normal construction equipment, resources, and materials that would be readily available for this purpose. Permitted TSDFs with hazardous and non-hazardous treatment and landfilling capabilities are available for implementation of off-site treatment and disposal.

Administratively, implementation and enforcement of excavation notification and excavated soil testing requirements would be relatively simple to implement. A construction permit would be required for excavation, but this would be relatively easy to obtain. Off-site transportation of the excavated soil might require the preparation and implementation of a traffic control plan and would require the completion of waste manifests. Off-site disposal of the excavated soil would require prior securing of waste acceptance from the TSDF. These administrative procedures, while constituting a significant effort, could readily be accomplished.

Cost

The estimated costs for Alternative 4 are:

- Capital cost: $421,000
- NPW of O&M cost: $0
- NPW: $421,000

A detailed breakdown of the cost estimate for this alternative is provided in Appendix G.

11.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section compares the analyses that were presented for each of the remedial alternatives in Section 10.0. The criteria for comparison are identical to those used for the detailed analysis of individual alternatives.

11.1 COMPARISON OF REMEDIAL ALTERNATIVES BY CRITERIA

The following remedial alternatives for soil are being compared in this section:

- Alternative 1: No Action
- Alternative 2: Institutional Controls and Monitoring
- Alternative 3: Surface Water Controls, Excavation, Surface Protection, Institutional Controls, and Monitoring
- Alternative 4: Surface Water Controls, Dewatering, Excavation, Off-Site Treatment and Disposal

11.1.1 Overall Protection of Human Health and the Environment

Alternative 1 would not be protective of human health and the environment because Arocor-1260 would remain at concentrations in soil in excess of its PRG. As a result, exposure to these concentrations could result. Also, under this alternative, no monitoring would occur; therefore, no warning would be provided if Arocor-1260 concentrations were to migrate through the drainage channel system.

Although Alternative 2 would allow Arocor-1260 concentrations to remain in soil and to possibly continue to migrate from contaminated areas, it would provide some protection by restricting access to contaminated media through fencing and site restrictions and would provide warning of potential contaminant migration through monitoring.

Alternative 3 would be more protective than Alternative 2 because it would essentially eliminate the potential for exposure to PCBs. Surface protection in conjunction with site controls would eliminate direct contact with contaminated media. Moreover, the surface protection would prevent the potential migration of contaminants through the drainage channel system via erosion.

Alternative 4 would provide the highest level of protection because contaminated soil would be removed from its present location and would be transported to an approved TSDF.

11.1.2 Compliance with ARARs and TBCs

Alternative 1 would not comply with chemical-specific ARARs. Action-specific ARARs or TBCs would not apply.

Alternatives 2 and 3 would not comply with chemical-specific ARARs and TBCs due to the pervasiveness of PCBs through the environment. Alternatives 2 and 3 would comply with action-specific ARARs and TBCs.

Alternative 4 would comply with chemical- and action-specific ARARs and TBCs.

There are no location-specific ARARs identified for Site 10.

11.1.3 Long-Term Effectiveness and Permanence

Alternative 1 would have very limited long-term effectiveness and permanence because no contaminant removal or reduction would occur. Because there would be no site controls to restrict access to Site 10, the potential would also exist for direct exposure to PCB-contaminated media. Because there would be no monitoring, potential PCBs migration would remain undetected.

Alternative 2 would provide some long-term effectiveness and permanence because fencing and site controls would reduce exposure to contaminated soil, and monitoring would provide indication of PCBs migration.

Alternative 3 would be more effective and permanent than Alternative 2 in the long term. Surface protection would be more effective and permanent than fencing in preventing direct contact with contaminants and preventing the erosional transport of PCBs through the drainage channel system. Inspection, maintenance, and repair of the surface protection would need to be conducted to ensure its continued structural integrity and effectiveness.

Alternative 4 would be the most long-term effective and permanent remedy. Under this alternative, contaminated soil would be removed from its present location and treated, as required, for ultimate disposal at a TSDF.

11.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 1 and 2 would not achieve any reduction of toxicity, mobility, or volume of PCB-contaminated media through treatment. Both alternatives might eventually achieve reduction of contaminant toxicity

and volume through natural attenuation; however, under Alternative 1, this reduction would neither be verified or quantified. There would be no treatment residuals associated with Alternative 2.

Alternative 3 would not achieve any reduction of toxicity or volume of PCB-contaminated media through treatment. However, Alternative 3 would significantly reduce PCB mobility because Arocor-1260 concentrations would be contained under the surface protection. There would be construction debris associated with this alternative.

Similarly, Alternative 4 would not achieve any reduction of toxicity or volume of PCB-contaminated media through treatment. However, Alternative 4 would reduce PCB mobility through off-site disposal. A wastewater residual might be generated by the sediment dewatering step, but it is anticipated that this wastewater could be discharged to surface water without treatment. There would be construction debris associated with this alternative.

11.1.5 Short-Term Effectiveness

Implementation of Alternative 1 would not result in risks to site workers or adversely impact the surrounding community or environment because no remedial activities would be performed. Alternative 1 would never achieve the RAOs, and although the Arocor-1260 PRG might eventually be attained through natural attenuation processes in the very long term, this occurrence would not be verified.

Implementation of Alternative 2 would result in a slight possibility of exposing site workers to PCB contamination during long-term monitoring activities. However, the risk of exposure would be effectively controlled through compliance with proper site-specific health and safety procedures. Implementation of Alternative 2 would not adversely impact the surrounding community or environment. Alternative 2 would be expected to achieve the RAOs immediately upon implementation of institutional controls and monitoring.

Implementation of Alternatives 3 and 4 would result in the possibility of exposing construction workers to PCB contamination during remedial activities. However, the risk of exposure would be effectively controlled by the implementation of engineering controls (e.g., dust suppression) and compliance with applicable OSHA regulations and proper site-specific health and safety procedures. Implementation of Alternative 4 would potentially impact the surrounding community because approximately 28 truckloads of PCB-contaminated material would be transported over public roads. However, the potential for adverse impact would be effectively addressed through implementation of such appropriate measures as decontamination of transport vehicles, traffic control, and spill prevention and emergency response. Alternatives 3 and 4 would be expected to achieve the RAOs immediately upon removal of the contaminated soil. Alternative 4 would also achieve PRGs upon implementation.

It is anticipated that Alternatives 2, 3, and 4 can be implemented in 1 day, 3 days, and 13 days, respectively.

11.1.6 Implementability

Alternative 1 would be extremely simple to implement because no action would occur.

The technical implementability of Alternative 2 would also be very simple because it would only require implementation of site controls and monitoring.

The technical implementability of Alternative 3 would be somewhat more difficult than that of Alternative 2. In addition to site controls and long-term monitoring, this alternative would require the use of surface water controls, excavation, and surface protection. However, these activities would be technically implementable. Resources, equipment, and materials are readily available to perform the tasks associated with Alternative 3. Alternative 4 would be somewhat harder to implement, although resources, equipment, and materials are readily available to perform the excavation, dewatering, and transportation activities.

Administratively, Alternatives 2 and 3 would require the development and implementation of LUCs and the performance of long-term monitoring and 5-year site reviews. Under Alternatives 3 and 4, off-site transportation of the excavated soil may require the preparation and implementation of a traffic control plan and would require the completion of waste manifests. Off-site treatment and disposal of the excavated soil would require prior securing of waste acceptance from the TSDF. Alternatives 3 and 4 would require a base permit to conduct remedial activities, manifesting of the material to be transported off base, and formal acceptance of this material by the off-base disposal facility. These administrative requirements could readily be met. Alternative 4 would not require site controls, long-term monitoring, or 5-year reviews because all soil with concentrations greater than the Arocor-1260 PRG would be removed from Site 10.

11.1.7 Cost

The capital and O&M costs and NPW of the alternatives are summarized as follows:

Alternative	Capital ($)	NPW of O&M ($)		NPW ($)	
1	0	0		0	
2	22,000	78,000	(30 Year)	100,000	(30 Year)
3	42,000	69,000	(30 Year)	111,000	(30 Year)
4	421,000	0	(1 Year)	421,000	(1 Year)

Detailed cost estimates are provided in Appendix G.

11.2 SUMMARY OF COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Table 11-1 summarizes the comparative analysis of the four remedial alternatives.

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TABLE 2-1

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY SAMPLING AND ANALYSIS SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

SAMPLE MATRIX	CHEMICAL ANALYSES							GEOTECHNICAL ANALYSIS	
	Pesticides/ PCBs	TCL VOCs	EDB	TCL SVOCs	Herbicides	TAL Metals	Cyanide	Grain Size	Atterburg Limits
Soil									
Phase I									
Shallow	18	14	14	--	--	--	--	--	--
Intermediate	18	14	14	--	--	--	--	--	--
Deep	18	14	14	--	--	--	--	--	--
Phase II									
Shallow	3	2	2	--	--	--	--	--	--
Intermediate	--	--	--	--	--	--	--	--	--
Deep	--	--	--	--	--	--	--	--	--
Phase III									
Shallow	5	5	--	5	5	5	5	--	--
Intermediate	1	1	--	1	1	1	1	--	--
Deep	--	--	--	--	--	--	--	--	--
Sediment									
Phase I	3	3	3	--	--	--	--	--	--
Phase II	3	3	3	--	--	--	--	--	--
Phase III	5	5	--	5	5	5	5	2	2
Surface Water									
Phase I	3	3	3	--	--	--	--	--	--
Phase II	--	--	--	--	--	--	--	--	--
Phase III	2	2	--	2	2	2	2	--	--
Groundwater									
Phase I	--	--	--	--	--	--	--	--	--
Phase II	5	5	5	--	--	--	--	--	--
Phase III	5	5	--	5	5	5	5	--	--

NOTES:
Phase I samples were collected in January 2002.
Phase II samples were collected in February 2002.
Phase III samples were collected in December 2003.

Shallow Interval = 1 to 2 feet bgs in ditch, 4 to 5 feet bgs outside of ditch.
Intermediate Interval = 8 to 13 feet bgs in ditch, 10 feet bgs outside of ditch.
Deep Interval = 18 to 20 feet bgs in ditch, 19 to 23 feet bgs outside of ditch.

bgs = Below ground surface.

TABLE 2-2

PHASE I SOIL SAMPLING SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Soil Boring	Location	Shallow Interval			Intermediate Interval			Deep Interval		
		Sample Depth Feet bgs	FID Results	Laboratory Analysis	Sample Depth bgs	FID Results	Laboratory Analysis	Sample Depth bgs	FID Results	Laboratory Analysis
NCBC10S01	Bank	5	0	P	10	0.1	P	23	0	P
NCBC10S02	Bank	5	2.1	P	10	0	P	23	0	P
NCBC10S03	Ditch	1	--	P/V	13	2.4	P/V	18	0	P/V
NCBC10S04	Ditch	1	--	P/V	11	4.3	P/V	20	5.4	P/V
NCBC10S05	Ditch	2	1156	P/V	11	1.4	P/V	20	0	P/V
NCBC10S06	Ditch	2	789	P/V	8	202	P/V	20	8.4	P/V
NCBC10S07	Bank	5	0	P/V	10	0.7	P/V	23	0	P/V
NCBC10S08	Bank	5	0.2	P/V	10	--	P/V	23	0.2	P/V
NCBC10S09	Bank	5	0.8	P/V	10	0.9	P/V	23	1.2	P/V
NCBC10S10	Bank	5	--	P/V	10	--	P/V	23	--	P/V
NCBC10S11	Bank	5	--	P/V	10	--	P/V	23	--	P/V
NCBC10S12	Bank	5	2.1	P/V	10	1.5	P/V	23	--	P/V
NCBC10S13	Bank	5	0	P/V	10	0.3	P/V	23	0.9	P/V
NCBC10S14	Bank	5	0	P/V	10	0.8	P/V	20	0.05	P/V
NCBC10S15	Bank	5	0	P/V	10	0	P/V	19	0	P/V
NCBC10S16	Bank	5	0	P/V	10	0	P/V	20	0	P/V
NCBC10S17	Ditch	2	986	P	11	4.1	P	20	4.2	P
NCBC10S18	Bank	5	1.1	P	10	4.4	P	23	0.5	P

NOTES:
Shallow Interval = 1 to 2 feet bgs in ditch, 4 to 5 feet bgs outside of ditch.
Intermediate Interval = 8 to 13 feet bgs in ditch, 10 feet bgs outside of ditch.
Deep Interval = 18 to 20 feet bgs in ditch, 19 to 23 feet bgs outside of ditch.

bgs = Below ground surface.
FID = Flame ionization detector. Results in ppm.
P = Pesticide/PCB analysis only.
P/V = Pesticide/PCB and VOC analysis.

TABLE 2-3

MONITORING WELL INSTALLATION DETAILS
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Well ID	Installation Date	Installation Method	Well Diameter	Installed Depth	Screen Length	Screened Interval	TOC Elevation	Ground Elevation
NCBC10G01	2/13/2002	HSA	2 inch	22 feet	15 feet	7-15 feet	28.29	28.27
NCBC10G02	2/13/2002	HSA	2 inch	22 feet	15 feet	7-15 feet	28.31	28.05
NCBC10G03	2/11/2002	HSA	2 inch	22 feet	15 feet	7-15 feet	28.28	28.09
NCBC10G04	2/11/2002	HSA	2 inch	22 feet	15 feet	7-15 feet	28.34	28.12
NCBC10G05	2/13/2002	HSA	2 inch	22 feet	15 feet	7-15 feet	28.57	28.33

NOTES:
HSA = Hollow-stem auger.
TOC = Top of casing.

TABLE 3-1

GROUNDWATER ELEVATION DATA
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Well ID	Installation Date	Installed Depth	Top of Casing Elevation	February 2002			December 16 2003		
				Measured Well Depth	Depth to Water (BTOC)	Groundwater Elevation (ft above msl)	Measured Well Depth	Depth to Water (BTOC)	Groundwater Elevation (ft above msl)
NCBC10G01	2/13/2002	19.5	28.29	19.05	2.15	26.14	19.02	1.91	26.38
NCBC10G02	2/13/2002	23.5	27.85	22.97	1.85	26.00	22.75	1.68	26.17
NCBC10G03	2/11/2002	23.5	27.81	23.15	1.65	26.16	22.80	1.49	26.32
NCBC10G04	2/11/2002	23.5	27.54	22.94	1.46	26.08	22.76	1.26	26.28
NCBC10G05	2/13/2002	23.5	28.29	23.20	2.05	26.24	23.13	1.80	26.49

NOTES:
BTOC = Below top of casing.
msl = Mean sea level.

TABLE 4-1

PHASES I AND II SOIL DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG		NCBC10S01	NCBC10S01	NCBC10S01	NCBC10S02	NCBC10S02	NCBC10S02	NCBC10S03	NCBC10S03
			5 - 5	10 - 10	23 - 23	5 - 5	10 - 10	23 - 23	1 - 1	13 - 13
	Restricted	Unrestricted	01/12/02	01/12/02	01/12/02	01/12/02	01/12/02	01/12/02	01/11/02	01/11/02
Volatile Organics (µg/kg)										
1,2-DICHLOROBENZENE	279,000	279,000							5.1 U	5.5 U
1,3-DICHLOROBENZENE	1,840,000	70,400							5.1 U	5.5 U
1,4-DICHLOROBENZENE	238,000	26,600							5.1 U	5.5 U
ACETONE	104,000,000	7,820,000							21 UJ	22 UJ
BENZENE	1,360	887							5.1 U	5.5 U
CARBON DISULFIDE	7,970	7,970							5.1 U	5.5 U
CHLOROBENZENE	1,190	1,190							5.1 U	5.5 U
Pesticides (µg/kg)										
4,4'-DDD	23,800	2,660	0.12 R	2.1 U	2.2 U	2.0 U	0.33 J	0.14 R	8.4 U	2.0 U
4,4'-DDE	16,800	1,880	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
4,4'-DDT	16,800	1,880	2.0 U	2.1 U	2.2 U	2.0 U	2	0.39 J	8.4 U	2.0 UJ
ALPHA-BHC	908	101	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	0.083 J
ALPHA-CHLORDANE	12,300	1,820	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
AROCLOR-1254	10,000	1,000	38 U	41 U	42 U	39 U	40 U	41 U	41 U	39 U
AROCLOR-1260	10,000	1,000	38 U	41 U	42 U	39 U	40 U	41 U	740	39 U
DELTA-BHC	3,180	355	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
DIELDRIN	358	40	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	2.1 R	2.0 U
ENDOSULFAN II	1,230,000	469,000	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	17	2.0 U
ENDRIN	61,300	23,500	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	5.7 R	2.0 U
ENDRIN ALDEHYDE	61,300	23,500	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	1.9 R	2.0 U

TABLE 4-1

PHASES I AND II SOIL DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG		NCBC10S03 13 - 13 01/11/02	NCBC10S03 18 - 18 01/11/02	NCBC10S04 1 - 1 01/11/02	NCBC10S04 11 - 11 01/11/02	NCBC10S04 20 - 20 01/11/02	NCBC10S05 2 - 2 01/11/02	NCBC10S05 11 - 11 01/11/02	NCBC10S05 20 - 20 01/11/02
	Restricted	Unrestricted								
Volatile Organics (µg/kg)										
1,2-DICHLOROBENZENE	279,000	279,000	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
1,3-DICHLOROBENZENE	1,840,000	70,400	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	12	6.5 U	6.2 U
1,4-DICHLOROBENZENE	238,000	26,600	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	34	6.5 U	6.2 U
ACETONE	104,000,000	7,820,000	22 UJ	25 UJ	8.7 J	21 UJ	23 UJ	6 J	26 UJ	25 UJ
BENZENE	1,360	887	5.6 U	6.2 U	110	5.2 U	5.8 U	120	6.5 U	6.2 U
CARBON DISULFIDE	7,970	7,970	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
CHLOROBENZENE	1,190	1,190	5.6 U	6.2 U	35	5.2 U	5.8 U	130	6.5 U	6.2 U
Pesticides (µg/kg)										
4,4'-DDD	23,800	2,660	2.0 U	2.0 U	10 U	2.0 U	2.2 UJ	10 U	2.1 U	0.24 J
4,4'-DDE	16,800	1,880	2.0 U	2.0 U	10 U	2.0 U	2.2 U	10 U	2.1 U	2.1 U
4,4'-DDT	16,800	1,880	2.0 UJ	2.0 UJ	30 R	2.0 UJ	2.2 UJ	24 R	2.1 UJ	2.1 UJ
ALPHA-BHC	908	101	2.0 U	2.0 U	10 U	2.0 U	2.2 U	10 U	2.1 U	2.1 U
ALPHA-CHLORDANE	12,300	1,820	2.0 U	2.0 U	9.5 R	2.0 U	2.2 U	5.2 R	2.1 U	2.1 U
AROCLOR-1254	10,000	1,000	39 U	39 U	390 U	39 U	43 U	400 U	40 U	41 U
AROCLOR-1260	10,000	1,000	39 U	39 U	6000	39 U	43 U	5200	40 U	41 U
DELTA-BHC	3,180	355	2.0 U	2.0 U	10 U	2.0 UJ	0.11 J	10 U	2.1 U	2.1 U
DIELDRIN	358	40	2.0 U	2.0 U	26 J	2.0 U	2.2 U	18 J	2.1 U	2.1 U
ENDOSULFAN II	1,230,000	469,000	2.0 U	2.0 U	120 J	2.0 U	2.2 U	110	2.1 U	2.1 U
ENDRIN	61,300	23,500	2.0 U	2.0 U	65 R	2.0 U	2.2 U	44 R	2.1 U	2.1 U
ENDRIN ALDEHYDE	61,300	23,500	2.0 U	2.0 U	15 R	0.38 J	2.2 U	13 R	2.1 U	2.1 U

TABLE 4-1

PHASES I AND II SOIL DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG		NCBC10S06	NCBC10S06	NCBC10S06	NCBC10S06	NCBC10S07	NCBC10S07	NCBC10S07	NCBC10S08
	Restricted	Unrestricted	2 - 2	8 - 8	20 - 20	20 - 20	5 - 5	10 - 10	23 - 23	5 - 5
			01/11/02	01/11/02	01/11/02	01/11/02	01/10/02	01/10/02	01/10/02	01/10/02
Volatile Organics (µg/kg)										
1,2-DICHLOROBENZENE	279,000	279,000	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
1,3-DICHLOROBENZENE	1,840,000	70,400	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
1,4-DICHLOROBENZENE	238,000	26,600	6.1 U	1.4 J	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
ACETONE	104,000,000	7,820,000	8.7 J	5.4 J	7.5 J	25 UJ	6.2 J	24 UJ	24 UJ	5.6 J
BENZENE	1,360	887	230	65	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	1.4 J
CARBON DISULFIDE	7,970	7,970	6.1 U	4.9 U	6.1 U	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
CHLOROBENZENE	1,190	1,190	110	75	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
Pesticides (µg/kg)										
4,4'-DDD	23,800	2,660	110 U	100 U	2.1 U	2.2 U	2.0 UJ	2.2 UJ	2.2 UJ	2.0 UJ
4,4'-DDE	16,800	1,880	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
4,4'-DDT	16,800	1,880	360 R	100 R	2.1 UJ	2.2 UJ	2.0 UJ	2.2 UJ	2.2 UJ	2.0 UJ
ALPHA-BHC	908	101	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
ALPHA-CHLORDANE	12,300	1,820	64 J	25 R	0.40 J	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
AROCLOR-1254	10,000	1,000	8600 U	2000 U	42 U	42 U	39 U	42 U	42 U	39 U
AROCLOR-1260	10,000	1,000	83000	19000	42 U	38 J	39 U	42 U	42 U	39 U
DELTA-BHC	3,180	355	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
DIELDRIN	358	40	240 R	60 R	2.1 U	0.14 J	2.0 U	2.2 U	2.2 U	2.0 U
ENDOSULFAN II	1,230,000	469,000	1500	370	2.1 U	0.76 J	2.0 U	2.2 U	2.2 U	2.0 U
ENDRIN	61,300	23,500	700 R	230 R	0.82 J	0.29 R	2.0 U	2.2 U	2.2 U	2.0 U
ENDRIN ALDEHYDE	61,300	23,500	190 R	53 R	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U

TABLE 4-1

PHASES I AND II SOIL DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG		NCBC10S08	NCBC10S08	NCBC10S09	NCBC10S09	NCBC10S09	NCBC10S09	NCBC10S10	NCBC10S10
			10 - 10	23 - 23	5 - 5	10 - 10	10 - 10	23 - 23	5 - 5	10 - 10
	Restricted	Unrestricted	01/10/02	01/10/02	01/10/02	01/10/02	01/10/02	01/10/02	01/09/02	01/09/02
Volatile Organics (µg/kg)										
1,2-DICHLOROBENZENE	279,000	279,000	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
1,3-DICHLOROBENZENE	1,840,000	70,400	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
1,4-DICHLOROBENZENE	238,000	26,600	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
ACETONE	104,000,000	7,820,000	9.7 J	23 UJ	18 UJ	15 J	13 J	9.2 J	21 UJ	9.5 J
BENZENE	1,360	887	1.3 J	5.8 U	0.94 J	1.6 J	1.4 J	8.4 U	5.4 U	5.8 U
CARBON DISULFIDE	7,970	7,970	5.7 U	5.8 U	4.6 U	3.8 J	2.5 J	8.4 U	5.4 U	5.8 U
CHLOROBENZENE	1,190	1,190	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
Pesticides (µg/kg)										
4,4'-DDD	23,800	2,660	2.0 U	2.1 U	1.9 UJ	2.0 UJ	2.1 UJ	2.2 UJ	2.0 U	0.30 J
4,4'-DDE	16,800	1,880	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
4,4'-DDT	16,800	1,880	2.0 UJ	2.1 UJ	1.9 UJ	2.0 UJ	2.1 UJ	2.2 UJ	2.0 UJ	2.1 U
ALPHA-BHC	908	101	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
ALPHA-CHLORDANE	12,300	1,820	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
AROCLOR-1254	10,000	1,000	39 U	42 U	37 U	39 U	40 U	42 U	39 U	41 U
AROCLOR-1260	10,000	1,000	39 U	42 U	37 U	39 U	40 U	42 U	39 U	41 U
DELTA-BHC	3,180	355	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
DIELDRIN	358	40	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
ENDOSULFAN II	1,230,000	469,000	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
ENDRIN	61,300	23,500	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
ENDRIN ALDEHYDE	61,300	23,500	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 UJ	2.1 U

TABLE 4-1

PHASES I AND II SOIL DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG		NCBC10S10 23 - 23 01/09/02	NCBC10S10 23 - 23 01/09/02	NCBC10S11 5 - 5 01/09/02	NCBC10S11 10 - 10 01/09/02	NCBC10S11 23 - 23 01/09/02	NCBC10S12 5 - 5 01/09/02	NCBC10S12 10 - 10 01/09/02	NCBC10S12 23 - 23 01/09/02
	Restricted	Unrestricted								
Volatile Organics (µg/kg)										
1,2-DICHLOROBENZENE	279,000	279,000	6.9 U	6 U	2.3 J	5 J	6 U	4.6 U	5.6 U	6.8 U
1,3-DICHLOROBENZENE	1,840,000	70,400	6.9 U	6 U	12	34	6 U	4.6 U	5.6 U	6.8 U
1,4-DICHLOROBENZENE	238,000	26,600	6.9 U	6 U	13	83	6 U	4.6 U	5.6 U	6.8 U
ACETONE	104,000,000	7,820,000	28 UJ	24 UJ	20 UJ	9.3 J	10 J	19 UJ	8.2 J	9.1 J
BENZENE	1,360	887	6.9 U	6 U	26	6.5	6 U	4.6 U	5.6 U	6.8 U
CARBON DISULFIDE	7,970	7,970	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
CHLOROBENZENE	1,190	1,190	6.9 U	6 U	110	76	6 U	4.6 U	5.6 U	6.8 U
Pesticides (µg/kg)										
4,4'-DDD	23,800	2,660	2.2 U	0.39 J	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
4,4'-DDE	16,800	1,880	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
4,4'-DDT	16,800	1,880	2.2 UJ	2.1 U	1.9 UJ	2.0 UJ	2.1 UJ	1.9 U	2.0 U	2.2 U
ALPHA-BHC	908	101	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
ALPHA-CHLORDANE	12,300	1,820	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
AROCLOR-1254	10,000	1,000	42 U	41 U	38 U	40 U	41 U	7.7 J	40 U	43 U
AROCLOR-1260	10,000	1,000	42 U	41 U	38 U	40 U	41 U	36 U	40 U	43 U
DELTA-BHC	3,180	355	2.2 UJ	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
DIELDRIN	358	40	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
ENDOSULFAN II	1,230,000	469,000	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
ENDRIN	61,300	23,500	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
ENDRIN ALDEHYDE	61,300	23,500	2.2 U	2.1 U	1.9 UJ	2.0 UJ	2.1 UJ	1.9 U	2.0 U	2.2 U

TABLE 4-1

PHASES I AND II SOIL DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG		NCBC10S13	NCBC10S13	NCBC10S13	NCBC10S14	NCBC10S14	NCBC10S14	NCBC10S14	NCBC10S15
			5 - 5	10 - 10	23 - 23	5 - 5	5 - 5	10 - 10	20 - 20	5 - 5
	Restricted	Unrestricted	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/08/02
Volatile Organics (µg/kg)										
1,2-DICHLOROBENZENE	279,000	279,000	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
1,3-DICHLOROBENZENE	1,840,000	70,400	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
1,4-DICHLOROBENZENE	238,000	26,600	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
ACETONE	104,000,000	7,820,000	21 UJ	6.3 J	12 J	20 U	19 UJ	23 UJ	29 UJ	21 UJ
BENZENE	1,360	887	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
CARBON DISULFIDE	7,970	7,970	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
CHLOROBENZENE	1,190	1,190	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
Pesticides (µg/kg)										
4,4'-DDD	23,800	2,660	2.0 U	2.0 U	2.2 U	1.9 U	0.18 R	2.1 U	2.6 U	1.9 U
4,4'-DDE	16,800	1,880	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
4,4'-DDT	16,800	1,880	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
ALPHA-BHC	908	101	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
ALPHA-CHLORDANE	12,300	1,820	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
AROCLOR-1254	10,000	1,000	39 U	39 U	42 U	38 U	38 U	40 U	50 U	38 U
AROCLOR-1260	10,000	1,000	39 U	39 U	42 U	38 U	38 U	40 U	50 U	11 J
DELTA-BHC	3,180	355	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
DIELDRIN	358	40	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
ENDOSULFAN II	1,230,000	469,000	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	0.17 J
ENDRIN	61,300	23,500	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
ENDRIN ALDEHYDE	61,300	23,500	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 UR	1.9 U

TABLE 4-1

PHASES I AND II SOIL DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG		NCBC10S15	NCBC10S15	NCBC10S16	NCBC10S16	NCBC10S16	NCBC10S17	NCBC10S17	NCBC10S17
			10 - 10	19 - 19	5 - 5	10 - 10	20 - 20	2 - 2	11 - 11	20 - 20
	Restricted	Unrestricted	01/08/02	01/08/02	01/08/02	01/08/02	01/08/02	01/12/02	01/12/02	01/12/02
Volatile Organics (µg/kg)										
1,2-DICHLOROBENZENE	279,000	279,000	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
1,3-DICHLOROBENZENE	1,840,000	70,400	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
1,4-DICHLOROBENZENE	238,000	26,600	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
ACETONE	104,000,000	7,820,000	6.6 J	8.6 J	21 UJ	7.6 J	27 UJ			
BENZENE	1,360	887	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
CARBON DISULFIDE	7,970	7,970	5.8 U	7.4 U	5.2 U	6.2 U	3.9 J			
CHLOROBENZENE	1,190	1,190	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
Pesticides (µg/kg)										
4,4'-DDD	23,800	2,660	2.1 U	2.1 U	10 U	2.0 U	2.1 U	1.1 J	2.1 U	2.4 U
4,4'-DDE	16,800	1,880	2.1 U	2.1 U	10 U	2.0 U	2.1 U	0.29 J	2.1 U	2.4 U
4,4'-DDT	16,800	1,880	2.1 U	2.1 U	11 R	2.0 U	2.1 U	0.20 R	2.1 U	0.29 J
ALPHA-BHC	908	101	2.1 U	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
ALPHA-CHLORDANE	12,300	1,820	2.1 U	2.1 U	2.2 R	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
AROCLOR-1254	10,000	1,000	40 U	40 U	160 U	38 U	41 U	38 U	40 U	46 U
AROCLOR-1260	10,000	1,000	40 U	40 U	1800	38 U	41 U	13 J	40 U	46 U
DELTA-BHC	3,180	355	0.094 R	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
DIELDRIN	358	40	2.1 U	2.1 U	46	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
ENDOSULFAN II	1,230,000	469,000	2.1 U	2.1 U	47 J	2.0 U	2.1 U	0.25 J	2.1 U	2.4 U
ENDRIN	61,300	23,500	2.1 U	2.1 U	19 R	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
ENDRIN ALDEHYDE	61,300	23,500	2.1 U	2.1 U	6.1 R	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U

TABLE 4-1

PHASES I AND II SOIL DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG		NCBC10S18	NCBC10S18	NCBC10S18	NCBC10S18	NCBC10S19	NCBC10S20	NCBC10S21	NCBC10S22
			5 - 5	10 - 10	10 - 10	23 - 23	5 - 5	5 - 5	5 - 5	5 - 5
	Restricted	Unrestricted	01/12/02	01/12/02	01/12/02	01/12/02	02/12/02	02/12/02	02/12/02	02/13/02
Volatile Organics (µg/kg)										
1,2-DICHLOROBENZENE	279,000	279,000								4.8 U
1,3-DICHLOROBENZENE	1,840,000	70,400								4.8 U
1,4-DICHLOROBENZENE	238,000	26,600								4.8 U
ACETONE	104,000,000	7,820,000								19 U
BENZENE	1,360	887								4.8 U
CARBON DISULFIDE	7,970	7,970								4.8 U
CHLOROBENZENE	1,190	1,190								4.8 U
Pesticides (µg/kg)										
4,4'-DDD	23,800	2,660	1.9 U	2.1 U	2.2 U	2.1 U				
4,4'-DDE	16,800	1,880	1.9 U	2.1 U	2.2 U	2.1 U				
4,4'-DDT	16,800	1,880	0.23 J	2.1 U	2.2 U	2.1 U				
ALPHA-BHC	908	101	1.9 U	2.1 U	2.2 U	2.1 U				
ALPHA-CHLORDANE	12,300	1,820	1.9 U	2.1 U	2.2 U	2.1 U				
AROCLOR-1254	10,000	1,000	38 U	41 U	42 U	42 U	39 U	38 U	37 U	
AROCLOR-1260	10,000	1,000	38 U	41 U	42 U	42 U	39 U	15 J	37 U	
DELTA-BHC	3,180	355	1.9 U	2.1 U	2.2 U	2.1 U				
DIELDRIN	358	40	1.9 U	2.1 U	2.2 U	2.1 U				
ENDOSULFAN II	1,230,000	469,000	1.9 U	2.1 U	2.2 U	2.1 U				
ENDRIN	61,300	23,500	1.9 U	2.1 U	2.2 U	2.1 U				
ENDRIN ALDEHYDE	61,300	23,500	1.9 U	2.1 U	2.2 U	2.1 U				

TABLE 4-1

PHASES I AND II SOIL DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG Restricted	REGULATORY CRITERIA Tier 1 TRG Unrestricted	NCBC10S23 5 - 5 02/13/02	SUMMARY OF DETECTIONS Frequency of Detection	SUMMARY OF DETECTIONS Range of Detection	SUMMARY OF DETECTIONS Range of Nondetects
Volatile Organics (µg/kg)						
1,2-DICHLOROBENZENE	279,000	279,000	5 U	2/44	2.3 - 5	4.6 - 8.4
1,3-DICHLOROBENZENE	1,840,000	70,400	5 U	3/44	12 - 34	4.6 - 8.4
1,4-DICHLOROBENZENE	238,000	26,600	5 U	4/44	1.4 - 83	4.6 - 8.4
ACETONE	104,000,000	7,820,000	20 U	20/44	5.4 - 15	18 - 29
BENZENE	1,360	887	5 U	10/44	0.94 - 230	4.6 - 8.4
CARBON DISULFIDE	7,970	7,970	5 U	2/44	2.5 - 3.9	4.6 - 8.4
CHLOROBENZENE	1,190	1,190	5 U	6/44	35 - 130	4.6 - 8.4
Pesticides (µg/kg)						
4,4'-DDD	23,800	2,660		5/52	0.24 - 1.1	1.9 - 110
4,4'-DDE	16,800	1,880		1/54	0.29	1.9 - 110
4,4'-DDT	16,800	1,880		4/48	0.23 - 2	1.9 - 8.4
ALPHA-BHC	908	101		1/54	0.083	1.9 - 110
ALPHA-CHLORDANE	12,300	1,820		2/50	0.4 - 64	1.9 - 8.4
AROCLOR-1254	10,000	1,000		1/57	7.7	37 - 8600
AROCLOR-1260	10,000	1,000		10/57	11 - 83000	36 - 50
DELTA-BHC	3,180	355		1/53	0.11	1.9 - 110
DIELDRIN	358	40		4/51	0.14 - 46	1.9 - 2.6
ENDOSULFAN II	1,230,000	469,000		9/54	0.17 - 1500	1.9 - 2.6
ENDRIN	61,300	23,500		1/48	0.82	1.9 - 2.6
ENDRIN ALDEHYDE	61,300	23,500		1/47	0.38	1.9 - 2.4

NOTES

TRG = Tier 1 Target Remedial Goal.
U = Below detection limit.
J = Estimated concentration.
R = Rejected.

Empty cells indicate sample was not analyzed for that parameter.

TABLE 4-2

PHASE III SOIL DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG		NCBC10S24 6 - 7 12/16/03	NCBC10S25 7 - 8 12/16/03	NCBC10S26 18 - 19 12/16/03	NCBC10S27 6 - 7 12/16/03	NCBC10S28 6 - 7 12/16/03	NCBC10S29 6 - 7 12/16/03
	Restricted	Unrestricted						
Inorganics (mg/kg)								
ALUMINUM	2040000	78200	2050	795	447	1310	1520	1330
ARSENIC	3.82	0.426	1.5	0.5	0.6	0.21	0.44	0.45
BARIUM	14300	5480	4.4	2.7	1.5	4.4	4.4	5.4
CALCIUM			51.2	33.1	31.3	48	30.9	30
CHROMIUM	381	227	3.3	1.4	0.73	1.4	1.8	1.2
COBALT	12300	4690	0.73	0.31 U	0.26 U	0.30 U	0.32	0.32
COPPER	8170	3130	1.1	0.65	0.68	1.1	1.2	1.4
IRON	613000	23500	278	132	303	170	185	207
MAGNESIUM			32.2	21	17.2	43.6	43.6	48.6
MANGANESE	4080	1560	1.1 U	1.6	1.1	1.1 U	1.3	1.1 U
NICKEL	4080	1560	1.5	1.26 U	1.06 U	1.22 U	1.28 U	1.29 U
POTASSIUM			48.19 U	49.80 U	41.85 U	48.31 U	58.2	51.12 U
SELENIUM	1020	391	0.27	0.24 U	0.20 U	0.23 U	0.25 U	0.25 U
SODIUM			9.2	10.4	9.4	10.3	13.7	14.8
VANADIUM	1430	548	3.1	1.4	0.99	1.8	2.5	1.6
ZINC	61300	23500	0.54	0.35	2.3	0.54	0.74	0.6
Semivolatile Organics (µg/kg)								
ACENAPHTHENE	123,000,000	4,690,000	280 J	400 U	390 U	280 J	410 U	400 U
DI-N-BUTYL PHTHALATE	2,280,000	2,280,000	260 J	280 J	260 J	390 U	410 U	260 J
Volatile Organics (µg/kg)								
1,2,3-TRICHLOROBENZENE			0.5 J	27	6 U	6 U	11 J	3 J
1,2,4-TRICHLOROBENZENE	824,000	782,000	6 U	660	6 U	6 U	550	160 J
1,3-DICHLOROBENZENE	1,840,000	70,400	6 U	160 J	6 U	6 U	87 J	57
1,4-DICHLOROBENZENE	238,000	26,600	6 U	390 J	6 U	6 U	290 J	140
ACETONE	104,000,000	7,820,000	18 J	30 U	30 U	29 U	33 UJ	28 U
BENZENE	1,360	887	6 U	8	6 U	6 U	4 J	6 U
CHLOROBENZENE	1,190	1,190	6 U	150	6 U	6 U	160 J	43
TOLUENE	38,000	38,000	1 J	6 U	6 U	6 U	7 UJ	6 U
TRICHLOROFLUOROMETHANE	143,000,000	23,500,000	6	1 J	4 J	1 J	7 UJ	3 J
Pesticides/PCBs (µg/kg)								
AROCLOR-1260	10,000	1,000	20 U	21 U	14 J	20 UJ	21 U	20 U

TABLE 4-2

PHASE III SOIL DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG Restricted	REGULATORY CRITERIA Tier 1 TRG Unrestricted	NCBC10S29 6 - 7 12/16/03	SUMMARY OF DETECTIONS Frequency of Detection	SUMMARY OF DETECTIONS Range of Detection	SUMMARY OF DETECTIONS Range of Nondetects
Inorganics (mg/kg)						
ALUMINUM	2040000	78200	1360	6/6	447 - 2050	0
ARSENIC	3.82	0.426	0.42	6/6	0.21 - 1.5	0
BARIUM	14300	5480	6	6/6	1.5 - 6	0
CALCIUM			32.1	6/6	30 - 51.2	0
CHROMIUM	381	227	1.3	6/6	0.73 - 3.3	0
COBALT	12300	4690	0.28 U	3/6	0.32 - 0.73	0.26 - 0.31
COPPER	8170	3130	1.2	6/6	0.65 - 1.4	0
IRON	613000	23500	207	6/6	132 - 303	0
MAGNESIUM			48.3	6/6	17.2 - 48.6	0
MANGANESE	4080	1560	1.2	4/6	1.1 - 1.6	1.1
NICKEL	4080	1560	1.13 U	1/6	1.5	1.06 - 1.29
POTASSIUM			44.92 U	1/6	58.2	41.85 - 51.12
SELENIUM	1020	391	0.22 U	1/6	0.27	0.2 - 0.25
SODIUM			12.8	6/6	9.2 - 14.8	0
VANADIUM	1430	548	1.6	6/6	0.99 - 3.1	0
ZINC	61300	23500	0.54	6/6	0.35 - 2.3	0
Semivolatile Organics (µg/kg)						
ACENAPHTHENE	123,000,000	4,690,000	390 U	2/6	280	390 - 410
DI-N-BUTYL PHTHALATE	2,280,000	2,280,000	250 J	4/6	250 - 280	390 - 410
Volatile Organics (µg/kg)						
1,2,3-TRICHLOROBENZENE			2 J	4/6	0.5 - 27	6
1,2,4-TRICHLOROBENZENE	824,000	782,000	100	3/6	100 - 660	6
1,3-DICHLOROBENZENE	1,840,000	70,400	59	3/6	57 - 160	6
1,4-DICHLOROBENZENE	238,000	26,600	160	3/6	140 - 390	6
ACETONE	104,000,000	7,820,000	31 U	1/6	18	28 - 33
BENZENE	1,360	887	6 U	2/6	4 - 8	6
CHLOROBENZENE	1,190	1,190	34	3/6	34 - 160	6
TOLUENE	38,000	38,000	6 U	1/6	1	6 - 7
TRICHLOROFLUOROMETHANE	143,000,000	23,500,000	7	5/6	1 - 7	7
Pesticides/PCBs (µg/kg)						
AROCLOR-1260	10,000	1,000	20 U	1/6	14	20 - 21

NOTES

TRG = Tier 1 Target Remedial Goal.
U = Below detection limit.
J = Estimated concentration.

Empty cells indicate sample was not analyzed for that parameter.

TABLE 4-3

PHASE II GROUNDWATER DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERION Tier 1 TRG	MW-01 NCBC10G01 02/14/02	MW-02 NCBC10G02 02/14/02	MW-03 NCBC10G03 02/13/02	MW-04 NCBC10G04 02/13/02	MW-04 NCBC10G04D 02/13/02	MW-05 NCBC10G05 02/14/02
Volatile Organics (mg/L)							
1,3-DICHLOROBENZENE	5.48	1 U	2.7	1 U	1 U	1 U	1 U
1,4-DICHLOROBENZENE	75	1 U	1.1	1 U	1 U	1 U	1 U

TABLE 4-3

PHASE II GROUNDWATER DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERION Tier 1 TRG	SUMMARY OF DETECTIONS			NOTES
		Frequency of Detection	Range of Detection	Range of Nondetects	TRG = Tier 1 Target Remedial Goal. U = Below detection limit.
Volatile Organics (mg/L)					
1,3-DICHLOROBENZENE	5.48	1/5	2.7	1	
1,4-DICHLOROBENZENE	75	1/5	1.1	1	

TABLE 4-4

PHASE III GROUNDWATER DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERON Tier 1 TRG	MW-01 MW1001G02 12/18/03	MW-02 MW1002G02 12/18/03	MW-02 MW1002G02D 12/18/03	MW-03 MW1003G02 12/18/03	MW-04 MW1004G02 12/18/03	MW-05 MW1005G02 12/18/03
Inorganics (µg/L)							
BARIUM	2,000	42.9	45.8	45.7	42.4	45.4	34
CALCIUM		7250	7990	7690	5950	3670	7180
CHROMIUM		0.88 U	1.1	0.88 U	0.88	0.88	0.88 U
COPPER	1,300	1.14 U	3.3 U	3.3 U	3.3 U	10	3.3 U
IRON	11,000	2610 J	3930	3790	3010	2780 J	1920
MAGNESIUM		1610	2220	2220	2170	1710	1420
MANGANESE	730	14.8	77.9	75.4	63.6	36.4	12.4
SODIUM		4220	9590	9710	6070	5180	3750
VANADIUM	256	1.2	3.6 U	3.6 U	3.6 U	0.74 U	3.6 U
ZINC	11,000	28.8 U	3.1 U	2.0 U	23	22.4 U	2.8 U
CYANIDE	200	10 U	10 U	10 U	10 U	7.3 J	10 U
Semivolatile Organics (µg/L)							
BENZO(K)FLUORANTHENE	0.917	10 U	11 J	10 UJ	10 U	10 U	11
Volatile Organics (µg/L)							
1,2,4-TRICHLOROBENZENE	70	1 U	25	24	1 U	1 U	1 U
1,2-DICHLOROBENZENE	600	1 U	0.4 J	0.4 J	1 U	1 U	1 U
1,3-DICHLOROBENZENE	5.48	1 U	4	4	1 U	1 U	1 U
1,4-DICHLOROBENZENE	75	1 U	6	6	1 U	1 U	1 U
BENZENE	5	1 U	3	3	1 U	1 U	1 U
CHLOROBENZENE	100	0.3 J	2	2	1 U	1 U	1 U
Pesticides/PCBs (µg/L)							
4,4'-DDD	0.279	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.03 J
4,4'-DDT	0.197	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.026 J
DELTA-BHC		0.02 J	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
DIELDRIN	0.00419	0.057	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U

TABLE 4-4

PHASE III GROUNDWATER DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERON Tier 1 TRG	SUMMARY OF DETECTIONS			NOTES
		Frequency of Detection	Range of Detection	Range of Nondetects	TRG = Tier 1 Target Remedial Goal.
					U = Below detection limit.
Inorganics (μg/L)					J = Estimated concentration.
BARIUM	2,000	5/5	34 - 45.8		
CALCIUM		5/5	3670 - 7990		
CHROMIUM		3/5	0.88 - 1.1	0.88	
COPPER	1,300	1/5	10	1.14 - 3.3	
IRON	11,000	5/5	1920 - 3930		
MAGNESIUM		5/5	1420 - 2220		
MANGANESE	730	5/5	12.4 - 77.9		
SODIUM		5/5	3750 - 9710		
VANADIUM	256	1/5	1.2	0.74 - 3.6	
ZINC	11,000	1/5	23	2 - 28.8	
CYANIDE	200	1/5	7.3	10	
Semivolatile Organics (μg/L)					
BENZO(K)FLUORANTHENE	0.917	2/5	11	10	
Volatile Organics (μg/L)					
1,2,4-TRICHLOROBENZENE	70	1/5	24 - 25	1	
1,2-DICHLOROBENZENE	600	1/5	0.4	1	
1,3-DICHLOROBENZENE	5.48	1/5	4	1	
1,4-DICHLOROBENZENE	75	1/5	6	1	
BENZENE	5	1/5	3	1	
CHLOROBENZENE	100	2/5	0.3 - 2	1	
Pesticides/PCBs (μg/L)					
4,4'-DDD	0.279	1/5	0.03	0.05	
4,4'-DDT	0.197	1/5	0.026	0.05	
DELTA-BHC		1/5	0.02	0.05	
DIELDRIN	0.00419	1/5	0.057	0.05	

TABLE 4-5

PHASE I SURFACE WATER DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA					NCBC10W01-D01 1/10/2002	NCBC10W01-D01-D 1/10/2002	NCBC10W02-D02 1/10/2002	NCBC10W03-D03 1/10/2002
	Groundwater	WPC-2							
		Aquatic Life - Fresh Water		Human Health					
	Tier 1 TRG	Acute	Chronic	Organisms	Water + Organisms				
Pesticides (µg/L)									
Aroclor-1260	0.0335	0.2	0.014			1.0 U	1.0 U	1.1	1.0 U
Dieldrin	0.00419	0.24	0.056	0.000144	0.000135	0.050 U	0.050 U	0.005 J	0.050 U
Endosulfan II		0.22	0.56	240	110	0.050 U	0.050 U	0.018 J	0.050 U
Endrin Aldehyde		0.086	0.036	0.814	0.76	0.050 U	0.006 J	0.050 U	0.050 U

TABLE 4-5

PHASE I SURFACE WATER DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	SUMMARY OF DETECTIONS			NOTES
	Frequency of Detection	Range of Detection	Range of Nondetects	WPC-2 = Water Quality Criteria for Intrastate, Interstate and Coastal Waters TRG = Tier 1 Target Remedial Goal. U = Below detection limit. J = Estimated concentration.
Pesticides (µg/L)				
Aroclor-1260	1/3	1.1	1	
Dieldrin	1/3	0.005	0.05	
Endosulfan II	1/3	0.018	0.05	
Endrin Aldehyde	1/3	0.006	0.05	

TABLE 4-6

PHASE III SURFACE WATER DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA					NCBC10W10-D10 12/18/2003	NCBC10W11-D11 12/18/2003
	Groundwater	WPC-2					
		Aquatic Life - Fresh Water		Human Health			
	Tier 1 TRG	Acute	Chronic	Organisms	Water + Organisms		
Inorganics (µg/L)							
ALUMINUM	36,500					874	496 U
BARIUM	2,000					22.2	17
CALCIUM						7450	11600
CHROMIUM		16	11	1470	98	1.4	1.4
COPPER	1,300	7	5	1000	1000	13.1	11.1
IRON	11,000					1420 J	616 J
MAGNESIUM						1580	1640
MANGANESE	730					24.1	8.3
SODIUM						6000	5610
VANADIUM	256					1.9	1.6
Semivolatile Organics (µg/L)							
FLUORANTHENE	1,460					9 J	8 J
INDENO(1,2,3-CD)PYRENE	0.0917					7 J	11 U
PHENANTHRENE	1,100					7 J	6 J
Volatile Organics (µg/L)							
CHLOROBENZENE	100					0.2 J	1 U

TABLE 4-6

PHASE III SURFACE WATER DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	SUMMARY OF DETECTIONS			NOTES
	Frequency of Detection	Range of Detection	Range of Nondetects	WPC-2 = Water Quality Criteria for Intrastate, Interstate and Coastal Waters TRG = Tier 1 Target Remedial Goal. U = Below detection limit. J = Estimated concentration.
Inorganics (µg/L)				
ALUMINUM	1/2	874	496	
BARIUM	2/2	17 - 22.2		
CALCIUM	2/2	7,450 - 11,600		
CHROMIUM	2/2	1.4		
COPPER	2/2	11.1 - 13.1		
IRON	2/2	616 - 1420		
MAGNESIUM	2/2	1,580 - 1,640		
MANGANESE	2/2	8.3 - 24.1		
SODIUM	2/2	5,610 - 6,000		
VANADIUM	2/2	1.6 - 1.9		
Semivolatile Organics (µg/L)				
FLUORANTHENE	2/2	8 - 9		
INDENO(1,2,3-CD)PYRENE	1/2	7	11	
PHENANTHRENE	2/2	6 - 7		
Volatile Organics (µg/L)				
CHLOROBENZENE	1/2	0.2	1	

TABLE 4-7

PHASES I AND II SEDIMENT DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG Restricted	REGULATORY CRITERIA Tier 1 TRG Unrestricted	NCBC10W01-D01 0 - 0.5 01/10/02	NCBC10W01-D01-D 0 - 0.5 01/10/02	NCBC10W02-D02 0 - 0.5 01/10/02	NCBC10W03-D03 0 - 0.5 01/10/02	NCBC10D04 0 - 0.5 02/12/02	NCBC10D05 0 - 0.5 02/12/02	NCBC10D06 0 - 0.5 02/12/02
Volatile Organics (µg/kg)									
2-BUTANONE	84,500	84,500	27 UJ	28 UJ	31 UJ	25 UJ	22 U	3.8 J	22 U
ACETONE	104,000,000	7,820,000	27 UJ	28 UJ	31 UJ	10 J	6.3 J	11 J	14 J
TOLUENE	38,000	38,000	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	5.3 J	5.5 U
Pesticides (µg/kg)									
ALPHA-BHC	908	101	0.30 J	2.3 U	2.2 U	2.1 U			
AROCLOR-1260	10,000	1,000	710 J	220 J	94	630	19 J	260	190
DIELDRIN	358	40	3.4 J	0.40 R	0.27 R	1.4 R			
ENDOSULFAN II	1,230,000	469,000	17 J	2.5 J	1.9 J	11			
GAMMA-BHC (LINDANE)	4,400	491	0.42 J	2.3 U	2.2 U	2.1 U			
HEPTACHLOR	195	127	0.34 J	2.3 U	2.2 U	2.1 U			

TABLE 4-7

PHASES I AND II SEDIMENT DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA		SUMMARY OF DETECTIONS		
	Tier 1 TRG		Frequency of	Range of	Range of
	Restricted	Unrestricted	Detection	Detection	Nondetects
Volatile Organics (µg/kg)					
2-BUTANONE	84,500	84,500	1/6	3.8	22 - 31
ACETONE	104,000,000	7,820,000	4/6	6.3 - 14	27 - 31
TOLUENE	38,000	38,000	1/6	5.3	5.5 - 7.8
Pesticides (µg/kg)					
ALPHA-BHC	908	101	1/3	0.3	2.1 - 2.3
AROCLOR-1260	10,000	1,000	6/6	19 - 710	
DIELDRIN	358	40	1/1	3.4	
ENDOSULFAN II	1,230,000	469,000	3/3	1.9 - 17	
GAMMA-BHC (LINDANE)	4,400	491	1/3	0.42	2.1 - 2.3
HEPTACHLOR	195	127	1/3	0.34	2.1 - 2.3

NOTES

TRG = Tier 1 Target Remedial Goal.
U = Below detection limit.
J = Estimated concentration.
R = Rejected.
Empty cells indicate sample was not analyzed for that parameter.

TABLE 4-8

PHASE III SEDIMENT DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA Tier 1 TRG		NCBC10D07 0 - 0.5	NCBC10D08 0 - 0.5	NCBC10D09 0 - 0.5	NCBC10W10-D10 0 - 0.5	NCBC10W10-D10-D 0 - 0.5	NCBC10W11-D11 0 - 0.5
	Restricted	Unrestricted	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03
Inorganics (mg/kg)								
ALUMINUM	2,040,000	78,200	1750	8320	8880	8820	8320	8000
ARSENIC	3.82	0.426	0.35	2.1	1.8	1.7	2.4	1.4
BARIUM	14,300	5,480	5.9	24.5	37.7	28.3	30.2	22.9
CALCIUM			132 J	429 J	5530 J	212 J	474 J	776 J
CHROMIUM			1.7	8.9	9.3	8.5	9.5	8.8
COBALT	12,300	4,690	0.29 U	0.95 J	1.2	0.96 J	0.95 J	0.92
COPPER	8,170	3,130	1.8	4.3	4.4	3.9	4.1	3.4
IRON	613,000	23,500	466	14400	9780	11600	14600	10800
LEAD	1,700	400	2.8	7.6	8.4	7.7	8	7.4
MAGNESIUM			86	325	487	345	366	375
MANGANESE	4,080	1,560	3.4	8.1	14.4	6	6.8 J	8.8
NICKEL	4,080	1,560	1.20 U	1.3 J	2.6	2.2 J	1.8 J	1.44 U
POTASSIUM			47.32 U	184	213	202	180	233
SELENIUM	1,020	391	0.25	0.4	0.35	0.38	0.38	0.51
SODIUM			16.6	22.4 J	31.2	22.1	23.1 J	23.5
VANADIUM	1,430	548	3.1	18.8	14.5	17.5	20.9	19.2
ZINC	61,300	23,500	8.8	5.4	12.5	4.6	6	6
Semivolatile Organics (µg/kg)								
BENZO(A)PYRENE	784	87.5	170 J	460 U	440 U	430 U	420 U	440 U
DI-N-BUTYL PHTHALATE	2,280,000	2,280,000	420 U	300 J	440 U	280 J	270 J	310 J
DIETHYL PHTHALATE	1,970,000	1,970,000	420 UJ	460 UJ	44 J	430 UJ	420 UJ	440 UJ
FLUORANTHENE	81,700,000	3,130,000	170 J	460 U	440 U	430 U	420 U	440 U
PHENANTHRENE	61,300,000	2,350,000	380 J	460 U	440 U	430 U	420 U	440 U
Volatile Organics (µg/kg)								
ACETONE	104,000,000	7,820,000	34 U	120 J	33 U	44 J	31 U	34 U
METHYLENE CHLORIDE	21,900	14,300	14 U	15 J	13 U	12 U	12 U	14 U
TRICHLOROFLUOROMETHANE	143,000,000	23,500,000	6 J	29 J	8	12	18	13
Pesticides/PCBs (µg/kg)								
AROCLOR-1260	10,000	1,000	65	81 J	22 U	22 U	22 U	22 U
DELTA-BHC			2.2 U	2.4 U	2.2 U	2.2 UJ	2.4 J	2.2 U

TABLE 4-8

PHASE III SEDIMENT DETECTION SUMMARY
SITE 10 REMEDIAL INVESTIGATION REPORT
NCBC GULFPORT, MISSISSIPPI

Analytical Parameter	REGULATORY CRITERIA		SUMMARY OF DETECTIONS		
	Tier 1 TRG		Frequency of	Range of	Range of
	Restricted	Unrestricted	Detection	Detection	Nondetects
Inorganics (mg/kg)					
ALUMINUM	2,040,000	78,200	5/5	1,750 - 8,880	
ARSENIC	3.82	0.426	5/5	0.35 - 2.4	
BARIUM	14,300	5,480	5/5	5.9 - 37.7	
CALCIUM			5/5	132 - 5,530	
CHROMIUM			5/5	1.7 - 9.5	
COBALT	12,300	4,690	4/5	0.92 - 1.2	0.29
COPPER	8,170	3,130	5/5	1.8 - 4.4	
IRON	613,000	23,500	5/5	466 - 14,600	
LEAD	1,700	400	5/5	2.8 - 8.4	
MAGNESIUM			5/5	86 - 487	
MANGANESE	4,080	1,560	5/5	3.4 - 14.4	
NICKEL	4,080	1,560	3/5	1.3 - 2.6	1.2 - 1.44
POTASSIUM			4/5	180 - 233	47.32
SELENIUM	1,020	391	5/5	0.25 - 0.51	
SODIUM			5/5	16.6 - 31.2	
VANADIUM	1,430	548	5/5	3.1 - 20.9	
ZINC	61,300	23,500	5/5	4.6 - 12.5	
Semivolatile Organics (µg/kg)					
BENZO(A)PYRENE	784	87.5	1/5	170	420 - 460
DI-N-BUTYL PHTHALATE	2,280,000	2,280,000	3/5	270 - 310	420 - 440
DIETHYL PHTHALATE	1,970,000	1,970,000	1/5	44	420 - 460
FLUORANTHENE	81,700,000	3,130,000	1/5	170	420 - 460
PHENANTHRENE	61,300,000	2,350,000	1/5	380	420 - 460
Volatile Organics (µg/kg)					
ACETONE	104,000,000	7,820,000	2/5	44 - 120	31 - 34
METHYLENE CHLORIDE	21,900	14,300	1/5	15	12 - 14
TRICHLOROFLUOROMETHANE	143,000,000	23,500,000	5/5	6 - 29	
Pesticides/PCBs (µg/kg)					
AROCLOR-1260	10,000	1,000	2/5	65 - 81	22
DELTA-BHC			1/5	2.4	2.2 - 2.4

NOTES

TRG = Tier 1 Target Remedial Goal.
U = Below detection limit.
J = Estimated concentration.

TABLE 5-1

ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS FOR ORGANIC CHEMICALS
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Chemical	Specific Gravity (@ 20/4°C)[1]	Vapor Pressure (mm Hg @ 20°C)[1]	Solubility (mg/L @ 20°C)[1]	Octanol/Water Partition Coefficient[1]	Organic Carbon Partition Coefficient[2]	Henry's Law Constant (atm-m^3/mole)[1]	Bioconcentration Factor (mg/L/mg/kg)[2]	Mobility Index log((solubility*VP) /Koc)
POLYNUCLEAR AROMATIC HYDROCARBONS (PAHs)								
Acenaphthene	1.07	5.00E-03	4.24E+02	8.32E+03	7.08E+03	1.55E-04	1.10E+03	-3.52E+00
Acenaphthylene	1.02	2.30E-02	1.61E+01	1.17E+04	2.00E+03	1.14E-04	3.80E+02	-3.73E+00
Anthracene	1.283 (25/4°C)	1.95E-4 (25°C)	1.29E+0 (25°C)	2.82E+04	2.95E+4 [3]	8.6E-5 (25°C)	4.70E+03	-8.07E+00
Benzo(a)anthracene	1.274	5.00E-09	1E-2 (24°C)	4.07E+05	3.98E+05 [3]	6.60E-07	5.30E+04	-1.59E+01
Benzo(b)fluoranthene	NA	5.00E-07	1.2E-3 (25°C)	3.72E+06	1.23E+06 [3]	1.20E-05	1.40E+05	-1.53E+01
Benzo(k)fluoranthene	NA	9.59E-11	5.5E-4 (25°C)	6.92E+06	1.23E+06 [3]	1.04E-03	1.40E+05	-1.94E+01
Benzo(g,h,i)perylene	NA	1.00E-10	2.6E-4 (25°C)	1.70E+07	1.60E+06	1.4E-7 (25°C)	3.50E+05	-1.98E+01
Benzo(a)pyrene	1.351	5.00E-09	3.8E-3 (25°C)	9.55E+05	1.02E+06 [3]	4.9E-7 (25°C)	1.40E+05	-1.67E+01
Carbazole	1.1	1.37E-06	7.48E+00	3.89E+03	3.39E+03	1.53E-08	5.01E+02	-8.52E+00
Chrysene	1.274 (20°C)	6.3E-9 (25°C)	6E-3 (25°C)	4.07E+05	3.98E+05 [3]	1.05E-6 (25°C)	5.30E+04	-1.60E+01
Dibenzo(a,h)anthracene	1.282	1.00E-10	5E-4 (25°C)	9.33E+05	3.80E+06 [3]	7.3E-8 (25°C)	6.90E+05	-1.99E+01
Dibenzofuran	1.0886	4.40E-02	4.22E+00	1.32E+04	8.13E+03	NA	8.00E+02	-4.64E+00
Fluoranthene	1.252	5.0E-6 (25°C)	2.65E-1 (25°C)	2.14E+05	1.07E+05 [3]	6.5E-6 (25°C)	1.20E+04	-1.09E+01
Fluorene	1.202	1.00E+01	1.98E+00	1.62E+04	1.38E+04	6.36E-05	3.80E+03	-2.84E+00
Indeno(1,2,3-cd)pyrene	NA	1E-10 (25°C)	6.20E-02	4.57E+07	3.47E+06 [3]	6.95E-8 (25°C)	3.50E+05	-1.77E+01
1-Methylnaphthalene	1.0202	5.39E-02	2.58E+01	7.41E+03	7.30E+02	2.60E-04	1.3E+02-6.8E+02	-2.72E+00
2-Methylnaphthalene	1.0058	1E+1 (105°C)	2.6E+1 (25°C)	7.24E+03	7.27E+2 [4]	4.99E-4 (25°C)	5.1E+2 [5]	-4.47E-01
Naphthalene	1.162	8.2E-2 (25°C)	3E+1 (25°C)	2.34E+03	2.00E+03 [3]	4.83E-4 (25°C)	4.20E+02	-2.91E+00
Phenanthrene	0.980 (4°C)	1E+0 (118.2°C)	8.16E-1 (21°C)	2.88E+04	1.40E+04	3.93E-5 (25°C)	4.70E+03	-4.23E+00
Pyrene	1.271 (23/4°C)	2.5E+0 (200°C)	1.6E-1 (26°C)	1.51E+05	1.05E+05 [3]	5.1E-6 (25°C)	1.20E+04	-5.42E+00

TABLE 5-1

ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS FOR ORGANIC CHEMICALS
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Chemical	Specific Gravity (@ 20/4°C)[1]	Vapor Pressure (mm Hg @ 20°C)[1]	Solubility (mg/L @ 20°C)[1]	Octanol/Water Partition Coefficient[1]	Organic Carbon Partition Coefficient[2]	Henry's Law Constant (atm-m^3/mole)[1]	Bioconcentration Factor (mg/L/mg/kg)[2]	Mobility Index log((solubility*VP) /Koc)
PESTICIDES								
Aldrin	1.18	2.31E-05	1.80E-01	3.16E+06	2.45E+06	6.97E-03	1.10E+02	-1.18E+01
Chlordane	1.61 (25°C)	1E-5 (25°C)	5.60E-02	6.03E+02	1.20E+05	4.79E-05 (25°C)	4.00E+04	-1.13E+01
4,4'-DDD	1.476	1.0E-06 (30°C)	1.6E-1 (24°C)	9.77E+05	1.00E+06 [3]	2.16E-05	1.80E+05	-1.28E+01
4,4'-DDE	NA	6.50E-06	4.00E-02	4.90E+05	4.47E+06 [3]	2.34E-05	8.90E+05	-1.32E+01
4,4'-DDT	1.5 (15/4°C)	1.50E-07	3.1E-3 (25°C)	1.55E+06	2.63E+06 [3]	3.89E-5 (25°C)	8.00E+06	-1.58E+01
Dieldrin	1.75	1.8E-7 (25°C)	1.86E-01	1.23E+04	2.14E+04 [3]	5.84E-5 (25°C)	7.10E+02	-1.18E+01
Endosulfan II	1.745 (20/20°C)	2.40E-5 (25°C)	5.1E-01 [6]	1.26E+04 [6]	2.04E+03 [6]	1.12E-05 [6]	2.9E+02 [7]	-8.22E+00
Endosulfan sulfate	NA	9.00E-03	1.17E-01	3.66E+00	3.76E+00	4.70E-07	3.56E+02	-3.55E+00
Endrin	1.65 (25°C)	2.0E-7 (25°C)	2.5E-01 [6]	1.15E+05 [6]	1.08E+04 [6]	7.52E-06 [6]	1.8E+03 [8]	-1.13E+01
Endrin aldehyde	1.65 (25°C)	2.0E-7 (25°C)	2.5E-01 [6]	1.15E+05 [6]	1.08E+04 [6]	7.52E-06 [6]	1.8E+03 [8]	-1.13E+01
Endrin ketone	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor epoxide	NA	3.00E-04	3.5E-1(15°C)	5.00E+00	8.32E+04	3.90E-04	7.50E+03	-8.90E+00
Methoxychlor	1.41 (25°C)	NA	4.0E-02 (24°C)	4.91E+00	1.07E+05	1.60E-05	8.10E+03	NA
POLYCHLORINATED BIPHENYLS (PCBs)								
Aroclor-1242	1.392	2.50E-04	2.00E-02	1.29E+04	5.03E+05	5.60E-04	3.6E+03 - 4.3E+04	-1.10E+01
Aroclor-1260	1.58 (25°C) [2]	4.05E-5 [2]	2.7E-3 [2]	1.4E+7 [2]	6.70E+06	7.4E-1 [2]	1.30E+06	-1.38E+01

NA = Not available.

1 USEPA, 1992. Handbook of RCRA Groundwater Monitoring Constituents: Chemical and Physical Properties. September.

2 USEPA, 1982. Aquatic Fate Process Data for Organic Priority Pollutants. December.

3 USEPA, 1996. Soil Screening Guidance. July.

4 Lyman et al., 1990.; Equation 4-5. Handbook of Chemical Property Estimation Methods.

5 Lyman et al., 1990. Equation 5-2. Handbook of Chemical Property Estimation Methods.

6 Lyman et al., 1990. Equation 5-3. Handbook of Chemical Property Estimation Methods.

7 ATSDR, 2000. Toxicity Profile for Endosulfan. September.

8 ATSDR, 1996. Toxicity Profile for Endrin. August.

TABLE 5-2

RELATIVE MOBILITIES OF METALS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH)
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Relative Mobility	Environmental Conditions			
	Oxidizing	**Acidic**	**Neutral/ Alkaline**	**Reducing**
Very High	––	––	Selenium	––
High	Selenium Zinc	Copper Mercury Nickel Selenium Silver Zinc	––	––
Medium	Arsenic Cadmium Copper Mercury Nickel Silver	Arsenic Cadmium	Arsenic Cadmium	––
Low	Barium Beryllium Lead	Barium Beryllium Lead	Barium Beryllium Lead	––
Very Low	Chromium Iron	Chromium	Chromium Copper Mercury Nickel Silver Zinc	Barium Beryllium Chromium Copper Lead Mercury Nickel Selenium Silver Zinc

TABLE 6-1

HUMAN HEALTH EXPOSURE SCENARIOS
SITE 10 REMEDIAL INVESTIGATION REPORT
NCBC GULFPORT

Receptor	Surface Soil Exposure	Subsurface Soil Exposure	Sediment Exposure	Surface Water Exposure	Groundwater Exposure
Construction/Excavation Worker	Ingestion Dermal Contact	Ingestion Dermal Contact	Ingestion Dermal Contact	Dermal Contact	Dermal Contact
Commercial/Industrial Worker	Ingestion Dermal Contact	Ingestion Dermal Contact	Ingestion Dermal Contact	Dermal Contact	
On-Site Worker	Ingestion Dermal Contact	Ingestion Dermal Contact	Ingestion Dermal Contact	Dermal Contact	
Recreational User/Trespasser	Ingestion Dermal Contact	Ingestion Dermal Contact	Ingestion Dermal Contact	Dermal Contact	
On-Site Resident	Ingestion Dermal Contact	Ingestion Dermal Contact	Ingestion Dermal Contact	Dermal Contact	Ingestion Dermal Contact Inhalation

TABLE 6-2

SUMMARY OF EXCEEDANCES OF HUMAN HEALTH SCREENING CRITERIA
SITE 10 REMEDIAL INVESTIGATION REPORT
NCBC GULFPORT

Analyte	Solid Media						Aqeous Media		
	Surface Soil		Subsurface Soil		Sediment		Groundwater	Surface Water	
Inorganics	Restricted TRG	Unrestricted TRG	Restricted TRG	Unrestricted TRG	Restricted TRG	Unrestricted TRG	TRG	TRG	WPC-2
Arsenic	0/5	4/5	0/1	1/1	0/5	4/5	--	--	--
Semivolatile Organics									
Benzo(a)pyrene	--	--	--	--	0/5	1/5	--	--	--
Benzo(k)fluoranthene	--	--	--	--	--	--	2/5	--	--
Indeno(1,2,3-CD)pyrene	--	--	--	--	--	--	--	1/2	NA
Pesticides/PCBs									
Aroclor 1260	1/26	3/26	1/37	0/37	--	--	--	1/5	NA
Dieldrin	0/24	1/24	0/37	0/37	--	--	1/10	1/5	1/5

Notes:

TRG = Target Remediation Goal
WPC-2 = Mississippi Commission on Environmental Quality Regualtion WPC-2
Unrestricted
Restricted

TABLE 6-3
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SEDIMENT
SITE 10
NCBC, GULFPORT, MISSISSIPPI

Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Site 10 Ditch

Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Location of Maximum Concentration	Detection Frequency (1)	Range of Nondetects (2)	Concentration Used for Screening (3)	EPA Region 4 Sediment Screening Values mg/kg (4)	Hazard Quotient (5)	COPC Yes/No	Notes
VOCs (mg/kg)												
2-Butanone	0.0038	J	0.0038	J	NCBC10D05	1/7	0.022 -0.0 31	0.0038	NA	NA	**Yes**	
Acetone	0.0063	J	0.12	J	NCBC10D08	6/13	0.027-0.034	0.12	NA	NA	**Yes**	
Toluene	0.0053	J	0.0053	J	NCBC10D05	1/7	0.0055 -0.0078	0.0053	NA	NA	**Yes**	
Trichlorofluoromethane	0.006	J	0.029	J	NCBC10D08	6/6	---	0.029	NA	NA	**Yes**	
Methylene Chloride	0.015	J	0.015	J	NCBC10D08	1/6	.012-.014	0.015	NA	NA	**Yes**	
SVOCs (mg/kg)												
Benzo)a)pyrene	0.17	J	0.17	J	NCBC10D07	1/6	0.420-0.460	0.17	0.33	0.52	No	
DI-N-Butyl Phthalate	0.27	J	0.31	J	NCBC10W11-D11	4/6	0.420 - 0.440	0.31	NA	NA	**Yes**	
Diethylphthalate	0.044	J	0.044	J	NCBC10D09	1/6	0.420 - 0.460	0.044	NA	NA	**Yes**	
Fluoranthene	0.17	J	0.17	J	NCBC10D07	1/6	0.420-0.460	0.17	0.33	0.52	No	
Phenanthrene	0.38	J	0.38	J	NCBC10D07	1/6	0.420 - 0.460	0.38	0.33	1.15	**Yes**	
Pesticides and PCBs (mg/kg)												
Alpha-BHC	0.0003	J	0.0003	J	NCBC10W01-D01	1/4	0.0021-0.0023	0.0003	0.0033	0.09	No	Value for Gamma BHC
Aroclor-1260	0.019	J	0.71	J	NCBC10W01-D01	9/13	0.022-0.022	0.71	0.033	21.52	**Yes**	
Delta-BHC	0.0024	J	0.0024	J	NCBC10W10-D10-D	1/6	.0022-.0024	0.0024	0.0033	0.73	No	Value for Gamma BHC
Dieldrin	0.0034	J	0.0034	J	NCBC10W01-D01	1/4	---	0.0034	0.0033	1.03	**Yes**	
Endosulfan II	0.0019	J	0.017	J	NCBC10W01-D01	4/4	---	0.017	NA	NA	**Yes**	
Gamma-BHC (Lindane)	0.00042	J	0.00042	J	NCBC10W01-D01	1/4	.0021-.0023	0.00042	0.0033	0.13	No	
Heptachlor	0.00034	J	0.00034	J	NCBC10W01-D01	1/4	.0021-.0023	0.00034	NA	NA	**Yes**	
Inorganics (mg/kg)												
Aluminum	1750		8880		NCBC10D09	6/6	---	8880	NA	NA	**Yes**	
Arsenic	0.35		2.4		NCBC10W10-D10-D	6/6	---	2.4	7	0.34	No	
Barium	5.9		37.7		NCBC10D09	6/6	---	37.7	NA	NA	**Yes**	
Calcium	132	J	5530	J	NCBC10D09	6/6	---	5530	NA	NA	No	NUT
Chromium	1.7		9.5		NCBC10W10-D10-D	6/6	---	9.5	52.3	0.18	No	
Cobalt	0.92		1.2		NCBC10D09	5/6	0.29-0.29	1.2	NA	NA	**Yes**	
Copper	1.8		4.4		NCBC10D09	6/6	---	4.4	18.7	0.24	No	
Iron	466		14600		NCBC10W10-D10-D	6/6	---	14600	NA	NA	**Yes**	
Lead	2.8		8.4		NCBC10D09	6/6	---	8.4	30.2	0.28	No	
Magnesium	86		487		NCBC10D09	6/6	---	487	NA	NA	No	NUT
Manganese	3.4		14.4		NCBC10D09	6/6	---	14.4	NA	NA	**Yes**	
Nickel	1.3	J	2.6		NCBC10D09	4/6	1.2-1.44	2.6	15.9	0.16	No	
Potassium	180		233		NCBC10W11-D11	5/6	47.32-47.32	233	NA	NA	No	NUT
Selenium	0.25		0.51		NCBC10W11-D11	6/6	---	0.51	NA	NA	**Yes**	
Sodium	16.6		31.2		NCBC10D09	6/6	---	31.2	NA	NA	No	NUT
Vanadium	3.1		20.9		NCBC10W10-D10-D	6/6	---	20.9	NA	NA	**Yes**	
Zinc	4.6		12.5		NCBC10D09	6/6	---	12.5	124	0.10	No	

Footnotes:
1 Sample and duplicate are counted as two separate samples when determining the minimum and maximum detected concentrations.
2 Values presented are sample-specific quantitation limits.
3 The maximum detected concentration is used for screening purposes.
4 Region 4 Waste Management Division Sediment Screening Values for Hazardous Waste Sites.
5 Hazard quotient = maximum detected concentration ÷ ecological screening value

Definitions:
COPC = Chemical of Potential Concern
mg/kg = milligrams per kilogram
J = Estimated Value
NA = Not Applicable/Not Available.
NUT = Essential Nutrient

TABLE 6-4
OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SURFACE WATER
SITE 10
NCBC, GULFPORT, MISSISSIPPI

Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Canal No. 1

Chemical	Minimum Concentration (1)	Minimum Qualifier	Maximum Concentration (1)	Maximum Qualifier	Location of Maximum Concentration	Detection Frequency (1)	Range of Nondetects (2)	Concentration Used for Screening (3)	EPA Region 4 Surface Water Screening Values (4) ug/L	Hazard Quotient (5)	COPC Yes/No	Notes
VOCs (ug/ml)												
Chlorobenzene	0.2	J	0.2	J	NCBC10W10-D10	1/2	1	0.2	195	0.001	No	
Semivolatile Organics (ug/l)												
Fluoranthene	8	J	9	J	NCBC10W10-D10	2/2	---	9	39.8	0.23	No	
Indeno(1,2,3-CD)Pyrene	7	J	7	J	NCBC10W10-D10	1/2	11	7	NA	NA	**Yes**	
Phenanthrene	6	J	7	J	NCBC10W10-D10	2/2	---	7	NA	NA	**Yes**	
Pesticides and PCBs (ug/L)												
Aroclor-1260	1.1		1.1		NCBC10W02-D02	1/4	1	1.1	0.014	78.57	**Yes**	
Dieldrin	0.005	J	0.005	J	NCBC10W02-D02	1/4	0.05	0.005	0.0019	2.63	**Yes**	
Endosulfan II	0.018	J	0.018	J	NCBC10W02-D02	1/4	0.05	0.018	0.056	0.32	No	ESV for Endosulfan B
Endrin Aldehyde	0.006	J	0.006	J	NCBC10W01-D01-D	1/4	0.05	0.006	0.0023	2.61	**Yes**	ESV for Endrin
Inorganics (ug/L)												
Aluminum	874		874		NCBC10W10-D10	1/2	496	874	87	10.05	**Yes**	
Barium	17		22.2		NCBC10W10-D10	2/2	---	22.2	NA	NA	**Yes**	
Calcium	7450		11600		NCBC10W11-D11	2/2	---	11600	NA	NA	**Yes**	NUT
Chromium	1.4		1.4		NCBC10W10-D10	2/2	---	1.4	11	0.1	No	Hexavalent chromium
Copper	11.1		13.1		NCBC10W10-D10	2/2	---	13.1	4.27	3.1	**Yes**	Hardness dependent[6]
Iron	616	J	1420	J	NCBC10W10-D10	2/2	---	1420	1000	1.4	**Yes**	
Magnesium	1580		1640		NCBC10W11-D11	2/2	---	1640	NA	NA	No	NUT
Manganese	8.3		24.1		NCBC10W10-D10	2/2	---	24.1	NA	NA	**Yes**	
Sodium	5610		6000		NCBC10W10-D10	2/2	---	6000	NA	NA	No	NUT
Vanadium	1.6		1.9		NCBC10W10-D10	2/2	---	1.9	NA	NA	**Yes**	

Footnotes:
1 Sample and duplicate are counted as two separate samples when determining the minimum and maximum detected concentrations.
2 Values presented are sample-specific quantitation limits.
3 The maximum detected concentration is used for screening purposes.
4 Based on Region 4 Water Management Division, Water Quality Standards
5 Hazard quotient = maximum detected concentration ÷ ecological screening value
6 Hardness Dependent. Screening value calculated based on hardness (mg/L as $CaCO_3$) = 30.4

Definitions:
COPC = Chemical of Potential Concern
ug/L = micrograms per liter
J = Estimated Value
NA = Not Applicable/Not Available.
NUT = Essential Nutrient

TABLE 8-1

ARARs AND TBC CRITERIA
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Name and Regulatory Citation	Description	Consideration in the Remedial Action Process	Type
	Federal		
USEPA Region III RBC Table	Provides risk-based concentrations for screening of soil.	Relevant and appropriate. These guidelines aid in the screening of chemicals in soil.	Chemical-specific
CERCLA and the NCP Regulations (CFR, Section 300.430)	Discusses the types of post-removal site controls to be established at CERCLA sites.	Applicable. These requirements may be used as guidance in establishing appropriate post-removal site controls at Site 10.	Action-specific
OSHA (29 CFR Part 1910)	Requires establishment of programs to ensure worker health and safety at hazardous waste sites.	Applicable. These requirements apply to response activities conducted in accordance with the NCP. During the implementation of any remedial alternative for Site 10, these regulations must be followed.	Action-specific
Hazardous Materials Transportation Act Regulations (49 CFR 171-179)	Provides requirements for packaging, labeling, manifesting, and transporting hazardous materials.	Applicable. If soil or sediment is excavated and transported and is found to be hazardous, the material would need to be handled, manifested, and transported as a hazardous waste.	Action-specific
National Emissions Standards for Hazardous Air Pollutants (40 CFR Part 61)	Standards promulgated under the Clean Air Act for significant sources of hazardous air pollutants.	Relevant and appropriate. Remedial action (e.g., soil excavation) may result in release of hazardous air pollutants.	Action-specific
(RCRA Treatment, Storage, and Disposal of Hazardous Waste (40 CFR 262-266)	Regulates the treatment, storage, and disposal of hazardous waste.	Relevant and appropriate. Hazardous waste generated by site remediation must meet RCRA generator and treatment, storage, or disposal requirements.	Action-specific
Land Disposal Restrictions (40 CFR Part 61)	Restricts certain listed or characteristic hazardous waste from placement or disposal on land without treatment.	Relevant and appropriate. Excavated soil and sediment or treatment residuals (e.g., spent granular activated carbon) may require disposal in a landfill.	Action-specific
PCBs Waste Removal / 15 USC 2605	Applicable to the storage and disposal of PCB-contaminated materials.	Potentially applicable. Applicable to alternatives that, if present, involve removal of solid wastes/materials containing PCBs greater than 50 ppm.	Action-specific
USEPA PCB Spill Cleanup Policy / 40 CFR §761, Subparts D, N, and O	Provides regulations governing disposal of PCB-contaminated waste (40 CFR §761.60) and cleanup and disposal options for PCB remediation wastes (40 CFR §761.61), which include PCB-contaminated environmental media. Subpart D applies to soils contaminated with PCB at concentrations greater	PCB concentrations in soil are greater than 50 mg/kg; therefore, Subpart D is applicable. Depending on the remedial action alternative, Subparts N and O would be relevant and appropriate.	

TABLE 8-1

ARARs AND TBC CRITERIA
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

Name and Regulatory Citation	Description	Consideration in the Remedial Action Process	Type
USEPA PCB Spill Cleanup Policy / 40 CFR §761, Subparts D, N, and O (Continued)	than 50 mg/kg. Subparts N and O govern sampling and verification of cleanup levels. Cleanup policy applies to intentional and accidental spills of material containing at least 50 ppm PCB occurring after May 4, 1987. For spills prior to that date, cleanup levels are established on a case-by-case basis using project-specific PCB cleanup levels.	Applicable. The PCB spill is believed to have occurred before May 4, 1987. Discussions with regulators from USEPA and State of Mississippi took place in July 2002. The regulators agreed that state cleanup goals should drive the decision for remedial action (see Appendix F).	Action-specific
State			
MDEQ TRGs (Mississippi Code Section 49-35-21)	Default screening levels. Human Health risk-based cleanup goals for soil and groundwater.	Applicable. These regulations apply to all remedial actions in the State of Mississippi.	Chemical - specific
MDEQ Risk Evaluation Procedures for Voluntary Cleanup and Redevelopment	Risk-based procedures and rationale for site evaluation and remediation.	TBC. These regulations apply to all Voluntary Cleanup and Brownfield actions in the State of Mississippi.	Guidance
MDEQ Office of Pollution Control Hazardous Waste Management Regulations	Adopts by reference specific sections of the federal Hazardous Waste regulations.	Relevant and Appropriate. These regulations may apply if material is removed from the base.	Action-specific

CERLA Comprehensive Environmental Response, Compensation, and Liability Act.
CFR Code of Federal Regulations.
MDEQ Maryland Department of Environmental Quality.
NCP National Oil and Hazardous Substances Pollution Contingency Plan.
OSHA Occupational Safety and Health Act.
PCB Polychlorinated biphenyls.
RBC Risk-Based Concentration.
RCRA Resource Conservation and Recovery Act.
TBC To be considered.
TRG Target Remediation Goal.
USC United States Code.
USEPA United States Environmental Protection Agency.

TABLE 9-1

PRELIMINARY SCREENING OF SOIL AND SEDIMENT REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
No Action	None	Not applicable	No activities conducted at the site to address contamination.	Required by NCP. Retain for baseline comparison to other technologies.
Limited Action	Institutional Controls	Active Controls: Physical Barriers/ Security Guards	Fencing, markers, warning signs, and monitoring to restrict site access.	Retained to minimize risk of exposure to contaminated soil and sediment. Fencing already exists around parts of Site 10.
		Passive Controls: Deed or Land Use Restrictions	Administrative action using property deeds or other land use prohibitions to restrict future site activities.	Retained to prevent future residential development.
	Monitoring	Sampling and Analysis	Sampling and analysis of site media to evaluate migration of chemical constituents in the environment.	Retained to assess migration of chemical constituents from Site 10.
Containment	Surface Protection	Concrete/Rip-Rap Cover/Asphalt	Installation of a cover to prevent direct exposure with contaminated soil and sediment and to prevent migration of contaminants through erosion.	Retained. An appropriate cover would prevent direct exposure to PCBs and erosion of PCBs through the drainage channel system.
	Surface Water Controls	Vertical Barriers	Installation of a vertical barrier to prevent water from entering into the work area and to prevent erosion of contaminated materials from work areas.	Retained. Vertical barriers such as sheet piling and silt screens are common methods for surface water control.
Removal	Bulk Excavation	Excavation	Use of construction equipment such as backhoe, front-end loader, gradall, etc. to remove contaminated soil and sediment.	Retained. Excavation would effectively remove contaminated soil and sediment from the site.
In-Situ Treatment	Biological	Anaerobic/Aerobic Treatment	Innoculation of microorganisms and nutrients to enhance naturally occurring biodegradation of COCs.	Eliminated because PCBs are very persistent and can only be biodegraded under carefully controlled environments that are not practical to implement in situ.

TABLE 9-1

PRELIMINARY SCREENING OF SOIL AND SEDIMENT REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
In-Situ Treatment (continued)	Physical/ Chemical	Dynamic Underground Stripping	Injection of steam at the periphery of the contaminated area to volatilize COCs and removal of these COCs through a centrally located extraction well.	Eliminated because of the low volatility of PCBs.
		Soil Vapor Extraction	Use of vacuum and possibly air sparging to volatilize COCs.	Eliminated because PCBs are not volatile.
		Chemical Fixation/ Solidification	Mixing of pozzolanic agents in the vadose zone to chemically fix COCs and solidify the matrix. This technology is primarily used to reduce the mobility of contaminants, but it can also be used to prepare a surface barrier.	Eliminated because the use of this technology to prepare a surface barrier by in-situ application would be difficult to control due to the very heterogeneous nature of the contaminated soil and sediment.
	Thermal	Vitrification/ Radiofrequency Heating	Use of moderate to high temperature to either volatilize COCs or to fuse them into a glass matrix.	Eliminated because PCBs are not volatile and in-situ application of this technology would be difficult to control due to the very heterogeneous nature of the soil and sediment.
Ex-Situ Treatment	Physical/ Chemical	Dewatering	Removal of water from saturated material.	Retained as a method to facilitate the handling of excavated material.
		Chemical Fixation/ Solidification	Mixing of pozzolanic agents to chemically fix COCs and to solidify the matrix.	Retained for the potential treatment of excavated soil and sediment to meet off-site disposal requirements.
	Biological	On-Site Landfarming	Spreading and tilling of contaminated soil into layers of clean surface soil to aerate and biodegrade organic COCs.	Eliminated because it would not be effective for the removal for a biologically recalcitrant chemical such as Aroclor-1260. Also, no suitable area is available for this purpose on base.

TABLE 9-1

PRELIMINARY SCREENING OF SOIL AND SEDIMENT REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT, MISSISSIPPI

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Ex-Situ Treatment (Continued)	Biological (Continued)	Bioslurry Reactor/Biopile	Treatment of soil in a bioslurry reactor or biopile under controlled conditions using natural or cultured microorganisms to biodegrade organic COCs.	Eliminated because it would not be effective for the removal for a biologically recalcitrant chemical such as Aroclor-1260.
	Thermal	Incineration	Use of high temperatures to destroy COCs.	Would effectively destroy PCBs, but is not necessary because waste material is solid and with a PCB concentration of less than 500 mg/kg.
		Low-Temperature Thermal Desorption (LTTD)	Use of low to moderate temperatures to evaporate COCs and remove them from soil.	Eliminated because it would be questionable in removing PCBs.
Disposal	Landfill	On-Site Landfilling	Disposal of excavated soil and treatment residues in an on-site landfill.	Eliminated because no suitable area is available on bse for this pupose.
		Off-Site Landfilling	Disposal of excavated soil and sediment and treatment residues in an off-base permitted TSDF. Disposal of recovered material such as metallic lead pieces.	Retained landfilling and recycling.

TABLE 11-1

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY
NCBC GULFPORT, MISSISSIPPI

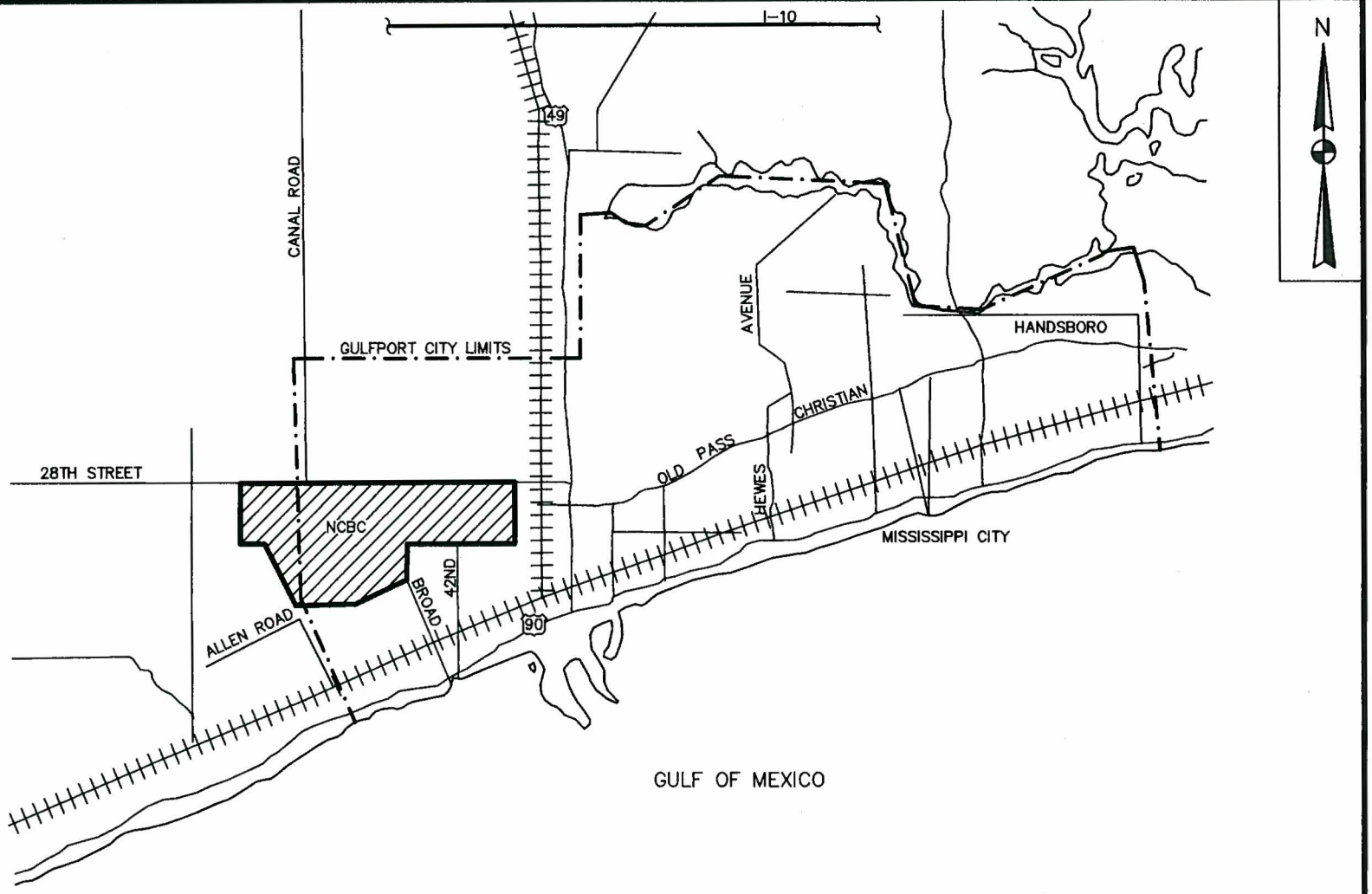
Evaluation Criteria	Alternative 1 – No Action	Alternative 2 – Institutional Controls and Monitoring
Threshold Criteria		
Overall Protection of Human Health and the Environment	No reduction in potential risks.	Institutional controls would reduce risks to human health and the environment. Direct exposure to PCBs would be minimized through fencing and deed restrictions. Migration of contaminants through the drainage channel system would continue to occur.
Compliance with ARARs		
Chemical-specific	Would not comply.	Would not comply although measures would be in place to prevent direct exposure.
Action-specific	Not applicable.	Would comply.
Location-specific	Not applicable. There are no location-specific ARARs.	Not applicable. There are no location-specific ARARs.
Primary Balancing Criteria		
Long-Term Effectiveness and Permanence	Not effective and permanent. Would allow risk to remain uncontrolled.	Institutional controls would provide some long-term effectiveness and permanence because fencing and site controls would reduce exposure to contaminated soil and sediment, and monitoring would provide indications of PCB migration.
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment is utilized.	No treatment is utilized.
Short-Term Effectiveness	Not applicable. No short-term impacts or concerns.	No impacts to community or environment. Exposure of workers to contaminated soil and sediment can be adequately controlled. One day to implement.
Implementability	No action is conducted; therefore, there are no activities to implement.	Alternative consists of site controls and monitoring that are readily available and implementable.
Costs		
Capital	$0	$21,279
O&M (Years 1 – 30)	$0	$3,900
O&M (Every 5 Years)	$0	$18,900
Present Worth	$0	$99,692
Modifying Criteria		
State Acceptance	Not applicable.	Accepted.
Community Acceptance	To be determined.	To be determined.

TABLE 11-1

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY
NCBC GULFPORT, MISSISSIPPI

Evaluation Criteria	Alternative 3 – Surface Water Controls, Excavation, Surface Protection, Institutional Controls, and Monitoring	Alternative 4 – Surface Water Controls, Dewatering, Excavation, Off-Site Treatment and Disposal
Threshold Criteria		
Overall Protection of Human Health and the Environment	More protective than Alternative 2. Surface protection and institutional controls would reduce risks to human health and the environment. Direct exposure to contaminants would be eliminated through surface protection and deed restrictions. Erosion of contaminants through the drainage channel system would also be mitigated by these measures.	More protective than Alternative 3. Excavation would also reduce risks to human health and the environment. All PCB concentrations greater than the PRGs would be removed from the site and treated and disposed and an approved TSDF.
Compliance with ARARs		
Chemical-specific	Would not comply although measures would be in place to prevent exposure to contaminants and prevent migration of contaminants.	Would comply.
Action-specific	Would comply	Would comply.
Location-specific	Not applicable. There are no location-specific ARARs	Not applicable. There are no location-specific ARARs
Primary Balancing Criteria		
Long-Term Effectiveness and Permanence	Surface protection would be effective and permanent in preventing direct contact with contaminants and preventing the erosional transport of PCBs through the drainage channel system.	Excavation would be the most long-term effective and permanent remedy. Contaminated soil and sediment would be removed from the site, treated, as required, for ultimate disposal at a TSDF.
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment is utilized.	No treatment to reduce toxicity or volume. Mobility would be reduced through off-site chemical fixation/solidification.
Short-Term Effectiveness	No impacts to community. Exposure of workers to contaminated soil and sediment can be adequately controlled. Three days to implement.	Potential impacts to community from transport of contaminated soil and sediment over public roads. However, impacts would be addressed through decontamination measures, traffic control, spill prevention and emergency response. Exposure of workers to contaminated soil and sediment can be adequately controlled. Twelve days to implement.
Implementability	Alternative consists of common remediation practices that are readily available and implementable.	Alternative consists of common remediation practices that are readily available and implementable.
Costs Capital O&M (Years 1 – 30) O&M (Every 5 Years) Present Worth	 $41,636 $3,100 $18,100 $111,350	 $421,398 $0 $0 $421,398
Modifying Criteria		
State Acceptance	Accepted.	Accepted.
Community Acceptance	To be determined.	To be determined.

ACAD:1831CM11.dwg 01/06/05 DM PIT



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CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-1 / REV. 0

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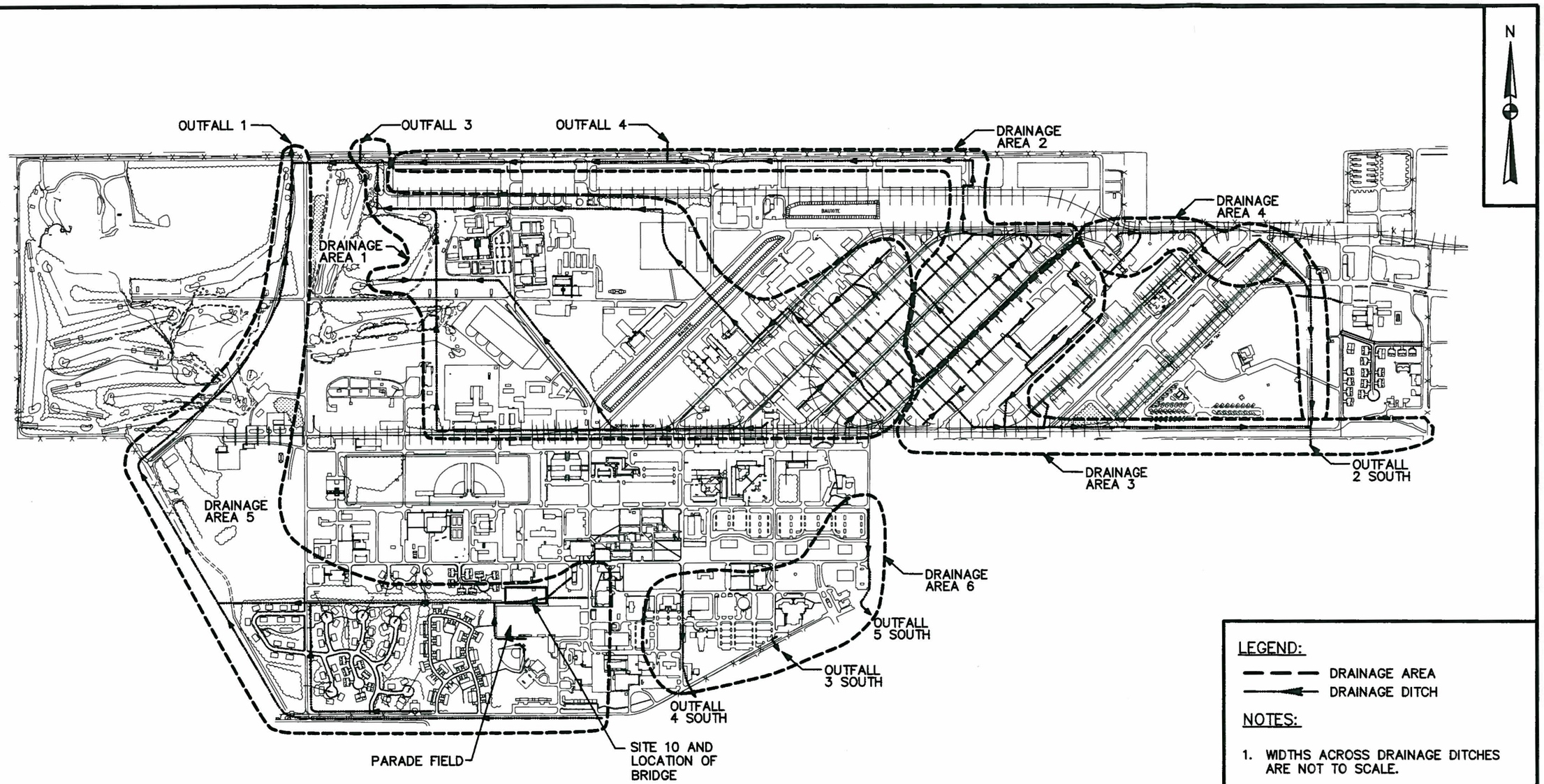
ACAD:1831CM12.dwg 01/06/05 DM PIT



LEGEND:

— — — DRAINAGE AREA

—◄— DRAINAGE DITCH

NOTES:

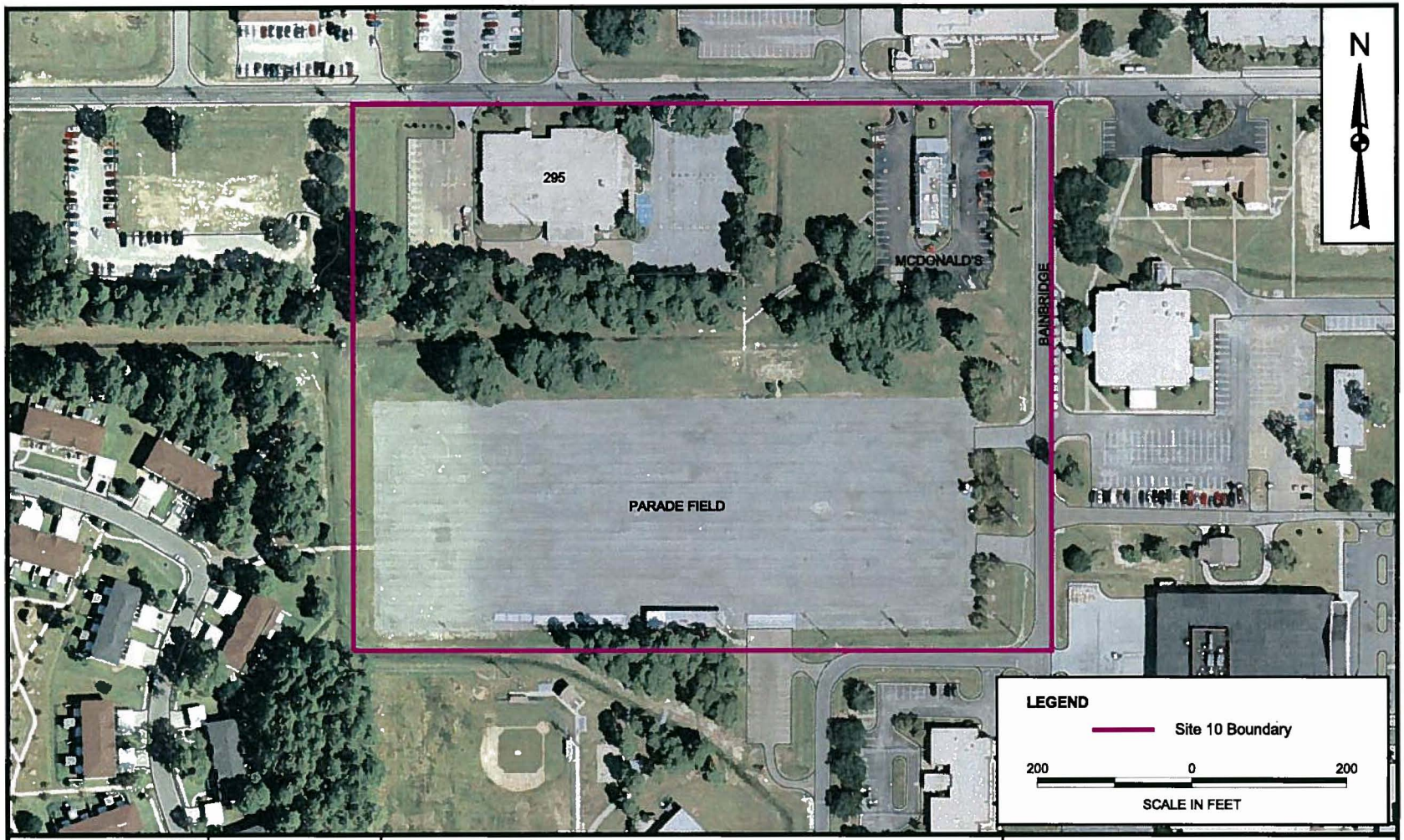
1. WIDTHS ACROSS DRAINAGE DITCHES ARE NOT TO SCALE.

0 1000 2000

GRAPHIC SCALE IN FEET

DRAWN BY DM	DATE 1/6/04	SITE LOCATION MAP REMEDIAL INVESTIGATION AND FEASIBILTY STUDY REPORT NCBC GULFPORT GULFPORT, MISSISSIPPI	CONTRACT NO. 1831
CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 1-2 / REV. 0

FORM CADD NO. SDIV-BH.DWG - REV 1 - 9/10/98



DRAWN BY	DATE
A. JANOCHA	2/25/04
CHECKED BY	DATE
J. BOURGEOIS	2/02/07
COST/SCHEDULE-AREA	
SCALE	AS NOTED

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SITE PLAN
SITE 10 REMEDIAL DESIGN
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 1-3	0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR SITE LAYOUT 2/02/07 SS

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A. JANOCHA	4/28/04
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J. BOURGEOIS	2/02/07
COST/SCHEDULE-AREA	
SCALE	AS NOTED

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1997 PCB DETECTIONS IN SEDIMENT

PARADE FIELD DITCH

SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT

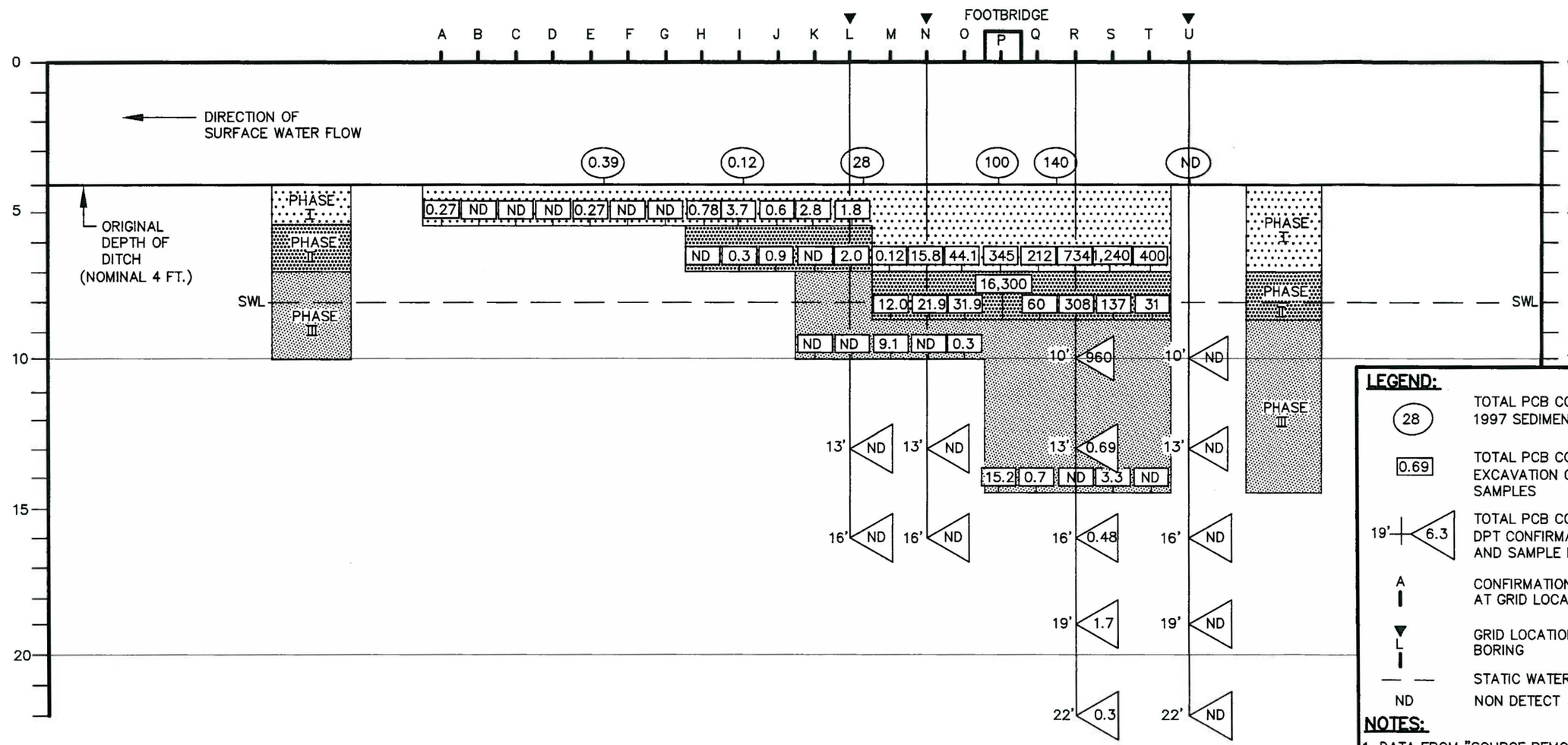
NCBC GULFPORT

GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 1 - 4	0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 1-4 1997 PCB DETECTION LAYOUT 02/02/07 SS

ACAD:1831GT03.dwg 01/06/05 DM PIT



LEGEND:

- (28) TOTAL PCB CONCENTRATION 1997 SEDIMENT SAMPLES
- [0.69] TOTAL PCB CONCENTRATION EXCAVATION CONFIRMATION SAMPLES
- 19' 6.3 TOTAL PCB CONCENTRATION DPT CONFIRMATION SAMPLES AND SAMPLE DEPTH
- A CONFIRMATION SAMPLING AT GRID LOCATION
- L GRID LOCATION WITH SOIL BORING
- STATIC WATER LEVEL
- ND NON DETECT

NOTES:

1. DATA FROM "SOURCE REMOVAL REPORT FOR THE EXCAVATION OF PCB CONTAMINATED SOIL FROM THE DRAINAGE DITCH ADJACENT TO THE PARADE FIELD, NAVAL CONSTRUCTION BATTALION CENTER GULFPORT," CCI 2000
2. CONCENTRATIONS IN PARTS PER MILLION

0 10 20
HORIZONTAL SCALE IN FEET
0 5 10
VERTICAL SCALE IN FEET

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REVISED BY	DATE	
SCALE AS NOTED		

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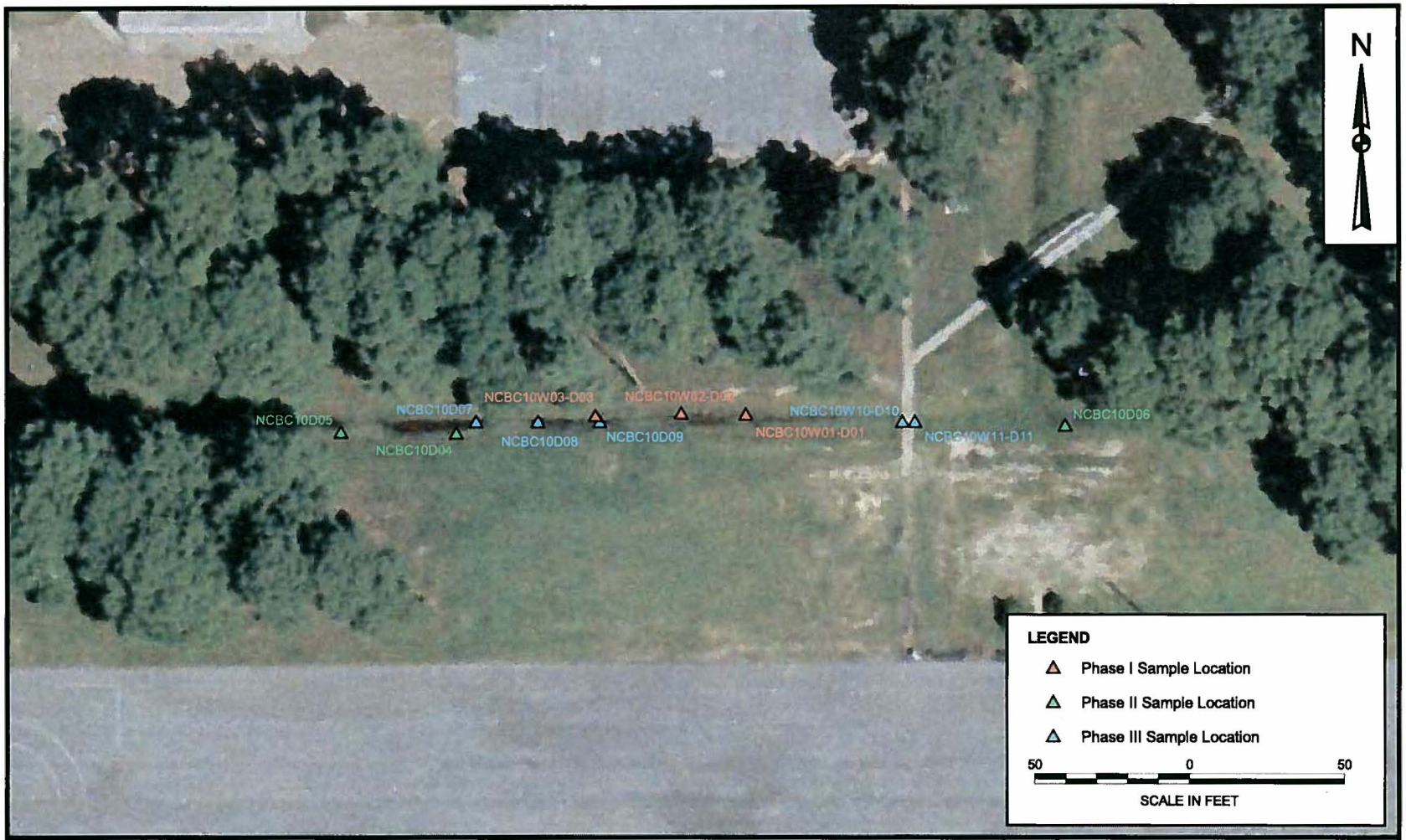
RESULTS OF PREVIOUS PCB SAMPLES
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT
GULFPORT, MISSISSSIPPI

CONTRACT NO. 1831	
OWNER NO. 0000	
APPROVED BY	DATE
DRAWING NO. FIGURE 1-5	REV. 0

FORM CADD NO. SDIV-BH.DWG - REV 1 - 9/10/98



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COST/SCHEDULE-AREA	
SCALE	AS NOTED

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SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS
SITE 10 REMEDIAL INVESTIGATION REPORT
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

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APPROVED BY	DATE
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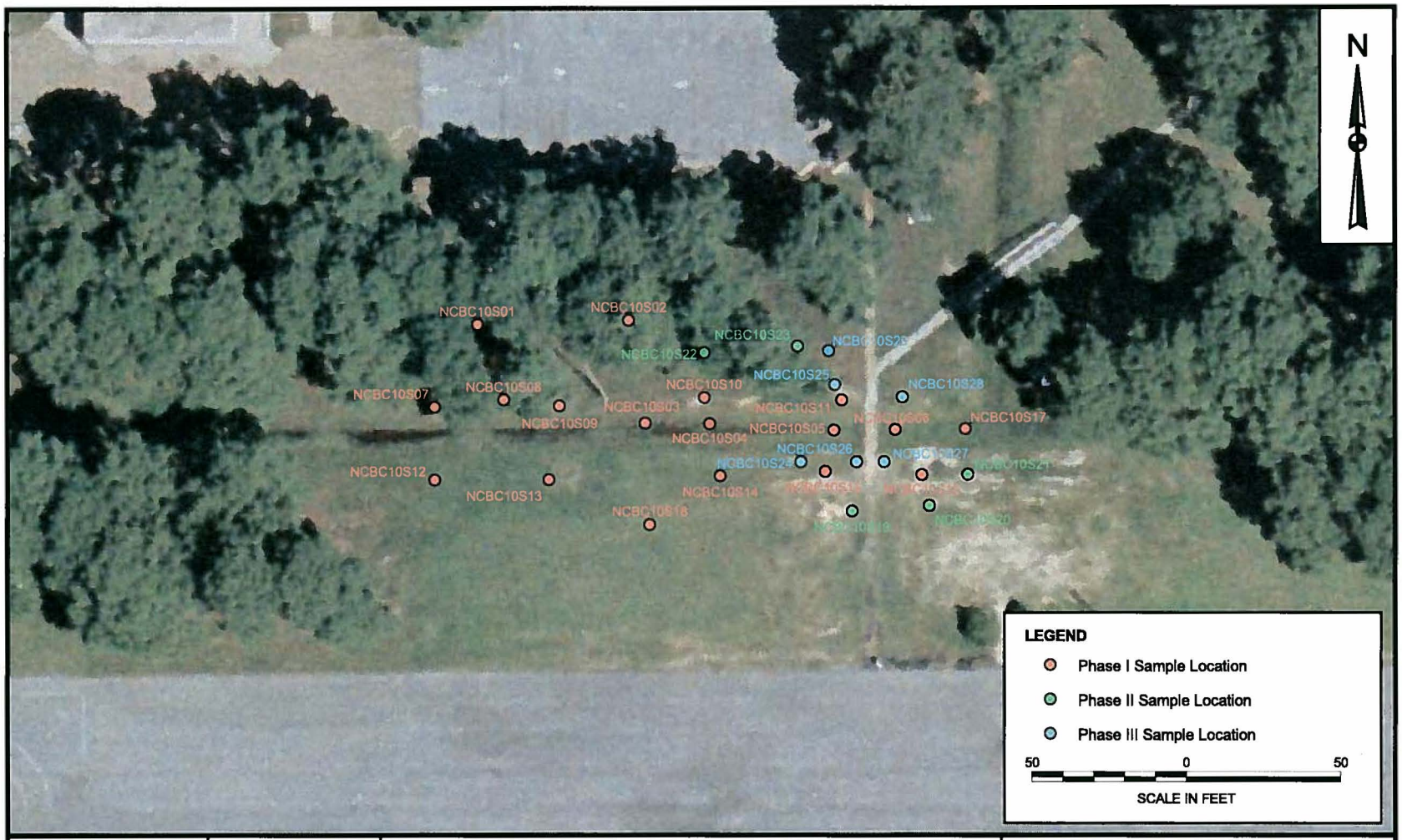
DRAWING NO.	REV
FIGURE 2-1	0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 2-1 SW & SD LOCATION LAYOUT 2/02/07 SS



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A. JANOCHA	2/25/04
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COST/SCHEDULE-AREA	
SCALE	AS NOTED

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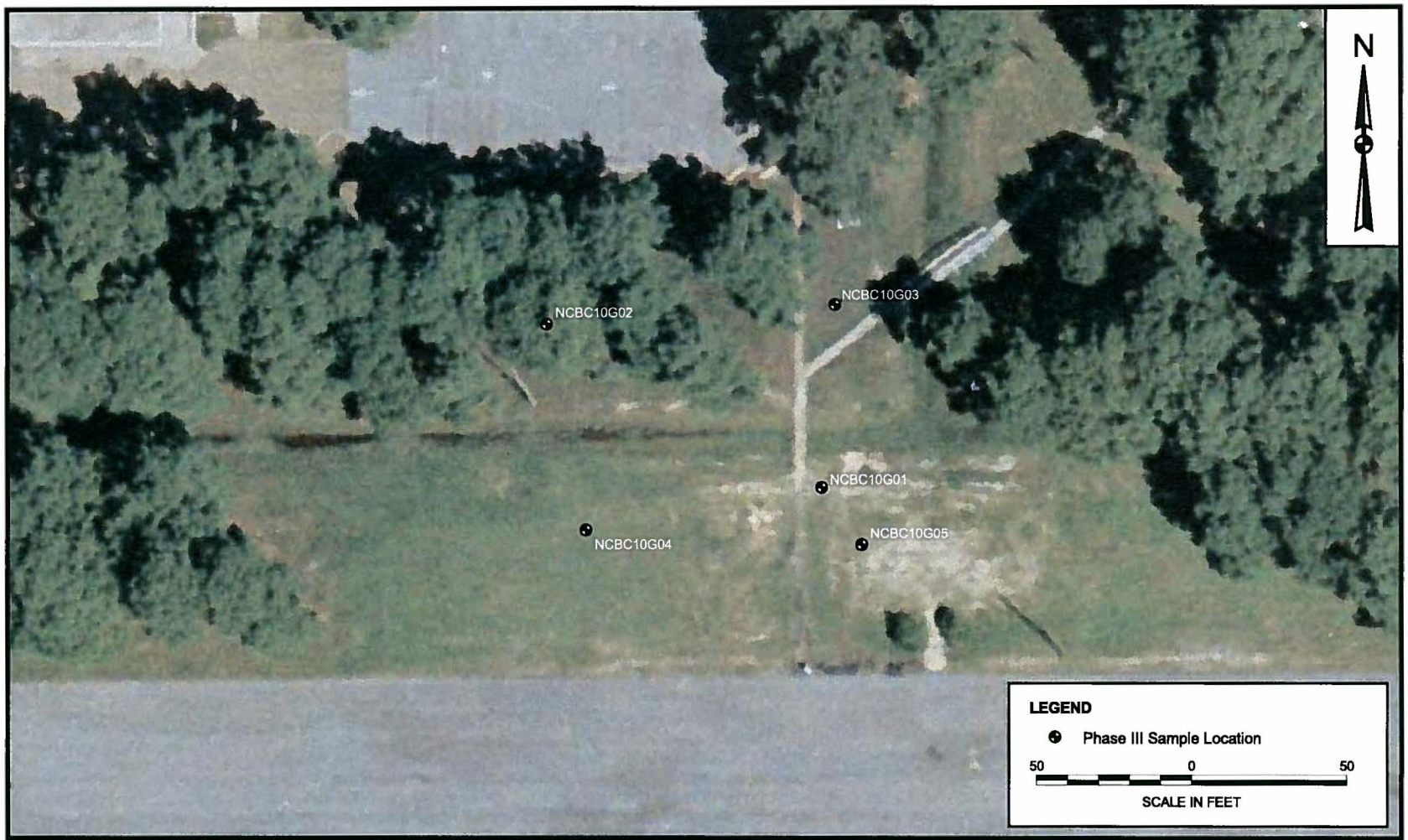
SOIL BORING LOCATIONS
SITE 10 REMEDIAL INVESTIGATION REPORT
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 2-2	0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 2-2 SB LOCATION LAYOUT 2/02/07 SS



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A. JANOCHA	2/25/04
CHECKED BY	DATE
J. BOURGEOIS	2/02/07
COST/SCHEDULE-AREA	
SCALE AS NOTED	

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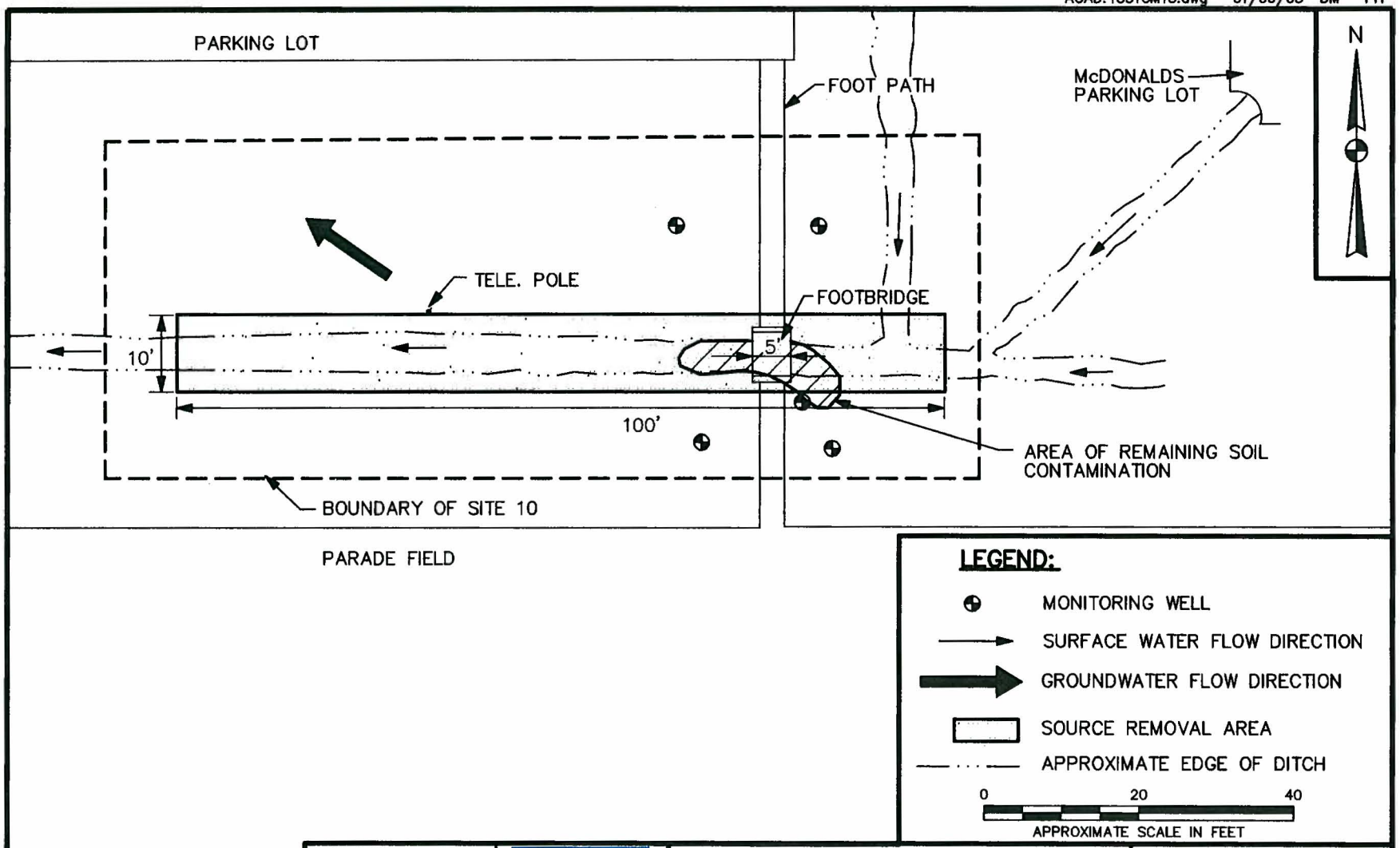
MONITORING WELL LOCATIONS
SITE 10 REMEDIAL INVESTIGATION REPORT
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER 1831	
APPROVED BY —	DATE —
APPROVED BY —	DATE —
DRAWING NO. FIGURE 2-3	REV 0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 2-2 MW LOCATION LAYOUT 2/02/07 SS

ACAD:1831CM13.dwg 01/06/05 DM PIT



DRAWN BY DM	DATE 1/6/05	SURFACE FEATURES OF STUDY AREA SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT NCBC GULFPORT GULFPORT, MISSISSIPPI	CONTRACT NO. 1831
CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 3-1 / REV. 0

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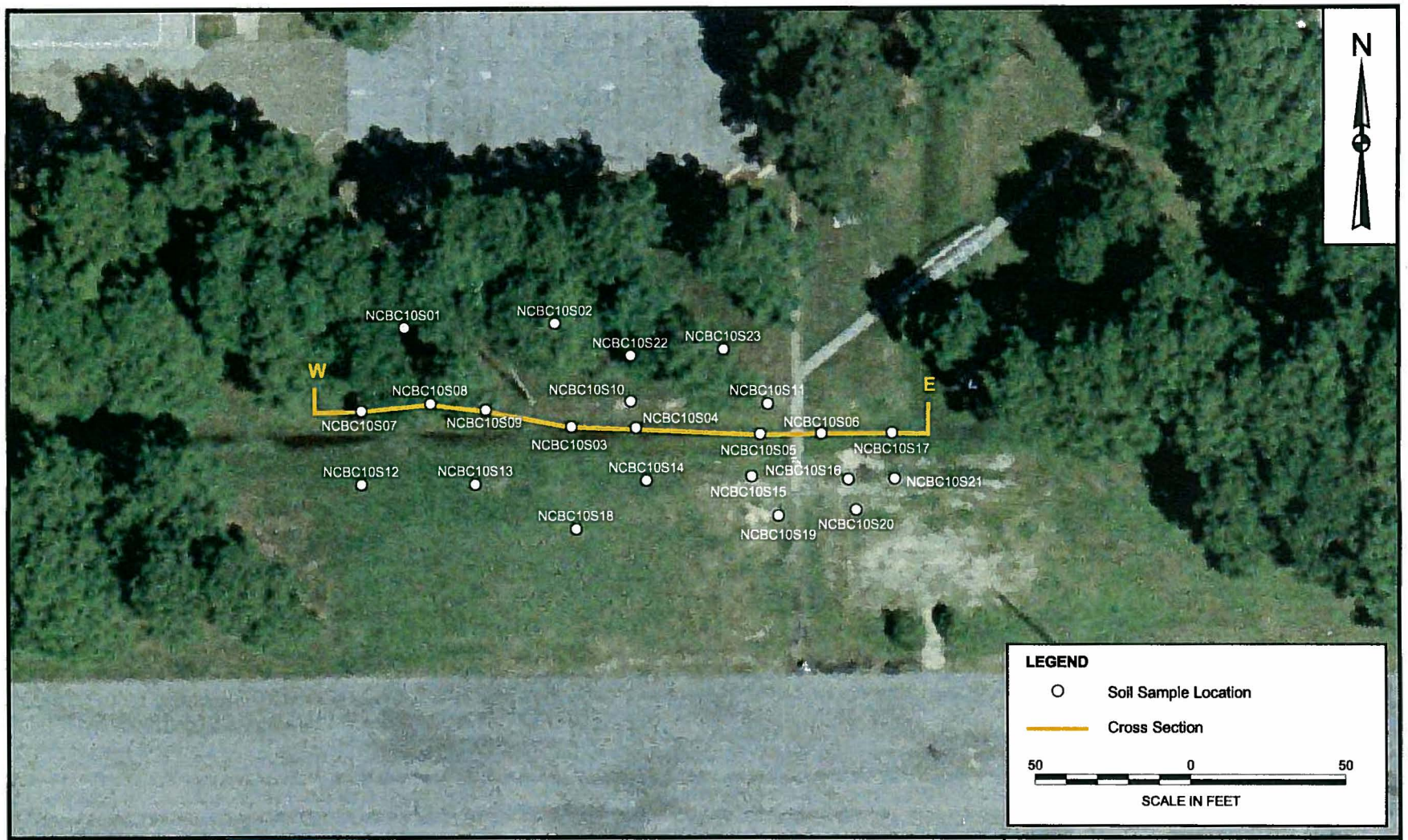
FORM CADD NO. SDIV-AH.DWG - REV 1 - 9/10/98



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A. JANOCHA	4/29/04
CHECKED BY	DATE
B. OLSON	4/30/04
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

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SITE PLAN FOR CROSS SECTION

SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT

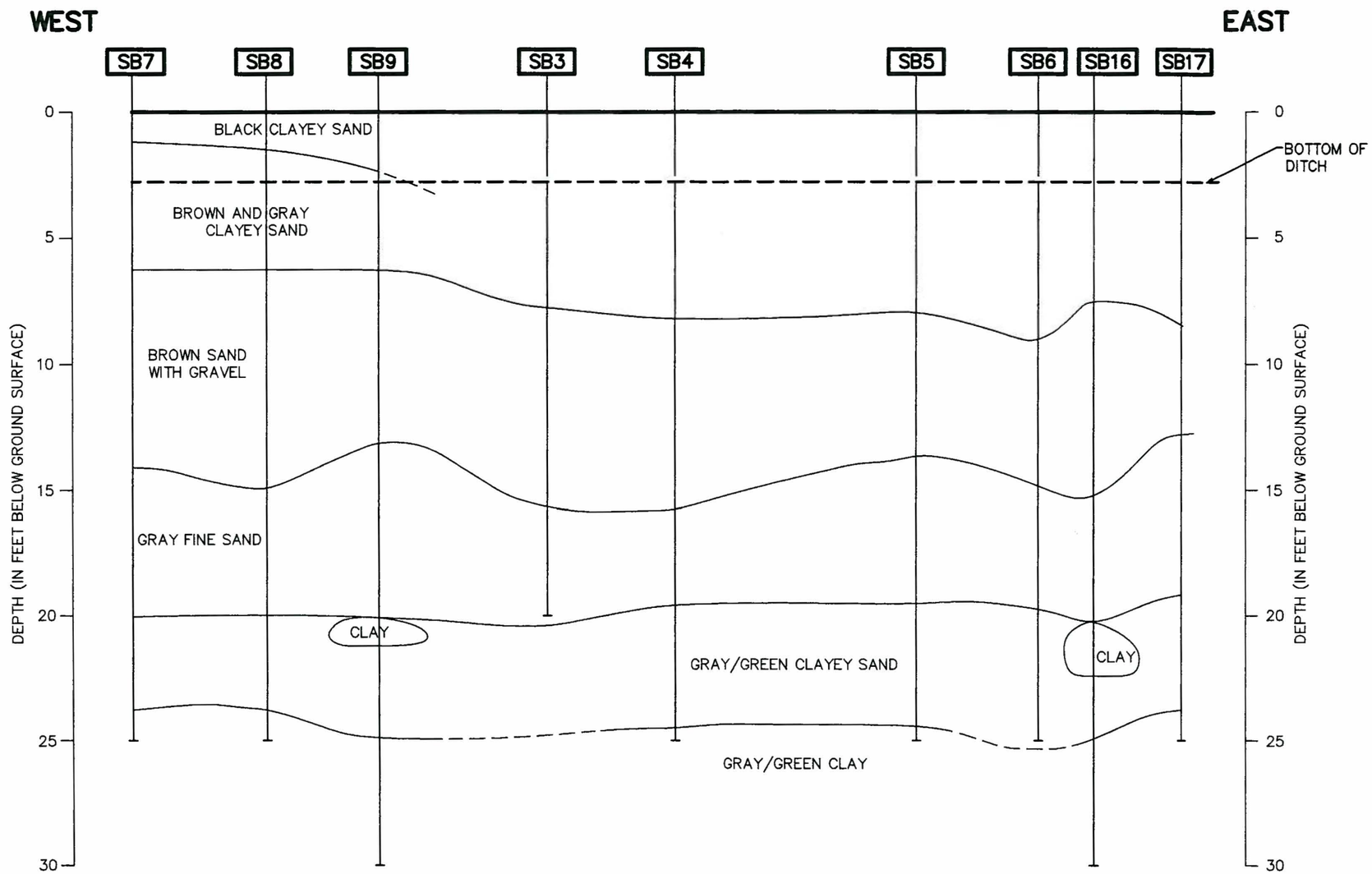
NCBC GULFPORT

GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 3 - 2	0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 3-4 CROSS SECTION LAYOUT 01/06/05 CF

ACAD:1831GX02.dwg 01/07/05 DM PIT



LEGEND:

BORING NUMBER — SB7

GROUND SURFACE

LITHOLOGIC CONTACT (DASHED WHERE INFERRED)

TOTAL DEPTH OF BORING (FT BGS) — TD 25.0

0 20 40
HORIZONTAL SCALE IN FEET

0 5 10
VERTICAL SCALE IN FEET

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CHECKED BY	DATE	
REVISED BY	DATE	
SCALE AS NOTED		

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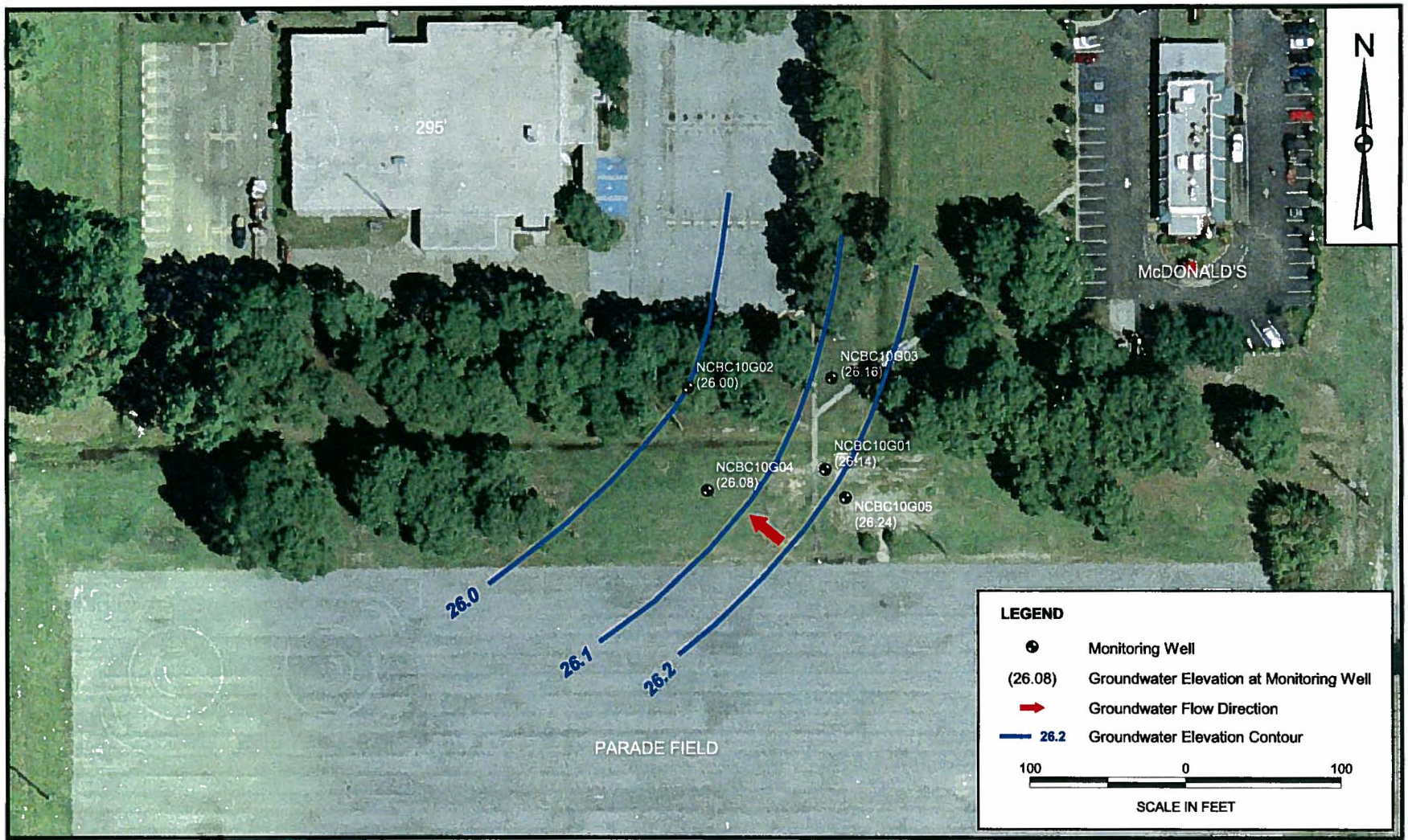
EAST/WEST CROSS SECTION
SITE 10 REMEDIAL INVESTIGATION
AND FEASIBILTY STUDY REPORT
NCBC GULFPORT
GULFPORT, MISSISSIPPI

CONTRACT NO. 1831	
OWNER NO. 0000	
APPROVED BY	DATE
DRAWING NO. FIGURE 3-3	REV. 0

FORM CADD NO. SDIV-BH.DWG - REV 1 - 9/10/98



DRAWN BY	DATE
A. JANOCHA	4/29/04
CHECKED BY	DATE
B. OLSON	4/30/04
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

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GROUNDWATER POTENTIOMETRIC SURFACE - FEBRUARY 2002

SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT

NCBC GULFPORT

GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
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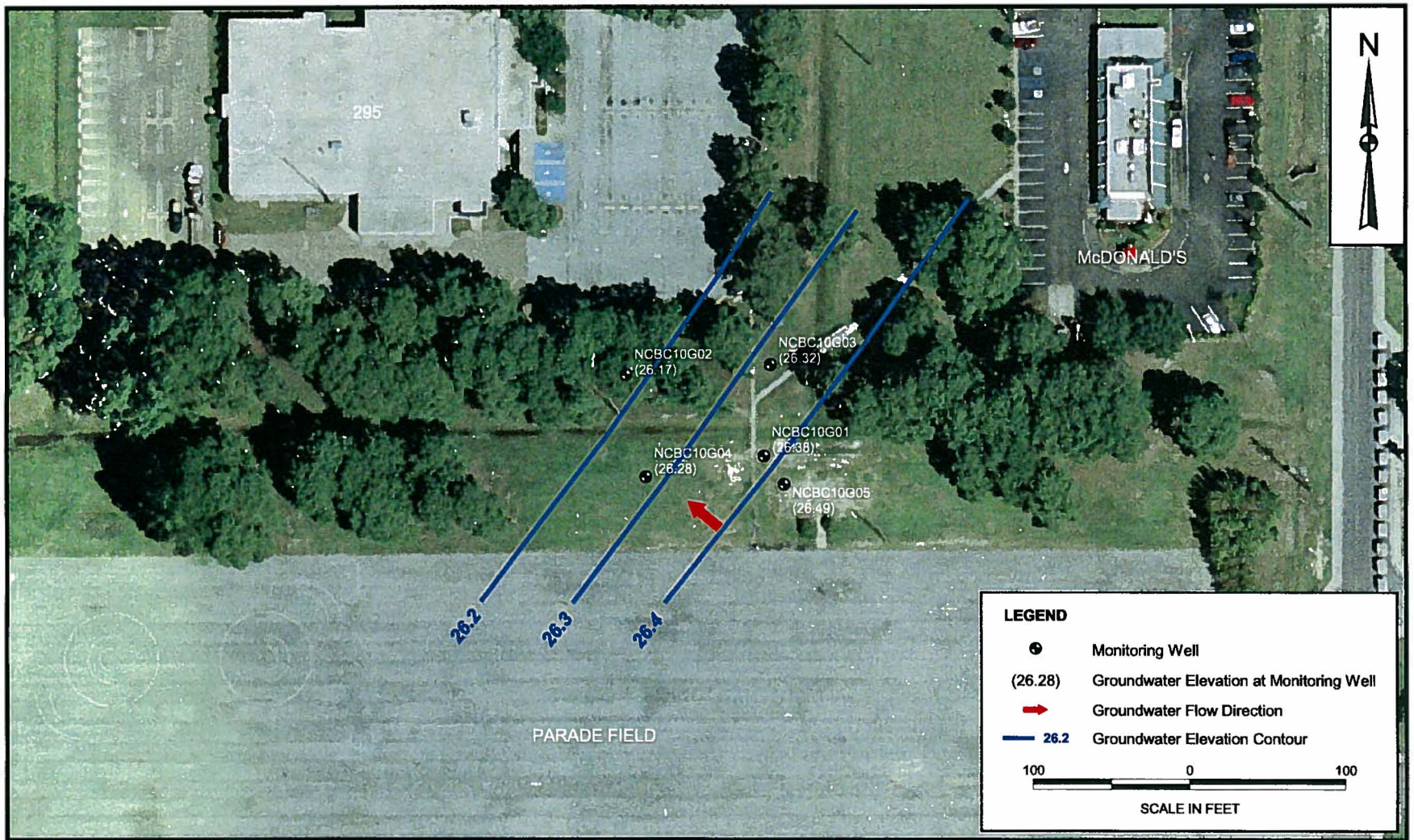
DRAWING NO.	REV
FIGURE 3 - 4	0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 3-6 POTENTIOMETRIC CONTOUR FEBRUARY 2002 LAYOUT 01/06/05 CF



DRAWN BY	DATE
A. JANOCHA	4/29/04
CHECKED BY	DATE
B. OLSON	4/30/04
COST/SCHEDULE-AREA	
SCALE	AS NOTED

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GROUNDWATER POTENTIOMETRIC SURFACE - DECEMBER 2003

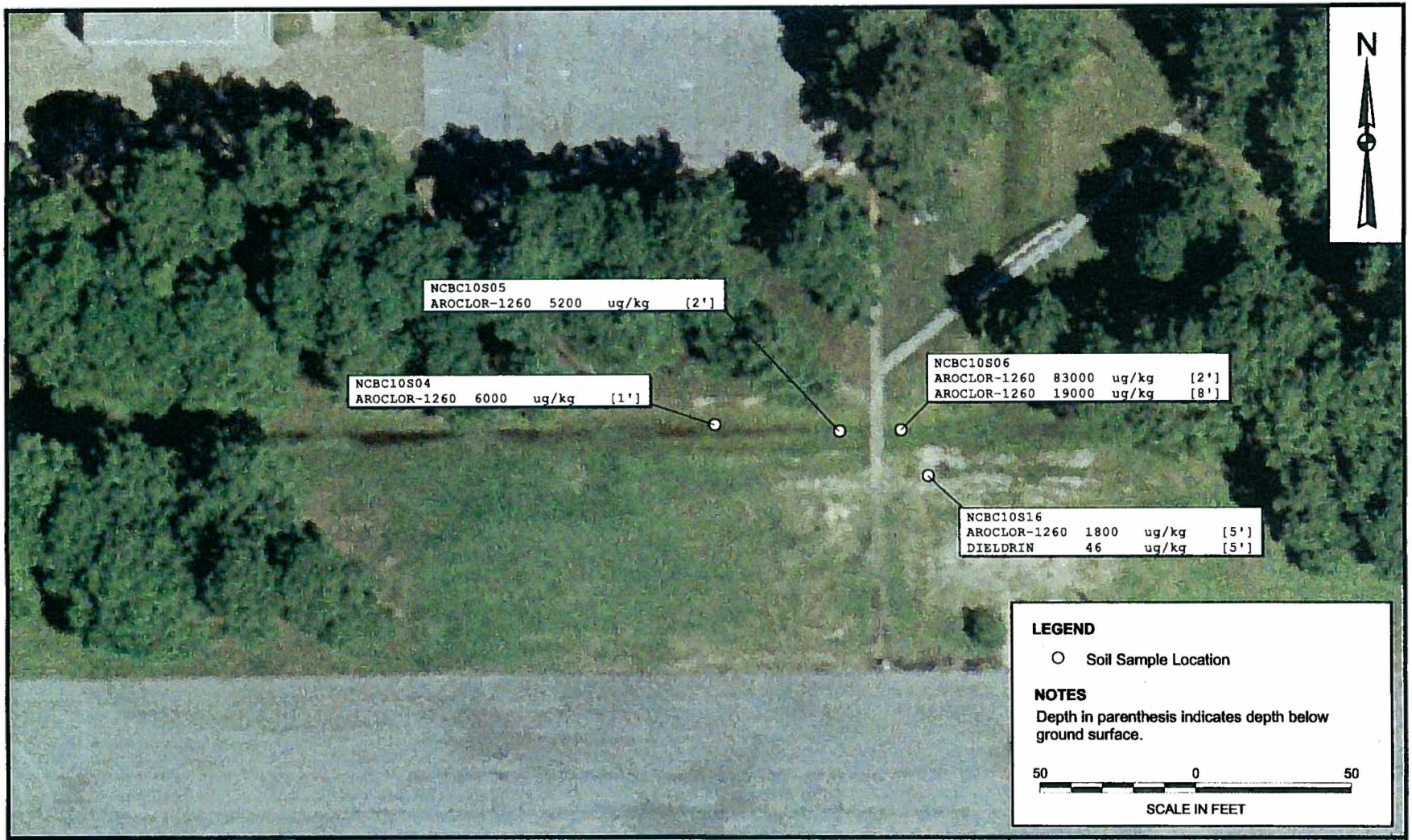
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT

NCBC GULFPORT

GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 3 - 5	0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 3-7 POTENTIOMETRIC CONTOUR DECEMBER 2003 LAYOUT 01/06/05



DRAWN BY	DATE
A. JANOCHA	4/29/04
CHECKED BY	DATE
B. OLSON	4/30/04
COST/SCHEDULE-AREA	
SCALE	AS NOTED

SOIL TRG EXCEEDANCES - ORGANICS

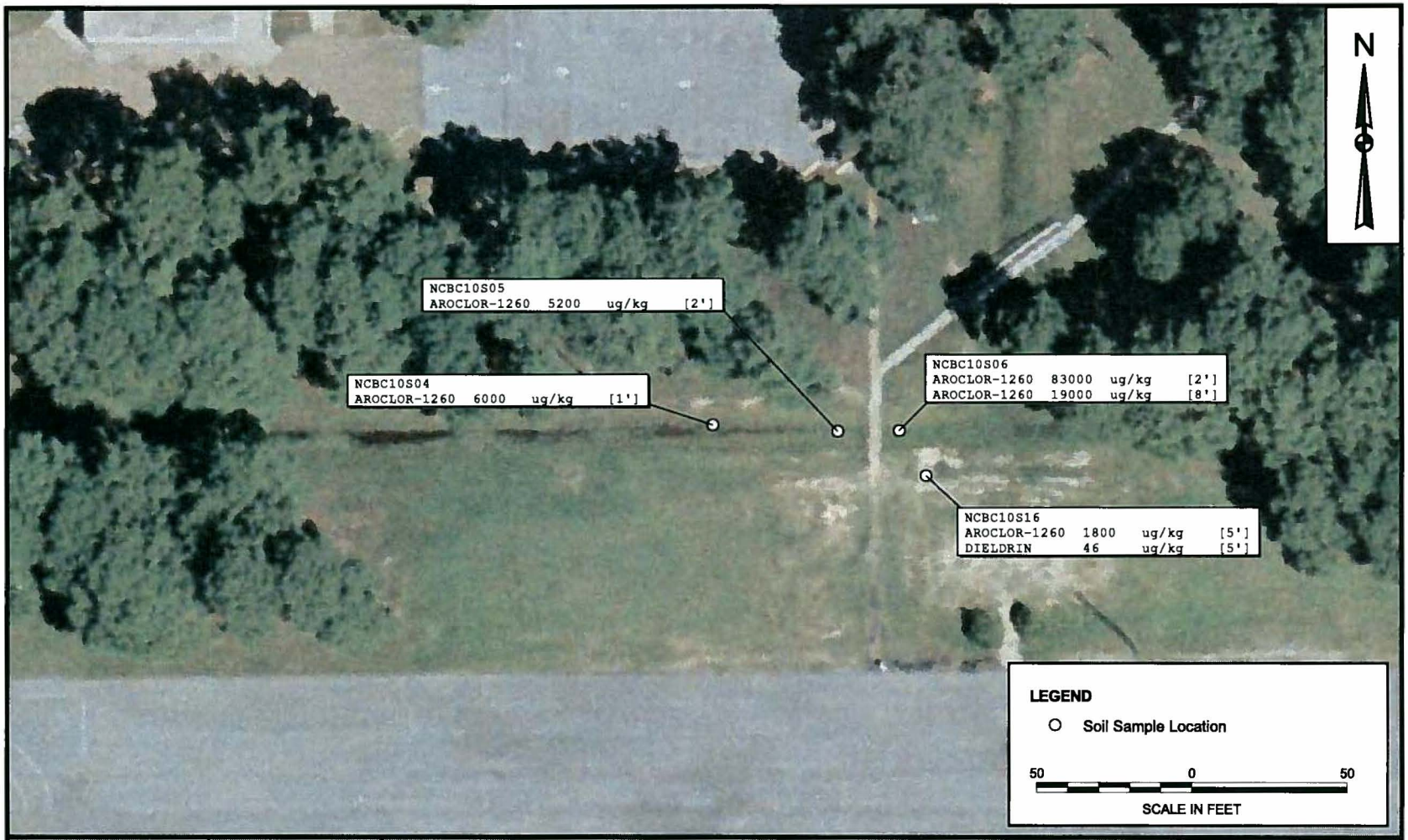
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT

NCBC GULFPORT

GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO. FIGURE 4 - 1	REV 0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 4-2 SOIL ORGANIC LAYOUT 01/06/05 CF



DRAWN BY	DATE
A. JANOCHA	4/29/04
CHECKED BY	DATE
J. BOURGEOIS	2/02/07
COST/SCHEDULE-AREA	
SCALE	AS NOTED

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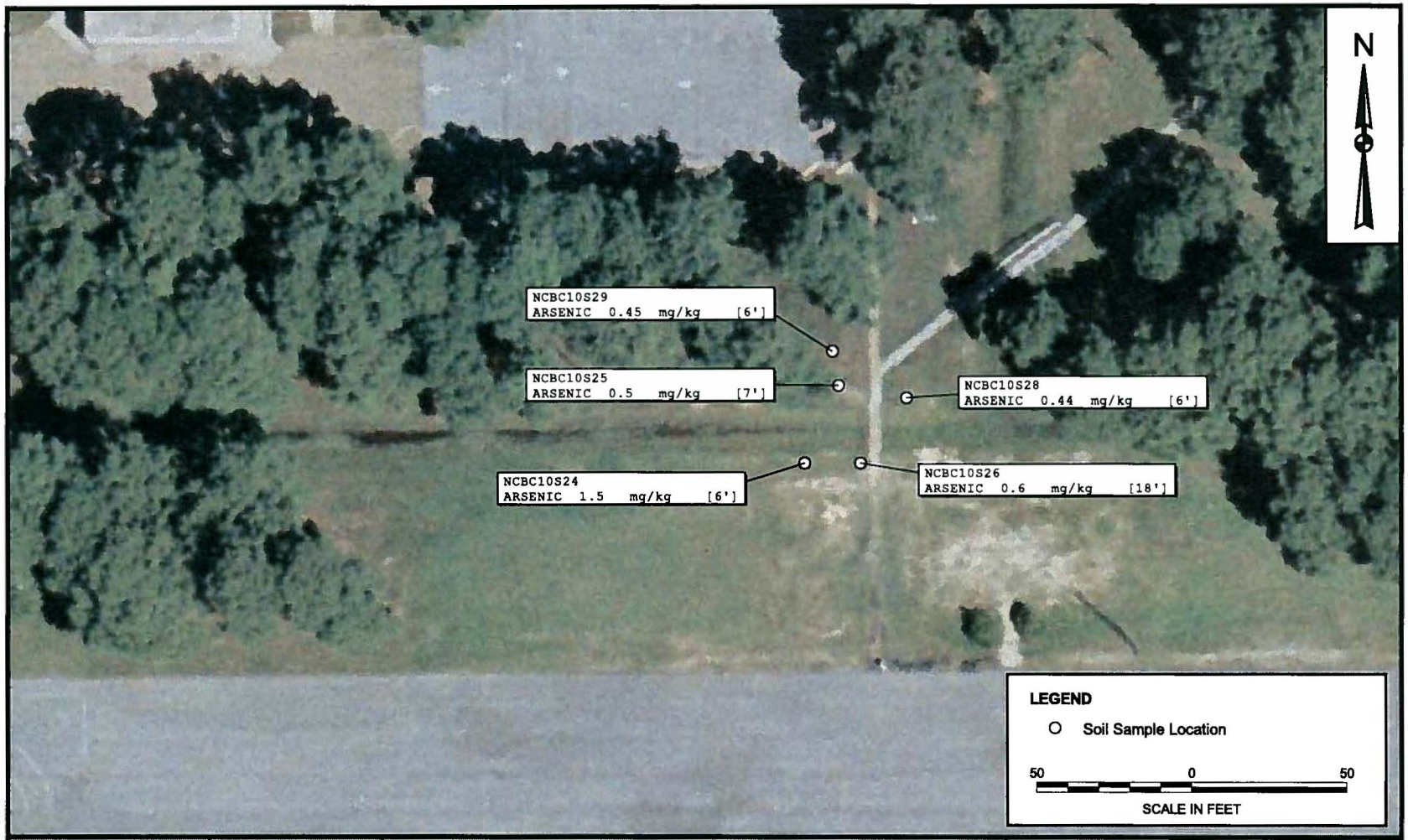
SOIL TRG EXCEEDANCES - ORGANICS
SITE 10 REMEDIAL INVESTIGATION REPORT
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO. FIGURE 4-2	REV 0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 4-2 SOIL ORGANIC TAG LAYOUT 2/02/07 SS



DRAWN BY	DATE
A. JANOCHA	4/29/04
CHECKED BY	DATE
J. BOURGEOIS	2/02/07
COST/SCHEDULE-AREA	
SCALE	AS NOTED

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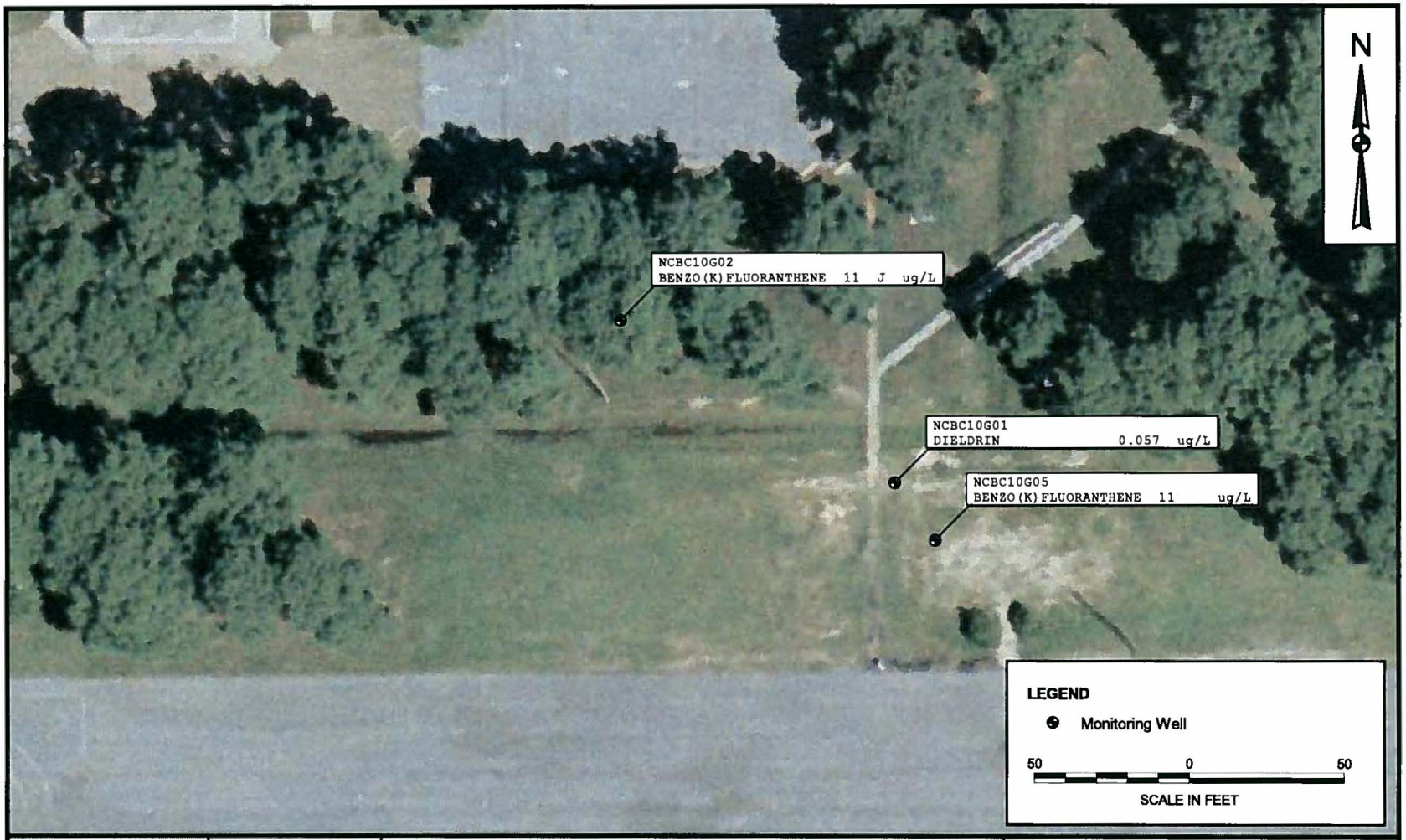
SOIL TRG EXCEEDANCES - INORGANICS
SITE 10 REMEDIAL INVESTIGATION REPORT
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 4-3	0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 4-3 SOIL INORGANIC LAYOUT 02/02/07 SS



DRAWN BY	DATE
A. JANOCHA	4/30/04
CHECKED BY	DATE
J. BOURGEOIS	2/02/07
COST/SCHEDULE-AREA	
SCALE	AS NOTED

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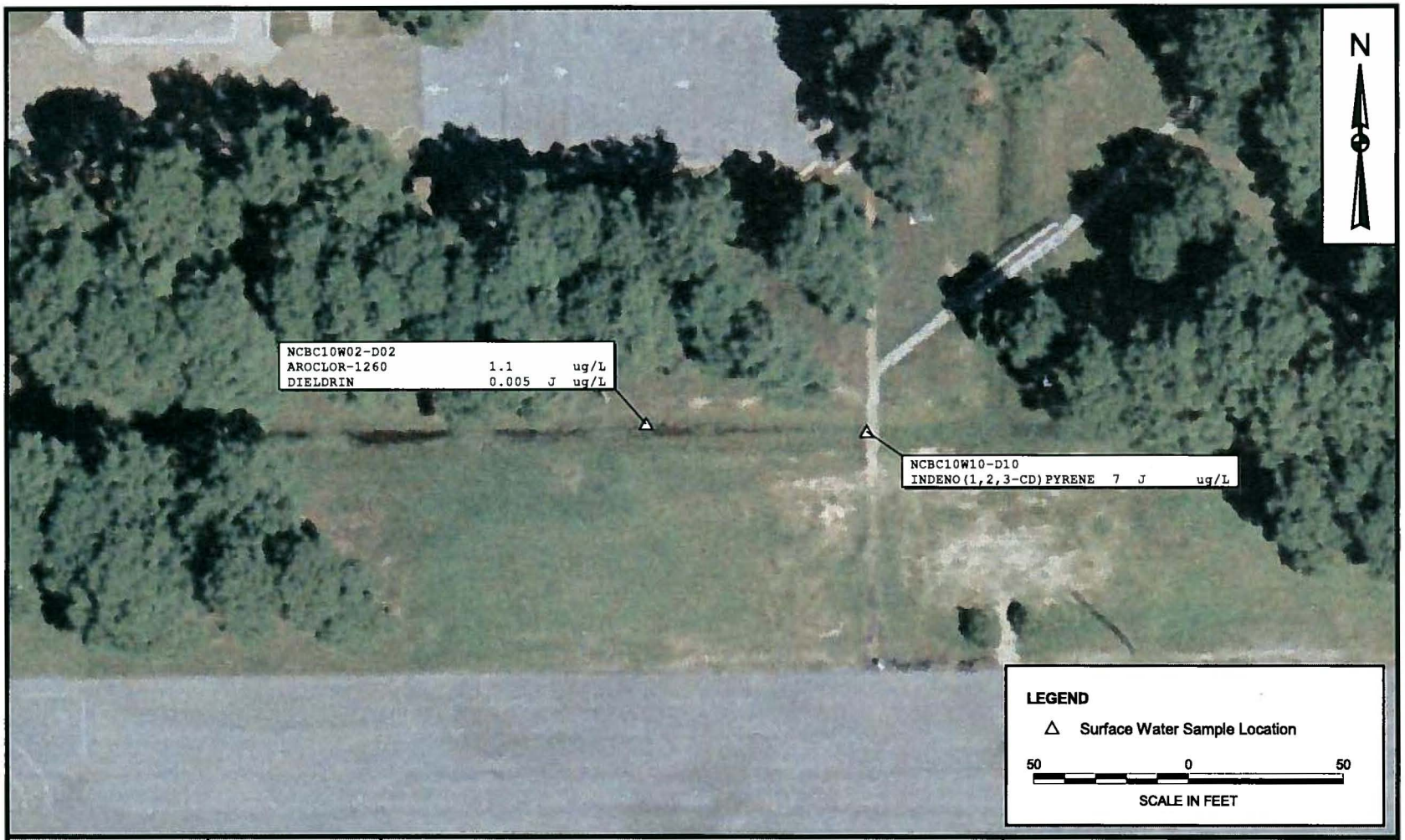
GROUNDWATER TRG EXCEEDANCES
SITE 10 REMEDIAL INVESTIGATION REPORT
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 4-4	0

P:\GIS\GULFPORT_CBC\APR\SITE10_APR 4-4 GROUNDWATER TAG LAYOUT 2/02/07 SS



DRAWN BY	DATE
A. JANOCHA	4/30/04
CHECKED BY	DATE
J. BOURGEOIS	2/02/07
COST/SCHEDULE-AREA	
SCALE AS NOTED	

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SURFACE WATER CRITERIA EXCEEDANCES
SITE 10 REMEDIAL INVESTIGATION REPORT
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER 1831	
APPROVED BY —	DATE —
APPROVED BY —	DATE —
DRAWING NO. FIGURE 4-5	REV 0

P:\GIS\GULFPORT_CBC\APR\SITE10.APR 4-5 SURFACE WATER TAG LAYOUT 2/02/07 SS

DRAWN BY	DATE
C. FOSTER	01/06/05
CHECKED BY	DATE
M. JAYNES	02/02/07
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

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AERIAL EXTENT OF CONTAMINATION

SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT

NCBC GULFPORT

GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 8 - 1	0

P:\GIS\GULFPORT_CBC\MAPDOCS\APR\SITE10.APR AREAL EXTENT OF CONTAMINATION 02/02/07 SS

DRAWN BY	DATE
C. FOSTER	12/08/04
CHECKED BY	DATE
M. JAYNES	02/02/07
COST/SCHEDULE-AREA	
SCALE	AS NOTED

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ALTERNATIVE 2 - INSTITUTIONAL CONTROLS AND MONITORING
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT
GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO. FIGURE 10 - 1	REV 0

P:\GIS\GULFPORT_CBC\MAPDOCS\APR\SITE10.APR ALTERNATIVE 2 LAYOUT 02/02/07 SS

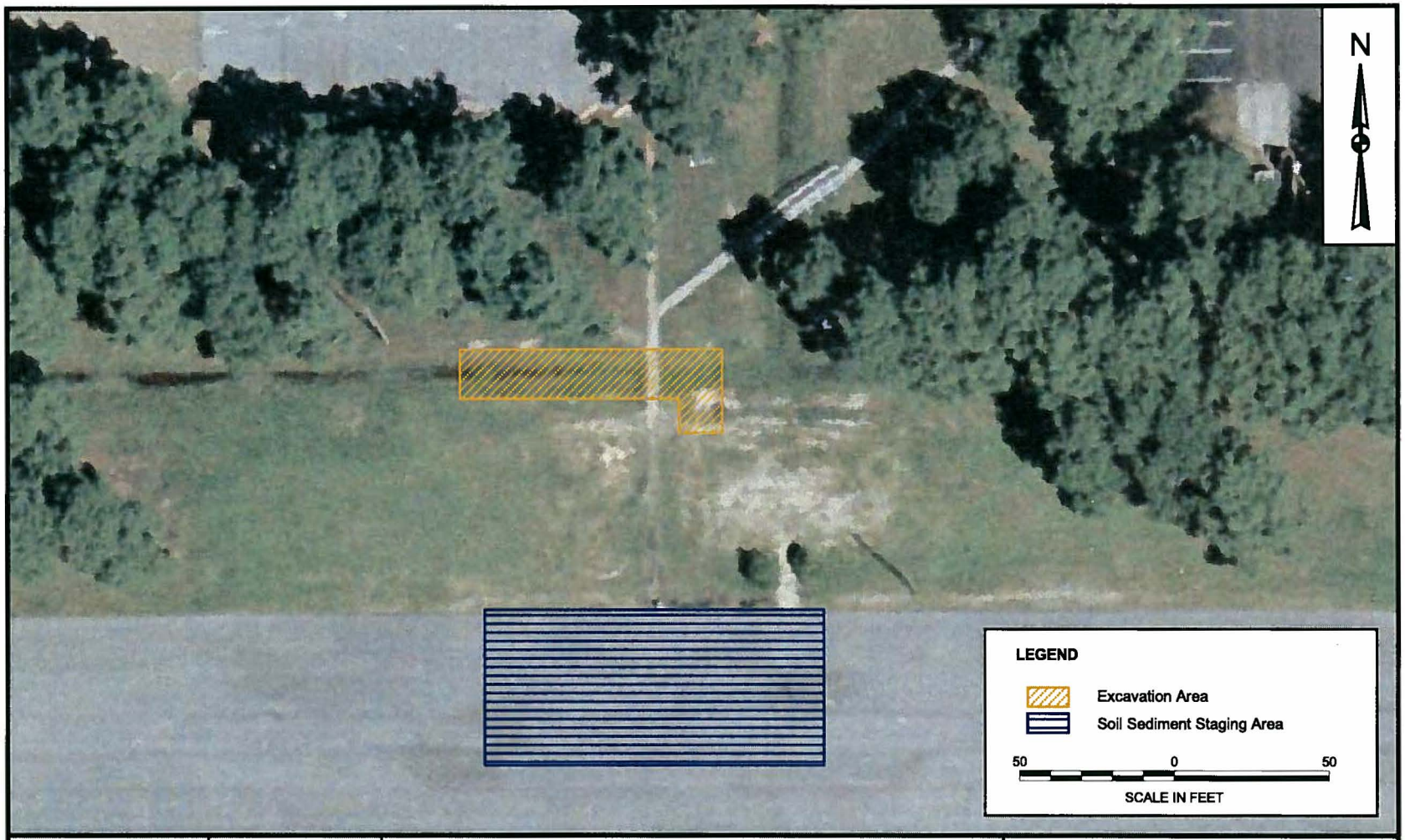
DRAWN BY	DATE
C. FOSTER	12/08/04
CHECKED BY	DATE
M. JAYNES	2/02/07
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

NAVFAC

ALTERNATIVE 3 - SURFACE WATER CONTROLS, EXCAVATION, SURFACE PROTECTION, INSTITUTIONAL CONTROLS, AND MONITORING
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT
GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 10 - 2	0

P:\GIS\GULFPORT_CBC\MAPDOCS\APR\SITE10.APR ALTERNATIVE 3 LAYOUT 02/02/07 SS



DRAWN BY	DATE
C. FOSTER	12/08/04
CHECKED BY	DATE
M. JAYNES	2/02/07
COST/SCHEDULE-AREA	
SCALE	AS NOTED

NAVFAC

ALTERNATIVE 4 - SURFACE WATER CONTROLS EXCAVATION
DEWATERING OFF-SITE TREATMENT AND DISPOSAL OF EXCAVATED SOIL
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NCBC GULFPORT
GULFPORT, MISSISSIPPI

CONTRACT NUMBER		
1831		
APPROVED BY	DATE	
—	—	
APPROVED BY	DATE	
—	—	
DRAWING NO.		REV
FIGURE 10 - 3		0

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APPENDIX A

FIELD DATA FORMS

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page ___ of ___

Project Site Name: NCBC Gulfport Site 10
Project No.: 1831

Sample ID No.: SD1006D01
Sample Location:
Sampled By:
C.O.C. No.:

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

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

GRAB SAMPLE DATA:

	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 12-19-03	6"		
Time: 1300			
Method: grab			
Monitor Reading (ppm): 0			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
VOA			
SVOA			
Pest/PCB			
Herb			
Metals			
CN-			
Atterberg Limits			
Grain Size			

OBSERVATIONS / NOTES:

MAP:

Circle If Applicable:

MS/MSD

Duplicate ID No. SD1006D01MS/MD

Signature(s):

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200 Geoprobe

BORING No.: SB-1
DATE: 01/12/02
GEOLOGIST: J Barton
DRILLER:

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			50			black	Sandy Clay			0	0	0	0
						dk gray	silty-f.g. sand			0			
						ltgray	f g sand			0			
										0			
5										0			
			90							0	0	95	0
						tan	Sand			0			
						dk brown	finegrained sand			0			
							-w/ coarse grained +		gravel spread	0			
							throughout			0			
10			90			gray brown	silty fine grained sand						
						dk gray							
							gravelly-coarse sand						
15			80			lt gray	fine grained sand						
						dk gray	Gravelly finegrained sand						
							silty-sand						
20			100			gray green	clayey sand			0	0	0	0
							fine grained silty sand			0			
										0			
										0			
25							clay		5' of clay	0			

* 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): X

Remarks:

Converted to Well: Yes ___ No X Well I.D. #:

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200 Geoprobe

BORING No.: SB-2
DATE: 01/12/02
GEOLOGIST: J. Barton
DRILLER:

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			80%			black	Sandy-clay			0.9	0.3	154	1.0
						dk	silty-f.g. Sand			0.5			
						gray	↓		mottled	0.5			
						lt. gray	f.g. sand			0.9			
5						↓	↓			2.1			
			80%							1.4	0	237	1.2
						tan	Sand			0.2			
						dk brown	gravelly-sand			2.8			
						↓	Sand to fine-grained			0			
							Sand-w/sporadic		gravel	0			
10										0			
			90%				Silty-fine-grained sand			0	0	554	0
						dk gray				1.2	~~0~~	~~348~~	~~0~~
										0.5			
							↓			0.5			
						↓	gravelly-coarse Sand			2.2			
15						lt gray	fine-grained sand			0	0	348	0
			80%							1.2			
							↓			0.6			
						dk gray	Gravelly-f.g sand			0			
						dk gray	silty-sand			0			
20						gray green	clayey-sand			0	0	1.3	0
			100				fine-grained silty sand			0			
							↓			0			
										0			
						↓	clay			0			
25													

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200-Geoprobe

BORING No.: SB-3
DATE: 01/11/02
GEOLOGIST: J. Barton
DRILLER:

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		0				No Recovery			–	0	/	0
			?			dark gray	sandy-clay		mottled	0	0	/	0
	5			*		lt. gray	fine grained sand			0.4			
						reddish brown	gravelly-san			1.0			
										0.9			
										0.9			
			90%			lt. brown	fine-grained sand w/ gravel			1.5	0	/	0
	10									1.3			
										2.8			
										1.8			
										2.4			
			9.5ft			lt. brown	fine-grained san			2.3	0	/	0
	15					lt. gray				3.8			
										4.6			
										3.6			
						dk gray	sandy-clay			0			
	20												

* 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: Rig - 2ft above ground surface
-bore hole under water
* Did not have intact sleeve, had to hammer sample out of rod

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200-Geoprobe

BORING No.: SB-4
DATE: 01/11/02
GEOLOGIST: J. Barton
DRILLER:

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		0				No Recovery		-Rod-full of water	-	-	-	0
							↓						
			90%			orange/gray	sandy clay			35	0.5		0
	5					dk gray	clayey-Sand			98.8			
						pigeon brown	Sand to fine grained sand			4.7			0
							w/ sporatic gravel			1.9			
						↓	↓			1.4			
			80			lt brown/tan	fine grained sand-			1.6	0.3	-	0
	10						w/ gravel			3.7			
							↓			4.3			
										1.6			
						↓	↓			0.7			
			90			tan	fine grained sand			6.6	0	-	0.1
	15					lt. gray	↓			6.4			
						↓	↓			0			
						gray/brown	silty-sand			1.0			
						dk gray	clayey-sand			0.0			
			100			gray/green	clayey-f.g. sand			1.4	0	-	0
	20						silty fine-grained sand			5.4			
							↓			4.3			
							Sandy clay			2.4			
						↓	clay			1.3			
	25												

* 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: -Rig - starting 2 ft above ground surface
-Not able to get a borehole FID reading - borehole under water

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Fugro
DRILLING RIG: 5280-Geoprobe

BORING No.: SB-5
DATE: 01/11/02
GEOLOGIST: J. Barton
DRILLER:

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		60%			brown orange	silty-clay		mottled	3.6	0	/	0
						dk gray brown	clayey-sand			1157			
										1616			
						green brown	2 inches - sand			509			
	5					dk brown	8 inches - sand			1169			
			0%				NO Recovery		~~sandy to~~	/	0	/	0
			80%			reddish brown	silty fine-grained sand			7.1	0	/	0
	10									2.3			
						brown	sand			1.4			
						lt. brown	fine grained sand			4.8			
			100							5.7			
						lt. brown gray	fine grained sand			1.2	0	/	0
	15					lt. gray				4.2			
										21			
										28			
						dk gray	sandy-clay			0.8			
			100			green gray	sandy-clay		fine grained	0.1	0	/	0
	20									0			
							fine-grained sand			0			
										0			
							clay			0			
	25												

* 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: Rig - 2 Ft above ground surface
Borehole - under water

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200 - Geoprobe

BORING No.: SB-6
DATE: 01/11/02
GEOLOGIST: J. Barton
DRILLER:

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		30%			orange gray	silty - clay		mottled	7.4	0	/	0
										7.8			
			10%			dk brown gray	fine grained sand			10.6	0	/	0
							No Recovery						
	5												
			80			dk gray brown reddish brown	fine grained sand			202	0	/	0
							gravelly fine-grained sand			11.4			
										1.9			
	10									7.6			
										15.9			
			90			brown lt brown tan	fine grained sand			0.8	0	/	0
										1.7			
										1.7			
	15									1.9			
						lt gray dk gray gray green	grades from fine to coarse sand		progressively darker	0.7			
			100				clay sand			2.1	0	/	0
							fine-grained sand			8.5			
										8.4			
	20						sandy clay			2.1			
										0.9			

* 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: - Borehole under water
- Rig ~7 ft above ground surface

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Fugro
DRILLING RIG: 5200 - Geoprobe

BORING No.: SB-07
DATE: 01/10/02
GEOLOGIST: J. Barton
DRILLER:

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		90%			black	clayey sand w/organics			0	0.0		0.0
						gray brown	clayey sand		mottled w/ orange	0			
	5						progressive		becoming predominately	0			
							sandy-clay		orange as get deeper	0			
						gray-brown taupe	silty-sand			0			
			80%						mostly root	0	0.0	1.3	0.0
						dk. brown	sand			0			
						reddish brown	sand			0			
										0			
	10									0.7			
			85%				gravelly-sand			0	0.0	0.0	0.0
						lt. brown	fine grained sand			0			
										0			
										0			
	15					lt. gray	fine-grained sand			0			
			100%							0	0	0.7	0
										0			
						DK Gray	fine-grained sand-			0			
							sporatic gravel			0			
										0			
	20												
			90%			Gray Green	very fine silty-sand			0	0	2.8	0.0
										0			
							sandy-clay			0			
										0			
	25						clay			0			

* When rock coring, enter rock brokeness.

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

Remarks:

Drilling Area Background (ppm): 0.

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Fungo
DRILLING RIG: 5200 Geoprobe

BORING No.: SB-08
DATE: 01/10/02
GEOLOGIST: J. Barton
DRILLER:

Depth (Ft.)	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				80%			black	clayey-sand w/organics			0.2	0.3	5.2	0.7
							dk. grey	- sand			0.2			
											0.2			
							grey	clay-sand		-mottled w/orange	0.1			
							lt. grey	fine grained - sand			0.2			
5				60%								0.2	4.8	0.7
							dk brown gray	silty - sand						
							reddish color	sand w/ gravel		- dk brown mottle				
10				0				No Recovery			/	/	23	0.5
15				90%			Gray Brown	Silty - Sand - fine grained			0.9	0.7	11.7	0.1
								silty - sand w/ sporatic gravel			0.2			
											0.2			
											0.2			
20							dk. Gray Brown			last inch sandy clay	0.2			
				50%			Gray Grey	Clayey - fine - grained sand			0.1	0.3	14	0.3
								sandy clay			0.1			
								silty - fine grained sand			0.2			
								clayey sand			0.1			
25								clay			0.4			

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0.4

Remarks: 0.0 - when rig is not running

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200-Geoprobe

BORING No.: SB-09
DATE: 01/10/02
GEOLOGIST: J. Barton
DRILLER:

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			80%			black	clayey-sand w/			0.9	1.1	2.4	1.4
						↓	organics			0.7			
						lauper brown-gray	silty-sand			0.8			
						↓				0.8			
						lt. gray	fine-grained sand		3inch band of white sand @ 4.5 ft. coarser	0.8			
5			80%			↓				0.9	1.1	1.8	1.7
						gray-brown	fine-grained sand			1.0			
						dk. brown	- sand w/ gravel			2.1			
						reddish brown	- sand w/ gravel			0.9			
						↓				0.9			
10			75%			brown	- sand - sporatic			0.7	0.9	1.4	0.7
						↓	gravel			0.9			
						tan	- fine-grained sand			0.8			
						gray	↓			0.7			
						↓	↓			0.7			
15			60%							1.2	0.7	3.0	1.8
							w/silt			1.2			
							↓			1.3			
							↓			1.4			
						dk gray	clayey-sand			1.1			
20			60%			gray green	sandy-clay			1.0	0.9	4.0	1.1
							clay			1.0			
							clayey-fine-grained			1.2			
							sand			1.2			
						↓	sandy-clay			0.9			

* When rock coring, enter rock brokeness.

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

Remarks: -0.0- when rig not running

Drilling Area Background (ppm): 0.4

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200 -Geoprobe

BORING No.: SB-09
DATE: 01/10/02
GEOLOGIST: J. Barton
DRILLER:

	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**
25				100			gray green	clay			0.3	0.3	4.0	0.4
								↓			0.4			
								sandy clay			0.4			
								↓			0.5			
30								clay			0.5			

* 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): 0.4

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200 - Geoprobe

BORING No.: SB10
DATE: 01/09/02
GEOLOGIST: J. Barton
DRILLER:

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**
			80%			orange	- clay - 6 inches						
						black	- silty - clay w/ organics						
						dk. Gray	Clayey - sand						
						lt. Gray	Sand						
			80%										
						lt. brown	Sand						
						brown (clayey)	sand w/ gravel						
			0				No Recovery						
			90%			lt. Gray	fine-grained Sand						
						gray-brown (clayey)	fine-grained sand w/ gravel						
			100%			gray-green	sandy-clay						
							silty - f.g. sand						
							sandy - clay - graded to clay						

* 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: FID not working

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Fugro
DRILLING RIG: 5200 - Geoprobe

BORING No.: SB-10
DATE: 01/09/02
GEOLOGIST: J. Barton
DRILLER:

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**
25			100%			Gray Green	clay						
							↓						
							sandy clay						
							clay						
30							↓						
			70%				f.g. sandy-silt						
							↓						
							silty-sand						
							fine grained-sandy-clay						
35			100										
							↓						
40													

* When rock coring, enter rock brokeness.

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

Remarks: FID not working

Drilling Area Background (ppm):

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200-Geoprobe

BORING No.: SB-11
DATE: 01/09/02
GEOLOGIST: J. Barton
DRILLER:

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			75%		black		black - sandy- silt. w/organic					0	0
					dk-gray-brown		clayey sand						
					gray-brow		~~fine sand~~ - to fine grained						
5			40%		No Rec.		NO Recovery						
					dk-brown black		Silty -sand						
					reddish brown		- Sand						
10			90%				- Sand						
							- sand w/some gravel						
					Lt grey-brown change		- Sand - fine-grained sand						
15			100%										
					Lt. Grey		fine-grained-sand- w/ sporatic gravel pieces						
20			100%		gray-green		sandy - clay						
							clayed fine-grained sand						
							sandy - clay						
25							clays						

* When rock coring, enter rock brokeness.

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

Remarks: ~~Depth~~ Did not smell anything - neither did drillers - FID not working

Drilling Area Background (ppm): 0

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200 - Geoprobe

BORING No.: SB-12
DATE: 01/09/02
GEOLOGIST: S. Barton
DRILLER:

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			80%		black		sandy - silt - w/organics			0.5	0.9	0.2	0.7
					dk. Gray		- (charcoal) - silty-sand			0.6			
							mottled w/ rust			0.6			
							~~w/ rust mott~~			0.7			
					lt. brown		fine grained sand			2.1			
5			80%							1.7		0.7	1.0
					dk. Grey		fine grained silty-sand			1.0			
					~~dk. brown~~ reddish brown		- gravelly - sand - (lft) gravely - sand			1.2			
										1.0			
										1.5			
10			90%		reddish brown		gravely - sand (gravel is finer then previous interval)			.9	1.1	0.3	1.1
										.8			
										.9			
										1.0			
					grey-~~brown~~		fine grained sand			1.0			
15			80%							1.2		2.4	1.3
					~~grey brown~~		fine grained - silty clayey sand			1.1			
										1.1			
					lt. grey		fine grained - sand			1.1			
					dk. ~~grey green~~		clayey - sand			1.4			
20			100%		~~grey green~~		clayey - fine grained sand		FID - NOT working	*			
							sandy - clay						
25													

* 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: FID - Quit working

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Fugro
DRILLING RIG: 5200-Geoprobe

BORING No.: SB-13
DATE: 1/9/02
GEOLOGIST: J. Barton
DRILLER:

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			85%		dk. brown		clay-silt-sand w/ organics			0	0	0	0.2
										0			
							-no-organics			0			
					lt. grey-brown w/ white layers		fine-grained-sand			0			
										0			
5			90%		Dr. Grey					0.1	0	1.5	0
					Reddish brown		-some silt			0	0		
										0	0		
										0.2	0		
										0.3	0		
10			100%							0.2	0.1	26.1	0.4
					reddish brown		gravely-fine grained sand			0.2			
										0.2			
										0.3			
					Lt-brown		silty-sand			0.2			
15			100%				silty-sand- to silty-fine-grained sand			0.5		11.2	0.4
										0.6			
										0.6			
										0.7			
20					grey-green		clayey-fine-grained sand			0.9			
			70%				clayey-fine-grained fine-grained sand			0.9	0	10.4	0.5
										1.0	0		
										0.9	0		
										0.9	0		
25							sandy-clayey			0.8	0		

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200-Geoprobe

BORING No.: SB-13
DATE: 2/9/02
GEOLOGIST: J. Barton
DRILLER:

	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**
25				100		Gray-Green		clay			1.0	12	9.2	1.4
											1.0			
											1.0			
											1.1			
30											1.2			

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200 - Geoprobe

BORING No.: SB-14
DATE: 7/9/02
GEOLOGIST: S. Barton
DRILLER:

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		85%			dk. brown	clayey-silt-sand w/ organics			0	0	0	0
						grey brown	silty-sand						
	5					dk. gray	sand-fine grained						
			50%			black	1/2-foot-sand			0	0	0	0
							reddish-brown sand						
	10									0.3			
			90%							1.0	0	0.7	0.4
						Lt brown color	fine-grained sand			1.2			
										1.2			
										1.2			
										0.4			
	15		85			Lt grey brown	fine-grained sand			0.1	0	0	0
										0	0	0	0
										0	0	0	0
										0	0	0	0
										.05	0	0	0
	20		100			Lt. gray green	clayey-sand			0	0	0.1	0.4
							silty-clay (sand)			0			
										0			
										0			
	25									0.6			0

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200 - Geoprobe

BORING No.: SB-15
DATE: 01/08/02
GEOLOGIST: S. Barton
DRILLER:

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			75%		~~red~~	reddish brown	silty-clay w/ organics			0	0	0.6	0
					~~black~~	black	sandy-silt			0	0		
						lt. gray-brown	sand			0	0		
5			80%			dk. brown	silty-sand			0	0	0	0
						reddish brown	sandy silt w/ intermittant gravel			0	0		
10			90%							0		82.8	1.6
						lt. brown	silty-sand			0			
15			100%			lt. gray	sand			0	0	50.1	0
						gray-green	clay			0			
20			100%				silty-clay clay			0	0	0	0
25										0			

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200-Geoprobe

BORING No.: SB16
DATE: 01/08/02
GEOLOGIST: J. Barton
DRILLER:

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		80%			dk gray	clayey-Sand w/ organics		Mottled w/ rust	6	0	0	0
	5					lt. grey brown	fine-grained sand						
			100%							0	0	0	0
							½ foot black sand						
						reddish brown	Sand to silty sand-w/gravel						
	10						sand-fig sand						
			100%				-gravel scattered			0	0	0	0
	15												
			95%				Sand			0	0	68	0
						lt. brown	silty-sand						
	20					black lt. gray	2" sand-clay w/organics -silty-sand w/gravel						
			95%			gray	clay			0	0	0	0
	25					lt gray	silty-clay						

* When rock coring, enter rock brokeness.

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

Remarks:

Drilling Area Background (ppm): 0

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200 - Geoprobe

BORING No.: SB-16
DATE: 01/08/02
GEOLOGIST: J. Barton
DRILLER:

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**
25			100%			Gray green	- clay			0	0	0	0
						Gray green	silty-clay						
30													

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Fugro
DRILLING RIG: 5200 Geoprobe

BORING No.: SB-17
DATE: 01/12/02
GEOLOGIST: J. Barton
DRILLER:

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			80	sample overlap		orange gray	sandy-clay		mottled	306	0	/	0
						tan (gray brown)	silty-sand		contact between first + second lith-highest PID	18			
						lt. gray	gravelly-fine grained sand		grades in color	32			
			40			dark gray reddish brown				107	0	/	0
5							gravelly-sand			3.7			
										2.1			
										3.8			
										1.7			
			100							4.9	0	/	0
										4.9			
10						brown	fine grained sand			4.1			
										7.4			
										10.1			
			100			dk tan				5.1	0	/	0
						tan				1.9			
15										3.4			
										3.1			
						gray	gravelly-sand			2.5			
			80			gray green	silty-sand			0	0	/	0
										4.2			
20							sandy-clay			4.2			
										2.9			
							clay			1.3			

* 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: Borehole under water
Rig 2 ft above ground surface

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC
PROJECT NUMBER:
DRILLING COMPANY: Furgo
DRILLING RIG: 5200 Geoprobe

BORING No.: SB-18
DATE: 01/12/02
GEOLOGIST: J. Barton
DRILLER:

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			90%			orange gray	clay		mottled	0.1	0	/	0
						dk gray	silty-sand			0			
						lt gray	fine-grained sand			0.1			
						tan				0.2			
5						lt. gray				1.1			
			90%				fine-grained sand			1.7	0	0.1	0
						dk brown	silty-fine-grained sand			4.5			
						reddish brown	gravelly fine-grained		-gravel is sporadic	4.7			
							sand			4.9			
										4.4			
10			85				fine-grained sand			1.3	0	1.6	0
									-sporadic gravel	2.0			
										4.5			
						brown				3.0			
							Sand			3.4			
15			90							0.5	0	0.1	0
						lt. gray	gravelly-sand			0.5			
										0.7			
										0.2			
										0.9			
20			100%			gray green	clayey sand			0.4	0	30	0
							silty-fine grained sand			0			
										0.5			
										0			
25							sandy-clay			0			

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC Gulfport
PROJECT NUMBER: 4046
DRILLING COMPANY: Fugro
DRILLING RIG: Hollow Stem Auger

BORING No.: SR-19
DATE: 3/12/02
GEOLOGIST: S. Bourgeois
DRILLER:

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					dk gray	clayey sand w/ organics			0	0	0	0
	5		80%			brown	fine-grained sand			0	0	0	0
						reddish brown	1/2 foot black sand w/ gravel						
	10		100%				-gravel scattered			0	0	0	0
	15		100%				sand			0	0	0	0
						lt. brown	silty-sand						
	20		96%				sand clay w/ organics						

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC Gulfport
PROJECT NUMBER: 4046
DRILLING COMPANY: Fugro
DRILLING RIG: Hollow Stem Auger

BORING No.: SB20
DATE: 2/12/02
GEOLOGIST: J. Bourgeois
DRILLER:

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					dk gray	clayey-sand w/ organics			0	0	0	0
	3		100%			H gray brown	fine-grained sand						

* When rock coring, enter rock brokeness.

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

Remarks:

Drilling Area Background (ppm): 0

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC Gulfport
PROJECT NUMBER: 4046
DRILLING COMPANY: Fugro
DRILLING RIG: Hollow Stem Auger

BORING No.: SB 21
DATE: 2/12/01
GEOLOGIST: J. Bourgeois
DRILLER:

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					dk gray	clayey-sand w/ organics			0	0	0	0
	3		100%			lt gray brown	fine-grained sand						

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC Gulfport
PROJECT NUMBER: 4046
DRILLING COMPANY: Fugro
DRILLING RIG: Hollow Stem Auger

BORING No.: SB22
DATE: 3/13/02
GEOLOGIST: J. Bourgeois
DRILLER:

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					dk gray	clayey-sand w/ organics			0	0	0	0
	5		100%			lt gray brown	fine-grained sand						

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC Gulfport
PROJECT NUMBER: 4046
DRILLING COMPANY: Fugro
DRILLING RIG: Hollow Stem Auger

BORING No.: SB23
DATE: 3/13/02
GEOLOGIST: J. Bourgeois
DRILLER:

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					dk gray	clayey-sand w/ organics			0	0	0	0
	5		100%			tan gray brown	fine-grained sand						

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC Gulfport
PROJECT NUMBER:
DRILLING COMPANY: Fugro
DRILLING RIG: Hollow Stem

BORING No.: MW-1
DATE: 2/14/02
GEOLOGIST: D. Bourgeois
DRILLER:

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					dk gray	clayey-sand w/ organics			0	0	0	0
	5		100%			brown	fine-grained sand			0	0	0	0
						reddish brown	silty-sand w/ gravel						
	10		100%							0	0	0	0
	15		100%			lt brown	sand silty sand			0	0	0	0
	20		100%			lt gray	sand w/ gravel clay			0	0	0	0
	25		100%			lt gray	silty clay						

* When rock coring, enter rock brokeness.

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

Remarks:

Drilling Area Background (ppm): 0

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC Gulfport
PROJECT NUMBER: 4046
DRILLING COMPANY: Fugro
DRILLING RIG: Hollow Stem

BORING No.: MW-2
DATE: 2/14/02
GEOLOGIST: J. Bourgeois
DRILLER:

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					black	sandy-clay			0	0	0	0
						lt gray	fine-grained sand						
	5									0	0	0	0
						tan	sand						
							gravelly-sand						
						dk brown	fine-grained w/ gravel						
	10									0	0	0	0
						lt gray	coarse sand						
	15									0	0	0	0
						dk gray	silty-sand						
	20					gray	clayey-sand			0	0	0	0
						green	fine-grained sand						
	25						clay						

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC Gulfport
PROJECT NUMBER: 4046
DRILLING COMPANY: Fugro
DRILLING RIG: Hollow Stem
BORING No.: MW-3
DATE: 2/11/02
GEOLOGIST: J. Bourgeois
DRILLER:

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				b	lt	sandy-silt w/organic			0	0	0	0
	5		100%			gray brown	fine-grained sand			0	0	0	0
	10		100%			reddish brown	silty-sand clay - sand			0	0	0	0
	15		100%			lt gray brown	-sand, fine-grained sand			0	0	0	0
	20		100%			lt gray	fine-grained sand w/gravel						
						gray green	-sandy, clay			0	0	0	0
	25		100%				fine grained sand-clayey sand						

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC Gulfport
PROJECT NUMBER: 4046
DRILLING COMPANY: Fugro
DRILLING RIG: Hollow Stem Auger

BORING No.: MW-4
DATE: 3/11/02
GEOLOGIST: D. Bourgeois
DRILLER:

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					orange gray	sandy-clay			0	0	0	0
							silty-clay						
						light gray	gravelly-fine grained sand						
	5		80%										
							gravelly sand			0	0	0	0
	10		100%										
						brown	fine grained sand			0	0	0	0
	15		100%										
										0	0	0	0
						gray	gravelly-sand						
							silty-sand						
	20		100%										
							sandy-clay			0	0	0	0
							clay						
	25		80%										

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NCBC Gulfport
PROJECT NUMBER: 4096
DRILLING COMPANY: Fugro
DRILLING RIG: Hollow Stem

BORING No.: MW-5
DATE: 2/14/02
GEOLOGIST: J. Bourgeois
DRILLER:

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					dk gray	clayey sand w/ organics						
	5					brown	f.g. sand						
						reddish brown	silty-sand w/ gravel						
	10												
	15												
						lt brown	sand, silty-sand						
	20												
						lt gray	sand w/ gravel						
	25					lt gray	silty clay						

* When rock coring, enter rock brokeness.

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

Drilling Area Background (ppm): 0

Remarks:

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

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Project Site Name: Site 10/Gulfport
Project No.: CTO 193/N4046

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: NCBC10G01
Sample Location: MW-1
Sampled By: JB/SS
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Date: 2/14/02								
Time: 1350								
Method: peristaltic	Cloudy	4.66	.093	19.6	188	8.30	0.00	

PURGE DATA:

	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date: 2/14/02								
Method: peristaltic	Initial	5.05	.104	16.3	985	9.42	0.00	
Monitor Reading (ppm): 0	1st	5.02	.093	19.0	560	7.98	0.00	
Well Casing Diameter & Material	2nd	5.06	.092	18.7	306	8.13	0.00	
Type: 2" PVC	3rd	4.95	.094	19.6	213	8.35	0.00	
Total Well Depth (TD): 19.05	4th	4.87	.091	19.5	189	8.46	0.00	
Static Water Level (WL): 2.15	5th	4.66	.093	19.6	188	8.30	0.00	
One Casing Volume(gal/L): 2.7								
Start Purge (hrs): 1255								
End Purge (hrs): 1346								
Total Purge Time (min): 111								
Total Vol. Purged (gal/L): 13.5								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
8260B	HCl	40 mL	2
504.1	$Na_2S_2O_3$	40 mL	2
8081A/8082		1L	1

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: Site 10/Gulfport
Project No.: CTO 193 / N4096

[] Domestic Well Data
[✓] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: NCBC10G02
Sample Location: MW-2
Sampled By: JB/SS
C.O.C. No.:
Type of Sample:
[✓] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 2/14/02	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Time: 1210								
Method: low flow peristaltic	cloudy	5.09	.289	18.1	660	8.37	0	

PURGE DATA:

Date: 2/14/02	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method: low flow peristaltic	Initial	8.98	.509	19.1	999	8.70	0	
Monitor Reading (ppm): Ø	1st	7.63	.302	18.1	999	8.78	0	
Well Casing Diameter & Material	2nd	6.40	.281	18.4	852	8.82	0	
Type: 2" PVC	3rd	5.44	.281	17.8	820	8.36	0	
Total Well Depth (TD): 22.97	4th	5.33	.291	18.0	954	8.61	0	
Static Water Level (WL): 1.85	5th	5.09	.289	18.1	660	8.37	0	
One Casing Volume(gal/L): 3.4								
Start Purge (hrs): 1030								
End Purge (hrs): 1210								
Total Purge Time (min): 100								
Total Vol. Purged (gal/L): 17.0								

22.97
−1.85
21.12
× .16
12672
2 2
3.3792

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
8260B	HCl	2 x 40mL	✓
504.1	$Na_2S_2O_3$	2 x 40mL	✓
8081A / 8082		2 x 1L	✓

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s): SSmith

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: Site 10 / Gulfport
Project No.: CTO 193 / N4046

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: NCBC10G03
Sample Location: MW-3
Sampled By: JB/SS
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 2/13/02	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Time: 1613								
Method: low flow peristaltic	clear	5.09	.087	19.1	110	9.61	0.00	

PURGE DATA:

Date: 2/13/02	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method: low flow peristaltic	Initial	4.75	.092	18.8	999	10.20	0.00	
Monitor Reading (ppm): 0	1st	4.56	.092	18.9	708	10.19	0.00	
Well Casing Diameter & Material	2nd	4.48	.096	18.8	170	10.00	0.00	
Type: 2" PVC	3rd	4.89	.091	19.2	137	9.72	0.00	
Total Well Depth (TD): 23.15	4th	4.87	.089	19.0	114	9.45	0.00	
Static Water Level (WL): 1.65	5th	5.09	.087	19.1	110	9.61	0.00	
One Casing Volume(gal/L): 3.4								
Start Purge (hrs): 1510								
End Purge (hrs): 1610								
Total Purge Time (min): 60								
Total Vol. Purged (gal/L): 17.0								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
8081A / 8082	—	2 x 1L	✓
8260B	HCl	2 x 40mL	✓
504.1	$Na_2S_2O_3$	2 x 40mL	✓

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s): S Smith

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Project Site Name: Site 10
Project No.: CTO 193 / N4046

[] Domestic Well Data
[✓] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: NCBC10G04
Sample Location: MW-4
Sampled By: JB/SS
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 2/13/02 Time: 1352	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Method: low flow peristaltic	cloudy	5.25	.104	20.7	323	12.62	0	

PURGE DATA:

Date: 2/13/02	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method: low flow peristaltic	Initial	5.16	.127	19.9	999	10.25	0	
Monitor Reading (ppm): Ø	1st	5.35	.124	20.9	999	10.51	0	
Well Casing Diameter & Material	2nd	5.45	.109	20.8	761	11.80	0	
Type: 2" PVC	3rd	5.26	.114	20.8	451	12.53	0	
Total Well Depth (TD): 22.94	4th	5.25	.104	20.7	323	12.62	0	
Static Water Level (WL): 1.46								
One Casing Volume(gal/L): 3.4								
Start Purge (hrs): 12:15								
End Purge (hrs): 1350								
Total Purge Time (min): 95								
Total Vol. Purged (gal/L): 13.6								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
8081A/8082	—	2 x 1L	✓
504.1	Sodium thiosulfate	2 x 40mL	✓
8260B	HCl	2 x 40mL	✓

OBSERVATIONS / NOTES:

Circle if Applicable:
MS/MSD
Duplicate ID No.: NCBC10G04D

Signature(s): S Smith

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Project Site Name: Site 10 / Gulfport
Project No.: CT0193 / N4046

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: NCRC10G05
Sample Location: Site 10 MW-5
Sampled By: DB/SS
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Date: 2/14/02								
Time: 1400								
Method: peristaltic	clear	5.09	.126	18.7	115	8.58	0.00	

PURGE DATA:

	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date: 2/14/02								
Method: peristaltic	Initial	4.99	.119	18.5	364	8.44	0.00	
Monitor Reading (ppm): Ø	1st	5.02	.119	18.8	163	8.34	0.00	
Well Casing Diameter & Material	2nd	5.15	.120	18.2	113	8.73	0.00	
Type: 2" PVC	3rd	4.88	.128	19.4	146	8.53	0.00	
Total Well Depth (TD): 23.20	4th	4.75	.129	19.3	139	8.42	0.00	
Static Water Level (WL): 2.05	5th	5.09	.126	18.7	115	8.58	0.00	
One Casing Volume(gal/L): 3.4								
Start Purge (hrs): 1245								
End Purge (hrs): 1400								
Total Purge Time (min): 75								
Total Vol. Purged (gal/L): 17.0 g								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
8260B	HCl	40mL	2
504.1	$Na_2S_2O_3$	40mL	2
8081A / 8082	—	1L	1

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:	Signature(s):

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NCBC Gulfport Site 10
Project No.: 1831

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: MW1001G02
Sample Location:
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 12-19-03	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Time: 1215								
Method: low flow	clear	5.43	.075	23.29	3.2	0.00	—	-171

PURGE DATA:

Date: 12-19-03	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other ORP
Method: low flow	Initial	5.71	.102	23.84	19	2.24	—	-99
Monitor Reading (ppm): Ø								
Well Casing Diameter & Material	1st	5.59	.087	23.30	9.1	0.00	—	-144
Type: 2" PVC								
Total Well Depth (TD): 19.02	2nd	5.46	.075	23.37	6.8	0.00	—	-166
Static Water Level (WL): 2.15								
One Casing Volume (gal/L): 2.15	3rd	5.43	.074	23.26	4.1	0.00	—	-171
Start Purge (hrs): 1135								
End Purge (hrs): 1215	4th	5.43	.075	23.29	3.2	0.00	—	-171
Total Purge Time (min): 40								
Total Vol. Purged (gal/L): ~~6.45~~ 9								

.60

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
VOA			
SVOA			
Herb			
Pest/PCB			
TAL Metals			
CN-			

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:	Signature(s):

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NCBC Gulfport Site 10
Project No.: 1831

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: MW1002G02
Sample Location:
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 12-19-03	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Time: low flow								
Method: 2200	clear	5.54	.111	20.92	10	0.00	—	-187

PURGE DATA:

Date: 12-19-03	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	ORP
Method: low flow	Initial	5.58	.116	21.12	130	0.57	—	-144
Monitor Reading (ppm): Ø								
Well Casing Diameter & Material	1st	5.53	.110	20.93	25	0.03	—	-174
Type: 2" PVC								
Total Well Depth (TD): 22.75	2nd	5.52	.112	20.93	17	0.00	—	-182
Static Water Level (WL): 1.94								
One Casing Volume(gal/L): 3.83	3rd	5.54	.111	20.92	10	0.00	—	-187
Start Purge (hrs): 2100								
End Purge (hrs): 2200								
Total Purge Time (min): 60								
Total Vol. Purged (gal/L): 10.0								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
VOA			
SVOA			
Herb			
Pest/PCB			
TAL Metals			
CN-			

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD

Duplicate ID No.: MW1002G02D

Signature(s):

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NCBC Gulfport Site 10
Project No.: 1831

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: MW1003G02
Sample Location:
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 12-19-03	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Time: 2400								
Method: low flow	clear	5.34	.083	21.84	4.11	0.00	—	-166

PURGE DATA:

Date: 12-19-03	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	ORP
Method: low flow	Initial	6.82	.087	21.34	71.1	3.85	—	-65
Monitor Reading (ppm): Ø								
Well Casing Diameter & Material	1st	5.31	.087	21.88	18.9	0.00	—	-138
Type: 2" PVC								
Total Well Depth (TD): 22.80	2nd	5.33	.083	21.89	9.71	0.00	—	-156
Static Water Level (WL): 1.79								
One Casing Volume (gal/L): 3.36	3rd	5.34	.083	21.84	4.11	0.00	—	-166
Start Purge (hrs): 2220								
End Purge (hrs): 2400								
Total Purge Time (min): 100								
Total Vol. Purged (gal/L): 10.1								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
VOA			
SVOA			
Herb			
Pest/PCB			
TAL Metals			
CN-			

OBSERVATIONS / NOTES:

Circle if Applicable:
MS/MSD
Duplicate ID No.: MS/MSD MW1003G02MS/MD

Signature(s):

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Project Site Name: UCBC Gulfport Site 10
Project No.: 1831

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: MW1004G02
Sample Location:
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Date: 12-19-03								ORP
Time: 1115								
Method: low flow	clear	5.17	.068	23.72	Ø	0.10	Ø	-181

PURGE DATA:

	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date: 12-19-03								ORP
Method: low flow	Initial	4.78	.104	22.12	81.9	2.29	Ø	-29
Monitor Reading (ppm): Ø	1st	5.20	.073	23.47	15	0.33	Ø	-153
Well Casing Diameter & Material	2nd	5.22	.070	23.67	7.0	0.11	Ø	-179
Type: 2" PVC	3rd	5.17	.068	23.72	Ø	0.10	Ø	-181
Total Well Depth (TD): 22.76								
Static Water Level (WL): 1.43								
One Casing Volume (gal/L): 3.4/5								
Start Purge (hrs): 1045								
End Purge (hrs): 1115								
Total Purge Time (min): 30								
Total Vol. Purged (gal/L): 10.2								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
VOA			
SVOA			
Herb			
Pest/PCB			
TAL Metals			
CN-			

OBSERVATIONS / NOTES:

Circle If Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: NCBC Gulfport Site 10
Project No.: 1831

[] Domestic Well Data
[X] Monitoring Well Data
[] Other Well Type:
[] QA Sample Type:

Sample ID No.: MW1005G02
Sample Location:
Sampled By:
C.O.C. No.:
Type of Sample:
[X] Low Concentration
[] High Concentration

SAMPLING DATA:

Date: 12-19-03	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	Other
Time: 2030								
Method: low flow	clear	5.56	.069	21.99	3.0	0.13	—	-178

PURGE DATA:

Date: 12-19-03	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	~~Other~~ ORP
Method: low flow	Initial	5.55	.073	23.52	40	2.98	—	-126
Monitor Reading (ppm): 0								
Well Casing Diameter & Material	1st	5.45	.070	22.56	21	0.57	—	-154
Type: 2" PVC								
Total Well Depth (TD): 23.13	2nd	5.57	.071	21.80	19	1.02	—	-144
Static Water Level (WL): 2.02	Pump Battery Dead, Stop Purge							
One Casing Volume(gal/L): 3.38								
Start Purge (hrs): 1500	3rd	5.57	.069	~~4.4~~ 22.03	4.4	0.36	—	-172
End Purge (hrs): 2030								
Total Purge Time (min): 70	4th	5.56	.069	21.99	3.0	0.13	—	-178
Total Vol. Purged (gal/L): 13.5								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
VOA			
SVOA			
Herb			
Pest/PCB			
TAL Metals			
CN⁻			

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:	Signature(s):

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: NCBC Gulfport Site 10
Project No.: N1831
Location: Gulfport, MS
Personnel: J. Bourgeois, B. Fisher
Weather Conditions: Cool, Clear
Measuring Device: WLI
Tidally Influenced: Yes ___ No X
Remarks:

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Groundwater Elevation (feet)*	Comments
1	12/16/03	1315		19.02	1.91			
2		1318		22.75	1.68			
3		1320		22.80	1.49			
4		1323		22.76	1.26			
5	X	1325		23.13	1.80			

* All measurements to the nearest 0.01 foot

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Page ___ of ___

Well: MW-1
Site: 10
Date Installed: 2/13/02
Date Developed: 3/14/02
Dev. Method: pump/surge
Pump Type: whale (sub)

Depth to Bottom (ft.): 19.05
Static Water Level Before (ft.): 2.14
Static Water Level After (ft.): 2.15
Screen Length (ft.): 15'
Specific Capacity: ___
Casing ID (in.): 2"

Responsible Personnel: S. Bourgeois / S. Smith
Drilling Co.: Fugro
Project Name: NCBC Gulfport
Project Number: N4046

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units ____)	Turbidity (NTU)	Remarks (odor, color, etc.) D.O.
1100	0	0	2.14	19.9	5.65	.140	999	7.78
1103	0	2.7	2.14	19.9	5.55	.132	999	7.81
1110	0	10	2.14	19.8	5.11	.113	999	8.06
1115	0	15	2.14	19.9	5.12	.100	999	7.62
1120	0	20	2.15	21.1	5.10	.099	999	7.48

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Well: MW-2
Site: 10
Date Installed: 2/13/02
Date Developed: 2/14/02
Dev. Method: pump/surge
Pump Type: whale (sub)

Depth to Bottom (ft.): 22.97
Static Water Level Before (ft.): 1.80
Static Water Level After (ft.): 1.85
Screen Length (ft.): 15'
Specific Capacity:
Casing ID (in.): 2"

Responsible Personnel: J. Bourgeois / S. Smith
Drilling Co.: Fugro
Project Name: NCBC Gulfport
Project Number: 4046

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units ____)	Turbidity (NTU)	Remarks (odor, color, etc.) D.O.
0950	0	0	1.80	16.3	9.55	2.31	145	7.38
0955	0	3.4	1.80	17.6	9.64	1.73	999	7.46
1000	0	10	1.81	17.7	9.30	.677	999	7.72
1005	0	15	1.81	17.7	8.62	.379	999	7.85
1010	0	20	1.82	17.6	8.10	.339	999	7.91
1015	0	25	1.83	18.3	7.70	.320	999	8.15
1020	0	30	1.83	18.7	7.40	.302	999	8.29
1025	0	35	1.85	18.3	7.02	.309	999	8.90

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Page ___ of ___

Well: MW-3
Site: 10
Date Installed: 2/11/02
Date Developed: 2/13/02
Dev. Method: surge/bail
Pump Type:

Depth to Bottom (ft.): 23.15
Static Water Level Before (ft.): 1.67
Static Water Level After (ft.): 1.65
Screen Length (ft.): 15
Specific Capacity:
Casing ID (in.): 2"

Responsible Personnel: J. Bourgeois / S. Smith
Drilling Co.: Fugro
Project Name: NCBC Gulfport
Project Number: 4046

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units ____)	Turbidity (NTU)	Remarks (odor, color, etc.)
0850	0	0	1.67	16.7	4.97	.145	375	7.82
0858	0	3.4	1.67	14.7	5.20	.135	999	7.57
0910	0	10	1.66	17.5	5.31	.119	999	7.82
0915	0	15	1.65	17.9	5.22	.120	999	8.81
0920	0	20	1.65	18.8	5.34	.108	999	8.79
0925	0	25	1.66	18.8	5.02	.097	999	8.64
0930	0	30	1.65	18.5	5.10	.105	999	8.70

21.48
× .16
12888
2148
3.4368

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Well: MW-4
Site: 10
Date Installed: 2/11/02
Date Developed: 2/13/02
Dev. Method: Surge / bail
Pump Type: —

Depth to Bottom (ft.): 22.94
Static Water Level Before (ft.): 1.40
Static Water Level After (ft.): 1.46
Screen Length (ft.): 15'
Specific Capacity:
Casing ID (in.): 2"

Responsible Personnel: J. Bourgeois / S. Smith
Drilling Co.: Fugro
Project Name: NCBC Gulfport
Project Number: 4046

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units ____)	Turbidity (NTU)	Remarks (odor, color, etc.) D.O:
0930 ~~0850~~	0	0	1.40	18.1	5.44	.178	999	10.90
0935	0	3.5	1.42	18.6	5.48	.145	999	8.84
0945	0	10	1.43	18.9	5.40	.145	999	8.54
1000	0	15	1.42	19.4	5.40	.138	999	8.42

21.54
x .16
12924
2154
3.4464

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Well: MW-5
Site: 10
Date Installed: 2/13/02
Date Developed: 2/14/02
Dev. Method: pump/surge
Pump Type: whale (sub)

Depth to Bottom (ft.): 23.20
Static Water Level Before (ft.): 2.01
Static Water Level After (ft.): 2.05
Screen Length (ft.): 15
Specific Capacity:
Casing ID (in.): 2"

Responsible Personnel: J. Bourgeois / S. Smith
Drilling Co.: Fugro
Project Name: NCBC Gulfport
Project Number: 4046

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units ____)	Turbidity (NTU)	Remarks (odor, color, etc.) D.O.
1030	0	0	2.01	19.1	7.32	.217	999	8.17
1035	0	3.4	2.02	19.1	7.24	.201	999	8.14
1040	0	10	2.02	19.1	6.82	.150	676	8.19
1045	0	15	2.03	18.1	6.54	.184	651	8.51
1050	0	20	2.04	18.4	6.31	1.62	631	8.24
1055	0	25	2.05	14.0	6.30	.161	608	8.76

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME: NCBC Gulfport

SITE NAME: Site 10

PROJECT No.: 1831

INSTRUMENT NAME/MODEL: 2020 Turbidimeter

MANUFACTURER: LaMotte

SERIAL NUMBER: 03357

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		
			1.0		10.0			
12-19-03		J. Bergeron	1.0	1.0	10.0	10.0		

Tetra Tech NUS, Inc.

HORIBA U-22 CALIBRATION LOG

Project Name: NCBC Gulfport
Site Name: Site 10
Project No,: 1831

Instrument Name/Model: U-22
Manufacturer: Horiba
Serial Number: ~~035524~~ T10920

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Pre-Calibration Readings			DO	Post-Calibration Readings			DO	Calibration Standard (Lot No.)	Remarks and Comments
			pH	Spec. Cond.	Turbidity (NTU)	~~Temp~~	pH	Spec. Cond.	Turbidity (NTU)	~~Temp~~		
12-19-03		D. Bergeron	3.81	3.99	4.5	11.48	4.00	4.55	0.2	10.80	3502	

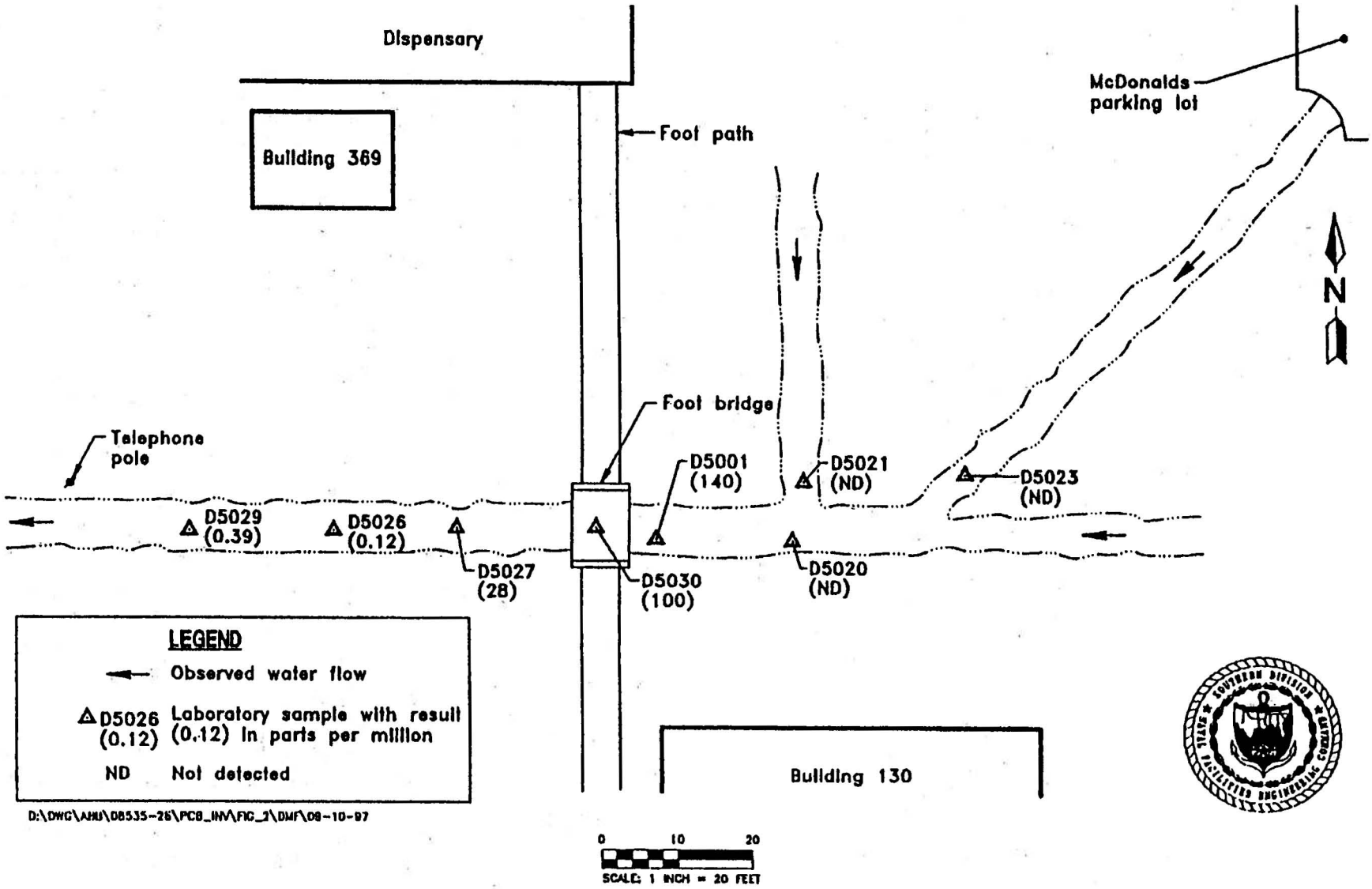

Figure 1-1
Laboratory PCB Results
PCB Investigation Adjacent to Parade Field
Naval Construction Battalion Center, [illegible]t, Mississippi

APPENDIX B

REMEDIAL INVESTIGATION ANALYTICAL DATA

order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S01	NCBC10S01	NCBC10S01	NCBC10S02	NCBC10S02	NCBC10S02	NCBC10S03	NCBC10S03
nsample	NCBC10S0105	NCBC10S0110	NCBC10S0123	NCBC10S0205	NCBC10S0210	NCBC10S0223	NCBC10S0301	NCBC10S0313
sample	NCBC10S0105	NCBC10S0110	NCBC10S0123	NCBC10S0205	NCBC10S0210	NCBC10S0223	NCBC10S0301	NCBC10S0313
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	23 - 23	5 - 5	10 - 10	23 - 23	1 - 1	13 - 13
gis_date	20020112	20020112	20020112	20020112	20020112	20020112	20020111	20020111
sample_dat	01/12/02	01/12/02	01/12/02	01/12/02	01/12/02	01/12/02	01/11/02	01/11/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
Volatile Organics (ug/kg)								
1,1,1-TRICHLOROETHANE							5.1 U	5.5 U
1,1,2,2-TETRACHLOROETHANE							5.1 U	5.5 U
1,1,2-TRICHLOROETHANE							5.1 U	5.5 U
1,1,2-TRICHLOROTRIFLUOROETHANE								
1,1-DICHLOROETHANE							5.1 U	5.5 U
1,1-DICHLOROETHENE							5.1 U	5.5 U
1,2,3-TRICHLOROBENZENE								
1,2,4-TRICHLOROBENZENE								
1,2-DIBROMO-3-CHLOROPROPANE							10 U	11 U
1,2-DIBROMOETHANE							5.1 U	5.5 U
1,2-DICHLOROBENZENE							5.1 U	5.5 U
1,2-DICHLOROETHANE							5.1 U	5.5 U
1,2-DICHLOROPROPANE							5.1 U	5.5 U
1,3-DICHLOROBENZENE							5.1 U	5.5 U
1,4-DICHLOROBENZENE							5.1 U	5.5 U
2-BUTANONE							21 UJ	22 UJ
2-HEXANONE							21 U	22 U
4-METHYL-2-PENTANONE							21 U	22 U
ACETONE							21 UJ	22 UJ
BENZENE							5.1 U	5.5 U
BROMOCHLOROMETHANE								
BROMODICHLOROMETHANE							5.1 U	5.5 U
BROMOFORM							5.1 U	5.5 U
BROMOMETHANE							10 UJ	11 UJ
CARBON DISULFIDE							5.1 U	5.5 U
CARBON TETRACHLORIDE							5.1 UJ	5.5 UJ
CHLOROBENZENE							5.1 U	5.5 U
CHLORODIBROMOMETHANE							5.1 U	5.5 U
CHLOROETHANE							10 U	11 U
CHLOROFORM							5.1 U	5.5 U
CHLOROMETHANE							10 UJ	11 UJ
CIS-1,2-DICHLOROETHENE							5.1 U	5.5 U
CIS-1,3-DICHLOROPROPENE							5.1 U	5.5 U
CYCLOHEXANE								
DICHLORODIFLUOROMETHANE								
ETHYLBENZENE							5.1 U	5.5 U
ISOPROPYLBENZENE								
M+P-XYLENES								
METHYL ACETATE								
METHYL CYCLOHEXANE								
METHYL TERT-BUTYL ETHER								
METHYLENE CHLORIDE							5.1 U	5.5 U

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CTO 288
soils
full appendix results

order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S01	NCBC10S01	NCBC10S01	NCBC10S02	NCBC10S02	NCBC10S02	NCBC10S03	NCBC10S03
nsample	NCBC10S0105	NCBC10S0110	NCBC10S0123	NCBC10S0205	NCBC10S0210	NCBC10S0223	NCBC10S0301	NCBC10S0313
sample	NCBC10S0105	NCBC10S0110	NCBC10S0123	NCBC10S0205	NCBC10S0210	NCBC10S0223	NCBC10S0301	NCBC10S0313
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	23 - 23	5 - 5	10 - 10	23 - 23	1 - 1	13 - 13
gis_date	20020112	20020112	20020112	20020112	20020112	20020112	20020111	20020111
sample_dat	01/12/02	01/12/02	01/12/02	01/12/02	01/12/02	01/12/02	01/11/02	01/11/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
O-XYLENE								
STYRENE							5.1 U	5.5 U
TETRACHLOROETHENE							5.1 U	5.5 U
TOLUENE							5.1 U	5.5 U
TOTAL 1,2-DICHLOROETHENE							5.1 U	5.5 U
TOTAL XYLENES							15 U	17 U
TRANS-1,2-DICHLOROETHENE							5.1 U	5.5 U
TRANS-1,3-DICHLOROPROPENE							5.1 U	5.5 U
TRICHLOROETHENE							5.1 U	5.5 U
TRICHLOROFLUOROMETHANE							10 UJ	11 UJ
VINYL CHLORIDE							10 U	11 U
Semivolatile Organics (ug/kg)								
1,1-BIPHENYL								
2,2'-OXYBIS(1-CHLOROPROPANE)								
2,4,5-TRICHLOROPHENOL								
2,4,6-TRICHLOROPHENOL								
2,4-DICHLOROPHENOL								
2,4-DIMETHYLPHENOL								
2,4-DINITROPHENOL								
2,4-DINITROTOLUENE								
2,6-DINITROTOLUENE								
2-CHLORONAPHTHALENE								
2-CHLOROPHENOL								
2-METHYLNAPHTHALENE								
2-METHYLPHENOL								
2-NITROANILINE								
2-NITROPHENOL								
3,3'-DICHLOROBENZIDINE								
3-NITROANILINE								
4,6-DINITRO-2-METHYLPHENOL								
4-BROMOPHENYL PHENYL ETHER								
4-CHLORO-3-METHYLPHENOL								
4-CHLOROANILINE								
4-CHLOROPHENYL PHENYL ETHER								
4-METHYLPHENOL								
4-NITROANILINE								
4-NITROPHENOL								
ACENAPHTHENE								
ACENAPHTHYLENE								
ACETOPHENONE								
ANTHRACENE								
ATRAZINE								
BENZALDEHYDE								

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from _10sores.xls
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order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S01	NCBC10S01	NCBC10S01	NCBC10S02	NCBC10S02	NCBC10S02	NCBC10S03	NCBC10S03
nsample	NCBC10S0105	NCBC10S0110	NCBC10S0123	NCBC10S0205	NCBC10S0210	NCBC10S0223	NCBC10S0301	NCBC10S0313
sample	NCBC10S0105	NCBC10S0110	NCBC10S0123	NCBC10S0205	NCBC10S0210	NCBC10S0223	NCBC10S0301	NCBC10S0313
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	23 - 23	5 - 5	10 - 10	23 - 23	1 - 1	13 - 13
gis_date	20020112	20020112	20020112	20020112	20020112	20020112	20020111	20020111
sample_dat	01/12/02	01/12/02	01/12/02	01/12/02	01/12/02	01/12/02	01/11/02	01/11/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
BENZO(A)ANTHRACENE								
BENZO(A)PYRENE								
BENZO(B)FLUORANTHENE								
BENZO(G,H,I)PERYLENE								
BENZO(K)FLUORANTHENE								
BIS(2-CHLOROETHOXY)METHANE								
BIS(2-CHLOROETHYL)ETHER								
BIS(2-ETHYLHEXYL)PHTHALATE								
BUTYL BENZYL PHTHALATE								
CAPROLACTAM								
CARBAZOLE								
CHRYSENE								
DI-N-BUTYL PHTHALATE								
DI-N-OCTYL PHTHALATE								
DIBENZO(A,H)ANTHRACENE								
DIBENZOFURAN								
DIETHYL PHTHALATE								
DIMETHYL PHTHALATE								
FLUORANTHENE								
FLUORENE								
HEXACHLOROBENZENE								
HEXACHLOROBUTADIENE								
HEXACHLOROCYCLOPENTADIENE								
HEXACHLOROETHANE								
INDENO(1,2,3-CD)PYRENE								
ISOPHORONE								
N-NITROSO-DI-N-PROPYLAMINE								
N-NITROSODIPHENYLAMINE								
NAPHTHALENE								
NITROBENZENE								
PENTACHLOROPHENOL								
PHENANTHRENE								
PHENOL								
PYRENE								
Pesticides/PCBs (ug/kg)								
4,4'-DDD	0.12 R	2.1 U	2.2 U	2.0 U	0.33 J	0.14 R	8.4 U	2.0 U
4,4'-DDE	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
4,4'-DDT	2.0 U	2.1 U	2.2 U	2.0 U	2	0.39 J	8.4 U	2.0 UJ
ALDRIN	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
ALPHA-BHC	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	0.083 J
ALPHA-CHLORDANE	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
AROCLOR-1016	38 U	41 U	42 U	39 U	40 U	41 U	41 U	39 U
AROCLOR-1221	38 U	41 U	42 U	39 U	40 U	41 U	41 U	39 U

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CTO 288
soils
full appendix results

order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S01	NCBC10S01	NCBC10S01	NCBC10S02	NCBC10S02	NCBC10S02	NCBC10S03	NCBC10S03
nsample	NCBC10S0105	NCBC10S0110	NCBC10S0123	NCBC10S0205	NCBC10S0210	NCBC10S0223	NCBC10S0301	NCBC10S0313
sample	NCBC10S0105	NCBC10S0110	NCBC10S0123	NCBC10S0205	NCBC10S0210	NCBC10S0223	NCBC10S0301	NCBC10S0313
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	23 - 23	5 - 5	10 - 10	23 - 23	1 - 1	13 - 13
gis_date	20020112	20020112	20020112	20020112	20020112	20020112	20020111	20020111
sample_dat	01/12/02	01/12/02	01/12/02	01/12/02	01/12/02	01/12/02	01/11/02	01/11/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
AROCLOR-1232	38 U	41 U	42 U	39 U	40 U	41 U	41 U	39 U
AROCLOR-1242	38 U	41 U	42 U	39 U	40 U	41 U	41 U	39 U
AROCLOR-1248	38 U	41 U	42 U	39 U	40 U	41 U	41 U	39 U
AROCLOR-1254	38 U	41 U	42 U	39 U	40 U	41 U	41 U	39 U
AROCLOR-1260	38 U	41 U	42 U	39 U	40 U	41 U	740	39 U
BETA-BHC	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
DELTA-BHC	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
DIELDRIN	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	2.1 R	2.0 U
ENDOSULFAN I	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
ENDOSULFAN II	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	17	2.0 U
ENDOSULFAN SULFATE	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
ENDRIN	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	5.7 R	2.0 U
ENDRIN ALDEHYDE	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	1.9 R	2.0 U
ENDRIN KETONE	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
GAMMA-BHC (LINDANE)	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
GAMMA-CHLORDANE	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
HEPTACHLOR	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
HEPTACHLOR EPOXIDE	2.0 U	2.1 U	2.2 U	2.0 U	2.0 U	2.1 U	8.4 U	2.0 U
METHOXYCHLOR	3.8 U	4.1 U	4.2 U	3.9 U	4.0 U	4.1 U	16 U	3.9 U
TOXAPHENE	78 U	83 U	86 U	79 U	81 U	84 U	330 U	79 U
Herbicides (ug/kg)								
2,4,5-T								
2,4,5-TP (SILVEX)								
2,4-D								
DINOSEB								
Inorganics (mg/kg)								
ALUMINUM								
ANTIMONY								
ARSENIC								
BARIUM								
BERYLLIUM								
CADMIUM								
CALCIUM								
CHROMIUM								
COBALT								
COPPER								
IRON								
LEAD								
MAGNESIUM								
MANGANESE								
MERCURY								
NICKEL								
POTASSIUM								

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order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S01	NCBC10S01	NCBC10S01	NCBC10S02	NCBC10S02	NCBC10S02	NCBC10S03	NCBC10S03
nsample	NCBC10S0105	NCBC10S0110	NCBC10S0123	NCBC10S0205	NCBC10S0210	NCBC10S0223	NCBC10S0301	NCBC10S0313
sample	NCBC10S0105	NCBC10S0110	NCBC10S0123	NCBC10S0205	NCBC10S0210	NCBC10S0223	NCBC10S0301	NCBC10S0313
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	23 - 23	5 - 5	10 - 10	23 - 23	1 - 1	13 - 13
gis_date	20020112	20020112	20020112	20020112	20020112	20020112	20020111	20020111
sample_dat	01/12/02	01/12/02	01/12/02	01/12/02	01/12/02	01/12/02	01/11/02	01/11/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
SELENIUM								
SILVER								
SODIUM								
THALLIUM								
VANADIUM								
ZINC								
Miscellaneous Parameters (mg/kg)								
CYANIDE								
TOTAL SOLIDS (%)								

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CTO 288
soils
full appendix results

order	009	010	011	012	013	014	015	016
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S03	NCBC10S03	NCBC10S04	NCBC10S04	NCBC10S04	NCBC10S05	NCBC10S05	NCBC10S05
nsample	NCBC10S0313-D	NCBC10S0318	NCBC10S0401	NCBC10S0411	NCBC10S0420	NCBC10S0502	NCBC10S0511	NCBC10S0520
sample	NCBC10S0313D	NCBC10S0318	NCBC10S0401	NCBC10S0411	NCBC10S0420	NCBC10S0502	NCBC10S0511	NCBC10S0520
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	13 - 13	18 - 18	1 - 1	11 - 11	20 - 20	2 - 2	11 - 11	20 - 20
gis_date	20020111	20020111	20020111	20020111	20020111	20020111	20020111	20020111
sample_dat	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**	**c_013**	**c_014**	**c_015**	**c_016**
Volatile Organics (ug/kg)								
1,1,1-TRICHLOROETHANE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
1,1,2,2-TETRACHLOROETHANE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
1,1,2-TRICHLOROETHANE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
1,1,2-TRICHLOROTRIFLUOROETHANE								
1,1-DICHLOROETHANE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
1,1-DICHLOROETHENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
1,2,3-TRICHLOROBENZENE								
1,2,4-TRICHLOROBENZENE								
1,2-DIBROMO-3-CHLOROPROPANE	11 U	12 U	11 U	10 U	12 U	11 U	13 U	12 U
1,2-DIBROMOETHANE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
1,2-DICHLOROBENZENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
1,2-DICHLOROETHANE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
1,2-DICHLOROPROPANE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
1,3-DICHLOROBENZENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	12	6.5 U	6.2 U
1,4-DICHLOROBENZENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	34	6.5 U	6.2 U
2-BUTANONE	22 UJ	25 UJ	21 UJ	21 UJ	23 UJ	21 UJ	26 UJ	25 UJ
2-HEXANONE	22 U	25 U	21 U	21 U	23 U	21 U	26 U	25 U
4-METHYL-2-PENTANONE	22 U	25 U	21 U	21 U	23 U	21 U	26 U	25 U
ACETONE	22 UJ	25 UJ	8.7 J	21 UJ	23 UJ	6 J	26 UJ	25 UJ
BENZENE	5.6 U	6.2 U	110	5.2 U	5.8 U	120	6.5 U	6.2 U
BROMOCHLOROMETHANE								
BROMODICHLOROMETHANE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
BROMOFORM	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
BROMOMETHANE	11 UJ	12 UJ	11 U	10 U	12 U	11 UJ	13 UJ	12 UJ
CARBON DISULFIDE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
CARBON TETRACHLORIDE	5.6 UJ	6.2 UJ	5.4 UJ	5.2 UJ	5.8 UJ	5.3 UJ	6.5 UJ	6.2 UJ
CHLOROBENZENE	5.6 U	6.2 U	35	5.2 U	5.8 U	130	6.5 U	6.2 U
CHLORODIBROMOMETHANE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
CHLOROETHANE	11 U	12 U	11 U	10 U	12 U	11 U	13 U	12 U
CHLOROFORM	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
CHLOROMETHANE	11 UJ	12 UJ	11 U	10 U	12 U	11 UJ	13 UJ	12 UJ
CIS-1,2-DICHLOROETHENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
CIS-1,3-DICHLOROPROPENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
CYCLOHEXANE								
DICHLORODIFLUOROMETHANE								
ETHYLBENZENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
ISOPROPYLBENZENE								
M+P-XYLENES								
METHYL ACETATE								
METHYL CYCLOHEXANE								
METHYL TERT-BUTYL ETHER								
METHYLENE CHLORIDE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U

from _10sosam.dbf
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order	009	010	011	012	013	014	015	016
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S03	NCBC10S03	NCBC10S04	NCBC10S04	NCBC10S04	NCBC10S05	NCBC10S05	NCBC10S05
nsample	NCBC10S0313-D	NCBC10S0318	NCBC10S0401	NCBC10S0411	NCBC10S0420	NCBC10S0502	NCBC10S0511	NCBC10S0520
sample	NCBC10S0313D	NCBC10S0318	NCBC10S0401	NCBC10S0411	NCBC10S0420	NCBC10S0502	NCBC10S0511	NCBC10S0520
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	13 - 13	18 - 18	1 - 1	11 - 11	20 - 20	2 - 2	11 - 11	20 - 20
gis_date	20020111	20020111	20020111	20020111	20020111	20020111	20020111	20020111
sample_dat	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**	**c_013**	**c_014**	**c_015**	**c_016**
O-XYLENE								
STYRENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
TETRACHLOROETHENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
TOLUENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
TOTAL 1,2-DICHLOROETHENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
TOTAL XYLENES	17 U	19 U	16 U	16 U	18 U	16 U	19 U	19 U
TRANS-1,2-DICHLOROETHENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
TRANS-1,3-DICHLOROPROPENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
TRICHLOROETHENE	5.6 U	6.2 U	5.4 U	5.2 U	5.8 U	5.3 U	6.5 U	6.2 U
TRICHLOROFLUOROMETHANE	11 UJ	12 UJ	11 UJ	10 UJ	12 UJ	11 UJ	13 UJ	12 UJ
VINYL CHLORIDE	11 U	12 U	11 U	10 U	12 U	11 U	13 U	12 U
Semivolatile Organics (ug/kg)								
1,1-BIPHENYL								
2,2'-OXYBIS(1-CHLOROPROPANE)								
2,4,5-TRICHLOROPHENOL								
2,4,6-TRICHLOROPHENOL								
2,4-DICHLOROPHENOL								
2,4-DIMETHYLPHENOL								
2,4-DINITROPHENOL								
2,4-DINITROTOLUENE								
2,6-DINITROTOLUENE								
2-CHLORONAPHTHALENE								
2-CHLOROPHENOL								
2-METHYLNAPHTHALENE								
2-METHYLPHENOL								
2-NITROANILINE								
2-NITROPHENOL								
3,3'-DICHLOROBENZIDINE								
3-NITROANILINE								
4,6-DINITRO-2-METHYLPHENOL								
4-BROMOPHENYL PHENYL ETHER								
4-CHLORO-3-METHYLPHENOL								
4-CHLOROANILINE								
4-CHLOROPHENYL PHENYL ETHER								
4-METHYLPHENOL								
4-NITROANILINE								
4-NITROPHENOL								
ACENAPHTHENE								
ACENAPHTHYLENE								
ACETOPHENONE								
ANTHRACENE								
ATRAZINE								
BENZALDEHYDE								

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CTO 288
soils
full appendix results

order	009	010	011	012	013	014	015	016
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S03	NCBC10S03	NCBC10S04	NCBC10S04	NCBC10S04	NCBC10S05	NCBC10S05	NCBC10S05
nsample	NCBC10S0313-D	NCBC10S0318	NCBC10S0401	NCBC10S0411	NCBC10S0420	NCBC10S0502	NCBC10S0511	NCBC10S0520
sample	NCBC10S0313D	NCBC10S0318	NCBC10S0401	NCBC10S0411	NCBC10S0420	NCBC10S0502	NCBC10S0511	NCBC10S0520
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	13 - 13	18 - 18	1 - 1	11 - 11	20 - 20	2 - 2	11 - 11	20 - 20
gis_date	20020111	20020111	20020111	20020111	20020111	20020111	20020111	20020111
sample_dat	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**	**c_013**	**c_014**	**c_015**	**c_016**
BENZO(A)ANTHRACENE								
BENZO(A)PYRENE								
BENZO(B)FLUORANTHENE								
BENZO(G,H,I)PERYLENE								
BENZO(K)FLUORANTHENE								
BIS(2-CHLOROETHOXY)METHANE								
BIS(2-CHLOROETHYL)ETHER								
BIS(2-ETHYLHEXYL)PHTHALATE								
BUTYL BENZYL PHTHALATE								
CAPROLACTAM								
CARBAZOLE								
CHRYSENE								
DI-N-BUTYL PHTHALATE								
DI-N-OCTYL PHTHALATE								
DIBENZO(A,H)ANTHRACENE								
DIBENZOFURAN								
DIETHYL PHTHALATE								
DIMETHYL PHTHALATE								
FLUORANTHENE								
FLUORENE								
HEXACHLOROBENZENE								
HEXACHLOROBUTADIENE								
HEXACHLOROCYCLOPENTADIENE								
HEXACHLOROETHANE								
INDENO(1,2,3-CD)PYRENE								
ISOPHORONE								
N-NITROSO-DI-N-PROPYLAMINE								
N-NITROSODIPHENYLAMINE								
NAPHTHALENE								
NITROBENZENE								
PENTACHLOROPHENOL								
PHENANTHRENE								
PHENOL								
PYRENE								
Pesticides/PCBs (ug/kg)								
4,4'-DDD	2.0 U	2.0 U	10 U	2.0 U	2.2 UJ	10 U	2.1 U	0.24 J
4,4'-DDE	2.0 U	2.0 U	10 U	2.0 U	2.2 U	10 U	2.1 U	2.1 U
4,4'-DDT	2.0 UJ	2.0 UJ	30 R	2.0 UJ	2.2 UJ	24 R	2.1 UJ	2.1 UJ
ALDRIN	2.0 U	2.0 U	10 U	2.0 U	2.2 U	10 U	2.1 U	2.1 U
ALPHA-BHC	2.0 U	2.0 U	10 U	2.0 U	2.2 U	10 U	2.1 U	2.1 U
ALPHA-CHLORDANE	2.0 U	2.0 U	9.5 R	2.0 U	2.2 U	5.2 R	2.1 U	2.1 U
AROCLOR-1016	39 U	39 U	390 U	39 U	43 U	400 U	40 U	41 U
AROCLOR-1221	39 U	39 U	390 U	39 U	43 U	400 U	40 U	41 U

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order	009	010	011	012	013	014	015	016
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S03	NCBC10S03	NCBC10S04	NCBC10S04	NCBC10S04	NCBC10S05	NCBC10S05	NCBC10S05
nsample	NCBC10S0313-D	NCBC10S0318	NCBC10S0401	NCBC10S0411	NCBC10S0420	NCBC10S0502	NCBC10S0511	NCBC10S0520
sample	NCBC10S0313D	NCBC10S0318	NCBC10S0401	NCBC10S0411	NCBC10S0420	NCBC10S0502	NCBC10S0511	NCBC10S0520
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	13 - 13	18 - 18	1 - 1	11 - 11	20 - 20	2 - 2	11 - 11	20 - 20
gis_date	20020111	20020111	20020111	20020111	20020111	20020111	20020111	20020111
sample_dat	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**	**c_013**	**c_014**	**c_015**	**c_016**
AROCLOR-1232	39 U	39 U	390 U	39 U	43 U	400 U	40 U	41 U
AROCLOR-1242	39 U	39 U	390 U	39 U	43 U	400 U	40 U	41 U
AROCLOR-1248	39 U	39 U	390 U	39 U	43 U	400 U	40 U	41 U
AROCLOR-1254	39 U	39 U	390 U	39 U	43 U	400 U	40 U	41 U
AROCLOR-1260	39 U	39 U	6000	39 U	43 U	5200	40 U	41 U
BETA-BHC	2.0 U	2.0 U	10 U	2.0 U	2.2 U	10 U	2.1 U	2.1 U
DELTA-BHC	2.0 U	2.0 U	10 U	2.0 UJ	0.11 J	10 U	2.1 U	2.1 U
DIELDRIN	2.0 U	2.0 U	26 J	2.0 U	2.2 U	18 J	2.1 U	2.1 U
ENDOSULFAN I	2.0 U	2.0 U	10 U	2.0 U	2.2 U	10 U	2.1 U	2.1 U
ENDOSULFAN II	2.0 U	2.0 U	120 J	2.0 U	2.2 U	110	2.1 U	2.1 U
ENDOSULFAN SULFATE	2.0 U	2.0 U	10 U	2.0 UJ	2.2 U	10 U	2.1 U	2.1 U
ENDRIN	2.0 U	2.0 U	65 R	2.0 U	2.2 U	44 R	2.1 U	2.1 U
ENDRIN ALDEHYDE	2.0 U	2.0 U	15 R	0.38 J	2.2 U	13 R	2.1 U	2.1 U
ENDRIN KETONE	2.0 U	2.0 U	10 U	2.0 UJ	2.2 U	10 U	2.1 U	2.1 U
GAMMA-BHC (LINDANE)	2.0 U	2.0 U	10 U	2.0 U	2.2 U	10 U	2.1 U	2.1 U
GAMMA-CHLORDANE	2.0 U	2.0 U	10 U	2.0 U	2.2 U	10 U	2.1 U	2.1 U
HEPTACHLOR	2.0 U	2.0 U	10 U	2.0 U	2.2 U	10 U	2.1 U	2.1 U
HEPTACHLOR EPOXIDE	2.0 U	2.0 U	10 U	2.0 U	2.2 U	10 U	2.1 U	2.1 U
METHOXYCHLOR	3.9 U	3.9 U	20 U	3.9 UJ	4.3 U	20 U	4.0 U	4.1 U
TOXAPHENE	80 U	80 U	400 U	79 U	88 U	410 U	81 U	83 U
Herbicides (ug/kg)								
2,4,5-T								
2,4,5-TP (SILVEX)								
2,4-D								
DINOSEB								
Inorganics (mg/kg)								
ALUMINUM								
ANTIMONY								
ARSENIC								
BARIUM								
BERYLLIUM								
CADMIUM								
CALCIUM								
CHROMIUM								
COBALT								
COPPER								
IRON								
LEAD								
MAGNESIUM								
MANGANESE								
MERCURY								
NICKEL								
POTASSIUM								

from _10sosam.dbf
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from _10sores.xls
from q:\sql_server\gulfport\upload

CTO 288
soils
full appendix results

order	009	010	011	012	013	014	015	016
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S03	NCBC10S03	NCBC10S04	NCBC10S04	NCBC10S04	NCBC10S05	NCBC10S05	NCBC10S05
nsample	NCBC10S0313-D	NCBC10S0318	NCBC10S0401	NCBC10S0411	NCBC10S0420	NCBC10S0502	NCBC10S0511	NCBC10S0520
sample	NCBC10S0313D	NCBC10S0318	NCBC10S0401	NCBC10S0411	NCBC10S0420	NCBC10S0502	NCBC10S0511	NCBC10S0520
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	13 - 13	18 - 18	1 - 1	11 - 11	20 - 20	2 - 2	11 - 11	20 - 20
gis_date	20020111	20020111	20020111	20020111	20020111	20020111	20020111	20020111
sample_dat	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02	01/11/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**	**c_013**	**c_014**	**c_015**	**c_016**
SELENIUM								
SILVER								
SODIUM								
THALLIUM								
VANADIUM								
ZINC								
Miscellaneous Parameters (mg/kg)								
CYANIDE								
TOTAL SOLIDS (%)								

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order	017	018	019	020	021	022	023	024
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S06	NCBC10S06	NCBC10S06	NCBC10S06	NCBC10S07	NCBC10S07	NCBC10S07	NCBC10S08
nsample	NCBC10S0602	NCBC10S0608	NCBC10S0620	NCBC10S0620-D	NCBC10S0705	NCBC10S0710	NCBC10S0723	NCBC10S0805
sample	NCBC10S0602	NCBC10S0608	NCBC10S0620	NCBC10S0620D	NCBC10S0705	NCBC10S0710	NCBC10S0723	NCBC10S0805
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	2 - 2	8 - 8	20 - 20	20 - 20	5 - 5	10 - 10	23 - 23	5 - 5
gis_date	20020111	20020111	20020111	20020111	20020110	20020110	20020110	20020110
sample_dat	01/11/02	01/11/02	01/11/02	01/11/02	01/10/02	01/10/02	01/10/02	01/10/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_017**	**c_018**	**c_019**	**c_020**	**c_021**	**c_022**	**c_023**	**c_024**
Volatile Organics (ug/kg)								
1,1,1-TRICHLOROETHANE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 UJ	6.1 UJ	6 U	5.4 UJ
1,1,2,2-TETRACHLOROETHANE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
1,1,2-TRICHLOROETHANE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
1,1,2-TRICHLOROTRIFLUOROETHANE								
1,1-DICHLOROETHANE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
1,1-DICHLOROETHENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
1,2,3-TRICHLOROBENZENE								
1,2,4-TRICHLOROBENZENE								
1,2-DIBROMO-3-CHLOROPROPANE	12 U	9.9 U	12 UJ	12 UJ	10 U	12 U	12 U	11 U
1,2-DIBROMOETHANE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
1,2-DICHLOROBENZENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
1,2-DICHLOROETHANE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
1,2-DICHLOROPROPANE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
1,3-DICHLOROBENZENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
1,4-DICHLOROBENZENE	6.1 U	1.4 J	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
2-BUTANONE	24 UJ	20 UJ	24 UJ	25 UJ	21 U	24 U	24 UJ	21 U
2-HEXANONE	24 U	20 U	24 UJ	25 UJ	21 U	24 U	24 U	21 U
4-METHYL-2-PENTANONE	24 U	20 U	24 UJ	25 UJ	21 U	24 U	24 U	21 U
ACETONE	8.7 J	5.4 J	7.5 J	25 UJ	6.2 J	24 UJ	24 UJ	5.6 J
BENZENE	230	65	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	1.4 J
BROMOCHLOROMETHANE								
BROMODICHLOROMETHANE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
BROMOFORM	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
BROMOMETHANE	12 UJ	9.9 UJ	12 UJ	12 UJ	10 U	12 U	12 U	11 U
CARBON DISULFIDE	6.1 U	4.9 U	6.1 U	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
CARBON TETRACHLORIDE	6.1 UJ	4.9 UJ	6.1 UJ	6.1 UJ	5.2 UJ	6.1 UJ	6 UJ	5.4 UJ
CHLOROBENZENE	110	75	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
CHLORODIBROMOMETHANE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
CHLOROETHANE	12 U	9.9 U	12 UJ	12 UJ	10 U	12 U	12 U	11 U
CHLOROFORM	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
CHLOROMETHANE	12 UJ	9.9 UJ	12 UJ	12 UJ	10 U	12 U	12 U	11 U
CIS-1,2-DICHLOROETHENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
CIS-1,3-DICHLOROPROPENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
CYCLOHEXANE								
DICHLORODIFLUOROMETHANE								
ETHYLBENZENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
ISOPROPYLBENZENE								
M+P-XYLENES								
METHYL ACETATE								
METHYL CYCLOHEXANE								
METHYL TERT-BUTYL ETHER								
METHYLENE CHLORIDE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U

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CTO 288
soils
full appendix results

order	017	018	019	020	021	022	023	024
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S06	NCBC10S06	NCBC10S06	NCBC10S06	NCBC10S07	NCBC10S07	NCBC10S07	NCBC10S08
nsample	NCBC10S0602	NCBC10S0608	NCBC10S0620	NCBC10S0620-D	NCBC10S0705	NCBC10S0710	NCBC10S0723	NCBC10S0805
sample	NCBC10S0602	NCBC10S0608	NCBC10S0620	NCBC10S0620D	NCBC10S0705	NCBC10S0710	NCBC10S0723	NCBC10S0805
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	2 - 2	8 - 8	20 - 20	20 - 20	5 - 5	10 - 10	23 - 23	5 - 5
gis_date	20020111	20020111	20020111	20020111	20020110	20020110	20020110	20020110
sample_dat	01/11/02	01/11/02	01/11/02	01/11/02	01/10/02	01/10/02	01/10/02	01/10/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_017**	**c_018**	**c_019**	**c_020**	**c_021**	**c_022**	**c_023**	**c_024**
O-XYLENE								
STYRENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
TETRACHLOROETHENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 UJ	6.1 UJ	6 U	5.4 UJ
TOLUENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
TOTAL 1,2-DICHLOROETHENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
TOTAL XYLENES	18 U	15 U	18 UJ	18 UJ	16 U	18 U	18 U	16 U
TRANS-1,2-DICHLOROETHENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
TRANS-1,3-DICHLOROPROPENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
TRICHLOROETHENE	6.1 U	4.9 U	6.1 UJ	6.1 UJ	5.2 U	6.1 U	6 U	5.4 U
TRICHLOROFLUOROMETHANE	12 UJ	9.9 UJ	12 UJ	12 UJ	10 UJ	12 UJ	12 UJ	11 UJ
VINYL CHLORIDE	12 U	9.9 U	12 UJ	12 UJ	10 U	12 U	12 U	11 U
Semivolatile Organics (ug/kg)								
1,1-BIPHENYL								
2,2'-OXYBIS(1-CHLOROPROPANE)								
2,4,5-TRICHLOROPHENOL								
2,4,6-TRICHLOROPHENOL								
2,4-DICHLOROPHENOL								
2,4-DIMETHYLPHENOL								
2,4-DINITROPHENOL								
2,4-DINITROTOLUENE								
2,6-DINITROTOLUENE								
2-CHLORONAPHTHALENE								
2-CHLOROPHENOL								
2-METHYLNAPHTHALENE								
2-METHYLPHENOL								
2-NITROANILINE								
2-NITROPHENOL								
3,3'-DICHLOROBENZIDINE								
3-NITROANILINE								
4,6-DINITRO-2-METHYLPHENOL								
4-BROMOPHENYL PHENYL ETHER								
4-CHLORO-3-METHYLPHENOL								
4-CHLOROANILINE								
4-CHLOROPHENYL PHENYL ETHER								
4-METHYLPHENOL								
4-NITROANILINE								
4-NITROPHENOL								
ACENAPHTHENE								
ACENAPHTHYLENE								
ACETOPHENONE								
ANTHRACENE								
ATRAZINE								
BENZALDEHYDE								

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order	017	018	019	020	021	022	023	024
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S06	NCBC10S06	NCBC10S06	NCBC10S06	NCBC10S07	NCBC10S07	NCBC10S07	NCBC10S08
nsample	NCBC10S0602	NCBC10S0608	NCBC10S0620	NCBC10S0620-D	NCBC10S0705	NCBC10S0710	NCBC10S0723	NCBC10S0805
sample	NCBC10S0602	NCBC10S0608	NCBC10S0620	NCBC10S0620D	NCBC10S0705	NCBC10S0710	NCBC10S0723	NCBC10S0805
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	2 - 2	8 - 8	20 - 20	20 - 20	5 - 5	10 - 10	23 - 23	5 - 5
gis_date	20020111	20020111	20020111	20020111	20020110	20020110	20020110	20020110
sample_dat	01/11/02	01/11/02	01/11/02	01/11/02	01/10/02	01/10/02	01/10/02	01/10/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_017**	**c_018**	**c_019**	**c_020**	**c_021**	**c_022**	**c_023**	**c_024**
BENZO(A)ANTHRACENE								
BENZO(A)PYRENE								
BENZO(B)FLUORANTHENE								
BENZO(G,H,I)PERYLENE								
BENZO(K)FLUORANTHENE								
BIS(2-CHLOROETHOXY)METHANE								
BIS(2-CHLOROETHYL)ETHER								
BIS(2-ETHYLHEXYL)PHTHALATE								
BUTYL BENZYL PHTHALATE								
CAPROLACTAM								
CARBAZOLE								
CHRYSENE								
DI-N-BUTYL PHTHALATE								
DI-N-OCTYL PHTHALATE								
DIBENZO(A,H)ANTHRACENE								
DIBENZOFURAN								
DIETHYL PHTHALATE								
DIMETHYL PHTHALATE								
FLUORANTHENE								
FLUORENE								
HEXACHLOROBENZENE								
HEXACHLOROBUTADIENE								
HEXACHLOROCYCLOPENTADIENE								
HEXACHLOROETHANE								
INDENO(1,2,3-CD)PYRENE								
ISOPHORONE								
N-NITROSO-DI-N-PROPYLAMINE								
N-NITROSODIPHENYLAMINE								
NAPHTHALENE								
NITROBENZENE								
PENTACHLOROPHENOL								
PHENANTHRENE								
PHENOL								
PYRENE								
Pesticides/PCBs (ug/kg)								
4,4'-DDD	110 U	100 U	2.1 U	2.2 U	2.0 UJ	2.2 UJ	2.2 UJ	2.0 UJ
4,4'-DDE	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
4,4'-DDT	360 R	100 R	2.1 UJ	2.2 UJ	2.0 UJ	2.2 UJ	2.2 UJ	2.0 UJ
ALDRIN	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
ALPHA-BHC	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
ALPHA-CHLORDANE	64 J	25 R	0.40 J	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
AROCLOR-1016	8600 U	2000 U	42 U	42 U	39 U	42 U	42 U	39 U
AROCLOR-1221	8600 U	2000 U	42 U	42 U	39 U	42 U	42 U	39 U

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CTO 288
soils
full appendix results

order	017	018	019	020	021	022	023	024
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S06	NCBC10S06	NCBC10S06	NCBC10S06	NCBC10S07	NCBC10S07	NCBC10S07	NCBC10S08
nsample	NCBC10S0602	NCBC10S0608	NCBC10S0620	NCBC10S0620-D	NCBC10S0705	NCBC10S0710	NCBC10S0723	NCBC10S0805
sample	NCBC10S0602	NCBC10S0608	NCBC10S0620	NCBC10S0620D	NCBC10S0705	NCBC10S0710	NCBC10S0723	NCBC10S0805
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	2 - 2	8 - 8	20 - 20	20 - 20	5 - 5	10 - 10	23 - 23	5 - 5
gis_date	20020111	20020111	20020111	20020111	20020110	20020110	20020110	20020110
sample_dat	01/11/02	01/11/02	01/11/02	01/11/02	01/10/02	01/10/02	01/10/02	01/10/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_017**	**c_018**	**c_019**	**c_020**	**c_021**	**c_022**	**c_023**	**c_024**
AROCLOR-1232	8600 U	2000 U	42 U	42 U	39 U	42 U	42 U	39 U
AROCLOR-1242	8600 U	2000 U	42 U	42 U	39 U	42 U	42 U	39 U
AROCLOR-1248	8600 U	2000 U	42 U	42 U	39 U	42 U	42 U	39 U
AROCLOR-1254	8600 U	2000 U	42 U	42 U	39 U	42 U	42 U	39 U
AROCLOR-1260	83000	19000	42 U	38 J	39 U	42 U	42 U	39 U
BETA-BHC	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
DELTA-BHC	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
DIELDRIN	240 R	60 R	2.1 U	0.14 J	2.0 U	2.2 U	2.2 U	2.0 U
ENDOSULFAN I	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
ENDOSULFAN II	1500	370	2.1 U	0.76 J	2.0 U	2.2 U	2.2 U	2.0 U
ENDOSULFAN SULFATE	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
ENDRIN	700 R	230 R	0.82 J	0.29 R	2.0 U	2.2 U	2.2 U	2.0 U
ENDRIN ALDEHYDE	190 R	53 R	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
ENDRIN KETONE	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
GAMMA-BHC (LINDANE)	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
GAMMA-CHLORDANE	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
HEPTACHLOR	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
HEPTACHLOR EPOXIDE	110 U	100 U	2.1 U	2.2 U	2.0 U	2.2 U	2.2 U	2.0 U
METHOXYCHLOR	210 U	200 U	4.2 U	4.2 U	3.9 U	4.2 U	4.2 U	3.9 U
TOXAPHENE	4400 U	4000 U	85 U	86 U	79 U	86 U	85 U	79 U
Herbicides (ug/kg)								
2,4,5-T								
2,4,5-TP (SILVEX)								
2,4-D								
DINOSEB								
Inorganics (mg/kg)								
ALUMINUM								
ANTIMONY								
ARSENIC								
BARIUM								
BERYLLIUM								
CADMIUM								
CALCIUM								
CHROMIUM								
COBALT								
COPPER								
IRON								
LEAD								
MAGNESIUM								
MANGANESE								
MERCURY								
NICKEL								
POTASSIUM								

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order	017	018	019	020	021	022	023	024
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S06	NCBC10S06	NCBC10S06	NCBC10S06	NCBC10S07	NCBC10S07	NCBC10S07	NCBC10S08
nsample	NCBC10S0602	NCBC10S0608	NCBC10S0620	NCBC10S0620-D	NCBC10S0705	NCBC10S0710	NCBC10S0723	NCBC10S0805
sample	NCBC10S0602	NCBC10S0608	NCBC10S0620	NCBC10S0620D	NCBC10S0705	NCBC10S0710	NCBC10S0723	NCBC10S0805
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	2 - 2	8 - 8	20 - 20	20 - 20	5 - 5	10 - 10	23 - 23	5 - 5
gis_date	20020111	20020111	20020111	20020111	20020110	20020110	20020110	20020110
sample_dat	01/11/02	01/11/02	01/11/02	01/11/02	01/10/02	01/10/02	01/10/02	01/10/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_017**	**c_018**	**c_019**	**c_020**	**c_021**	**c_022**	**c_023**	**c_024**
SELENIUM								
SILVER								
SODIUM								
THALLIUM								
VANADIUM								
ZINC								
Miscellaneous Parameters (mg/kg)								
CYANIDE								
TOTAL SOLIDS (%)								

from _10sosam.dbf
from _10sores.dbf
from _10sores.xls
from q:\sql_server\gulfport\upload

CTO 288
soils
full appendix results

order	025	026	027	028	029	030	031	032
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S08	NCBC10S08	NCBC10S09	NCBC10S09	NCBC10S09	NCBC10S09	NCBC10S10	NCBC10S10
nsample	NCBC10S0810	NCBC10S0823	NCBC10S0905	NCBC10S0910	NCBC10S0910-D	NCBC10S0923	NCBC10S1005	NCBC10S1010
sample	NCBC10S0810	NCBC10S0823	NCBC10S0905	NCBC10S0910	NCBC10S0910D	NCBC10S0923	NCBC10S1005	NCBC10S1010
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	10 - 10	23 - 23	5 - 5	10 - 10	10 - 10	23 - 23	5 - 5	10 - 10
gis_date	20020110	20020110	20020110	20020110	20020110	20020110	20020109	20020109
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	01/10/02	01/10/02	01/09/02	01/09/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	c_025	c_026	c_027	c_028	c_029	c_030	c_031	c_032
Volatile Organics (ug/kg)								
1,1,1-TRICHLOROETHANE	5.7 UJ	5.8 U	4.6 UJ	6.5 UJ	5.7 UJ	8.4 UJ	5.4 U	5.8 UJ
1,1,2,2-TETRACHLOROETHANE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
1,1,2-TRICHLOROETHANE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
1,1,2-TRICHLOROTRIFLUOROETHANE								
1,1-DICHLOROETHANE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
1,1-DICHLOROETHENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
1,2,3-TRICHLOROBENZENE								
1,2,4-TRICHLOROBENZENE								
1,2-DIBROMO-3-CHLOROPROPANE	11 U	12 U	9.2 U	13 U	11 U	17 U	11 U	12 U
1,2-DIBROMOETHANE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
1,2-DICHLOROBENZENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
1,2-DICHLOROETHANE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
1,2-DICHLOROPROPANE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
1,3-DICHLOROBENZENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
1,4-DICHLOROBENZENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
2-BUTANONE	23 U	23 UJ	18 U	26 U	23 U	33 U	21 U	23 U
2-HEXANONE	23 U	23 U	18 U	26 U	23 U	33 U	21 U	23 U
4-METHYL-2-PENTANONE	23 U	23 U	18 U	26 U	23 U	33 U	21 U	23 U
ACETONE	9.7 J	23 UJ	18 UJ	15 J	13 J	9.2 J	21 UJ	9.5 J
BENZENE	1.3 J	5.8 U	0.94 J	1.6 J	1.4 J	8.4 U	5.4 U	5.8 U
BROMOCHLOROMETHANE								
BROMODICHLOROMETHANE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
BROMOFORM	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
BROMOMETHANE	11 U	12 U	9.2 U	13 U	11 U	17 U	11 UJ	12 U
CARBON DISULFIDE	5.7 U	5.8 U	4.6 U	3.8 J	2.5 J	8.4 U	5.4 U	5.8 U
CARBON TETRACHLORIDE	5.7 UJ	5.8 UJ	4.6 UJ	6.5 UJ	5.7 UJ	8.4 UJ	5.4 U	5.8 UJ
CHLOROBENZENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
CHLORODIBROMOMETHANE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
CHLOROETHANE	11 U	12 U	9.2 U	13 U	11 U	17 U	11 U	12 U
CHLOROFORM	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
CHLOROMETHANE	11 U	12 U	9.2 U	13 U	11 U	17 U	11 UJ	12 U
CIS-1,2-DICHLOROETHENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
CIS-1,3-DICHLOROPROPENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
CYCLOHEXANE								
DICHLORODIFLUOROMETHANE								
ETHYLBENZENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
ISOPROPYLBENZENE								
M+P-XYLENES								
METHYL ACETATE								
METHYL CYCLOHEXANE								
METHYL TERT-BUTYL ETHER								
METHYLENE CHLORIDE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U

from _10sosam.dbf
from _10sores.dbf
from _10sores.xls
from q:\s[illegible]ver\gulfport\upload

order	025	026	027	028	029	030	031	032
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S08	NCBC10S08	NCBC10S09	NCBC10S09	NCBC10S09	NCBC10S09	NCBC10S10	NCBC10S10
nsample	NCBC10S0810	NCBC10S0823	NCBC10S0905	NCBC10S0910	NCBC10S0910-D	NCBC10S0923	NCBC10S1005	NCBC10S1010
sample	NCBC10S0810	NCBC10S0823	NCBC10S0905	NCBC10S0910	NCBC10S0910D	NCBC10S0923	NCBC10S1005	NCBC10S1010
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	10 - 10	23 - 23	5 - 5	10 - 10	10 - 10	23 - 23	5 - 5	10 - 10
gis_date	20020110	20020110	20020110	20020110	20020110	20020110	20020109	20020109
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	01/10/02	01/10/02	01/09/02	01/09/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_025**	**c_026**	**c_027**	**c_028**	**c_029**	**c_030**	**c_031**	**c_032**
O-XYLENE								
STYRENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
TETRACHLOROETHENE	5.7 UJ	5.8 U	4.6 UJ	6.5 UJ	5.7 UJ	8.4 UJ	5.4 U	5.8 UJ
TOLUENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
TOTAL 1,2-DICHLOROETHENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
TOTAL XYLENES	17 U	17 U	14 U	19 U	17 U	25 U	16 U	17 U
TRANS-1,2-DICHLOROETHENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
TRANS-1,3-DICHLOROPROPENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
TRICHLOROETHENE	5.7 U	5.8 U	4.6 U	6.5 U	5.7 U	8.4 U	5.4 U	5.8 U
TRICHLOROFLUOROMETHANE	11 UJ	12 UJ	9.2 UJ	13 UJ	11 UJ	17 UJ	11 UJ	12 UJ
VINYL CHLORIDE	11 U	12 U	9.2 U	13 U	11 U	17 U	11 U	12 U
Semivolatile Organics (ug/kg)								
1,1-BIPHENYL								
2,2'-OXYBIS(1-CHLOROPROPANE)								
2,4,5-TRICHLOROPHENOL								
2,4,6-TRICHLOROPHENOL								
2,4-DICHLOROPHENOL								
2,4-DIMETHYLPHENOL								
2,4-DINITROPHENOL								
2,4-DINITROTOLUENE								
2,6-DINITROTOLUENE								
2-CHLORONAPHTHALENE								
2-CHLOROPHENOL								
2-METHYLNAPHTHALENE								
2-METHYLPHENOL								
2-NITROANILINE								
2-NITROPHENOL								
3,3'-DICHLOROBENZIDINE								
3-NITROANILINE								
4,6-DINITRO-2-METHYLPHENOL								
4-BROMOPHENYL PHENYL ETHER								
4-CHLORO-3-METHYLPHENOL								
4-CHLOROANILINE								
4-CHLOROPHENYL PHENYL ETHER								
4-METHYLPHENOL								
4-NITROANILINE								
4-NITROPHENOL								
ACENAPHTHENE								
ACENAPHTHYLENE								
ACETOPHENONE								
ANTHRACENE								
ATRAZINE								
BENZALDEHYDE								

from _10sosam.dbf
from _10sores.dbf
from _10sores.xls
from q:\sql_server\gulfport\upload

CTO 288
soils
full appendix results

order	025	026	027	028	029	030	031	032
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S08	NCBC10S08	NCBC10S09	NCBC10S09	NCBC10S09	NCBC10S09	NCBC10S10	NCBC10S10
nsample	NCBC10S0810	NCBC10S0823	NCBC10S0905	NCBC10S0910	NCBC10S0910-D	NCBC10S0923	NCBC10S1005	NCBC10S1010
sample	NCBC10S0810	NCBC10S0823	NCBC10S0905	NCBC10S0910	NCBC10S0910D	NCBC10S0923	NCBC10S1005	NCBC10S1010
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	10 - 10	23 - 23	5 - 5	10 - 10	10 - 10	23 - 23	5 - 5	10 - 10
gis_date	20020110	20020110	20020110	20020110	20020110	20020110	20020109	20020109
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	01/10/02	01/10/02	01/09/02	01/09/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_025**	**c_026**	**c_027**	**c_028**	**c_029**	**c_030**	**c_031**	**c_032**
BENZO(A)ANTHRACENE								
BENZO(A)PYRENE								
BENZO(B)FLUORANTHENE								
BENZO(G,H,I)PERYLENE								
BENZO(K)FLUORANTHENE								
BIS(2-CHLOROETHOXY)METHANE								
BIS(2-CHLOROETHYL)ETHER								
BIS(2-ETHYLHEXYL)PHTHALATE								
BUTYL BENZYL PHTHALATE								
CAPROLACTAM								
CARBAZOLE								
CHRYSENE								
DI-N-BUTYL PHTHALATE								
DI-N-OCTYL PHTHALATE								
DIBENZO(A,H)ANTHRACENE								
DIBENZOFURAN								
DIETHYL PHTHALATE								
DIMETHYL PHTHALATE								
FLUORANTHENE								
FLUORENE								
HEXACHLOROBENZENE								
HEXACHLOROBUTADIENE								
HEXACHLOROCYCLOPENTADIENE								
HEXACHLOROETHANE								
INDENO(1,2,3-CD)PYRENE								
ISOPHORONE								
N-NITROSO-DI-N-PROPYLAMINE								
N-NITROSODIPHENYLAMINE								
NAPHTHALENE								
NITROBENZENE								
PENTACHLOROPHENOL								
PHENANTHRENE								
PHENOL								
PYRENE								
Pesticides/PCBs (ug/kg)								
4,4'-DDD	2.0 U	2.1 U	1.9 UJ	2.0 UJ	2.1 UJ	2.2 UJ	2.0 U	0.30 J
4,4'-DDE	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
4,4'-DDT	2.0 UJ	2.1 UJ	1.9 UJ	2.0 UJ	2.1 UJ	2.2 UJ	2.0 UJ	2.1 U
ALDRIN	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
ALPHA-BHC	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
ALPHA-CHLORDANE	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
AROCLOR-1016	39 U	42 U	37 U	39 U	40 U	42 U	39 U	41 U
AROCLOR-1221	39 U	42 U	37 U	39 U	40 U	42 U	39 U	41 U

from _10sosam.dbf
from _10sores.dbf
from _10sores.xls
from q:\s[illegible]er\gulfport\upload

order	025	026	027	028	029	030	031	032
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S08	NCBC10S08	NCBC10S09	NCBC10S09	NCBC10S09	NCBC10S09	NCBC10S10	NCBC10S10
nsample	NCBC10S0810	NCBC10S0823	NCBC10S0905	NCBC10S0910	NCBC10S0910-D	NCBC10S0923	NCBC10S1005	NCBC10S1010
sample	NCBC10S0810	NCBC10S0823	NCBC10S0905	NCBC10S0910	NCBC10S0910D	NCBC10S0923	NCBC10S1005	NCBC10S1010
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	10 - 10	23 - 23	5 - 5	10 - 10	10 - 10	23 - 23	5 - 5	10 - 10
gis_date	20020110	20020110	20020110	20020110	20020110	20020110	20020109	20020109
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	01/10/02	01/10/02	01/09/02	01/09/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_025**	**c_026**	**c_027**	**c_028**	**c_029**	**c_030**	**c_031**	**c_032**
AROCLOR-1232	39 U	42 U	37 U	39 U	40 U	42 U	39 U	41 U
AROCLOR-1242	39 U	42 U	37 U	39 U	40 U	42 U	39 U	41 U
AROCLOR-1248	39 U	42 U	37 U	39 U	40 U	42 U	39 U	41 U
AROCLOR-1254	39 U	42 U	37 U	39 U	40 U	42 U	39 U	41 U
AROCLOR-1260	39 U	42 U	37 U	39 U	40 U	42 U	39 U	41 U
BETA-BHC	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
DELTA-BHC	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
DIELDRIN	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
ENDOSULFAN I	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
ENDOSULFAN II	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
ENDOSULFAN SULFATE	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
ENDRIN	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
ENDRIN ALDEHYDE	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 UJ	2.1 U
ENDRIN KETONE	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
GAMMA-BHC (LINDANE)	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
GAMMA-CHLORDANE	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
HEPTACHLOR	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
HEPTACHLOR EPOXIDE	2.0 U	2.1 U	1.9 U	2.0 U	2.1 U	2.2 U	2.0 U	2.1 U
METHOXYCHLOR	3.9 U	4.2 U	3.7 U	3.9 U	4.0 U	4.2 U	3.9 U	4.1 U
TOXAPHENE	80 U	84 U	76 U	80 U	82 U	85 U	79 U	83 U
Herbicides (ug/kg)								
2,4,5-T								
2,4,5-TP (SILVEX)								
2,4-D								
DINOSEB								
Inorganics (mg/kg)								
ALUMINUM								
ANTIMONY								
ARSENIC								
BARIUM								
BERYLLIUM								
CADMIUM								
CALCIUM								
CHROMIUM								
COBALT								
COPPER								
IRON								
LEAD								
MAGNESIUM								
MANGANESE								
MERCURY								
NICKEL								
POTASSIUM								

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from q:\sql_server\gulfport\upload

CTO 288
soils
full appendix results

order	025	026	027	028	029	030	031	032
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S08	NCBC10S08	NCBC10S09	NCBC10S09	NCBC10S09	NCBC10S09	NCBC10S10	NCBC10S10
nsample	NCBC10S0810	NCBC10S0823	NCBC10S0905	NCBC10S0910	NCBC10S0910-D	NCBC10S0923	NCBC10S1005	NCBC10S1010
sample	NCBC10S0810	NCBC10S0823	NCBC10S0905	NCBC10S0910	NCBC10S0910D	NCBC10S0923	NCBC10S1005	NCBC10S1010
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	10 - 10	23 - 23	5 - 5	10 - 10	10 - 10	23 - 23	5 - 5	10 - 10
gis_date	20020110	20020110	20020110	20020110	20020110	20020110	20020109	20020109
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	01/10/02	01/10/02	01/09/02	01/09/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_025**	**c_026**	**c_027**	**c_028**	**c_029**	**c_030**	**c_031**	**c_032**
SELENIUM								
SILVER								
SODIUM								
THALLIUM								
VANADIUM								
ZINC								
Miscellaneous Parameters (mg/kg)								
CYANIDE								
TOTAL SOLIDS (%)								

from _10sosam.dbf
from _10sores.dbf
from _10sores.xls
from q:\s[illegible]er\gulfport\upload

order	033	034	035	036	037	038	039	040
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S10	NCBC10S10	NCBC10S11	NCBC10S11	NCBC10S11	NCBC10S12	NCBC10S12	NCBC10S12
nsample	NCBC10S1023	NCBC10S1023-D	NCBC10S1105	NCBC10S1110	NCBC10S1123	NCBC10S1205	NCBC10S1210	NCBC10S1223
sample	NCBC10S1023	NCBC10S1023D	NCBC10S1105	NCBC10S1110	NCBC10S1123	NCBC10S1205	NCBC10S1210	NCBC10S1223
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	23 - 23	23 - 23	5 - 5	10 - 10	23 - 23	5 - 5	10 - 10	23 - 23
gis_date	20020109	20020109	20020109	20020109	20020109	20020109	20020109	20020109
sample_dat	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_033**	**c_034**	**c_035**	**c_036**	**c_037**	**c_038**	**c_039**	**c_040**
Volatile Organics (ug/kg)								
1,1,1-TRICHLOROETHANE	6.9 UJ	6 UJ	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
1,1,2,2-TETRACHLOROETHANE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
1,1,2-TRICHLOROETHANE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
1,1,2-TRICHLOROTRIFLUOROETHANE								
1,1-DICHLOROETHANE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
1,1-DICHLOROETHENE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
1,2,3-TRICHLOROBENZENE								
1,2,4-TRICHLOROBENZENE								
1,2-DIBROMO-3-CHLOROPROPANE	14 U	12 U	10 U	11 U	12 U	9.3 U	11 U	14 U
1,2-DIBROMOETHANE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
1,2-DICHLOROBENZENE	6.9 U	6 U	2.3 J	5 J	6 U	4.6 U	5.6 U	6.8 U
1,2-DICHLOROETHANE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
1,2-DICHLOROPROPANE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
1,3-DICHLOROBENZENE	6.9 U	6 U	12	34	6 U	4.6 U	5.6 U	6.8 U
1,4-DICHLOROBENZENE	6.9 U	6 U	13	83	6 U	4.6 U	5.6 U	6.8 U
2-BUTANONE	28 U	24 U	20 U	22 U	24 U	19 U	22 U	27 U
2-HEXANONE	28 U	24 U	20 U	22 U	24 U	19 U	22 U	27 U
4-METHYL-2-PENTANONE	28 U	24 U	20 U	22 U	24 U	19 U	22 U	27 U
ACETONE	28 UJ	24 UJ	20 UJ	9.3 J	10 J	19 UJ	8.2 J	9.1 J
BENZENE	6.9 U	6 U	26	6.5	6 U	4.6 U	5.6 U	6.8 U
BROMOCHLOROMETHANE								
BROMODICHLOROMETHANE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
BROMOFORM	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
BROMOMETHANE	14 U	12 U	10 UJ	11 UJ	12 UJ	9.3 UJ	11 UJ	14 UJ
CARBON DISULFIDE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
CARBON TETRACHLORIDE	6.9 UJ	6 UJ	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
CHLOROBENZENE	6.9 U	6 U	110	76	6 U	4.6 U	5.6 U	6.8 U
CHLORODIBROMOMETHANE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
CHLOROETHANE	14 U	12 U	10 U	11 U	12 U	9.3 U	11 U	14 U
CHLOROFORM	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
CHLOROMETHANE	14 U	12 U	10 UJ	11 UJ	12 UJ	9.3 UJ	11 UJ	14 UJ
CIS-1,2-DICHLOROETHENE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
CIS-1,3-DICHLOROPROPENE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
CYCLOHEXANE								
DICHLORODIFLUOROMETHANE								
ETHYLBENZENE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
ISOPROPYLBENZENE								
M+P-XYLENES								
METHYL ACETATE								
METHYL CYCLOHEXANE								
METHYL TERT-BUTYL ETHER								
METHYLENE CHLORIDE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U

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CTO 288
soils
full appendix results

order	033	034	035	036	037	038	039	040
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S10	NCBC10S10	NCBC10S11	NCBC10S11	NCBC10S11	NCBC10S12	NCBC10S12	NCBC10S12
nsample	NCBC10S1023	NCBC10S1023-D	NCBC10S1105	NCBC10S1110	NCBC10S1123	NCBC10S1205	NCBC10S1210	NCBC10S1223
sample	NCBC10S1023	NCBC10S1023D	NCBC10S1105	NCBC10S1110	NCBC10S1123	NCBC10S1205	NCBC10S1210	NCBC10S1223
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	23 - 23	23 - 23	5 - 5	10 - 10	23 - 23	5 - 5	10 - 10	23 - 23
gis_date	20020109	20020109	20020109	20020109	20020109	20020109	20020109	20020109
sample_dat	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_033**	**c_034**	**c_035**	**c_036**	**c_037**	**c_038**	**c_039**	**c_040**
O-XYLENE								
STYRENE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
TETRACHLOROETHENE	6.9 UJ	6 UJ	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
TOLUENE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
TOTAL 1,2-DICHLOROETHENE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
TOTAL XYLENES	21 U	18 U	15 U	17 U	18 U	14 U	17 U	20 U
TRANS-1,2-DICHLOROETHENE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
TRANS-1,3-DICHLOROPROPENE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
TRICHLOROETHENE	6.9 U	6 U	5 U	5.5 U	6 U	4.6 U	5.6 U	6.8 U
TRICHLOROFLUOROMETHANE	14 UJ	12 UJ	10 UJ	11 UJ	12 UJ	9.3 UJ	11 UJ	14 UJ
VINYL CHLORIDE	14 U	12 U	10 U	11 U	12 U	9.3 U	11 U	14 U
Semivolatile Organics (ug/kg)								
1,1-BIPHENYL								
2,2'-OXYBIS(1-CHLOROPROPANE)								
2,4,5-TRICHLOROPHENOL								
2,4,6-TRICHLOROPHENOL								
2,4-DICHLOROPHENOL								
2,4-DIMETHYLPHENOL								
2,4-DINITROPHENOL								
2,4-DINITROTOLUENE								
2,6-DINITROTOLUENE								
2-CHLORONAPHTHALENE								
2-CHLOROPHENOL								
2-METHYLNAPHTHALENE								
2-METHYLPHENOL								
2-NITROANILINE								
2-NITROPHENOL								
3,3'-DICHLOROBENZIDINE								
3-NITROANILINE								
4,6-DINITRO-2-METHYLPHENOL								
4-BROMOPHENYL PHENYL ETHER								
4-CHLORO-3-METHYLPHENOL								
4-CHLOROANILINE								
4-CHLOROPHENYL PHENYL ETHER								
4-METHYLPHENOL								
4-NITROANILINE								
4-NITROPHENOL								
ACENAPHTHENE								
ACENAPHTHYLENE								
ACETOPHENONE								
ANTHRACENE								
ATRAZINE								
BENZALDEHYDE								

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order	033	034	035	036	037	038	039	040
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S10	NCBC10S10	NCBC10S11	NCBC10S11	NCBC10S11	NCBC10S12	NCBC10S12	NCBC10S12
nsample	NCBC10S1023	NCBC10S1023-D	NCBC10S1105	NCBC10S1110	NCBC10S1123	NCBC10S1205	NCBC10S1210	NCBC10S1223
sample	NCBC10S1023	NCBC10S1023D	NCBC10S1105	NCBC10S1110	NCBC10S1123	NCBC10S1205	NCBC10S1210	NCBC10S1223
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	23 - 23	23 - 23	5 - 5	10 - 10	23 - 23	5 - 5	10 - 10	23 - 23
gis_date	20020109	20020109	20020109	20020109	20020109	20020109	20020109	20020109
sample_dat	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_033**	**c_034**	**c_035**	**c_036**	**c_037**	**c_038**	**c_039**	**c_040**
BENZO(A)ANTHRACENE								
BENZO(A)PYRENE								
BENZO(B)FLUORANTHENE								
BENZO(G,H,I)PERYLENE								
BENZO(K)FLUORANTHENE								
BIS(2-CHLOROETHOXY)METHANE								
BIS(2-CHLOROETHYL)ETHER								
BIS(2-ETHYLHEXYL)PHTHALATE								
BUTYL BENZYL PHTHALATE								
CAPROLACTAM								
CARBAZOLE								
CHRYSENE								
DI-N-BUTYL PHTHALATE								
DI-N-OCTYL PHTHALATE								
DIBENZO(A,H)ANTHRACENE								
DIBENZOFURAN								
DIETHYL PHTHALATE								
DIMETHYL PHTHALATE								
FLUORANTHENE								
FLUORENE								
HEXACHLOROBENZENE								
HEXACHLOROBUTADIENE								
HEXACHLOROCYCLOPENTADIENE								
HEXACHLOROETHANE								
INDENO(1,2,3-CD)PYRENE								
ISOPHORONE								
N-NITROSO-DI-N-PROPYLAMINE								
N-NITROSODIPHENYLAMINE								
NAPHTHALENE								
NITROBENZENE								
PENTACHLOROPHENOL								
PHENANTHRENE								
PHENOL								
PYRENE								
Pesticides/PCBs (ug/kg)								
4,4'-DDD	2.2 U	0.39 J	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
4,4'-DDE	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
4,4'-DDT	2.2 UJ	2.1 U	1.9 UJ	2.0 UJ	2.1 UJ	1.9 U	2.0 U	2.2 U
ALDRIN	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
ALPHA-BHC	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
ALPHA-CHLORDANE	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
AROCLOR-1016	42 U	41 U	38 U	40 U	41 U	36 U	40 U	43 U
AROCLOR-1221	42 U	41 U	38 U	40 U	41 U	36 U	40 U	43 U

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CTO 288
soils
full appendix results

order	033	034	035	036	037	038	039	040
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S10	NCBC10S10	NCBC10S11	NCBC10S11	NCBC10S11	NCBC10S12	NCBC10S12	NCBC10S12
nsample	NCBC10S1023	NCBC10S1023-D	NCBC10S1105	NCBC10S1110	NCBC10S1123	NCBC10S1205	NCBC10S1210	NCBC10S1223
sample	NCBC10S1023	NCBC10S1023D	NCBC10S1105	NCBC10S1110	NCBC10S1123	NCBC10S1205	NCBC10S1210	NCBC10S1223
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	23 - 23	23 - 23	5 - 5	10 - 10	23 - 23	5 - 5	10 - 10	23 - 23
gis_date	20020109	20020109	20020109	20020109	20020109	20020109	20020109	20020109
sample_dat	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_033**	**c_034**	**c_035**	**c_036**	**c_037**	**c_038**	**c_039**	**c_040**
AROCLOR-1232	42 U	41 U	38 U	40 U	41 U	36 U	40 U	43 U
AROCLOR-1242	42 U	41 U	38 U	40 U	41 U	36 U	40 U	43 U
AROCLOR-1248	42 U	41 U	38 U	40 U	41 U	36 U	40 U	43 U
AROCLOR-1254	42 U	41 U	38 U	40 U	41 U	7.7 J	40 U	43 U
AROCLOR-1260	42 U	41 U	38 U	40 U	41 U	36 U	40 U	43 U
BETA-BHC	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
DELTA-BHC	2.2 UJ	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
DIELDRIN	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
ENDOSULFAN I	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
ENDOSULFAN II	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
ENDOSULFAN SULFATE	2.2 UJ	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
ENDRIN	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
ENDRIN ALDEHYDE	2.2 U	2.1 U	1.9 UJ	2.0 UJ	2.1 UJ	1.9 U	2.0 U	2.2 U
ENDRIN KETONE	2.2 UJ	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
GAMMA-BHC (LINDANE)	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
GAMMA-CHLORDANE	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
HEPTACHLOR	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
HEPTACHLOR EPOXIDE	2.2 U	2.1 U	1.9 U	2.0 U	2.1 U	1.9 U	2.0 U	2.2 U
METHOXYCHLOR	4.2 UJ	4.1 U	3.8 U	4.0 U	4.1 U	3.6 U	4.0 U	4.3 U
TOXAPHENE	85 U	83 U	77 U	81 U	84 U	74 U	80 U	86 U
Herbicides (ug/kg)								
2,4,5-T								
2,4,5-TP (SILVEX)								
2,4-D								
DINOSEB								
Inorganics (mg/kg)								
ALUMINUM								
ANTIMONY								
ARSENIC								
BARIUM								
BERYLLIUM								
CADMIUM								
CALCIUM								
CHROMIUM								
COBALT								
COPPER								
IRON								
LEAD								
MAGNESIUM								
MANGANESE								
MERCURY								
NICKEL								
POTASSIUM								

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order	033	034	035	036	037	038	039	040
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S10	NCBC10S10	NCBC10S11	NCBC10S11	NCBC10S11	NCBC10S12	NCBC10S12	NCBC10S12
nsample	NCBC10S1023	NCBC10S1023-D	NCBC10S1105	NCBC10S1110	NCBC10S1123	NCBC10S1205	NCBC10S1210	NCBC10S1223
sample	NCBC10S1023	NCBC10S1023D	NCBC10S1105	NCBC10S1110	NCBC10S1123	NCBC10S1205	NCBC10S1210	NCBC10S1223
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	23 - 23	23 - 23	5 - 5	10 - 10	23 - 23	5 - 5	10 - 10	23 - 23
gis_date	20020109	20020109	20020109	20020109	20020109	20020109	20020109	20020109
sample_dat	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_033**	**c_034**	**c_035**	**c_036**	**c_037**	**c_038**	**c_039**	**c_040**
SELENIUM								
SILVER								
SODIUM								
THALLIUM								
VANADIUM								
ZINC								
Miscellaneous Parameters (mg/kg)								
CYANIDE								
TOTAL SOLIDS (%)								

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CTO 288
soils
full appendix results

order	041	042	043	044	045	046	047	048
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S13	NCBC10S13	NCBC10S13	NCBC10S14	NCBC10S14	NCBC10S14	NCBC10S14	NCBC10S15
nsample	NCBC10S1305	NCBC10S1310	NCBC10S1323	NCBC10S1405	NCBC10S1405-D	NCBC10S1410	NCBC10S1420	NCBC10S1505
sample	NCBC10S1305	NCBC10S1310	NCBC10S1323	NCBC10S1405	NCBC10S1405D	NCBC10S1410	NCBC10S1420	NCBC10S1505
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	23 - 23	5 - 5	5 - 5	10 - 10	20 - 20	5 - 5
gis_date	20020109	20020109	20020109	20020109	20020109	20020109	20020109	20020108
sample_dat	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/08/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_041**	**c_042**	**c_043**	**c_044**	**c_045**	**c_046**	**c_047**	**c_048**
Volatile Organics (ug/kg)								
1,1,1-TRICHLOROETHANE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
1,1,2,2-TETRACHLOROETHANE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
1,1,2-TRICHLOROETHANE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
1,1,2-TRICHLOROTRIFLUOROETHANE								
1,1-DICHLOROETHANE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
1,1-DICHLOROETHENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
1,2,3-TRICHLOROBENZENE								
1,2,4-TRICHLOROBENZENE								
1,2-DIBROMO-3-CHLOROPROPANE	11 U	11 U	12 UJ	10 U	9.6 U	12 U	14 U	11 U
1,2-DIBROMOETHANE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
1,2-DICHLOROBENZENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
1,2-DICHLOROETHANE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
1,2-DICHLOROPROPANE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
1,3-DICHLOROBENZENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
1,4-DICHLOROBENZENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
2-BUTANONE	21 U	22 U	24 UJ	20 U	19 U	23 U	29 U	21 U
2-HEXANONE	21 U	22 U	24 UJ	20 U	19 U	23 U	29 U	21 U
4-METHYL-2-PENTANONE	21 U	22 U	24 UJ	20 U	19 U	23 U	29 U	21 U
ACETONE	21 UJ	6.3 J	12 J	20 U	19 UJ	23 UJ	29 UJ	21 UJ
BENZENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
BROMOCHLOROMETHANE								
BROMODICHLOROMETHANE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
BROMOFORM	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
BROMOMETHANE	11 UJ	11 UJ	12 UJ	10 UJ	9.6 UJ	12 UJ	14 UJ	11 UJ
CARBON DISULFIDE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
CARBON TETRACHLORIDE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
CHLOROBENZENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
CHLORODIBROMOMETHANE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
CHLOROETHANE	11 U	11 U	12 UJ	10 U	9.6 U	12 U	14 U	11 U
CHLOROFORM	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
CHLOROMETHANE	11 UJ	11 UJ	12 UJ	10 UJ	9.6 UJ	12 UJ	14 UJ	11 UJ
CIS-1,2-DICHLOROETHENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
CIS-1,3-DICHLOROPROPENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
CYCLOHEXANE								
DICHLORODIFLUOROMETHANE								
ETHYLBENZENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
ISOPROPYLBENZENE								
M+P-XYLENES								
METHYL ACETATE								
METHYL CYCLOHEXANE								
METHYL TERT-BUTYL ETHER								
METHYLENE CHLORIDE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U

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order	041	042	043	044	045	046	047	048
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S13	NCBC10S13	NCBC10S13	NCBC10S14	NCBC10S14	NCBC10S14	NCBC10S14	NCBC10S15
nsample	NCBC10S1305	NCBC10S1310	NCBC10S1323	NCBC10S1405	NCBC10S1405-D	NCBC10S1410	NCBC10S1420	NCBC10S1505
sample	NCBC10S1305	NCBC10S1310	NCBC10S1323	NCBC10S1405	NCBC10S1405D	NCBC10S1410	NCBC10S1420	NCBC10S1505
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	23 - 23	5 - 5	5 - 5	10 - 10	20 - 20	5 - 5
gis_date	20020109	20020109	20020109	20020109	20020109	20020109	20020109	20020108
sample_dat	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/08/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_041**	**c_042**	**c_043**	**c_044**	**c_045**	**c_046**	**c_047**	**c_048**
O-XYLENE								
STYRENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
TETRACHLOROETHENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
TOLUENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
TOTAL 1,2-DICHLOROETHENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
TOTAL XYLENES	16 U	16 U	18 UJ	15 U	14 U	18 U	22 U	16 U
TRANS-1,2-DICHLOROETHENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
TRANS-1,3-DICHLOROPROPENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
TRICHLOROETHENE	5.3 U	5.4 U	5.9 UJ	5 U	4.8 U	5.9 U	7.2 U	5.3 U
TRICHLOROFLUOROMETHANE	11 UJ	11 UJ	12 UJ	10 UJ	9.6 UJ	12 UJ	14 UJ	11 UJ
VINYL CHLORIDE	11 U	11 U	12 UJ	10 U	9.6 U	12 U	14 U	11 U
Semivolatile Organics (ug/kg)								
1,1-BIPHENYL								
2,2'-OXYBIS(1-CHLOROPROPANE)								
2,4,5-TRICHLOROPHENOL								
2,4,6-TRICHLOROPHENOL								
2,4-DICHLOROPHENOL								
2,4-DIMETHYLPHENOL								
2,4-DINITROPHENOL								
2,4-DINITROTOLUENE								
2,6-DINITROTOLUENE								
2-CHLORONAPHTHALENE								
2-CHLOROPHENOL								
2-METHYLNAPHTHALENE								
2-METHYLPHENOL								
2-NITROANILINE								
2-NITROPHENOL								
3,3'-DICHLOROBENZIDINE								
3-NITROANILINE								
4,6-DINITRO-2-METHYLPHENOL								
4-BROMOPHENYL PHENYL ETHER								
4-CHLORO-3-METHYLPHENOL								
4-CHLOROANILINE								
4-CHLOROPHENYL PHENYL ETHER								
4-METHYLPHENOL								
4-NITROANILINE								
4-NITROPHENOL								
ACENAPHTHENE								
ACENAPHTHYLENE								
ACETOPHENONE								
ANTHRACENE								
ATRAZINE								
BENZALDEHYDE								

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CTO 288
soils
full appendix results

order	041	042	043	044	045	046	047	048
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S13	NCBC10S13	NCBC10S13	NCBC10S14	NCBC10S14	NCBC10S14	NCBC10S14	NCBC10S15
nsample	NCBC10S1305	NCBC10S1310	NCBC10S1323	NCBC10S1405	NCBC10S1405-D	NCBC10S1410	NCBC10S1420	NCBC10S1505
sample	NCBC10S1305	NCBC10S1310	NCBC10S1323	NCBC10S1405	NCBC10S1405D	NCBC10S1410	NCBC10S1420	NCBC10S1505
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	23 - 23	5 - 5	5 - 5	10 - 10	20 - 20	5 - 5
gis_date	20020109	20020109	20020109	20020109	20020109	20020109	20020109	20020108
sample_dat	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/08/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_041**	**c_042**	**c_043**	**c_044**	**c_045**	**c_046**	**c_047**	**c_048**
BENZO(A)ANTHRACENE								
BENZO(A)PYRENE								
BENZO(B)FLUORANTHENE								
BENZO(G,H,I)PERYLENE								
BENZO(K)FLUORANTHENE								
BIS(2-CHLOROETHOXY)METHANE								
BIS(2-CHLOROETHYL)ETHER								
BIS(2-ETHYLHEXYL)PHTHALATE								
BUTYL BENZYL PHTHALATE								
CAPROLACTAM								
CARBAZOLE								
CHRYSENE								
DI-N-BUTYL PHTHALATE								
DI-N-OCTYL PHTHALATE								
DIBENZO(A,H)ANTHRACENE								
DIBENZOFURAN								
DIETHYL PHTHALATE								
DIMETHYL PHTHALATE								
FLUORANTHENE								
FLUORENE								
HEXACHLOROBENZENE								
HEXACHLOROBUTADIENE								
HEXACHLOROCYCLOPENTADIENE								
HEXACHLOROETHANE								
INDENO(1,2,3-CD)PYRENE								
ISOPHORONE								
N-NITROSO-DI-N-PROPYLAMINE								
N-NITROSODIPHENYLAMINE								
NAPHTHALENE								
NITROBENZENE								
PENTACHLOROPHENOL								
PHENANTHRENE								
PHENOL								
PYRENE								
Pesticides/PCBs (ug/kg)								
4,4'-DDD	2.0 U	2.0 U	2.2 U	1.9 U	0.18 R	2.1 U	2.6 U	1.9 U
4,4'-DDE	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
4,4'-DDT	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
ALDRIN	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
ALPHA-BHC	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
ALPHA-CHLORDANE	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
AROCLOR-1016	39 U	39 U	42 U	38 U	38 U	40 U	50 U	38 U
AROCLOR-1221	39 U	39 U	42 U	38 U	38 U	40 U	50 U	38 U

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order	041	042	043	044	045	046	047	048
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S13	NCBC10S13	NCBC10S13	NCBC10S14	NCBC10S14	NCBC10S14	NCBC10S14	NCBC10S15
nsample	NCBC10S1305	NCBC10S1310	NCBC10S1323	NCBC10S1405	NCBC10S1405-D	NCBC10S1410	NCBC10S1420	NCBC10S1505
sample	NCBC10S1305	NCBC10S1310	NCBC10S1323	NCBC10S1405	NCBC10S1405D	NCBC10S1410	NCBC10S1420	NCBC10S1505
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	23 - 23	5 - 5	5 - 5	10 - 10	20 - 20	5 - 5
gis_date	20020109	20020109	20020109	20020109	20020109	20020109	20020109	20020108
sample_dat	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/08/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_041**	**c_042**	**c_043**	**c_044**	**c_045**	**c_046**	**c_047**	**c_048**
AROCLOR-1232	39 U	39 U	42 U	38 U	38 U	40 U	50 U	38 U
AROCLOR-1242	39 U	39 U	42 U	38 U	38 U	40 U	50 U	38 U
AROCLOR-1248	39 U	39 U	42 U	38 U	38 U	40 U	50 U	38 U
AROCLOR-1254	39 U	39 U	42 U	38 U	38 U	40 U	50 U	38 U
AROCLOR-1260	39 U	39 U	42 U	38 U	38 U	40 U	50 U	11 J
BETA-BHC	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
DELTA-BHC	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
DIELDRIN	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
ENDOSULFAN I	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
ENDOSULFAN II	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	0.17 J
ENDOSULFAN SULFATE	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
ENDRIN	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
ENDRIN ALDEHYDE	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 UR	1.9 U
ENDRIN KETONE	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
GAMMA-BHC (LINDANE)	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
GAMMA-CHLORDANE	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
HEPTACHLOR	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
HEPTACHLOR EPOXIDE	2.0 U	2.0 U	2.2 U	1.9 U	2.0 U	2.1 U	2.6 U	1.9 U
METHOXYCHLOR	3.9 U	3.9 U	4.2 U	3.8 U	3.8 U	4.0 U	5.0 U	3.8 U
TOXAPHENE	79 U	79 U	86 U	77 U	77 U	82 U	100 U	77 U
Herbicides (ug/kg)								
2,4,5-T								
2,4,5-TP (SILVEX)								
2,4-D								
DINOSEB								
Inorganics (mg/kg)								
ALUMINUM								
ANTIMONY								
ARSENIC								
BARIUM								
BERYLLIUM								
CADMIUM								
CALCIUM								
CHROMIUM								
COBALT								
COPPER								
IRON								
LEAD								
MAGNESIUM								
MANGANESE								
MERCURY								
NICKEL								
POTASSIUM								

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CTO 288
soils
full appendix results

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site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S13	NCBC10S13	NCBC10S13	NCBC10S14	NCBC10S14	NCBC10S14	NCBC10S14	NCBC10S15
nsample	NCBC10S1305	NCBC10S1310	NCBC10S1323	NCBC10S1405	NCBC10S1405-D	NCBC10S1410	NCBC10S1420	NCBC10S1505
sample	NCBC10S1305	NCBC10S1310	NCBC10S1323	NCBC10S1405	NCBC10S1405D	NCBC10S1410	NCBC10S1420	NCBC10S1505
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	23 - 23	5 - 5	5 - 5	10 - 10	20 - 20	5 - 5
gis_date	20020109	20020109	20020109	20020109	20020109	20020109	20020109	20020108
sample_dat	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/09/02	01/08/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_041**	**c_042**	**c_043**	**c_044**	**c_045**	**c_046**	**c_047**	**c_048**
SELENIUM								
SILVER								
SODIUM								
THALLIUM								
VANADIUM								
ZINC								
Miscellaneous Parameters (mg/kg)								
CYANIDE								
TOTAL SOLIDS (%)								

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order	049	050	051	052	053	054	055	056
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S15	NCBC10S15	NCBC10S16	NCBC10S16	NCBC10S16	NCBC10S17	NCBC10S17	NCBC10S17
nsample	NCBC10S1510	NCBC10S1519	NCBC10S1605	NCBC10S1610	NCBC10S1620	NCBC10S1702	NCBC10S1711	NCBC10S1720
sample	NCBC10S1510	NCBC10S1519	NCBC10S1605	NCBC10S1610	NCBC10S1620	NCBC10S1702	NCBC10S1711	NCBC10S1720
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	10 - 10	19 - 19	5 - 5	10 - 10	20 - 20	2 - 2	11 - 11	20 - 20
gis_date	20020108	20020108	20020108	20020108	20020108	20020112	20020112	20020112
sample_dat	01/08/02	01/08/02	01/08/02	01/08/02	01/08/02	01/12/02	01/12/02	01/12/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_049**	**c_050**	**c_051**	**c_052**	**c_053**	**c_054**	**c_055**	**c_056**
Volatile Organics (ug/kg)								
1,1,1-TRICHLOROETHANE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
1,1,2,2-TETRACHLOROETHANE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
1,1,2-TRICHLOROETHANE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
1,1,2-TRICHLOROTRIFLUOROETHANE								
1,1-DICHLOROETHANE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
1,1-DICHLOROETHENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
1,2,3-TRICHLOROBENZENE								
1,2,4-TRICHLOROBENZENE								
1,2-DIBROMO-3-CHLOROPROPANE	12 U	15 U	10 U	12 U	13 U			
1,2-DIBROMOETHANE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
1,2-DICHLOROBENZENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
1,2-DICHLOROETHANE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
1,2-DICHLOROPROPANE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
1,3-DICHLOROBENZENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
1,4-DICHLOROBENZENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
2-BUTANONE	23 U	29 U	21 U	25 U	27 U			
2-HEXANONE	23 U	29 U	21 U	25 U	27 U			
4-METHYL-2-PENTANONE	23 U	29 U	21 U	25 U	27 U			
ACETONE	6.6 J	8.6 J	21 UJ	7.6 J	27 UJ			
BENZENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
BROMOCHLOROMETHANE								
BROMODICHLOROMETHANE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
BROMOFORM	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
BROMOMETHANE	12 UJ	15 UJ	10 UJ	12 UJ	13 UJ			
CARBON DISULFIDE	5.8 U	7.4 U	5.2 U	6.2 U	3.9 J			
CARBON TETRACHLORIDE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
CHLOROBENZENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
CHLORODIBROMOMETHANE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
CHLOROETHANE	12 U	15 U	10 U	12 U	13 U			
CHLOROFORM	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
CHLOROMETHANE	12 UJ	15 UJ	10 UJ	12 UJ	13 UJ			
CIS-1,2-DICHLOROETHENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
CIS-1,3-DICHLOROPROPENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
CYCLOHEXANE								
DICHLORODIFLUOROMETHANE								
ETHYLBENZENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
ISOPROPYLBENZENE								
M+P-XYLENES								
METHYL ACETATE								
METHYL CYCLOHEXANE								
METHYL TERT-BUTYL ETHER								
METHYLENE CHLORIDE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			

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CTO 288
soils
full appendix results

order	049	050	051	052	053	054	055	056
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S15	NCBC10S15	NCBC10S16	NCBC10S16	NCBC10S16	NCBC10S17	NCBC10S17	NCBC10S17
nsample	NCBC10S1510	NCBC10S1519	NCBC10S1605	NCBC10S1610	NCBC10S1620	NCBC10S1702	NCBC10S1711	NCBC10S1720
sample	NCBC10S1510	NCBC10S1519	NCBC10S1605	NCBC10S1610	NCBC10S1620	NCBC10S1702	NCBC10S1711	NCBC10S1720
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	10 - 10	19 - 19	5 - 5	10 - 10	20 - 20	2 - 2	11 - 11	20 - 20
gis_date	20020108	20020108	20020108	20020108	20020108	20020112	20020112	20020112
sample_dat	01/08/02	01/08/02	01/08/02	01/08/02	01/08/02	01/12/02	01/12/02	01/12/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_049**	**c_050**	**c_051**	**c_052**	**c_053**	**c_054**	**c_055**	**c_056**
O-XYLENE								
STYRENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
TETRACHLOROETHENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
TOLUENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
TOTAL 1,2-DICHLOROETHENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
TOTAL XYLENES	17 U	22 U	16 U	19 U	20 U			
TRANS-1,2-DICHLOROETHENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
TRANS-1,3-DICHLOROPROPENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
TRICHLOROETHENE	5.8 U	7.4 U	5.2 U	6.2 U	6.7 U			
TRICHLOROFLUOROMETHANE	12 UJ	15 UJ	10 UJ	12 UJ	13 UJ			
VINYL CHLORIDE	12 U	15 U	10 U	12 U	13 U			
Semivolatile Organics (ug/kg)								
1,1-BIPHENYL								
2,2'-OXYBIS(1-CHLOROPROPANE)								
2,4,5-TRICHLOROPHENOL								
2,4,6-TRICHLOROPHENOL								
2,4-DICHLOROPHENOL								
2,4-DIMETHYLPHENOL								
2,4-DINITROPHENOL								
2,4-DINITROTOLUENE								
2,6-DINITROTOLUENE								
2-CHLORONAPHTHALENE								
2-CHLOROPHENOL								
2-METHYLNAPHTHALENE								
2-METHYLPHENOL								
2-NITROANILINE								
2-NITROPHENOL								
3,3'-DICHLOROBENZIDINE								
3-NITROANILINE								
4,6-DINITRO-2-METHYLPHENOL								
4-BROMOPHENYL PHENYL ETHER								
4-CHLORO-3-METHYLPHENOL								
4-CHLOROANILINE								
4-CHLOROPHENYL PHENYL ETHER								
4-METHYLPHENOL								
4-NITROANILINE								
4-NITROPHENOL								
ACENAPHTHENE								
ACENAPHTHYLENE								
ACETOPHENONE								
ANTHRACENE								
ATRAZINE								
BENZALDEHYDE								

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soils
full appendix results

order	049	050	051	052	053	054	055	056
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S15	NCBC10S15	NCBC10S16	NCBC10S16	NCBC10S16	NCBC10S17	NCBC10S17	NCBC10S17
nsample	NCBC10S1510	NCBC10S1519	NCBC10S1605	NCBC10S1610	NCBC10S1620	NCBC10S1702	NCBC10S1711	NCBC10S1720
sample	NCBC10S1510	NCBC10S1519	NCBC10S1605	NCBC10S1610	NCBC10S1620	NCBC10S1702	NCBC10S1711	NCBC10S1720
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	10 - 10	19 - 19	5 - 5	10 - 10	20 - 20	2 - 2	11 - 11	20 - 20
gis_date	20020108	20020108	20020108	20020108	20020108	20020112	20020112	20020112
sample_dat	01/08/02	01/08/02	01/08/02	01/08/02	01/08/02	01/12/02	01/12/02	01/12/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_049**	**c_050**	**c_051**	**c_052**	**c_053**	**c_054**	**c_055**	**c_056**
BENZO(A)ANTHRACENE								
BENZO(A)PYRENE								
BENZO(B)FLUORANTHENE								
BENZO(G,H,I)PERYLENE								
BENZO(K)FLUORANTHENE								
BIS(2-CHLOROETHOXY)METHANE								
BIS(2-CHLOROETHYL)ETHER								
BIS(2-ETHYLHEXYL)PHTHALATE								
BUTYL BENZYL PHTHALATE								
CAPROLACTAM								
CARBAZOLE								
CHRYSENE								
DI-N-BUTYL PHTHALATE								
DI-N-OCTYL PHTHALATE								
DIBENZO(A,H)ANTHRACENE								
DIBENZOFURAN								
DIETHYL PHTHALATE								
DIMETHYL PHTHALATE								
FLUORANTHENE								
FLUORENE								
HEXACHLOROBENZENE								
HEXACHLOROBUTADIENE								
HEXACHLOROCYCLOPENTADIENE								
HEXACHLOROETHANE								
INDENO(1,2,3-CD)PYRENE								
ISOPHORONE								
N-NITROSO-DI-N-PROPYLAMINE								
N-NITROSODIPHENYLAMINE								
NAPHTHALENE								
NITROBENZENE								
PENTACHLOROPHENOL								
PHENANTHRENE								
PHENOL								
PYRENE								
Pesticides/PCBs (ug/kg)								
4,4'-DDD	2.1 U	2.1 U	10 U	2.0 U	2.1 U	1.1 J	2.1 U	2.4 U
4,4'-DDE	2.1 U	2.1 U	10 U	2.0 U	2.1 U	0.29 J	2.1 U	2.4 U
4,4'-DDT	2.1 U	2.1 U	11 R	2.0 U	2.1 U	0.20 R	2.1 U	0.29 J
ALDRIN	2.1 U	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
ALPHA-BHC	2.1 U	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
ALPHA-CHLORDANE	2.1 U	2.1 U	2.2 R	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
AROCLOR-1016	40 U	40 U	160 U	38 U	41 U	38 U	40 U	46 U
AROCLOR-1221	40 U	40 U	160 U	38 U	41 U	38 U	40 U	46 U

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CTO 288
soils
full appendix results

order	049	050	051	052	053	054	055	056
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S15	NCBC10S15	NCBC10S16	NCBC10S16	NCBC10S16	NCBC10S17	NCBC10S17	NCBC10S17
nsample	NCBC10S1510	NCBC10S1519	NCBC10S1605	NCBC10S1610	NCBC10S1620	NCBC10S1702	NCBC10S1711	NCBC10S1720
sample	NCBC10S1510	NCBC10S1519	NCBC10S1605	NCBC10S1610	NCBC10S1620	NCBC10S1702	NCBC10S1711	NCBC10S1720
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	10 - 10	19 - 19	5 - 5	10 - 10	20 - 20	2 - 2	11 - 11	20 - 20
gis_date	20020108	20020108	20020108	20020108	20020108	20020112	20020112	20020112
sample_dat	01/08/02	01/08/02	01/08/02	01/08/02	01/08/02	01/12/02	01/12/02	01/12/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_049**	**c_050**	**c_051**	**c_052**	**c_053**	**c_054**	**c_055**	**c_056**
AROCLOR-1232	40 U	40 U	160 U	38 U	41 U	38 U	40 U	46 U
AROCLOR-1242	40 U	40 U	160 U	38 U	41 U	38 U	40 U	46 U
AROCLOR-1248	40 U	40 U	160 U	38 U	41 U	38 U	40 U	46 U
AROCLOR-1254	40 U	40 U	160 U	38 U	41 U	38 U	40 U	46 U
AROCLOR-1260	40 U	40 U	1800	38 U	41 U	13 J	40 U	46 U
BETA-BHC	2.1 U	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
DELTA-BHC	0.094 R	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
DIELDRIN	2.1 U	2.1 U	46	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
ENDOSULFAN I	2.1 U	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
ENDOSULFAN II	2.1 U	2.1 U	47 J	2.0 U	2.1 U	0.25 J	2.1 U	2.4 U
ENDOSULFAN SULFATE	2.1 U	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
ENDRIN	2.1 U	2.1 U	19 R	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
ENDRIN ALDEHYDE	2.1 U	2.1 U	6.1 R	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
ENDRIN KETONE	2.1 U	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
GAMMA-BHC (LINDANE)	2.1 U	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
GAMMA-CHLORDANE	2.1 U	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
HEPTACHLOR	2.1 U	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
HEPTACHLOR EPOXIDE	2.1 U	2.1 U	10 U	2.0 U	2.1 U	2.0 U	2.1 U	2.4 U
METHOXYCHLOR	4.0 U	4.0 U	20 U	3.8 U	4.1 U	3.8 U	4.0 U	4.6 U
TOXAPHENE	81 U	81 U	400 U	77 U	82 U	77 U	82 U	93 U
Herbicides (ug/kg)								
2,4,5-T								
2,4,5-TP (SILVEX)								
2,4-D								
DINOSEB								
Inorganics (mg/kg)								
ALUMINUM								
ANTIMONY								
ARSENIC								
BARIUM								
BERYLLIUM								
CADMIUM								
CALCIUM								
CHROMIUM								
COBALT								
COPPER								
IRON								
LEAD								
MAGNESIUM								
MANGANESE								
MERCURY								
NICKEL								
POTASSIUM								

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order	049	050	051	052	053	054	055	056
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S15	NCBC10S15	NCBC10S16	NCBC10S16	NCBC10S16	NCBC10S17	NCBC10S17	NCBC10S17
nsample	NCBC10S1510	NCBC10S1519	NCBC10S1605	NCBC10S1610	NCBC10S1620	NCBC10S1702	NCBC10S1711	NCBC10S1720
sample	NCBC10S1510	NCBC10S1519	NCBC10S1605	NCBC10S1610	NCBC10S1620	NCBC10S1702	NCBC10S1711	NCBC10S1720
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	10 - 10	19 - 19	5 - 5	10 - 10	20 - 20	2 - 2	11 - 11	20 - 20
gis_date	20020108	20020108	20020108	20020108	20020108	20020112	20020112	20020112
sample_dat	01/08/02	01/08/02	01/08/02	01/08/02	01/08/02	01/12/02	01/12/02	01/12/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_049**	**c_050**	**c_051**	**c_052**	**c_053**	**c_054**	**c_055**	**c_056**
SELENIUM								
SILVER								
SODIUM								
THALLIUM								
VANADIUM								
ZINC								
Miscellaneous Parameters (mg/kg)								
CYANIDE								
TOTAL SOLIDS (%)								

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CTO 288
soils
full appendix results

order	057	058	059	060	061	062	063	064
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S18	NCBC10S18	NCBC10S18	NCBC10S18	NCBC10S19	NCBC10S20	NCBC10S21	NCBC10S22
nsample	NCBC10S1805	NCBC10S1810	NCBC10S1810-D	NCBC10S1823	NCBC10S1905	NCBC10S2005	NCBC10S2105	NCBC10S2205
sample	NCBC10S1805	NCBC10S1810	NCBC10S1810D	NCBC10S1823	NCBC10S1905	NCBC10S2005	NCBC10S2105	NCBC10S2205
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	10 - 10	23 - 23	5 - 5	5 - 5	5 - 5	5 - 5
gis_date	20020112	20020112	20020112	20020112	20020212	20020212	20020212	20020213
sample_dat	01/12/02	01/12/02	01/12/02	01/12/02	02/12/02	02/12/02	02/12/02	02/13/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_057**	**c_058**	**c_059**	**c_060**	**c_061**	**c_062**	**c_063**	**c_064**
Volatile Organics (ug/kg)								
1,1,1-TRICHLOROETHANE								4.8 U
1,1,2,2-TETRACHLOROETHANE								4.8 U
1,1,2-TRICHLOROETHANE								4.8 U
1,1,2-TRICHLOROTRIFLUOROETHANE								
1,1-DICHLOROETHANE								4.8 U
1,1-DICHLOROETHENE								4.8 U
1,2,3-TRICHLOROBENZENE								
1,2,4-TRICHLOROBENZENE								
1,2-DIBROMO-3-CHLOROPROPANE								9.5 U
1,2-DIBROMOETHANE								4.8 U
1,2-DICHLOROBENZENE								4.8 U
1,2-DICHLOROETHANE								4.8 U
1,2-DICHLOROPROPANE								4.8 U
1,3-DICHLOROBENZENE								4.8 U
1,4-DICHLOROBENZENE								4.8 U
2-BUTANONE								19 U
2-HEXANONE								19 U
4-METHYL-2-PENTANONE								19 U
ACETONE								19 U
BENZENE								4.8 U
BROMOCHLOROMETHANE								
BROMODICHLOROMETHANE								4.8 U
BROMOFORM								4.8 U
BROMOMETHANE								9.5 U
CARBON DISULFIDE								4.8 U
CARBON TETRACHLORIDE								4.8 U
CHLOROBENZENE								4.8 U
CHLORODIBROMOMETHANE								4.8 U
CHLOROETHANE								9.5 U
CHLOROFORM								4.8 U
CHLOROMETHANE								9.5 U
CIS-1,2-DICHLOROETHENE								4.8 U
CIS-1,3-DICHLOROPROPENE								4.8 U
CYCLOHEXANE								
DICHLORODIFLUOROMETHANE								
ETHYLBENZENE								4.8 U
ISOPROPYLBENZENE								
M+P-XYLENES								
METHYL ACETATE								
METHYL CYCLOHEXANE								
METHYL TERT-BUTYL ETHER								
METHYLENE CHLORIDE								4.8 U

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order	057	058	059	060	061	062	063	064
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S18	NCBC10S18	NCBC10S18	NCBC10S18	NCBC10S19	NCBC10S20	NCBC10S21	NCBC10S22
nsample	NCBC10S1805	NCBC10S1810	NCBC10S1810-D	NCBC10S1823	NCBC10S1905	NCBC10S2005	NCBC10S2105	NCBC10S2205
sample	NCBC10S1805	NCBC10S1810	NCBC10S1810D	NCBC10S1823	NCBC10S1905	NCBC10S2005	NCBC10S2105	NCBC10S2205
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	10 - 10	23 - 23	5 - 5	5 - 5	5 - 5	5 - 5
gis_date	20020112	20020112	20020112	20020112	20020212	20020212	20020212	20020213
sample_dat	01/12/02	01/12/02	01/12/02	01/12/02	02/12/02	02/12/02	02/12/02	02/13/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_057**	**c_058**	**c_059**	**c_060**	**c_061**	**c_062**	**c_063**	**c_064**
O-XYLENE								
STYRENE								4.8 U
TETRACHLOROETHENE								4.8 U
TOLUENE								4.8 U
TOTAL 1,2-DICHLOROETHENE								4.8 U
TOTAL XYLENES								14 U
TRANS-1,2-DICHLOROETHENE								4.8 U
TRANS-1,3-DICHLOROPROPENE								4.8 U
TRICHLOROETHENE								4.8 U
TRICHLOROFLUOROMETHANE								9.5 U
VINYL CHLORIDE								9.5 U
Semivolatile Organics (ug/kg)								
1,1-BIPHENYL								
2,2'-OXYBIS(1-CHLOROPROPANE)								
2,4,5-TRICHLOROPHENOL								
2,4,6-TRICHLOROPHENOL								
2,4-DICHLOROPHENOL								
2,4-DIMETHYLPHENOL								
2,4-DINITROPHENOL								
2,4-DINITROTOLUENE								
2,6-DINITROTOLUENE								
2-CHLORONAPHTHALENE								
2-CHLOROPHENOL								
2-METHYLNAPHTHALENE								
2-METHYLPHENOL								
2-NITROANILINE								
2-NITROPHENOL								
3,3'-DICHLOROBENZIDINE								
3-NITROANILINE								
4,6-DINITRO-2-METHYLPHENOL								
4-BROMOPHENYL PHENYL ETHER								
4-CHLORO-3-METHYLPHENOL								
4-CHLOROANILINE								
4-CHLOROPHENYL PHENYL ETHER								
4-METHYLPHENOL								
4-NITROANILINE								
4-NITROPHENOL								
ACENAPHTHENE								
ACENAPHTHYLENE								
ACETOPHENONE								
ANTHRACENE								
ATRAZINE								
BENZALDEHYDE								

from _10sosam.dbf
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CTO 288
soils
full appendix results

order	057	058	059	060	061	062	063	064
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S18	NCBC10S18	NCBC10S18	NCBC10S18	NCBC10S19	NCBC10S20	NCBC10S21	NCBC10S22
nsample	NCBC10S1805	NCBC10S1810	NCBC10S1810-D	NCBC10S1823	NCBC10S1905	NCBC10S2005	NCBC10S2105	NCBC10S2205
sample	NCBC10S1805	NCBC10S1810	NCBC10S1810D	NCBC10S1823	NCBC10S1905	NCBC10S2005	NCBC10S2105	NCBC10S2205
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	10 - 10	23 - 23	5 - 5	5 - 5	5 - 5	5 - 5
gis_date	20020112	20020112	20020112	20020112	20020212	20020212	20020212	20020213
sample_dat	01/12/02	01/12/02	01/12/02	01/12/02	02/12/02	02/12/02	02/12/02	02/13/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER;R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_057**	**c_058**	**c_059**	**c_060**	**c_061**	**c_062**	**c_063**	**c_064**
BENZO(A)ANTHRACENE								
BENZO(A)PYRENE								
BENZO(B)FLUORANTHENE								
BENZO(G,H,I)PERYLENE								
BENZO(K)FLUORANTHENE								
BIS(2-CHLOROETHOXY)METHANE								
BIS(2-CHLOROETHYL)ETHER								
BIS(2-ETHYLHEXYL)PHTHALATE								
BUTYL BENZYL PHTHALATE								
CAPROLACTAM								
CARBAZOLE								
CHRYSENE								
DI-N-BUTYL PHTHALATE								
DI-N-OCTYL PHTHALATE								
DIBENZO(A,H)ANTHRACENE								
DIBENZOFURAN								
DIETHYL PHTHALATE								
DIMETHYL PHTHALATE								
FLUORANTHENE								
FLUORENE								
HEXACHLOROBENZENE								
HEXACHLOROBUTADIENE								
HEXACHLOROCYCLOPENTADIENE								
HEXACHLOROETHANE								
INDENO(1,2,3-CD)PYRENE								
ISOPHORONE								
N-NITROSO-DI-N-PROPYLAMINE								
N-NITROSODIPHENYLAMINE								
NAPHTHALENE								
NITROBENZENE								
PENTACHLOROPHENOL								
PHENANTHRENE								
PHENOL								
PYRENE								
Pesticides/PCBs (ug/kg)								
4,4'-DDD	1.9 U	2.1 U	2.2 U	2.1 U				
4,4'-DDE	1.9 U	2.1 U	2.2 U	2.1 U				
4,4'-DDT	0.23 J	2.1 U	2.2 U	2.1 U				
ALDRIN	1.9 U	2.1 U	2.2 U	2.1 U				
ALPHA-BHC	1.9 U	2.1 U	2.2 U	2.1 U				
ALPHA-CHLORDANE	1.9 U	2.1 U	2.2 U	2.1 U				
AROCLOR-1016	38 U	41 U	42 U	42 U	39 U	38 U	37 U	
AROCLOR-1221	38 U	41 U	42 U	42 U	39 U	38 U	37 U	

from _10sosam.dbf
from _10sores.dbf
from _10sores.xls
from q:\sql_server\gulfport\upload

order	057	058	059	060	061	062	063	064
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S18	NCBC10S18	NCBC10S18	NCBC10S18	NCBC10S19	NCBC10S20	NCBC10S21	NCBC10S22
nsample	NCBC10S1805	NCBC10S1810	NCBC10S1810-D	NCBC10S1823	NCBC10S1905	NCBC10S2005	NCBC10S2105	NCBC10S2205
sample	NCBC10S1805	NCBC10S1810	NCBC10S1810D	NCBC10S1823	NCBC10S1905	NCBC10S2005	NCBC10S2105	NCBC10S2205
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	10 - 10	23 - 23	5 - 5	5 - 5	5 - 5	5 - 5
gis_date	20020112	20020112	20020112	20020112	20020212	20020212	20020212	20020213
sample_dat	01/12/02	01/12/02	01/12/02	01/12/02	02/12/02	02/12/02	02/12/02	02/13/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_057**	**c_058**	**c_059**	**c_060**	**c_061**	**c_062**	**c_063**	**c_064**
AROCLOR-1232	38 U	41 U	42 U	42 U	39 U	38 U	37 U	
AROCLOR-1242	38 U	41 U	42 U	42 U	39 U	38 U	37 U	
AROCLOR-1248	38 U	41 U	42 U	42 U	39 U	38 U	37 U	
AROCLOR-1254	38 U	41 U	42 U	42 U	39 U	38 U	37 U	
AROCLOR-1260	38 U	41 U	42 U	42 U	39 U	15 J	37 U	
BETA-BHC	1.9 U	2.1 U	2.2 U	2.1 U				
DELTA-BHC	1.9 U	2.1 U	2.2 U	2.1 U				
DIELDRIN	1.9 U	2.1 U	2.2 U	2.1 U				
ENDOSULFAN I	1.9 U	2.1 U	2.2 U	2.1 U				
ENDOSULFAN II	1.9 U	2.1 U	2.2 U	2.1 U				
ENDOSULFAN SULFATE	1.9 U	2.1 U	2.2 U	2.1 U				
ENDRIN	1.9 U	2.1 U	2.2 U	2.1 U				
ENDRIN ALDEHYDE	1.9 U	2.1 U	2.2 U	2.1 U				
ENDRIN KETONE	1.9 U	2.1 U	2.2 U	2.1 U				
GAMMA-BHC (LINDANE)	1.9 U	2.1 U	2.2 U	2.1 U				
GAMMA-CHLORDANE	1.9 U	2.1 U	2.2 U	2.1 U				
HEPTACHLOR	1.9 U	2.1 U	2.2 U	2.1 U				
HEPTACHLOR EPOXIDE	1.9 U	2.1 U	2.2 U	2.1 U				
METHOXYCHLOR	3.8 U	4.1 U	4.2 U	4.2 U				
TOXAPHENE	76 U	83 U	86 U	84 U				
Herbicides (ug/kg)								
2,4,5-T								
2,4,5-TP (SILVEX)								
2,4-D								
DINOSEB								
Inorganics (mg/kg)								
ALUMINUM								
ANTIMONY								
ARSENIC								
BARIUM								
BERYLLIUM								
CADMIUM								
CALCIUM								
CHROMIUM								
COBALT								
COPPER								
IRON								
LEAD								
MAGNESIUM								
MANGANESE								
MERCURY								
NICKEL								
POTASSIUM								

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CTO 288
soils
full appendix results

order	057	058	059	060	061	062	063	064
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S18	NCBC10S18	NCBC10S18	NCBC10S18	NCBC10S19	NCBC10S20	NCBC10S21	NCBC10S22
nsample	NCBC10S1805	NCBC10S1810	NCBC10S1810-D	NCBC10S1823	NCBC10S1905	NCBC10S2005	NCBC10S2105	NCBC10S2205
sample	NCBC10S1805	NCBC10S1810	NCBC10S1810D	NCBC10S1823	NCBC10S1905	NCBC10S2005	NCBC10S2105	NCBC10S2205
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	10 - 10	10 - 10	23 - 23	5 - 5	5 - 5	5 - 5	5 - 5
gis_date	20020112	20020112	20020112	20020112	20020212	20020212	20020212	20020213
sample_dat	01/12/02	01/12/02	01/12/02	01/12/02	02/12/02	02/12/02	02/12/02	02/13/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_057**	**c_058**	**c_059**	**c_060**	**c_061**	**c_062**	**c_063**	**c_064**
SELENIUM								
SILVER								
SODIUM								
THALLIUM								
VANADIUM								
ZINC								
Miscellaneous Parameters (mg/kg)								
CYANIDE								
TOTAL SOLIDS (%)								

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order	065	066	067	068	069	070	071	072
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S23	NCBC10S24	NCBC10S25	NCBC10S26	NCBC10S27	NCBC10S28	NCBC10S29	NCBC10S29
nsample	NCBC10S2305	DP1024S01	DP1025S01	DP1026S01	DP1027S01	DP1028S01	DP1029S01	DP1029S01-D
sample	NCBC10S2305	DP1024S01	DP1025S01	DP1026S01	DP1027S01	DP1028S01	DP1029S01	DP1029S01D
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	6 - 7	7 - 8	18 - 19	6 - 7	6 - 7	6 - 7	6 - 7
gis_date	20020213	20031216	20031216	20031216	20031216	20031216	20031216	20031216
sample_dat	02/13/02	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	288	288	288	288	288	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_065**	**c_066**	**c_067**	**c_068**	**c_069**	**c_070**	**c_071**	**c_072**
Volatile Organics (ug/kg)								
1,1,1-TRICHLOROETHANE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
1,1,2,2-TETRACHLOROETHANE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
1,1,2-TRICHLOROETHANE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
1,1,2-TRICHLOROTRIFLUOROETHANE		6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
1,1-DICHLOROETHANE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
1,1-DICHLOROETHENE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
1,2,3-TRICHLOROBENZENE		0.5 J	27	6 U	6 U	11 J	3 J	2 J
1,2,4-TRICHLOROBENZENE		6 U	660	6 U	6 U	550	160 J	100
1,2-DIBROMO-3-CHLOROPROPANE	9.9 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
1,2-DIBROMOETHANE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
1,2-DICHLOROBENZENE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
1,2-DICHLOROETHANE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
1,2-DICHLOROPROPANE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
1,3-DICHLOROBENZENE	5 U	6 U	160 J	6 U	6 U	87 J	57	59
1,4-DICHLOROBENZENE	5 U	6 U	390 J	6 U	6 U	290 J	140	160
2-BUTANONE	20 U	29 U	30 U	30 U	29 U	33 UJ	28 U	31 U
2-HEXANONE	20 U	29 U	30 U	30 U	29 U	33 UJ	28 U	31 U
4-METHYL-2-PENTANONE	20 U	29 U	30 U	30 U	29 U	33 UJ	28 U	31 U
ACETONE	20 U	18 J	30 U	30 U	29 U	33 UJ	28 U	31 U
BENZENE	5 U	6 U	8	6 U	6 U	4 J	6 U	6 U
BROMOCHLOROMETHANE		6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
BROMODICHLOROMETHANE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
BROMOFORM	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
BROMOMETHANE	9.9 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
CARBON DISULFIDE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
CARBON TETRACHLORIDE	5 U	6 UJ	6 UJ	6 UJ	6 UJ	7 UJ	6 UJ	6 UJ
CHLOROBENZENE	5 U	6 U	150	6 U	6 U	160 J	43	34
CHLORODIBROMOMETHANE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
CHLOROETHANE	9.9 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
CHLOROFORM	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
CHLOROMETHANE	9.9 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
CIS-1,2-DICHLOROETHENE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
CIS-1,3-DICHLOROPROPENE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
CYCLOHEXANE		6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
DICHLORODIFLUOROMETHANE		6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
ETHYLBENZENE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
ISOPROPYLBENZENE		6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
M+P-XYLENES		12 U	12 U	12 U	12 U	13 UJ	11 U	12 U
METHYL ACETATE		6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
METHYL CYCLOHEXANE		6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
METHYL TERT-BUTYL ETHER		12 U	12 U	12 U	12 U	13 UJ	11 U	12 U
METHYLENE CHLORIDE	5 U	10 U	12 U	12 U	12 U	13 UJ	11 U	12 U

from _10sosam.dbf
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from _10sores.xls
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CTO 288
soils
full appendix results

order	065	066	067	068	069	070	071	072
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S23	NCBC10S24	NCBC10S25	NCBC10S26	NCBC10S27	NCBC10S28	NCBC10S29	NCBC10S29
nsample	NCBC10S2305	DP1024S01	DP1025S01	DP1026S01	DP1027S01	DP1028S01	DP1029S01	DP1029S01-D
sample	NCBC10S2305	DP1024S01	DP1025S01	DP1026S01	DP1027S01	DP1028S01	DP1029S01	DP1029S01D
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	6 - 7	7 - 8	18 - 19	6 - 7	6 - 7	6 - 7	6 - 7
gis_date	20020213	20031216	20031216	20031216	20031216	20031216	20031216	20031216
sample_dat	02/13/02	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	288	288	288	288	288	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_065**	**c_066**	**c_067**	**c_068**	**c_069**	**c_070**	**c_071**	**c_072**
O-XYLENE		6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
STYRENE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
TETRACHLOROETHENE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
TOLUENE	5 U	1 J	6 U	6 U	6 U	7 UJ	6 U	6 U
TOTAL 1,2-DICHLOROETHENE	5 U	12 U	12 U	12 U	12 U	13 UJ	11 U	12 U
TOTAL XYLENES	15 U	18 U	18 U	18 U	18 U	20 UJ	17 U	18 U
TRANS-1,2-DICHLOROETHENE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
TRANS-1,3-DICHLOROPROPENE	5 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
TRICHLOROETHENE	5 U	6 UR	6 U	6 U	6 U	7 UJ	6 U	6 U
TRICHLOROFLUOROMETHANE	9.9 U	6	1 J	4 J	1 J	7 UJ	3 J	7
VINYL CHLORIDE	9.9 U	6 U	6 U	6 U	6 U	7 UJ	6 U	6 U
Semivolatile Organics (ug/kg)								
1,1-BIPHENYL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
2,2'-OXYBIS(1-CHLOROPROPANE)		400 UJ	400 UJ	390 UJ	390 UJ	410 UJ	400 UJ	390 UJ
2,4,5-TRICHLOROPHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
2,4,6-TRICHLOROPHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
2,4-DICHLOROPHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
2,4-DIMETHYLPHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
2,4-DINITROPHENOL		400 UJ	400 UJ	390 UJ	390 UJ	410 UJ	400 UJ	390 UJ
2,4-DINITROTOLUENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
2,6-DINITROTOLUENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
2-CHLORONAPHTHALENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
2-CHLOROPHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
2-METHYLNAPHTHALENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
2-METHYLPHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
2-NITROANILINE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
2-NITROPHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
3,3'-DICHLOROBENZIDINE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
3-NITROANILINE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
4,6-DINITRO-2-METHYLPHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
4-BROMOPHENYL PHENYL ETHER		400 U	400 U	390 U	390 U	410 U	400 U	390 U
4-CHLORO-3-METHYLPHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
4-CHLOROANILINE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
4-CHLOROPHENYL PHENYL ETHER		400 U	400 U	390 U	390 U	410 U	400 U	390 U
4-METHYLPHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
4-NITROANILINE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
4-NITROPHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
ACENAPHTHENE		280 J	400 U	390 U	280 J	410 U	400 U	390 U
ACENAPHTHYLENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
ACETOPHENONE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
ANTHRACENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
ATRAZINE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
BENZALDEHYDE		400 UJ	400 UJ	390 UJ	390 UJ	410 UJ	400 UJ	390 UJ

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from _10sores.dbf
from _10sores.xls
from q:\sc[illegible]r\gulfport\upload

soils

full appendix results

order	065	066	067	068	069	070	071	072
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S23	NCBC10S24	NCBC10S25	NCBC10S26	NCBC10S27	NCBC10S28	NCBC10S29	NCBC10S29
nsample	NCBC10S2305	DP1024S01	DP1025S01	DP1026S01	DP1027S01	DP1028S01	DP1029S01	DP1029S01-D
sample	NCBC10S2305	DP1024S01	DP1025S01	DP1026S01	DP1027S01	DP1028S01	DP1029S01	DP1029S01D
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	6 - 7	7 - 8	18 - 19	6 - 7	6 - 7	6 - 7	6 - 7
gis_date	20020213	20031216	20031216	20031216	20031216	20031216	20031216	20031216
sample_dat	02/13/02	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	288	288	288	288	288	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_065**	**c_066**	**c_067**	**c_068**	**c_069**	**c_070**	**c_071**	**c_072**
BENZO(A)ANTHRACENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
BENZO(A)PYRENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
BENZO(B)FLUORANTHENE		470 U	400 U	460 U	390 U	410 U	460 U	390 U
BENZO(G,H,I)PERYLENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
BENZO(K)FLUORANTHENE		470 U	400 U	460 U	390 U	410 U	460 U	390 U
BIS(2-CHLOROETHOXY)METHANE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
BIS(2-CHLOROETHYL)ETHER		400 U	400 U	390 U	390 U	410 U	400 U	390 U
BIS(2-ETHYLHEXYL)PHTHALATE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
BUTYL BENZYL PHTHALATE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
CAPROLACTAM		400 UJ	400 UJ	390 UJ	390 UJ	410 UJ	400 UJ	390 UJ
CARBAZOLE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
CHRYSENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
DI-N-BUTYL PHTHALATE		260 J	280 J	260 J	390 U	410 U	260 J	250 J
DI-N-OCTYL PHTHALATE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
DIBENZO(A,H)ANTHRACENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
DIBENZOFURAN		400 U	400 U	390 U	390 U	410 U	400 U	390 U
DIETHYL PHTHALATE		400 UJ	400 UJ	390 UJ	390 UJ	410 UJ	400 UJ	390 UJ
DIMETHYL PHTHALATE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
FLUORANTHENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
FLUORENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
HEXACHLOROBENZENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
HEXACHLOROBUTADIENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
HEXACHLOROCYCLOPENTADIENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
HEXACHLOROETHANE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
INDENO(1,2,3-CD)PYRENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
ISOPHORONE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
N-NITROSO-DI-N-PROPYLAMINE		400 UJ	400 UJ	390 UJ	390 UJ	410 U	400 UJ	390 UJ
N-NITROSODIPHENYLAMINE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
NAPHTHALENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
NITROBENZENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
PENTACHLOROPHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
PHENANTHRENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
PHENOL		400 U	400 U	390 U	390 U	410 U	400 U	390 U
PYRENE		400 U	400 U	390 U	390 U	410 U	400 U	390 U
Pesticides/PCBs (ug/kg)								
4,4'-DDD		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
4,4'-DDE		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
4,4'-DDT		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
ALDRIN		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
ALPHA-BHC		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
ALPHA-CHLORDANE		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
AROCLOR-1016		20 U	21 U	20 U	20 UJ	21 U	20 U	20 U
AROCLOR-1221		20 U	21 U	20 U	20 UJ	21 U	20 U	20 U

from _10sosam.dbf
from _10sores.dbf
from _10sores.xls
from q:\sql_server\gulfport\upload

CTO 288
soils
full appendix results

order	065	066	067	068	069	070	071	072
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S23	NCBC10S24	NCBC10S25	NCBC10S26	NCBC10S27	NCBC10S28	NCBC10S29	NCBC10S29
nsample	NCBC10S2305	DP1024S01	DP1025S01	DP1026S01	DP1027S01	DP1028S01	DP1029S01	DP1029S01-D
sample	NCBC10S2305	DP1024S01	DP1025S01	DP1026S01	DP1027S01	DP1028S01	DP1029S01	DP1029S01D
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	6 - 7	7 - 8	18 - 19	6 - 7	6 - 7	6 - 7	6 - 7
gis_date	20020213	20031216	20031216	20031216	20031216	20031216	20031216	20031216
sample_dat	02/13/02	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	288	288	288	288	288	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_065**	**c_066**	**c_067**	**c_068**	**c_069**	**c_070**	**c_071**	**c_072**
AROCLOR-1232		20 U	21 U	20 U	20 UJ	21 U	20 U	20 U
AROCLOR-1242		20 U	21 U	20 U	20 UJ	21 U	20 U	20 U
AROCLOR-1248		20 U	21 U	20 U	20 UJ	21 U	20 U	20 U
AROCLOR-1254		20 U	21 U	20 U	20 UJ	21 U	20 U	20 U
AROCLOR-1260		20 U	21 U	14 J	20 UJ	21 U	20 U	20 U
BETA-BHC		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
DELTA-BHC		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
DIELDRIN		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
ENDOSULFAN I		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
ENDOSULFAN II		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
ENDOSULFAN SULFATE		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
ENDRIN		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
ENDRIN ALDEHYDE		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
ENDRIN KETONE		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
GAMMA-BHC (LINDANE)		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
GAMMA-CHLORDANE		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
HEPTACHLOR		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
HEPTACHLOR EPOXIDE		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
METHOXYCHLOR		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
TOXAPHENE		2 U	2.1 U	2 U	2 U	2.1 U	2 U	2 U
Herbicides (ug/kg)								
2,4,5-T		24 U	25 U	24 U	24 U	24 U	24 U	24 U
2,4,5-TP (SILVEX)		12 U	12 U	12 U	12 U	12 U	12 U	12 U
2,4-D		83 U	86 U	84 U	84 U	84 U	85 U	84 U
DINOSEB		59 U	61 U	60 U	60 U	60 U	61 U	60 U
Inorganics (mg/kg)								
ALUMINUM		2050	795	447	1310	1520	1330	1360
ANTIMONY		0.33 U	0.22 U	0.17 U	0.18 U	0.26 U	0.25 U	0.16 U
ARSENIC		1.5	0.5	0.6	0.21	0.44	0.45	0.42
BARIUM		4.4	2.7	1.5	4.4	4.4	5.4	6
BERYLLIUM		0.11 U	0.05 U	0.03 U	0.05 U	0.08 U	0.07 U	0.07 U
CADMIUM		0.27 U	0.28 U	0.23 U	0.27 U	0.28 U	0.28 U	0.25 U
CALCIUM		51.2	33.1	31.3	48	30.9	30	32.1
CHROMIUM		3.3	1.4	0.73	1.4	1.8	1.2	1.3
COBALT		0.73	0.31 U	0.26 U	0.30 U	0.32	0.32	0.28 U
COPPER		1.1	0.65	0.68	1.1	1.2	1.4	1.2
IRON		278	132	303	170	185	207	207
LEAD		0.90 U	0.54 U	0.74 U	0.84 U	1.0 U	0.66 U	0.82 U
MAGNESIUM		32.2	21	17.2	43.6	43.6	48.6	48.3
MANGANESE		1.1 U	1.6	1.1	1.1 U	1.3	1.1 U	1.2
MERCURY		0.01 U	0.02 U	0.01 U	0.02 U	0.03 U	0.02 U	0.02 U
NICKEL		1.5	1.26 U	1.06 U	1.22 U	1.28 U	1.29 U	1.13 U
POTASSIUM		48.19 U	49.80 U	41.85 U	48.31 U	58.2	51.12 U	44.92 U

from _10sosam.dbf
from _10sores.dbf
from _10s[illegible].xls
from q:\[illegible]er\gulfport\upload

order	065	066	067	068	069	070	071	072
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10S23	NCBC10S24	NCBC10S25	NCBC10S26	NCBC10S27	NCBC10S28	NCBC10S29	NCBC10S29
nsample	NCBC10S2305	DP1024S01	DP1025S01	DP1026S01	DP1027S01	DP1028S01	DP1029S01	DP1029S01-D
sample	NCBC10S2305	DP1024S01	DP1025S01	DP1026S01	DP1027S01	DP1028S01	DP1029S01	DP1029S01D
matrix	SO	SO	SO	SO	SO	SO	SO	SO
depth_rang	5 - 5	6 - 7	7 - 8	18 - 19	6 - 7	6 - 7	6 - 7	6 - 7
gis_date	20020213	20031216	20031216	20031216	20031216	20031216	20031216	20031216
sample_dat	02/13/02	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03	12/16/03
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	288	288	288	288	288	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_065**	**c_066**	**c_067**	**c_068**	**c_069**	**c_070**	**c_071**	**c_072**
SELENIUM		0.27	0.24 U	0.20 U	0.23 U	0.25 U	0.25 U	0.22 U
SILVER		0.12 U	0.12 U	0.10 U	0.12 U	0.12 U	0.12 U	0.11 U
SODIUM		9.2	10.4	9.4	10.3	13.7	14.8	12.8
THALLIUM		0.55 U	0.52 U	0.27 U	0.36 U	0.53 U	0.48 U	0.33 U
VANADIUM		3.1	1.4	0.99	1.8	2.5	1.6	1.6
ZINC		0.54	0.35	2.3	0.54	0.74	0.6	0.54
Miscellaneous Parameters (mg/kg)								
CYANIDE		0.60 U	0.61 U	0.59 U	0.60 U	0.62 U	0.60 U	0.59 U
TOTAL SOLIDS (%)		83 %	82 %	84 %	84 %	80 %	83 %	85 %

from _10sosam.dbf
from _10sores.dbf
from _10sores.xls
from q:\sql_server\gulfport\upload

groundwaters
full appendix results

order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
round	2003Q4	2003Q4	2003Q4	2003Q4	2003Q4	2003Q4	2002Q1	2002Q1
location	NCBC10G01	NCBC10G02	NCBC10G02	NCBC10G03	NCBC10G04	NCBC10G05	NCBC10G01	NCBC10G02
nsample	MW1001G02	MW1002G02	MW1002G02-D	MW1003G02	MW1004G02	MW1005G02	NCBC10G01	NCBC10G02
sample	MW1001G02	MW1002G02	MW1002G02D	MW1003G02	MW1004G02	MW1005G02	NCBC10G01	NCBC10G02
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20031218	20031218	20031218	20031218	20031218	20031218	20020214	20020214
sample_dat	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03	02/14/02	02/14/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	288	288	288	288	288	288	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
Volatile Organics (ug/L)								
1,1,1-TRICHLOROETHANE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-TETRACHLOROETHANE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-TRICHLOROETHANE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-TRICHLOROTRIFLUOROETHANE	1 U	1 U	1 U	1 U	1 UJ	1 U		
1,1-DICHLOROETHANE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-DICHLOROETHENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,3-TRICHLOROBENZENE	1 U	1 U	1 U	1 U	1 U	1 U		
1,2,4-TRICHLOROBENZENE	1 U	25	24	1 U	1 U	1 U		
1,2-DIBROMO-3-CHLOROPROPANE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-DIBROMOETHANE	1 U	1 U	1 U	1 U	1 U	1 U	0.02 U	0.02 U
1,2-DICHLOROBENZENE	1 U	0.4 J	0.4 J	1 U	1 U	1 U	1 U	1 U
1,2-DICHLOROETHANE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-DICHLOROPROPANE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,3-DICHLOROBENZENE	1 U	4	4	1 U	1 U	1 U	1 U	2.7
1,4-DICHLOROBENZENE	1 U	6	6	1 U	1 U	1 U	1 U	1.1
2-BUTANONE	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
2-HEXANONE	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
4-METHYL-2-PENTANONE	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
ACETONE	5 UR	5 UR	5 UR	5 UR	5 UR	5 UR	10 UJ	10 UJ
BENZENE	1 U	3	3	1 U	1 U	1 U	1 U	1 U
BROMOCHLOROMETHANE	1 U	1 U	1 U	1 U	1 U	1 U		
BROMODICHLOROMETHANE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
BROMOFORM	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
BROMOMETHANE	2 U	2 U	2 U	2 U	2 U	2 U	1 U	1 U
CARBON DISULFIDE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
CARBON TETRACHLORIDE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
CHLOROBENZENE	0.3 J	2	2	1 U	1 U	1 U	1 U	1 U
CHLORODIBROMOMETHANE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
CHLOROETHANE	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
CHLOROFORM	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
CHLOROMETHANE	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
CIS-1,2-DICHLOROETHENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
CIS-1,3-DICHLOROPROPENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
CYCLOHEXANE	1 U	1 U	1 U	1 U	1 U	1 U		
DICHLORODIFLUOROMETHANE	2 U	2 U	2 U	2 U	2 U	2 U		
ETHYLBENZENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
ISOPROPYLBENZENE	1 U	1 U	1 U	1 U	1 U	1 U		
M+P-XYLENES	2 U	2 U	2 U	2 U	2 U	2 U		
METHYL ACETATE	1 U	1 U	1 U	1 U	1 U	1 U		
METHYL CYCLOHEXANE	1 U	1 U	1 U	1 U	1 U	1 U		
METHYL TERT-BUTYL ETHER	2 U	2 U	2 U	2 U	2 UJ	2 U		
METHYLENE CHLORIDE	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U

from _10gwsam.dbf
from _10gwres.dbf
from _10gwres.xls
from q:\sql_server\gulfport\upload

CTO 288
groundwaters
full appendix results

order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
round	2003Q4	2003Q4	2003Q4	2003Q4	2003Q4	2003Q4	2002Q1	2002Q1
location	NCBC10G01	NCBC10G02	NCBC10G02	NCBC10G03	NCBC10G04	NCBC10G05	NCBC10G01	NCBC10G02
nsample	MW1001G02	MW1002G02	MW1002G02-D	MW1003G02	MW1004G02	MW1005G02	NCBC10G01	NCBC10G02
sample	MW1001G02	MW1002G02	MW1002G02D	MW1003G02	MW1004G02	MW1005G02	NCBC10G01	NCBC10G02
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20031218	20031218	20031218	20031218	20031218	20031218	20020214	20020214
sample_dat	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03	02/14/02	02/14/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	288	288	288	288	288	288	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
O-XYLENE	1 U	1 U	1 U	1 U	1 U	1 U		
STYRENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
TETRACHLOROETHENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
TOLUENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
TOTAL 1,2-DICHLOROETHENE	2 U	2 U	2 U	2 U	2 U	2 U	1 U	1 U
TOTAL XYLENES	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
TRANS-1,2-DICHLOROETHENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
TRANS-1,3-DICHLOROPROPENE	1 U	1 U	1 U	1 U	1 U.	1 U	1 U	1 U
TRICHLOROETHENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
TRICHLOROFLUOROMETHANE	5 U	5 U	5 U	5 U	5 U	5 U	2 U	2 U
VINYL CHLORIDE	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Semivolatile Organics (ug/L)								
1,1-BIPHENYL	10 U	10 U	10 U	10 U	10 U	10 U		
2,2'-OXYBIS(1-CHLOROPROPANE)	10 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ		
2,4,5-TRICHLOROPHENOL	25 U	25 U	25 U	25 U	25 U	25 U		
2,4,6-TRICHLOROPHENOL	10 U	10 U	10 U	10 U	10 U	10 U		
2,4-DICHLOROPHENOL	10 U	10 U	10 U	10 U	10 U	10 U		
2,4-DIMETHYLPHENOL	10 U	10 U	10 U	10 U	10 U	10 U		
2,4-DINITROPHENOL	25 U	25 UJ	25 UJ	25 UJ	25 U	25 UJ		
2,4-DINITROTOLUENE	10 U	10 U	10 U	10 U	10 U	10 U		
2,6-DINITROTOLUENE	10 UJ	10 U	10 U	10 U	10 UJ	10 U		
2-CHLORONAPHTHALENE	10 U	10 U	10 U	10 U	10 U	10 U		
2-CHLOROPHENOL	10 U	10 U	10 U	10 U	10 U	10 U		
2-METHYLNAPHTHALENE	10 U	10 U	10 U	10 U	10 U	10 U		
2-METHYLPHENOL	10 U	10 U	10 U	10 U	10 U	10 U		
2-NITROANILINE	25 UJ	25 U	25 U	25 U	25 UJ	25 U		
2-NITROPHENOL	10 UJ	10 U	10 U	10 U	10 UJ	10 U		
3,3'-DICHLOROBENZIDINE	10 UJ	10 U	10 U	10 U	10 UJ	10 U		
3-NITROANILINE	25 UJ	25 U	25 U	25 U	25 UJ	25 U		
4,6-DINITRO-2-METHYLPHENOL	25 U	25 U	25 U	25 U	25 U	25 U		
4-BROMOPHENYL PHENYL ETHER	10 U	10 U	10 U	10 U	10 U	10 U		
4-CHLORO-3-METHYLPHENOL	10 U	10 U	10 U	10. U	10 U	10 U		
4-CHLOROANILINE	10 U	10 U	10 U	10 U	10 U	10 U		
4-CHLOROPHENYL PHENYL ETHER	10 U	10 U	10 U	10 U	10 U	10 U		
4-METHYLPHENOL	10 U	10 U	10 U	10 U	10 U	10 U		
4-NITROANILINE	25 U	25 U	25 U	25 U	25 U	25 U		
4-NITROPHENOL	25 U	25 U	25 U	25 U	25 U	25 U		
ACENAPHTHENE	10 U	10 U	10 U	10 U	10 U	10 U		
ACENAPHTHYLENE	10 U	10 U	10 U	10 U	10 U	10 U		
ACETOPHENONE	10 U	10 U	10 U	10 U	10 U	10 U		
ANTHRACENE	10 U	10 U	10 U	10 U	10 U	10 U		
ATRAZINE	10 U	10 U	10 U	10 U	10 U	10 U		
BENZALDEHYDE	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ		

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order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
round	2003Q4	2003Q4	2003Q4	2003Q4	2003Q4	2003Q4	2002Q1	2002Q1
location	NCBC10G01	NCBC10G02	NCBC10G02	NCBC10G03	NCBC10G04	NCBC10G05	NCBC10G01	NCBC10G02
nsample	MW1001G02	MW1002G02	MW1002G02-D	MW1003G02	MW1004G02	MW1005G02	NCBC10G01	NCBC10G02
sample	MW1001G02	MW1002G02	MW1002G02D	MW1003G02	MW1004G02	MW1005G02	NCBC10G01	NCBC10G02
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20031218	20031218	20031218	20031218	20031218	20031218	20020214	20020214
sample_dat	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03	02/14/02	02/14/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	288	288	288	288	288	288	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
BENZO(A)ANTHRACENE	10 U	10 U	10 U	10 U	10 U	10 U		
BENZO(A)PYRENE	10 U	10 U	10 U	10 U	10 U	10 U		
BENZO(B)FLUORANTHENE	10 U	11 U	10 U	10 U	10 U	11 U		
BENZO(G,H,I)PERYLENE	10 UJ	10 U	10 U	10 U	10 UJ	10 U		
BENZO(K)FLUORANTHENE	10 U	11 J	10 UJ	10 U	10 U	11		
BIS(2-CHLOROETHOXY)METHANE	10 UJ	10 U	10 U	10 U	10 UJ	10 U		
BIS(2-CHLOROETHYL)ETHER	10 U	10 U	10 U	10 U	10 U	10 U		
BIS(2-ETHYLHEXYL)PHTHALATE	10 U	10 U	10 U	10 U	10 U	10 U		
BUTYL BENZYL PHTHALATE	10 U	10 U	10 U	10 U	10 U	10 U		
CAPROLACTAM	10 U	10 U	10 U	10 U	10 U	10 U		
CARBAZOLE	10 U	10 U	10 U	10 U	10 U	10 U		
CHRYSENE	10 U	10 U	10 U	10 U	10 U	10 U		
DI-N-BUTYL PHTHALATE	10 U	10 U	10 U	10 U	10 U	10 U		
DI-N-OCTYL PHTHALATE	10 U	10 U	10 U	10 U	10 U	10 U		
DIBENZO(A,H)ANTHRACENE	10 UJ	10 U	10 U	10 U	10 UJ	10 U		
DIBENZOFURAN	10 U	10 U	10 U	10 U	10 U	10 U		
DIETHYL PHTHALATE	10 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ		
DIMETHYL PHTHALATE	10 U	10 U	10 U	10 U	10 U	10 U		
FLUORANTHENE	10 U	10 U	10 U	10 U	10 U	10 U		
FLUORENE	10 U	10 U	10 U	10 U	10 U	10 U		
HEXACHLOROBENZENE	10 U	10 U	10 U	10 U	10 U	10 U		
HEXACHLOROBUTADIENE	10 U	10 U	10 U	10 U	10 U	10 U		
HEXACHLOROCYCLOPENTADIENE	10 U	10 U	10 U	10 U	10 U	10 U		
HEXACHLOROETHANE	10 U	10 U	10 U	10 U	10 U	10 U		
INDENO(1,2,3-CD)PYRENE	10 U	10 U	10 U	10 U	10 U	10 U		
ISOPHORONE	10 U	10 U	10 U	10 U	10 U	10 U		
N-NITROSO-DI-N-PROPYLAMINE	10 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ		
N-NITROSODIPHENYLAMINE	10 U	10 U	10 U	10 U	10 U	10 U		
NAPHTHALENE	10 U	10 U	10 U	10 U	10 U	10 U		
NITROBENZENE	10 UJ	10 U	10 U	10 U	10 UJ	10 U		
PENTACHLOROPHENOL	25 U	25 U	25 U	25 U	25 U	25 U		
PHENANTHRENE	10 U	10 U	10 U	10 U	10 U	10 U		
PHENOL	10 U	10 U	10 U	10 U	10 U	10 U		
PYRENE	10 U	10 U	10 U	10 U	10 U	10 U		
Pesticides/PCBs (ug/L)								
4,4'-DDD	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.03 J	0.050 U	0.050 U
4,4'-DDE	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
4,4'-DDT	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.026 J	0.050 U	0.050 U
ALDRIN	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
ALPHA-BHC	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
ALPHA-CHLORDANE	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
AROCLOR-1016	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1.0 U	1.0 U
AROCLOR-1221	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1.0 U	1.0 U

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CTO 288
groundwaters
full appendix results

order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
round	2003Q4	2003Q4	2003Q4	2003Q4	2003Q4	2003Q4	2002Q1	2002Q1
location	NCBC10G01	NCBC10G02	NCBC10G02	NCBC10G03	NCBC10G04	NCBC10G05	NCBC10G01	NCBC10G02
nsample	MW1001G02	MW1002G02	MW1002G02-D	MW1003G02	MW1004G02	MW1005G02	NCBC10G01	NCBC10G02
sample	MW1001G02	MW1002G02	MW1002G02D	MW1003G02	MW1004G02	MW1005G02	NCBC10G01	NCBC10G02
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20031218	20031218	20031218	20031218	20031218	20031218	20020214	20020214
sample_dat	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03	02/14/02	02/14/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	288	288	288	288	288	288	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
AROCLOR-1232	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1.0 U	1.0 U
AROCLOR-1242	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1.0 U	1.0 U
AROCLOR-1248	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1.0 U	1.0 U
AROCLOR-1254	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1.0 U	1.0 U
AROCLOR-1260	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1.0 U	1.0 U
BETA-BHC	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
DELTA-BHC	0.02 J	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
DIELDRIN	0.057	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
ENDOSULFAN I	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
ENDOSULFAN II	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
ENDOSULFAN SULFATE	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
ENDRIN	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
ENDRIN ALDEHYDE	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
ENDRIN KETONE	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
GAMMA-BHC (LINDANE)	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
GAMMA-CHLORDANE	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
HEPTACHLOR	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
HEPTACHLOR EPOXIDE	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.050 U	0.050 U
METHOXYCHLOR	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.10 U	0.10 U
TOXAPHENE	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	2.0 U	2.0 U
Herbicides (ug/L)								
2,4,5-T	3 U	3 U	3 U	3 U	3 U	3 U		
2,4,5-TP (SILVEX)	1 U	1 U	1 U	1 U	1 U	1 U		
2,4-D	3 U	3 U	3 U	3 U	3 U	3 U		
DINOSEB	5 U	5 U	5 U	5 U	5 U	5 U		
Inorganics (ug/L)								
ALUMINUM	386 U	307 U	270 U	310 U	234 U	96.6 U		
ANTIMONY	1.74 U	1.74 U	1.74 U	1.74 U	1.74 U	1.74 U		
ARSENIC	2.13 U	2.13 U	2.13 U	2.13 U	2.13 U	2.13 U		
BARIUM	42.9	45.8	45.7	42.4	45.4	34		
BERYLLIUM	0.22 U	0.61 U	0.63 U	0.65 U	0.22 U	0.88 U		
CADMIUM	0.25 U	2.66 U	2.66 U	2.66 U	0.25 U	2.66 U		
CALCIUM	7250	7990	7690	5950	3670	7180		
CHROMIUM	0.88 U	1.1	0.88 U	0.88	0.88	0.88 U		
COBALT	0.58 U	0.58 U	0.58 U	0.58 U	0.58 U	0.58 U		
COPPER	1.14 U	3.3 U	3.3 U	3.3 U	10	3.3 U		
IRON	2610 J	3930	3790	3010	2780 J	1920		
LEAD	3.4 U	1.56 U	1.56 U	1.56 U	3.3 U	1.56 U		
MAGNESIUM	1610	2220	2220	2170	1710	1420		
MANGANESE	14.8	77.9	75.4	63.6	36.4	12.4		
MERCURY	0.04 U	0.06 U	0.06 U	0.09 U	0.04 U	0.04 U		
NICKEL	1.9 U	11.9 U	12.1 U	11.6 U	1.9 U	11.5 U		
POTASSIUM	694 U	767 U	561 U	708 U	770 U	479 U		

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order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
round	2003Q4	2003Q4	2003Q4	2003Q4	2003Q4	2003Q4	2002Q1	2002Q1
location	NCBC10G01	NCBC10G02	NCBC10G02	NCBC10G03	NCBC10G04	NCBC10G05	NCBC10G01	NCBC10G02
nsample	MW1001G02	MW1002G02	MW1002G02-D	MW1003G02	MW1004G02	MW1005G02	NCBC10G01	NCBC10G02
sample	MW1001G02	MW1002G02	MW1002G02D	MW1003G02	MW1004G02	MW1005G02	NCBC10G01	NCBC10G02
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20031218	20031218	20031218	20031218	20031218	20031218	20020214	20020214
sample_dat	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03	02/14/02	02/14/02
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	288	288	288	288	288	288	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
SELENIUM	2.32 U	2.32 U	2.32 U	2.32 U	2.32 U	2.32 U		
SILVER	1.16 U	3.6 U	3.6 U	3.6 U	1.16 U	3.6 U		
SODIUM	4220	9590	9710	6070	5180	3750		
THALLIUM	2.77 U	2.77 U	2.77 U	2.77 U	2.77 U	2.77 U		
VANADIUM	1.2	3.6 U	3.6 U	3.6 U	0.74 U	3.6 U		
ZINC	28.8 U	3.1 U	2.0 U	23	22.4 U	2.8 U		
Miscellaneous Parameters (ug/L)								
CYANIDE	10 U	10 U	10 U	10 U	7.3 J	10 U		

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CTO 288
groundwaters
full appendix results

order	009	010	011	012
site	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
round	2002Q1	2002Q1	2002Q1	2002Q1
location	NCBC10G03	NCBC10G04	NCBC10G04	NCBC10G05
nsample	NCBC10G03	NCBC10G04	NCBC10G04-D	NCBC10G05
sample	NCBC10G03	NCBC10G04	NCBC10G04D	NCBC10G05
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20020213	20020213	20020213	20020214
sample_dat	02/13/02	02/13/02	02/13/02	02/14/02
validated	Y	Y	Y	Y
cto_proj	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**
Volatile Organics (ug/L)				
1,1,1-TRICHLOROETHANE	1 U	1 U	1 U	1 U
1,1,2,2-TETRACHLOROETHANE	1 U	1 U	1 U	1 U
1,1,2-TRICHLOROETHANE	1 U	1 U	1 U	1 U
1,1,2-TRICHLOROTRIFLUOROETHANE				
1,1-DICHLOROETHANE	1 U	1 U	1 U	1 U
1,1-DICHLOROETHENE	1 U	1 U	1 U	1 U
1,2,3-TRICHLOROBENZENE				
1,2,4-TRICHLOROBENZENE				
1,2-DIBROMO-3-CHLOROPROPANE	1 U	1 U	1 U	1 U
1,2-DIBROMOETHANE	0.02 U	0.02 U	0.02 U	0.02 U
1,2-DICHLOROBENZENE	1 U	1 U	1 U	1 U
1,2-DICHLOROETHANE	1 U	1 U	1 U	1 U
1,2-DICHLOROPROPANE	1 U	1 U	1 U	1 U
1,3-DICHLOROBENZENE	1 U	1 U	1 U	1 U
1,4-DICHLOROBENZENE	1 U	1 U	1 U	1 U
2-BUTANONE	5 U	5 U	5 U	5 U
2-HEXANONE	5 U	5 U	5 U	5 U
4-METHYL-2-PENTANONE	5 U	5 U	5 U	5 U
ACETONE	10 UJ	10 UJ	10 UJ	10 UJ
BENZENE	1 U	1 U	1 U	1 U
BROMOCHLOROMETHANE				
BROMODICHLOROMETHANE	1 U	1 U	1 U	1 U
BROMOFORM	1 U	1 U	1 U	1 U
BROMOMETHANE	1 U	1 U	1 U	1 U
CARBON DISULFIDE	1 U	1 U	1 U	1 U
CARBON TETRACHLORIDE	1 U	1 U	1 U	1 U
CHLOROBENZENE	1 U	1 U	1 U	1 U
CHLORODIBROMOMETHANE	1 U	1 U	1 U	1 U
CHLOROETHANE	2 U	2 U	2 U	2 U
CHLOROFORM	1 U	1 U	1 U	1 U
CHLOROMETHANE	2 U	2 U	2 U	2 U
CIS-1,2-DICHLOROETHENE	1 U	1 U	1 U	1 U
CIS-1,3-DICHLOROPROPENE	1 U	1 U	1 U	1 U
CYCLOHEXANE				
DICHLORODIFLUOROMETHANE				
ETHYLBENZENE	1 U	1 U	1 U	1 U
ISOPROPYLBENZENE				
M+P-XYLENES				
METHYL ACETATE				
METHYL CYCLOHEXANE				
METHYL TERT-BUTYL ETHER				
METHYLENE CHLORIDE	2 U	2 U	2 U	2 U

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order	009	010	011	012
site	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
round	2002Q1	2002Q1	2002Q1	2002Q1
location	NCBC10G03	NCBC10G04	NCBC10G04	NCBC10G05
nsample	NCBC10G03	NCBC10G04	NCBC10G04-D	NCBC10G05
sample	NCBC10G03	NCBC10G04	NCBC10G04D	NCBC10G05
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20020213	20020213	20020213	20020214
sample_dat	02/13/02	02/13/02	02/13/02	02/14/02
validated	Y	Y	Y	Y
cto_proj	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**
O-XYLENE				
STYRENE	1 U	1 U	1 U	1 U
TETRACHLOROETHENE	1 U	1 U	1 U	1 U
TOLUENE	1 U	1 U	1 U	1 U
TOTAL 1,2-DICHLOROETHENE	1 U	1 U	1 U	1 U
TOTAL XYLENES	3 U	3 U	3 U	3 U
TRANS-1,2-DICHLOROETHENE	1 U	1 U	1 U	1 U
TRANS-1,3-DICHLOROPROPENE	1 U	1 U	1 U	1 U
TRICHLOROETHENE	1 U	1 U	1 U	1 U
TRICHLOROFLUOROMETHANE	2 U	2 U	2 U	2 U
VINYL CHLORIDE	2 U	2 U	2 U	2 U
Semivolatile Organics (ug/L)				
1,1-BIPHENYL				
2,2'-OXYBIS(1-CHLOROPROPANE)				
2,4,5-TRICHLOROPHENOL				
2,4,6-TRICHLOROPHENOL				
2,4-DICHLOROPHENOL				
2,4-DIMETHYLPHENOL				
2,4-DINITROPHENOL				
2,4-DINITROTOLUENE				
2,6-DINITROTOLUENE				
2-CHLORONAPHTHALENE				
2-CHLOROPHENOL				
2-METHYLNAPHTHALENE				
2-METHYLPHENOL				
2-NITROANILINE				
2-NITROPHENOL				
3,3'-DICHLOROBENZIDINE				
3-NITROANILINE				
4,6-DINITRO-2-METHYLPHENOL				
4-BROMOPHENYL PHENYL ETHER				
4-CHLORO-3-METHYLPHENOL				
4-CHLOROANILINE				
4-CHLOROPHENYL PHENYL ETHER				
4-METHYLPHENOL				
4-NITROANILINE				
4-NITROPHENOL				
ACENAPHTHENE				
ACENAPHTHYLENE				
ACETOPHENONE				
ANTHRACENE				
ATRAZINE				
BENZALDEHYDE				

from _10gwsam.dbf
from _10gwres.dbf
from _10gwres.xls
from q:\sql_server\gulfport\upload

CTO 288
groundwaters
full appendix results

order	009	010	011	012
site	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
round	2002Q1	2002Q1	2002Q1	2002Q1
location	NCBC10G03	NCBC10G04	NCBC10G04	NCBC10G05
nsample	NCBC10G03	NCBC10G04	NCBC10G04-D	NCBC10G05
sample	NCBC10G03	NCBC10G04	NCBC10G04D	NCBC10G05
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20020213	20020213	20020213	20020214
sample_dat	02/13/02	02/13/02	02/13/02	02/14/02
validated	Y	Y	Y	Y
cto_proj	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**
BENZO(A)ANTHRACENE				
BENZO(A)PYRENE				
BENZO(B)FLUORANTHENE				
BENZO(G,H,I)PERYLENE				
BENZO(K)FLUORANTHENE				
BIS(2-CHLOROETHOXY)METHANE				
BIS(2-CHLOROETHYL)ETHER				
BIS(2-ETHYLHEXYL)PHTHALATE				
BUTYL BENZYL PHTHALATE				
CAPROLACTAM				
CARBAZOLE				
CHRYSENE				
DI-N-BUTYL PHTHALATE				
DI-N-OCTYL PHTHALATE				
DIBENZO(A,H)ANTHRACENE				
DIBENZOFURAN				
DIETHYL PHTHALATE				
DIMETHYL PHTHALATE				
FLUORANTHENE				
FLUORENE				
HEXACHLOROBENZENE				
HEXACHLOROBUTADIENE				
HEXACHLOROCYCLOPENTADIENE				
HEXACHLOROETHANE				
INDENO(1,2,3-CD)PYRENE				
ISOPHORONE				
N-NITROSO-DI-N-PROPYLAMINE				
N-NITROSODIPHENYLAMINE				
NAPHTHALENE				
NITROBENZENE				
PENTACHLOROPHENOL				
PHENANTHRENE				
PHENOL				
PYRENE				
Pesticides/PCBs (ug/L)				
4,4'-DDD	0.050 U	0.050 U	0.050 U	0.050 U
4,4'-DDE	0.050 U	0.050 U	0.050 U	0.050 U
4,4'-DDT	0.050 U	0.050 U	0.050 U	0.050 U
ALDRIN	0.050 U	0.050 U	0.050 U	0.050 U
ALPHA-BHC	0.050 U	0.050 U	0.050 U	0.050 U
ALPHA-CHLORDANE	0.050 U	0.050 U	0.050 U	0.050 U
AROCLOR-1016	1.0 U	1.0 U	1.0 U	1.0 U
AROCLOR-1221	1.0 U	1.0 U	1.0 U	1.0 U

from _10gwsam.dbf
from _10gwres.dbf
from _10gwres.xls
from q:\s[illegible]er\gulfport\upload

order	009	010	011	012
site	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
round	2002Q1	2002Q1	2002Q1	2002Q1
location	NCBC10G03	NCBC10G04	NCBC10G04	NCBC10G05
nsample	NCBC10G03	NCBC10G04	NCBC10G04-D	NCBC10G05
sample	NCBC10G03	NCBC10G04	NCBC10G04D	NCBC10G05
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20020213	20020213	20020213	20020214
sample_dat	02/13/02	02/13/02	02/13/02	02/14/02
validated	Y	Y	Y	Y
cto_proj	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**
AROCLOR-1232	1.0 U	1.0 U	1.0 U	1.0 U
AROCLOR-1242	1.0 U	1.0 U	1.0 U	1.0 U
AROCLOR-1248	1.0 U	1.0 U	1.0 U	1.0 U
AROCLOR-1254	1.0 U	1.0 U	1.0 U	1.0 U
AROCLOR-1260	1.0 U	1.0 U	1.0 U	1.0 U
BETA-BHC	0.050 U	0.050 U	0.050 U	0.050 U
DELTA-BHC	0.050 U	0.050 U	0.050 U	0.050 U
DIELDRIN	0.050 U	0.050 U	0.050 U	0.050 U
ENDOSULFAN I	0.050 U	0.050 U	0.050 U	0.050 U
ENDOSULFAN II	0.050 U	0.050 U	0.050 U	0.050 U
ENDOSULFAN SULFATE	0.050 U	0.050 U	0.050 U	0.050 U
ENDRIN	0.050 U	0.050 U	0.050 U	0.050 U
ENDRIN ALDEHYDE	0.050 U	0.050 UR	0.050 U	0.050 U
ENDRIN KETONE	0.050 U	0.050 U	0.050 U	0.050 U
GAMMA-BHC (LINDANE)	0.050 U	0.050 U	0.050 U	0.050 U
GAMMA-CHLORDANE	0.050 U	0.050 U	0.050 U	0.050 U
HEPTACHLOR	0.050 U	0.050 U	0.050 U	0.050 U
HEPTACHLOR EPOXIDE	0.050 U	0.050 U	0.050 U	0.050 U
METHOXYCHLOR	0.10 U	0.10 U	0.10 U	0.10 U
TOXAPHENE	2.0 U	2.0 U	2.0 U	2.0 U
Herbicides (ug/L)				
2,4,5-T				
2,4,5-TP (SILVEX)				
2,4-D				
DINOSEB				
Inorganics (ug/L)				
ALUMINUM				
ANTIMONY				
ARSENIC				
BARIUM				
BERYLLIUM				
CADMIUM				
CALCIUM				
CHROMIUM				
COBALT				
COPPER				
IRON				
LEAD				
MAGNESIUM				
MANGANESE				
MERCURY				
NICKEL				
POTASSIUM				

from _10gwsam.dbf
from _10gwres.dbf
from _10gwres.xls
from q:\sql_server\gulfport\upload

CTO 288
groundwaters
full appendix results

order	009	010	011	012
site	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
round	2002Q1	2002Q1	2002Q1	2002Q1
location	NCBC10G03	NCBC10G04	NCBC10G04	NCBC10G05
nsample	NCBC10G03	NCBC10G04	NCBC10G04-D	NCBC10G05
sample	NCBC10G03	NCBC10G04	NCBC10G04D	NCBC10G05
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20020213	20020213	20020213	20020214
sample_dat	02/13/02	02/13/02	02/13/02	02/14/02
validated	Y	Y	Y	Y
cto_proj	193	193	193	193
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**
SELENIUM				
SILVER				
SODIUM				
THALLIUM				
VANADIUM				
ZINC				
Miscellaneous Parameters (ug/L)				
CYANIDE				

from _10gwsam.dbf
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C. ..d8
surface water
full appendix results

order	001	002	003	004	005	006
site	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10W01-D01	NCBC10W01-D01	NCBC10W02-D02	NCBC10W03-D03	NCBC10W10-D10	NCBC10W11-D11
nsample	NCBC10W01	NCBC10W01-D	NCBC10W02	NCBC10W03	SW1006W01	SW1007W01
sample	NCBC10W01	NCBC10W01D	NCBC10W02	NCBC10W03	SW1006W01	SW1007W01
matrix	SW	SW	SW	SW	SW	SW
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20020110	20020110	20020110	20020110	20031218	20031218
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	12/18/03	12/18/03
validated	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**
Volatile Organics (ug/L)						
1,1,1-TRICHLOROETHANE	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-TETRACHLOROETHANE	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-TRICHLOROETHANE	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-TRICHLOROTRIFLUOROETHANE					1 U	1 U
1,1-DICHLOROETHANE	1 U	1 U	1 U	1 U	1 U	1 U
1,1-DICHLOROETHENE	1 U	1 U	1 U	1 U	1 U	1 U
1,2,3-TRICHLOROBENZENE					1 U	1 U
1,2,4-TRICHLOROBENZENE					1 U	1 U
1,2-DIBROMO-3-CHLOROPROPANE	1 UJ	1 UJ	1 UJ	1 UJ	1 U	1 U
1,2-DIBROMOETHANE	0.02 U	0.02 U	0.02 U	0.02 U	1 U	1 U
1,2-DICHLOROBENZENE	1 U	1 U	1 U	1 U	1 U	1 U
1,2-DICHLOROETHANE	1 U	1 U	1 U	1 U	1 U	1 U
1,2-DICHLOROPROPANE	1 U	1 U	1 U	1 U	1 U	1 U
1,3-DICHLOROBENZENE	1 U	1 U	1 U	1 U	1 U	1 U
1,4-DICHLOROBENZENE	1 U	1 U	1 U	1 U	1 U	1 U
2-BUTANONE	5 UJ	5 UJ	5 UJ	5 UJ	5 U	5 U
2-HEXANONE	5 UJ	5 UJ	5 UJ	5 UJ	5 U	5 U
4-METHYL-2-PENTANONE	5 UJ	5 UJ	5 UJ	5 UJ	5 U	5 U
ACETONE	10 UJ	10 UJ	10 UJ	10 UJ	5 U	5 UR
BENZENE	1 U	1 U	1 U	1 U	1 U	1 U
BROMOCHLOROMETHANE					1 U	1 U
BROMODICHLOROMETHANE	1 U	1 U	1 U	1 U	1 U	1 U
BROMOFORM	1 U	1 U	1 U	1 U	1 U	1 U
BROMOMETHANE	1 UJ	1 UJ	1 UJ	1 UJ	2 U	2 U
CARBON DISULFIDE	1 U	1 U	1 U	1 U	1 U	1 U
CARBON TETRACHLORIDE	1 U	1 U	1 U	1 U	1 U	1 U
CHLOROBENZENE	1 U	1 U	1 U	1 U	0.2 J	1 U
CHLORODIBROMOMETHANE	1 U	1 U	1 U	1 U	1 U	1 U
CHLOROETHANE	2 U	2 U	2 U	2 U	2 U	2 U
CHLOROFORM	1 U	1 U	1 U	1 U	1 U	1 U
CHLOROMETHANE	2 UJ	2 UJ	2 UJ	2 UJ	2 U	2 U
CIS-1,2-DICHLOROETHENE	1 U	1 U	1 U	1 U	1 U	1 U
CIS-1,3-DICHLOROPROPENE	1 U	1 U	1 U	1 U	1 U	1 U
CYCLOHEXANE					1 U	1 U
DICHLORODIFLUOROMETHANE					2 U	2 U
ETHYLBENZENE	1 U	1 U	1 U	1 U	1 U	1 U
ISOPROPYLBENZENE					1 U	1 U
M+P-XYLENES					2 U	2 U
METHYL ACETATE					1 U	1 U
METHYL CYCLOHEXANE					1 U	1 U
METHYL TERT-BUTYL ETHER					2 U	2 U
METHYLENE CHLORIDE	2 U	2 U	2 U	2 U	2 U	2 U

from _10swsam.dbf
from _10swres.dbf
from _10swres.xls
from q:\sql_server\gulfport\upload

CTO 288
surface water
full appendix results

order	001	002	003	004	005	006
site	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10W01-D01	NCBC10W01-D01	NCBC10W02-D02	NCBC10W03-D03	NCBC10W10-D10	NCBC10W11-D11
nsample	NCBC10W01	NCBC10W01-D	NCBC10W02	NCBC10W03	SW1006W01	SW1007W01
sample	NCBC10W01	NCBC10W01D	NCBC10W02	NCBC10W03	SW1006W01	SW1007W01
matrix	SW	SW	SW	SW	SW	SW
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20020110	20020110	20020110	20020110	20031218	20031218
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	12/18/03	12/18/03
validated	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**
O-XYLENE					1 U	1 U
STYRENE	1 UJ	1 UJ	1 UJ	1 UJ	1 U	1 U
TETRACHLOROETHENE	1 U	1 U	1 U	1 U	1 U	1 U
TOLUENE	1 U	1 U	1 U	1 U	1 U	1 U
TOTAL 1,2-DICHLOROETHENE	1 U	1 U	1 U	1 U	2 U	2 U
TOTAL XYLENES	3 U	3 U	3 U	3 U	3 U	3 U
TRANS-1,2-DICHLOROETHENE	1 U	1 U	1 U	1 U	1 U	1 U
TRANS-1,3-DICHLOROPROPENE	1 U	1 U	1 U	1 U	1 U	1 U
TRICHLOROETHENE	1 UJ	1 UJ	1 UJ	1 UJ	1 U	1 U
TRICHLOROFLUOROMETHANE	2 UJ	2 UJ	2 UJ	2 UJ	5 U	5 U
VINYL CHLORIDE	2 U	2 U	2 U	2 U	2 U	2 U
Semivolatile Organics (ug/L)						
1,1-BIPHENYL					12 U	11 U
2,2'-OXYBIS(1-CHLOROPROPANE)					12 U	11 U
2,4,5-TRICHLOROPHENOL					30 U	27 U
2,4,6-TRICHLOROPHENOL					12 U	11 U
2,4-DICHLOROPHENOL					12 U	11 U
2,4-DIMETHYLPHENOL					12 U	11 U
2,4-DINITROPHENOL					30 U	27 U
2,4-DINITROTOLUENE					12 U	11 UJ
2,6-DINITROTOLUENE					12 UJ	11 U
2-CHLORONAPHTHALENE					12 U	11 U
2-CHLOROPHENOL					12 U	11 U
2-METHYLNAPHTHALENE					12 U	11 U
2-METHYLPHENOL					12 U	11 U
2-NITROANILINE					30 UJ	27 UJ
2-NITROPHENOL					12 UJ	11 UJ
3,3'-DICHLOROBENZIDINE					12 UJ	11 UJ
3-NITROANILINE					30 UJ	27 UJ
4,6-DINITRO-2-METHYLPHENOL					30 U	27 U
4-BROMOPHENYL PHENYL ETHER					12 U	11 U
4-CHLORO-3-METHYLPHENOL					12 U	11 U
4-CHLOROANILINE					12 U	11 U
4-CHLOROPHENYL PHENYL ETHER					12 U	11 U
4-METHYLPHENOL					12 U	11 U
4-NITROANILINE					30 U	27 U
4-NITROPHENOL					30 U	27 U
ACENAPHTHENE					12 U	11 U
ACENAPHTHYLENE					12 U	11 U
ACETOPHENONE					12 U	11 U
ANTHRACENE					12 U	11 U
ATRAZINE					12 U	11 U
BENZALDEHYDE					12 UJ	11 UJ

from _10swsam.dbf
from _10swres.dbf
from _10swres.xls
from q:\s[illegible]er\gulfport\upload

order	001	002	003	004	005	006
site	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10W01-D01	NCBC10W01-D01	NCBC10W02-D02	NCBC10W03-D03	NCBC10W10-D10	NCBC10W11-D11
nsample	NCBC10W01	NCBC10W01-D	NCBC10W02	NCBC10W03	SW1006W01	SW1007W01
sample	NCBC10W01	NCBC10W01D	NCBC10W02	NCBC10W03	SW1006W01	SW1007W01
matrix	SW	SW	SW	SW	SW	SW
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20020110	20020110	20020110	20020110	20031218	20031218
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	12/18/03	12/18/03
validated	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**
BENZO(A)ANTHRACENE					12 U	11 U
BENZO(A)PYRENE					12 U	11 U
BENZO(B)FLUORANTHENE					12 U	11 U
BENZO(G,H,I)PERYLENE					12 UJ	11 UJ
BENZO(K)FLUORANTHENE					12 U	11 U
BIS(2-CHLOROETHOXY)METHANE					12 UJ	11 UJ
BIS(2-CHLOROETHYL)ETHER					12 U	11 U
BIS(2-ETHYLHEXYL)PHTHALATE					12 U	11 U
BUTYL BENZYL PHTHALATE					12 U	11 U
CAPROLACTAM					12 U	11 U
CARBAZOLE					12 U	11 U
CHRYSENE					12 U	11 U
DI-N-BUTYL PHTHALATE					12 U	11 U
DI-N-OCTYL PHTHALATE					12 U	11 U
DIBENZO(A,H)ANTHRACENE					12 UJ	11 U
DIBENZOFURAN					12 U	11 U
DIETHYL PHTHALATE					12 U	11 U
DIMETHYL PHTHALATE					12 U	11 U
FLUORANTHENE					9 J	8 J
FLUORENE					12 U	11 U
HEXACHLOROBENZENE					12 U	11 U
HEXACHLOROBUTADIENE					12 U	11 U
HEXACHLOROCYCLOPENTADIENE					12 U	11 U
HEXACHLOROETHANE					12 U	11 U
INDENO(1,2,3-CD)PYRENE					7 J	11 U
ISOPHORONE					12 U	11 U
N-NITROSO-DI-N-PROPYLAMINE					12 U	11 U
N-NITROSODIPHENYLAMINE					12 U	11 U
NAPHTHALENE					12 U	11 U
NITROBENZENE					12 UJ	11 UJ
PENTACHLOROPHENOL					30 U	27 U
PHENANTHRENE					7 J	6 J
PHENOL					12 U	11 U
PYRENE					12 U	11 U
Pesticides/PCBs (ug/L)						
4,4'-DDD	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
4,4'-DDE	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
4,4'-DDT	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
ALDRIN	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
ALPHA-BHC	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
ALPHA-CHLORDANE	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
AROCLOR-1016	1.0 U	1.0 U	1.0 U	1.0 U	0.5 UJ	0.56 UJ
AROCLOR-1221	1.0 U	1.0 U	1.0 U	1.0 U	0.5 UJ	0.56 UJ

from _10swsam.dbf
from _10swres.dbf
from _10swres.xls
from q:\sql_server\gulfport\upload

CTO 288
surface water
full appendix results

order	001	002	003	004	005	006
site	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10W01-D01	NCBC10W01-D01	NCBC10W02-D02	NCBC10W03-D03	NCBC10W10-D10	NCBC10W11-D11
nsample	NCBC10W01	NCBC10W01-D	NCBC10W02	NCBC10W03	SW1006W01	SW1007W01
sample	NCBC10W01	NCBC10W01D	NCBC10W02	NCBC10W03	SW1006W01	SW1007W01
matrix	SW	SW	SW	SW	SW	SW
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20020110	20020110	20020110	20020110	20031218	20031218
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	12/18/03	12/18/03
validated	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**
AROCLOR-1232	1.0 U	1.0 U	1.0 U	1.0 U	0.5 UJ	0.56 UJ
AROCLOR-1242	1.0 U	1.0 U	1.0 U	1.0 U	0.5 UJ	0.56 UJ
AROCLOR-1248	1.0 U	1.0 U	1.0 U	1.0 U	0.5 UJ	0.56 UJ
AROCLOR-1254	1.0 U	1.0 U	1.0 U	1.0 U	0.5 UJ	0.56 UJ
AROCLOR-1260	1.0 U	1.0 U	1.1	1.0 U	0.5 UJ	0.56 UJ
BETA-BHC	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
DELTA-BHC	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
DIELDRIN	0.050 U	0.050 U	0.005 J	0.050 U	0.05 U	0.056 U
ENDOSULFAN I	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
ENDOSULFAN II	0.050 U	0.050 U	0.018 J	0.050 U	0.05 U	0.056 U
ENDOSULFAN SULFATE	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
ENDRIN	0.050 U	0.050 U	0.008 R	0.050 U	0.05 U	0.056 U
ENDRIN ALDEHYDE	0.050 U	0.006 J	0.050 U	0.050 U	0.05 U	0.056 U
ENDRIN KETONE	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
GAMMA-BHC (LINDANE)	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
GAMMA-CHLORDANE	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
HEPTACHLOR	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
HEPTACHLOR EPOXIDE	0.050 U	0.050 U	0.050 U	0.050 U	0.05 U	0.056 U
METHOXYCHLOR	0.10 U	0.10 U	0.10 U	0.10 U	0.05 U	0.056 U
TOXAPHENE	2.0 U	2.0 U	2.0 U	2.0 U	0.05 U	0.056 U
Herbicides (ug/L)						
2,4,5-T					4.3 U	3.3 U
2,4,5-TP (SILVEX)					1.4 U	1.1 U
2,4-D					4.3 U	3.3 U
DINOSEB					7.2 U	5.4 U
Inorganics (ug/L)						
ALUMINUM					874	496 U
ANTIMONY					1.74 U	1.74 U
ARSENIC					2.13 U	2.13 U
BARIUM					22.2	17
BERYLLIUM					0.22 U	0.22 U
CADMIUM					0.25 U	0.25 U
CALCIUM					7450	11600
CHROMIUM					1.4	1.4
COBALT					0.58 U	0.58 U
COPPER					13.1	11.1
IRON					1420 J	616 J
LEAD					4.1 U	2.9 U
MAGNESIUM					1580	1640
MANGANESE					24.1	8.3
MERCURY					0.06 U	0.04 U
NICKEL					2.8 U	3.0 U
POTASSIUM					855 U	906 U

from _10swsam.dbf
from _10swres.dbf
from _10swres.xls
from q:\so[illegible]ver\gulfport\upload

CTO 288
surface water
full appendix results

order	001	002	003	004	005	006
site	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10W01-D01	NCBC10W01-D01	NCBC10W02-D02	NCBC10W03-D03	NCBC10W10-D10	NCBC10W11-D11
nsample	NCBC10W01	NCBC10W01-D	NCBC10W02	NCBC10W03	SW1006W01	SW1007W01
sample	NCBC10W01	NCBC10W01D	NCBC10W02	NCBC10W03	SW1006W01	SW1007W01
matrix	SW	SW	SW	SW	SW	SW
depth_rang	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
gis_date	20020110	20020110	20020110	20020110	20031218	20031218
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	12/18/03	12/18/03
validated	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**
SELENIUM					2.32 U	2.32 U
SILVER					1.16 U	1.16 U
SODIUM					6000	5610
THALLIUM					2.77 U	2.77 U
VANADIUM					1.9	1.6
ZINC					90.2 U	92.9 U
Miscellaneous Parameters (ug/L)						
CYANIDE					10 U	10 U

from _10swsam.dbf
from _10swres.dbf
from _10swres.xls
from q:\sql_server\gulfport\upload

order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10W01-D01	NCBC10W01-D01	NCBC10W02-D02	NCBC10W03-D03	NCBC10D04	NCBC10D05	NCBC10D06	NCBC10D07
nsample	NCBC10D01	NCBC10D01-D	NCBC10D02	NCBC10D03	NCBC10D04	NCBC10D05	NCBC10D06	SD1006D01
sample	NCBC10D01	NCBC10D01D	NCBC10D02	NCBC10D03	NCBC10D04	NCBC10D05	NCBC10D06	SD1006D01
sacode	ORIG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
depth_rang	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
gis_date	20020110	20020110	20020110	20020110	20020212	20020212	20020212	20031218
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	02/12/02	02/12/02	02/12/02	12/18/03
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
Volatile Organics (ug/kg)								
1,1,1-TRICHLOROETHANE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
1,1,2,2-TETRACHLOROETHANE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
1,1,2-TRICHLOROETHANE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
1,1,2-TRICHLOROTRIFLUOROETHANE								7 U
1,1-DICHLOROETHANE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
1,1-DICHLOROETHENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
1,2,3-TRICHLOROBENZENE								7 U
1,2,4-TRICHLOROBENZENE								7 U
1,2-DIBROMO-3-CHLOROPROPANE	13 U	14 U	16 U	13 U	11 U	12 U	11 U	7 U
1,2-DIBROMOETHANE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
1,2-DICHLOROBENZENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
1,2-DICHLOROETHANE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
1,2-DICHLOROPROPANE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
1,3-DICHLOROBENZENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
1,4-DICHLOROBENZENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
2-BUTANONE	27 UJ	28 UJ	31 UJ	25 UJ	22 U	3.8 J	22 U	34 U
2-HEXANONE	27 U	28 U	31 U	25 U	22 U	24 U	22 U	34 U
4-METHYL-2-PENTANONE	27 U	28 U	31 U	25 U	22 U	24 U	22 U	34 U
ACETONE	27 UJ	28 UJ	31 UJ	10 J	6.3 J	11 J	14 J	34 U
BENZENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
BROMOCHLOROMETHANE								7 U
BROMODICHLOROMETHANE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
BROMOFORM	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
BROMOMETHANE	13 U	14 U	16 U	13 U	11 U	12 U	11 U	7 U
CARBON DISULFIDE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
CARBON TETRACHLORIDE	6.7 UJ	7.1 UJ	7.8 UJ	6.3 UJ	5.6 U	6.1 U	5.5 U	7 UJ
CHLOROBENZENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
CHLORODIBROMOMETHANE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
CHLOROETHANE	13 U	14 U	16 U	13 U	11 U	12 U	11 U	7 U
CHLOROFORM	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
CHLOROMETHANE	13 U	14 U	16 U	13 U	11 U	12 U	11 U	7 U
CIS-1,2-DICHLOROETHENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
CIS-1,3-DICHLOROPROPENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
CYCLOHEXANE								7 U
DICHLORODIFLUOROMETHANE								7 U
ETHYLBENZENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
ISOPROPYLBENZENE								7 U
M+P-XYLENES								14 U
METHYL ACETATE								7 U
METHYL CYCLOHEXANE								7 U
METHYL TERT-BUTYL ETHER								14 U
METHYLENE CHLORIDE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	14 U

from _10sdsam.dbf
from _10sdres.dbf
from _10sdres.xls
from q:\sql_server\gulfport\upload

CTO 288
sediments
full appendix results

order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10W01-D01	NCBC10W01-D01	NCBC10W02-D02	NCBC10W03-D03	NCBC10D04	NCBC10D05	NCBC10D06	NCBC10D07
nsample	NCBC10D01	NCBC10D01-D	NCBC10D02	NCBC10D03	NCBC10D04	NCBC10D05	NCBC10D06	SD1006D01
sample	NCBC10D01	NCBC10D01D	NCBC10D02	NCBC10D03	NCBC10D04	NCBC10D05	NCBC10D06	SD1006D01
sacode	ORIG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
depth_rang	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
gis_date	20020110	20020110	20020110	20020110	20020212	20020212	20020212	20031218
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	02/12/02	02/12/02	02/12/02	12/18/03
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
O-XYLENE								7 U
STYRENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
TETRACHLOROETHENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
TOLUENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	5.3 J	5.5 U	7 U
TOTAL 1,2-DICHLOROETHENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	14 U
TOTAL XYLENES	20 U	21 U	23 U	19 U	17 U	18 U	16 U	20 U
TRANS-1,2-DICHLOROETHENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
TRANS-1,3-DICHLOROPROPENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 U
TRICHLOROETHENE	6.7 U	7.1 U	7.8 U	6.3 U	5.6 U	6.1 U	5.5 U	7 UR
TRICHLOROFLUOROMETHANE	13 UJ	14 UJ	16 UJ	13 UJ	11 U	12 U	11 U	6 J
VINYL CHLORIDE	13 U	14 U	16 U	13 U	11 U	12 U	11 U	7 U
Semivolatile Organics (ug/kg)								
1,1-BIPHENYL								420 U
2,2'-OXYBIS(1-CHLOROPROPANE)								420 U
2,4,5-TRICHLOROPHENOL								420 U
2,4,6-TRICHLOROPHENOL								420 U
2,4-DICHLOROPHENOL								420 U
2,4-DIMETHYLPHENOL								420 U
2,4-DINITROPHENOL								420 UJ
2,4-DINITROTOLUENE								420 U
2,6-DINITROTOLUENE								420 U
2-CHLORONAPHTHALENE								420 U
2-CHLOROPHENOL								420 U
2-METHYLNAPHTHALENE								420 U
2-METHYLPHENOL								420 U
2-NITROANILINE								420 U
2-NITROPHENOL								420 U
3,3'-DICHLOROBENZIDINE								420 U
3-NITROANILINE								420 U
4,6-DINITRO-2-METHYLPHENOL								420 U
4-BROMOPHENYL PHENYL ETHER								420 U
4-CHLORO-3-METHYLPHENOL								420 U
4-CHLOROANILINE								420 U
4-CHLOROPHENYL PHENYL ETHER								420 U
4-METHYLPHENOL								420 U
4-NITROANILINE								420 U
4-NITROPHENOL								420 U
ACENAPHTHENE								420 U
ACENAPHTHYLENE								420 U
ACETOPHENONE								420 U
ANTHRACENE								420 U
ATRAZINE								420 U
BENZALDEHYDE								420 UJ

from _10sdsam.dbf
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from _10sdres.xls
from q:\ ver\gulfport\upload

CTO 288
sediments
full appendix results

order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10W01-D01	NCBC10W01-D01	NCBC10W02-D02	NCBC10W03-D03	NCBC10D04	NCBC10D05	NCBC10D06	NCBC10D07
nsample	NCBC10D01	NCBC10D01-D	NCBC10D02	NCBC10D03	NCBC10D04	NCBC10D05	NCBC10D06	SD1006D01
sample	NCBC10D01	NCBC10D01D	NCBC10D02	NCBC10D03	NCBC10D04	NCBC10D05	NCBC10D06	SD1006D01
sacode	ORIG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
depth_rang	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
gis_date	20020110	20020110	20020110	20020110	20020212	20020212	20020212	20031218
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	02/12/02	02/12/02	02/12/02	12/18/03
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
BENZO(A)ANTHRACENE								420 U
BENZO(A)PYRENE								170 J
BENZO(B)FLUORANTHENE								500 U
BENZO(G,H,I)PERYLENE								420 U
BENZO(K)FLUORANTHENE								500 U
BIS(2-CHLOROETHOXY)METHANE								420 U
BIS(2-CHLOROETHYL)ETHER								420 U
BIS(2-ETHYLHEXYL)PHTHALATE								420 U
BUTYL BENZYL PHTHALATE								420 U
CAPROLACTAM								420 U
CARBAZOLE								420 U
CHRYSENE								420 U
DI-N-BUTYL PHTHALATE								420 U
DI-N-OCTYL PHTHALATE								420 U
DIBENZO(A,H)ANTHRACENE								420 U
DIBENZOFURAN								420 U
DIETHYL PHTHALATE								420 UJ
DIMETHYL PHTHALATE								420 U
FLUORANTHENE								170 J
FLUORENE								420 U
HEXACHLOROBENZENE								420 U
HEXACHLOROBUTADIENE								420 U
HEXACHLOROCYCLOPENTADIENE								420 U
HEXACHLOROETHANE								420 U
INDENO(1,2,3-CD)PYRENE								420 U
ISOPHORONE								420 U
N-NITROSO-DI-N-PROPYLAMINE								420 U
N-NITROSODIPHENYLAMINE								420 U
NAPHTHALENE								420 U
NITROBENZENE								420 U
PENTACHLOROPHENOL								420 U
PHENANTHRENE								380 J
PHENOL								420 U
PYRENE								420 U
Pesticides/PCBs (ug/kg)								
4,4'-DDD	2.3 U	2.3 U	2.2 U	2.1 U				2.2 U
4,4'-DDE	1.2 R	2.3 U	2.2 U	2.1 U				2.2 U
4,4'-DDT	4.0 R	2.3 U	2.2 U	3.6 R				2.2 U
ALDRIN	2.3 U	2.3 U	2.2 U	2.1 U				2.2 U
ALPHA-BHC	0.30 J	2.3 U	2.2 U	2.1 U				2.2 U
ALPHA-CHLORDANE	0.90 R	2.3 U	2.2 U	0.92 R				2.2 U
AROCLOR-1016	44 U	45 U	42 U	41 U	41 U	43 U	41 U	22 U
AROCLOR-1221	44 U	45 U	42 U	41 U	41 U	43 U	41 U	22 U

from _10sdsam.dbf
from _10sdres.dbf
from _10sdres.xls
from q:\sql_server\gulfport\upload

CTO 288
sediments
full appendix results

order	001	002	003	004	005	006	007	008
site	00010	00010	00010	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10W01-D01	NCBC10W01-D01	NCBC10W02-D02	NCBC10W03-D03	NCBC10D04	NCBC10D05	NCBC10D06	NCBC10D07
nsample	NCBC10D01	NCBC10D01-D	NCBC10D02	NCBC10D03	NCBC10D04	NCBC10D05	NCBC10D06	SD1006D01
sample	NCBC10D01	NCBC10D01D	NCBC10D02	NCBC10D03	NCBC10D04	NCBC10D05	NCBC10D06	SD1006D01
sacode	ORIG	DUP	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
depth_rang	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
gis_date	20020110	20020110	20020110	20020110	20020212	20020212	20020212	20031218
sample_dat	01/10/02	01/10/02	01/10/02	01/10/02	02/12/02	02/12/02	02/12/02	12/18/03
validated	Y	Y	Y	Y	Y	Y	Y	Y
cto_proj	193	193	193	193	193	193	193	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_001**	**c_002**	**c_003**	**c_004**	**c_005**	**c_006**	**c_007**	**c_008**
AROCLOR-1232	44 U	45 U	42 U	41 U	41 U	43 U	41 U	22 U
AROCLOR-1242	44 U	45 U	42 U	41 U	41 U	43 U	41 U	22 U
AROCLOR-1248	44 U	45 U	42 U	41 U	41 U	43 U	41 U	22 U
AROCLOR-1254	44 U	45 U	42 U	41 U	41 U	43 U	41 U	22 U
AROCLOR-1260	710 J	220 J	94	630	19 J	260	190	65
BETA-BHC	2.3 U	2.3 U	2.2 U	2.1 U				2.2 U
DELTA-BHC	2.3 U	2.3 U	2.2 U	2.1 U				2.2 U
DIELDRIN	3.4 J	0.40 R	0.27 R	1.4 R				2.2 U
ENDOSULFAN I	2.3 U	2.3 U	2.2 U	2.1 U				2.2 U
ENDOSULFAN II	17 J	2.5 J	1.9 J	11				2.2 U
ENDOSULFAN SULFATE	2.3 U	2.3 U	2.2 U	2.1 U				2.2 U
ENDRIN	7.3 R	1.4 R	0.85 R	5.3 R				2.2 U
ENDRIN ALDEHYDE	2.4 R	2.3 U	2.2 U	2.3 R				2.2 U
ENDRIN KETONE	2.3 U	2.3 U	2.2 U	2.1 U				2.2 U
GAMMA-BHC (LINDANE)	0.42 J	2.3 U	2.2 U	2.1 U				2.2 U
GAMMA-CHLORDANE	2.3 U	2.3 U	2.2 U	2.1 U				2.2 U
HEPTACHLOR	0.34 J	2.3 U	2.2 U	2.1 U				2.2 U
HEPTACHLOR EPOXIDE	2.3 U	2.3 U	2.2 U	2.1 U				2.2 U
METHOXYCHLOR	4.4 U	4.5 U	4.2 U	4.1 U				2.2 U
TOXAPHENE	89 U	92 U	86 U	84 U				2.2 U

from _10sdsam.dbf
from _10sdres.dbf
from _10sdres.xls
from q:\s[illegible]ver\gulfport\upload

order	009	010	011	012	013
site	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10D08	NCBC10D09	NCBC10W10-D10	NCBC10W10-D10	NCBC10W11-D11
nsample	SD1007D01	SD1008D01	SD1009D01	SD1009D01-D	SD1010D01
sample	SD1007D01	SD1008D01	SD1009D01	SD1009D01D	SD1010D01
sacode	NORMAL	NORMAL	ORIG	DUP	NORMAL
depth_rang	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
gis_date	20031218	20031218	20031218	20031218	20031218
sample_dat	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03
validated	Y	Y	Y	Y	Y
cto_proj	288	288	288	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**	**c_013**
Volatile Organics (ug/kg)					
1,1,1-TRICHLOROETHANE	6 UJ	7 U	6 U	6 U	7 U
1,1,2,2-TETRACHLOROETHANE	6 UJ	7 U	6 U	6 U	7 U
1,1,2-TRICHLOROETHANE	6 UJ	7 U	6 U	6 U	7 U
1,1,2-TRICHLOROTRIFLUOROETHANE	6 UJ	7 U	6 U	6 U	7 U
1,1-DICHLOROETHANE	6 UJ	7 U	6 U	6 U	7 U
1,1-DICHLOROETHENE	6 UJ	7 U	6 U	6 U	7 U
1,2,3-TRICHLOROBENZENE	6 UJ	7 U	6 U	6 U	7 U
1,2,4-TRICHLOROBENZENE	6 UJ	7 U	6 U	6 U	7 U
1,2-DIBROMO-3-CHLOROPROPANE	6 UJ	7 U	6 U	6 U	7 U
1,2-DIBROMOETHANE	6 UJ	7 U	6 U	6 U	7 U
1,2-DICHLOROBENZENE	6 UJ	7 U	6 U	6 U	7 U
1,2-DICHLOROETHANE	6 UJ	7 U	6 U	6 U	7 U
1,2-DICHLOROPROPANE	6 UJ	7 U	6 U	6 U	7 U
1,3-DICHLOROBENZENE	6 UJ	7 U	6 U	6 U	7 U
1,4-DICHLOROBENZENE	6 UJ	7 U	6 U	6 U	7 U
2-BUTANONE	33 UJ	33 U	31 U	31 U	34 U
2-HEXANONE	33 UJ	33 U	31 U	31 U	34 U
4-METHYL-2-PENTANONE	33 UJ	33 U	31 U	31 U	34 U
ACETONE	120 J	33 U	44 J	31 U	34 U
BENZENE	6 UJ	7 U	6 U	6 U	7 U
BROMOCHLOROMETHANE	6 UJ	7 U	6 U	6 U	7 U
BROMODICHLOROMETHANE	6 UJ	7 U	6 U	6 U	7 U
BROMOFORM	6 UJ	7 U	6 U	6 U	7 U
BROMOMETHANE	6 UJ	7 U	6 U	6 U	7 U
CARBON DISULFIDE	6 UJ	7 U	6 U	6 U	7 U
CARBON TETRACHLORIDE	6 UJ	7 UJ	6 UJ	6 UJ	7 UJ
CHLOROBENZENE	6 UJ	7 U	6 U	6 U	7 U
CHLORODIBROMOMETHANE	6 UJ	7 U	6 U	6 U	7 U
CHLOROETHANE	6 UJ	7 U	6 U	6 U	7 U
CHLOROFORM	6 UJ	7 U	6 U	6 U	7 U
CHLOROMETHANE	6 UJ	10 U	6 U	6 U	7 U
CIS-1,2-DICHLOROETHENE	6 UJ	7 U	6 U	6 U	7 U
CIS-1,3-DICHLOROPROPENE	6 UJ	7 U	6 U	6 U	7 U
CYCLOHEXANE	6 UJ	7 U	6 U	6 U	7 U
DICHLORODIFLUOROMETHANE	6 UJ	7 U	6 U	6 U	7 U
ETHYLBENZENE	6 UJ	7 U	6 U	6 U	7 U
ISOPROPYLBENZENE	6 UJ	7 U	6 U	6 U	7 U
M+P-XYLENES	13 UJ	13 U	12 U	12 U	14 U
METHYL ACETATE	6 UJ	7 U	6 U	6 U	7 U
METHYL CYCLOHEXANE	6 UJ	7 U	6 U	6 U	7 U
METHYL TERT-BUTYL ETHER	13 UJ	13 U	12 U	12 U	14 U
METHYLENE CHLORIDE	15 J	13 U	12 U	12 U	14 U

from _10sdsam.dbf
from _10sdres.dbf
from _10sdres.xls
from q:\sql_server\gulfport\upload

CTO 288
sediments
full appendix results

order	009	010	011	012	013
site	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10D08	NCBC10D09	NCBC10W10-D10	NCBC10W10-D10	NCBC10W11-D11
nsample	SD1007D01	SD1008D01	SD1009D01	SD1009D01-D	SD1010D01
sample	SD1007D01	SD1008D01	SD1009D01	SD1009D01D	SD1010D01
sacode	NORMAL	NORMAL	ORIG	DUP	NORMAL
depth_rang	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
gis_date	20031218	20031218	20031218	20031218	20031218
sample_dat	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03
validated	Y	Y	Y	Y	Y
cto_proj	288	288	288	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**	**c_013**
O-XYLENE	6 UJ	7 U	6 U	6 U	7 U
STYRENE	6 UJ	7 U	6 U	6 U	7 U
TETRACHLOROETHENE	6 UJ	7 U	6 U	6 U	7 U
TOLUENE	6 UJ	7 U	6 U	6 U	7 U
TOTAL 1,2-DICHLOROETHENE	13 UJ	13 U	12 U	12 U	14 U
TOTAL XYLENES	20 UJ	20 U	19 U	18 U	20 U
TRANS-1,2-DICHLOROETHENE	6 UJ	7 U	6 U	6 U	7 U
TRANS-1,3-DICHLOROPROPENE	6 UJ	7 U	6 U	6 U	7 U
TRICHLOROETHENE	6 UR	7 UR	6 UR	6 UR	7 UR
TRICHLOROFLUOROMETHANE	29 J	8	12	18	13
VINYL CHLORIDE	6 UJ	7 U	6 U	6 U	7 U
Semivolatile Organics (ug/kg)					
1,1-BIPHENYL	460 U	440 U	430 U	420 U	440 U
2,2'-OXYBIS(1-CHLOROPROPANE)	460 U	440 U	430 U	420 U	440 U
2,4,5-TRICHLOROPHENOL	460 U	440 U	430 U	420 U	440 U
2,4,6-TRICHLOROPHENOL	460 U	440 U	430 U	420 U	440 U
2,4-DICHLOROPHENOL	460 U	440 U	430 U	420 U	440 U
2,4-DIMETHYLPHENOL	460 U	440 U	430 U	420 U	440 U
2,4-DINITROPHENOL	460 UJ	440 UJ	430 UJ	420 UJ	440 UJ
2,4-DINITROTOLUENE	460 U	440 U	430 U	420 U	440 U
2,6-DINITROTOLUENE	460 U	440 U	430 U	420 U	440 U
2-CHLORONAPHTHALENE	460 U	440 U	430 U	420 U	440 U
2-CHLOROPHENOL	460 U	440 U	430 U	420 U	440 U
2-METHYLNAPHTHALENE	460 U	440 U	430 U	420 U	440 U
2-METHYLPHENOL	460 U	440 U	430 U	420 U	440 U
2-NITROANILINE	460 U	440 U	430 U	420 U	440 U
2-NITROPHENOL	460 U	440 U	430 U	420 U	440 U
3,3'-DICHLOROBENZIDINE	460 U	440 U	430 U	420 U	440 U
3-NITROANILINE	460 U	440 U	430 U	420 U	440 U
4,6-DINITRO-2-METHYLPHENOL	460 U	440 U	430 U	420 U	440 U
4-BROMOPHENYL PHENYL ETHER	460 U	440 U	430 U	420 U	440 U
4-CHLORO-3-METHYLPHENOL	460 U	440 U	430 U	420 U	440 U
4-CHLOROANILINE	460 U	440 U	430 U	420 U	440 U
4-CHLOROPHENYL PHENYL ETHER	460 U	440 U	430 U	420 U	440 U
4-METHYLPHENOL	460 U	440 U	430 U	420 U	440 U
4-NITROANILINE	460 U	440 U	430 U	420 U	440 U
4-NITROPHENOL	460 U	440 U	430 U	420 U	440 U
ACENAPHTHENE	460 U	440 U	430 U	420 U	440 U
ACENAPHTHYLENE	460 U	440 U	430 U	420 U	440 U
ACETOPHENONE	460 U	440 U	430 U	420 U	440 U
ANTHRACENE	460 U	440 U	430 U	420 U	440 U
ATRAZINE	460 U	440 U	430 U	420 U	440 U
BENZALDEHYDE	460 UJ	440 UJ	430 UJ	420 UJ	440 UJ

from _10sdsam.dbf
from _10sdres.dbf
from _10sdres.xls
from q:\s[illegible]er\gulfport\upload

order	009	010	011	012	013
site	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10D08	NCBC10D09	NCBC10W10-D10	NCBC10W10-D10	NCBC10W11-D11
nsample	SD1007D01	SD1008D01	SD1009D01	SD1009D01-D	SD1010D01
sample	SD1007D01	SD1008D01	SD1009D01	SD1009D01D	SD1010D01
sacode	NORMAL	NORMAL	ORIG	DUP	NORMAL
depth_rang	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
gis_date	20031218	20031218	20031218	20031218	20031218
sample_dat	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03
validated	Y	Y	Y	Y	Y
cto_proj	288	288	288	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**	**c_013**
BENZO(A)ANTHRACENE	460 U	440 U	430 U	420 U	440 U
BENZO(A)PYRENE	460 U	440 U	430 U	420 U	440 U
BENZO(B)FLUORANTHENE	540 U	440 U	430 U	420 U	440 U
BENZO(G,H,I)PERYLENE	460 U	440 U	430 U	420 U	440 U
BENZO(K)FLUORANTHENE	540 U	440 U	430 U	420 U	440 U
BIS(2-CHLOROETHOXY)METHANE	460 U	440 U	430 U	420 U	440 U
BIS(2-CHLOROETHYL)ETHER	460 U	440 U	430 U	420 U	440 U
BIS(2-ETHYLHEXYL)PHTHALATE	460 U	440 U	430 U	420 U	440 U
BUTYL BENZYL PHTHALATE	460 U	440 U	430 U	420 U	440 U
CAPROLACTAM	460 U	440 U	430 U	420 U	440 U
CARBAZOLE	460 U	440 U	430 U	420 U	440 U
CHRYSENE	460 U	440 U	430 U	420 U	440 U
DI-N-BUTYL PHTHALATE	300 J	440 U	280 J	270 J	310 J
DI-N-OCTYL PHTHALATE	460 U	440 U	430 U	420 U	440 U
DIBENZO(A,H)ANTHRACENE	460 U	440 U	430 U	420 U	440 U
DIBENZOFURAN	460 U	440 U	430 U	420 U	440 U
DIETHYL PHTHALATE	460 UJ	44 J	430 UJ	420 UJ	440 UJ
DIMETHYL PHTHALATE	460 U	440 U	430 U	420 U	440 U
FLUORANTHENE	460 U	440 U	430 U	420 U	440 U
FLUORENE	460 U	440 U	430 U	420 U	440 U
HEXACHLOROBENZENE	460 U	440 U	430 U	420 U	440 U
HEXACHLOROBUTADIENE	460 U	440 U	430 U	420 U	440 U
HEXACHLOROCYCLOPENTADIENE	460 U	440 U	430 U	420 U	440 U
HEXACHLOROETHANE	460 U	440 U	430 U	420 U	440 U
INDENO(1,2,3-CD)PYRENE	460 U	440 U	430 U	420 U	440 U
ISOPHORONE	460 U	440 U	430 U	420 U	440 U
N-NITROSO-DI-N-PROPYLAMINE	460 U	440 U	430 U	420 U	440 U
N-NITROSODIPHENYLAMINE	460 U	440 U	430 U	420 U	440 U
NAPHTHALENE	460 U	440 U	430 U	420 U	440 U
NITROBENZENE	460 U	440 U	430 U	420 U	440 U
PENTACHLOROPHENOL	460 U	440 U	430 U	420 U	440 U
PHENANTHRENE	460 U	440 U	430 U	420 U	440 U
PHENOL	460 U	440 U	430 U	420 U	440 U
PYRENE	460 U	440 U	430 U	420 U	440 U
Pesticides/PCBs (ug/kg)					
4,4'-DDD	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
4,4'-DDE	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
4,4'-DDT	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
ALDRIN	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
ALPHA-BHC	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
ALPHA-CHLORDANE	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
AROCLOR-1016	24 UJ	22 U	22 U	22 U	22 U
AROCLOR-1221	24 UJ	22 U	22 U	22 U	22 U

from _10sdsam.dbf
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CTO 288
sediments
full appendix results

order	009	010	011	012	013
site	00010	00010	00010	00010	00010
aoc	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH	PCB IN DRAIN DITCH
location	NCBC10D08	NCBC10D09	NCBC10W10-D10	NCBC10W10-D10	NCBC10W11-D11
nsample	SD1007D01	SD1008D01	SD1009D01	SD1009D01-D	SD1010D01
sample	SD1007D01	SD1008D01	SD1009D01	SD1009D01D	SD1010D01
sacode	NORMAL	NORMAL	ORIG	DUP	NORMAL
depth_rang	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
gis_date	20031218	20031218	20031218	20031218	20031218
sample_dat	12/18/03	12/18/03	12/18/03	12/18/03	12/18/03
validated	Y	Y	Y	Y	Y
cto_proj	288	288	288	288	288
proj_manag	FISHER,R	FISHER,R	FISHER,R	FISHER,R	FISHER,R
sort	**c_009**	**c_010**	**c_011**	**c_012**	**c_013**
AROCLOR-1232	24 UJ	22 U	22 U	22 U	22 U
AROCLOR-1242	24 UJ	22 U	22 U	22 U	22 U
AROCLOR-1248	24 UJ	22 U	22 U	22 U	22 U
AROCLOR-1254	24 UJ	22 U	22 U	22 U	22 U
AROCLOR-1260	81 J	22 U	22 U	22 U	22 U
BETA-BHC	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
DELTA-BHC	2.4 U	2.2 U	2.2 UJ	2.4 J	2.2 U
DIELDRIN	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
ENDOSULFAN I	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
ENDOSULFAN II	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
ENDOSULFAN SULFATE	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
ENDRIN	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
ENDRIN ALDEHYDE	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
ENDRIN KETONE	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
GAMMA-BHC (LINDANE)	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
GAMMA-CHLORDANE	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
HEPTACHLOR	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
HEPTACHLOR EPOXIDE	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
METHOXYCHLOR	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U
TOXAPHENE	2.4 U	2.2 U	2.2 U	2.2 U	2.2 U

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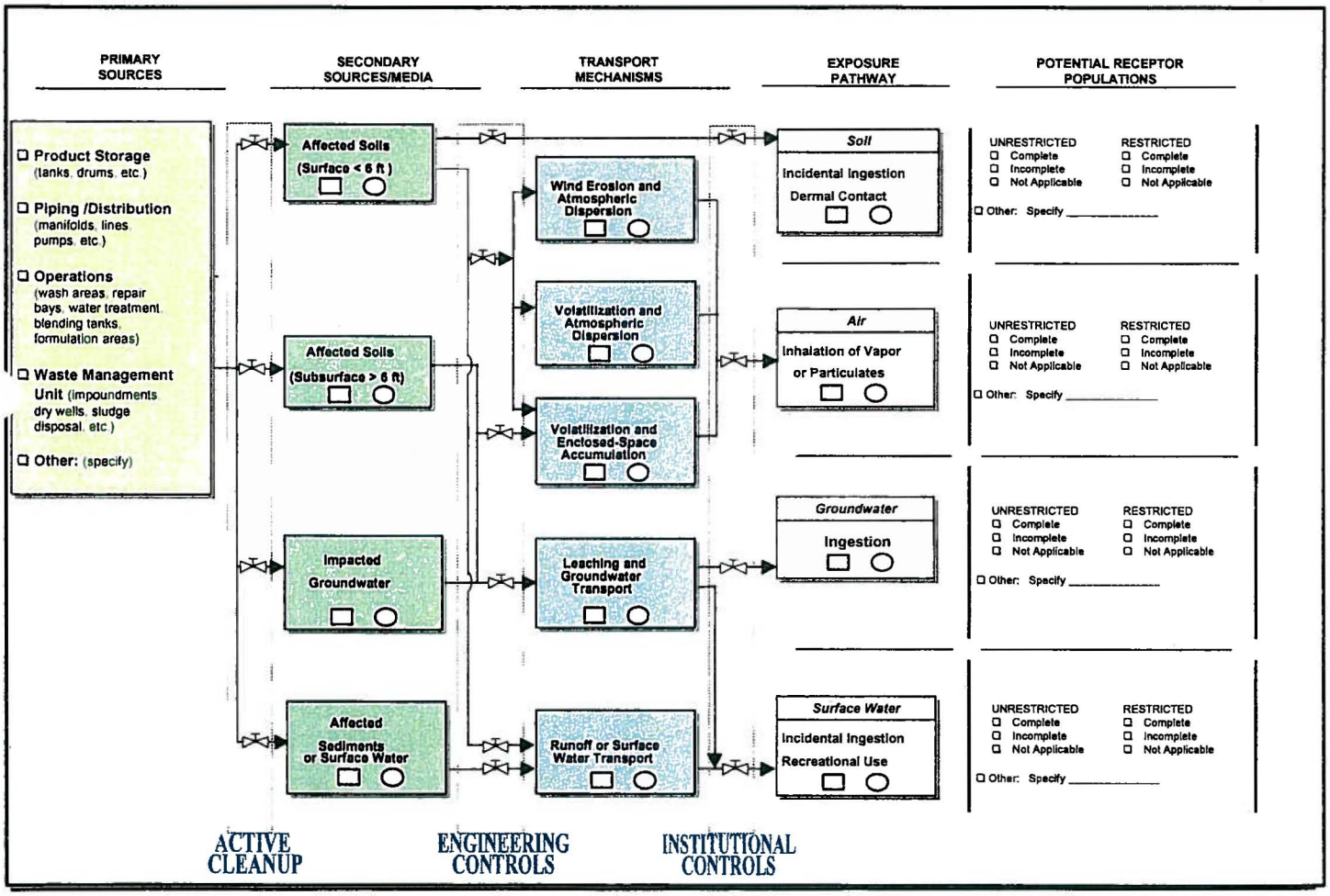
APPENDIX C

BASELINE SCEM WORKSHEET

Worksheet **Baseline Site Conceptual Exposure Model (SCEM)**

Site Name: Completed By: ☐ Complete ☐ Draft
Site Location: Revision Date: ○ Potentially Complete ☐ Final



→ = *Potential pathway*

APPENDIX D

95-PERCENT UCL CALCULATIONS AND TIER 2 RISK EVALUATION SUPPORT DATA

Interpolation calculations for the H-statistic:

s-value: 2.22

Rows	Values
14	2
15	2.5

n-value: 37

Columns	Values
8	31
9	51

Percentages		0%	30%	100%
	Values	31	37	51
0%	2	3.812	3.728	3.533
43%	2.217	4.148	4.054	3.834
100%	2.5	4.588	4.480	4.228

Final interpolated H-statistic value shaded in Red
n values shaded in green
s values shaded in yellow
Corresponding H-statistic table value shaded in blue
Intermediate H-statistic values shaded in gray

	Column #	1	2	3	4	5	6	7	8	9	10
	n value	3	5	7	10	12	15	21	31	51	101
Row	s value										
1	0.1	2.75	2.035	1.886	1.802	1.775	1.749	1.722	1.701	1.684	1.67
2	0.2	3.295	2.198	1.992	1.881	1.843	1.809	1.771	1.742	1.718	1.697
3	0.3	4.109	2.402	2.125	1.977	1.927	1.882	1.833	1.793	1.761	1.733
4	0.4	5.22	2.631	2.282	2.089	2.026	1.968	1.905	1.856	1.813	1.777
5	0.5	6.495	2.947	2.465	2.22	2.141	2.068	1.989	1.928	1.876	1.83
6	0.6	7.807	3.287	2.673	2.368	2.271	2.181	2.085	2.01	1.946	1.891
7	0.7	9.12	3.662	2.904	2.532	2.414	2.306	2.191	2.102	2.025	1.96
8	0.8	10.43	4.062	3.155	2.71	2.57	2.443	2.307	2.202	2.112	2.035
9	0.9	11.74	4.478	3.402	2.902	2.738	2.589	2.432	2.31	2.206	2.117
10	1	13.05	4.905	3.698	3.103	2.915	2.744	2.564	2.423	2.306	2.205
11	1.25	16.33	6.001	4.426	3.639	3.389	3.163	2.923	2.737	2.58	2.447
12	1.5	19.6	7.12	5.184	4.207	3.896	3.612	3.311	3.077	2.881	2.713
13	1.75	22.87	8.25	5.96	4.795	4.422	4.081	3.719	3.437	3.2	2.997
14	2	26.14	9.387	6.747	5.396	4.962	4.564	4.141	3.812	3.533	3.295
15	2.5	32.69	11.67	8.339	6.621	6.067	5.557	5.013	4.588	4.228	3.92
16	3	39.23	13.97	9.945	7.864	7.191	6.57	5.907	5.388	4.947	4.569
17	3.5	45.77	16.27	11.56	9.118	8.326	7.596	6.815	6.201	5.681	5.233
18	4	52.31	18.58	13.18	10.38	9.469	8.63	7.731	7.024	6.424	5.908
19	4.5	58.85	20.88	14.8	11.64	10.62	9.669	8.652	7.854	7.174	6.59
20	5	65.39	23.19	16.43	12.91	11.77	10.71	9.579	8.688	7.929	7.277
21	6	78.47	27.81	19.68	15.45	14.08	12.81	11.44	10.36	9.449	8.661
22	7	91.55	32.43	22.94	18	16.39	14.9	13.31	12.05	10.98	10.05
23	8	104.6	37.06	26.2	20.55	18.71	17.01	15.18	13.74	12.51	11.45
24	9	117.7	41.68	29.46	23.1	21.03	19.11	17.05	15.43	14.05	12.85
25	10	130.8	46.31	32.73	25.66	23.35	21.22	18.93	17.13	15.59	14.26

Reference for the H-statistic table:
Gilbert, R. O., Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, New York, 1987.

The purpose of this spreadsheet is to calculate the Lognormal 95% UCL-AM for a data set.

Do not use zero (0.00) for non-detects, rather use 1/2 of the SQL as a proxy concentration.

Enter the data points in the green shaded cells below.
The yellow shaded areas are calculated value please do not overwrite.

Concentration (mg/kg)	Natural log (LN) of concentration
19	2.94
19	2.94
740	6.61
6000	8.70
5200	8.56
83000	11.33
19	2.94
19	2.94
18	2.89
19	2.94
19	2.94
18	2.89
19	2.94
19	2.94
11	2.40
1800	7.50
13	2.56
19	2.94
19	2.94
15	2.71
18	2.89
10	2.30
10	2.30
10	2.30
10	2.30
10	2.30
710	6.57
94	4.54
630	6.45
19	.94
260	5.5
190	5.25
65	4.17
81	4.39
11	2.40
11	2.4
11	2.40

Site info:	NCBC Gulfport Site 10 Surface Soil and Sediment
Constituent:	Aroclor 1260 (Concentrations in ug/KG)

$$95\%\ UCL = e^{\left[X + (.5)(S^2) + \frac{(S)(H)}{\sqrt{n-1}}\right]}$$

95% UCL-AM = 2,777.135

Maximum detected: 83000.000

Determination and definition of varibles used in the above calculations.

n:	37
x:	3.974
s:	2.27
H:	4.054

n = number of samples
x = mean of the log transformed data
s = standard deviation of the transformed data
H = Land's H-statistic, based upon n and s

Reference for the 95% UCL-AM equation and methodology:
USEPA Supplemental Guidance to RAGS: Calculating the Concentration Term, 1992 (Publication 9285.7-081).

Analysis performed on **12/24/2004**

The purpose of this spreadsheet is to calculate the Lognormal 95% UCL-AM for a data set.

Do not use zero (0.00) for non-detects, rather use 1/2 of the SQL as a proxy concentration.

Enter the data points in the green shaded cells below.
The yellow shaded areas are calculated values please do not overwrite.

Concentration (mg/kg)	Natural log (LN) of concentration
19	2.94

Site Info:	NCBC Gulfport Site 10 Surface Soil and Sediment
Constituent:	Aroclor 1260 (Concentrations in ug/KG)

Analysis performed on **12/24/2004**

The purpose of this spreadsheet is to calculate the Lognormal 95% UCL-AM for a data set.

Do not use zero (0.00) for non-detects, rather use 1/2 of the SQL as a proxy concentration.

Enter the data points in the green shaded cells below.
The yellow shaded areas are calculate values please do not overwrite.

Concentration (mg/kg)	Natural log (LN) of concentration
19	2.94

Site info:	NCBC Gulfport Site 10 Surface Soil and Sediment
Constituent:	Aroclor 1260 (Concentrations in ug/KG)

Interpolation calculations for the H-statistic:

s-value: 0.83

Rows	Values
8	0.8
9	0.9

n-value: 10

Columns	Values
4	10

Percentages		100%		
	Values	10	10	
0%	0.8	2.710		
33%	0.833	2.774	2.774	
100%	0.9	2.902		

Final interpolated H-statistic value shaded in Red
n values shaded in green
s values shaded in yellow
Corresponding H-statistic table value shaded in blue
Intermediate H-statistic values shaded in gray

	Column #	1	2	3	4	5	6	7	8	9	10
	n value	3	5	7	10	12	15	21	31	51	101
Row #	s value										
1	0.1	2.75	2.035	1.886	1.802	1.775	1.749	1.722	1.701	1.684	1.67
2	0.2	3.295	2.198	1.992	1.881	1.843	1.809	1.771	1.742	1.718	1.697
3	0.3	4.109	2.402	2.125	1.977	1.927	1.882	1.833	1.793	1.761	1.733
4	0.4	5.22	2.631	2.282	2.089	2.026	1.968	1.905	1.856	1.813	1.777
5	0.5	6.495	2.947	2.465	2.22	2.141	2.068	1.989	1.928	1.876	1.83
6	0.6	7.807	3.287	2.673	2.368	2.271	2.181	2.085	2.01	1.946	1.891
7	0.7	9.12	3.662	2.904	2.532	2.414	2.306	2.191	2.102	2.025	1.96
8	0.8	10.43	4.062	3.155	2.71	2.57	2.443	2.307	2.202	2.112	2.035
9	0.9	11.74	4.478	3.402	2.902	2.738	2.589	2.432	2.31	2.206	2.117
10	1	13.05	4.905	3.698	3.103	2.915	2.744	2.564	2.423	2.306	2.205
11	1.25	16.33	6.001	4.426	3.639	3.389	3.163	2.923	2.737	2.58	2.447
12	1.5	19.6	7.12	5.184	4.207	3.896	3.612	3.311	3.077	2.881	2.713
13	1.75	22.87	8.25	5.96	4.795	4.422	4.081	3.719	3.437	3.2	2.997
14	2	26.14	9.387	6.747	5.396	4.962	4.564	4.141	3.812	3.533	3.295
15	2.5	32.69	11.67	8.339	6.621	6.067	5.557	5.013	4.588	4.228	3.92
16	3	39.23	13.97	9.945	7.864	7.191	6.57	5.907	5.388	4.947	4.569
17	3.5	45.77	16.27	11.56	9.118	8.326	7.596	6.815	6.201	5.681	5.233
18	4	52.31	18.58	13.18	10.38	9.469	8.63	7.731	7.024	6.424	5.908
19	4.5	58.85	20.88	14.8	11.64	10.62	9.669	8.652	7.854	7.174	6.59
20	5	65.39	23.19	16.43	12.91	11.77	10.71	9.579	8.688	7.929	7.277
21	6	78.47	27.81	19.68	15.45	14.08	12.81	11.44	10.36	9.449	8.661
22	7	91.55	32.43	22.94	18	16.39	14.9	13.31	12.05	10.98	10.05
23	8	104.6	37.06	26.2	20.55	18.71	17.01	15.18	13.74	12.51	11.45
24	9	117.7	41.68	29.46	23.1	21.03	19.11	17.05	15.43	14.05	12.85
25	10	130.8	46.31	32.73	25.66	23.35	21.22	18.93	17.13	15.59	14.26

Reference for the H-statistic table:

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

The purpose of this spreadsheet is to calculate the Lognormal 95% UCL-AM for a data set.

Do not use zero (0.00) for non-detects, rather use 1/2 of the SQL as a proxy concentration.

Enter the data points in the green shaded cells below.
The yellow shaded areas are calculated values please do not overwrite.

Concentration (mg/kg)	Natural log (LN) of concentration
1.50	0.41
0.50	-0.69
0.21	-1.56
0.44	-0.82
0.45	-0.80
0.35	-1.05
2.10	0.74
1.80	0.59
1.70	0.53
1.40	0.34

Site info:	NCBC Gulfport Site 10 Surface Soil and Sediment
Constituent:	Arsenic

$$95\%\ UCL = e^{\left[X + (.5)(S^2) + \frac{(S)(H)}{\sqrt{n-1}}\right]}$$

95% UCL-AM =	2.423

Maximum detected:	2.100

Determination and definition of varibles used in the above calculations.

n:	10
x:	-0.232
s:	0.833
H:	2.774

n = number of samples
x = mean of the log transformed data
s = standard deviation of the transformed data
H = Land's H-statistic, based upon n and s

Reference for the 95% UCL-AM equation and methodology:
USEPA Supplemental Guidance to RAGS: Calculating the Concentration Term, 1992 (Publication 9285.7-081).

Analysis performed on **12/24/2004**

The purpose of this spreadsheet is to calculate the Lognormal 95% UCL-AM for a data set.

Do not use zero (0.00) for non-detects, rather use 1/2 of the SQL as a proxy concentration.	

Enter the data points in the green shaded cells below
The yellow shaded areas are calculated values please do not overwrite

Concentration (mg/kg)	Natural log (LN) of concentration
1.50	0.41

Site info:	NCBC Gulfport Site 10 Surface Soil and Sediment
Constituent:	Arsenic

The purpose of this spreadsheet is to calculate the Lognormal 95% UCL-AM for a data set.

Do not use zero (0.00) for non-detects, rather use 1/2 of the SQL as a proxy concentration.

Enter the data points in the green shaded cells below.
The yellow shaded areas are calculated values please do not overwrite.

Concentration (mg/kg)	Natural log (LN) of concentration
1.50	0.41

Site Info:	NCBC Gulfport Site 10 Surface Soil and Sediment
Constituent:	Arsenic

Interpolation calculations for the H-statistic:

s-value: 0.26

Rows	Values
2	0.2
3	0.3

n-value: 10

Columns	Values
4	10

Percentages		100%		
	Values	10	10	
0%	0.2	1.881		
61%	0.261	1.939	1.939	
100%	0.3	1.977		

Final interpolated H-statistic value shaded in Red
n values shaded in green
s values shaded in yellow
Corresponding H-statistic table value shaded in blue
Intermediate H-statistic values shaded in gray

	Column #	1	2	3	4	5	6	7	8	9	10
	n value	3	5	7	10	12	15	21	31	51	101
Row #	s value										
1	0.1	2.75	2.035	1.886	1.802	1.775	1.749	1.722	1.701	1.684	1.67
2	0.2	3.295	2.198	1.992	1.881	1.843	1.809	1.771	1.742	1.718	1.697
3	0.3	4.109	2.402	2.125	1.977	1.927	1.882	1.833	1.793	1.761	1.733
4	0.4	5.22	2.631	2.282	2.089	2.026	1.968	1.905	1.856	1.813	1.777
5	0.5	6.495	2.947	2.465	2.22	2.141	2.068	1.989	1.928	1.876	1.83
6	0.6	7.807	3.287	2.673	2.368	2.271	2.181	2.085	2.01	1.946	1.891
7	0.7	9.12	3.662	2.904	2.532	2.414	2.306	2.191	2.102	2.025	1.96
8	0.8	10.43	4.062	3.155	2.71	2.57	2.443	2.307	2.202	2.112	2.035
9	0.9	11.74	4.478	3.402	2.902	2.738	2.589	2.432	2.31	2.206	2.117
10	1	13.05	4.905	3.698	3.103	2.915	2.744	2.564	2.423	2.306	2.205
11	1.25	16.33	6.001	4.426	3.639	3.389	3.163	2.923	2.737	2.58	2.447
12	1.5	19.6	7.12	5.184	4.207	3.896	3.612	3.311	3.077	2.881	2.713
13	1.75	22.87	8.25	5.96	4.795	4.422	4.081	3.719	3.437	3.2	2.997
14	2	26.14	9.387	6.747	5.396	4.962	4.564	4.141	3.812	3.533	3.295
15	2.5	32.69	11.67	8.339	6.621	6.067	5.557	5.013	4.588	4.228	3.92
16	3	39.23	13.97	9.945	7.864	7.191	6.57	5.907	5.388	4.947	4.569
17	3.5	45.77	16.27	11.56	9.118	8.326	7.596	6.815	6.201	5.681	5.233
18	4	52.31	18.58	13.18	10.38	9.469	8.63	7.731	7.024	6.424	5.908
19	4.5	58.85	20.88	14.8	11.64	10.62	9.669	8.652	7.854	7.174	6.59
20	5	65.39	23.19	16.43	12.91	11.77	10.71	9.579	8.688	7.929	7.277
21	6	78.47	27.81	19.68	15.45	14.08	12.81	11.44	10.36	9.449	8.661
22	7	91.55	32.43	22.94	18	16.39	14.9	13.31	12.05	10.98	10.05
23	8	104.6	37.06	26.2	20.55	18.71	17.01	15.18	13.74	12.51	11.45
24	9	117.7	41.68	29.46	23.1	21.03	19.11	17.05	15.43	14.05	12.85
25	10	130.8	46.31	32.73	25.66	23.35	21.22	18.93	17.13	15.59	14.26

Reference for the H-statistic table:

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

The purpose of this spreadsheet is to calculate the Lognormal 95% UCL-AM for a data set.

Do not use zero (0.00) for non-detects, rather use 1/2 of the SQL as a proxy concentration.

Enter the data points in the green shaded cells below.
The yellow shaded areas are calculated values please do not overwrite.

Concentration (mg/kg)	Natural log (LN) of concentration
0.06	-2.86
0.03	-3.69
0.03	-3.69
0.03	-3.69
0.03	-3.69
0.03	-3.69
0.03	-3.69
0.03	-3.69
0.03	-3.69
0.03	-3.69

Site info:	NCBC Gulfport Site 10 Groundwater
Constituent:	Dieldrin (concentrations in ug/L)

$$95\%\ UCL = e^{\left[X + (.5)(S^2) + \frac{(S)(H)}{\sqrt{n-1}}\right]}$$

95% UCL-AM =	0.033

Maximum detected:	0.057

Determination and definition of varibles used in the above calculations.

n:	10
x:	-3.606
s:	0.261
H:	1.939

n = number of samples
x = mean of the log transformed data
s = standard deviation of the transformed data
H = Land's H-statistic, based upon n and s

Reference for the 95% UCL-AM equation and methodology:
USEPA Supplemental Guidance to RAGS: Calculating the Concentration Term, 1992 (Publication 9285.7-081).

Analysis performed on **12/24/2004**

The purpose of this spreadsheet is to calculate the Lognormal 95% UCL-AM for a data set.

Do not use zero (0.00) for non-detects, rather use 1/2 of the SQL as a proxy concentration.

Enter the data points in the green shaded cells below.
The yellow shaded areas are calculated values please do not overwrite.

Concentration (mg/kg)	Natural log (LN) of concentration
0.06	-2.86

Site Info:	NCBC Gulfport Site 10 Groundwater
Constituent:	Dieldrin (concentrations in ug/L)

Analysis performed on **12/24/2004**

The purpose of this spreadsheet is to calculate the Lognormal 95% UCL-AM for a data set.

Do not use zero (0.00) for non-detects, rather use 1/2 of the SQL as a proxy concentration.	

Enter the data points in the green shaded cells below.
The yellow shaded areas are calculated values; please do not overwrite.

Concentration (mg/kg)	Natural log (LN) of concentration
0.06	-2.86

Site Info:	NCBC Gulfport Site 10 Groundwater
Constituent:	Dieldrin (concentrations in ug/L)

Interpolation calculations for the H-statistic:

s-value: 1.01

Rows	Values
10	1
11	1.25

n-value: 31

Columns	Values
8	31

Percentages		100%		
	Values	31	31	
0%	1	2.423		
5%	1.012	2.438	2.438	
100%	1.25	2.737		

Final interpolated H-statistic value shaded in Red
n values shaded in green
s values shaded in yellow
Corresponding H-statistic table value shaded in blue
Intermediate H-statistic values shaded in gray

	Column #	1	2	3	4	5	6	7	8	9	10
	n value	3	5	7	10	12	15	21	31	51	101
Row #	s value										
1	0.1	2.75	2.035	1.886	1.802	1.775	1.749	1.722	1.701	1.684	1.67
2	0.2	3.295	2.198	1.992	1.881	1.843	1.809	1.771	1.742	1.718	1.697
3	0.3	4.109	2.402	2.125	1.977	1.927	1.882	1.833	1.793	1.761	1.733
4	0.4	5.22	2.631	2.282	2.089	2.026	1.968	1.905	1.856	1.813	1.777
5	0.5	6.495	2.947	2.465	2.22	2.141	2.068	1.989	1.928	1.876	1.83
6	0.6	7.807	3.287	2.673	2.368	2.271	2.181	2.085	2.01	1.946	1.891
7	0.7	9.12	3.662	2.904	2.532	2.414	2.306	2.191	2.102	2.025	1.96
8	0.8	10.43	4.062	3.155	2.71	2.57	2.443	2.307	2.202	2.112	2.035
9	0.9	11.74	4.478	3.402	2.902	2.738	2.589	2.432	2.31	2.206	2.117
10	1	13.05	4.905	3.698	3.103	2.915	2.744	2.564	2.423	2.306	2.205
11	1.25	16.33	6.001	4.426	3.639	3.389	3.163	2.923	2.737	2.58	2.447
12	1.5	19.6	7.12	5.184	4.207	3.896	3.612	3.311	3.077	2.881	2.713
13	1.75	22.87	8.25	5.96	4.795	4.422	4.081	3.719	3.437	3.2	2.997
14	2	26.14	9.387	6.747	5.396	4.962	4.564	4.141	3.812	3.533	3.295
15	2.5	32.69	11.67	8.339	6.621	6.067	5.557	5.013	4.588	4.228	3.92
16	3	39.23	13.97	9.945	7.864	7.191	6.57	5.907	5.388	4.947	4.569
17	3.5	45.77	16.27	11.56	9.118	8.326	7.596	6.815	6.201	5.681	5.233
18	4	52.31	18.58	13.18	10.38	9.469	8.63	7.731	7.024	6.424	5.908
19	4.5	58.85	20.88	14.8	11.64	10.62	9.669	8.652	7.854	7.174	6.59
20	5	65.39	23.19	16.43	12.91	11.77	10.71	9.579	8.688	7.929	7.277
21	6	78.47	27.81	19.68	15.45	14.08	12.81	11.44	10.36	9.449	8.661
22	7	91.55	32.43	22.94	18	16.39	14.9	13.31	12.05	10.98	10.05
23	8	104.6	37.06	26.2	20.55	18.71	17.01	15.18	13.74	12.51	11.45
24	9	117.7	41.68	29.46	23.1	21.03	19.11	17.05	15.43	14.05	12.85
25	10	130.8	46.31	32.73	25.66	23.35	21.22	18.93	17.13	15.59	14.26

Reference for the H-statistic table:
Gilbert, R. O., Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, New York, 1987.

The purpose of this spreadsheet is to calculate the Lognormal 95% UCL-AM for a data set.

Do not use zero (0.00) for non-detects, rather use 1/2 of the SQL as a proxy concentration.

Enter the data points in the green shaded cells below.
The yellow shaded areas are calculated values please do not overwrite.

Concentration (mg/kg)	Natural log (LN) of concentration
1	0.00
1	0.00
1	0.00
26	3.26
18	2.89
1	0.00
1	0.00
1	0.00
1	0.00
1	0.00
1	0.00
1	0.00
1	0.00
1	0.00
1	0.00
46	3.83
1	0.00
1	0.00
1	0.00
1	0.00
1	0.00
1	0.00
1	0.00
3.4	1.22
1	0.00
1	0.00
1.1	0.10
1.2	0.18
1.1	0.10
1.1	0.10
1.1	0.10

Site Info:	NCBC Gulfport Site 10 Surface Soil and Sediment
Constituent:	Dieldrin (concentrations in ug/Kg)

$$95\%\ UCL = e^{\left[X + (.5)(S^2) + \frac{(S)(H)}{\sqrt{n-1}}\right]}$$

95% UCL-AM =	3.828

Maximum detected:	46.000

Determination and definition of varibles used in the above calculations.

n:	31
x:	0.379
s:	1.012
H:	2.438

n = number of samples
x = mean of the log transformed data
s = standard deviation of the transformed data
H = Land's H-statistic, based upon n and s

Reference for the 95% UCL-AM equation and methodology:
USEPA Supplemental Guidance to RAGS: Calculating the Concentration Term, 1992 (Publication 9285.7-081).

Analysis performed on **12/24/2004**

The purpose of this spreadsheet is to calculate the Lognormal 95% UCL-AM for a data set.

Do not use zero (0.00) for non-detects, rather use 1/2 of the SQL as a proxy concentration.

Enter the data points in the green shaded cells below.
The yellow shaded areas are calculated values please do not overwrite.

Concentration (mg/kg)	Natural log (LN) of concentration
1	0.00

Site Info:	NCBC Gulfport Site 10 Surface Soil and Sediment
Constituent:	Dieldrin (concentrations in ug/Kg)

Analysis performed on **12/24/2004**

The purpose of this spreadsheet is to calculate the Lognormal 95% UCL-AM for a data set.

Do not use zero (0.00) for non-detects, rather use 1/2 of the SQL as a proxy concentration.	

Enter the data points in the green shaded cells below.
The yellow shaded areas are calculated values please do not overwrite.

Concentration (mg/kg)	Natural log (LN) of concentration
1	0.00

Site info:	NCBC Gulfport Site 10 Surface Soil and Sediment
Constituent:	Dieldrin (concentrations in ug/Kg)

APPENDIX E

USEPA AND MDEQ DECISION ON SITE 10

To: Jason Brown

From: Robert Fisher

CC: file

Date: December 13, 2004

Re: EPA(TOSCA) and MDEQ Decision on Site 10

On 09 Jul 02, with receipt of the post-removal/confirmation data indicating PCB in the soil/sediment at Site 10 above the TOSCA notification level of 50 ppm, Tetra Tech NUS, Inc. contacted Region IV EPA and MDEQ. The draft Confirmation Report was forwarded to Craig Benedikt (EPA) and Bob Merrill (MDEQ), and a phone conference was scheduled for 15 Jul 02.

During the meeting on 15 Jul 02, Craig Benedikt stated that, based on the report, TOSCA rules would not require any further action at this site – if as the Report states, the wastes were pre-1978. We discussed the types of polychlorinated phenols reported at the site and the report from Mississippi Power stating that all of these types of transformers had been replaced by the mid-1970s.

Mr. Benedikt recognized that MDEQ had lower action levels, is the lead agency on the other sites at NCBC Gulfport, and would therefore be better suited to continue in that role.

Mr. Benedikt also discussed the "Self Directed" option, but Mr. Merrill preferred to maintain a stronger role in the project. Both Mr. Merrill and Mr. Benedikt agreed that the next steps should include a brief RI/FS and limited actions in the future to limit potential exposure. Mr. Benedikt recommended a barrier of some type rather than a removal action, Mr. Merrill agreed.

MDEQ was provided with a final Confirmation Report in December 2002 and a courtesy copy was provided to Mr. Benedikt.

APPENDIX F

CALCULATIONS

CLIENT: NCBC GULFPORT			JOB NUMBER: 112GN1831 0000.PP0110100	
SUBJECT: SITE 10 - PARADE FIELD DITCH VOLUME CALCULATION				
BASED ON:			DRAWING NUMBER:	
BY: MOJ Date: 1-19-07		CHECKED BY: Date:	APPROVED BY:	DATE:

OBJECTIVE:

To calculate the volume of soil to be excavated under Alternative 3 (Surface Water Controls, Excavation, Surface Protection, Institutional Controls, and Monitoring) and Alternative 4 (Surface Water Controls, Dewatering, Excavation, Off-Site Treatment and Disposal of Excavated Soil) for the Feasibility Study for Site 10 - Parade Field Ditch at the Naval Construction Battalion Center in Gulfport, Mississippi.

APPROACH:

1. Evaluate the analytical data to determine the sample locations that exceed the Aroclor-1260 PRG of 1,000 µg/kg. The area of investigation for both alternatives will be the area around the samples that exceed the PRG.

2. For Alternative 3, assume an excavation depth of 1 foot. Calculate the excavation volume.

3. For Alternative 4, determine the excavation depth at each location. The excavation depth will extend to one half the distance between the sample that exceeds the Aroclor-1260 PRG and the sample that does not exceed the Aroclor-1260 PRG. Use Terramodel Computer Software to calculate the excavation volume.

CALCULATIONS

1. Determine the Area in Exceedence of PRG.

From the analytical data presented in Attachment 1, it was determined that the following locations exceed the Aroclor-1260 PRG of 1,000 µg/kg:

Location	Depth (ft bgs)	Concentration (µg/kg)
NCBC10S04	1	6,000
NCBC10S05	2	5,200
NCBC10S06	2	83,000
NCBC10S06	8	19,000
NCBC10S16	5	1,800

Figure 1 (Page 3 of 6) shows the area around the samples listed above. The total area of investigation is as follows:

Perimeter Around Samples =	224	ft
Area Around Samples =	1,514	sf
=	168	sy

2. Alternative 3

CLIENT: NCBC GULFPORT		JOB NUMBER: 112GN1831 0000.PP0110100	
SUBJECT: SITE 10 - PARADE FIELD DITCH VOLUME CALCULATION			
BASED ON:		DRAWING NUMBER:	
BY: MOJ Date: 1-19-07	CHECKED BY: Date:	APPROVED BY:	DATE:

Under Alternative 3, it assumed that additional pavement will be placed between the area of investigation and the current walk way. Therefore, the excavation area will be different than that of Alternative 4. The volume of excavation under Alternative 3 is calculated by multiplying the area of excavation times 1 foot.

Area of Investigation =	1,514	sf
Additional Area for Pavement =	88	sf
Total Excavation Area =	1,602	sf
Excavation Volume =	1,602	cf
=	59	cy

3. Alternative 4

The depth of excavation under Alternative 4 will extend to one half the distance between the sample that exceeds the Aroclor-1260 PRG and the sample that does not exceed the Aroclor-1260 PRG.

Location	Depth (ft bgs)	Concentration (µg/kg)	Distance Between Results (ft)	Excavation Depth (ft bgs)
NCBC10S04	1	6,000	10	6
NCBC10S04	11	39 U		
NCBC10S05	2	5,200	9	6.5
NCBC10S05	11	40 U		
NCBC10S06	2	83,000	12	14
NCBC10S06	8	19,000		
NCBC10S06	20	38 J		
NCBC10S16	5	1,800	5	7.5
NCBC10S16	10	38 U		

The profile of the ditch at Site 10 as measured in the field is presented in Figure 2A (Page 4 of 6). This profile was entered into Terramodel as shown on Figure 2B (Page 4 of 6). The excavation depths at each sample location were then entered into Terramodel to compute the excavation volume as follows:

Volume of Excavation = 449 cy

Terramodel output is presented on Page 5 of 6. The excavation profile from Terramodel is presented in Figure 3 (Page 6 of 6).

APPENDIX G

COST ESTIMATE

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
FEASIBILITY STUDY
ALTERNATIVE 2: INSTITUTIONAL CONTROLS AND MONITORING
CAPITAL COST

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING											
1.1 Prepare Documents & Plans Including Permits	40	hours			$25.00		$0	$0	$1,000	$0	$1,000
2 INSTITUTIONAL CONTROLS											
2.1 Chain Link Fence	224	lf		$22.00	$4.97	$2.88	$0	$4,928	$1,113	$645	$6,686
2.2 Privacy Slats	1,472	sf		$1.07	$0.42		$0	$1,575	$618	$0	$2,193
2.3 Warning Signs	2	ea		$45.85	$17.27	$9.99	$0	$92	$35	$20	$146
Subtotal							0	$6,595	$2,766	$665	$10,026
Local Area Adjustments							100.0%	105.4%	86.4%	86.4%	
							$0	$6,951	$2,390	$575	$9,915
Overhead on Labor Cost @ 30%									$717		$717
G & A on Labor Cost @ 10%									$239		$239
G & A on Material Cost @ 10%								$695			$695
G & A on Subcontract Cost @ 10%							$0				$0
G & A on Equipment Cost @ 10%										$57	$57
Total Direct Cost							$0	$7,646	$3,346	$632	$11,624
Indirects on Total Direct Cost @ 35%											$4,068
Profit on Total Direct Cost @ 10%											$1,162
Subtotal											$16,855
Health & Safety Monitoring @ 1%											$169
Total Field Cost											$17,023
Contingency on Total Field Costs @ 20%											$3,405
Engineering on Total Field Cost @ 5%											$851
TOTAL COST											**$21,279**

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
FEASIBILITY STUDY
ALTERNATIVE 2: INSTITUTIONAL CONTROLS AND MONITORING
ANNUAL COST

Item	Item Cost Years 1 - 30	Item Cost Every 5 Years	Notes
Sampling	$400		Collect surface water and sediment samples.
Analysis	$1,500	$224	Analyze four surface water, four sediment, and two QA/QC samples for PCBs.
Report	$2,000		Obtain lab, prepare sampling plan, document sampling events and results.
Site Review		$15,000	Review of documents and data evaluation/recommendations.
TOTALS	**$3,900**	**$15,224**	

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
FEASIBILITY STUDY
ALTERNATIVE 2: INSTITUTIONAL CONTROLS AND MONITORING
PRESENT WORTH ANALYSIS

Year	Capital Cost	Annual Cost	Annual Discount Rate at 7%	Present Worth
0	$21,279		1.000	$21,279
1		$3,900	0.935	$3,647
2		$3,900	0.873	$3,405
3		$3,900	0.816	$3,182
4		$224	0.763	$171
5		$19,124	0.713	$13,635
6		$3,900	0.666	$2,597
7		$3,900	0.623	$2,430
8		$3,900	0.582	$2,270
9		$3,900	0.544	$2,122
10		$19,124	0.508	$9,715
11		$3,900	0.475	$1,853
12		$3,900	0.444	$1,732
13		$3,900	0.415	$1,619
14		$3,900	0.388	$1,513
15		$19,124	0.362	$6,923
16		$3,900	0.339	$1,322
17		$3,900	0.317	$1,236
18		$3,900	0.296	$1,154
19		$3,900	0.277	$1,080
20		$19,124	0.258	$4,934
21		$3,900	0.242	$944
22		$3,900	0.226	$881
23		$3,900	0.211	$823
24		$3,900	0.197	$768
25		$19,124	0.184	$3,519
26		$3,900	0.172	$671
27		$3,900	0.161	$628
28		$3,900	0.150	$585
29		$3,900	0.141	$550
30		$19,124	0.131	$2,505
			TOTAL PRESENT WORTH	**$99,692**

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
FEASIBILITY STUDY
ALTERNATIVE 3: SURFACE WATER CONTROLS, EXCAVATION, SURFACE PROTECTION, INSTITUTIONAL CONTROLS AND MONITORING
CAPITAL COST

	Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1	**PROJECT PLANNING**											
1.1	Prepare Documents & Plans Including Permits	40	hours			$28.00		$0	$0	$1,120	$0	$1,120
2	**MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT**											
2.1	Construction Survey	0.1	ac	$1,998.00				$200	$0	$0	$0	$200
2.2	Equipment Mobilization/Demobilization	2	ea			$150.00	$350.00	$0	$0	$300	$700	$1,000
3	**DECONTAMINATION**											
3.1	Decontamination Services	0.1	mo		$210.00	$1,800.00	$315.00	$0	$21	$180	$32	$233
3.2	Decon Water	250	gal		$0.20			$0	$50	$0	$0	$50
3.3	Decon Water Storage Tank, 550 gallon	0.1	mo				$300.00	$0	$0	$0	$30	$30
3.4	Disposal of Decon Waste (liquid & solid)	0.1	mo	$900.00				$90	$0	$0	$0	$90
5	**EXCAVATE CONTAMINATED SOIL**											
5.2	Clearing Brush	0.04	ac			$185.00	$150.00	$0	$0	$7	$6	$13
5.3	Sheet Piling	448	sf		$2.04	$1.92	$2.13	$0	$914	$860	$954	$2,728
5.4	Trash Pump With Hose	1	day				$75.00	$0	$0	$0	$75	$75
5.5	Backhoe-Loader, 1-1/4 cy Capacity	2	day			$272.00	$192.99	$0	$0	$544	$386	$930
5.6	Laborer	2	day			$212.00		$0	$0	$424	$0	$424
6	**DISPOSAL**											
6.1	Waste Characterization Testing (PCB, TCLP Metals)	1	ea	$360.00	$5.00	$22.00	$12.00	$360	$5	$22	$12	$399
6.2	Off-Site Transportation & Disposal, Nonhazardous (Soil)	45	cy	$75.00				$3,375	$0	$0	$0	$3,375
6.3	Off-Site Transportation & Disposal, Nonhazardous (Bridge	2	cy	$75.00				$150	$0	$0	$0	$150
7	**SURFACE PROTECTION**											
7.1	Rip Rap	38	cy		$20.00	$9.00	$8.50	$0	$760	$342	$323	$1,425
7.2	Pavement (6" Stone, 2" Binder Course, 1" Surface Course	27	sy	$15.00				$405	$0	$0	$0	$405
8	**SITE RESTORATION**											
8.1	Pedestrian Bridge	125	sf		$40.00	$5.50	$2.12	$0	$5,000	$688	$265	$5,953
8.2	Warning Signs	2	ea		$46.50	$17.27	$9.99	$0	$93	$35	$20	$148
9	**MISCELLANEOUS**											
9.1	Construction Oversight (1p * 3 days)	3	day			$224.00		$0	$0	$672	$0	$672
9.2	Post-Construction Documents	40	hr			$28.00		$0	$0	$1,120	$0	$1,120
	Subtotal							4579.8	$6,843	$6,314	$2,803	$20,539
	Local Area Adjustments							100.0%	105.4%	86.4%	86.4%	
								$4,580	$7,212	$5,455	$2,422	$19,669
	Overhead on Labor Cost @ 30%									$1,636		$1,636
	G & A on Labor Cost @ 10%									$545		$545
	G & A on Material Cost @ 10%								$721			$721
	G & A on Subcontract Cost @ 10%							$458				$458
	G & A on Equipment Cost @ 10%										$242	$242
	Total Direct Cost							$5,038	$7,934	$7,637	$2,664	$23,272
	Indirects on Total Direct Cost @ 35%			(Total Direct Cost Minus Transportation and Disposal Costs)								$6,880
	Profit on Total Direct Cost @ 10%											$2,327
	Subtotal											$32,479

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
FEASIBILITY STUDY
ALTERNATIVE 3: SURFACE WATER CONTROLS, EXCAVATION, SURFACE PROTECTION, INSTITUTIONAL CONTROLS AND MONITORING
CAPITAL COST

Item	Quantity	Unit	Unit Cost				Extended Cost				Subtotal
			Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	
Health & Safety Monitoring @	3%										$974
Total Field Cost											$33,454
Contingency on Total Field Costs @	20%										$6,691
Engineering on Total Field Cost @	5%		(Total Field Cost Minus Transportation and Disposal Costs)								$1,492
TOTAL COST											**$41,636**

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
FEASIBILITY STUDY
ALTERNATIVE 3: SURFACE WATER CONTROLS, EXCAVATION, SURFACE PROTECTION, INSTITUTIONAL CONTROLS AND MONITORING
ANNUAL COST

Item	Item Cost Years 1 - 30	Item Cost Every 5 Years	Notes
Sampling	$200		Collect surface water and sediment samples.
Analysis/Soil	$900		Analyze two surface water, two sediment, and two QA/QC samples for PCBs.
Report	$2,000		Obtain lab, prepare sampling plan, document sampling events and results.
Site Review		$15,000	Review of documents and data evaluation/recommendations.
TOTALS	**$3,100**	**$15,000**	

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
FEASIBILITY STUDY
ALTERNATIVE 3: SURFACE WATER CONTROLS, EXCAVATION, SURFACE PROTECTION, INSTITUTIONAL CONTROLS AND MONITORING
PRESENT WORTH ANALYSIS

Year	Capital Cost	Annual Cost	Annual Discount Rate at 7%	Present Worth
0	$41,636		1.000	$41,636
1		$3,100	0.935	$2,899
2		$3,100	0.873	$2,706
3		$3,100	0.816	$2,530
4		$3,100	0.763	$2,365
5		$18,100	0.713	$12,905
6		$3,100	0.666	$2,065
7		$3,100	0.623	$1,931
8		$3,100	0.582	$1,804
9		$3,100	0.544	$1,686
10		$18,100	0.508	$9,195
11		$3,100	0.475	$1,473
12		$3,100	0.444	$1,376
13		$3,100	0.415	$1,287
14		$3,100	0.388	$1,203
15		$18,100	0.362	$6,552
16		$3,100	0.339	$1,051
17		$3,100	0.317	$983
18		$3,100	0.296	$918
19		$3,100	0.277	$360
20		$18,100	0.258	$4,670
21		$3,100	0.242	$750
22		$3,100	0.226	$701
23		$3,100	0.211	$654
24		$3,100	0.197	$15
25		$18,100	0.184	$3,330
26		$3,100	0.172	$533
27		$3,100	0.161	$499
28		$3,100	0.150	$465
29		$3,100	0.141	$437
30		$18,100	0.131	$2,371
			TOTAL PRESENT WORTH	**$111,350**

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
FEASIBILITY STUDY
ALTERNATIVE 4: SURFACE WATER CONTROLS, EXCAVATION, DEWATERING, OFF-SITE TRANSPORTATION AND DISPOSAL OF EXCAVATED SOIL
CAPITAL COST

	Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1	**PROJECT PLANNING**											
1.1	Prepare Documents & Plans Including Permits	100	hours			$28.00		$0	$0	$2,800	$0	$2,800
2	**MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT**											
2.1	Mobilization Field Support and Equipment, Utilities, Surve	1.0	ls	$2,000.00	$247.50	$300.00	$1,300.00	$2,000	$248	$300	$1,300	$3,848
3	**DECONTAMINATION**											
3.1	Equipment Decon Pad	1	ls		$5,900.00	$6,700.00	$750.00	$0	$5,900	$6,700	$750	$13,350
3.2	Decontamination Services	0.25	mo		$210.00	$1,800.00	$315.00	$0	$53	$450	$79	$581
3.3	Decon Water	250	gal		$0.22			$0	$55	$0	$0	$55
3.4	Decon Water Storage Tank, 6,000 gallon	0.25	mo				$650.00	$0	$0	$0	$163	$163
3.5	Clean Water Storage Tank, 4,000 gallon	0.25	mo				$600.00	$0	$0	$0	$150	$150
3.6	Disposal of Decon Waste (liquid & solid)	0.25	mo	$950.00				$238	$0	$0	$0	$238
4	**DEWATERING SYSTEM**											
4.1	Well Point system with pumps and hoses	4	day	$8,200.00				$32,800	$0	$0	$0	$32,800
4.2	Frac Tank Rental (2 tanks for 1 month)	2	month				$2,800.00	$0	$0	$0	$5,600	$5,600
4.3	Treatment (stripper/GAC drums)	4	day	$4,000.00			$500.00	$16,000	$0	$0	$2,000	$18,000
5	**EXCAVATE CONTAMINATED SOIL**											
5.1	Clearing Brush	0.04	ac			$179.00	$148.00	$0	$0	$7	$6	$13
5.2	Control Ditch	1	day	$500.00			$148.00	$500	$0	$0	$148	$648
5.3	Control Berm	1	day	$500.00			$148.00	$500	$0	$0	$148	$648
5.4	Steel Sheet Piling	2,285	sf	$25.00				$57,125	$0	$0	$0	$57,125
5.5	Trash Pump	5	day				$70.00	$0	$0	$0	$350	$350
5.6	Excavator, Crawler Mounted, 1 1/2 cy	5	day			$275.00	$565.00	$0	$0	$1,375	$2,825	$4,200
5.7	Laborer	5	day			$208.00		$0	$0	$1,040	$0	$1,040
6	**DISPOSAL**											
6.1	Waste Characterization Testing (PCB, TCLP Metals)	2	ea	$325.00	$5.00	$22.00	$12.00	$650	$10	$44	$24	$728
6.2	Verification Sampling (PCB)	8	ea	$175.00	$22.00	$55.00	$22.00	$1,400	$176	$440	$176	$2,192
6.3	Off-Site Transportation, Hazardous	7	hauls	$800.00				$5,600	$0	$0	$0	$5,600
6.4	Off-Site Disposal, Hazardous	100	cy	$225.00				$22,500	$0	$0	$0	$22,500
6.5	Off-Site Transportation & Disposal, Nonhazardous (Soil)	349	cy	$75.00				$26,175	$0	$0	$0	$26,175
6.6	Off-Site Transportation & Disposal, Nonhazardous (Bridge	2	cy	$75.00				$150	$0	$0	$0	$150
7	**SITE RESTORATION**											
7.1	Import Clean Backfill	421	cy		$8.15			$0	$3,431	$0	$0	$3,431
7.2	Excavator, Crawler Mounted, 1 1/2 cy	2	day			$275.00	$565.00	$0	$0	$550	$1,130	$1,680
7.3	Import Topsoil (6" Thick)	28	cy		$19.00			$0	$532	$0	$0	$532
7.4	Place/Grade Topsoil	28	cy			$2.05	$1.30	$0	$0	$57	$36	$94
7.5	Fine Grading & Seeding	202	sy		$0.42	$1.40	$0.25	$0	$85	$283	$51	$418
7.6	Pedestrian Bridge	125	sf		$45.00	$5.50	$2.20	$0	$5,625	$688	$275	$6,588
8	**MISCELLANEOUS**											
8.1	Construction Oversight (1 p * 14 days)	14	day			$224.00		$0	$0	$3,136	$0	$3,136
8.2	Post-Construction Documents	100	hr			$28.00		$0	$0	$2,800	$0	$2,800
	Subtotal							$165,638	$16,114	$20,670	$15,210	$217,631
	Local Area Adjustments							100.0%	105.4%	86.4%	86.4%	
								$165,638	$16,984	$17,859	$13,142	$213,622
	Overhead on Labor Cost @ 30%									$5,358		$5,358
	G & A on Labor Cost @ 10%									$1,786		$1,786
	G & A on Material Cost @ 10%								$1,698			$1,698
	G & A on Subcontract Cost @ 10%							$16,564				$16,564
	G & A on Equipment Cost @ 10%										$1,314	$1,314
	Total Direct Cost							$182,201	$18,683	$25,002	$14,456	$240,342
	Indirects on Total Direct Cost @ 35%			(Total Direct Cost Minus Transportation and Disposal Costs)								$65,040

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
FEASIBILITY STUDY
ALTERNATIVE 4: SURFACE WATER CONTROLS, EXCAVATION, DEWATERING, OFF-SITE TRANSPORTATION AND DISPOSAL OF EXCAVATED SOIL
CAPITAL COST

Item	Quantity	Unit	Unit Cost				Extended Cost				Subtotal
			Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	
Profit on Total Direct Cost @	10%										$24,034
Subtotal											$329,416
Health & Safety Monitoring @	3%										$9,882
Total Field Cost											$339,299
Contingency on Total Field Costs @	20%										$67,860
Engineering on Total Field Cost @	5%		(Total Field Cost Minus Transportation and Disposal Costs)								$14,239
TOTAL COST											**$421,398**

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI
FEASIBILITY STUDY
ALTERNATIVE 4: SURFACE WATER CONTROLS, EXCAVATION, DEWATERING, OFF-SITE TRANSPORTATION AND DISPOSAL OF EXCAVATED SOIL
MOBILIZATION COSTS

Item	Quantity	Unit	Unit Cost				Extended Cost				Subtotal
			Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer	0.8	mo				$400.00	$0	$0	$0	$300	$300
2.2 Field Office Support	0.8	mo				$250.00	$0	$0	$0	$188	$188
2.3 Storage Trailer	0.8	mo				$150.00	$0	$0	$0	$113	$113
2.4 Utility Connection/Disconnection (Phone/Electric)	1	ls	$1,600.00				$1,600	$0	$0	$0	$1,600
2.5 Construction Survey	0.1	ac	$2,100.00				$210	$0	$0	$0	$210
2.6 Equipment Mobilization/Demobilization	2	ea			$150.00	$350.00	$0	$0	$300	$700	$1,000
2.7 Site Utilities	0.8	mo		$330.00			$0	$248	$0	$0	$248

CLIENT: NCBC GULFPORT		JOB NUMBER: 112GN1831 0000.PP0110100	
SUBJECT: SITE 10 - PARADE FIELD DITCH ALTERNATIVE 2			
BASED ON:		DRAWING NUMBER:	
BY: MOJ Date: 1-17-07	CHECKED BY: Date:	APPROVED BY:	DATE:

OBJECTIVE:

To provide support for the quantities used in the Naval Construction Battalion Center Gulfport Site 10 – Parade Field Ditch Cost Estimate for Alternative 2 of the Feasibility Study Report.

CALCULATIONS:

This alternative consists of restricting access to soil with concentrations of Aroclor 1260 greater than 1,000 mg/kg by installing fencing around the site. The area of fence installation can be found in Figure 10-1. The total length of fence required is as follows:

Length of Fence = 224 ft

Signs would be posted every 100 ft to warn against unauthorized digging activities.

Number of Signs = 2 ft

A total of four surface water and four sediment samples will be collected annually for a period of 30 years.

CLIENT:	NCBC GULFPORT	JOB NUMBER:	112GN1831 0000.PP0110100
SUBJECT:	SITE 10 - PARADE FIELD DITCH ALTERNATIVE 3		
BASED ON:		DRAWING NUMBER:	
BY: MOJ Date: 1-17-07	CHECKED BY: Date:	APPROVED BY:	DATE:

OBJECTIVE:
To provide support for the quantities used in the Naval Construction Battalion Center Gulfport Site 10 – Parade Field Ditch Cost Estimate for Alternative 3 of the Feasibility Study Report.

CALCULATIONS:
This alternative consists of surface water controls, excavation of soil to a depth of 9 inches, off-site non-hazardous waste disposal, surface protection, and institutional controls and monitoring. A portion of the excavated area would be lined with 9 inches of concrete and/or rip rap while another portion of the excavated area would be paved.

A survey will be performed before construction begins and after construction is finished to record the site characteristics. The final area on the cost estimate page is twice the original area since two surveys will be performed.

Construction Survey = Area of Excavation + 20%

Areas of Excavation =	1,602	sf
=	1,922.4	sf
=	0.05	acres

Marine-grade PVC sheet piling will be placed around the excavation area. This will allow for dewatering of the excavation area.

Perimeter of Sheet Piling =	224	ft
Depth of Sheet Piling =	2	ft
Area of Sheet Piling =	448	sf

A backhoe-loader will be rented to excavate the soil. The volume of soil to excavate and dispose off-site was calculated in the Volume Calculation. It is assumed that excavation will take place in 1 day. An additional day of the backhoe was added to account for the demolition of the pedestrian bridge.

Volume of Soil to Excavate =	45	cy
Days to Excavate =	1	day
Additional Days for Demolition =	1	day

Waste Characterization Testing (1 per 1,000 cy) = 1 sample

The demolition of the pedestrian bridge will result in the following volume for transportation and disposal of nonhazardous waste:

Length of Bridge =	25	ft
Width of Bridge =	5	ft
Thickness of Wood =	0.25	ft
Volume of Bridge =	31	cf
=	2	cy

CLIENT: NCBC GULFPORT		JOB NUMBER: 112GN1831 0000.PP0110100	
SUBJECT: SITE 10 - PARADE FIELD DITCH ALTERNATIVE 3			
BASED ON:		DRAWING NUMBER:	
BY: MOJ Date: 1-17-07	CHECKED BY: Date:	APPROVED BY:	DATE:

Riprap will be placed within the drainage channel to a depth of 9 inches. The area of riprap placement can be found on Figure 10-2.

Area of Riprap Placement =	1,360	sf
Volume of Riprap =	38	cy

Pavement will be placed as shown on Figure 10-2.

Area of Pavement =	242	sf
=	27	sy

The pedestrian bridge spanning the ditch will be replaced.

Length of Bridge =	25	ft
Width of Bridge =	5	ft
Area of Bridge =	125	sf

Signs would be posted every 100 ft to warn against unauthorized digging activities.

Number of Signs =	2	ft

A total of two surface water and two sediment samples will be collected annually for a period of 30 years.

CLIENT:	NCBC GULFPORT	JOB NUMBER:	112GN1831 0000.PP0110100
SUBJECT:	SITE 10 - PARADE FIELD DITCH ALTERNATIVE 4		
BASED ON:		DRAWING NUMBER:	
BY: MOJ Date: 1-17-07	CHECKED BY: Date:	APPROVED BY:	DATE:

OBJECTIVE:

To provide support for the quantities used in the Naval Construction Battalion Center Gulfport Site 10 – Parade Field Ditch Cost Estimate for Alternative 4 of the Feasibility Study Report.

CALCULATIONS:

This alternative consists of surface water controls, dewatering, excavation of soil/sediment, and off-site treatment and disposal of excavated soil/sediment. Excavated areas will be backfilled with common fill, covered with topsoil, and revegetated.

A survey will be performed before construction begins and after construction is finished to record the site characteristics. The final area on the cost estimate page is twice the original area since two surveys will be performed.

Construction Survey = Area of Excavation + 20%

Areas of Excavation =	1,514	sf
=	1,816.8	sf
=	0.05	acres

Steel sheet piling will be placed around the perimeter of the excavation area. This will allow for dewatering of the excavation area.

Perimeter of Sheet Piling =	158	ft
Depth of Sheet Piling =	8.5	ft
Area of Sheet Piling =	1,343	sf
Perimeter of Sheet Piling =	30	ft
Depth of Sheet Piling =	20	ft
Area of Sheet Piling =	600	sf
Perimeter of Sheet Piling =	36	ft
Depth of Sheet Piling =	9.5	ft
Area of Sheet Piling =	342	sf

CLIENT: NCBC GULFPORT		JOB NUMBER: 112GN1831 0000.PP0110100	
SUBJECT: SITE 10 - PARADE FIELD DITCH ALTERNATIVE 4			
BASED ON:		DRAWING NUMBER:	
BY: MOJ Date: 1-17-07	CHECKED BY: Date:	APPROVED BY:	DATE:

Total Area of Sheet Piling = 2,285 sf

A hydraulic excavator will be rented to excavate the soil. The volume of soil to excavate and dispose off-site was calculated in the Volume Calculation.

Volume of Soil to Excavate = 449 cy

Assumed Volume of Hazardous Waste = 100 cy
Volume of Nonhazardous Waste = 349 cy

Collect waste characterization samples to determine the type of disposal (hazardous or nonhazardous). Collect verification samples from the sidewalls and floor of excavation. Assume five samples plus three quality control samples.

Waste Characterization Testing (1 per type of waste) = 2 samples
Verification Samples = 8 samples

The number of hauls needed to transport the hazardous waste to dipsoal was calculated by assuming a conversion of 1.5 ton/cy and that approximately 22 tons will consist of one haul.

Volume of Hazardous Waste = 100 cy
= 150 ton
Volume Per Haul = 22 ton
Number of Hauls = 7 haul

The demolition of the pedestrian bridge will result in the following volume for transportation and disposal of nonhazardous waste:

Length of Bridge = 25 ft
Width of Bridge = 5 ft
Thickness of Wood = 0.25 ft
Volume of Bridge = 31 cf
= 2 cy

Topsoil will be placed along the top 6 inches of the drainage channel.

Area of Excavation = 1,514 sf
Volume of Topsoil = Area of Excavation x 6 inches
= 757 cf
= 28 cy

CLIENT: NCBC GULFPORT		JOB NUMBER: 112GN1831 0000.PP0110100	
SUBJECT: SITE 10 - PARADE FIELD DITCH ALTERNATIVE 4			
BASED ON:		DRAWING NUMBER:	
BY: MOJ Date: 1-17-07	CHECKED BY: Date:	APPROVED BY:	DATE:

Clean fill will be placed within the excavated drainage channel to a depth of 6 inches below pre-excavation

Volume of Excavation =	449	cy
Volume of Topsoil =	28	cy
Volume of Clean Fill =	421	cy

The area to fine grade and seed is equal to the excavation area plus 20% to account for staging areas.

Seed Area =	Excavation Area + 20%	
Areas of Excavation =	1,514	sf
Seed Area =	1,817	sf
=	202	sy

Time of Excavation

Total Excavation Volume =	449	cy

Assume 16 cy per truck.

Number of Truck Loads =	28	truckloads
Number of Truck Loads/Day =	16	truckloads/day
Number of Days =	2	days
Additional Days for Weather =	1	day
Additional Days for Demolition =	1	day
Total Nubmer of Days =	4	days

An additional day of the excavator was added to account for the demolition of the pedestrian bridge.

Time of Backfill

Volume of Clean Fill =	421	cy
Volume of Topsoil =	28	cy
Total Backfill Volume =	449	cy

CLIENT: NCBC GULFPORT		JOB NUMBER: 112GN1831 0000.PP0110100	
SUBJECT: SITE 10 - PARADE FIELD DITCH ALTERNATIVE 4			
BASED ON:		DRAWING NUMBER:	
BY: MOJ Date: 1-17-07	CHECKED BY: Date:	APPROVED BY:	DATE:

Assume 16 cy per truck.

Number of Truck Loads =	28	truckloads
Number of Truck Loads/Day =	40	truckloads/day
Number of Days =	1	days
Additional Days for Weather =	1	days
Total Number of Days =	2	days

Approximate Construction Schedule

Activity	Days	
Mobilization	2	
Site Setup	3	
Excavate & Dispose	4	
Backfill and Seed	2	
Demobilization	2	
	13	Days or
	0.6	Months

Institutional controls and 5-year reviews will not be required.

APPENDIX B

EXCAVATION VOLUME CALCULATIONS

CLIENT: NCBC GULFPORT			JOB NUMBER: 112GN1831 0000.PP0140130	
SUBJECT: SITE 10 - PARADE FIELD DITCH EXCAVATION VOLUME CALCULATION				
BASED ON:			DRAWING NUMBER:	
BY: MOJ Date: 4-12-07		CHECKED BY: Date:	APPROVED BY:	DATE:

OBJECTIVE:

To calculate the volume of soil to be excavated under the selected alternative, Alternative 4 (Surface Water Controls, Dewatering, Excavation, Off-Site Treatment and Disposal of Excavated Soil), for the Remedial Design for Site 10 - Parade Field Ditch at the Naval Construction Battalion Center in Gulfport, Mississippi.

APPROACH:

1. Evaluate the analytical data to determine the sample locations that exceed the Aroclor-1260 PRG of 1,000 µg/kg. The area of investigation will be the area around the samples that exceed the PRG.

2. For Alternative 4, determine the excavation depth at each location. The excavation depth will extend to one half the distance between the sample that exceeds the Aroclor-1260 PRG and the sample that does not exceed the Aroclor-1260 PRG. Use Terramodel Computer Software to calculate the excavation volume.

CALCULATIONS:

1. Determine the Area in Exceedence of PRG.

From the analytical data presented in Attachment 1, it was determined that the following locations exceed the Aroclor-1260 PRG of 1,000 µg/kg:

Location	Depth (ft bgs)	Concentration (µg/kg)
NCBC10S04	1	6,000
NCBC10S05	2	5,200
NCBC10S06	2	83,000
NCBC10S06	8	19,000
NCBC10S16	5	1,800

Figure 1 (Page 3 of 6) shows the area around the samples listed above. The total area of investigation is as follows:

Perimeter Around Samples =	224	ft
Area Around Samples =	1,514	sf
=	168	sy

2. Alternative 4 - Excavation Volume

The depth of excavation under Alternative 4 will extend to one half the distance between the sample that exceeds the Aroclor-1260 PRG and the sample that does not exceed the Aroclor-1260 PRG.

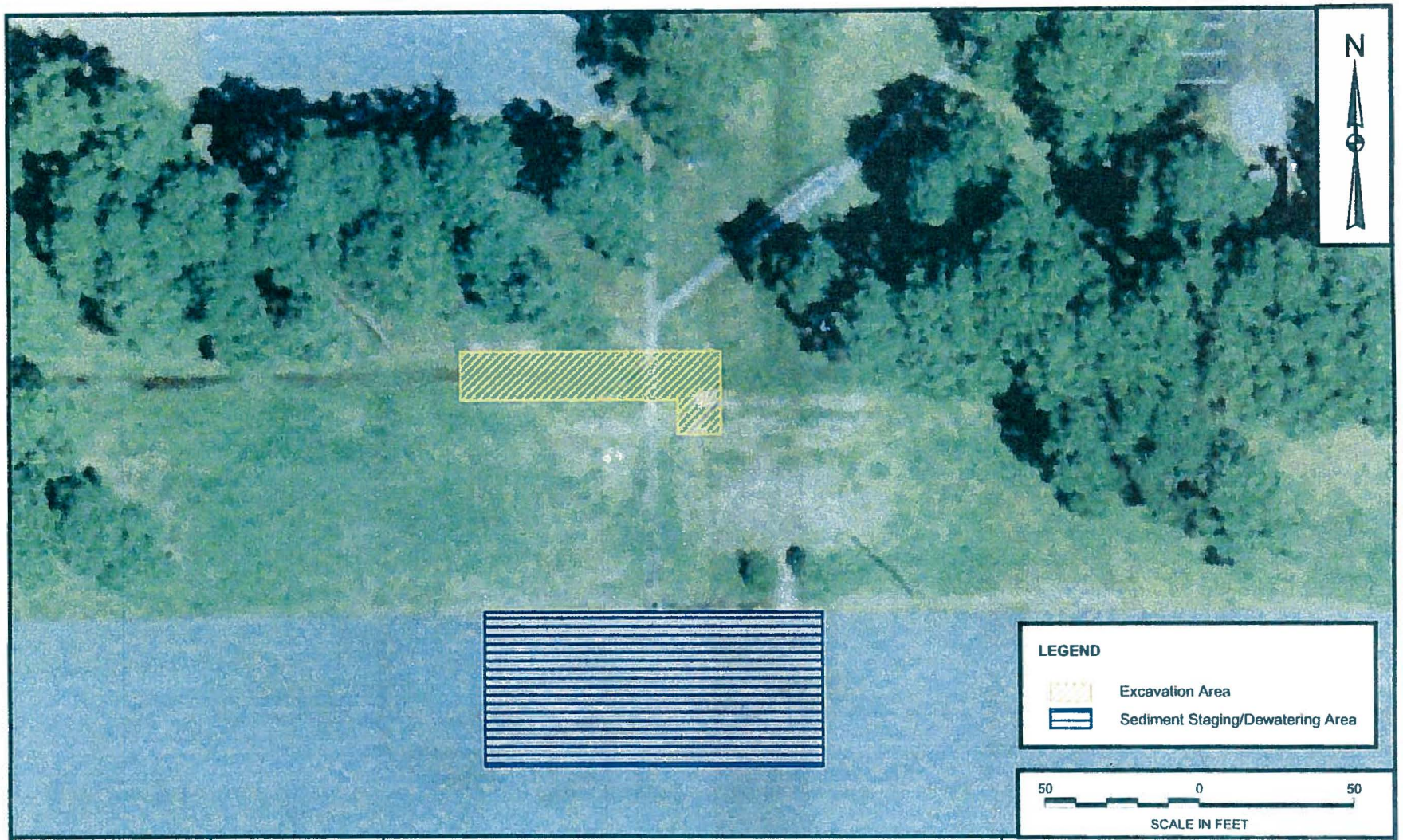
CLIENT:	NCBC GULFPORT	JOB NUMBER:	112GN1831 0000.PP0140130
SUBJECT:	SITE 10 - PARADE FIELD DITCH EXCAVATION VOLUME CALCULATION		
BASED ON:		DRAWING NUMBER:	
BY: MOJ Date: 4-12-07	CHECKED BY: Date:	APPROVED BY:	DATE:

Location	Depth (ft bgs)	Concentration (µg/kg)	Distance Between Results (ft)	Excavation Depth (ft bgs)
NCBC10S04	1	6,000	10	6
NCBC10S04	11	39 U		
NCBC10S05	2	5,200	9	6.5
NCBC10S05	11	40 U		
NCBC10S06	2	83,000	12	14
NCBC10S06	8	19,000		
NCBC10S06	20	38 J		
NCBC10S16	5	1,800	5	7.5
NCBC10S16	10	38 U		

The profile of the ditch at Site 10 as measured in the field is presented in Figure 2A (Page 4 of 6). This profile was entered into Terramodel as shown on Figure 2B (Page 4 of 6). The excavation depths at each sample location were then entered into Terramodel to compute the excavation volume as follows:

Volume of Excavation = **449** **cy**

Terramodel output is presented on Page 5 of 6. The excavation profile from Terramodel is presented on Figure 3 (Page 6 of 6).



DRAWN BY	DATE
C. FOSTER	12/08/04
CHECKED BY	DATE
J. BROWN	12/10/04
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

ALTERNATIVE 4 - SURFACE WATER CONTROLS, EXCAVATION, DEWATERING, OFF-SITE TREATMENT AND DISPOSAL OF EXCAVATED SOIL
SITE 10 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT
NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

CONTRACT NUMBER	
1831	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO	REV
FIGURE 1	0

P:\GIS\GULFPORT_CBC\MAPDOCS\APR\SITE10 APR ALTERNATIVE 4 LAYOUT 12/10/04 CF

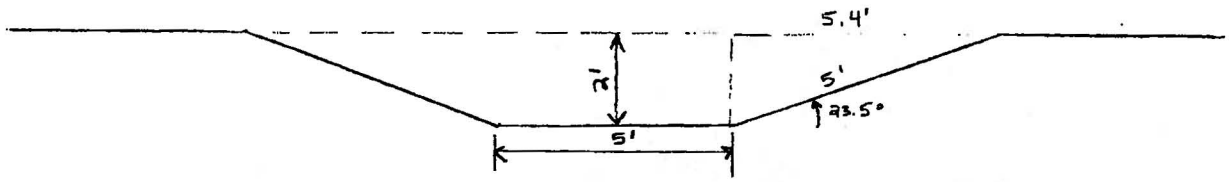


FIGURE 2A
DRAINAGE DITCH CROSS-SECTION
CHANNEL WIDTH = 5' + 2 (5.4') = 15.8' (ASSUME 16')

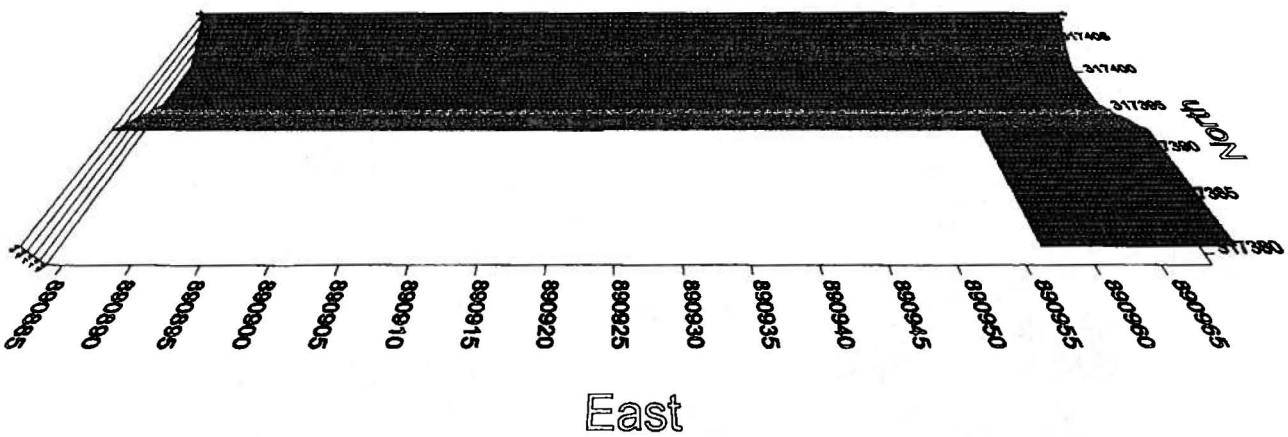


FIGURE 2B
DRAINAGE DITCH TERRAMODEL PROFILE

Spectra Precision Software, Inc.
5901 Peachtree-Dunwoody Rd., Suite A-300
Atlanta, GA 30328-5548
800-235-4972
Wed Dec 08 13:34:20 2004

PROJECT: ra\Terramodel Files\Gulfport\Site 10\Feasibility Study Alt 3-Alt 4.pro

DTM TO DTM VOLUME

Cut and Fill Volumes

Shrinkage/swell factors: Cut 1.0000 Fill 1.0000

Original DTM Layer Name	# of Points	Final DTM Layer Name	# of Points
EXISTING	11	ALTERNATIVE 4	27

Cut Volume (Cu. Yd.)	Cumulative Cut Volume	Fill Volume (Cu. Yd.)	Cumulative Fill Volume
449.0	449.0	0.0	0.0

Net Difference: 449.0 Cu. Yd. WASTE

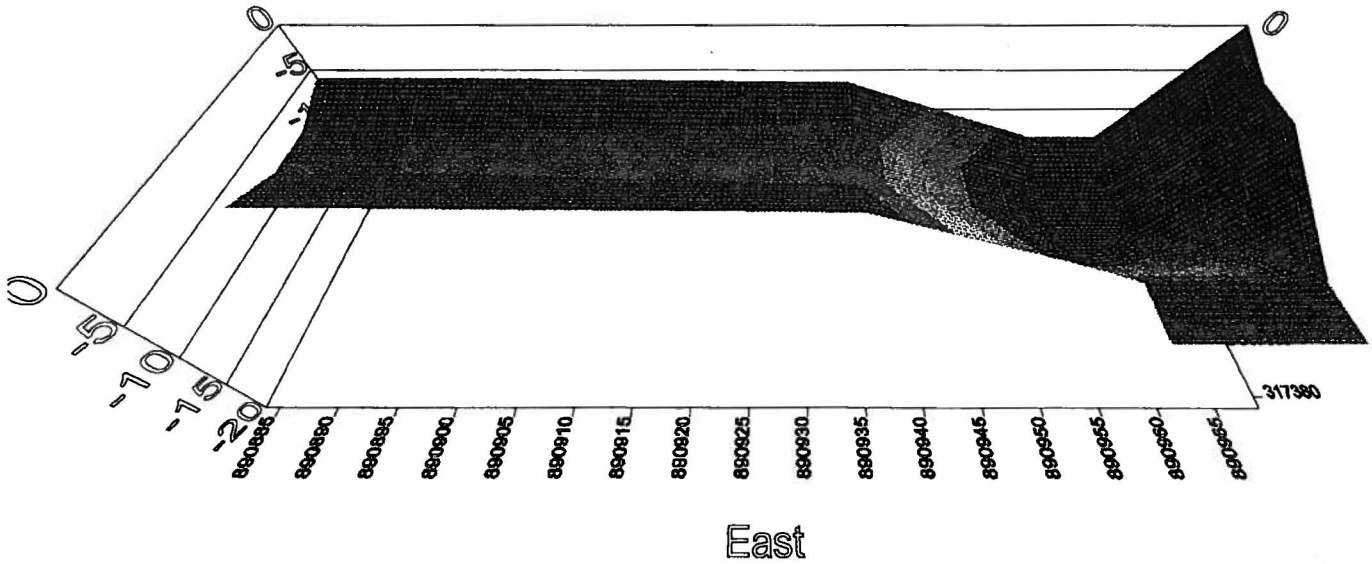


FIGURE 3
TERRAMODEL EXCAVATION PROFILE
ALTERNATIVE 4

ATTACHMENT 1

SOIL DATA
SITE 10 - PARADE FIELD DITCH
NCBC GULFPORT, MISSISSIPPI

site	matrix	location	nsample	sample_date	depth_ range	parameter	val_res	val_ qual	units	northing	easting
00010	SO	NCBC10S01	NCBC10S0105	1/12/2002 0:00	5 - 5	AROCLOR-1260	38	U	UG/KG	317432.77	890818.54
00010	SO	NCBC10S01	NCBC10S0110	1/12/2002 0:00	10 - 10	AROCLOR-1260	41	U	UG/KG	317432.77	890818.54
00010	SO	NCBC10S01	NCBC10S0123	1/12/2002 0:00	23 - 23	AROCLOR-1260	42	U	UG/KG	317432.77	890818.54
00010	SO	NCBC10S02	NCBC10S0205	1/12/2002 0:00	5 - 5	AROCLOR-1260	39	U	UG/KG	317434.09	890867.68
00010	SO	NCBC10S02	NCBC10S0210	1/12/2002 0:00	10 - 10	AROCLOR-1260	40	U	UG/KG	317434.09	890867.68
00010	SO	NCBC10S02	NCBC10S0223	1/12/2002 0:00	23 - 23	AROCLOR-1260	41	U	UG/KG	317434.09	890867.68
00010	SO	NCBC10S03	NCBC10S0301	1/11/2002 0:00	1 - 1	AROCLOR-1260	740		UG/KG	317400.79	890872.95
00010	SO	NCBC10S03	NCBC10S0313	1/11/2002 0:00	13 - 13	AROCLOR-1260	39	U	UG/KG	317400.79	890872.95
00010	SO	NCBC10S03	NCBC10S0313-AV(	1/11/2002 0:00	13 - 13	AROCLOR-1260	39	U	UG/KG	317400.79	890872.95
00010	SO	NCBC10S03	NCBC10S0313-D	1/11/2002 0:00	13 - 13	AROCLOR-1260	39	U	UG/KG	317400.79	890872.95
00010	SO	NCBC10S03	NCBC10S0318	1/11/2002 0:00	18 - 18	AROCLOR-1260	39	U	UG/KG	317400.79	890872.95
00010	SO	NCBC10S04	NCBC10S0401	1/11/2002 0:00	1 - 1	AROCLOR-1260	6000		UG/KG	317400.5	890893.93
00010	SO	NCBC10S04	NCBC10S0411	1/11/2002 0:00	11 - 11	AROCLOR-1260	39	U	UG/KG	317400.5	890893.93
00010	SO	NCBC10S04	NCBC10S0420	1/11/2002 0:00	20 - 20	AROCLOR-1260	43	U	UG/KG	317400.5	890893.93
00010	SO	NCBC10S05	NCBC10S0502	1/11/2002 0:00	2 - 2	AROCLOR-1260	5200		UG/KG	317398.43	890934.31
00010	SO	NCBC10S05	NCBC10S0511	1/11/2002 0:00	11 - 11	AROCLOR-1260	40	U	UG/KG	317398.43	890934.31
00010	SO	NCBC10S05	NCBC10S0520	1/11/2002 0:00	20 - 20	AROCLOR-1260	41	U	UG/KG	317398.43	890934.31
00010	SO	NCBC10S06	NCBC10S0602	1/11/2002 0:00	2 - 2	AROCLOR-1260	83000		UG/KG	317398.64	890954.15
00010	SO	NCBC10S06	NCBC10S0608	1/11/2002 0:00	8 - 8	AROCLOR-1260	19000		UG/KG	317398.64	890954.15
00010	SO	NCBC10S06	NCBC10S0620-AV(	1/11/2002 0:00	20 - 20	AROCLOR-1260	38	J	UG/KG	317398.64	890954.15
00010	SO	NCBC10S06	NCBC10S0620-D	1/11/2002 0:00	20 - 20	AROCLOR-1260	38	J	UG/KG	317398.64	890954.15
00010	SO	NCBC10S06	NCBC10S0620	1/11/2002 0:00	20 - 20	AROCLOR-1260	42	U	UG/KG	317398.64	890954.15
00010	SO	NCBC10S07	NCBC10S0705	1/10/2002 0:00	5 - 5	AROCLOR-1260	39	U	UG/KG	317406.02	890804.59
00010	SO	NCBC10S07	NCBC10S0710	1/10/2002 0:00	10 - 10	AROCLOR-1260	42	U	UG/KG	317406.02	890804.59
00010	SO	NCBC10S07	NCBC10S0723	1/10/2002 0:00	23 - 23	AROCLOR-1260	42	U	UG/KG	317406.02	890804.59
00010	SO	NCBC10S08	NCBC10S0805	1/10/2002 0:00	5 - 5	AROCLOR-1260	39	U	UG/KG	317408.34	890827.07
00010	SO	NCBC10S08	NCBC10S0810	1/10/2002 0:00	10 - 10	AROCLOR-1260	39	U	UG/KG	317408.34	890827.07
00010	SO	NCBC10S08	NCBC10S0823	1/10/2002 0:00	23 - 23	AROCLOR-1260	42	U	UG/KG	317408.34	890827.07
00010	SO	NCBC10S09	NCBC10S0905	1/10/2002 0:00	5 - 5	AROCLOR-1260	37	U	UG/KG	317406.39	890845.18
00010	SO	NCBC10S09	NCBC10S0910	1/10/2002 0:00	10 - 10	AROCLOR-1260	39	U	UG/KG	317406.39	890845.18
00010	SO	NCBC10S09	NCBC10S0910-AV(	1/10/2002 0:00	10 - 10	AROCLOR-1260	39.5	U	UG/KG	317406.39	890845.18
00010	SO	NCBC10S09	NCBC10S0910-D	1/10/2002 0:00	10 - 10	AROCLOR-1260	40	U	UG/KG	317406.39	890845.18
00010	SO	NCBC10S09	NCBC10S0923	1/10/2002 0:00	23 - 23	AROCLOR-1260	42	U	UG/KG	317406.39	890845.18
00010	SO	NCBC10S10	NCBC10S1005	1/9/2002 0:00	5 - 5	AROCLOR-1260	39	U	UG/KG	317409.06	890892.2
00010	SO	NCBC10S10	NCBC10S1010	1/9/2002 0:00	10 - 10	AROCLOR-1260	41	U	UG/KG	317409.06	890892.2
00010	SO	NCBC10S10	NCBC10S1023	1/9/2002 0:00	23 - 23	AROCLOR-1260	42	U	UG/KG	317409.06	890892.2
00010	SO	NCBC10S10	NCBC10S1023-AV(	1/9/2002 0:00	23 - 23	AROCLOR-1260	41.5	U	UG/KG	317409.06	890892.2
00010	SO	NCBC10S10	NCBC10S1023-D	1/9/2002 0:00	23 - 23	AROCLOR-1260	41	U	UG/KG	317409.06	890892.2
00010	SO	NCBC10S11	NCBC10S1105 .	1/9/2002 0:00	5 - 5	AROCLOR-1260	38	U	UG/KG	317408.17	890936.79
00010	SO	NCBC10S11	NCBC10S1110	1/9/2002 0:00	10 - 10	AROCLOR-1260	40	U	UG/KG	317408.17	890936.79
00010	SO	NCBC10S11	NCBC10S1123	1/9/2002 0:00	23 - 23	AROCLOR-1260	41	U	UG/KG	317408.17	890936.79
00010	SO	NCBC10S12	NCBC10S1205	1/9/2002 0:00	5 - 5	AROCLOR-1260	36	U	UG/KG	317382.47	890804.59
00010	SO	NCBC10S12	NCBC10S1210	1/9/2002 0:00	10 - 10	AROCLOR-1260	40	U	UG/KG	317382.47	890804.59
00010	SO	NCBC10S12	NCBC10S1223	1/9/2002 0:00	23 - 23	AROCLOR-1260	43	U	UG/KG	317382.47	890804.59
00010	SO	NCBC10S13	NCBC10S1305	1/9/2002 0:00	5 - 5	AROCLOR-1260	39	U	UG/KG	317382.5	890841.67
00010	SO	NCBC10S13	NCBC10S1310	1/9/2002 0:00	10 - 10	AROCLOR-1260	39	U	UG/KG	317382.5	890841.67
00010	SO	NCBC10S13	NCBC10S1323	1/9/2002 0:00	23 - 23	AROCLOR-1260	42	U	UG/KG	317382.5	890841.67

SOIL DATA
SITE 10 - PARADE FIELD DITCH
NCBC GULFPORT, MISSISSIPPI

site	matrix	location	nsample	sample_date	depth_ range	parameter	val_res	val_ qual	units	northing	easting
00010	SO	NCBC10S14	NCBC10S1405	1/9/2002 0:00	5 - 5	AROCLOR-1260	38	U	UG/KG	317383.63	890897.34
00010	SO	NCBC10S14	NCBC10S1405-AV(	1/9/2002 0:00	5 - 5	AROCLOR-1260	38	U	UG/KG	317383.63	890897.34
00010	SO	NCBC10S14	NCBC10S1405-D	1/9/2002 0:00	5 - 5	AROCLOR-1260	38	U	UG/KG	317383.63	890897.34
00010	SO	NCBC10S14	NCBC10S1410	1/9/2002 0:00	10 - 10	AROCLOR-1260	40	U	UG/KG	317383.63	890897.34
00010	SO	NCBC10S14	NCBC10S1420	1/9/2002 0:00	20 - 20	AROCLOR-1260	50	U	UG/KG	317383.63	890897.34
00010	SO	NCBC10S15	NCBC10S1510	1/8/2002 0:00	10 - 10	AROCLOR-1260	40	U	UG/KG	317385.05	890931.42
00010	SO	NCBC10S15	NCBC10S1519	1/8/2002 0:00	19 - 19	AROCLOR-1260	40	U	UG/KG	317385.05	890931.42
00010	SO	NCBC10S15	NCBC10S1505	1/8/2002 0:00	5 - 5	AROCLOR-1260	11	J	UG/KG	317385.05	890931.42
00010	SO	NCBC10S16	NCBC10S1610	1/8/2002 0:00	10 - 10	AROCLOR-1260	38	U	UG/KG	317384.05	890962.83
00010	SO	NCBC10S16	NCBC10S1605	1/8/2002 0:00	5 - 5	AROCLOR-1260	1800		UG/KG	317384.05	890962.83
00010	SO	NCBC10S16	NCBC10S1620	1/8/2002 0:00	20 - 20	AROCLOR-1260	41	U	UG/KG	317384.05	890962.83
00010	SO	NCBC10S17	NCBC10S1711	1/12/2002 0:00	11 - 11	AROCLOR-1260	40	U	UG/KG	317398.89	890976.88
00010	SO	NCBC10S17	NCBC10S1702	1/12/2002 0:00	2 - 2	AROCLOR-1260	13	J	UG/KG	317398.89	890976.88
00010	SO	NCBC10S17	NCBC10S1720	1/12/2002 0:00	20 - 20	AROCLOR-1260	46	U	UG/KG	317398.89	890976.88
00010	SO	NCBC10S18	NCBC10S1805	1/12/2002 0:00	5 - 5	AROCLOR-1260	38	U	UG/KG	317367.99	890874.43
00010	SO	NCBC10S18	NCBC10S1810	1/12/2002 0:00	10 - 10	AROCLOR-1260	41	U	UG/KG	317367.99	890874.43
00010	SO	NCBC10S18	NCBC10S1810-AV(	1/12/2002 0:00	10 - 10	AROCLOR-1260	41.5	U	UG/KG	317367.99	890874.43
00010	SO	NCBC10S18	NCBC10S1810-D	1/12/2002 0:00	10 - 10	AROCLOR-1260	42	U	UG/KG	317367.99	890874.43
00010	SO	NCBC10S18	NCBC10S1823	1/12/2002 0:00	23 - 23	AROCLOR-1260	42	U	UG/KG	317367.99	890874.43
00010	SO	NCBC10S19	NCBC10S1905	2/12/2002 0:00	5 - 5	AROCLOR-1260	39	U	UG/KG	317372.2684	890940.1134
00010	SO	NCBC10S20	NCBC10S2005	2/12/2002 0:00	5 - 5	AROCLOR-1260	15	J	UG/KG	317374.0928	890965.2287
00010	SO	NCBC10S21	NCBC10S2105	2/12/2002 0:00	5 - 5	AROCLOR-1260	37	U	UG/KG	317384.1104	890977.7104
00010	SO	NCBC10S24	DP1024S01	12/16/2003 0:00	6 - 7	AROCLOR-1260	20	U	UG/KG	317388.1809	890923.601
00010	SO	NCBC10S25	DP1025S01	12/16/2003 0:00	7 - 8	AROCLOR-1260	21	U	UG/KG	317413.1809	890934.601
00010	SO	NCBC10S26	DP1026S01	12/16/2003 0:00	18 - 19	AROCLOR-1260	14	J	UG/KG	317388.1809	890941.601
00010	SO	NCBC10S27	DP1027S01	12/16/2003 0:00	6 - 7	AROCLOR-1260	20	UJ	UG/KG	317388.1809	890950.601
00010	SO	NCBC10S28	DP1028S01	12/16/2003 0:00	6 - 7	AROCLOR-1260	21	U	UG/KG	317409.1809	890956.601
00010	SO	NCBC10S29	DP1029S01	12/16/2003 0:00	6 - 7	AROCLOR-1260	20	U	UG/KG	317424.1809	890932.601
00010	SO	NCBC10S29	DP1029S01-AVG	12/16/2003 0:00	6 - 7	AROCLOR-1260	20	U	UG/KG	317424.1809	890932.601
00010	SO	NCBC10S29	DP1029S01-D	12/16/2003 0:00	6 - 7	AROCLOR-1260	20	U	UG/KG	317424.1809	890932.601

APPENDIX C

VERIFICATION SAMPLING INFORMATION (CD)

Sampling Strategies and Statistics Training Materials

for

Part 201 Cleanup Criteria

Michigan Department of Environmental Quality
Remediation and Redevelopment Division
www.michigan.gov/deq
John Engler, Governor
Russell J. Harding, Director

2002

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TABLE OF CONTENTS

Table of Contents i

Introduction 1.0

Applicability of Statistics to Each Condition to Evaluate 2.0

Statistical Analysis Worksheets 3.0

Sampling Strategies 4.0
- Table of Contents 4.1
- Introduction 4.4
- Chapter 1: Biased Sampling Strategies 4.7
- Chapter 2: Statistical Sampling Strategies 4.24
- Summary 4.53

Part 201 Statistical Evaluation Guidesheets 5.0

Use of Statistics in Assessing "Due Care" Compliance 6.0

Statistical Methods for Comparing Facility Data to Part 201 Criteria 7.0
- Table of Contents 7.1
- Introduction 7.6
- Chapter 1: Statistical Distributions 7.9
- Chapter 2: Identification and Treatment of Outliers 7.42
- Chapter 3: Calculation of a 95% Upper Confidence Limit (UCL) For the Mean Concentration 7.62
- Chapter 4: Comparison of Facility Data to Background 7.80
- Chapter 5: Censored Data 7.90

Solid and Hazardous Waste Characterization 8.0

Acronyms / Glossary 9.0
- Acronyms 9.1
- Glossary 9.3
- Glossary of Common Statistical Terms 9.6

References 10.0

Appendices – Reference Materials A.0
- Appendix A: Excerpts from EPA Guidance for Data Quality Assessment A.1
- Appendix B: MERA Operational Memorandum #15 ..... B.1

Tab 1.0

Introduction

INTRODUCTION

INTRODUCTION

Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria (S^3TM) was developed to help staff of the Michigan Department of Environmental Quality (MDEQ) by providing recommendations on:

1. sampling of environmental media for various sampling objectives under Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), and

2. determining when it is appropriate to use statistics and which statistical methods to use for comparing data to Part 201 cleanup criteria.

Appropriate sampling strategies differ based on the sampling objectives (e.g, *FACILITY* characterization, verification of remediation, comparison to criteria, or waste characterization), the variability of hazardous substances in the media to be sampled, knowledge about the distribution of hazardous substances on a property, and costs. The S^3TM provides recommendations on sampling strategies based on these considerations. Biased and statistical sampling strategies are presented and discussed.

After sampling has been completed, the degree to which statistics can be used and the selection of statistical method(s) will vary depending on the exposure pathway, land-use category, and type of determination being made (i.e., *FACILITY* determination, remedial action, and verification of remediation and closure). These training materials do not reflect an increased expectation by the department for the use of statistics, but rather are provided to guide decision-making when statistics are used or *PROPOSED* to help assure it is done properly (terms in capitalized italicized font are defined in the tabbed section titled, "Acronyms / Glossary").

Specifically, the S^3TM will help staff answer three basic questions for making cleanup determinations or know when to seek assistance if statistics are being used to assess compliance with applicable criteria:

1. Is a statistical analysis appropriate?
2. What is the appropriate data set to statistically derive a *REPRESENTATIVE CONCENTRATION* for comparison to cleanup criteria?
3. What is the appropriate statistical method to use for comparison to the cleanup criteria?

1. <u>Is a statistical analysis appropriate?</u>

Statistical Guidesheets have been developed to describe the extent to which statistical analysis of data may be relied upon to evaluate each exposure pathway and condition. At the top of each Statistical Guidesheet is an Applicability of Statistics Section which summarizes the primary factors to consider for that exposure pathway or condition. "**YES**," "Generally Not Practical (**GNP**)" or "**NO**" appear in a box to the right of the Applicability of Statistics heading to indicate the degree to which statistical analysis is appropriate. The Statistical Guidesheets are lettered and numbered to correspond with the Criteria Application Guidesheets presented in the Cleanup Criteria Training Material (CCTM).

Statistical Guidesheets categorized as "**YES**" indicate that use of statistics may be appropriate for the exposure pathway/condition and that sufficient data are likely to be available to calculate a *REPRESENTATIVE CONCENTRATION* for comparison to cleanup criteria. Statistical Guidesheets designated as "**GNP**" indicate that statistical applications may be appropriate but that data are not likely to be available and/or the complexities of the exposure pathway/condition make it difficult to derive a *REPRESENTATIVE CONCENTRATION* for comparison to cleanup criteria. Conditions for which no generic criteria have been developed (e.g., polluted soil runoff to surface water), are also designated as **GNP**. Finally, the exposure pathway categorized as "**NO**" means that statistical analysis is not allowed due to an administrative rule requirement. This is true only for the drinking water pathway for which Administrative Rule 709(3) requires that criteria be met at every point in the affected aquifer.

For quick reference, the CCTM general reference table titled, "Conditions to Evaluate in Assessing Compliance with Part 201 Cleanup Criteria," has been expanded to identify the applicability of statistics for each condition to evaluate. This table can be found in the tabbed section titled, "Applicability of Statistics." Remember that in cases where criteria are not applicable, it is not necessary to conduct a statistical analysis of *FACILITY* data.

2. <u>What is the appropriate data set to statistically derive a *REPRESENTATIVE CONCENTRATION* for comparison to cleanup criteria?</u>

Selecting the proper data set for a statistical analysis, if a statistical analysis is appropriate for the exposure pathway or condition, is an important step given the manner in which sampling data are typically obtained at sites. Section 2 of the Statistical Guidesheets addresses Selection of Data for Statistical Analysis.

FACILITY characterization is a necessary first step before an appropriate data set can be identified for statistical comparison to cleanup criteria. Adequate knowledge of contaminant distribution and the presence of *HOT SPOTS* are essential due to assumptions underlying the statistical methods recommended for comparing site data to cleanup criteria (i.e., 95% upper confidence limits (UCLs) for the mean concentration). Adherence to these assumptions is necessary if an accurate statistical conclusion is to be drawn. Once defined, *HOT SPOTS* should not be included in a statistical analysis for comparison to most criteria. *HOT SPOTS* must be addressed separately. These concepts are discussed in more detail in Section 2.4.1 of the tabbed section titled, "Sampling Strategies."

Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. The statistical methods described in this document require independence of the data (i.e., the data were obtained through *RANDOM* sampling). However, data gathered from *FACILITY* investigations may not be suitable for statistical comparison to cleanup criteria. Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos.

There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that represent the exposure pathway or condition and the relevant land-use category. For many of the exposure pathways *EXPOSURE UNITS* are defined to describe the area over which a person may be exposed to hazardous substances and data required for each *EXPOSURE UNIT*. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to adequately represent hazardous substance concentrations and allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling will often be required to

support statistical analyses after the nature and extent of contamination has been defined. Although *RANDOM* samples are preferred for deriving a *REPRESENTATIVE CONCENTRATION*, previous sample results may be used on a *FACILITY*-specific basis. See further discussion of this issue in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."

The appropriate data set for statistical analysis also depends on the size and variability of hazardous substance concentrations in the *EXPOSURE UNIT*. The size of the *EXPOSURE UNIT* varies between different exposure pathways and the land-use category being considered. Generally, only data from one *EXPOSURE UNIT* may be used in each statistical analysis for comparison to cleanup criteria.

Section 2 of the Statistical Guidesheets also provides information related to unique aspects of the exposure pathway/condition that affect which data may be included in a statistical analysis for comparison to criteria. For example, only groundwater data from *GSI MONITORING WELLS* within the *AVERAGING AREA* may be used for statistical comparison to chronic mixing zone-based groundwater surface water interface (GSI) criteria.

3. <u>What is the appropriate statistical method to use for comparison to the cleanup criteria</u>?

Proper evaluation of data sets to assess compliance for an exposure pathway and/or condition is an important objective of the S^3TM. Once the applicability of statistics has been established and an appropriate data set identified, it is necessary to select the appropriate statistical method(s) for comparing those data to Part 201 criteria.

For characterizing human exposure potential to hazardous substances, the Environmental Protection Agency (EPA) recommends that a 95% UCL for the mean be used to estimate a reasonable maximum exposure (RME) concentration for Superfund risk assessments. The MDEQ also recommends use of a 95% UCL for the mean to compare *FACILITY* data to Part 201 criteria.

Use of a 95% UCL for the mean to compare *FACILITY* data to Part 201 criteria corresponds to a baseline assumption that the mean hazardous substance concentration is at or above its respective criterion unless the data provide sufficient evidence to conclude otherwise. This baseline assumption is consistent with EPA's recommendations in the context of federal cleanup programs (e.g., Superfund and Resource Conservation and Recovery Act (RCRA) Corrective Action).

Various methods are available for calculating UCLs for the mean concentration. Selection of the appropriate method requires an evaluation of the assumptions underlying each method. One of these assumptions is the statistical distribution of the data set (i.e., normal, lognormal, or neither). Consequently, each data set must be evaluated for the best-fitting statistical distribution. Chapter 1 of the tabbed section titled, "Statistical Methods" provides several techniques to accomplish this task. As described in Chapter 1, these techniques should be used in combination to best evaluate the statistical distribution.

Chapter 2 of the tabbed section titled, "Statistical Methods" provides techniques for identifying whether suspect data points are statistical outliers. Recommendations for treatment of outliers, once identified, are also provided in Chapter 2.

Methods for calculating UCLs for the mean concentration are provided in Chapter 3 of the tabbed section titled, "Statistical Methods."

Relationship to the Part 201 CCTM

This S^3TM builds on the framework of the CCTM of January 1998 by providing guidance for statistically analyzing sample data to assess compliance with Part 201 cleanup criteria. Part 201 Section 20a(14) states: "the department shall approve the use of probabilistic or statistical methods or other scientific methods of evaluating environmental data when determining compliance with a pertinent cleanup criterion if the methods are determined by the department to be reliable, scientifically valid, and best represent actual site conditions and exposure potential." Since many divisions of the MDEQ utilize Part 201 criteria, the S^3TM will be useful for this purpose across the MDEQ.

Statistical Considerations Related to *BACKGROUND*

Under Part 201, *BACKGROUND* becomes the Part 201 criterion when the *BACKGROUND* concentration for a hazardous substance is greater than its corresponding risk-based criterion. In this case, *FACILITY* data may be compared to *BACKGROUND* concentrations instead. Chapter 4 of the tabbed section titled, "Statistical Methods" provides recommended statistical methods for this purpose. Recommended methods vary depending on: 1) type of *BACKGROUND* being considered (i.e., *STATEWIDE DEFAULT BACKGROUND*, *REGIONAL BACKGROUND*, or *FACILITY-SPECIFIC BACKGROUND*) and 2) whether a statistical analysis of *FACILITY* data is appropriate for comparison to risk-based criteria. Because statistical distribution and presence of outliers remain important considerations for selection of appropriate method(s) to compare *FACILITY* data to *BACKGROUND* data, Chapter 4 refers back to Chapters 1 and 2 for these considerations.

Relationship to the "Verification of Soil Remediation" (VSR) Guidance Document (MDNR 1994; Revision 1)

Topics addressed in the VSR have been incorporated into the S^3TM and updated as necessary to reflect regulatory requirements under Part 201. The VSR was written in the context of the Michigan Environmental Response Act (MERA), 1982 PA 307, as amended, prior to the 1995 amendments. Consequently, recommendations in the VSR do not address concepts addressed by Part 201 such as evaluation of exposure pathways. Statistical methods presented in the VSR have also been updated to reflect more state-of-the-art recommendations in the statistical analysis of environmental data.

The VSR provided sampling recommendations for both verifying remediation and characterizing wastes. The VSR also presented some statistical methods for evaluating verification or characterization data. Sampling strategies for verifying remediation are described in Sections 1.3 and 2.3 of the tabbed section titled, "Sampling Strategies." Statistical methods for comparing data to criteria are provided the tabbed section titled, "Statistical Methods." Waste characterization is addressed in the tabbed section titled, "Waste Characterization."

Professional Judgment

The S^3TM supplements the tools available to aid in decision-making and do not replace or diminish the use of other appropriate tools such as professional judgment. For example, professional judgment may be used to determine that a *FACILITY* has been adequately characterized based primarily on biased sampling. Professional judgment may also be used to evaluate the significance of environmental data in a manner that does not require a statistical

analysis of *FACILITY* data. If it is determined that data are not representative of a quantity of hazardous substance that could result in an unacceptable risk, it may be appropriate to draw a conclusion without using statistics, even if one or more data points are greater than the cleanup criteria.

Cleanup criteria that are based on projections of the fate and transport of a hazardous substance from one media to another (e.g., groundwater volatilization to indoor air), and the screening levels (i.e., flammability and explosivity, acute inhalation) are good examples of pathways where the quantity of hazardous substance that is present can be considered in applying the screening levels or criteria. If a single data point exceeds an acute inhalation screening level, but that data point is representative of only a small area of groundwater, the sample is from considerable depth below ground surface, and the concentration is not substantially greater than the screening level, it may be concluded that there is no need for response activity to address this situation. This is a conclusion based on professional judgment, not on a statistical evaluation.

The S^3TM is aimed primarily at sampling (i.e., recommended approaches to data gathering) and the use of statistics in decision-making under Part 201. Some decisions, however, will be determined on a qualitative basis (e.g., source control), since cleanup criteria are not available for all conditions.

Self-Implementation

Part 201 Section 14(2) states: "A person may undertake response activity without prior approval by the department unless that response activity is being done pursuant to an administrative order or agreement or judicial decree which requires prior department approval. Any such action shall not relieve any person of liability for further response activity as may be required by the department." A self-implemented response activity using statistics to support determinations must be documented in a manner that fully and clearly addresses the three questions outlined in this Introduction.

Waste Characterization

Characterization of wastes for the purpose of disposal must often be addressed at Part 201 *FACILITIES*. Waste characterization is regulated under Part 111, Hazardous Waste Management and Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). Because there is a great deal of overlap in sampling strategies and statistical methods that can be used to compare data to criteria under Parts 201, 111 and 115, considerations related to waste characterization are also provided in this document. The tabbed section titled, "Waste Characterization" provides most of the recommendations related to waste characterization. Many of these considerations have also been incorporated in the tabbed sections titled, "Sampling Strategies" and "Statistical Methods."

APPLICABILITY OF STATISTICS TO EACH CONDITION TO EVALUATE

APPLICABILITY OF STATISTICS TO EACH CONDITION TO EVALUATE
General Reference Table

	CONDITION	REFERENCE GUIDESHEET(S)	APPLICABILITY OF STATISTICS
SOURCES:			
1	Abandoned substances not yet dispersed & free phase liquids	A 7, 20	GNP Pathway Dependent
RISKS DUE TO GROUNDWATER CONTAMINATION:			
2	Drinking water usage	**1**, 2, 7	NO
3	Dermal exposures such as by utility workers	**6**, 7, 8, 9	GNP
4	Indoor air hazards (chronic/systemic)	**4**, 5, 7, 8, 9	GNP
5	Hazards to surface waters	**3**, 7	YES / NO
RISKS DUE TO SOIL CONTAMINATION:			
6	Hazards due to direct contact (ingestion, dermal)	10, **19**, 20, 27, 28, 29	YES
7	Ambient air inhalation hazards	10, **15**, **16**, **17**, **18**, 20, 23, 24, 25, 26	YES
8	Indoor air inhalation hazards	10, **14**, 20, 22	GNP
9	Injury to drinking water use of aquifer	10, **11**, 20, 21	GNP
10	Risk from contact (utility work) with groundwater	10, **13**, 20	GNP
11	Causes groundwater to be hazardous to surface water	10, **12**, 20	GNP
12	Polluted soil runoff to surface water	B, 10, 20	GNP
RISKS DUE TO CONTAMINATION OF SURFACE WATER SEDIMENTS:			
13	Aquatic flora/fauna/food chain hazards/aesthetics	C	GNP
OTHER RISKS:			
14	Acute toxic impacts/physical hazards	D, 8, 9	GNP
15	Terrestrial flora/fauna/food chain hazards/aesthetics	E	GNP
16	Asbestos containing materials	F	Pathway Dependent

Note: **Bold** guidesheet references indicate generic residential cleanup criteria.

APPLICABILITY OF STATISTICS

YES: Use of statistics may be appropriate for this pathway/condition and sufficient data are likely to be available to calculate a *REPRESENTATIVE CONCENTRATION* for comparison to cleanup criteria.

NO: Use of statistics is not allowed for this pathway/condition due to an administrative rule requirement. This is true only for the drinking water pathway in which administrative rule 709(3) requires that criteria be met at every point in the affected aquifer.

GNP: Use of statistics may be appropriate for this pathway/condition but data are not likely to be available and/or the complexities of the exposure pathway/condition make it difficult to derive a *REPRESENTATIVE CONCENTRATION* for comparison to cleanup criteria. Conditions for which no generic criteria have been developed (e.g., polluted soil runoff to surface water) are also designated as “GNP.”

STATISTICAL ANALYSIS WORKSHEETS

STATISTICAL ANALYSIS REVIEW WORKSHEET

GENERAL INFORMATION

SITE/PROJECT: _____

☐ **RAP** ☐ **Final IR** ☐ **Due Care** ☐ **Other** _____

Submittal Being Evaluated: _____

Release Area: _____

Substance evaluated: _____

Pathway/Land use: _____

Current criterion value: _____

Applicability of Statistics: ☐ **Yes** ☐ **No*** ☐ **GNP***

*** DEQ Action Taken:** _____

_____

Conclusion of Submittal For This Substance:

Representative Concentration: _____

Statistical Method Used: ☐ 95% UCL for the mean ☐ Other _____

ADEQUACY OF CHARACTERIZATION

1) Nature and extent of contaminant distribution determined? ☐ Yes ☐ No

Comments: _____

_____

2) Is there evidence "Hot Spots" or potential "Hot Spots" remain present? ☐ Yes ☐ No ☐ Unknown

Comments: _____

_____

Characterization adequate to proceed with statistical analysis? ☐ Yes ☐ No*

*DEQ Action Taken:

REVIEW OF DATA SET

CHARACTERISTICS	SUBMITTAL	GUIDESHEET RECOMMENDATION	RECOMMENDATION SATISFIED?
Size of Area Evaluated (Exposure Unit / Averaging Area)	_____ ☐ Acres ☐ Sq. Ft. ☐ _____	_____ Acres / sq.ft. guidesheet number _____ or, matches areas used for mixing zone determination.	☐ Yes ☐ No Comments:_____
Number of Observations		9 minimum per exposure unit per stats guidesheet	☐ Yes ☐ No Comments:_____
Basis For Sample Points		Random, per stats guidesheet	☐ Yes ☐ No ☐ Unknown Comments:_____
Detection Limit		_____ Per op memo #6	☐ Yes ☐ No Comments:_____
Percent Non-Detects		<50% for use of std. methods per statistical methods section (alt. methods to be proposed if >50%.)	☐ Yes ☐ No Comments:_____

REVIEW OF STATISTICAL ANALYSIS

1) STATISTICAL DISTRIBUTION OF DATA SET

Submittal

Distribution: ☐ Normal ☐ Lognormal ☐ Neither

Formal Test: ☐ Shapiro-Wilk Test ☐ Shapiro-Francia Test

Graphical Technique: ☐ Probability Plots ☐ Box Plots

Summary Statistics: ☐ Coefficient of Variation ☐ Coefficient of Skewness

DEQ Review

Distribution: ☐ Normal ☐ Lognormal ☐ Neither

Formal Test: ☐ Shapiro-Wilk Test ☐ Shapiro-Francia Test

Graphical Technique ☐ Probability Plots ☐ Box Plots

Summary Statistics: ☐ Coefficient of Variation ☐ Coefficient of Skewness

Attach notes / worksheets for above method(s) used. Analysis must include a formal test, a probability plot and summary statistics.

2) OUTLIER EVALUATION

Submittal

Was data set evaluated for outliers?

☐ No
☐ Yes

How were outliers identified?
(Check all that apply)

☐ Graphically

☐ Probability Plot ☐ Box Plot ☐ Other_____

☐ Formal tests (Assumed distribution: _____)

☐ Grubbs' Test ☐ Dixon's Test

☐ Rosner's Test ☐ Other_____

CONCLUSIONS

☐ Value(s) not outliers(s)
☐ Value(s) confirmed as outliers

Treatment of outlier value(s)

☐ Included in statistical analysis
☐ Excluded from statistical analysis

Justification (for either): _____

_____

_____

DEQ Review

☐ No potential outliers in data set based upon qualitative review and / or plots
*(**Proceed to #3**)*

☐ Potential outliers evident in dataset

Is data set either normal or lognormal?

☐ Yes, outlier(s) tested by:

☐ Grubbs' Test ☐ Dixon's Test
☐ Rosner's Test ☐ Other _____

☐ No, outlier(s) tested by:

☐ Iterative Approach

☐ Other _____

CONCLUSIONS

☐ Value(s) not outliers(s) (Proceed to #3)
☐ Value(s) confirmed as outlier(s)

Treatment of outlier(s)

☐ Outlier value investigated and found to be erroneous because:

_____

_____

Correct value =_____ **or** ☐ Not discernible
(Return to #1) (Exclude value and document, proceed to #3)

☐ Outlier value apparently accurate, but extreme for population and not from a Hot Spot (Proceed to #3)

☐ Outlier value apparently accurate and may represent a Hot Spot (Return to Adequacy of Characterization)

3) CALCULATION OF REPRESENTATIVE CONCENTRATION

Submittal

Statistical method used:

☐ Student's t (for normally distributed data sets)

☐ Land's Method (lognormally distributed data)

☐ Other _____

Representative Concentration:

DEQ Review

Statistical method used

☐ Student's t (for normally distributed data sets)

☐ Land's Method (lognormally distributed data)

☐ Other formulas as proposed and discussed with DEQ Statistician

Representative Concentration:

CONCLUSIONS OF REVIEW

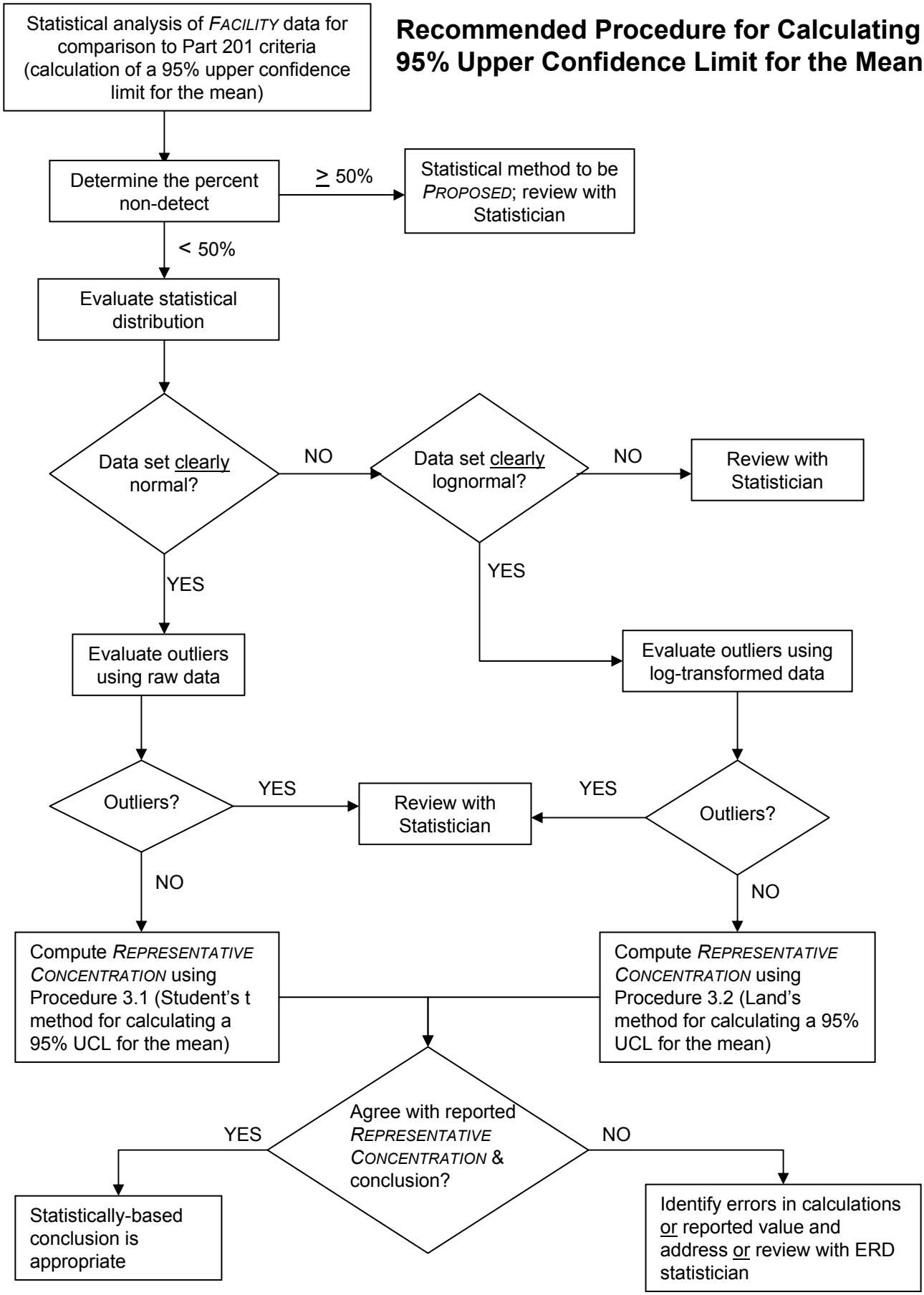
☐ **Review supports conclusion of the submittal for the representative concentration of this substance at this location OR**
☐ **Review finds conclusion of the submittal for the representative concentration of this substance IS NOT appropriate because:**

_____

AND Statistical Analysis ☐ DOES ☐ DOES NOT provide evidence of compliance with this criterion for this substance at this location.

Staff Reviewer: _____ Review Date: _____

Recommended Procedure for Calculating a 95% Upper Confidence Limit for the Mean



SAMPLING STRATEGIES

SAMPLING STRATEGIES TABLE OF CONTENTS

INTRODUCTION **4.4**

CHAPTER 1: BIASED SAMPLING STRATEGIES **4.7**

SECTION 1.1 INTRODUCTION TO BIASED SAMPLING 4.7

SECTION 1.2 *FACILITY* CHARACTERIZATION 4.8

Section 1.2.1 *RELEASE* Area(s) 4.8

Section 1.2.2 *BACKGROUND* 4.13

SECTION 1.3 VERIFICATION OF REMEDIATION 4.15

Section 1.3.1 Selecting Numbers and Locations of Verification Samples in Excavations 4.15

Section 1.3.2 Selecting Numbers and Locations of Soil Verification Samples for Ex Situ Remedies 4.17

Section 1.3.3 Selecting Numbers and Locations of Soil Verification Samples for In Situ Remedies 4.18

SECTION 1.4 COMPARISON TO CRITERIA 4.21

Section 1.4.1 Demonstrating Compliance on a Point-by-Point Basis 4.21

Section 1.4.2 Comparison of *FACILITY* Data to *FACILITY-SPECIFIC BACKGROUND* Concentrations 4.22

Section 1.4.3 Recommended Summary Report Format for Biased Sampling 4.22

SECTION 1.5 WASTE CHARACTERIZATION 4.23

CHAPTER 2: STATISTICAL SAMPLING STRATEGIES **4.24**

SECTION 2.1 INTRODUCTION TO STATISTICAL SAMPLING 4.24

SECTION 2.2 *FACILITY* CHARACTERIZATION 4.26

Section 2.2.1 *RELEASE* Area(s) 4.26

Section 2.2.1.1 Sampling Grids for *HOT SPOT* Identification 4.29

Section 2.2.1.2 Sampling Grid Based on Size of Area to Be Sampled 4.33

Section 2.2.2 *BACKGROUND* 4.35

SECTION 2.3 VERIFICATION OF REMEDIATION 4.35

Section 2.3.1 Selecting Numbers and Locations of Verification Samples in Excavations 4.36

Section 2.3.2 Selecting Numbers and Locations of Soil Verification Samples for Ex Situ Remedies 4.38

Section 2.3.3 Selecting Numbers and Locations of Soil Verification Samples for In Situ Remedies 4.39
SECTION 2.4 DEMONSTRATING COMPLIANCE WITH PART 201 CRITERIA USING STATISTICS 4.40
Section 2.4.1 General Considerations When Demonstrating Compliance Using Statistics 4.40
Section 2.4.2 *RANDOM* Sampling of *EXPOSURE UNITS* 4.42
Section 2.4.2.1 Simple *RANDOM* Sampling 4.43
Section 2.4.2.2 Systematic *RANDOM* Sampling 4.45
Section 2.4.2.3 Three-Dimensional Sampling 4.48
Section 2.4.2.4 Use of Site Characterization Data in Place of *RANDOM* Sample Locations 4.49
Section 2.4.3 Comparison of *FACILITY* Data to *FACILITY-SPECIFIC BACKGROUND* Concentrations 4.50
Section 2.4.4 Recommended Summary Report Format 4.51
SECTION 2.5 WASTE CHARACTERIZATION 4.52

SUMMARY 4.53

EXAMPLES

Example 1.1 Collection of *BACKGROUND* When Multiple Soil Horizons are Present 4.14
Example 1.2 Examples of Biased Vertical Sampling Strategies 4.20
Example 2.1 Example of When Statistical Sampling Strategies Should Be Considered 4.28
Example 2.2 Use of *HOT SPOT* Identification Techniques to Select a Grid Interval for Finding a Pre-Specified *HOT SPOT* 4.30
Example 2.3 Use of *HOT SPOT* Identification Techniques to Identify the Size of a *HOT SPOT* That Can Be Found Using a Pre-Specified Sampling Grid 4.31
Example 2.4 Use of *HOT SPOT* Identification Techniques to Select a Grid Interval for Finding a Rectangular *HOT SPOT* 4.32
Example 2.5 Subgridding 4.34
Example 2.6 Further *RANDOMIZATION* Using Sampling Grids 4.35
Example 2.7 Two-Dimensional Node Sampling Excavation Grid 4.38
Example 2.8 Simple *RANDOM* Sampling 4.44
Example 2.9 Systematic *RANDOM* Sampling 4.46
Example 2.10 Systematic *RANDOM* Sampling of an Odd-Shaped *EXPOSURE UNIT* 4.47

FIGURES

Figure 2.1 Concentric Ellipse and Circle Bounding the Rectangular *HOT SPOT* 4.31
Figure 2.2 Simulated Simple *RANDOM* Sample of Nine Observations from a 100 ft x 100 ft (1/4 Acre) *EXPOSURE UNIT* 4.44
Figure 2.3 Systematic *RANDOM* Sample of Nine Observations Collected from a 300 ft x 300 ft *EXPOSURE UNIT* 4.45
Figure 2.4 Systematic *RANDOM* Sampling of a Two Acre *EXPOSURE UNIT* 4.47
Figure 2.5 Systematic *RANDOM* Sampling of an Odd-Shaped *EXPOSURE UNIT* 4.47

TABLES

Table 1.1 Number of Excavation Floor Samples 4.16
Table 1.2 Number of Excavation Sidewall Samples 4.17
Table 1.3 Number of Samples for Ex Situ Remedies 4.18
Table 2.1 Approximate Grid Ranges Based on Size of Area to be Sampled 4.33

INTRODUCTION

Environmental sampling is often conducted to support a variety of interrelated data objectives. When developing a sampling plan, these objectives require careful consideration if useful data are to be obtained. The objectives for sampling addressed in this tabbed section include:

- identifying and characterizing *RELEASE* areas;
- verifying remediation of *RELEASE* areas;
- comparing *FACILITY* data to Part 201 cleanup criteria, either on a point-by-point basis or using statistics to derive a *REPRESENTATIVE CONCENTRATION*;
- characterizing wastes; and
- establishing *BACKGROUND* concentrations.

Systematic selection of the appropriate sampling strategy is an important first step in satisfying the environmental sampling objectives listed above. Two basic sampling strategies or designs are commonly used for environmental sampling: biased (judgmental) or *RANDOMIZED* (statistical). Further discussion of these strategies occurs in Chapters 1 and 2, respectively.

The DEQ recognizes that sampling to meet these environmental management objectives is a challenging and complex undertaking. This is due in part to the dynamic nature of environmental media (air, water, soil, sediments). Data from environmental sampling are static, representing only a single location and point in time. The complexity and dynamic nature of environmental media is often overlooked in sample planning, collection and cleanup decisions based on static sample data. Thoughtful consideration of the following questions will result in a more effective and efficient sampling strategy.

- Why sample?
  - What is the goal or purpose (data objective) of sampling (e.g., characterization, release area identification, verification of remediation, demonstration of compliance using statistics, demonstration of due care)?
  - Will sample results be used to draw conclusions about human health risks through various exposure pathways, natural resource damage, biological impacts?

- What to sample?
  - Sample media: air, water, soil, sediments, waste materials
  - Hazardous substances: *FACILITY*-specific constituents of concern, organic constituents and their breakdown products, inorganic constituents, metals

- Where to sample?
  - Locations based on biased versus *RANDOM* sampling strategies
  - Vertical sampling components

- When to sample?
  - Are there seasonal variations?
  - Time or history of *RELEASE* – when did the *RELEASE* occur?
  - What are the dynamics of the system(s)?

- How to sample?
  - Discrete grab sample versus continuous sampling
  - Field methodologies

The location and number of samples to be collected depends on factors such as the sampling strategy, the spatial and temporal variability of hazardous substances in the media to be sampled, the level of confidence desired (either in locating a *HOT SPOT* or in drawing conclusions about a mean concentration), and the costs involved.

As described in the following chapters, a combination of sampling strategies is often recommended to best address the sampling objective(s). When characterizing a *FACILITY* (Sections 1.2 and 2.2), biased sampling should be used whenever information is available with which to reliably select sampling locations. However, there are limitations to using biased sampling strategies alone since unexpected areas of contamination will not be identified. To eliminate sampler bias, statistical or *RANDOMIZED* sampling strategies should often be used to supplement biased sampling. The number of samples can be estimated to locate a *HOT SPOT* of an assumed size and shape with a specified level of confidence (Section 2.2.1.1), to proportionally represent an area of a given size (Section 2.2.1.2) or by selecting a particular data objective to satisfy, such as estimating mean concentration with specified levels of precision and confidence.

For verifying remediation of soils, biased sampling is recommended in small areas (i.e., less than ¼ acre) and statistical sampling is recommended in medium- to large-sized areas (Sections 1.3 and 2.3, respectively). Because identification and consideration of *HOT SPOTS* is necessary for statistical comparison of verification data to criteria, biased sampling may also be necessary.

Hazardous substance concentrations in biased samples must generally be compared to criteria on a point-by-point basis (Section 1.4). If all concentrations meet criteria and the *FACILITY* is believed to be adequately characterized, sampling may be complete. If one or more concentrations are present above criteria, a statistical analysis may be considered for comparison to criteria. Further statistical sampling may be necessary with the sampling objective of statistical estimation of a *REPRESENTATIVE CONCENTRATION* for comparison to criteria (Section 2.4). The additional samples would be collected to obtain a sufficient number of *RANDOMLY* located samples to: 1) allow for an appropriate statistical analysis (see the tabbed section titled, “Statistical Methods”) and 2) adequately represent both exposures for a given exposure pathway and hazardous substance concentrations. However, considerations such as applicability of statistics and adequacy of characterization must first be addressed as described in Section 2.4.

Sampling for the purpose of waste characterization is discussed in Sections 1.5 and 2.5 and described in more detail in the tabbed section titled, “Waste Characterization.”

COMPOSITE SAMPLES

Demonstration of compliance with Part 201 cleanup criteria generally requires collection of discrete soil samples. Compositing of samples is not accepted without prior DEQ approval.

SAMPLE ANALYSIS

All test methods and associated target detection levels must be consistent with those specified in rules and procedures under Part 201. These include:

- analytical methodologies
- target detection levels
- quality control procedures

Generally, constituents in soil will be measured on a total, dry weight basis. Considerations for other media (i.e., groundwater, sediments, waste, leachate) must be addressed on a site-specific basis.

CHAPTER 1: BIASED SAMPLING STRATEGIES

1.1 INTRODUCTION TO BIASED SAMPLING

"Biased" sampling strategies generally involve use of professional judgment to collect soil samples from areas most likely to contain contamination. Often, biased sampling is utilized for smaller areas (e.g., less than a 1/4 acre). However, biased sampling also plays a role on large properties. Biased sampling should be used to focus on known or suspected areas of concern.

Use of biased sampling is premised on enough detailed property information on which to base selection of sample locations. The sample locations are purposefully chosen based on the goal of investigating known or suspected areas of concern. With sufficient knowledge of existing conditions, historic activities, or field indicators (e.g., visual, olfactory, or field screening instrumentation), these areas can be focused on reliably.

Any biased sampling plan requires use of professional judgment. A thorough justification must be documented for each sample location explaining the rationale used to select the location. Without this important detail, biased sampling alone will not be adequate. The reporting section of this document should be carefully followed to ensure adequate documentation of the selection of sample locations (see Section 1.4.2).

It is often necessary to use a combination of sampling strategies for both known or suspected areas of concern as well as areas believed to be unimpacted. Since unexpected areas of contamination will not be identified through biased sampling alone, statistical sampling should often be used to supplement biased sampling. This concept is addressed in the following sections for each of the sampling objectives.

Analytical results from biased sampling must generally be compared to Part 201 criteria on a point-by-point basis and individual exceedances noted. When point-by-point comparisons are made, professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of a hazardous substance.

A statistical analysis of data generated from biased sampling is generally <u>not</u> appropriate. This is due to the underlying assumptions of most statistical methods used to compare *FACILITY* data to cleanup criteria. One underlying assumption is that the data being evaluated were obtained through *RANDOM* sampling of a single, homogeneous population that can be described by a single statistical distribution (e.g., a normal distribution with a mean of 3.6 and a standard deviation of 0.78). Biased sampling can be used to help identify if this is the case or if differing populations (e.g., *RELEASE* areas) are present.

If statistical sampling is completed in addition to biased sampling, it may be appropriate to combine analytical results from the statistical sampling with some or even all of the biased sampling results in a statistical analysis. However, there are several key considerations which must first be addressed, as described in Section 2.4.1 of Sampling Strategies.

Biased sampling strategies require collection of discrete soil samples. Compositing of samples is not accepted without prior DEQ approval.

The remainder of this chapter provides considerations for selection of biased sample locations according to the following sampling objectives:

- *FACILITY* characterization
- Verification of remediation
- Comparison to criteria for demonstration of compliance
- Waste characterization

Chapter 2 of Sampling Strategies provides statistical sampling methods for each of these objectives.

1.2 *FACILITY* CHARACTERIZATION

FACILITY characterization often includes the collection of samples for the purpose of representing *FACILITY-SPECIFIC BACKGROUND* conditions in addition to the investigation of *RELEASE* areas. Sampling for the identification of *RELEASE* areas is described in Section 1.2.1. Sampling to characterize *FACILITY-SPECIFIC BACKGROUND* conditions is described in Section 1.2.2.

1.2.1 *RELEASE* Area(s)

Sampling strategies for investigation of *RELEASE* areas should incorporate information on known or suspected areas of contamination whenever this information is available. Existing information on areas of contamination is often incorporated in sampling plans through biased sampling of areas most likely to be impacted. Application of a statistical sampling approach such as simple *RANDOM* sampling alone would not be appropriate since it would not incorporate this site-specific knowledge. Known or suspected areas of contamination may not be sampled.

It is often necessary to use a combination of sampling strategies when characterizing soils on a property. For example, biased sampling should be used to focus on known or suspected areas of contamination. However, statistical sampling should also be considered to supplement biased sampling. The necessity of statistical sampling will depend on the accuracy and level of detail of site-specific information used to: 1) select biased sample locations and 2) rule out areas not sampled. For example, if known or suspected contamination is limited to a well defined area, statistical sampling of that area or surrounding areas may not be necessary. If well-defined locations do not exist, statistical sampling may be necessary to either locate the contamination or to adequately demonstrate that the area meets criteria. Statistical sampling should be considered for areas believed to be unimpacted in order to confirm this. Statistical sampling approaches such those described in Sections 2.1.1.1 and 2.2.1.2 can be used.

Use of biased sampling may result in reduced sampling costs when there is sufficient knowledge of known or suspected *RELEASE* areas and adequate documentation of the selected sample locations. However, analytical results from biased sampling must generally be compared to Part 201 criteria on a point-by-point basis. Statistical analysis of biased sampling data is generally not appropriate. If statistical sampling is completed to supplement biased sampling, it may be appropriate to combine analytical results from the statistical sampling with some or even all of the biased sampling results in a statistical analysis for comparison to Part 201 criteria (Section 2.4.2). However, the considerations described in Section 2.4.1 must first be addressed.

The number of samples to be collected will be based on professional judgment, considering the level of certainty and quality of information used to identify the location(s) and extent of known or suspected areas of contamination or to judge an area as unimpacted. The size of appropriate exposure units will also impact the number of samples necessary to adequately characterize a property.

Once sampling has been conducted for the purpose of characterization, a judgment must be made as to whether a site has been adequately characterized. This judgment is generally subjective based upon available information and knowledge of site conditions as described above. Furthermore, a *FACILITY* that was thought to be adequately characterized may need supplemental characterization based on data generated through subsequent *RANDOM* sampling if a statistical analysis is to be used to estimate a *REPRESENTATIVE CONCENTRATION* for comparison to criteria, as described in Section 2.4.2. This may be due to the discovery of unexpected results such as previously unidentified *HOT SPOTS*.

Considerations for Biased Sampling

The biased sampling approach specified in this document recommends sampling from areas most likely to exceed cleanup criteria. The location of soil samples relies on site-specific information on the *RELEASE* or contaminant distribution and specific conditions (e.g., soil type, *RELEASE* type) encountered. Sources of information about a property may include historic and/or current:

- aerial photos,
- property photos,
- detailed property maps,
- utility/activity maps or diagrams,
- historic documentation of activities associated with potential *RELEASES*,
- documentation of containment structures,
- documented field observations (such as stained or visible *RELEASE* areas, odors in an area), and/or
- previous remediation activities.

In addition to the sources of information listed above, other factors may be useful in biasing sample locations and depths towards areas most likely to be contaminated as well as in selection of appropriate analytical parameters. The following describes some of these factors.

a. Sample Locations

Using a biased sampling approach, samples must be collected where they will most likely encounter contamination which could exceed the cleanup criteria. This will minimize the number of samples needed to characterize a property. A sampling strategy that uses bias to choose sample locations is recommended. While it is inappropriate for this document to dictate exact locations for sample collection in this strategy, site specific information concerning the *RELEASE* (e.g., the location of leaks in an underground storage tank or its piping) and soil conditions should be used along with professional judgment and the general information provided here to select appropriate soil sampling locations.

Where to sample:

- Existing information on a property should be used to the degree possible when selecting biased sample locations. Field personnel present during the investigation and/or remediation activities should be sufficiently familiar with the conditions on-site to implement an appropriate biased sampling strategy. A soil sampling strategy should incorporate all pertinent biases of a site which may include, but are not limited to, those listed below:

    - source areas,
    - stained soils,
    - preferential pathways for contaminant migration,
    - other site specific "clues" (e.g., fractures in clays),
    - changes in soil characteristics (e.g., sand/clay interfaces),
    - soil types and characteristics , and/or
    - time lapse between *RELEASE* and investigation.

- For example, if a leak was confirmed on the south side of a tank, more extensive sampling should be conducted on the south side. It would be incorrect to sample the north side of the tank area as extensively as the south side when the leak was known and confirmed to be on the south side of the tank.

b. Depths and Soil Types

Medium sand or larger grains

Medium to larger grain size sand has from 20 to 40% porosity. Most sands in Michigan are composed of quartz, limestone, and small amounts of metamorphic rock fragments. These soils have a low capacity for adsorbing metals or hydrophilic (soluble) organic chemicals. Hydrophobic (insoluble) organic chemicals with low molecular weight will adsorb to this soil in small amounts. Hydrophobic chemicals with high molecular weight will adsorb in moderate amounts (Cline & Brown, 1989). These soils have a low capacity to hold contaminants in the grain interstices due to low capillary action. Contaminants that are held in these soils adhere to the grains themselves in dry soils and are forced into the smaller pore spaces in wet soils (Schwille, 1988).

Where to sample:

- In these soils, the capillary force is low enough to ignore its effects in transporting contaminants lateral to gravity. This is especially true for low surface tension products such as gasoline. Therefore, samples should generally be located below the source and/or *RELEASE* area at depths most likely to intercept contaminant migration.

- Limestone sand grains can act as a buffer to contaminants that cause pH changes (e.g., steel mill pickling acids). For these types of contaminants, the sampler should be on the lookout for intra-granular precipitates. These can appear as grain surface staining or make the soil appear clumpy or aggregated. Soils containing precipitates should be sampled.

Fine sand and silt

These soils have strong capillary action due to the small inter-granular distances. A determination of the fluid surface tension of the spilled product is helpful. High surface tension aids in the ability of a substance to overcome gravity by capillary action. As before, higher molecular weight products can be expected to adsorb to the grains to a greater degree. This allows a product to move lateral to gravity and, to a degree, upward from the leak location. Low surface tension products, such as TCE (trichloroethene), are more likely to go straight down than oils in these kinds of soils. However, the hydraulic head (i.e., the amount of product in the original spill) must be substantial to force a dense non-aqueous phase liquid through a medium with a hydraulic conductivity less than 1×10^{-3} cm/sec (Schwille, 1988).

Where to sample:

- Interfaces between fine sand layers with larger grains above should be sampled. When high surface tension contaminants are suspected, silt layers should be sampled.

Clays

Clay soils are very different from the sands and silts. Clays possess a net negative charge. This causes heavy metal cations (e.g., Cr^{+6}, Cd^{+2}, Pb^{+2}) to adsorb to the clay surface. In fact, this is true for any positive ionizable substance. Clays also have a much greater secondary porosity than primary (primary porosity is the space between the soil particles; secondary porosity is the space between fractures, bedding planes, and soil structures). As a result, spills in clay soils tend to follow preferred pathways. Clays will often show signs of shrinkage cracks or fractures that will allow contaminants to migrate in what would otherwise be considered a "tight" soil in a lab analysis of permeability. Signs of fracturing include "patterned" mottling. This is where the iron (and also manganese) will be oxidized to a red, yellow, or reddish brown color along the crack while the matrix remains the reduced blue/gray color (Lindsay, 1979). Additionally, studies have also indicated that dense non-aqueous phase liquids (DNAPL) tend to reside in clay layers where those conditions exist.

Where to sample:

- It is very important to take clay soil samples from fractures. The fractures are the avenue of travel for contaminants in clay soils. Clay soils may also have sand lenses which should always be sampled. Sand lenses in clays tend to collect fluids. As such, they may harbor contaminants.

Organic carbon content of soil

The organic carbon content of soils is a key factor in the ability of any soil to adsorb contaminants. For a variety of reasons (Lindsay, 1979), an increase in organic carbon content leads to an increase in the adsorption of several classes of chemicals.

Where to sample:

- Soils that appear to have excess organic carbon (e.g. peat, muck, darker soils) should be preferentially sampled.

Bedrock

RELEASES into bedrock present difficult problems. Unlike clay, some bedrock formations have substantial primary porosity as well as secondary porosity. In Michigan, these are sandstones, conglomerates, and brecciated/coarse grained limestone. Examples of bedrock in Michigan with low primary porosity are fine grained limestone, shale, and crystalline metamorphic rocks (e.g., gneiss). If the sampler is unaware of the type of bedrock that is being investigated in a *RELEASE* area, a geologist must be consulted.

Where to sample:

> *RELEASES* into areas with shallow bedrock that have significant primary porosity must be sampled in both the fractures and the matrix. Bedrock without primary porosity should have sampling predominantly in the fractures as in the clay situation. Weathered zones in bedrock will hold contaminants better than unweathered zones. This is due to the increased number of adsorption sites available in weathered rock.

c. Changes Over Time and Chemical Transformations

Many organic chemicals may undergo aerobic and anaerobic degradation. A detailed description of these processes is beyond the scope of this document. The subject is approached here, however, to be sure that samplers are aware that the chemical(s) spilled may not be the only chemical(s) in the soil after a transformation has occurred. These transformations should be considered in the *FACILITY* investigation.

The professional literature contains many articles on this subject (Cline and Brown, 1989; Borden and Bedient, 1987; Wilson and Wilson, 1985). The interested reader is directed to these articles.

What to analyze:

- Analyses should be done for all chemicals that have been *RELEASED* as well as those identified as breakdown products of these chemicals.

- For example, soils surrounding a tank containing tetrachloroethylene that had valve leakage occurring over the last ten years should be sampled for the tetrachloroethylene as well as all breakdown products (TCE, dichloroethylene and vinyl chloride).

d. Exposure Pathways

The characteristics of the exposure pathway for each applicable cleanup criterion are critical to consider when locating samples, since sampling data is ultimately compared or interpreted relative to a cleanup criterion. Information on land use, receptor (exposed) population, exposure medium, exposure route (e.g., oral, inhalation and or dermal), hazardous substance and for some criteria pathways contaminant transport/migration, is all integrated into the development of each cleanup criterion. It follows, therefore, that these same characteristics should be considered when samples are collected for comparison to criteria.

Each cleanup criterion conveys an acceptable exposure concentration for a particular exposure pathway. An objective of biased sampling, therefore, may be to purposely collect samples from locations that will represent the unique characteristics of the exposure pathway of concern. The characteristics of each exposure pathway must be considered to assure that sample results are obtained from representative/appropriate locations. For some pathways, exposure to a

hazardous substance occurs in the medium being sampled (e.g., drinking water and soil direct contact criteria), while for other pathways exposure is to a different medium or location from that which is sampled (e.g., soil to groundwater protection criteria, GSI criteria). Biased sampling strategies may, therefore, be designed to achieve one of the following objectives depending on the criteria/pathway of interest: 1) represent the concentration in the medium to which a person may be exposed, or 2) represent the concentration in a medium that is protective of a different exposure medium.

The phrase "may be exposed" is underlined to emphasize that exposures under the generic context of unrestricted future use of property could occur to areas within the soil or groundwater contaminant profile that are currently not available for exposure, but may be in the future depending on property activities.

The exposure pathways considered under Part 201 are listed in the tabbed section titled, "Applicability of Statistics."

1.2.2 *BACKGROUND*

Under Part 201, the term *BACKGROUND* is defined as:

> *the concentration or level of a hazardous substance which exists in the environment at or regionally proximate to a site that is not attributable to any release at or regionally proximate to the site.*

Consequently, *BACKGROUND* samples must be collected from areas that are representative of *BACKGROUND* conditions and have not been impacted by a *RELEASE* at or regionally proximate to the site.

According to Section 20a(11), when *BACKGROUND* concentrations of a hazardous substance are greater than the corresponding Part 201 risk-based criterion, *BACKGROUND* becomes the Part 201 criterion. Consequently, *FACILITY* data will generally be compared to *BACKGROUND* concentrations only when *BACKGROUND* concentrations are greater than the applicable risk-based criterion.

Establishing *BACKGROUND* concentrations for soil can be accomplished by utilizing Operational Memorandum #15. The types of *BACKGROUND* that will generally be considered include: 1) *STATEWIDE DEFAULT BACKGROUND*, 2) *REGIONAL BACKGROUND*, and 3) *FACILITY-SPECIFIC BACKGROUND*. Additional information on each type of *BACKGROUND* is provided in Chapter 4 of the tabbed section titled, "Statistical Methods."

Sampling considerations for *FACILITY-SPECIFIC BACKGROUND* are described below. *FACILITY-SPECIFIC BACKGROUND* samples are not typically collected using statistical or probabilistic approaches. An effort is made to reflect the same natural conditions observed at a *FACILITY.* Consequently, *FACILITY-SPECIFIC BACKGROUND* data are somewhat biased. Although not described here, statistical or probabilistic methods could be incorporated into *FACILITY-SPECIFIC BACKGROUND* soil sampling. If multiple soil types or horizons are present, this could be accomplished through *RANDOM* sampling of each soil type or horizon independently.

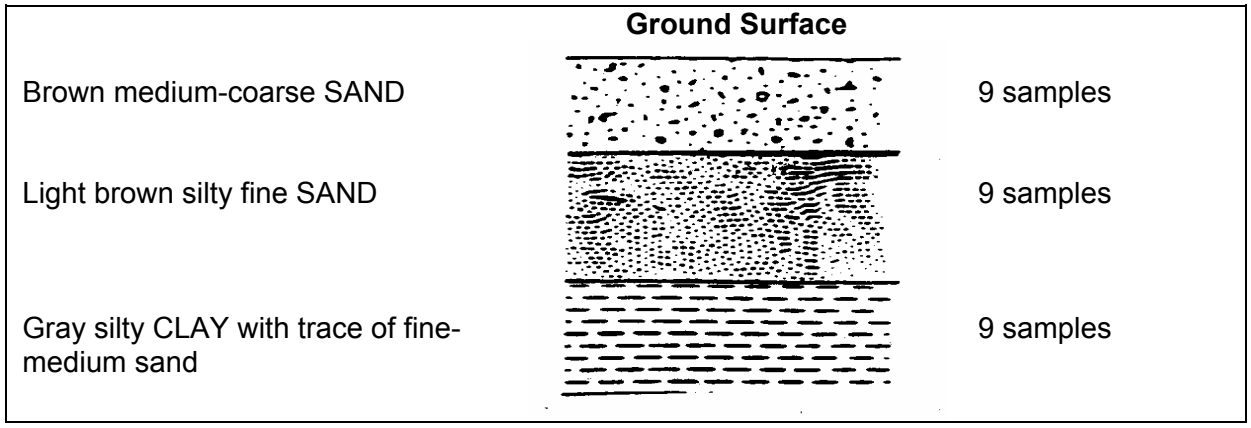
Number of *FACILITY-SPECIFIC BACKGROUND* Samples

Approximately nine samples must be used to establish *FACILITY-SPECIFIC BACKGROUND* concentrations in soils. This recommendation is based on statistical considerations only. It is necessary that an adequate number of samples is available to evaluate the underlying statistical distribution of the *FACILITY-SPECIFIC BACKGROUND* data (i.e., normal, lognormal, or neither).

The goal of collecting *FACILITY-SPECIFIC BACKGROUND* data is to adequately represent the magnitude and variability of naturally occurring concentrations in samples collected from the *FACILITY* of interest. Ideally, a *FACILITY-SPECIFIC BACKGROUND* data set should provide an equal representation of natural soil conditions identified at the *FACILITY*, the key difference being the potential for a *RELEASE*. If a *FACILITY* and the numbers of samples being collected from that *FACILITY* are large, it would be prudent to collect a sufficient number of *FACILITY-SPECIFIC BACKGROUND* samples to adequately represent the same naturally occurring conditions observed in *FACILITY* samples. For this reason, nine samples may not always be adequate to represent or characterize the magnitude and variability of *FACILITY-SPECIFIC BACKGROUND* concentrations.

Furthermore, if multiple soil horizons are present, approximately nine *FACILITY-SPECIFIC BACKGROUND* samples should be collected *from each soil horizon* and a *FACILITY-SPECIFIC BACKGROUND* concentration established for each horizon separately. It is generally not appropriate to combine data from multiple populations or statistical distributions for statistical analysis since this will inflate the variability of the data set, resulting in inflated *BACKGROUND* concentrations.

Example 1.1 Collection of *BACKGROUND* When Multiple Soil Horizons are Present



Additional Considerations for Selection of *FACILITY-SPECIFIC BACKGROUND* Sample Locations

Many factors can play a part in the *BACKGROUND* concentrations of a chemical in soil. Consideration of these factors is particularly important when establishing *FACILITY-SPECIFIC BACKGROUND* concentrations. For example, the geologic origin (e.g., the parent rock) of glacial drift may have been high in copper, lead, or other metals that may be potential contaminants. Additionally, the hydrogeologic situation can alter the quantity of these elements. Groundwater recharge areas (e.g., highlands) are frequently leached of metals while groundwater discharge areas (e.g., swamps, floodplain) are the recipients of leached metals. Thus, sites in low areas will usually have higher *BACKGROUND* concentrations than upland areas. Other conditions, such

as precipitation and atmospheric fallout from widely dispersed human and natural activities, also affect soil concentrations.

In addition, an estimate of contamination depth should be made and *BACKGROUND* samples taken at comparable depths for the particular soil type. This estimate should be made based on waste type, contaminant mobility, operation practices, and soil type (sand, silty sand, clay).

Selection of Analytical Parameters

BACKGROUND should be established as appropriate for site-specific waste constituents, specific chemicals used in various processes, *FACILITY* operations, or remedial investigation results. Sample analyses will generally include metals and other site-specific inorganic constituents of concern. Analytical parameters could possibly include organic constituents if consideration of *NON-RELEASE ANTHROPOGENIC BACKGROUND* conditions is justified.

1.3 VERIFICATION OF REMEDIATION

When verifying remediation of small areas (i.e., less than 10,890 ft^2 or 1/4 acre), biased sampling is recommended. "Biased" sampling involves collecting soil samples from areas most likely to still exceed cleanup criteria after remediation. When biased sampling is conducted to verify remediation of soils, analytical results must generally be compared to Part 201 cleanup criteria on a point-by-point basis. A statistical analysis of verification sample results may not be used to compare the data to Part 201 cleanup criteria.

Although it is unlikely, it is possible that biased sampling could be used to verify remediation in areas larger than 10,890 ft^2. However, statistical sampling methods are generally recommended for these larger areas. (See Section 2.3 of Sampling Strategies.) As noted in Section 2.3, when statistical sampling methods are used, it may be appropriate to conduct a statistical analysis of verification sample results for comparison to Part 201 criteria; however, the considerations summarized in Section 2.4 must first be addressed.

Compositing samples for verifying soil remediation is not acceptable without prior DEQ approval. When verifying a soil remediation is complete, contaminant concentrations will be low. Compositing may result in the contaminant concentrations not being representative of what remains in the soil. If concentrations are low, compositing may dilute the concentrations of a contaminant to below its threshold detection limit. Additionally, if contamination is indicated in a composite sample, the location of the contamination remains unknown.

Any biased sampling plan requires professional judgment. A thorough justification must be documented for each sample location explaining the rationale used to select the location. Without this important detail, it is often necessary to apply a broader sampling strategy to include unknown areas. (See Section 1.4.2)

1.3.1 Selecting Numbers and Locations of Verification Samples in Excavations

Verifying that contaminated soil is remediated by means of excavation requires samples from the excavation bottom and sidewalls. The following tables provide the minimum number of samples necessary to verify cleanup for various size excavations. Considerations for selection of biased sample locations are also discussed.

It should be noted that "excavation" as used here refers only to that area excavated for remediation purposes and being verified to meet Part 201 cleanup criteria.

When biased sampling is used for verifying remediation, a point-by-point comparison of verification sample results to cleanup criteria is specified. If the cleanup criteria are exceeded at any point, this verification methodology may require additional excavation at that point until the criteria are attained.

Number of Samples

The following tables are used to determine the minimum number of samples necessary from the floor and sidewalls of an excavation no greater than 10,890 ft^2 using a biased sampling approach. If the area of the excavation floor exceeds 10,890 ft^2, refer to Section 2.3 of Sampling Strategies.

Determine the minimum number of excavation floor samples from the table below.

Table 1.1 Number of Excavation Floor Samples

Area of Floor (ft^2)	*Number of Samples*
< 500	2
500 < 1,000	3
1,000 < 1,500	4
1,500 < 2,500	5
2,500 < 4,000	6
4,000 < 6,000	7
6,000 < 8,500	8
8,500 <10,890	9

Sidewall samples are required to verify that the horizontal extent of contamination has been remediated. Use Table 1.2 to determine the minimum number of required sidewall samples. In no case is less than one sample on each sidewall (i.e., four) acceptable. In the case of irregularly shaped excavations in which four walls are not readily discernible, divide the total wall area into four segments of approximately equal size. Sidewall samples should be located in accordance with "biases" outlined below.

Table 1.2 Number of Excavation Sidewall Samples

Total Area of Sidewalls (ft^2)	*Number of Samples*
< 500	4
500 < 1,000	5
1,000 < 1,500	6
1,500 < 2,000	7
2,000 < 3,000	8
3,000 < 4,000	9
> 4,000	1 sample per 45 lineal feet of sidewall

Considerations for Biased Sampling

"Biased" sampling involves collecting soil samples from areas most likely to still exceed cleanup criteria. Specific considerations for biasing sample locations are described in detail in Section 1.2.1 under *FACILITY* characterization. The fundamental approaches for biasing sample location are basically the same for verifying remediation; however, the biased sampling is now focused on post-remediation activities.

A site may have an appropriate number of samples collected for verification, but if the samples are not collected from the appropriate locations and adequately reported remediation may not be considered adequate. The location of the sample collection points relies on site-specific analysis of the *RELEASE* or contaminant distribution and the soil types encountered in the excavation. For example, when selecting verification sample locations in an excavation, more extensive verification sampling should be completed on the south side of the excavation if a leak was confirmed on the south side of a tank. It would be incorrect to sample the north side of an excavation pit as extensively as the south side when the leak was confirmed on the south side of the tank.

Sampling and analyzing the locations most likely to have contaminants can minimize the number of samples needed to verify remediation is complete. Professional judgment and site-specific knowledge are required for selection of biased sampling locations. The verification report must accurately locate and describe all sample locations. A thorough justification must be documented for each sample location explaining the rationale used to select the location.

1.3.2 Selecting Numbers and Locations of Soil Verification Samples for Ex Situ Remedies

Verification samples from ex situ remediation activities can also be collected in a biased manner. Again, sampling and analyzing the locations most likely to have contaminant concentrations above Part 201 cleanup criteria can minimize the number of samples needed to verify remediation is complete. However, biased verification soil sample results must generally be compared to cleanup criteria on a point-by-point basis. A statistical analysis of data generated from biased sampling is generally <u>not</u> appropriate.

Number of Samples

The number of verification soil samples to be collected from a soil pile should be based on the volume of the soil pile. The following table provides recommended numbers of verification samples for biased sampling.

Table 1.3 Number of Samples for Ex Situ Remedies

Volume (cubic yards)	0-25	26-100	101-500	501-1,000	1,001-2,000	> 2,000
Number of samples (depending on basis of bias)	3-4	6-8	8-10	10-12	13-15	15 + 3 for every additional 500 cubic yards

If it is demonstrated that concentrations of hazardous substances in the soil under consideration represent a single, homogeneous population, the effectiveness of ex situ soil remedies may be verified by three-dimensional *RANDOM* soil sampling. Refer to Section 2.2 of Sampling Strategies for recommended statistical sampling strategies. Because these strategies are two dimensional, a vertical component must be added. Certain ex situ remedies, such as bio-piles or aboveground vapor extraction, may be more amenable to statistical sampling strategies or batch sampling. Any *PROPOSED* sampling strategy for ex situ remedies should be pre-approved by the DEQ.

Considerations for Biased Sampling

Specific considerations for biasing sample locations are described in detail in Section 1.2.1 under *FACILITY* characterization. The fundamental approaches for biasing sample location are basically the same for verifying remediation; however, the biased sampling is now focused on post-remediation activities.

1.3.3 Selecting Numbers and Locations of Soil Verification Samples for In Situ Remedies

In situ verification soil sampling is required to evaluate the effectiveness of the remedy or to *PROPOSE* closure upon completion of an in situ soil corrective action (e.g., soil vapor extraction, bioventing, in situ bioremediation, and natural attenuation). The purpose of the in situ verification soil sampling is to demonstrate that the entire volume of contaminated soil is below Part 201 cleanup criteria. Because the in situ verification soil sampling is characterizing a volume of soil, additional samples will be required beyond the number of sidewall and floor samples recommended above for excavations, as described below.

Biased verification soil sample results must generally be compared to cleanup criteria on a point-by-point basis. A statistical analysis of data generated from biased sampling is generally <u>not</u> appropriate.

Number of Sample Locations

The number of biased sampling locations should be selected using Tables 1.1 and 1.2 shown in Section 1.3.1 (Excavation Floor Samples and Excavation Sidewall Samples, respectively). Table 1.2 is also considered since it is important to verify remediation around the lateral extent of the remediated area.

Statistical sampling methods are generally recommended for areas larger than 10,890 ft^2. These methods are described in Section 2.2 of Sampling Strategies. Because these strategies are two dimensional, a vertical component must be added. Any *PROPOSED* sampling strategy for in situ remedies should be pre-approved by the DEQ.

Considerations for Biased Sampling

Specific considerations for biasing sample locations are described in detail in Section 1.2.1 under *FACILITY* characterization. The fundamental approaches for biasing sample location are basically the same for verifying remediation; however, the biased sampling is now focused on post-remediation activities.

A biased sampling strategy should also be used to select the vertical sampling intervals that are the most likely to still contain contaminant concentrations above Part 201 cleanup criteria. The following areas should be considered for vertical sampling intervals: areas of probable high contaminant concentrations (based on previous sample results, field observations, and/or the field screening instrumentation) and areas where the flow of air, water and/or nutrients will be impeded (e.g., low permeability lenses and the capillary fringe zone). If air flow modeling indicates the possible presence of stagnation zones, these areas should be sampled.

At least one sample should be collected from each five feet of the verification sample boring, with the exception of borings that are advanced through uncontaminated backfill. Verification soil samples are not required from uncontaminated backfill material. If there is no basis for further biasing the sample from within a five-foot interval, then the five-foot interval may be subdivided into six-inch intervals, and an interval *RANDOMLY* selected for sampling.

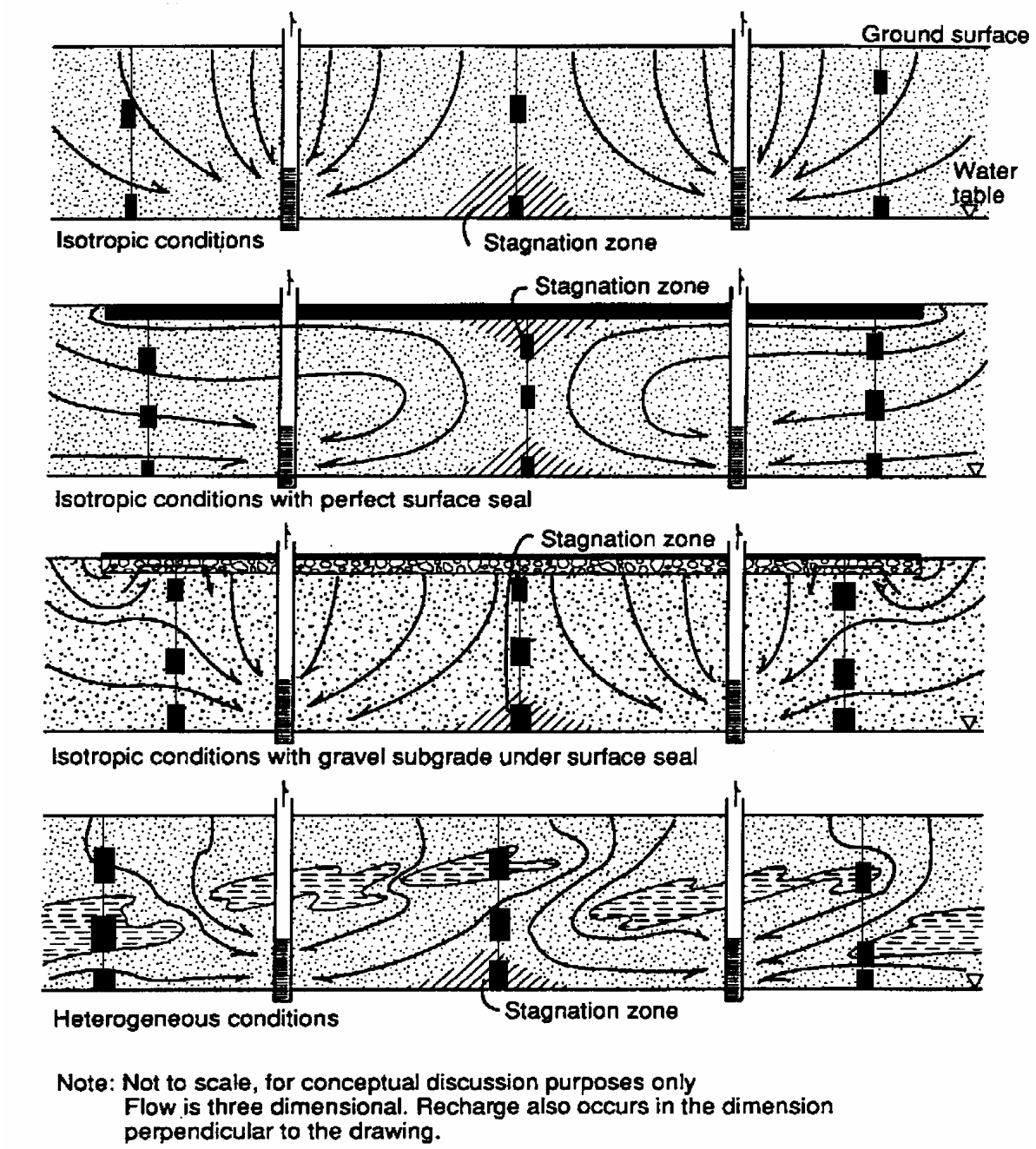
The verification soil borings must extend at least as far as the known depth of the soil contamination. If a confining layer is determined to be the lower boundary of the contamination (as should have already been determined during the investigation phase), at least one soil sample should be collected from the top of the lower confining layer to verify this. If the confining layer is not the lower boundary of the contamination, then a sampling of this layer and below must be conducted in relation to the remediation activity.

Other Considerations

Partial dewatering of an aquifer can allow soil vapor extraction and/or bioventing systems to remediate the residual soil contamination below the water table. If the groundwater potentiometric surface is being lowered during remediation, then the verification soil samples should be collected while the soils in question are still dewatered. The groundwater dewatering system should then be discontinued and verification groundwater samples collected.

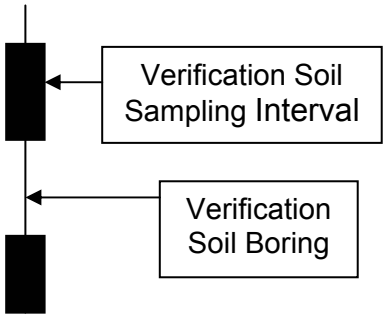
Examples of biased strategies for vertical sampling are shown on the following page.

Example 1.2 Examples of Biased Vertical Sampling Strategies



Note: Not to scale, for conceptual discussion purposes only
Flow is three dimensional. Recharge also occurs in the dimension perpendicular to the drawing.

(Revised from WDNR, 1993)



1.4 COMPARISON TO CRITERIA

1.4.1 Demonstrating Compliance on a Point-by-Point Basis

Use of biased sampling may require fewer samples to demonstrate compliance than statistical or probabilistic approaches. However, a limitation to biased sampling is that unexpected areas of contamination will not be identified. Consequently, statistical sampling should often be used to supplement biased sampling.

Analytical data generated using biased sampling strategies must generally be compared to Part 201 criteria on a point-by-point basis and individual exceedances noted. When point-by-point comparisons are made, professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of a hazardous substance.

Interpretation of Analytical Results

If all samples in an area are below cleanup criteria based on biased sampling and the area is believed to be adequately characterized, the investigation for this area may be complete. A thorough justification must be documented for each sample location explaining the rationale used to select the location. Adequate documentation of all sample locations must also be provided with respect to known or suspected *RELEASE* areas.

If one or more samples contain contaminant concentrations above cleanup criteria, this may indicate one or more of the following:

- additional site characterization is necessary to better understand the exceedance (e.g., if no exceedances were expected in an area/depth), and possibly a change in sampling strategy from biased to statistical (e.g., identification of an unexpected Hot Spot, unless documented to be a localized Release, may necessitate statistical sampling with the objective of identifying similar Hot Spots (see Section 2.2.1.1);
- vertical and horizontal delineation of elevated concentrations in the area of the biased sample location is necessary;
- alternate approaches should be considered to demonstrate appropriate pathway protection (e.g., leach testing, if a protection of groundwater criterion is exceeded); and/or
- remediation (or further remediation) is necessary.

Statistical analyses of data from biased sampling is generally not appropriate. This is due to the underlying assumptions of most statistical methods used to compare *FACILITY* data to cleanup criteria. One underlying assumption is that the data being evaluated were obtained through *RANDOM* sampling of a single population that can be described by a single statistical distribution (e.g., a normal distribution with a mean of 3.6 and a standard deviation of 0.78).

If statistical sampling is also completed in an area that was previously sampled using a biased approach, it may be appropriate to combine analytical results from the statistical sampling with some or even all of the biased sampling results in a statistical analysis. See Section 2.4.2 of Sampling Strategies for further detail. However, it is first necessary to address the considerations summarized in Section 2.4.1.

1.4.2 Comparison of *FACILITY* Data to *FACILITY-SPECIFIC BACKGROUND* Concentrations

When Part 201 criteria are established as *BACKGROUND* concentrations, the objective becomes to determine whether the *FACILITY* concentrations are significantly higher than *BACKGROUND* concentrations for a hazardous substance. To make this determination in most cases, *FACILITY* data will be compared to *FACILITY-SPECIFIC BACKGROUND* concentrations on a point-by-point basis. That is, concentrations of each hazardous substance in each *FACILITY* sample will be compared to directly to the *FACILITY-SPECIFIC BACKGROUND* concentration and individual exceedances will be noted. This will most often be the case when *FACILITY* samples are collected in a biased manner. However, it may also be necessary to compare *FACILITY* data collected using statistical sampling strategies to *FACILITY-SPECIFIC BACKGROUND* concentrations on a point-by-point basis.

For information on establishment of *BACKGROUND* concentrations, see Chapter 4 of the tabbed section titled, “Statistical Methods.”

1.4.3 Recommended Summary Report Format for Biased Sampling

Summary Reports for sites utilizing biased sampling strategies must identify the number and location of samples and provide the justification of the sample locations selected. The Summary Report should contain site maps and cross-sections, drawn to scale, which depict the area and volume of contaminated soil; any remediation area(s); the locations of any air/fluid injection and/or extraction wells with their estimated zones of influence; the sampling grids; and the soil boring/sample locations and vertical sampling intervals. The Summary Report should also include the calculations for determining the sampling grid intervals and a statement documenting the sampling strategy utilized for selection of the sampling locations.

The list below identifies items recommended to properly evaluate a closure certification. These items are not "absolutes." Other information or substitutions may be provided which technically justify and certify a "clean closure."

The report must include the following:

1. MAP(s) and CROSS SECTIONS
   Provide a scaled map of the investigated and remediated area (i.e. the estimated *RELEASE* area, or floor and walls of an excavation, or the vertical and horizontal area treated for in situ remediations, etc.) with sample locations identified. If a cross section is utilized to display the remediation activities and data, it should show the relation of key elevations, depict the stratigraphy, fractures, soil types, discolorations, unusual characteristics, possibly indicate the original *RELEASE* source location, sample locations/elevations, etc.

2. SAMPLE LOCATION RATIONALE
   - All sample locations including *BACKGROUND* samples, investigative samples, and/or verification samples
   - Sample depths
   - Sample collection procedures
   - Describe basis of sampling biases and the rationale used for collecting each sample (e.g., clay fractures, discolored soil, location of leak in tank)

3. DATA ANALYSES
   - Analytical parameters
   - Analytical methods used
   - Method detection limits
   - Laboratory Quality Assurance/Quality Control
   - Summary of decontamination procedures

4. STATISTICAL ANALYSIS OF BACKGROUND DATA, IF APPLICABLE
   - Lab results/data tabulation
   - Complete statistical calculations as described in Chapters 1, 2, and 4 of the tabbed section titled, "Statistical Methods"
   - Narrative explanation of *BACKGROUND* concentrations
   - Point-by-point comparisons of *FACILITY* data to cleanup criteria and/or *BACKGROUND* concentrations

5. CONCLUSIONS
   This portion of the report should include a summary of activities and final conclusions, accounting for the work and testing completed and how completed activity(ies) fit in with the site-wide remediation plan (i.e. land use issues, possible closure requirements, whether there is a Remedial Action Plan, resumption of operations, etc.)

1.5 WASTE CHARACTERIZATION

Characterization of wastes for the purpose of disposal must often be addressed at Part 201 *FACILITIES*. The regulatory context for waste characterization is different than the context described in previous sections of this chapter, however. Sections 1.1 through 1.4 describe sampling and analysis of data for the purpose of demonstrating compliance under Part 201. Waste characterization is regulated under Parts 111 and 115. Consequently, sampling strategies and statistical analysis of data for this purpose have been described in a separate tabbed section titled, "Waste Characterization."

CHAPTER 2: STATISTICAL SAMPLING STRATEGIES

2.1 INTRODUCTION TO STATISTICAL SAMPLING

Statistical sampling, also referred to as unbiased or probabilistic sampling, is based on the theory of *RANDOM* chance probabilities in order to choose samples which are representative of a given area. The probability of selecting any sampling location is equal or at least known as with stratified sampling designs. Because sampler bias is not of concern, the error in data accuracy of a *RANDOM* sampling scheme can be objectively measured. Furthermore, knowledge of the contaminant distribution is not always necessary depending on the sampling objective.

In some cases it is preferable to choose statistical sampling strategies over biased sampling strategies since they can be used to produce increased data accuracy while eliminating sampler bias. This will depend on the purpose of sampling and the amount of available information with which to bias sampling. In some cases, a combination of approaches will yield the most comprehensive information.

Several statistical sampling strategies can be used to produce an unbiased, representative sampling program. The principles behind the three basic types of *RANDOM* sampling and the situations for which they are best suited are described below. To achieve true *RANDOM* sampling, composite sampling is not acceptable.

1. ***Simple RANDOM sampling*** is a method that requires little or no prior knowledge of material distribution. It relies on *RANDOM* chance probability theory – where each sampling location has an equal and known probability of being selected. In this way, sampling error can be accurately estimated. Often, the area of interest is sectioned into a two- or three-dimensional grid pattern and *RANDOM* coordinates are chosen for sampling.

2. ***Systematic RANDOM sampling*** is an extension of simple *RANDOM* sampling that may produce a more efficient sampling survey. It can be more efficient by reducing the sampling error while maintaining the sample number, or by reducing the number of samples needed to achieve a specified sampling error, or by reducing the cost of collection. This method also requires little or no knowledge about the waste distribution, but bias and imprecision can be introduced if unseen trends or cycles exist. Two methods used to select sample locations under this method follow.

    A) *RANDOMLY* select a transect or transects and sample at pre-selected intervals.

    B) Pre-select both the transect or transects and the sampling interval and starting from a *RANDOMLY* selected point. This is the method used most throughout this chapter.

3. ***Stratified RANDOM sampling*** requires some knowledge about the waste distribution. When stratification is known or suspected, sampling efficiency can be improved by dividing the material into strata that are more homogeneous than the total area. Simple or systematic *RANDOM* sampling techniques can then be used to sample each stratum independently. Each stratum is divided into a grid pattern and the sampling points are selected *RANDOMLY*. If the area is vertically stratified, the sampling points in each stratum are selected *RANDOMLY* and then selected depths are sampled. If the area is horizontally stratified, the sampling

points within each stratum are selected *RANDOMLY*, but the total depth is sampled. An analysis of variance (ANOVA) may be used to determine if the analytical results differ significantly among strata. This can help evaluate whether use of stratified *RANDOM* sampling was necessary and statistically valid. When the volumes of the strata differ or the number of samples within each stratum differs, the results must be weighed appropriately to avoid bias if the data are to be combined in order to draw conclusions.

Of these methods, Systematic *RANDOM* sampling is generally recommended for each sampling purpose described in this chapter. As noted above, this approach is often the most efficient since it involves collection of samples at equal intervals, simplifying the location of samples in the field. Furthermore, systematic *RANDOM* sampling can serve many purposes. When samples are collected on a regular grid interval, conclusions can be drawn about the size of a *HOT SPOT* likely to be identified (or missed), as described in Section 2.1. Furthermore, because the sampling locations are *RANDOMIZED* through systematic *RANDOM* sampling (i.e., by *RANDOMLY* selecting transects and/or the initial sampling point), it may be appropriate to include the analytical results in a statistical analysis for the purpose of comparison to Part 201 cleanup criteria. However, the considerations described in Section 2.4.1 must first be addressed.

Three methods for establishing grids intervals for systematic *RANDOM* sampling are described. Selection of the appropriate method will depend on the purpose for sampling.

1) **Establish a grid interval based on the size of a *HOT SPOT* to be identified.** *HOT SPOT* shape and size and the level of confidence for finding the *HOT SPOT* are prespecified in this approach. This method is described in Section 2.2 for the purpose of *FACILITY* characterization. See Section 2.2.1.1 for details.
2) **Establish a grid interval based on the size of the area to be sampled.** This approach was originally presented in the medium- to large-site portion of the April 1994 MDEQ guidance document titled, “Verification of Soil Remediation (Revision 1)”. This method is described in both Sections 2.2 and 2.3 since it may be useful for either *FACILITY* characterization or verification of remediation. See Section 2.2.1.2 and 2.3.1 for details.
3) **Collect *RANDOM* samples for the purpose of demonstrating compliance with Part 201 criteria using statistics.** This method involves collection of a prespecified number of samples (minimum of nine) for the purpose of estimating a *REPRESENTATIVE CONCENTRATION* for comparison to criteria. As described in Section 2.4, use of this method presumes that the area has already been adequately characterized and represents a single homogeneous population that can be described by a single statistical distribution.

It is often necessary to use a combination of sampling strategies. For example, biased sampling is commonly completed before statistical sampling strategies are employed. Statistical sampling strategies should be considered to supplement characterization. Once characterization is complete, it may be necessary to collect additional samples for the purpose of using statistics to estimate a *REPRESENTATIVE CONCENTRATION* for comparison to criteria.

When conducting the statistical analysis, it may be appropriate to combine some or all of the data from biased sampling with data collected using statistical sampling strategies. See Section 2.4 for further detail. See also the tabbed section titled, “Statistical Guidesheets” for key considerations which must be addressed before a statistical analysis is conducted to compare data to Part 201 criteria.

Statistical sampling strategies require collection of discrete soil samples. Compositing of samples is not accepted without prior DEQ approval.

The remainder of this chapter describes statistical sampling strategies for each of the following sampling objectives:

- *FACILITY* characterization
- Verification of remediation
- Comparison to criteria for demonstration of compliance using statistics
- Waste characterization

Chapter 1 of Sampling Strategies provides considerations for selecting biased sample locations for each of these objectives.

2.2 *FACILITY* CHARACTERIZATION

Statistical sampling strategies may be useful as part of an overall sampling plan for *FACILITY* characterization. This section provides several statistical sampling strategies for this purpose.

In addition to the investigation of *RELEASE* areas, *FACILITY* characterization often includes the collection of samples for the purpose of representing *FACILITY-SPECIFIC BACKGROUND* conditions. Sampling for the identification of *RELEASE* areas is described in Section 2.2.1. Sampling to characterize *FACILITY-SPECIFIC BACKGROUND* conditions is described in Section 2.2.2.

2.2.1 *RELEASE* Area(s)

An important goal of *FACILITY* characterization is to identify existing environmental conditions in areas potentially affected by *RELEASE*s of hazardous substances. This includes identifying the nature and extent of contamination and whether *HOT SPOTS* are present in these areas. The answers to these questions will play a role in subsequent site evaluations and/or actions.

HOT SPOTS

For the purpose of evaluating data from Part 201 *FACILITIES*, a *HOT SPOT* is defined as:

> *Two or more adjacent sample locations in reasonably close proximity at which concentrations are sufficiently above criteria and surrounding location (i.e., spatially correlated concentrations sufficiently above criteria) to indicate that they:*
>
> – *represent a different statistical population and*
> – *pose a potential risk that should not be masked by a statistical analysis.*

Professional judgment may be used to determine if the magnitude of concentrations and/or the number and proximity of spatially correlated samples above criteria are sufficient to classify an area as a *HOT SPOT*. That is, the data should support the conclusion that the samples reflect a second statistical population influenced by a localized *RELEASE*, such as a tank spill, resulting in concentrations above criteria. Spatially correlated concentrations below criteria may also exist; however, these will not be classified as *HOT SPOTS* for the purpose of statistical analysis. Particular consideration should be given to contaminants that are present above soil saturation

(Csat) screening levels and contaminants for which criteria are based on acute toxicological effects and/or physical hazards.

A single sample location may represent a potential *HOT SPOT*, or an area at which concentrations are sufficiently above criteria to necessitate additional sampling to determine if a *HOT SPOT* exists. Once again, professional judgment may be used by staff to determine if the magnitude of the concentration is sufficient to warrant additional sampling.

To identify *HOT SPOTS*, data should be qualitatively evaluated for spatial correlation, or patterns indicating that high or low concentrations generally occur in localized areas. Spatial correlation may exist horizontally and/or vertically. Spatial correlation may also be seen along geological bedding planes or between different lithologies. For example, contaminants could accumulate on top of a sloping clay layer, resulting in spatial correlation even though depth to contamination will vary.

HOT SPOT areas identified for one exposure pathway/condition may not represent *HOT SPOTS* for another exposure pathway/condition due to differences in criteria, *EXPOSURE UNITS* sizes, and significance of exceedances.

If *HOT SPOTS* are present, they must be addressed independent of other non-*HOT SPOT* areas, possibly through remediation or mitigation of exposures through institutional controls. A statistical analysis combining *HOT SPOT* data with non-*HOT SPOT* data is not appropriate.

Considerations for Statistical Sampling

As described in Chapter 1, sampling strategies for *FACILITY* characterization should incorporate information on known or suspected areas of contamination whenever this information is available. Often, biased sampling is conducted for this purpose. However, use of biased sampling to demonstrate compliance with Part 201 criteria requires sufficient knowledge of existing conditions, historic activities, or field indicators (e.g., visual, olfactory, or field screening instrumentation) and thorough documentation of the selection of sampling locations based on this information. Consequently, there is a limitation that must be recognized when using biased sampling for the purpose of *FACILITY* characterization: the resulting information is only as complete and accurate as the information used to select sample locations.

For example, a previously undocumented area of contamination may be present; however, this area may be missed using a biased sampling approach, particularly if there are no observable field indications that the contamination exists. Furthermore, if biased sampling is conducted in an area of known or suspected contamination, areas of contamination can still be missed if the information used to select sample locations is not accurate or sufficiently detailed. In these instances, statistical sampling should be used to supplement biased sampling.

Example 2.1 Example of When Statistical Sampling Strategies Should Be Considered

It is known that waste materials were placed in an area. However, there is limited documentation regarding the exact locations where the materials were placed. Some field observations can be made, but they cannot be fully relied upon due to the nature of the materials or the condition of the area (e.g., overgrown with dense vegetation). Some biased samples may be collected based on the limited knowledge of environmental conditions, but it would be necessary to supplement with statistical sampling of this area to evaluate in an unbiased manner whether *HOT SPOTS* are present.

General Recommendations

In general, the following recommendations are being made with regard to selection of sampling strategies for *FACILITY* characterization:

- A combination of sampling strategies should be considered for the purpose of *FACILITY* characterization.
- Biased sampling should be used whenever information is available with which to reliably bias sample locations.
- Systematic *RANDOM* sampling should be considered to supplement data obtained from most biased sampling programs. The number of samples and/or grid interval necessary to supplement biased sampling results will require use of professional judgment depending on the level of detail and accuracy of existing information used to bias sample locations.
- Systematic *RANDOM* sampling should also be conducted in areas believed to be unimpacted. Professional judgment will be necessary to determine the number of samples and/or the grid interval necessary to confirm that the area(s) meet cleanup criteria. For example, only a small number of samples may be needed if sufficiently detailed and accurate information exists to support that the area is unimpacted.

The *HOT SPOT* identification techniques described in Section 2.2.1.1 may be used to determine the required grid interval for finding a *HOT SPOT* of a given size and shape with a prespecified level of confidence. Section 2.2.1.2 provides formulas that can be used to determine a grid interval based on the size of the area to be sampled.

A benefit when using statistical sampling strategies, either alone or in conjunction with biased sampling, is that it may be appropriate to compare resulting data to Part 201 criteria using statistics. Furthermore, it may be appropriate to combine analytical results from statistical sampling with some or even all of the biased sampling results in a statistical analysis as described in Section 2.4.2 of this chapter. However, considerations summarized in Section 2.4.1 must first be addressed.

Once sampling has been conducted for the purpose of characterization, a judgment must be made as to whether a site has been adequately characterized. This judgment is generally subjective based upon the body of data collected and knowledge of site conditions. Furthermore, a *FACILITY* that was thought to be adequately characterized may need supplemental characterization based on data generated through subsequent sampling (e.g., when sampling for the purpose of estimating a *REPRESENTATIVE CONCENTRATION*, as described in Section 2.4.2.) This may be due to the discovery of unexpected results such as previously unidentified *HOT SPOTS*.

PROPOSALS for grid strategies other than those presented in this chapter may be submitted for DEQ review and approval on a case-by-case basis.

2.2.1.1 Sampling Grids for *HOT SPOT* Identification

Statistical tools are available that may be used to assist in the identification of *HOT SPOTS* during *FACILITY* characterization, particularly when there is limited knowledge about the location of *RELEASE* areas. These tools will be most useful to supplement biased sampling or for locating relatively large *HOT SPOTS.* In addition, these techniques may be useful for evaluating trade-offs between sampling costs and the probability of locating *HOT SPOTS* of a given size. For example, financial constraints may limit the number of samples to be collected from a property. The statistical methods for identifying *HOT SPOTS* described in this section can be used to evaluate the size of the *HOT SPOT* likely to be identified (or missed), given that a specified number of samples are collected along a sampling grid. Furthermore, when sampling is conducted using a grid system, these methods may give some perspective on the likelihood that *HOT SPOTS* exist which have not been found.

The methods described in this section may not be practical if the goal is to locate relatively small *HOT SPOTS* over large areas. Large numbers of samples may be necessary to locate small *HOT SPOTS* with an acceptable level of confidence. **It is not expected that these statistically-based tools will be used to identify small *HOT SPOTS* in this manner.**

Use of the statistical tools described in this section should not replace the use of professional judgment for characterization and/or locating *HOT SPOTS*.

Statistical Tools for Identifying *HOT SPOTS*

Statistical methods for identifying *HOT SPOTS* may be used to answer the following questions (Gilbert, 1987):

1. What size grid interval is necessary to locate a *HOT SPOT* with a specified level of confidence?
2. If a grid interval is pre-specified, what is the probability of locating a *HOT SPOT* of a specific size and shape?
3. What is the probability that a *HOT SPOT* exists when no *HOT SPOTS* were found by sampling on a grid?

Questions 2 and 3 may be of particular interest when sampling is conducted using the method described in Section 2.4.2, "*RANDOM* Sampling of *EXPOSURE UNITS*," since the number of samples (i.e., a minimum of nine) and the corresponding grid interval are predetermined. The size of a *HOT SPOT* likely to be identified (or missed) using this sampling method may be evaluated.

Procedures that can be used for *HOT SPOT* identification and detection are described in "Chapter 10: Locating *HOT SPOTS*" in Gilbert's book, "Statistical Methods for Environmental Pollution Monitoring" (1987). The methods outlined in Chapter 10 are based upon several important assumptions. These include:

- the *HOT SPOT* is circular or elliptical in shape
- samples are collected on a square, rectangular, or triangular grid
- contaminant concentration levels constituting a *HOT SPOT* are clearly defined (e.g., sufficiently above Part 201 criteria; see definition in Section 2.2.1)
- there are no measurement misclassification errors – that is, no errors are made in deciding when a *HOT SPOT* has been found

The method for identifying *HOT SPOTS* described by Gilbert does not incorporate a vertical component. For subsurface *HOT SPOTS*, the method targets the projection of the *HOT SPOT* to the surface. This is a limitation when applying this method for *FACILITY* characterization since many *RELEASE* areas may be present below the surface. Consequently, any sampling plan for identifying *HOT SPOTS* must also incorporate a vertical component.

A brief description of the method follows. For details, see Chapter 10 of Gilbert (1987). For the sake of simplicity, the square sampling grids described in Section 2.4.2, "*RANDOM* Sampling of *EXPOSURE UNITS*," are recommended. The equations and graphs in Gilbert (1987) provide the necessary tools to answer the three questions listed above.

The method for locating *HOT SPOTS* described by Gilbert generally involves specifying:

- the shape of the *HOT SPOT,*
- the allowable probability that a *HOT SPOT* will be missed,
- the spacing of the sampling grid,
- some combination of the above, depending on the objective of the analysis.

Then a graph and an equation are used to determine the quantity of interest. Overall, Gilbert's (1987) method is simple and easy to use, and it provides a sound, defensible technique for designing or evaluating a sampling program for *HOT SPOT* detection.

Example 2.2 Use of *HOT SPOT* Identification Techniques to Select a Grid Interval for Finding a Pre-Specified *HOT SPOT*

Suppose that we want to be able to detect a circular *HOT SPOT* with a radius of 10 ft (diameter of 20 ft) with 90% probability in a rectangular (80 x 125 ft) *EXPOSURE UNIT*. Using a square grid, what size of grid interval and approximately how many samples would be required to find this *HOT SPOT* with the specified probability?

Using Gilbert (1987), the grid interval should be about 18 ft. Consequently, approximately 31 samples would be required to cover this *EXPOSURE UNIT* using systematic sampling with a grid interval of 18 ft.

Example 2.3 Use of *HOT SPOT* Identification Techniques to Identify the Size of a *HOT SPOT* That Can Be Found Using a Pre-Specified Sampling Grid

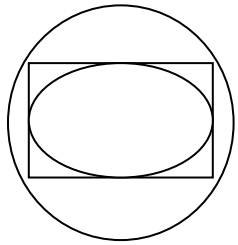
Now suppose that nine samples are to be collected from a square (300 x 300 ft) *EXPOSURE UNIT* using systematic sampling. The objective of the samples is to estimate a *REPRESENTATIVE CONCENTRATION* for comparison to criteria. Using the equation provided in the Section 2.4.2, "*RANDOM* Sampling of *EXPOSURE UNITS*," the approximate grid interval is 100 ft. using a square sampling grid. Assuming that a potential *HOT SPOT* is circular, what size *HOT SPOT* would be detected with 80% probability?

Given these specifications, the methods in Gilbert (1987) suggest that a circular *HOT SPOT* with a radius of 50 ft (diameter of 100 ft) would be detected 80% of the time using a 100 ft grid interval. A circular *HOT SPOT* with a radius of 70 ft (diameter of 140 ft) would be detected 100% of the time using a 100 ft grid interval.

It is not surprising that the grid intervals in the above examples are close in size to the intended target.

A limitation of the method described by Gilbert (1987) is that the *HOT SPOT* must be circular or elliptical in shape. But what about when the *HOT SPOT* is square or rectangular in shape? One option is to evaluate the objective considering a circle constructed around the hypothesized square or rectangular *HOT SPOT* and an ellipse fitting inside the *HOT SPOT* (Figure 2.1). Using the Gilbert (1987) method with the circle and the ellipse, bounds can be obtained for the quantity of interest.

Figure 2.1 Concentric Ellipse and Circle Bounding the Rectangular *HOT SPOT*



Example 2.4 Use of *HOT SPOT* Identification Techniques to Select a Grid Interval for Finding a Rectangular *HOT SPOT*

Suppose that you were designing a sampling plan for a 300 x 300 ft square site and wanted to find a 20 x 40 ft rectangular *HOT SPOT* with a probability of 80%. Using the methods in Gilbert (1987), a grid interval of 26.7 ft (approximately 126 systematic samples) is required to detect the small ellipse and an interval of 44.7 ft (approximately 45 systematic samples) is required to detect the larger circle with a probability of 80%. To find the rectangular *HOT SPOT*, the appropriate grid interval and number of samples lies somewhere between these bounds. The radius of the circle can be determined using the following equation:

$$Radius = \frac{\sqrt{w^2 + l^2}}{2}$$

where w is the width of the rectangle and l is the length of the rectangle.

Setting the Grid

After the grid interval is calculated, it is recommended that a scaled grid overlay be made to superimpose on a map of the area. A point (usually the southwest corner) should be designated as the (0,0) coordinate. The grid can then be adjusted to maximize sampling coverage. Some grid adjustment may be necessary for unusually shaped areas.

Variations on Basic Approach

When the goal is to identify *HOT SPOTS*, further *RANDOMIZATION* of sample locations as described in Section 2.2.1.2 is generally not appropriate. Grid stations must be equally spaced to be able to draw conclusions about the size of the *HOT SPOT* that can be identified.

Available Software for Identification of *HOT SPOTS*

Software tools are also available that can be used to assist in the design of sampling plans for *HOT SPOT* detection. Visual Sampling Plan (VSP) and Fully-Integrated Environmental Location Decision Support system (FIELDS) are two of these programs. VSP is a freeware downloadable program developed by Richard Gilbert and other staff of the Pacific Northwest National Laboratory and is available at http://dqo.pnl.gov/vsp. Once a site map and a sampling plan have been imported or generated, VSP has the capability of identifying the largest unsampled *HOT SPOT* that may be present. In addition, it can determine the number of samples needed to obtain a desired level of precision, the total cost of various sampling plans, and the locations that should be sampled based on *RANDOM* or systematic sampling.

The FIELDS program is also freeware, but the program disk must be requested (see http://www.epa.gov/region5fields/htm/software.htm for more information). FIELDS offers many of the same sampling plan design capabilities (determining the number of samples, grid intervals, sample locations, and unsampled *HOT SPOT* sizes) with additional capabilities for spatial interpolation and modeling. However, ArcView (a Geographical Information System program) is required to run FIELDS. Because of this, FIELDS may be of limited utility for smaller-scale site assessments or for those without access to ArcView.

2.2.1.2 Sampling Grid Based on Size of Area to be Sampled

The equations and tables in this section provide a simple basis for establishing a grid system to facilitate unbiased selection of sampling points and sample coverage proportional to the area being sampled.

Basic Approach

This method for calculating grid intervals provides a grid point representation that is proportioned to the size of the area being sampled. The following equations provide grid interval estimates for small, medium and large sites, respectively. Small sites are defined as less than 1/4 acre (i.e., < 1/4 acre). Medium sized sites range from larger than 1/4 acre to three acres. Large sites are those which are more than three acres in size. Once a grid interval is determined, a grid system can established over the area to be sampled.

$$small\ \ site \qquad \frac{\sqrt{A/\pi}}{2} = GI$$

$$medium\ \ site \qquad \frac{\sqrt{A/\pi}}{4} = GI$$

$$large\ \ site \qquad \sqrt{\frac{A\pi}{SF}} = GI$$

where: A = area to be grid (ft^2)
GI = grid interval
SF = Site Factor, length of area to be grid (unitless)

To simplify this application, the following chart may be used based on an average size range of sites (one acre = 43,560 ft^2). The approximate grid ranges are provided as a quick check on numbers generated for specific sites using the above formulas.

Table 2.1 Approximate Grid Ranges Based on Size of Area to be Sampled

Acreage of Area to be Sampled	*Square Feet*	*≈ Grid Interval Ranges*
up to 0.25 (small)	up to 10,890	0-29 ft
0.25-3.00 (medium)	10,890-130,680	15-50 ft
3.0 and over (large)	130,680 +	30 ft plus

Setting the Grid

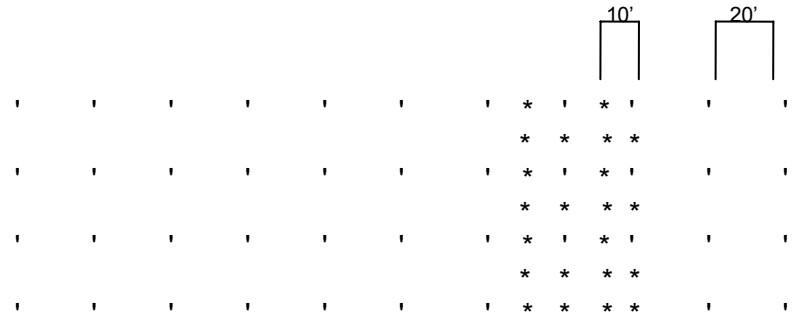
After the grid interval is calculated, it is recommended that a scaled grid overlay be made to superimpose on a map of the area. A point (usually the southwest corner) should be designated as the (0,0) coordinate. The grid can then be adjusted to maximize sampling coverage. Some grid adjustment may be necessary for unusually shaped areas.

Variations on Basic Approach

1. Subgridding

It may be warranted to apply grids with different intervals portions of the area to be sampled so that a proportional sampling can be focused on suspect areas (such as sumps, tank leak areas, etc.).

Example 2.5 Subgridding

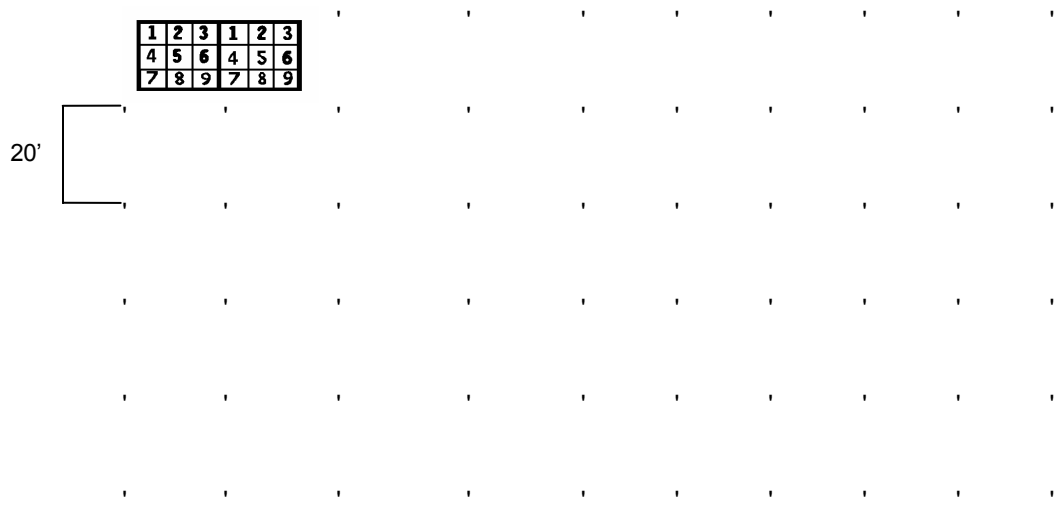


' = Area I Sample Station, 80' x 200', GI = 20'
* = Area II (subset of I) Sample Station, 30' x 50', GI = 10'

2. Further *RANDOMIZATION*

Sites that may have a patterned distribution of waste or contamination due to time sequence of filling, production sequences, or physical site conditions (i.e., furrows) may require a further *RANDOMIZATION* of sampling. In such cases, the following grid cell sampling format may be selected instead of using regular grid point stations. Each grid cell to be sampled may be divided into nine equal sized "subcells." Next, a *RANDOM* numbers table is used to select one of the nine subcells for sampling. The *RANDOM* numbers table can be used again to select a subcell for the next cell and so on.

Example 2.6 Further *RANDOMIZATION* Using Sampling Grids



Area = 120' x 200', GI = 20'

In the example above, a sampling grid was set up with grid point stations 20 ft apart using the appropriate formula. Two cells have been divided into nine subcells each to illustrate further *RANDOMIZATION*. Two *RANDOM* numbers were selected: 4 and 2. Samples should be collected from subcell #4 in the first cell and subcell #2 in the other cell. This process would be continued for all of the cells.

It would generally not be appropriate to apply this technique to the sampling grids described in Section 2.2.1.1. Because the goal of the sampling approach described in Section 2.2.1.1 is to identify *HOT SPOTS*, the grid stations must be equally spaced to be able to draw conclusions about the size of the *HOT SPOT* that can be identified.

2.2.2 *BACKGROUND*

Establishment of *FACILITY-SPECIFIC BACKGROUND* concentrations is described in Section 1.2.2. *FACILITY-SPECIFIC BACKGROUND* samples are not typically collected using statistical or probabilistic approaches. An effort is made to reflect the same natural conditions observed at a *FACILITY.* Consequently, *FACILITY-SPECIFIC BACKGROUND* data are somewhat biased. Although not described here, statistical or probabilistic methods could be incorporated into *FACILITY-SPECIFIC BACKGROUND* soil sampling. If multiple soil types or horizons are present, this could be accomplished through *RANDOM* sampling of each soil type or horizon independently.

2.3 VERIFICATION OF REMEDIATION

This section describes the use of statistical or probabilistic sampling strategies for the purpose of verifying remediation. When verifying remediation of medium- or large-sized areas, statistical sampling strategies are generally recommended. Medium-sized areas are generally defined as

areas ranging from 1/4 acre to three acres. Large areas are those which are larger than three acres.

For each type of remediation described below, statistical analyses for comparing verification data to Part 201 criteria may be appropriate if the data are generated using a statistical sampling approach. However, there are several key considerations which must first be addressed, as described in Section 2.4.1.

If a statistical analysis is used to compare verification data to Part 201 criteria, verification data from other areas should not generally be combined with data from remediated areas. In addition, verification of remediation should be demonstrated independently for each remediated area. If more than one area has been remediated (e.g., through excavation of soils), it is not appropriate to combine areas for the purpose of verifying remediation, regardless of the exposure pathway being evaluated. In the case of in situ or ex situ remediation, previous soil sample data should generally not be included with the new verification soil sample data for statistical analysis.

Compositing samples for verifying soil remediation is not acceptable without prior DEQ approval. When verifying a soil remediation is complete, contaminant concentrations will be low. Compositing may result in the contaminant concentrations not being representative of what remains in the soil. If concentrations are low, compositing may dilute the concentrations of a contaminant to below its threshold detection limit. Additionally, if contamination is indicated in a composited sample, the location of the contamination remains unknown.

2.3.1 Selecting Numbers and Locations of Verification Samples in Excavations

Verifying that contaminated soil is remediated by means of excavation requires collection of samples from the excavation bottom and sidewalls. It should be noted that "excavation" as used here refers only to that area excavated for remediation purposes and being verified to meet Part 201 cleanup criteria.

If sampling and statistical analysis indicate that Part 201 cleanup criteria have not been met, additional remediation will be required. If any portion of the soil in question appears to be causing the material to fail, the area above criteria may be identified through additional sampling and selectively removed. Subsequent sampling must be done to confirm that the remaining material meets Part 201 criteria.

Number of Samples

The number of samples to be collected will be determined based on application of a sampling grid to the area to be sampled. The method for establishing a grid interval described in Section 2.2.1.2 should generally be used. The “area” term in the formula used to determine the grid interval should reflect the total area of the excavation base and sidewalls.

A grid system should be established over the entire area of the excavation using the grid interval determined as above. The grid should extend over sidewalls and base. Grid placement may need to be adjusted to accommodate a minimum of at least one sample from each sidewall.

Sampling of Grid

If the use of statistics is appropriate for comparing soil verification data to Part 201 cleanup criteria, sampling of grids may include all of the grid stations or a phased subset of the total stations. A subset of grid stations may be created by assigning coordinates to all of the grid nodes and *RANDOMLY* selecting nodes for sampling using a *RANDOM* number generator or a *RANDOM* number table. A minimum of nine samples or 25% of the total number of grid points, whichever is larger, should be sampled to allow for a large enough data pool for statistical analysis. However, if statistics are to be used to compare verification data to Part 201 criteria, the considerations in Section 2.4.1 must also be addressed. If an excavation is divided into *EXPOSURE UNITS* to address a specific exposure pathway, a minimum of nine samples per *EXPOSURE UNIT* is necessary for statistical analysis. Consequently, it is advisable that extra samples also be collected and kept under proper chain of custody and storage procedures at the time of initial sampling to avoid an unnecessary return trip to the field.

Lambda Relationship

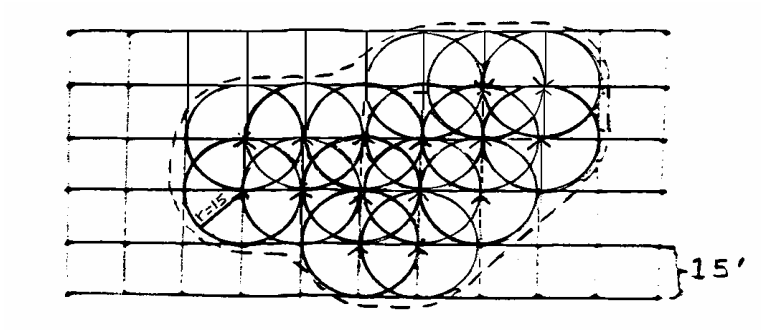
Methods for calculating the sample size requirements, including the Lambda Relationship, are presented in Section 3.2 of the tabbed section titled, “Statistical Methods.” These methods may be useful if an appropriately conducted statistical analysis results in a UCL for the mean that is above the cleanup criterion of interest, but the mean concentration is below. If this occurs, collection of additional samples may result in a lower UCL for the mean which is below the Part 201 criterion. The methods described in Section 3.2 can be used to estimate the number of additional samples that would be required, assuming that the data used in the original analysis were representative.

Grid Approach to Additional Remediation

One of the following two approaches may be used to help guide additional remediation through excavation. Selection of the appropriate method depends on whether verification samples were collected using a regular grid interval or if samples were further *RANDOMIZED* using subcells.

1. *Two-Dimensional Node Sampling Excavation Grid.* Verification sampling as described above will at times indicate that remediation is incomplete. Excavation of contaminated areas should be based on the established grid system interval. Where a subset of grid points has indicated that the entire area exceeds the cleanup, the nodes adjacent to the sampled nodes that are causing the exceedance should be sampled, and this process repeated until the "*HOT SPOTS*" requiring removal have been defined. The radius of excavation around the contaminated sample point(s) is equal to the grid interval (GI=r). Excavation depth is to the deepest point of contamination or to the depth where acceptable levels are anticipated. After excavation, the impacted point(s) must be resampled at their new elevations to verify that the area meets the selected cleanup criteria. If continued contamination is detected, the excavation format is repeated until a satisfactory result is obtained. Remediation of contaminated soil by excavation will be in accordance with the NREPA. The *PROPOSED* remedial action plan must be approved by the DEQ.

Example 2.7 Two-Dimensional Node Sampling Excavation Grid



GL = 150
A = 11,250
GI = 14.9

Sample
Station x
Contaminated Station
r = GI = 15 ft

2. *Two-Dimensional Subcell Sampling Excavation Grid*. The radius of excavation around a contaminated point may need to be adjusted to greater than the GI distance. This adjustment is due to the variable distances between sampling points.

2.3.2 Selecting Numbers and Locations of Soil Verification Samples for Ex Situ Remedies

The number of verification soil samples to be collected from a soil pile should be based on the volume of the soil pile. The table presented in Section 1.3.2 may be used for biased sampling.

If a statistical sampling strategy is to be used, a grid interval can be established for sampling of the soil pile. If the materials are heterogeneous and do not represent a single statistical distribution (e.g., a normal distribution with a mean of 3.6 and a standard deviation of 0.78), the sampling strategy described in Section 2.2.1.2 should be applied based on the size of a *HOT SPOT* to be identified. Since identification of *HOT SPOTS* is a two dimensional sampling technique, a vertical component must be added.

If it is demonstrated or reasonably concluded that concentrations of hazardous substances in the soil under consideration represent a single, homogeneous population, the effectiveness of ex situ soil remedies may be verified by three-dimensional *RANDOM* soil sampling. A minimum of nine samples should be collected from the waste pile if a statistical analysis is used for comparison to criteria. Additional samples may be necessary to adequately represent the variability of concentrations in the soil pile. Application of a sampling grid as described in Section 2.4 can be considered for placement of samples in the two-dimensional horizontal plane. A *RANDOM* numbers generator should be used to select the vertical sampling interval.

Fewer samples may be collected if hazardous substances concentrations are homogeneous; however, a point-by-point comparison to criteria must be made.

Certain ex situ remedies, such as bio-piles or aboveground vapor extraction, may be more amenable to statistical sampling strategies or batch sampling. Any *PROPOSED* sampling strategy for in situ or ex situ remedies should be pre-approved by the DEQ.

Statistical sampling strategies require discrete soil samples. Compositing of samples is not accepted without prior DEQ approval.

If ex situ treatment processes of contaminated soil or waste is used in the remediation, a sampling program for the process stream needs to be developed. The basis of this program is to get representative samples over time versus a spatial approach.

2.3.3 Selecting Numbers and Locations of Soil Verification Samples for In Situ Remedies

In situ verification soil sampling is required to evaluate the effectiveness of the remedy or to *PROPOSE* closure upon completion of an in situ soil corrective action (e.g., soil vapor extraction, bioventing, in situ bioremediation, and natural attenuation). The purpose of the in situ verification soil sampling is to demonstrate that the entire volume of contaminated soil is below Part 201 cleanup criteria. Because the in situ verification soil sampling is verifying remediation for a volume of soil, additional samples will be required beyond the number of sidewall and floor samples recommended above for excavations, as described below.

Number of Sample Locations

The number of samples to be collected will be determined based on application of a sampling grid over the area to be sampled. A grid interval can be established for sampling the volume of soil. If the materials are heterogeneous and do not represent a single statistical distribution (e.g., a normal distribution with a mean of 3.6 and a standard deviation of 0.78), the sampling strategies described in Sections 2.2.1.1 and 2.2.1.2 should be considered. Since these are two dimensional sampling techniques, a vertical component must be added.

However, if statistics are to be used to compare verification data to Part 201 criteria, the considerations in Section 2.4.1 must also be addressed. This may have an impact on the number of samples necessary to verify remediation. Fewer samples may be collected if hazardous substances concentrations are homogeneous; however, a point-by-point comparison to criteria must be made.

Grid placement may need to be adjusted to provide for a sufficient number of samples along the horizontal and vertical boundaries of the volume of soil that was remediated.

Determining Vertical Sampling Intervals for In Situ Verification Sampling

At least one sample should be collected from each five feet of the verification sample boring, with the exception of borings that are advanced through uncontaminated backfill or native soils. The five-foot interval may be subdivided into six-inch intervals, and an interval *RANDOMLY* selected for sampling.

The verification soil borings must extend at least as far as the known depth of the soil contamination. If a confining layer is determined to be the lower boundary of the contamination (as should have already been determined during the investigation phase), at least one soil sample should be collected from the top of the lower confining layer to verify this. If the confining layer is not the lower boundary of the contamination, then a sampling of this layer and below must be conducted in relation to the remediation activity.

Other Considerations

Partial dewatering of an aquifer can allow soil vapor extraction and/or bioventing systems to remediate the residual soil contamination below the water table. If the groundwater potentiometric surface is being lowered during remediation, then the verification soil samples should be collected while the soils in question are still dewatered. The groundwater dewatering system should then be discontinued and verification groundwater samples collected.

2.4 DEMONSTRATING COMPLIANCE WITH PART 201 CRITERIA USING STATISTICS

Sampling conducted for the purpose of identifying and characterizing *RELEASE* areas may not yield adequate data to estimate a *REPRESENTATIVE CONCENTRATION* (the 95% UCL for the mean) for comparison to Part 201 criteria. Therefore, once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to cleanup criteria, if statistics are to be used. The goal of samples used to estimate a *REPRESENTATIVE CONCENTRATION* is to represent both exposures and hazardous substance concentrations in an appropriate *EXPOSURE UNIT*. Consequently, an *EXPOSURE UNIT* must first be identified that adequately represents exposures (e.g., a 1/4 acre *EXPOSURE UNIT* for evaluating compliance with generic residential soil direct contact criteria). Systematic *RANDOM* sampling may then be used to identify locations for collecting the minimum of nine samples necessary for statistical analysis.

Note that if all samples in an area are below cleanup criteria and the area is believed to be adequately characterized, the investigation for that area may be complete. A statistical analysis is not required. Adequate documentation of all sample locations must be provided based on sufficient knowledge of known or suspected *RELEASE* areas. A thorough justification must be documented for each sample location explaining the rationale used to select the location.

2.4.1 General Considerations When Demonstrating Compliance Using Statistics

Before assembling a data set and conducting a statistical analysis for comparison to criteria, it is important to give careful consideration to the following:

FACILITY Characterization

FACILITY characterization is a necessary first step before conducting an appropriate statistical analysis of *FACILITY* data for comparison to Part 201 cleanup criteria. Adequate knowledge of contaminant distribution and the presence of *HOT SPOTS* is essential.

Adequate *FACILITY* characterization is necessary due to assumptions underlying the statistical methods recommended by both the DEQ and the Environmental Protection Agency for comparing site data to cleanup criteria (i.e., 95% UCLs for the mean concentration). Adherence to these assumptions is necessary if an accurate statistical conclusion is to be drawn. One key assumption is that the data are independently and identically distributed (iid). For this assumption to be true, the following are generally necessary:

- Samples must be *independent* and representative of the area included in the analysis. In statistical terms, this means that the data were collected *RANDOMLY*.
- For the data to be identically distributed, each data point must have been drawn from the same *identical* statistical distribution (e.g., a normal distribution with a mean of 3.6 ppm and a standard deviation of 0.78 ppm). Data from a *HOT SPOT* area would be represented by a different statistical distribution than data from non-*HOT SPOT* areas. In other words, the mean concentration in a *HOT SPOT* area would be higher than in the non-*HOT SPOT* areas and the standard deviation would likely differ as well.

Consequently, adequate characterization and identification of *HOT SPOT* areas is necessary before an appropriate statistical analysis can be conducted.

Once defined, *HOT SPOTS* should not be included in a statistical analysis for comparison to most criteria. *HOT SPOTS* must be addressed separately. This is necessary to avoid combining data from different statistical distributions and violating the assumptions of the statistical methods. Furthermore, combining samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis will dilute the sample results that represent *HOT SPOTS*, potentially leaving unacceptable levels of hazardous substances in place. Specific recommendations for treatment of *HOT SPOTS* are provided in the Statistical Guidesheets for each of the pathways and closure categories (see tabbed section titled, "Statistical Guidesheets").

Applicability of Statistics

Before using statistics to compare *FACILITY* data to any Part 201 cleanup criterion, it is important to consider the applicability of statistics for demonstrating compliance with that criterion. Statistical Guidesheets have been developed to describe the extent to which statistical analysis of data may be relied upon to evaluate each exposure pathway and condition. At the top of each Statistical Guidesheet is an Applicability of Statistics Section which summarizes the primary factors to consider for that exposure pathway or condition. "YES," "Generally Not Practical (GNP)" or "NO" appear in a box to the right of the Applicability of Statistics heading to indicate the degree to which statistical analysis is appropriate.

Statistical Guidesheets categorized as "YES" indicate that use of statistics may be appropriate for the exposure pathway/condition and that sufficient data are likely to be available to calculate a *REPRESENTATIVE CONCENTRATION* for comparison to cleanup criteria. Statistical Guidesheets designated as "GNP" indicate that statistical applications may be appropriate but that data are not likely to be available and/or the complexities of the exposure pathway/condition make it difficult to derive a *REPRESENTATIVE CONCENTRATION* for comparison to cleanup criteria. Conditions for which no generic criteria have been developed (e.g., polluted soil runoff to surface water), are also designated as "GNP." Finally, the exposure pathway categorized as "NO" means that statistical analysis is not allowed due to an administrative rule requirement. This is true only for the drinking water pathway for which administrative rule 709(3) requires that criteria be met at every point in the affected aquifer.

Identification of an Appropriate Data Set for Statistical Analysis

Selecting the proper data set for a statistical analysis, if a statistical analysis is appropriate for the exposure pathway or condition, is an important step given the manner in which sampling data are typically obtained at sites. Section 2 of the Statistical Guidesheets addresses Selection of Data for Statistical Analysis.

All data gathered from *FACILITY* investigations may not be suitable for statistical comparison to cleanup criteria. Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that represent the exposure pathway or condition and the relevant land use category. For many of the exposure pathways *EXPOSURE UNITS* are defined to describe the area over which a person may be exposed to hazardous substances and data required for each *EXPOSURE UNIT*. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to adequately represent hazardous substance concentrations and allow for proper statistical analysis and development

of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling will often be required to support statistical analyses after the nature and extent of contamination has been defined. Although *RANDOM* samples are preferred for deriving a *REPRESENTATIVE CONCENTRATION*, previous sample results may be used on a *FACILITY*-specific basis. See further discussion of this issue in Section 2.4.2.

The appropriate data set for statistical analysis also depends on the size and variability of hazardous substance concentrations in the *EXPOSURE UNIT*. The size of the *EXPOSURE UNIT* varies between different exposure pathways and the land use category being considered. Generally, only data from one *EXPOSURE UNIT* may be used in each statistical analysis for comparison to cleanup criteria.

Section 2 of the Statistical Guidesheets also provides information related to unique aspects of the exposure pathway/condition that affect which data may be included in a statistical analysis for comparison to criteria. For example, only groundwater data from *GSI MONITORING WELLS* within the *AVERAGING AREA* may be used for statistical comparison to chronic mixing zone-based groundwater surface water interface (GSI) criteria.

Selecting the Appropriate Statistical Method for Comparison to Criteria

Once the applicability of statistics has been established and an appropriate data set identified, it is necessary to select the appropriate statistical method(s) for comparing those data to Part 201 criteria.

A 95% UCL for the mean should be utilized to compare *FACILITY* data to Part 201 criteria. Various methods are available for calculating UCLs for the mean concentration. Selection of the appropriate method requires an evaluation of the assumptions underlying each method. One of these assumptions is the statistical distribution of the data set (i.e., normal, lognormal, or neither). Consequently, each data set must be evaluated for the best-fitting statistical distribution. Chapter 1 of the tabbed section titled, “Statistical Methods” provides several techniques to accomplish this task. As described in Chapter 1, these techniques should be used in combination to best evaluate the statistical distribution.

Chapter 2 of the tabbed section titled, “Statistical Methods” provides techniques for identifying whether suspect data points are statistical outliers. Recommendations for treatment of outliers, once identified, are also provided in Chapter 2.

Methods for calculating UCLs for the mean concentration are provided in Chapter 3 of the tabbed section titled, “Statistical Methods.”

2.4.2 *RANDOM* Sampling of *EXPOSURE UNITS*

One of the most important factors that affect the quality of a statistical assessment of hazardous substances is sample design. Sample design simply refers to the methodology used to locate and collect samples. However, the conceptual simplicity of designing a sampling scheme belies its importance. Because most statistical methods require a *RANDOM* sample from the population under study, without a proper sampling design a *RANDOM* sample cannot be assured. Without a *RANDOM* sample, drawing accurate conclusions is difficult, if not impossible.

Sampling for the purpose of estimating a *REPRESENTATIVE CONCENTRATION* for comparison to Part 201 criteria should involve some form of *RANDOM* sampling within an *EXPOSURE UNIT.* Two methods for *RANDOM* sampling are described below. *RANDOM* sampling within an appropriate *EXPOSURE UNIT* will yield data which are representative of: 1) the exposure pathway or condition given the relevant land use category, and 2) concentrations of hazardous substances within the *EXPOSURE UNIT*.

Biased sampling strategies require discrete soil samples. Compositing samples is not accepted without prior DEQ approval.

2.4.2.1 Simple *RANDOM* Sampling

Simple *RANDOM* sampling is a common sampling design, particularly in applications other than environmental studies. This design consists of *RANDOMLY* selecting locations within a specified area (e.g., an *EXPOSURE UNIT*) and then collecting a sample at each selected location. Although simple *RANDOM* sampling does provide a *RANDOM* sample from the population, it can be somewhat inefficient and costly to implement.

Determining the *RANDOM* locations and subsequently locating them is a laborious task, possibly requiring a computer and a Global Positioning System (GPS). In addition, simple *RANDOM* sampling tends to unevenly sample the area under consideration. Some areas would likely contain several sample locations in close proximity, while other areas would remain unsampled. The uneven coverage that can result from simple *RANDOM* sampling is illustrated below.

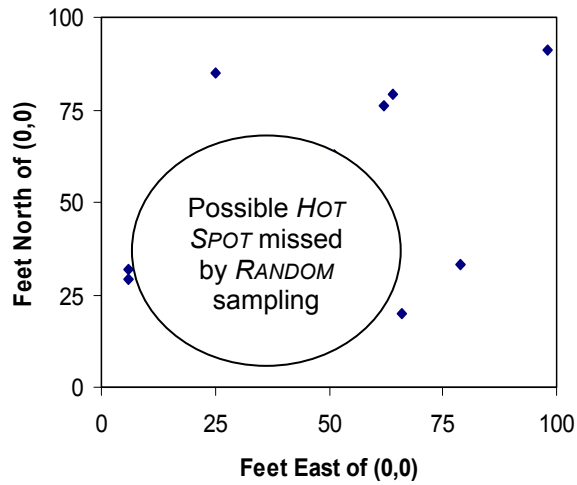
Example 2.8 Simple *RANDOM* Sampling

Figure 2.2 illustrates a sampling design where nine samples were collected *RANDOMLY* over a 100 ft x 100 ft area (approximately 1/4 acre). To locate each sample, a pair of *RANDOM* numbers between 0 and 100 was generated using the Microsoft Excel function:

=RANDBETWEEN(L,U)

where L is the lower number (set to 0 in this case) and U is the upper number (set to 100 in this case). The results for the first sample location were 5 and 27. Starting from the southwest corner of the *EXPOSURE UNIT*, this sample was located by moving 5 ft east and 27 ft north.

Figure 2.2 Simulated Simple *RANDOM* Sample of Nine Observations from a 100 ft x 100 ft (1/4 Acre) *EXPOSURE UNIT*.



Notice that several large areas are not sampled whereas other areas are sampled rather intensively. This is because in *RANDOM* sampling, each location in an area has an equal probability of being sampled, without regard to locations of other samples. Due to the uneven coverage associated with this *RANDOM* sampling design, the likelihood of detecting a *HOT SPOT*, if one exists, is relatively low. With increased sampling intensity (i.e., increasing the number of samples collected), more of the *EXPOSURE UNIT* would be sampled and hence coverage would be improved. However, because systematic *RANDOM* sampling (described below) is more efficient and results in better coverage with better *HOT SPOT* detection capabilities, it is generally superior to simple *RANDOM* sampling for a statistical assessment of hazardous substances.

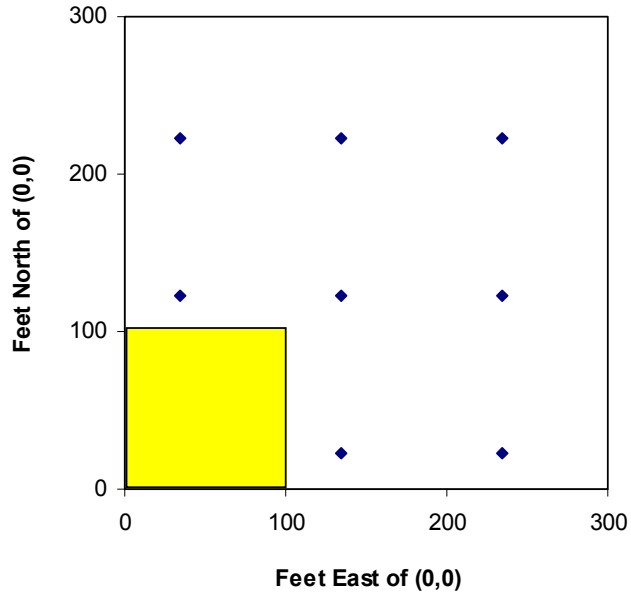
Note that we have made the assumption that the *FACILITY* has been adequately characterized prior to calculation of *REPRESENTATIVE CONCENTRATIONS*. Therefore, in most instances, *HOT SPOT* detection capabilities at this point should not be of major concern. However, because the approach described in the following section may serve both purposes of obtaining a *RANDOM* sample for estimation of a *REPRESENTATIVE CONCENTRATION* and *HOT SPOT* identification, this approach should be considered during the characterization stage in areas where no previous information is available to bias *FACILITY* characterization samples. Furthermore, to the extent that a *HOT SPOT* was missed in the characterization stage, this approach may help in the identification of remaining *HOT SPOTS*.

2.4.2.2 Systematic *RANDOM* Sampling

A preferable alternative to simple *RANDOM* sampling is systematic *RANDOM* sampling. This sampling design consists of dividing the total area to be sampled into subsections based on the number of samples to be collected (e.g., for nine samples, divide the total area into nine subsections) and *RANDOMLY* selecting a starting point within the first subsection. Subsequent sampling locations are then identified on a grid that is anchored at the starting point. The grid nodes represent locations to be sampled and all nodes are located based on the first *RANDOMLY*-selected location.

Figure 2.3 illustrates how systematic *RANDOM* sampling works. First, a 300 ft x 300 ft area was divided into nine subsections of equal area (100 ft x 100 ft). A point was *RANDOMLY* selected from the lower left cell of the *EXPOSURE UNIT*. Subsequent samples were identified systematically using a 100 ft grid extended from the first point.

Figure 2.3 Systematic *RANDOM* Sample of Nine Observations Collected from a 300 ft x 300 ft *EXPOSURE UNIT*.



The shaded area represents the cell from which the first sample was *RANDOMLY* selected.

The advantages of this design are numerous. First, it results in a *RANDOMIZED* sample from the population, thus satisfying the statistical requirements. Second, once the first location has been selected, locating the remaining sample locations is relatively straightforward and doesn't require a computer or GPS system. Third, because the coverage is fairly uniform, most of the *EXPOSURE UNIT* will be sampled and the likelihood of missing a large *HOT SPOT* is reduced. Furthermore, since sample locations are identified using a grid, statistical tools described in the tabbed section titled, "Identification and Consideration of *HOT SPOTS*," may be used to estimate the size of a *HOT SPOT* that might be identified (or missed) using this sampling approach. However, there is a danger that, if contamination occurs with some pattern, samples located on

a grid could systematically "miss" the contamination. If this is a concern, use of an unaligned grid (Gilbert, 1987, page 93) should be considered.

To determine the grid spacing, first determine the number of samples that are to be collected. The recommended minimum number is nine, based on statistical considerations only. Additional samples may be necessary to adequately represent spatial variability in the *EXPOSURE UNIT*. Next, use the following equation to determine an approximate grid interval:

$$\text{Grid Interval} = \sqrt{\frac{Area}{n}}$$

Where *Area* represents the total area of the *EXPOSURE UNIT* and *n* represents the number of samples that are to be collected.

The grid interval equation given above provides a rough approximation to a reasonable grid interval. The unique shape and size of the *EXPOSURE UNIT*, as well as the number of samples to be collected, will influence what the appropriate grid interval should be and where samples should be collected. The aim of systematic *RANDOM* sampling is to evenly cover the sampled area while collecting a *RANDOM* sample. Judgment must be used to decide on a sampling plan that is appropriate for individual *EXPOSURE UNITS*.

Example 2.9 Systematic *RANDOM* Sampling

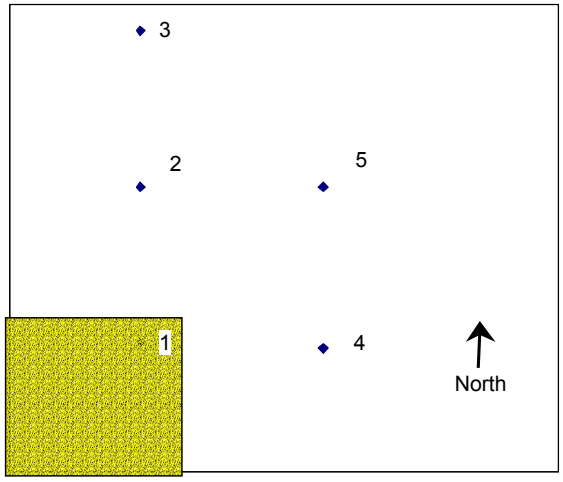
Figure 2.4 represents a square *EXPOSURE UNIT* of approximately two acres (i.e., 300 ft x 300 ft). Suppose that nine samples are to be collected. Using the above equation, the resulting grid interval is 100 ft. The *EXPOSURE UNIT* was divided into nine subsections of equal area (100 ft x 100 ft) and a sample location was *RANDOMLY* selected from the 100 ft x 100 ft cell in the lower left corner of the *EXPOSURE UNIT*. Based on the point selected, subsequent points are collected at the nodes of a grid with the grid interval equal to 100 ft.

The initial *RANDOM* sample location within the 100 x 100 ft cell in the southwest corner of the *EXPOSURE UNIT* was obtained as follows (which corner you start from is irrelevant, but for the sake of consistency, we recommend beginning in the southwest corner). First, generate two *RANDOM* numbers between 0 and 100 using the Microsoft Excel function:

=RANDBETWEEN(L,U)

where L is the lower number (set to 0 in this case) and U is the upper number (set to 100 in this case). The results were 80 and 94. Starting from the southwest corner of the *EXPOSURE UNIT*, move 80 ft east and 94 ft north to establish the *RANDOM* starting point within the southwest cell. The remaining eight sample locations are then positioned at the nodes of a grid with a 100 ft grid interval. For example, the second sample would be located 100 ft north of the first and the third would be located 200 ft north of the first. The fourth would be located 100 ft east of the first, and the fifth would be located 100 ft north of the fourth. This process would continue until all nine systematic *RANDOM* sample locations had been identified.

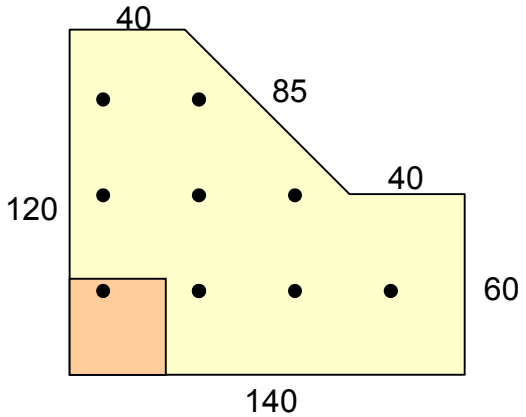
Figure 2.4 Systematic *RANDOM* Sampling of a Two Acre *EXPOSURE UNIT*



Example 2.10 Systematic *RANDOM* Sampling of an Odd-Shaped *EXPOSURE UNIT*

Figure 2.5 represents an odd-shaped *EXPOSURE UNIT* with the dimensions as listed (in feet). The first step is to determine the total area of the polygon, which is 12,600 ft^2. Suppose that nine samples need to be collected by systematic *RANDOM* sampling. Using the above equation, the approximate grid interval is 37 ft. To determine the *RANDOM* starting point, we generate two *RANDOM* numbers, 9 and 27. Starting in the lower-left corner of the polygon, we move nine ft east and 27 ft north to establish the first sample location. Subsequent samples are located on a grid anchored on the first point with a grid interval of 37 ft. If we denote the lower-left corner of the polygon as the (0,0) point on a (x, y) coordinate plane, the nine sample locations depicted are at (9,27), (9,64), (9,101), (46,27), (46,64), (46,101), (83,27), (83,64), and (120,27). Professional judgment may be used to increase the number of samples to be collected if nine samples do not appear to provide adequate coverage of an odd-shaped *EXPOSURE UNIT*.

Figure 2.5 Systematic *RANDOM* Sampling of an Odd-Shaped *EXPOSURE UNIT*



2.4.2.3 Three-Dimensional Sampling

There is often a need to sample a volume of soil rather than simply the surface soils. Sampling a volume of soil involves three-dimensional sampling. That is, rather than sampling in two dimensions only (e.g., North-South and East-West), a third dimension is incorporated (i.e., depth). In many cases, the vertical component is not sampled *RANDOMLY*, but rather based on knowledge of the underlying geology. For example, vertical sampling intervals may be selected so that samples are collected at an interface between two differing soil horizons.

The design of a three dimensional sampling plan (or any sampling plan for that matter) depends on how the population is defined. For example, if the population of concern is a fill layer from three-six feet in an *EXPOSURE UNIT*, then sampling surface soils in the *EXPOSURE UNIT* would be an improper sampling design. The sampling plan should be designed in such a way that representative samples from the intended population are collected.

If the goal is to use statistics to estimate a *REPRESENTATIVE CONCENTRATION* of hazardous substances in a defined layer, *RANDOM* sampling vertically as well as horizontally within the defined layer should be considered. That is, three-dimensional sampling should be considered in which systematic *RANDOM* sampling is completed in the horizontal dimension with an additional *RANDOM* component to sample depth. This approach will be most useful for evaluation of fill materials in which contamination is generally distributed throughout and differing soil horizons are not of a concern. **If initial *FACILITY* characterization shows that contamination is not homogeneous in the vertical dimension, this approach should not be used and sampling should be focused on depths of likely *RELEASES*.**

Using the methods outlined above, first define horizontal sampling locations. At each sample location, *RANDOMLY* select a depth for collecting the sample. The Microsoft Excel function shown below may be used to generate uniform *RANDOM* numbers between an upper and lower limit. This function is:

=RANDBETWEEN(L,U)

Where L is the lower limit and U is the upper limit for the *RANDOM* numbers. For example, if soils from 0-3 ft (i.e., 0-36 inches) are the intended population within an *EXPOSURE UNIT*, then this function can be used to generate a set of *RANDOM* depths from which to obtain samples. Since vertical sampling is often completed in six-inch intervals, the total depth of 36 inches can be divided into six intervals of six inches each. The above function can then be used to *RANDOMLY* select one of the six intervals (i.e., set L = 1 and U = 6) for sampling at each grid node.

An important caveat of three-dimensional sampling is the sample density (the number of samples per unit of volume or area). Sampling a volume (three dimensions) without increasing the total number of samples results in a lower sample density compared to sampling a two-dimensional area. If the sample density is too low, then the power to make statistical inferences is greatly reduced. Therefore, adequately sampling a volume will generally require more samples to be collected than would a two-dimensional sampling plan, particularly if the depth over which samples are to be collected is large.

For example, consider a two-dimensional systematic sampling plan where 10 samples from the top inch of soil are collected over a 25 x 30 ft area. This results in a sample density of approximately 0.16 samples/ft^3. Now contrast this with a three dimensional systematic sampling

plan where 10 samples from the top six inches of soil are collected over the same 25 x 30 ft area. This would result in a sample density of approximately 0.03 samples/ft^3. In fact, a total of 60 samples would need to be collected in the three-dimensional case to attain the same sample density as the two-dimensional case. This lower sample density in this three-dimensional sampling scenario reduces the relative power of the statistical inference about the sampled population.

2.4.2.4 Use of Site Characterization Data in Place of *RANDOM* Sample Locations

As previously stated, *RANDOM* sampling is important if accurate conclusions are to be drawn from a statistical analysis of data. *FACILITY* characterization data are typically biased, based on historical information such as previous sampling, past practices, visual impacts, and aerial photos. However, it may be impractical and cost prohibitive to sample every *EXPOSURE UNIT* from scratch using a *RANDOM* sampling design without use of existing data, where appropriate. Consequently, the following guidelines are recommended with regard to use of existing characterization data for a statistical analysis.

Divide the *EXPOSURE UNIT* into at least nine cells as described under Systematic *RANDOM* Sampling. (The number of cells is determined by the number of samples to be collected in the *EXPOSURE UNIT*.) If a single previous characterization sample location is present in a cell and the sample is representative of current conditions (e.g., the sample was collected from an area that has not been actively remediated), it may not be necessary to collect a new *RANDOM* sample from that cell. However, the sample must be comparable in terms of sampling and analytical methods and detection limits before making this determination and including the analytical result in the statistical analysis.

If more than one site characterization sample was collected from a cell, some judgment must be used to determine which data to include in the statistical analysis. In some cases, it will be appropriate to include all existing data from that cell in the statistical analysis; however, in some cases it will be appropriate to include only some of the data or to select one value to include in the statistical analysis. This determination must be made on a case-by-case basis.

The nature of the previous sampling is the main factor that needs to be considered when evaluating how much of the previous data can be included. For example, suppose that characterization samples present in a given cell are not clustered and are not associated with a *HOT SPOT*. Consider including each of the results in the statistical analysis because, presumably, the samples were collected independently and are representative of the overall variation in that area. However, if the characterization samples were highly clustered in a small area, and were collected for the purpose of investigating and/or confirming sample results in that limited area, the results may not represent the overall variability of concentrations in the *EXPOSURE UNIT.* Additional samples may be necessary. In this case, it would also be more appropriate to select a single value from the cluster of samples to avoid placing a disproportionately large weight on samples collected in a limited area.

It is also important to evaluate the extent to which the samples provide duplicative information. If sample analytical results are spatially correlated, the information provided by these samples is not independent, as required by the statistical methods presented in the S^3TM. Independence is necessary since, if sample results are correlated over space, the effective sample size is reduced. Each correlated sample does not provide as much “new” information about hazardous substance concentrations in an *EXPOSURE UNIT* because its value is partially determined by the value of adjacent observations.

Consequently, the following approach is recommended (alternate approaches may be acceptable on a case-by-case basis):

1. Divide each *EXPOSURE UNIT* into nine or more cells, as previously described.

2. Qualitatively evaluate the number of independent sample locations in each cell. Consider samples collected in a cluster to represent one sample location. At least one independent sample location is necessary in each cell if statistics are to be used to compare data from the *EXPOSURE UNIT* to criteria.

3. Select data for inclusion in the statistical analysis. Samples collected in a cluster: select the original sample result only for inclusion in the statistical analysis. That is, do not include any of the confirmatory sample results. Samples not collected in a cluster: consider including each sample in the statistical analysis. Note: Including more than one sample from a cell will result in more than nine samples from an *EXPOSURE UNIT* for statistical analysis, since at least one sample from each cell is necessary. Areas with spatially correlated concentrations above criteria (i.e., *HOT SPOTS*) must generally be excluded from the statistical analysis and addressed separately.

2.4.3 Comparison of *FACILITY* Data to *FACILITY-SPECIFIC BACKGROUND* Concentrations

When Part 201 criteria are established as *BACKGROUND* concentrations, the objective becomes to determine whether the *FACILITY* concentrations are significantly higher than *BACKGROUND* concentrations for a hazardous substance. To make this determination in most cases, *FACILITY* data will be compared to *FACILITY-SPECIFIC BACKGROUND* concentrations on a point-by-point basis. That is, concentrations of each hazardous substance in each *FACILITY* sample will be compared to directly to the *FACILITY-SPECIFIC BACKGROUND* concentration and individual exceedances will be noted. This will most often be the case when *FACILITY* samples are collected in a biased manner. However, it may also be necessary to compare *FACILITY* data collected using statistical sampling strategies to *FACILITY-SPECIFIC BACKGROUND* concentrations on a point-by-point basis.

If statistics are used to compare *FACILITY* data to *FACILITY-SPECIFIC BACKGROUND* data, a “two-sample test” may be used (i.e. a test that compares two data sets to each other). See Chapter 4 of the tabbed section titled, “Statistical Methods” for additional information. The appropriateness of using a statistical method to compare *FACILITY* data to *FACILITY-SPECIFIC BACKGROUND* data must be evaluated. This depends on: 1) the type of *BACKGROUND* being considered, 2) the manner in which *FACILITY* data were collected (i.e., using a biased or statistical approach), and 3) whether a statistical analysis of *FACILITY* data for comparison to *BACKGROUND* is appropriate. Statistical Guidesheets for the applicable pathways/conditions should be consulted to determine the applicability of statistics for comparing *FACILITY* data to Part 201 criteria and key considerations for selection of the appropriate data set(s). Recommendations provided in the Statistical Guidesheets apply to all Part 201 criteria, including *BACKGROUND*. A statistical analysis of *FACILITY* data for comparison to *BACKGROUND* will most likely be appropriate for pathways/conditions categorized as **YES**, or for those categorized as **GNP** for which a statistical analysis is demonstrated to be appropriate.

For additional information on statistical comparisons to *BACKGROUND*, see Section 2.2.2 of Sampling Strategies and Chapter 4 of the tabbed section titled, “Statistical Methods.”

2.4.4 Recommended Summary Report Format

Soil Summary Reports for sites utilizing statistical sampling strategies must identify the number and location of samples and provide the justification of the sample locations selected (why and how). The Summary Report should contain site maps and cross-sections, drawn to scale, which depict the area and volume of contaminated soil; any remediation area(s); the locations of any air/fluid injection and/or extraction wells with their estimated zones of influence; the sampling grids; and the verification soil boring locations and vertical sampling intervals. The Summary Report should also include the calculations for determining the sampling grid intervals, a statement documenting the *RANDOM* sampling strategy utilized for selection of the sampling locations, the number of soil borings/samples and any statistical calculations used to evaluate the sample data.

The checklist below identifies items recommended to properly evaluate a closure certification. These items are not "absolutes." Other information or substitutions may be provided which technically justify and certify a "clean closure."

The verification report must include the following:

1. MAP(s) and CROSS SECTIONS
   Provide a scaled map of the investigated and remediated area (i.e. the estimated *RELEASE* area, or floor and walls of an excavation, or the vertical and horizontal area treated for in situ remediations, etc.) with sample locations identified. If a cross section is utilized to display the remediation activities and data, it should show the relation of key elevations, depict the stratigraphy, fractures, soil types, discolorations, unusual characteristics, possibly indicate the original *RELEASE* source location, sample locations/elevations, etc.

2. SAMPLE LOCATION RATIONALE
   - All sample locations (including *BACKGROUND* samples, *FACILITY* samples, and/or verification samples)
   - Sample depths
   - Sample collection procedures
   - Basis of sampling biases (where used) and the rationale used for collecting each sample (e.g., clay fractures, discolored soil, location of leak in tank)

3. DATA ANALYSES
   - Analytical parameters
   - Analytical methods used
   - Method detection limits
   - Laboratory Quality Assurance/Quality Control
   - Summary of decontamination procedures

4. STATISTICAL ANALYSES
   - Lab results/data tabulation
   - Complete statistical calculations as described in the tabbed section titled, “Statistical Methods”
   - If considered, development of *BACKGROUND* concentrations and/or statistical comparisons to *BACKGROUND* as described in Chapter 4 of the tabbed section titled, “Statistical Methods”

- Narrative explanation of all statistical calculations completed using *FACILITY* and/or *BACKGROUND* concentrations
- Comparisons of *FACILITY* data to cleanup criteria and/or *BACKGROUND* (either point-by-point or statistical)
- Completed worksheet for each statistical comparison (see the tabbed section titled, "Statistical Analysis Worksheets")

5. CONCLUSIONS
   This portion of the report should include a summary of activities and final conclusions, accounting for the work and testing completed and how completed activity(ies) fit in with the site-wide remediation plan (i.e. land use issues, possible closure requirements, whether there is a Remedial Action Plan, resumption of operations, etc.)

2.5 WASTE CHARACTERIZATION

Characterization of wastes for the purpose of disposal must often be addressed at Part 201 *FACILITIES*. The regulatory context for waste characterization is different than the context described in previous sections of this chapter, however. Sections 2.1 through 2.4 describe sampling and analysis of data for the purpose of demonstrating compliance under Part 201. Waste characterization is regulated under Parts 111 and 115. Consequently, sampling strategies and statistical analysis of data for this purpose have been described in a separate tabbed section titled, "Waste Characterization."

SUMMARY

Selection of a sampling plan to collect environmental samples is a complex, multifaceted, and multi-phased problem. As pointed out during the previous discussions of sampling strategies, the ***goal*** of any sampling plan is to collect samples that represent the environmental media and conditions being defined.

The beginning point is usually a conceptual model of the environmental conditions that exist at a property or *FACILITY* based on historical records, previous sampling, or site reviews. An evaluation of the completeness of the conceptual model is made to determine if existing information allows a reasonable model or if further characterization is needed to conceptualize the environmental conditions at the property or *FACILITY*.

If additional sampling is to be conducted, an objective should be set for the sampling plan (e.g., *FACILITY* characterization, identification of *RELEASE* areas, verification of remediation, comparison to regulatory criteria, waste characterization). This plan may involve a combination of sampling techniques (i.e., biased and/or statistical). The sampling plan should be guided by answering "why, what, when, where, and how" to sample. A continuous and sequential review and evaluation of the resulting data should be made to determine if the goal of the sampling plan has been met. Rarely is this sequence a straightforward, single-pathway, or simple analysis. Each sample as it is collected, analyzed, and evaluated may change the conceptual model and the overall sampling strategy. For example, identification of a previously unknown *HOT SPOT* may lead back to further characterization.

As new data become available, an iterative process should be conducted to continuously evaluate whether the data make sense in light of existing data and the conceptual model of the environmental conditions and whether characterization is complete.

The following example illustrates the iterative nature of this process and use of a combination of sampling techniques.

1) A site being investigated has a wealth of existing data (e.g., existing sampling locations and analytical results, documented site history, detailed and accurate information on operational procedures and equipment location). Therefore, additional site characterization will be completed using a biased sampling approach based on known conditions.
2) Sample results indicate that concentrations of one or more hazardous substances are highly elevated at a sample location. It must be decided whether to further characterize at this location by:
   a. continuing biased sampling, or
   b. initiating a statistical sampling plan.

The conceptual model of environmental conditions had been incomplete. To decide on a next step, it is necessary to evaluate why an unexpectedly high concentration was present at the sample location. Was it caused by a discrete release that could be documented as a result of further research? If so, biased sampling may be useful to focus on that location to identify the nature and extent of contamination. If not, it must be concluded that high concentrations may be present at more locations. If no reliable information is available with which to bias additional sampling, a statistical sampling strategy should be used to better characterize the area.

Summary

The decision was made to redirect the sampling plan to use a statistical sampling approach. Although some additional areas with elevated concentrations were identified as a result, none were confirmed to be *HOT SPOTS*. Biased samples were collected by stepping out around each elevated location to make this determination.

The next step is to make a determination on compliance with cleanup criteria. Since locations are present at which criteria are exceeded but none of these locations represented *HOT SPOTS*, it may be appropriate to consider a statistical analysis for comparison to criteria. However, before proceeding it is necessary to first evaluate several key considerations including the applicability of statistics for the exposure pathway(s) being evaluated, adequacy of characterization, and selection of the appropriate data set to represent exposures and hazardous substance concentrations in an appropriate exposure area. These concepts are addressed throughout Sampling Strategies (particularly Section 2.4.1) as well as in the tabbed section titled, "Statistical Guidesheets."

PART 201 STATISTICAL EVALUATION GUIDESHEETS

LIST OF PART 201 STATISTICAL EVALUATION GUIDESHEETS

A. Abandoned Substances Not Yet Dispersed and Free Phase Liquid
B. Soil: Contaminated Soil Runoff to Surface Waters
C. Surface Water Sediment: Aquatic Flora/Fauna/Food Chain Hazards and Aesthetics
D. Acute Toxicity and Physical Hazards: Acute Inhalation Toxicity and Flammability/ Explosivity, Corrosivity, Ignitability, and Reactivity
E. Ecological and Aesthetic Impacts: Terrestrial Flora, Fauna, Food Chain, Aesthetic or Other Impacts
F. Asbestos Containing Materials: Asbestos

GROUNDWATER

1. Generic Residential and Commercial I Drinking Water Criteria (DWC)
2. Generic Commercial II, III, IV and Industrial Drinking Water Criteria (DWC)
3. Generic and Mixing Zone-Based Groundwater Surface Water Interface (GSI) Criteria
4. Generic Residential and Commercial I Groundwater Volatilization to Indoor Air Inhalation Criteria (GVIIC)
5. Generic Commercial II, III, IV and Industrial Groundwater Volatilization to Indoor Air Inhalation Criteria (GVIIC)
6. Generic Groundwater Contact Criteria (GCC)
7. Water Solubility
8. Generic Screening Levels for Flammability and Explosivity
9. Generic Acute Inhalation Toxicity Screening Levels

SOIL

10. Soil Background
11. Generic Soil Criteria Protective of Residential and Commercial I Drinking Water
12. Soil Criteria Protective of the Groundwater Surface Water Interface (GSI)
13. Generic Soil Criteria Protective for Groundwater Contact
14. Generic Residential and Commercial I Soil Volatilization to Indoor Air Inhalation Criteria (SVIIC)

15.-17. Generic Residential and Commercial I Infinite and Finite Volatile Soil Inhalation Criteria (VSIC) for Ambient Air

18. Generic Residential and Commercial I Particulate Soil Inhalation Criteria (PSIC) for Ambient Air
19. Generic Residential and Commercial I Direct Contact Criteria (DCC)
20. Generic Soil Saturation (CSAT) Screening Levels
21. Generic Soil Criteria Protective of Commercial II, III, IV and Industrial Drinking Water
22. Generic Commercial II, III, IV and Industrial Soil Volatilization to Indoor Air Inhalation Criteria (SVIIC)

23.-25. Generic Commercial II, III, IV and Industrial Infinite Source Volatile Soil Inhalation Criteria (VSIC) for Ambient Air

26. Generic Commercial II, III, IV and Industrial Particulate Soil Inhalation Criteria (PSIC) for Ambient Air

27.-29. Generic Industrial and Commercial II, III, IV Direct Contact Criteria (DCC)

INTRODUCTION TO PART 201 STATISTICAL EVALUATION GUIDESHEETS

Statistical Guidesheets are lettered or numbered to correspond with the Criteria Application Guidesheets. Words that are in capital letters and italicized are defined terms that are presented in the tabbed section titled, "Acronyms / Glossary." Bullets presented as ★ are used to highlight considerations that are unique to the exposure pathway or condition.

The Statistical Guidesheets have been organized into sections to focus attention to the key considerations for each purpose for evaluating data. Section 1 of the Statistical Guidesheet addresses the use of statistical analysis for determining if a property is a *"FACILITY."* Section 2 identifies the key factors to consider when selecting data to include in a statistical analysis for the purpose of deriving a *REPRESENTATIVE CONCENTRATION* for comparison to cleanup criteria. Section 3 highlights the factors to consider when making comparison to the cleanup criteria, and Section 4 specifies the important considerations when using statistical analyses to demonstrate a verification of remediation or closure.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL AND GROUNDWATER** DATA	Statistical Guidesheet **A**
ABANDONED SUBSTANCES NOT YET DISPERSED AND FREE PHASE LIQUID	
May assist in evaluation of condition(s):	1
Applicability of Statistics	**GNP**
Statistics are generally not practical as a tool for assessing this condition because source control evaluations will generally be conducted on a qualitative basis.	

Key Considerations:		
	Section 1	**Facility Determination**
		★ The determination that property is a *FACILITY* is generally based on data which show that one or more generic residential cleanup criterion is exceeded. Information that documents the presence of abandoned hazardous substances which are not yet dispersed, or the presence of free phase liquid hazardous substances that have been *RELEASED* is also potentially sufficient to support a conclusion that property is a *FACILITY*. Consult your supervisor for guidance if necessary. Since *FACILITY* determinations that are based on the presence of abandoned sources or free phase liquids are generally not based on review of laboratory data, statistics are not expected to be relevant to those *FACILITY* determinations.
	Section 2	**Selection of Data For Statistical Analysis**
		• Not applicable - see Section 3.
	Section 3	**Risk Analysis – Comparison to Criteria**
		★ Since source control evaluations will generally be conducted on a qualitative basis (i.e., not based on rigorous comparison of *FACILITY* data to cleanup criteria or another value), statistics are not expected to be necessary.
	Section 4	**Verification of Remediation or Closure**
		• Not applicable.

Additional Information:	Criteria Application Guidesheet A and Appendix A (Part 201 Cleanup Criteria Training Materials: Source Control Obligations for Part 201 Facilities.)
Recommended Statistical Methods for Comparison to Criteria:	Not applicable.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR SOIL DATA	Statistical Guidesheet B
CONTAMINATED SOIL RUNOFF TO SURFACE WATERS	
May assist in evaluation of condition(s):	12
Applicability of Statistics	**GNP**
Statistics are generally not practical as a tool for assessing this condition because there are no generic cleanup criteria.	

Key Considerations:	**Section 1**	**Facility Determination**
		• The determination that property is a *FACILITY* is generally based on data which show that one or more generic residential cleanup criterion is exceeded. Since there are not generic cleanup criteria available for this condition, *FACILITY* determinations will not generally be based on this condition. If you are evaluating property where you suspect problems with this condition and no data are available to demonstrate that the property is a *FACILITY* for other reasons, consult your supervisor for guidance.
	Section 2	**Selection of Data For Statistical Analysis**
		• Not applicable - see Section 3.
	Section 3	**Risk Analysis – Comparison to Criteria**
		• Since there are no generic cleanup criteria available for this condition, statistical analysis of data is not generally expected to be used for risk analysis.
	Section 4	**Verification of Remediation or Closure**
		• Since there are no generic cleanup criteria available for this condition, statistical analysis of data is not generally expected to be used for verification of remediation or closure.

Additional Information:	Criteria Application Guidesheet B
Recommended Statistical Methods for Comparison to Criteria:	The statistical method for comparing *FACILITY* data to criteria will be determined on a case-by-case basis.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SURFACE WATER SEDIMENT** DATA	Statistical Guidesheet **C**
AQUATIC FLORA/FAUNA/FOOD CHAIN HAZARDS AND AESTHETICS	
May assist in evaluation of condition(s):	13
Applicability of Statistics	**GNP**

Statistics are generally not practical as a tool for initially assessing this condition because there are no generic sediment cleanup criteria. If the condition is determined to require response activity and site-specific criteria are developed, statistical evaluation of data may be possible. See Sections 2 and 3 below.

Key Considerations:		
	Section 1	**Facility Determination**
		★ The determination that property is a *FACILITY* is generally based on data which show that one or more generic residential cleanup criterion is exceeded. Since there are no generic cleanup criteria available for this condition, *FACILITY* determinations using numerical data will not generally be based on this condition. However, site-specific sediment cleanup criteria may be developed for a *FACILITY* determination and Section 20a(17) allows for a qualitative *FACILITY* determination based on unacceptable risk to surface water and sediment. If you are evaluating property where you suspect problems with this condition and no data are available to demonstrate that the property is a *FACILITY* for other reasons, consult your supervisor for guidance.
	Section 2	**Selection of Data For Statistical Analysis**
		★ Generic cleanup criteria are not available for this condition; all sediment cleanup criteria are developed on a site-specific basis. This statistical guidesheet provides information on selecting data for comparison to site-specific criteria when available. • Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies." • A statistical analysis of soil data should be completed only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.

	Section 2: (Continued)	• It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.2.1 of the tabbed section titled, "Sampling Strategies." ★ The selection of sediment characterization data that are appropriate for statistical analysis will depend on the exposures or other impacts that are the basis for the sediment cleanup criteria. See Guidesheet C in the Part 201 Cleanup Criteria Training Materials and Rule 717(5)(a) to (l) for information about the factors that must be considered in establishing sediment cleanup criteria.
	Section 3	**Risk Analysis – Comparison to Criteria** ★ Cleanup criteria for contaminated sediments will be established by the department, if necessary, based on the factors described in Rule 717(5)(a) to (l). The appropriateness of statistics as a tool for determining compliance will depend on which of the factors in that rule were used as the basis for each site-specific criterion (e.g., if adverse aesthetics is the basis for a sediment cleanup criterion, statistics may not be applicable). • If DEQ approval of a response activity is being sought, a *PROPOSAL* for a statistical analysis must be submitted to the DEQ for approval to assure that data needs and/or complexities of the pathway are addressed. *PROPOSALS* for the use of statistics must include a justification that relates the *PROPOSAL* to the basis for the cleanup criteria (e.g., mitigating degradation of benthos, or eliminating fish consumption restrictions).
	Section 4	**Verification of Remediation or Closure** ★ Cleanup criteria for contaminated sediments will be established by the Department, if necessary, based on the factors described in Rule 717(5)(a) to (l). The appropriateness of statistics as a tool for determining the adequacy of remedial actions will depend on which of the factors in that rule were used as the basis for each site-specific criterion (e.g., if adverse aesthetics is the basis for a sediment cleanup criterion, statistics may not be applicable). ★ If DEQ approval of a response activity is being sought, a *PROPOSAL* for a statistical analysis must be submitted to the DEQ for approval to assure that data needs and/or complexities of the pathway are addressed. *PROPOSALS* for use of statistics to evaluate sediment data for verifying remediation or closure must include a justification that relates the *PROPOSAL* to the basis for the cleanup criteria (e.g., mitigating degradation of benthos, or eliminating fish consumption restrictions).

Additional Information:	Criteria Application Guidesheet C
Recommended Statistical Methods for Comparison to Criteria:	The statistical method for comparing *FACILITY* data to criteria will be determined on a case-by-case basis.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **ACUTE TOXICITY AND PHYSICAL HAZARDS**	Statistical Guidesheet **D**

ACUTE INHALATION TOXICITY AND FLAMABILITY/EXPOLSIVITY, CORROSIVITY, IGNITABILITY, AND REACTIVITY

May assist in evaluation of condition(s):	14
Applicability of Statistics	**GNP**

Statistics are generally not practical as a tool for assessing this condition because it deals with acute risks and any exceedance of screening levels requires further consideration.

Key Considerations:		
	Section 1	**Facility Determination**
		• The determination that property is a *FACILITY* is generally based on data which show that one or more generic residential cleanup criterion is exceeded. Since there are no generic cleanup criteria available for this condition, *FACILITY* determinations will not generally be based on this condition. If you are evaluating property where you suspect problems with this condition and no data are available to demonstrate that the property is a *FACILITY* for other reasons, consult your supervisor for guidance.
	Section 2	**Selection of Data For Statistical Analysis**
		• Not applicable – see Section 3.
	Section 3	**Risk Analysis – Comparison to Criteria**
		★ Since this condition deals with acute risks, any exceedance of flammability/explosivity or acute inhalation screening levels requires further consideration. See Statistical Guidesheets 8 and 9 for additional discussion about application of screening values for acute effects.
		• Statistical treatment of data is not expected to be a practical tool for making decisions about the need for response activity related to this condition.
		• Professional judgment will be required to determine the significance of any data that relates to this condition. The quantity of the hazardous substance that is present above potential levels of concern is a factor that determines whether there may be an unacceptable risk.
	Section 4	**Verification of Remediation or Closure**
		• See Section 3.

Additional Information:	Statistical Guidesheets 8 and 9; Criteria Application Guidesheets D, 8 and 9.
Recommended Statistical Methods for Comparison to Criteria:	The statistical method for comparing *FACILITY* data to criteria will be determined on a case-by-case basis.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **ECOLOGICAL AND AESTHETIC IMPACTS**	Statistical Guidesheet **E**
TERRESTIAL FLORA, FAUNA, FOOD CHAIN, AESTHETIC OR OTHER IMPACTS	
May assist in evaluation of condition(s):	15
Applicability of Statistics	**GNP**
Statistics are generally not practical as a tool for assessing this condition because there are no generic cleanup criteria.	

Key Considerations:		
	Section 1	**Facility Determination**
		• The determination that property is a *FACILITY* is generally based on data which show that one or more generic residential cleanup criterion is exceeded. Since there are no generic cleanup criteria available for this condition, *FACILITY* determinations will not generally be based on this condition. If you are evaluating property where you suspect problems with this condition and no data are available to demonstrate that the property is a *FACILITY* for other reasons, consult your supervisor for guidance.
	Section 2	**Selection of Data For Statistical Analysis**
		• Not applicable - see Section 3.
	Section 3	**Risk Analysis – Comparison to Criteria**
		• Since there are no generic cleanup criteria available for this condition, statistical analysis of data is not generally expected to be used for risk analysis.
	Section 4	**Verification of Remediation or Closure**
		• Since there are no generic cleanup criteria available for this condition, statistical analysis of data is not generally expected to be used for verification of remediation or closure.

Additional Information:	Criteria Application Guidesheet E
Recommended Statistical Methods for Comparison to Criteria:	The statistical method for comparing *FACILITY* data to criteria will be determined on a case-by-case basis.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR CONTROL OF **ASBESTOS CONTAINING MATERIALS**	Statistical Guidesheet **F**
ASBESTOS	
May assist in evaluation of condition(s):	2, 6, 7, 12
Applicability of Statistics	**Pathway Dependent**
See Applicability of Statistics discussion on Statistical Guidesheet for relevant exposure pathway.	

Key Considerations:		
	Section 1	**Facility Determination**
		• A *FACILITY* determination based on the presence of asbestos would generally depend on an exceedance of a generic residential cleanup criterion (e.g., drinking water or particulate soil inhalation). See relevant exposure pathway statistical guidesheets for further guidance on making *FACILITY* determinations. Also see Statistical Guidesheet A for discussion of the ways in which abandoned substances that are not yet dispersed may constitute a *FACILITY*.
	Section 2	**Selection of Data For Statistical Analysis**
		• See statistical guidesheets for relevant exposure pathways.
	Section 3	**Risk Analysis – Comparison to Criteria**
		• See statistical guidesheets for relevant exposure pathways.
	Section 4	**Verification of Remediation or Closure**
		• See statistical guidesheets for relevant exposure pathways.

Additional Information:	Statistical Guidesheets 1, 2, 18, and 26; Criteria Application Guidesheets 1, 2, 18 and 26.
Recommended Statistical Methods for Comparison to Criteria:	See statistical guidesheets for relevant exposure pathways.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **GROUNDWATER** DATA	Statistical Guidesheet 1
GENERIC RESIDENTIAL AND COMMERCIAL I DRINKING WATER CRITERIA (DWC)	
May assist in evaluation of condition(s):	2
Applicability of Statistics	**NO**

Statistics are not applicable for assessing this exposure pathway because Rule 709(3) states that the point of exposure is presumed to be any point in the affected aquifer. As a result, cleanup criteria must be met at all points.

Key Considerations:		
	Section 1	**Facility Determination**
		• For the purposes of a BEA or initial *FACILITY* determination, property may be classified as a *FACILITY* if one or more samples contain concentrations above generic residential criteria or *BACKGROUND* concentrations, whichever is greater, provided that there is not a greater body of evidence that the property is not a *FACILITY*. For purposes other than *FACILITY* determination (e.g., remediation and/or closure), additional data will likely be required.
	Section 2	**Selection of Data For Statistical Analysis**
		• Not applicable – see Section 3.
	Section 3	**Risk Analysis – Comparison to Criteria**
		★ Statistical analysis of *FACILITY* groundwater concentrations for comparison to criteria (either across well locations or over time in an individual well) is not acceptable. Since the point of exposure is presumed to be any point in the affected aquifer [Rule 709(3)], groundwater drinking water criteria must be met at each point in an aquifer. Therefore, evaluation of groundwater concentrations must be completed on a point-by-point basis* (i.e., each concentration at a given time and location must be compared individually to criteria). • If *BACKGROUND* concentrations are greater than criteria for naturally occurring substances, groundwater concentrations may be compared to *BACKGROUND* concentrations. If comparison is made to *BACKGROUND* the comparison must be completed on a point-by-point basis.* See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods." ★ Statistical analysis of groundwater concentrations over time in an individual well will not be allowed for comparison to criteria or *BACKGROUND*.
	Section 4	**Verification of Remediation or Closure**
		• **No Action Needed**: If the data evaluation completed under Section 3 demonstrates that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4.

	Section 4: (Continued)	• **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. To demonstrate verification of remediation or closure, concentrations in groundwater must meet criteria during a specified number of consecutive sampling events. The number of consecutive sampling events must be selected on a case-by-case basis to reflect seasonal variation in groundwater quality, flow rates, and initial distribution of contamination in groundwater. Ordinarily, this demonstration should be made using data from at least one year of quarterly sampling. • **Containment**: Generally groundwater sampling used to verify a groundwater containment remedy will be done at the perimeter of the containment system. Statistical analysis is not allowed for reasons described in Section 3. This verification will be an ongoing part of the remedy as long as hazardous substances are present above criteria. • Comparisons to criteria or *BACKGROUND* must be made on a point-by-point basis.* See Section 3.

Additional Information:	Criteria Application Guidesheet 1
Recommended Statistical Methods for Comparison to Criteria:	Not applicable.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **GROUNDWATER** DATA	Statistical Guidesheet **2**
GENERIC COMMERCIAL II, III, IV AND INDUSTRIAL DRINKING WATER CRITERIA (DWC)	
May assist in evaluation of condition(s):	2
Applicability of Statistics	**NO**
Statistics are not applicable for assessing this exposure pathway because the point of exposure is presumed to be any point in the affected aquifer. As a result, cleanup criteria must be met at all points.	

Key Considerations:	**Section 1**	**Facility Determination**
		• Not applicable.
	Section 2	**Selection of Data For Statistical Analysis**
		• Not applicable – see Section 3.
	Section 3	**Risk Analysis – Comparison to Criteria**
		★ Statistical analysis of *FACILITY* groundwater concentrations for comparison to criteria (either across well locations or over time in an individual well) is not acceptable. Since the point of exposure is presumed to be any point in the affected aquifer, groundwater drinking water criteria must be met at each point in an aquifer. Therefore, evaluation of groundwater concentrations must be completed on a point-by-point basis* (i.e., each concentration at a given time and location must be compared individually to criteria).
		• If *BACKGROUND* concentrations are greater than criteria for naturally occurring substances, groundwater concentrations may be compared to *BACKGROUND* concentrations. If comparison is made to *BACKGROUND* the comparison must be completed on a point-by-point basis.* See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods."
		★ Statistical analysis of groundwater concentrations over time in an individual well will not be allowed for comparison to criteria or *BACKGROUND*.
	Section 4	**Verification of Remediation or Closure**
		• **No Action Needed**: If the data evaluation completed under Section 3 demonstrates that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4.

	Section 4: (Continued)	• **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. To demonstrate verification of remediation or closure, concentrations in groundwater must meet criteria during a specified number of consecutive sampling events. The number of consecutive sampling events must be selected on a case-by-case basis to reflect seasonal variation in groundwater quality, flow rates, and initial distribution of contamination in groundwater. Ordinarily, this demonstration should be made using data from at least one year of quarterly sampling. • **Containment**: Generally groundwater sampling used to verify a groundwater containment remedy will be done at the perimeter of the containment system. Statistical analysis is not allowed for reasons described in Section 3. This verification will be an ongoing part of the remedy as long as hazardous substances are present above criteria. • Comparisons to criteria or *BACKGROUND* must be made on a point-by-point basis.* See Section 3.
Additional Information:		Criteria Application Guidesheet 2
Recommended Statistical Methods for Comparison to Criteria:		Not applicable.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **GROUNDWATER** DATA	Statistical Guidesheet 3
GENERIC AND MIXING ZONE-BASED GROUNDWATER SURFACE WATER INTERFACE (GSI) CRITERIA	
May assist in evaluation of condition(s):	5
Applicability of Statistics	**YES - Chronic; NO - Generic and Acute**

Statistics are applicable for evaluating compliance with chronic mixing zone-based GSI criteria since the "average" impact of hazardous substances in groundwater is considered. Statistics are not applicable for acute mixing zone-based GSI criteria, since point-by-point exceedances of these criteria can result in unacceptable impacts. Statistics are also not applicable for comparison to generic GSI criteria, since these criteria do not take into account any dilution or mixing with receiving waters.

Key Considerations:

Section 1

Facility Determination

- For the purposes of a BEA or initial *FACILITY* determination, property may be classified as a *FACILITY* if one or more samples contain concentrations above generic residential criteria or *BACKGROUND* concentrations, whichever is greater, provided that there is not a greater body of evidence that the property is not a *FACILITY*. For purposes other than *FACILITY* determination (e.g., remediation and/or closure), additional data will likely be required.
- If a statistical analysis is relied upon for making a *FACILITY* determination see Sections 2 and 3.

★ In certain cases, professional judgment may dictate that this pathway is not relevant due to lack of proximity to the surface water and other factors described in Cleanup Criteria Application Guidesheet 3. In this case, these criteria are not applicable and are not the basis for a property being considered a *FACILITY*.

Section 2

Selection of Data For Statistical Analysis

★ Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from appropriately placed wells at the GSI. Second, if statistics are used, data sets must be from the *AVERAGING AREA* and contain a sufficient number of sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* is often required after the nature and extent of contamination have been defined.

★ A statistical analysis is appropriate only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined. This means that the horizontal and vertical extent of contamination exceeding generic GSI criteria in groundwater, and sources that may result in GSI criteria exceedances in the future, must be defined.

	Section 2: (Continued)	The following bullets relate to evaluation of groundwater data from *GSI MONITORING WELLS* only: ★ Statistical analysis of groundwater data is not allowed for comparison to generic GSI criteria or acute mixing zone-based criteria. ★ Statistical analysis of groundwater data from *GSI MONITORING WELLS* is allowed for comparison to chronic mixing zone-based criteria only. Only groundwater data from *GSI MONITORING WELLS* within the *AVERAGING AREA* may be used for statistical comparison to chronic mixing zone-based GSI criteria. The *AVERAGING AREA* is the cross sectional area of the hazardous substance plume used to estimate the discharge rate of venting groundwater in the request for a mixing zone determination. This cross section represents the area in which hazardous substance concentrations exceed or are expected to exceed the generic GSI criteria. ★ It is appropriate to combine samples from *HOT SPOT* areas within the *AVERAGING AREA* with samples from other areas within the *AVERAGING AREA* for statistical purposes when comparing data to chronic mixing zone based criteria. ★ The horizontal limits of the cross sectional area typically extend to the nearest adjacent wells along the GSI in which groundwater concentrations are consistently below generic GSI criteria; it is assumed that groundwater concentrations exceed generic GSI criteria up to these boundary points. Therefore, the horizontal boundaries of the cross sectional area extend up to, but do not include, these adjacent wells. Consequently, the adjacent wells (below generic GSI) should not be included in the *AVERAGING AREA* and data from these wells should not be included in the statistical analysis. ★ Different *AVERAGING AREAS* may be required for different hazardous substances depending on whether more than one cross sectional area was used to estimate discharge rates of venting groundwater in the request for the mixing zone determination. ★ The groundwater data used in the statistical analysis must be representative of the *AVERAGING AREA* and include all monitoring points located within the *AVERAGING AREA*. Samples from a minimum of nine distinct GSI monitoring points must be used in the statistical analysis. This does not necessarily mean nine individual wells (e.g., three screened intervals in each of two wells would yield nine distinct monitoring points). This number is based on statistical considerations only, but may not be practical for groundwater plumes that have very narrow *AVERAGING AREAS*. Additional samples may be necessary to represent spatial variability in the *AVERAGING AREA* depending on such factors as soil type, and size of the *AVERAGING AREA*. ★ Statistical analysis of groundwater data over time is not allowed for comparison to chronic mixing zone-based criteria. The statistical analysis must generally be completed using data from a single sampling event. If resampling is conducted to confirm the presence of elevated hazardous substance concentrations in one or more individual wells, results from resampling should not be incorporated into the statistical analysis. However, all wells in the *AVERAGING AREA* may be resampled for the purpose of a separate statistical evaluation.
	Section 3	**Risk Analysis – Comparison to Criteria** ★ In certain cases, professional judgment may dictate that these criteria are not applicable due to lack of proximity to surface water and other factors as described in Cleanup Criteria Application Guidesheet 3.

	Section 3: (Continued)	★ Comparison of groundwater data to generic GSI criteria and acute mixing zone-based criteria must be completed on a point-by-point basis.* That is, statistical analysis of groundwater concentrations across well locations or over time in an individual well will not be allowed for comparison to these criteria. ★ Whole effluent acute toxicity test results must be compared to the *ONE ACUTE TOXIC UNIT* criterion on a point-by-point basis.* The *ONE ACUTE TOXIC UNIT* has the same regulatory significance as an acute mixing-zone-based GSI criterion. ★ Statistical analysis of groundwater data is allowed for comparison to chronic mixing zone-based criteria only. Only data from *GSI MONITORING WELLS* within the *AVERAGING AREA* may be included in the statistical analysis. The statistical analysis must generally be completed using data from a single sampling event. See Section 2 for a description of the *AVERAGING AREA* and additional details on *FACILITY* characterization data that may be included in the statistical analysis. • Statistical analyses must include an evaluation of the underlying statistical distribution of the data (i.e., normal, lognormal, or neither) and the level of censoring (i.e., proportion of the data below the detection limit). See the tabbed section titled, "Statistical Methods." This evaluation must be completed for each hazardous substance. The statistical method used for comparison of groundwater data to chronic mixing zone-based criteria must be selected for each hazardous substance based on statistical distribution and level of censoring. ★ If *BACKGROUND* concentrations are greater than criteria for naturally occurring substances, groundwater data may be compared to *BACKGROUND* concentrations. This evaluation will generally be made on a point-by-point basis,* except for certain chronic mixing zone-based criteria. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods."
	Section 4	**Verification of Remediation or Closure** • For the purposes of verification of remediation or closure, compliance of groundwater data with GSI criteria at the GSI may be determined in the same manner described in Section 3. To demonstrate verification of remediation or closure, concentrations in groundwater must meet criteria during a specified number of consecutive sampling events. The number of consecutive sampling events must be selected on a case-by-case basis to reflect seasonal variation in groundwater quality, flow rates, and initial distribution of contamination in groundwater. ★ **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of generic GSI criteria, and there is no reason to believe there will be exceedances in the future at the GSI, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **In situ/Ex situ Treatment**: For the purposes of verification of remediation or closure, compliance of groundwater data with these criteria may be determined in the same manner described in Section 3. Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data as allowed in Sections 2 and 3. To demonstrate verification of remediation or closure, concentrations in groundwater must meet criteria during a specified number of consecutive sampling events. The number of consecutive sampling events must be selected on a case-by-case basis to reflect seasonal variation in groundwater quality, flow rates, and initial distribution of contamination in groundwater.

	Section 4: (Continued)	• **Containment**: For the purposes of verification of remediation or closure, compliance of groundwater data with these criteria may be determined in the same manner described in Section 3. Generally groundwater sampling used to verify a groundwater containment remedy will be done at the perimeter of the containment system. These plans may or may not depend on statistical analysis of data as allowed in Sections 2 and 3. This verification will be ongoing part of the remedy as long as hazardous substances are present above criteria. ★ **For all the preceding cases**, in addition to demonstrating compliance with GSI criteria at the GSI, it is necessary to demonstrate that groundwater at the GSI will continue to meet GSI criteria for verification of remediation or closure. This demonstration must include an evaluation of upgradient groundwater and soil concentrations and sources. ★ If *BACKGROUND* concentrations are greater than criteria for naturally occurring substances, groundwater data may be compared to *BACKGROUND* concentrations. This evaluation will generally be made on a point-by-point basis,* except for certain chronic mixing zone-based criteria. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods."

Additional Information:	Criteria Application Guidesheet 3
Recommended Statistical Methods for Comparison to Criteria:	For chronic mixing zone-based criteria only, compare *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **GROUNDWATER** DATA	Statistical Guidesheet **4**
GENERIC RESIDENTIAL AND COMMERCIAL I GROUNDWATER VOLATILIZATION TO INDOOR AIR INHALATION CRITERIA (GVIIC)	
May assist in evaluation of condition(s):	4
Applicability of Statistics	**GNP**

Statistics are generally not practical as a tool for assessing this exposure pathway because of the spatial and temporal variability of groundwater hazardous substance plumes and the resulting soil gas plumes that are generated from hazardous substances in groundwater.

Key Considerations:

Section 1

Facility Determination

- For the purposes of a BEA or initial *FACILITY* determination, property may be classified as a *FACILITY* if one or more samples contain concentrations above generic residential criteria, provided that there is not a greater body of evidence that the property is not a *FACILITY*. For purposes other than *FACILITY* determination (e.g., remediation and/or closure), additional data will likely be required.
- If a statistical analysis is relied upon for making a *FACILITY* determination see Sections 2 and 3.

Section 2

Selection of Data For Statistical Analysis

- Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."
- A statistical analysis is appropriate only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.
- It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.1.1 of the tabbed section titled "Sampling Strategies."

★ Sample locations with concentrations equal to or greater than the hazardous substance's water solubility must not be included in the data set for statistical evaluation. Areas where data exceed solubility must be addressed separately and cannot be ignored.

	Section 2 (Continued)	★ Generally only groundwater data from a 1,200 ft^2 *EXPOSURE UNIT* (i.e., the building footprint) may be used in a statistical calculation for remedial compliance.
	Section 3	**Risk Analysis – Comparison to Criteria**
		★ Statistical analysis of *FACILITY* groundwater data for comparison to GVIIC is generally not practical given the spatial and temporal variability of groundwater plumes and the dynamics of the resulting soil gas plume that is generated by hazardous substances in groundwater. Determining the impact of these factors within a 1,200 ft^2 area (i.e., the building footprint) further complicates application of statistical approaches. As a result, comparison to these criteria will generally be completed on a point-by-point basis* (i.e., each concentration at each location must be compared individually to criteria). • If DEQ approval of a response activity is being sought, a *PROPOSAL* for a statistical analysis must be submitted to the DEQ for approval to assure that data needs and/or complexities of the pathway are addressed. • Statistical analysis of groundwater concentrations over time in an individual well will not be allowed for comparison to criteria.
	Section 4	**Verification of Remediation or Closure**
		• **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. To demonstrate verification of remediation or closure, concentrations in groundwater must meet criteria during a specified number of consecutive sampling events. The number of consecutive sampling events must be selected on a case-by-case basis to reflect seasonal variation in groundwater quality, flow rates, and initial distribution of contamination in groundwater. Ordinarily, this demonstration should be made using data from at least one year of quarterly sampling. • **Cover/Containment**: In the context of this pathway, cover/containment will typically be a vapor barrier. Generally groundwater sampling will not be used to verify remediation or closure that relies on vapor barrier. Verification of remediation in areas outside the cover/containment structure will be done using the options above. • Statistical analysis of groundwater concentrations over time in an individual well will not be allowed for comparison to criteria.

Additional Information	Criteria Application Guidesheet 4
Recommended Statistical Methods for Comparison to Criteria:	If statistical analysis is documented to be practical, the recommended statistical method is comparison of *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **GROUNDWATER** DATA	Statistical Guidesheet **5**
GENERIC COMMERCIAL II, III, IV AND INDUSTRIAL GROUNDWATER VOLATILIZATION TO INDOOR AIR INHALATION CRITERIA (GVIIC)	
May assist in evaluation of condition(s):	4
Applicability of Statistics	**GNP**

Statistics are generally not practical as a tool for assessing this exposure pathway because of the spatial and temporal variability of groundwater hazardous substance plumes and the resulting soil gas plumes that are generated from hazardous substances in groundwater.

Key Considerations:		
	Section 1	**Facility Determination**
		• Not applicable.
	Section 2	**Selection of Data For Statistical Analysis**
		• Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."
		• A statistical analysis is appropriate only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.
		• It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."
		★ Sample locations with concentrations equal to or greater than the hazardous substance's water solubility must not be included in the data set for statistical evaluation. Areas where data exceed solubility must be addressed separately and cannot be ignored.
		★ Generally only groundwater data from a 4,000 ft^2 *EXPOSURE UNIT* (i.e., the building footprint) may be used in a statistical calculation for remedial compliance.

	Section 3	**Risk Analysis – Comparison to Criteria**
		★ Statistical analysis of *FACILITY* groundwater concentrations for comparison to GVIIC is generally not practical given the spatial and temporal variability of groundwater plumes and the dynamics of the resulting soil gas plume that is generated by hazardous substances in groundwater. Determining the impact of these factors within a 4,000 ft^2 area (i.e., the building footprint) adds further complications with application of statistical approaches. As a result, comparison to these criteria will generally be completed on a point-by-point basis* (i.e., each concentration at each location must be compared individually to criteria). • If DEQ approval of a response activity is being sought, a *PROPOSAL* for a statistical analysis must be submitted to the DEQ for approval to assure that data needs and/or complexities of the pathway are addressed. • Statistical analysis of groundwater concentrations over time in an individual well will not be allowed for comparison to criteria.
	Section 4	**Verification of Remediation or Closure**
		• **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. To demonstrate verification of remediation or closure, concentrations in groundwater must meet criteria during a specified number of consecutive sampling events. The number of consecutive sampling events must be selected on a case-by-case basis to reflect seasonal variation in groundwater quality, flow rates, and initial distribution of contamination in groundwater. Ordinarily, this demonstration should be made using data from at least one year of quarterly sampling. • **Cover/Containment**: In the context of this pathway, cover/containment will typically be a vapor barrier. Generally groundwater sampling will not be used to verify remediation or closure that relies on a vapor barrier. Verification of remediation in areas outside the cover/containment structure will be done using the options above. • Statistical analysis of groundwater concentrations over time in an individual well will not be allowed for comparison to criteria.

Additional Information:	Criteria Application Guidesheet 5
Recommended Statistical Methods for Comparison to Criteria:	If statistical analysis is documented to be practical, the recommended statistical method is comparison of *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **GROUNDWATER** DATA	Statistical Guidesheet 6
GENERIC GROUNDWATER CONTACT CRITERIA (GCC)	
May assist in evaluation of condition(s):	3
Applicability of Statistics	**GNP**

Statistics are generally not practical as a tool for assessing this exposure pathway because it is unlikely that a sufficient number of samples will be collected to allow for valid analysis in the very small areas where groundwater contact may occur.

Key Considerations:

Section 1

Facility Determination

- For the purposes of a BEA or initial *FACILITY* determination, property may be classified as a *FACILITY* if one or more samples contain concentrations above generic residential criteria or *BACKGROUND* concentrations, whichever is greater, provided that there is not a greater body of evidence that the property is not a *FACILITY*. For purposes other than *FACILITY* determination (e.g., remediation and/or closure), additional data will likely be required.

- If a statistical analysis is relied upon for making a *FACILITY* determination see Sections 2 and 3.

★ In certain cases, professional judgment may dictate that this pathway is not relevant if the depth to groundwater is greater than the depth to utilities and the depth at which other subsurface work may be performed. These factors and additional considerations are described in Criteria Application Guidesheet 6. If the pathway is not relevant, these criteria are not applicable and are not the basis for a property being considered a *FACILITY*.

Section 2

Selection of Data For Statistical Analysis

- Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."

- A statistical analysis is appropriate only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.

- It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."

	Section 3	**Risk Analysis – Comparison to Criteria** ★ In certain cases, professional judgment may dictate that these criteria are not applicable due to factors such as depth to groundwater relative to the depth where subsurface activities may occur, and other factors as described in Criteria Application Guidesheet 6. ★ Statistical analysis of *FACILITY* groundwater concentrations for comparison to criteria is generally not practical, since exposure to groundwater may be limited to very small areas such as an area the size of a manhole. Therefore, comparisons to GCC will generally be completed on a point-by-point basis* (i.e., each concentration at each time and location must be compared individually to criteria). • If DEQ approval of a response activity is being sought, a *PROPOSAL* for a statistical analysis must be submitted to the DEQ for approval to assure that data needs and/or complexities of the pathway are addressed. • If *BACKGROUND* concentrations are greater than criteria for naturally occurring substances, groundwater concentrations may be compared to *BACKGROUND* concentrations. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods." This evaluation will generally be made on a point-by-point basis* because of the lack of data. • Statistical analysis of groundwater concentrations over time in an individual well will not be allowed for comparison to criteria or *BACKGROUND*.
	Section 4	**Verification of Remediation or Closure** • **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **In situ/Ex situ Treatment**: For the purposes of verification of remediation or closure, compliance of groundwater data with these criteria may be determined in the same manner described in Section 3. Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data as allowed in Sections 2 and 3. To demonstrate verification of remediation or closure, concentrations in groundwater must meet criteria during a specified number of consecutive sampling events. The number of consecutive sampling events must be selected on a case-by-case basis to reflect seasonal variation in groundwater quality, flow rates, and initial distribution of contamination in groundwater. Ordinarily, this demonstration should be made using data from at least one year of quarterly sampling. • **Containment**: Generally groundwater sampling used to verify a groundwater containment remedy will be done at the perimeter of the containment system. Statistical analysis is generally not practical for reasons described in Sections 2 and 3. This verification will be an ongoing part of the remedy as long as hazardous substances are present above criteria. • If *BACKGROUND* concentrations are greater than criteria for naturally occurring substances, groundwater concentrations may be compared to *BACKGROUND* concentrations. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods." This evaluation will generally be made on a point-by-point basis* because of the lack of data.

Additional Information:	Criteria Application Guidesheet 6
Recommended Statistical Methods for Comparison to Criteria:	If statistical analysis is documented to be practical, the recommended statistical method is comparison of *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, “Statistical Methods”). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **GROUNDWATER** DATA	Statistical Guidesheet 7
WATER SOLUBILITY	
May assist in evaluation of condition(s):	1-5
Applicability of Statistics	**Pathway Dependent**
See the Statistical Guidesheet for the exposure pathway where the cleanup criterion defaults to water solubility to determine the applicability of statistics.	

Key Considerations:	**Section 1**	**Facility Determination**
		• See the Statistical Guidesheet for the generic criterion that defaults to the water solubility value.
	Section 2	**Selection of Data For Statistical Analysis**
		• See the Statistical Guidesheet for the generic criterion that defaults to the water solubility value. • Data that are greater than water solubility should not be included in a statistical analysis.
	Section 3	**Risk Analysis – Comparison to Criteria**
		• See Section 2.
	Section 4	**Verification of Remediation or Closure**
		• See Section 2.

Additional Information:	Criteria Application Guidesheets 7 and A, and Appendix A.
Recommended Statistical Methods for Comparison to Criteria:	See Statistical Guidesheets for relevant exposure pathways.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **GROUNDWATER** DATA	Statistical Guidesheet **8**
GENERIC SCREENING LEVELS FOR FLAMMABILITY AND EXPLOSIVITY	
May assist in evaluation of condition(s):	3, 4, 14
Applicability of Statistics	**GNP**
Statistics are generally not practical as a tool for assessing this condition because it deals with acute risks and any exceedance of screening levels requires further consideration.	

Key Considerations:		
	Section 1	**Facility Determination**
		• The determination that property is a *FACILITY* is generally based on data which show that one or more generic residential cleanup criterion is exceeded. Since the values developed for this condition are screening levels and not cleanup criteria, *FACILITY* determinations generally will not be based on this condition. If you are evaluating property where you suspect problems with this condition and no data are available to demonstrate that the property is a *FACILITY* for other reasons, consult your supervisor for guidance.
	Section 2	**Selection of Data For Statistical Analysis**
		• Not applicable - see Section 3.
	Section 3	**Risk Analysis – Comparison to Criteria**
		★ Since this condition deals with acute risks, any exceedance of screening levels requires further consideration. Statistical treatment of data is not expected to be a practical tool for making decisions about the need for response activity related to this condition. Professional judgment will be required to determine the significance of any data that relates to this condition. The quantity of the hazardous substance that is present above its screening level(s) is a factor that determines whether there may be an unacceptable risk.
	Section 4	**Verification of Remediation or Closure**
		• See Section 3.

Additional Information:	Criteria Application Guidesheet 8
Recommended Statistical Methods for Comparison to Criteria:	The statistical method for comparing *FACILITY* data to criteria will be determined on a case-by-case basis.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **GROUNDWATER** DATA	Statistical Guidesheet 9
GENERIC ACUTE INHALATION TOXICITY SCREENING LEVELS	
May assist in evaluation of condition(s):	3, 4, 14
Applicability of Statistics	**GNP**
Statistics are generally not practical as a tool for assessing this condition because it deals with acute risks and any exceedance of screening levels requires further consideration.	

Key Considerations:		
	Section 1	**Facility Determination**
		• The determination that property is a *FACILITY* is generally based on data which show that one or more generic residential cleanup criterion is exceeded. Since the values developed for this condition are screening levels and not cleanup criteria, *FACILITY* determinations generally will not be based on this condition. If you are evaluating property where you suspect problems with this condition and no data are available to demonstrate that the property is a *FACILITY* for other reasons, consult your supervisor for guidance.
	Section 2	**Selection of Data For Statistical Analysis**
		• Not applicable - see Section 3.
	Section 3	**Risk Analysis – Comparison to Criteria**
		★ Since this condition deals with acute risks, any exceedance of screening levels requires further consideration. Statistical treatment of data is not expected to be a practical tool for making decisions about the need for response activity related to this condition. Professional judgment will be required to determine the significance of any data that relates to this condition. The quantity of the hazardous substance that is present above its screening level(s) is a factor that determines whether there may be an unacceptable risk.
	Section 4	**Verification of Remediation or Closure**
		• See Section 3.

Additional Information:	Criteria Application Guidesheet 9
Recommended Statistical Methods for Comparison to Criteria:	The statistical method for comparing *FACILITY* data to criteria will be determined on a case-by-case basis.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheet **10**
SOIL BACKGROUND	
May assist in evaluation of Condition(s):	6-12
Applicability of Statistics	**YES** - Determining *BACKGROUND*; **Pathway Dependent** - Comparison to *FACILITY* Data

See the Statistical Guidesheet for the soil exposure pathway to determine if criteria may default to *BACKGROUND* and if statistical analysis of *FACILITY* data is appropriate for comparison to *BACKGROUND* (or if a point-by-point comparison of *FACILITY* data to *BACKGROUND* is necessary).

Key Considerations:		
	Section 1	**Facility Determination**
		• For the purposes of a BEA or initial *FACILITY* determination, property may be classified as a *FACILITY* if one or more samples contain concentrations above generic residential criteria or *BACKGROUND* concentrations, whichever is greater, provided that there is not a greater body of evidence that the property is not a *FACILITY*. However, if concentrations of a hazardous substance from the property are less than the *STATEWIDE DEFAULT BACKGROUND* concentration in Operational Memorandum #15 for that hazardous substance, the property is not a *FACILITY* with respect to that hazardous substance. For purposes other than *FACILITY* determination (e.g., remediation and/or closure), additional data will likely be required. • If a statistical analysis is relied upon for making a *FACILITY* determination see Sections 2 and 3.
	Section 2	**Selection of Data For Statistical Analysis**
		★ For all other Statistical Guidesheets, this section addresses selection of *FACILITY* data for statistical analysis. However, for this Statistical Guidesheet, the following comments address selection of *BACKGROUND* data for establishing *BACKGROUND* concentrations. ★ Establishing soil *BACKGROUND* can be accomplished by utilizing the *STATEWIDE DEFAULT BACKGROUND* criteria provided in Operational Memorandum #15 or by developing *FACILITY-SPECIFIC BACKGROUND* criteria. In addition, *REGIONAL BACKGROUND* may be *PROPOSED* on a case-by-case basis, as described in Operational Memorandum #15. ★ If multiple soil horizons are present at a *FACILITY*, *FACILITY-SPECIFIC BACKGROUND* should be established for each distinct soil horizon being evaluated at the *FACILITY*. ★ *FACILITY-SPECIFIC BACKGROUND* samples should be taken in each distinct soil type or horizon and at comparable depths to *FACILITY* soil samples being compared to *FACILITY-SPECIFIC BACKGROUND*. A minimum of nine samples for each distinct soil horizon should be used to establish *FACILITY-SPECIFIC BACKGROUND* concentrations. This is to help account for the natural variability inherent within each distinct soil horizon. Fewer than nine samples may be *PROPOSED* on a case-by-case basis.

	Section 2: (Continued)	★ *FACILITY-SPECIFIC BACKGROUND* samples must reflect naturally occurring concentrations except as described in the following bullet. This is necessary to comply with the definition of *BACKGROUND* under Part 201: "The concentration or level of a hazardous substance which exists in the environment at or regionally proximate to a site that is not attributable to any release at or regionally proximate to the site." ★ *BACKGROUND* soil samples are typically used to establish naturally occurring levels of metals. *NON-RELEASE ANTHROPOGENIC BACKGROUND* may be *PROPOSED* on a case-by-case basis for other classes of hazardous substances if the presence of these hazardous substances is not present due to a *RELEASE* (e.g., compounds present in the soil resulting from application of pesticides in accordance with label directions). ★ *FACILITY-SPECIFIC BACKGROUND* samples should be collected using the same methodology, analytical methods and detection limits as *FACILITY* samples. ★ *BACKGROUND* soil samples must be analyzed using methods and detection limits found in Operational Memorandum #6, Rev 5.
	Section 3	**Risk Analysis – Comparison to Criteria** ★ According to Section 20a(11), *BACKGROUND* concentrations become the Part 201 cleanup criteria when *BACKGROUND* concentrations are greater than corresponding risk-based criteria. ★ The recommended statistical method for comparing *FACILITY* data to *BACKGROUND* depends on the type of *BACKGROUND* being used and whether a statistical analysis was appropriate for comparing *FACILITY* data to Part 201 risk-based criteria. See Chapter 4 of the tabbed section titled, "Statistical Methods." • When *FACILITY-SPECIFIC BACKGROUND* is utilized, the analysis *OF FACILITY-SPECIFIC BACKGROUND* data must include an evaluation of the underlying statistical distribution of the data (i.e., normal, lognormal, or neither) and level of censoring (i.e., proportion of data below the detection limit). See the tabbed section titled, "Statistical Methods." This evaluation must be completed for each hazardous substance. • The presence of outliers in the *FACILITY-SPECIFIC BACKGROUND* data set should be evaluated using the procedures outlined in Chapter 2 of the tabbed section titled, "Statistical Methods."
	Section 4	**Verification of Remediation or Closure** ★ Refer to the statistical guidesheets corresponding to the pathway/condition. When appropriate, verification samples may be compared to *BACKGROUND* concentrations as described in Sections 2 and 3 of this guidesheet.

Additional Information:	Criteria Application Guidesheet 10
Recommended Statistical Methods for Comparison to Criteria:	See Chapter 4 of the tabbed section titled, "Statistical Methods." Other statistical methods may be acceptable on a case-by-case basis.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheet **11**

GENERIC SOIL CRITERIA PROTECTIVE OF RESIDENTIAL AND COMMERCIAL I DRINKING WATER

May assist in evaluation of condition(s):	9
Applicability of Statistics	**GNP**

Statistics are generally not practical as a tool for assessing this exposure pathway because of the difficulty in projecting the impact on groundwater of hazardous substances in soil and the need to assure that drinking water cleanup criteria are met at all points in the aquifer.

Key Considerations:

Section 1

Facility Determination

- For the purposes of a BEA or initial *FACILITY* determination, property may be classified as a *FACILITY* if one or more samples contain concentrations above generic residential criteria or *BACKGROUND* concentrations, whichever is greater, provided that there is not a greater body of evidence that the property is not a *FACILITY* or leachate sample results are less than the groundwater criterion. However, if concentrations of a hazardous substance from the property are less than the *STATEWIDE DEFAULT BACKGROUND* value in Operational Memorandum #15 for that hazardous substance, the property is not a *FACILITY* with respect to that hazardous substance. For purposes other than *FACILITY* determination (e.g., remediation and/or closure), additional data will likely be required.

- If a statistical analysis is relied upon for making a *FACILITY* determination see Sections 2 and 3.

Section 2

Selection of Data For Statistical Analysis

- Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."

- A statistical analysis is appropriate only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.

- It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."

	Section 3	**Risk Analysis – Comparison to Criteria**
		★ Statistical analysis of *FACILITY* soil concentrations for comparison to soil criteria protective of the drinking water criteria may be acceptable in limited circumstances. Sufficient data must be available to demonstrate that areas of contaminated soil above criteria are not large enough to result in groundwater concentrations in an aquifer above criteria. This may require a fairly rigorous data set that is not often practical to obtain. Similarly, statistical analysis of *FACILITY* leachate concentrations for comparison to drinking water criteria may also be acceptable in limited circumstances. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for comparing to *BACKGROUND* will also vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods." • Statistical analysis of *FACILITY* data is not allowed for hazardous substances present above Csat screening levels without further evaluation of risk and the extent of the area exceeding Csat. • Statistical analysis of *FACILITY* data is not allowed for hazardous substances that have criteria based on acute toxicological effects and/or physical hazards.
	Section 4	**Verification of Remediation or Closure**
		• **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **Excavation**: Analytical results from verification sampling will generally be compared to Part 201 criteria on a point-by-point basis* in unsaturated soil. Numbers and locations of samples collected for verifying remediation of soil by excavation can be selected in accordance with either the tabbed section titled, "Sampling Strategies" (Sections 1.3 or 2.3 as appropriate based on size of excavation), or a DEQ-approved sampling plan. • **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data as allowed in Sections 2 and 3. • **Cover/Containment**: Generally soil sampling will not be used to verify remediation or closure that relies on a cover or containment. Instead, verification of remediation will involve verifying the integrity of the cover or containment structure on an ongoing basis. Groundwater sampling may be used in some cases to verify the effectiveness of the cover/containment. Verification of remediation in areas outside the cover/containment structure will be done using the options above. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for comparing to *BACKGROUND* will also vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods."

Additional Information:	Criteria Application Guidesheet 11; Statistical Guidesheet 1
Recommended Statistical Methods for Comparison to Criteria:	If statistical analysis is documented to be practical, the recommended statistical method is comparison of *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheet **12**

SOIL CRITERIA PROTECTIVE OF THE GROUNDWATER SURFACE WATER INTERFACE (GSI)

May assist in evaluation of condition(s):	11
Applicability of Statistics	**GNP**

Statistics are generally not practical as a tool for assessing this exposure pathway because of the difficulty in projecting the impact on groundwater of hazardous substances in soil and the need for analysis of transport of hazardous substance from areas that are remote from the GSI.

Key Considerations:

Section 1

Facility Determination

- For the purposes of a BEA or initial *FACILITY* determination, property may be classified as a *FACILITY* if one or more samples contain concentrations above generic residential criteria or *BACKGROUND* concentrations, whichever is greater, provided that there is not a greater body of evidence that the property is not a *FACILITY* or leachate sample results are less than the groundwater criterion. However, if concentrations of a hazardous substance from the property are less than the *STATEWIDE DEFAULT BACKGROUND* value in Operational Memorandum #15 for that hazardous substance, the property is not a *FACILITY* with respect to that hazardous substance. For purposes other than *FACILITY* determination (e.g., remediation and/or closure), additional data will likely be required.

- If a statistical analysis is relied upon for making a *FACILITY* determination see Sections 2 and 3.

★ In certain cases, professional judgment may dictate that this pathway is not relevant due to proximity to the surface water and other factors described in Cleanup Criteria Application Guidesheet 3. In this case, these criteria are not applicable and are not the basis for a property being considered a *FACILITY*.

Section 2

Selection of Data For Statistical Analysis

★ Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are representative of potential impacts for this migration pathway. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results from an appropriate area to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in section 2.4.2 of the tabbed section titled, “Sampling Strategies.”

- A statistical analysis is appropriate only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.

	Section 2: (Continued)	• It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."
	Section 3	**Risk Analysis – Comparison to Criteria** ★ Statistical analysis of *FACILITY* soil or leachate concentrations for comparison to soil criteria protective of the GSI based on generic critieria or mixing zone-based criteria may be acceptable in limited circumstances, but is generally not practical. Meaningful use of statistics in these cases would require identifying a contaminated soil volume that is remote from the GSI but related to points at the GSI with a degree of precision that is generally not practical to achieve. This is because of the uncertainties associated with distribution of hazardous substances and transport to the GSI at most sites. ★ Only soil or leachate concentrations from areas that impact groundwater concentrations at the *AVERAGING AREA* may be used for statistical comparison to a soil criteria protective of the GSI which is based on chronic mixing zone-based criteria. • If DEQ approval of a response activity is being sought, a *PROPOSAL* for a statistical analysis must be submitted to the DEQ for approval to assure that data needs and/or complexities of the pathway are addressed. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for comparing to *BACKGROUND* will also vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods." • Statistical analysis of *FACILITY* data is not allowed for hazardous substances present above Csat screening levels without further evaluation of risk and the extent of the area exceeding Csat.
	Section 4	**Verification of Remediation or Closure** • **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **Excavation**: Statistical analysis of *FACILITY* soil or leachate data is generally not practical. See Section 3. Analytical results from verification sampling will therefore generally be compared to Part 201 criteria on a point-by-point basis* in unsaturated soil. Numbers and locations of samples collected for point-by-point comparison can be selected in accordance with either the tabbed section titled, "Sampling Strategies" (Sections 1.3 or 2.3 as appropriate based on size of excavation), or a DEQ-approved sampling plan. If a statistical analysis is relied upon for verifying remediation or closure follow the guidance presented in Sections 2 and 3 in this Guidesheet. • **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data.

	Section 4: (Continued)	• **Cover/Containment**: Generally soil sampling will not be used to verify remediation or closure that relies on a cover or containment. Instead, verification of remediation will involve verifying the integrity of the cover or containment structure on an ongoing basis. Groundwater sampling may be used in some cases to verify the effectiveness of the cover/containment. Verification of remediation in areas outside the cover/containment structure will be done using the options above. ★ For all the preceding cases, it is necessary to demonstrate that groundwater at the GSI will continue to meet GSI criteria. This conclusion must be based on a demonstration that soil conditions and sources will not result in a future exceedance of GSI criteria at the GSI. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for comparing to *BACKGROUND* will also vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods."

Additional Information:	Criteria Application Guidesheet 12; Statistical Guidesheet 3
Recommended Statistical Methods for Comparison to Criteria:	If statistical analysis is documented to be practical, the recommended statistical method is comparison of *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheet 13
GENERIC SOIL CRITERIA PROTECTIVE FOR GROUNDWATER CONTACT	
May assist in evaluation of condition(s):	10
Applicability of Statistics	**GNP**

Statistics are generally not practical as a tool for assessing this exposure pathway because of the difficulty in projecting the impact on groundwater of hazardous substances in soil and the need to assure compliance with GCC in potentially small areas.

Key Considerations:

Section 1

Facility Determination

- For the purposes of a BEA or initial *FACILITY* determination, property may be classified as a *FACILITY* if one or more samples contain concentrations above generic residential criteria or *BACKGROUND* concentrations, whichever is greater, provided that there is not a greater body of evidence that the property is not a *FACILITY* or leachate sample results are less than the groundwater criterion. However, if concentrations of a hazardous substance from the property are less than the *STATEWIDE DEFAULT BACKGROUND* value in Operational Memorandum #15 for that hazardous substance, the property is not a *FACILITY* with respect to that hazardous substance. For purposes other than *FACILITY* determination (e.g., remediation and/or closure), additional data will likely be required.
- If a statistical analysis is relied upon for making a *FACILITY* determination see Sections 2 and 3.

★ In certain cases, professional judgment may dictate that this pathway is not relevant if the depth to groundwater is greater than the depth to utilities and the depth at which other subsurface work may be performed. These factors and additional considerations are described in Cleanup Criteria Application Guidesheet 6. If the pathway is not relevant, these criteria are not applicable and are not the basis for a property being considered a *FACILITY*.

Section 2

Selection of Data For Statistical Analysis

- Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in section 2.4.2 of the tabbed section titled, "Sampling Strategies."
- A statistical analysis is appropriate only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.

	Section 2: (Continued)	• It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."
	Section 3	**Risk Analysis – Comparison to Criteria**
		★ Since sufficient data are generally not available to allow for a statistical evaluation within the limited area that would be necessary to assure compliance with GCC at all potential exposure points in groundwater, comparison of soil data to these criteria must generally be completed on a point-by-point basis* (i.e., each concentration at each location must be compared individually to criteria). Therefore, statistical analysis of *FACILITY* soil concentrations for comparison to soil criteria protective for groundwater contact is generally not practical. Statistical analysis of *FACILITY* leachate concentrations for comparison to criteria may be acceptable in limited circumstances, but is also generally not practical. ★ In certain cases, professional judgment may dictate that this pathway is not relevant if the depth to groundwater is greater than the depth to utilities and the depth at which other subsurface work may be performed. These factors and additional considerations are described in Cleanup Criteria Application Guidesheet 6. If the pathway is not relevant, these criteria are not applicable and are not the basis for a property being considered a *FACILITY*. • If DEQ approval of a response activity is being sought, a *PROPOSAL* for a statistical analysis must be submitted to the DEQ for approval to assure that data needs and/or complexities of the pathway are addressed. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for determining *BACKGROUND* concentrations will vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods." • Statistical analysis of *FACILITY* data is not allowed for hazardous substances present above Csat screening levels without further evaluation of risk and the extent of the area exceeding Csat.
	Section 4	**Verification of Remediation or Closure**
		• **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **Excavation**: Statistical analysis of *FACILITY* soil or leachate data is generally not practical. See Section 3. Analytical results from verification sampling will therefore generally be compared to Part 201 criteria on a point-by-point basis* in unsaturated soil. Numbers and locations of samples collected for point-by-point comparison can be selected in accordance with either the tabbed section titled, "Sampling Strategies" (Sections 1.3 or 2.3 as appropriate based on size of excavation), or a DEQ-approved sampling plan. If a statistical analysis is relied upon for verifying remediation or closure follow the guidance presented in Sections 2 and 3 of this Guidesheet.

	Section 4: (Continued)	• **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data. • **Cover/Containment**: Generally soil sampling will not be used to verify remediation or closure that relies on a cover or containment. Instead, verification of remediation will involve verifying the integrity of the cover or containment structure on an ongoing basis. Groundwater sampling may be used in some cases to verify the effectiveness of the cover/containment in which case groundwater data should be evaluated as described in Section 4 of Statistical Guidesheet 6. Verification of remediation in areas outside the cover/containment structure will be done using the options above. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for determining *BACKGROUND* concentrations will vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods."
Additional Information:		Criteria Application Guidesheet 13; Statistical Guidesheet 6
Recommended Statistical Methods for Comparison to Criteria:		If statistical analysis is documented to be practical, the recommended statistical method is comparison of *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheet **14**

GENERIC RESIDENTIAL AND COMMERCIAL I SOIL VOLATILIZATION TO INDOOR AIR INHALATION CRITERIA (SVIIC)

May assist in evaluation of condition(s):	8
Applicability of Statistics	**GNP**

Statistics are generally not practical as a tool for assessing this exposure pathway because it is unlikely that there will be a sufficient number of samples available from the generic building footprint size.

Key Considerations:

Section 1

Facility Determination

- For the purposes of a BEA or initial *FACILITY* determination, property may be classified as a *FACILITY* if one or more samples contain concentrations above generic residential criteria, provided that there is not a greater body of evidence that the property is not a *FACILITY*. For purposes other than *FACILITY* determination (e.g., remediation and/or closure), additional data will likely be required.
- If a statistical analysis is relied upon for making a *FACILITY* determination see Sections 2 and 3.

Section 2

Selection of Data For Statistical Analysis

★ Generally, only data from a 1,200 ft^2 *EXPOSURE UNIT* may be used in any particular statistical calculation.

- Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."
- A statistical analysis is appropriate only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.
- It is not appropriate to combine data from *HOT SPOT* areas with data from other areas of a property for statistical analysis. This is necessary to avoid averaging out or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."

★ Generally only soil data from a 1,200 ft^2 *EXPOSURE UNIT* (i.e., the building footprint) may be used in a statistical calculation for remedial compliance.

	Section 3	**Risk Analysis – Comparison to Criteria**
		★ Statistical analysis of *FACILITY* soil concentrations for comparison to residential SVIIC is generally not practical since sufficient data (i.e., a minimum of nine *RANDOMLY* located samples) are generally not available to allow for a statistical evaluation within the generic building footprint area of 1,200 ft^2. Therefore, comparisons to SVIIC must generally be completed on a point-by-point basis* (i.e., each concentration at each location must be compared individually to criteria). ★ Any statistical analysis must consider the potential for spatial variability of soil types to influence vapor migration. • If DEQ approval of a response activity is being sought, a *PROPOSAL* for a statistical analysis must be submitted to the DEQ for approval to assure that data needs and/or complexities of the pathway are addressed. • Statistical analysis of *FACILITY* data is not allowed for hazardous substances present above Csat screening levels without further evaluation of risk and the extent of the area exceeding Csat.
	Section 4	**Verification of Remediation or Closure**
		• **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **Excavation**: Statistical analysis of *FACILITY* soil data is generally not practical. See Section 3. Analytical results from verification sampling will therefore generally be compared to Part 201 criteria on a point-by-point basis* in unsaturated soil. Numbers and locations of samples collected for point-by-point comparison can be selected in accordance with either the tabbed section titled, "Sampling Strategies" (Sections 1.3 or 2.3 as appropriate based on size of excavation), or a DEQ-approved sampling plan. If a statistical analysis is relied upon for verifying remediation or closure follow the guidance presented in Sections 2 and 3 of this Guidesheet. • **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data. • **Cover/Containment**: In the context of this pathway, cover/containment will typically be a vapor barrier. Generally soil sampling will not be used to verify remediation or closure that relies on a cover or containment. Verification of remediation in areas outside the cover/containment structure will be done using the other options in this section. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for determining *BACKGROUND* concentrations will vary depending on which type of *BACKGROUND* is being considered. See Chapter 4 of the tabbed section titled, "Statistical Methods."

Additional Information:	Criteria Application Guidesheet 14
Recommended Statistical Methods for Comparison to Criteria:	If statistical analysis is documented to be practical, the recommended statistical method is comparison of *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheets **15, 16 and 17**

GENERIC RESIDENTIAL AND COMMERCIAL I INFINITE AND FINITE VOLATILE SOIL INHALATION CRITERIA (VSIC) FOR AMBIENT AIR

May assist in evaluation of condition(s):	7
Applicability of Statistics	**YES**

Statistics are applicable for evaluating this exposure pathway. Use of statistics is practical when there are adequate data sets available in the *EXPOSURE UNITS* or *EMISSION SOURCE AREAS*, as appropriate to the *FACILITY*.

Key Considerations:

Section 1

Facility Determination

- For the purposes of a BEA, or initial *FACILITY* determination, property may be classified as a *FACILITY* if one or more samples contain concentrations above generic residential, provided that there is not a greater body of evidence that the property is not a *FACILITY*. For purposes other than *FACILITY* determination (e.g., remediation and/or closure), additional data will likely be required.

- If a statistical analysis is relied upon for making a *FACILITY* determination see Sections 2 and 3.

Section 2

Selection of Data For Statistical Analysis

- Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."

- A statistical analysis of soil data should be completed only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.

- It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."

★ The horizontal and vertical extent of the *EMISSION SOURCE AREA* must be estimated to allow for selection of the *SOURCE SIZE MODIFIER* and infinite or finite source generic VSIC. Only data from the estimated *EMISSION SOURCE AREA* may be used in statistical analysis for comparison to criteria. See the "Part 201 Generic Soil Inhalation Criteria for Ambient Air: Technical Support Document" for information about source size characterization.

	Section 2: (Continued)	★ Characterization of the horizontal extent of contamination is necessary for both finite and infinite generic VSIC to estimate the *EMISSION SOURCE AREA* contributing to volatile emissions from soil. ★ Infinite generic VSIC are applicable to the entire contaminated vertical soil column since both surface and subsurface concentrations of hazardous substances in soil may contribute to volatile emissions. ★ Finite generic VSIC are applicable only when contamination is demonstrated to be limited to a two or five-foot vertical interval. Consequently, only data from the contaminated interval can be included in a statistical analysis. If contamination is not limited to a two or five-foot interval, infinite source VSIC are applicable. ★ A *SOURCE SIZE MODIFIER* must be selected for *EMISSION SOURCE SIZES* that are different than the assumed 1/2 acre *EMISSION SOURCE SIZE*. The *SOURCE SIZE MODIFIER* must correspond to an *EMISSION SOURCE SIZE* that is at least as large as the *EMISSION SOURCE SIZE* of the *FACILITY*. For example, if the *EMISSION SOURCE SIZE* at a *FACILITY* is at least eight acres, the generic soil inhalation criteria for a 1/2 acre *EMISSION SOURCE SIZE* is multiplied by the *SOURCE SIZE MODIFIER* for 10 acres to provide generic criteria for a 10 acre *FACILITY*. *SOURCE SIZE MODIFIERS* to adjust generic criteria for *EMISSION SOURCE SIZES* other than a 1/2 acre are provided in a table at the end of this guidesheet.
	Section 3	**Risk Analysis – Comparison to Criteria** ★ Criteria for this pathway depend on the *EMISSION SOURCE SIZE*, which must be estimated in both the horizontal and vertical dimension. Criteria shown in the cleanup criteria tables are based on a 1/2 acre *EMISSION SOURCE SIZE*. *SOURCE SIZE MODIFIERS* to adjust generic criteria for *EMISSION SOURCE SIZES* other than a 1/2 acre are provided in a table at the end of this guidesheet. For convenience, this table has been updated to include 1/4 acre and two acre *EMISSION SOURCE SIZES* for use at residential/commercial I and commercial II, III, IV and industrial land uses, respectively. Soil contamination for the VSIC pathway may occur in two general patterns that will affect the *EMISSION SOURCE SIZE* used to adjust the criteria for comparison to the *FACILITY* data: ★ **Properties or *FACILITIES* with a single *EMISSION SOURCE AREA*** If hazardous substances are detected in only a limited area within a 1/4 acre *EXPOSURE UNIT* and are not detected in other areas of the *EXPOSURE UNIT*, the *EMISSION SOURCE AREA* is equal to only the horizontal extent of the area with detectable concentrations. Only data within the *EMISSION SOURCE AREA* may be included in a statistical analysis. For an *EMISSION SOURCE AREA* that is larger than a 1/4 acre (i.e., *EXPOSURE UNIT*), soil concentrations within each 1/4 acre *EXPOSURE UNIT* must meet the VSIC adjusted for the *EMISSION SOURCE SIZE*.

	Section 3: (Continued)	★ **Properties with multiple *EMISSION SOURCE AREAS*** Properties larger than a 1/4 acre may contain several small *EMISSION SOURCE AREAS*. Where hazardous substances are not detected in the areas of the property between *EMISSION SOURCE AREAS*, the final *EMISSION SOURCE SIZE* is the sum of the horizontal extent of all individual *EMISSION SOURCE AREAS*. Soil concentrations within each *EMISSION SOURCE AREA* are compared to the generic criteria adjusted for the summed area of the individual *EMISSION SOURCE AREA* sizes. ★ Statistical analysis is possible for either the *EXPOSURE UNIT* or the *EMISSION SOURCE AREA* provided that sufficient data are available as described in Section 2. ★ Nine *RANDOMLY* located samples per *EXPOSURE UNIT* or *EMISSION SOURCE AREA*, whichever is smaller, should generally be used to conduct the statistical analysis. The actual number of samples to be collected may vary based on size of the *EMISSION SOURCE AREA*. Data collected for other purposes (as for identification of nature and extent) may be used where *RANDOM* sample locations fall on or reasonably close to existing sample locations and where data will be consistent in terms of sampling and analytical methods. • Statistical analyses must include an evaluation of the underlying statistical distribution of the data (i.e., normal, lognormal, or neither) and the level of censoring (i.e., proportion of the data below the detection limit). See the tabbed section titled, Statistical Methods." This evaluation must be completed for each hazardous substance. Additionally, the statistical methods used to compare *FACILITY* data to criteria must be selected based on statistical distribution and level of censoring. ★ Compliance with infinite generic VSIC must be demonstrated for the entire vertical soil column since both surface and subsurface soil concentrations of hazardous substances may contribute to volatile emissions. • Since a hazardous substance will <u>not</u> volatilize more when present at concentrations greater than Csat, sample data that exceeds Csat can be included in a statistical analysis to determine compliance with the VSIC as long as the Csat exceedance is not a *HOT SPOT*. • Statistical analysis of *FACILITY* data is not allowed for hazardous substances that have criteria based on acute toxicological effects and/or physical hazards.
	Section 4	**Verification of Remediation or Closure** • **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4.

	Section 4: (Continued)	• **Excavation**: Numbers and locations of samples collected for verifying remediation of soil can be selected in accordance with either the tabbed section titled, "Sampling Strategies" (Sections 1.3 or 2.3 as appropriate based on size of excavation), or a DEQ-approved sampling plan when a person is seeking DEQ approval of the response activity. Analytical results from verification sampling must be compared to Part 201 criteria on a point-by-point basis* unless a minimum of nine *RANDOMLY* located samples are available within the *EXPOSURE UNIT(S)* or *EMISSION SOURCE AREA*, whichever is smaller. If a statistical analysis is used, analytical results from verification sampling must be compared to Part 201 criteria as described in Sections 2 and 3. • **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data as allowed in Sections 2 and 3. • **Cover/Containment**: Generally soil sampling will not be used to verify Limited or Site-specific remediation or closure that relies on a cover or containment. Instead, verification of remediation will involve verifying the integrity of the cover or containment structure on an ongoing basis. Verification of remediation in areas outside the cover/containment structure will be done using the options above.
Additional Information:		Criteria Application Guidesheet 15; "Part 201 Generic Soil Inhalation Criteria for Ambient Air: Technical Support Document"
Recommended Statistical Methods for Comparison to Criteria:		Compare *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

***SOURCE SIZE MODIFIERS* for Ambient Air Soil Inhalation Criteria**

Modifiers		
Source Size (ft^2 or acres)	Q/C (g/m^2-s per kg/m^3)	Modifier
400 ft^2	261.26	3.17
1000 ft^2	180.76	2.2
2000 ft^2	144.91	1.76
1/4 acre	94.56	1.15
1/2 acre	82.33	1
1 acre	71.74	0.87
2 acre	63.51	0.77
5 acre	54.62	0.66
10 acre	49.13	0.6
32 acre	41.55	0.5
100 acre	35.66	0.43

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheet **18**

GENERIC RESIDENTIAL AND COMMERCIAL I PARTICULATE SOIL INHALATION CRITERIA (PSIC) FOR AMBIENT AIR

May assist in evaluation of condition(s):	7
Applicability of Statistics	**YES**

Statistics are applicable for evaluating this exposure pathway. Use of statistics is practical when there are adequate data sets available in the *EXPOSURE UNITS* or *EMISSION SOURCE AREAS*, as appropriate to the *FACILITY*.

Key Considerations:

Section 1

Facility Determination

- For the purposes of a BEA, or initial *FACILITY* determination, property may be classified as a *FACILITY* if one or more samples contain concentrations above generic residential criteria or *BACKGROUND* concentrations, whichever is greater, provided that there is not a greater body of evidence that the property is not a *FACILITY*. However, if concentrations of a hazardous substance from the property are less than the *STATEWIDE DEFAULT BACKGROUND* value in Operational Memorandum #15 for that hazardous substance, the property is not a *FACILITY* with respect to that hazardous substance. For purposes other than *FACILITY* determination (e.g., remediation and/or closure), additional data will likely be required.

- If a statistical analysis is relied upon for making a *FACILITY* determination see Sections 2 and 3.

Section 2

Selection of Data For Statistical Analysis

- Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in section 2.4.2 of the tabbed section titled, "Sampling Strategies."

- A statistical analysis of soil data should be completed only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.

- It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."

	Section 2: (Continued)	★ A *SOURCE SIZE MODIFIER* must be selected for *EMISSION SOURCE SIZES* that are different than the assumed 1/2 acre *EMISSION SOURCE SIZE*. The *SOURCE SIZE MODIFIER* must correspond to an *EMISSION SOURCE SIZE* that is at least as large as the *EMISSION SOURCE SIZE* of the *FACILITY*. For example, if the *EMISSION SOURCE SIZE* at a *FACILITY* is at least eight acres, the generic soil inhalation criteria for a 1/2 acre *EMISSION SOURCE SIZE* is multiplied by the *SOURCE SIZE MODIFIER* for 10 acres to provide generic criteria for a 10 acre *FACILITY*. *SOURCE SIZE MODIFIERS* to adjust generic criteria for *EMISSION SOURCE SIZES* other than a 1/2 acre are provided in a table at the end of this guidesheet.
	Section 3	**Risk Analysis – Comparison to Criteria** ★ Criteria for this pathway depend on the *EMISSION SOURCE SIZE*, which must be estimated in both the horizontal and vertical dimension. Criteria shown in the cleanup criteria tables are based on a 1/2 acre *EMISSION SOURCE SIZE*. *SOURCE SIZE MODIFIERS* to adjust generic criteria for *EMISSION SOURCE SIZES* other than a 1/2 acre are provided in a table at the end of this guidesheet. For convenience, this table has been updated to include 1/4 acre and two acre *EMISSION SOURCE SIZES* for use at residential/commercial I and commercial II, III, IV and industrial land uses, respectively. Soil contamination for the PSIC pathway may occur in two general patterns that will affect the *EMISSION SOURCE SIZE* used to adjust the criteria for comparison to the *FACILITY* data: ★ **Properties or *FACILITIES* with a single *EMISSION SOURCE AREA*** If hazardous substances are detected in only a limited area within a 1/4 acre *EXPOSURE UNIT* and are not detected in other areas of the *EXPOSURE UNIT*, the *EMISSION SOURCE AREA* is equal to only the horizontal extent of the area with detectable concentrations. Only data within the *EMISSION SOURCE AREA* may be included in a statistical analysis. For an *EMISSION SOURCE AREA* that is larger than a 1/4 acre (i.e., *EXPOSURE UNIT*), soil concentrations within each 1/4 acre *EXPOSURE UNIT* must meet the PSIC adjusted for the *EMISSION SOURCE SIZE.* ★ **Properties with multiple *EMISSION SOURCE AREAS*** Properties larger than a 1/4 acre may contain several small *EMISSION SOURCE AREAS*. Where hazardous substances are not detected in the areas of the property between *EMISSION SOURCE AREAS*, the final *EMISSION SOURCE SIZE* is the sum of the horizontal extent of all individual *EMISSION SOURCE AREAS*. Soil concentrations within each *EMISSION SOURCE AREA* are compared to the generic criteria adjusted for the summed area of the individual *EMISSION SOURCE AREA* sizes. ★ Statistical analysis is possible for either the *EXPOSURE UNIT* or the *EMISSION SOURCE AREA* provided that sufficient data are available as described in Section 2.

	Section 3: (Continued)	★ Nine *RANDOMLY* located samples per *EXPOSURE UNIT* or *EMISSION SOURCE AREA*, whichever is smaller, should generally be used to conduct the statistical analysis. The actual number of samples to be collected may vary based on size of the *EMISSION SOURCE AREA*. Data collected for other purposes (as for identification of nature and extent) may be used where *RANDOM* sample locations fall on or reasonably close to existing sample locations and where data will be consistent in terms of sampling and analytical methods. • Statistical analyses must include an evaluation of the underlying statistical distribution of the data (i.e., normal, lognormal, or neither) and the level of censoring (i.e., proportion of the data below the detection limit). See the tabbed section titled, Statistical Methods." This evaluation must be completed for each hazardous substance. Additionally, the statistical methods used to compare *FACILITY* data to criteria must be selected based on statistical distribution and level of censoring. ★ Compliance with infinite generic PSIC must be demonstrated for the entire vertical soil column since hazardous substances in subsurface soil may contribute to emissions if moved to the surface in the future. • Statistical analysis of *FACILITY* data is not allowed for hazardous substances that have criteria based on acute toxicological effects and/or physical hazards. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for determining *BACKGROUND* concentrations will vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods."
	Section 4	**Verification of Remediation or Closure** • **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **Excavation**: Numbers and locations of samples collected for verifying remediation of soil can be selected in accordance with either the tabbed section titled, "Sampling Strategies" (Sections 1.3 or 2.3 as appropriate based on size of excavation), or a DEQ-approved sampling plan when a person is seeking DEQ approval of the response activity. Analytical results from verification sampling must be compared to Part 201 criteria on a point-by-point basis* unless a minimum of nine *RANDOMLY* located samples are available within the *EXPOSURE UNIT(S)* or *EMISSION SOURCE AREA*, whichever is smaller. If a statistical analysis is used, analytical results from verification sampling must be compared to Part 201 criteria as described in Sections 2 and 3. • **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data as allowed in Sections 2 and 3.

	Section 4: (Continued)	• **Cover/Containment**: Generally soil sampling will not be used to verify Limited or Site-specific remediation or closure that relies on a cover or containment. Instead, verification of remediation will involve verifying the integrity of the cover or containment structure on an ongoing basis. Verification of remediation in areas outside the cover/containment structure will be done using the options above.
Additional Information:		Criteria Application Guidesheet 18; "Part 201 Generic Soil Inhalation Criteria for Ambient Air: Technical Support Document"
Recommended Statistical Methods for Comparison to Criteria:		Compare *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

***SOURCE SIZE MODIFIERS* for Ambient Air Soil Inhalation Criteria**

Modifiers		
Source Size (ft^2 or acres)	Q/C (g/m^2-s per kg/m^3)	Modifier
400 ft^2	261.26	3.17
1000 ft^2	180.76	2.2
2000 ft^2	144.91	1.76
1/4 acre	94.56	1.15
1/2 acre	82.33	1
1 acre	71.74	0.87
2 acre	63.51	0.77
5 acre	54.62	0.66
10 acre	49.13	0.6
32 acre	41.55	0.5
100 acre	35.66	0.43

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheet **19**
GENERIC RESIDENTIAL AND COMMERCIAL I DIRECT CONTACT CRITERIA (DCC)	
May assist in evaluation of condition(s):	6
Applicability of Statistics	**YES**

Statistics are applicable for evaluating this exposure pathway. Use of statistics is practical when there are adequate data sets available for the *EXPOSURE UNITS*.

Key Considerations:		
	Section 1	**Facility Determination**
		• For the purposes of a BEA, or initial *FACILITY* determination, property may be classified as a *FACILITY* if one or more samples contain concentrations above generic residential criteria or *BACKGROUND* concentrations, whichever is greater, provided that there is not a greater body of evidence that the property is not a *FACILITY*. However, if concentrations of a hazardous substance from the property are less than the *STATEWIDE DEFAULT BACKGROUND* value in Operational Memorandum #15 for that hazardous substance, the property is not a *FACILITY* with respect to that hazardous substance. For purposes other than *FACILITY* determination (e.g., remediation and/or closure), additional data will likely be required. • If a statistical analysis is relied upon for making a *FACILITY* determination see Sections 2 and 3.
	Section 2	**Selection of Data For Statistical Analysis**
		• Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. <u>Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined</u>. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies." • A statistical analysis of soil data should be completed only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined. • It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies." ★ Generally only soil data from a 1/4 acre *EXPOSURE UNIT* may be used in a statistical calculation for remedial compliance.

	Section 2: (Continued)	★ Soil data from an *EXPOSURE UNIT* that reflects current human activity patterns may be used in a statistical calculation for Due Care compliance. ★ Compliance with these criteria must be demonstrated separately for surface and subsurface soils unless there is little variability between surface and subsurface data. Surface soils are typically defined as the top six inches of the soil column. However, if contamination is predominantly located at the immediate surface (such as through air deposition of hazardous substances), surface soil samples should represent the immediate surface (e.g., top one inch). ★ Subsurface soils should be evaluated in the same manner as surface soils; however, larger *EXPOSURE UNITS* and/or fewer samples may be acceptable if characterization of the property indicates that contamination is predominantly at the surface. ★ *EXPOSURE UNITS* larger than the standard 1/4 acre may be used for both Due Care and Remedial Compliance if it has been demonstrated that there is little variability among concentrations of hazardous substances in the *EXPOSURE UNIT* to be evaluated.
	Section 3	**Risk Analysis – Comparison to Criteria** ★ For remedial compliance, the *FACILITY* must generally be divided into 1/4 acre *EXPOSURE UNITS* for comparison to generic residential criteria. *EXPOSURE UNIT* size can be different for surface and subsurface soil. Areas classified as *HOT SPOTS* must be evaluated separately. A minimum of nine *RANDOMLY* located samples per *EXPOSURE UNIT* (considering surface soil and subsurface soil separately) are required to conduct the statistical analysis. This number is based on statistical considerations only. Additional samples may be necessary to adequately characterize and represent spatial variability in the *EXPOSURE UNIT* depending on such factors as soil type and size of the *EXPOSURE UNIT*. ★ *EXPOSURE UNITS* for Due Care should be based on exposures currently occurring and reasonably likely to occur based on human activity patterns at the *FACILITY*. If activities are concentrated in an area smaller than the standard *EXPOSURE UNIT*, *EXPOSURE UNITS* smaller than 1/4 acre should be used. • Statistical analyses must include an evaluation of the underlying statistical distribution of the data (i.e., normal, lognormal, or neither) and the level of censoring (i.e., proportion of the data below the detection limit). See the tabbed section titled, "Statistical Methods." This evaluation must be completed for each hazardous substance. The statistical methods used to compare *FACILITY* data to criteria must be selected based on statistical distribution and level of censoring. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for determining *BACKGROUND* concentrations will vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods." • Statistical analysis of *FACILITY* data is not allowed for hazardous substances present above Csat screening levels without further evaluation of risk and the extent of the area exceeding Csat. • Statistical analysis of *FACILITY* data is not allowed for hazardous substances that have criteria based on acute toxicological effects and/or physical hazards.

	Section 4	**Verification of Remediation or Closure**
		• **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **Excavation**: Numbers and locations of samples collected for verifying remediation of soil can be selected in accordance with either the tabbed section titled, "Sampling Strategies" (Sections 1.3 or 2.3 as appropriate based on size of excavation), or a DEQ-approved sampling plan when a person is seeking DEQ approval of the response activity. Analytical results from verification sampling must be compared to Part 201 criteria on a point-by-point basis* unless a minimum of nine *RANDOMLY* located samples are available within the *EXPOSURE UNIT(S).* If a statistical analysis is used, analytical results from verification sampling must be compared to Part 201 criteria as described in Sections 2 and 3. • **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data as allowed in Sections 2 and 3. • **Cover/Containment**: Generally soil sampling will not be used to verify Limited or Site-specific remediation or closure that relies on a cover or containment. Instead, verification of remediation will involve verifying the integrity of the cover or containment structure on an ongoing basis. Verification of remediation in areas outside the cover/containment structure will be done using the options above. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for determining *BACKGROUND* concentrations will vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods."

Additional Information:	Criteria Application Guidesheet 19
Recommended Statistical Methods for Comparison to Criteria:	Compare *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR SOIL DATA	Statistical Guidesheet 20
GENERIC SOIL SATURATION (CSAT) SCREENING LEVELS	
May assist in evaluation of condition(s):	1 and 6-12
Applicability of Statistics	**Pathway Dependent**
See the Statistical Guidesheet for the exposure pathway where the cleanup criterion defaults to Csat to determine the applicability of statistics.	

Key Considerations:	**Section 1**	**Facility Determination**
		• See the Statistical Guidesheet for the generic criteria that defaults to the Csat screening level.
	Section 2	**Selection of Data For Statistical Analysis**
		• See the Statistical Guidesheet for the generic criteria that defaults to the Csat screening level. • Data that are greater than Csat should not be included in a statistical analysis unless a site-specific evaluation has shown that there is no free-phase hazardous substance. This does not apply to the generic volatile soil inhalation criteria (VSIC). See Section 3 of Statistical Guidesheets 15, 16 and 17 and 23, 24 and 25 for guidance in conducting statistical analysis of data with concentrations greater than Csat.
	Section 3	**Risk Analysis – Comparison to Criteria**
		• See Section 2.
	Section 4	**Verification of Remediation or Closure**
		• See Section 2.

Additional Information:	Criteria Application Guidesheet 20 and A, and Appendix A; Part 201 Generic Soil Saturation Screening Concentrations: Technical Support Document.
Recommended Statistical Methods for Comparison to Criteria:	See Statistical Guidesheet 7 for relevant exposure pathways. Pathway dependent.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheet **21**
GENERIC SOIL CRITERIA PROTECTIVE OF COMMERCIAL II, III, IV AND INDUSTRIAL DRINKING WATER	
May assist in evaluation of condition(s):	9
Applicability of Statistics	**GNP**

Statistics are generally not practical as a tool for assessing this exposure pathway because of the difficulty in projecting the impact on groundwater of hazardous substances in soil and the need to assure that drinking water cleanup criteria are met at all points in the aquifer.

Key Considerations:

Section 1

Facility Determination

- Not applicable.

Section 2

Selection of Data For Statistical Analysis

- Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."

- A statistical analysis is appropriate only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.

- It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."

Section 3

Risk Analysis – Comparison to Criteria

★ Statistical analysis of *FACILITY* soil concentrations for comparison to soil criteria protective of the drinking water criteria may be acceptable in limited circumstances. Sufficient data must be available to demonstrate that areas of contaminated soil above criteria are not large enough to result in groundwater concentrations in an aquifer above criteria. This may require a fairly rigorous data set that is not often practical to obtain. Similarly, statistical analysis of *FACILITY* leachate concentrations for comparison to drinking water criteria may also be acceptable in limited circumstances.

	Section 3: (Continued)	• If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for comparing to *BACKGROUND* will also vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods." • Statistical analysis of *FACILITY* data is not allowed for hazardous substances present above Csat screening levels without further evaluation of risk and the extent of the area exceeding Csat. • Statistical analysis of *FACILITY* data is not allowed for hazardous substances that have criteria based on acute toxicological effects and/or physical hazards.
	Section 4	**Verification of Remediation or Closure** • **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **Excavation**: Analytical results from verification sampling will generally be compared to Part 201 criteria on a point-by-point basis* in unsaturated soil. Numbers and locations of samples collected for verifying remediation of soil by excavation can be selected in accordance with either the tabbed section titled, "Sampling Strategies" (Sections 1.3 or 2.3 as appropriate based on size of excavation), or a DEQ-approved sampling plan. • **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data as allowed in Sections 2 and 3. • **Cover/Containment**: Generally soil sampling will not be used to verify remediation or closure that relies on a cover or containment. Instead, verification of remediation will involve verifying the integrity of the cover or containment structure on an ongoing basis. Groundwater sampling may be used in some cases to verify the effectiveness of the cover/containment. Verification of remediation in areas outside the cover/containment structure will be done using the options above. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for comparing to *BACKGROUND* will also vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods."

Additional Information:	Criteria Application Guidesheet 21; Statistical Guidesheet 2
Recommended Statistical Methods for Comparison to Criteria:	If statistical analysis is documented to be practical, the recommended statistical method is comparison of *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheet **22**

GENERIC COMMERCIAL II, III, IV AND INDUSTRIAL SOIL VOLATILIZATION TO INDOOR AIR INHALATION CRITERIA (SVIIC)

May assist in evaluation of condition(s):	8
Applicability of Statistics	**GNP**

Statistics are generally not practical as a tool for assessing this exposure pathway because it is unlikely that there will be a sufficient number of samples available from the generic building footprint size.

Key Considerations:

Section 1

Facility Determination

- Not applicable.

Section 2

Selection of Data For Statistical Analysis

- Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."

- A statistical analysis is appropriate only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.

- It is not appropriate to combine data from *HOT SPOT* areas with data from other areas of a property for statistical analysis. This is necessary to avoid averaging out or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."

★ Generally only soil data from a 4,000 ft^2 *EXPOSURE UNIT* (i.e., the building footprint) may be used in a statistical calculation for remedial compliance.

Section 3

Risk Analysis – Comparison to Criteria

★ Statistical analysis of *FACILITY* soil concentrations for comparison to residential SVIIC is generally not practical since sufficient data (i.e., a minimum of nine *RANDOMLY* located samples) are generally not available to allow for a statistical evaluation within the generic building footprint area of 4,000 ft^2. Therefore, comparisons to SVIIC must generally be completed on a point-by-point basis* (i.e., each concentration at each location must be compared individually to criteria).

	Section 3: (Continued)	★ Any statistical analysis must consider the potential for spatial variability of soil types to influence vapor migration. • If DEQ approval of a response activity is being sought, a *PROPOSAL* for a statistical analysis must be submitted to the DEQ for approval to assure that data needs and/or complexities of the pathway are addressed. • Statistical analysis of *FACILITY* data is not allowed for hazardous substances present above Csat screening levels without further evaluation of risk and the extent of the area exceeding Csat.
	Section 4	**Verification of Remediation or Closure** • **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **Excavation**: Statistical analysis of *FACILITY* soil data is generally not practical. See Section 3. Analytical results from verification sampling will therefore generally be compared to Part 201 criteria on a point-by-point basis* in unsaturated soil. Numbers and locations of samples collected for point-by-point comparison can be selected in accordance with either the tabbed section titled, "Sampling Strategies" (Sections 1.3 or 2.3 as appropriate based on size of excavation), or a DEQ-approved sampling plan. If a statistical analysis is relied upon for verifying remediation or closure follow the guidance presented in Sections 2 and 3 of this Guidesheet. • **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data. • **Cover/Containment**: In the context of this pathway, cover/containment will typically be a vapor barrier. Generally soil sampling will not be used to verify remediation or closure that relies on a cover or containment. Verification of remediation in areas outside the cover/containment structure will be done using the options above.

Additional Information:	Criteria Application Guidesheet 22
Recommended Statistical Methods for Comparison to Criteria:	If statistical analysis is documented to be practical, the recommended statistical method is comparison of *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheets **23, 24** and **25**

GENERIC COMMERCIAL II, III, IV AND INDUSTRIAL INFINITE SOURCE VOLATILE SOIL INHALATION CRITERIA (VSIC) FOR AMBIENT AIR

May assist in evaluation of condition(s):	7
Applicability of Statistics	**YES**

Statistics are applicable for evaluating this exposure pathway. Use of statistics is practical when there are adequate data sets available in the *EXPOSURE UNITS* or *EMISSION SOURCE AREAS*, as appropriate to the *FACILITY*.

Key Considerations:

Section 1

Facility Determination

- Not applicable.

Section 2

Selection of Data For Statistical Analysis

- Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."

- A statistical analysis of soil data should be completed only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.

- It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."

★ The horizontal and vertical extent of the *EMISSION SOURCE AREA* must be estimated to allow for selection of the *SOURCE SIZE MODIFIER* and infinite or finite source generic VSIC. Only data from the estimated *EMISSION SOURCE AREA* may be used in statistical analysis for comparison to criteria. See the "Part 201 Generic Soil Inhalation Criteria for Ambient Air: Technical Support Document" for information about source size characterization.

★ Characterization of the horizontal extent of contamination is necessary for both finite and infinite generic VSIC to estimate the *EMISSION SOURCE AREA* contributing to volatile emissions from soil.

	Section 2: (Continued)	★ Infinite generic VSIC are applicable to the entire contaminated vertical soil column since both surface and subsurface soil concentrations of hazardous substances may contribute to volatile emissions. ★ For an *EMISSION SOURCE AREA* that is larger than two acres (i.e., *EXPOSURE UNIT*), soil concentrations within each two acre *EXPOSURE UNIT* must meet the VSIC adjusted for the *EMISSION SOURCE SIZE*. ★ A *SOURCE SIZE MODIFIER* must be selected for *EMISSION SOURCE SIZES* that are different than the assumed 1/2 acre *EMISSION SOURCE SIZE*. The *SOURCE SIZE MODIFIER* must correspond to an *EMISSION SOURCE SIZE* that is at least as large as the *EMISSION SOURCE SIZE* of the *FACILITY*. For example, if the *EMISSION SOURCE SIZE* at a *FACILITY* is at least eight acres, the generic soil inhalation criteria for a 1/2 acre *EMISSION SOURCE SIZE* is multiplied by the *SOURCE SIZE MODIFIER* for 10 acres to provide generic criteria for a 10 acre *FACILITY*. *SOURCE SIZE MODIFIERS* to adjust generic criteria for *EMISSION SOURCE SIZES* other than a 1/2 acre are provided in a table at the end of this guidesheet.
	Section 3	**Risk Analysis – Comparison to Criteria** ★ Criteria for this pathway depend on the *EMISSION SOURCE SIZE*, which must be estimated in both the horizontal and vertical dimension. Criteria shown in the cleanup criteria tables are based on a 1/2 acre *EMISSION SOURCE SIZE*. *SOURCE SIZE MODIFIERS* to adjust generic criteria for *EMISSION SOURCE SIZES* other than a 1/2 acre are provided in a table at the end of this guidesheet. For convenience, this table has been updated to include 1/4 acre and two acre *EMISSION SOURCE SIZES* for use at residential/commercial I and commercial II, III, IV and industrial land uses, respectively. Soil contamination for the VSIC pathway may occur in two general patterns that will affect the *EMISSION SOURCE SIZE* used to adjust the criteria for comparison to the *FACILITY* data: ★ **Properties or *FACILITIES* with a single *EMISSION SOURCE AREA*** If hazardous substances are detected in only a limited area within a two acre *EXPOSURE UNIT* and are not detected in other areas of the *EXPOSURE UNIT*, the *EMISSION SOURCE AREA* is equal to only the horizontal extent of the area with detectable concentrations. Only data within the *EMISSION SOURCE AREA* may be included in a statistical analysis. For an *EMISSION SOURCE AREA* that is larger than two acres (i.e., *EXPOSURE UNIT*), soil concentrations within each two acre *EXPOSURE UNIT* must meet the VSIC adjusted for the *EMISSION SOURCE SIZE*. ★ **Properties with multiple *EMISSION SOURCE AREAS*** Properties larger than a two acre may contain several small *EMISSION SOURCE AREAS*. Where hazardous substances are not detected in the areas of the property between *EMISSION SOURCE AREAS*, the final *EMISSION SOURCE SIZE* is the sum of the horizontal extent of all individual *EMISSION SOURCE AREAS*. Soil concentrations within each *EMISSION SOURCE AREA* are compared to the generic criteria adjusted for the summed area of the individual *EMISSION SOURCE AREA* sizes.

	Section 3: (Continued)	★ Generally only soil data from a two acre *EXPOSURE UNIT* may be used in a statistical calculation for remedial compliance unless the property is smaller than two acres and the *FACILITY* is confined to the property. In that case, the *EXPOSURE UNIT* size will be same as the property size. <u>However, in cases where the *EMISSION SOURCE AREA* is smaller than two acres only soil data from the *EMISSION SOURCE AREA* may be used in a statistical calculation</u>. ★ Statistical analysis is possible for either the *EXPOSURE UNIT* or the *EMISSION SOURCE AREA* provided that sufficient data are available as described in Section 2. ★ Nine *RANDOMLY* located samples per *EXPOSURE UNIT* or *EMISSION SOURCE AREA*, whichever is smaller, should generally be used to conduct the statistical analysis. The actual number of samples to be collected may vary based on size of the *EMISSION SOURCE AREA*. Data collected for other purposes (as for identification of nature and extent) may be used where *RANDOM* sample locations fall on or reasonably close to existing sample locations and where data will be consistent in terms of sampling and analytical methods. • Statistical analyses must include an evaluation of the underlying statistical distribution of the data (i.e., normal, lognormal, or neither) and the level of censoring (i.e., proportion of the data below the detection limit). See the tabbed section titled, "Statistical Methods." This evaluation must be completed for each hazardous substance. Additionally, the statistical methods used to compare *FACILITY* data to criteria must be selected based on statistical distribution and level of censoring. ★ Compliance with infinite generic VSIC must be demonstrated for the entire vertical soil column since both surface and subsurface soil concentrations of hazardous substances may contribute to volatile emissions. • Since a hazardous substance will <u>not</u> volatilize more when present at concentrations greater than Csat, sample data that exceeds Csat can be included in a statistical analysis to determine compliance with the VSIC as long as the Csat exceedance is not a *HOT SPOT*. • Statistical analysis of *FACILITY* data is not allowed for hazardous substances that have criteria based on acute toxicological effects and/or physical hazards.
	Section 4	**Verification of Remediation or Closure** • **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **Excavation**: Numbers and locations of samples collected for verifying remediation of soil can be selected in accordance with either the tabbed section titled, "Sampling Strategies" (Sections 1.3 or 2.3 as appropriate based on size of excavation), or a DEQ-approved sampling plan when a person is seeking DEQ approval of the response activity. Analytical results from verification sampling must be compared to Part 201 criteria on a point-by-point basis* unless a minimum of nine *RANDOMLY* located samples are available within the *EXPOSURE UNIT(S)* or *EMISSION SOURCE AREA*, whichever is smaller. If a statistical analysis is used, analytical results from verification sampling must be compared to Part 201 criteria as described in Sections 2 and 3.

	Section 4: (Continued)	• **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data as allowed in Sections 2 and 3. • **Cover/Containment**: Generally soil sampling will not be used to verify Limited or Site-specific remediation or closure that relies on a cover or containment. Instead, verification of remediation will involve verifying the integrity of the cover or containment structure on an ongoing basis. Verification of remediation in areas outside the cover/containment structure will be done using the options above.

Additional Information:	Criteria Application Guidesheets 23, 24 and 25; "Part 201 Generic Soil Inhalation Criteria for Ambient Air: Technical Support Document".
Recommended Statistical Methods for Comparison to Criteria:	Compare *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

***SOURCE SIZE MODIFIERS* for Ambient Air Soil Inhalation Criteria**

Modifiers		
Source Size (ft^2 or acres)	Q/C (g/m^2-s per kg/m^3)	Modifier
400 ft^2	261.26	3.17
1000 ft^2	180.76	2.2
2000 ft^2	144.91	1.76
1/4 acre	94.56	1.15
1/2 acre	82.33	1
1 acre	71.74	0.87
2 acre	63.51	0.77
5 acre	54.62	0.66
10 acre	49.13	0.6
32 acre	41.55	0.5
100 acre	35.66	0.43

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheet **26**

GENERIC COMMERCIAL II, III, IV AND INDUSTRIAL PARTICULATE SOIL INHALATION CRITERIA (PSIC) FOR AMBIENT AIR

May assist in evaluation of condition(s):	7
Applicability of Statistics	**YES**

Statistics are applicable for evaluating this exposure pathway. Use of statistics is practical when there are adequate data sets available in the *EXPOSURE UNITS* or *EMISSION SOURCE AREAS*, as appropriate to the *FACILITY*.

Key Considerations:

Section 1

Facility Determination

- Not applicable.

Section 2

Selection of Data For Statistical Analysis

- Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."

- A statistical analysis of soil data should be completed only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.

- It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."

★ A *SOURCE SIZE MODIFIER* must be selected for *EMISSION SOURCE SIZES* that are different than the assumed 1/2 acre *EMISSION SOURCE SIZE*. The *SOURCE SIZE MODIFIER* must correspond to an *EMISSION SOURCE SIZE* that is at least as large as the *EMISSION SOURCE SIZE* of the *FACILITY*. For example, if the *EMISSION SOURCE SIZE* at a *FACILITY* is at least eight acres, the generic soil inhalation criteria for a 1/2 acre *EMISSION SOURCE SIZE* is multiplied by the *SOURCE SIZE MODIFIER* for 10 acres to provide generic criteria for a 10 acre *FACILITY*. *SOURCE SIZE MODIFIERS* to adjust generic criteria for *EMISSION SOURCE SIZES* other than a 1/2 acre are provided in a table at the end of this guidesheet.

Section 3

Risk Analysis – Comparison to Criteria

★ Criteria for this pathway depend on the *EMISSION SOURCE SIZE*, which must be estimated in both the horizontal and vertical dimension. Criteria shown in the cleanup criteria tables are based on a 1/2 acre *EMISSION SOURCE SIZE*. *SOURCE SIZE MODIFIERS* to adjust generic criteria for *EMISSION SOURCE SIZES* other than a 1/2 acre are provided in a table at the end of this guidesheet. For convenience, this table has been updated to include 1/4 acre and two acre *EMISSION SOURCE SIZES* for use at residential/commercial I and commercial II, III, IV and industrial land uses, respectively.

Soil contamination for the PSIC pathway may occur in two general patterns that will affect the *EMISSION SOURCE SIZE* used to adjust the criteria for comparison to the *FACILITY* data:

★ **Properties or *FACILITIES* with a single *EMISSION SOURCE AREA***

If hazardous substances are detected in only a limited area within a two acre *EXPOSURE UNIT* and are not detected in other areas of the *EXPOSURE UNIT*, the *EMISSION SOURCE AREA* is equal to only the horizontal extent of the area with detectable concentrations. Only data within the *EMISSION SOURCE AREA* may be included in a statistical analysis.

For an *EMISSION SOURCE AREA* that is larger than two acres (i.e., *EXPOSURE UNIT*), soil concentrations within each two acre *EXPOSURE UNIT* must meet the PSIC adjusted for the *EMISSION SOURCE SIZE*.

★ **Properties with multiple *EMISSION SOURCE AREAS***

Properties larger than two acres may contain several small *EMISSION SOURCE AREAS*. Where hazardous substances are not detected in the areas of the property between *EMISSION SOURCE AREAS*, the final *EMISSION SOURCE SIZE* is the sum of the horizontal extent of all individual *EMISSION SOURCE AREAS*. Soil concentrations within each *EMISSION SOURCE AREA* are compared to the generic criteria adjusted for the summed area of the individual *EMISSION SOURCE AREA* sizes.

★ Statistical analysis is possible for either the *EXPOSURE UNIT* or the *EMISSION SOURCE AREA* provided that sufficient data are available as described in Section 2.

★ Nine *RANDOMLY* located samples per *EXPOSURE UNIT* or *EMISSION SOURCE AREA*, whichever is smaller, should generally be used to conduct the statistical analysis. The actual number of samples to be collected may vary based on size of the *EMISSION SOURCE AREA*. Data collected for other purposes (as for identification of nature and extent) may be used where *RANDOM* sample locations fall on or reasonably close to existing sample locations and where data will be consistent in terms of sampling and analytical methods.

- Statistical analyses must include an evaluation of the underlying statistical distribution of the data (i.e., normal, lognormal, or neither) and the level of censoring (i.e., proportion of the data below the detection limit). See the tabbed section titled, Statistical Methods." This evaluation must be completed for each hazardous substance. Additionally, the statistical methods used to compare *FACILITY* data to criteria must be selected based on statistical distribution and level of censoring.

	Section 3: (Continued)	★ Compliance with infinite generic PSIC must be demonstrated for the entire vertical soil column since hazardous substances in subsurface soil may contribute to emissions if moved to the surface in the future. • Statistical analysis of *FACILITY* data is not allowed for hazardous substances that have criteria based on acute toxicological effects and/or physical hazards. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for determining *BACKGROUND* concentrations will vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods."
	Section 4	**Verification of Remediation or Closure** • **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **Excavation**: Numbers and locations of samples collected for verifying remediation of soil can be selected in accordance with either the tabbed section titled, "Sampling Strategies" (Sections 1.3 or 2.3 as appropriate based on size of excavation), or a DEQ-approved sampling plan when a person is seeking DEQ approval of the response activity. Analytical results from verification sampling must be compared to Part 201 criteria on a point-by-point basis* unless a minimum of nine *RANDOMLY* located samples are available within the *EXPOSURE UNIT(S)* or *EMISSION SOURCE AREA*, whichever is smaller. If a statistical analysis is used, analytical results from verification sampling must be compared to Part 201 criteria as described in Sections 2 and 3. • **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data as allowed in Sections 2 and 3. • **Cover/Containment**: Generally soil sampling will not be used to verify Limited or Site-specific remediation or closure that relies on a cover or containment. Instead, verification of remediation will involve verifying the integrity of the cover or containment structure on an ongoing basis. Verification of remediation in areas outside the cover/containment structure will be done using the options above.

Additional Information:	Criteria Application Guidesheet 22; "Part 201 Generic Soil Inhalation Criteria for Ambient Air: Technical Support Document"
Recommended Statistical Methods for Comparison to Criteria:	Compare *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on a case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

***SOURCE SIZE MODIFIERS* for Ambient Air Soil Inhalation Criteria**

Modifiers		
Source Size (ft^2 or acres)	Q/C (g/m^2-s per kg/m^3)	Modifier
400 ft^2	261.26	3.17
1000 ft^2	180.76	2.2
2000 ft^2	144.91	1.76
1/4 acre	94.56	1.15
1/2 acre	82.33	1
1 acre	71.74	0.87
2 acre	63.51	0.77
5 acre	54.62	0.66
10 acre	49.13	0.6
32 acre	41.55	0.5
100 acre	35.66	0.43

PART 201 STATISTICAL EVALUATION GUIDESHEET FOR **SOIL** DATA	Statistical Guidesheets **27, 28 and 29**

GENERIC INDUSTRIAL AND COMMERCIAL II, III, IV DIRECT CONTACT CRITERIA (DCC)

May assist in evaluation of condition(s):	6
Applicability of Statistics	**YES**

Statistics are applicable for evaluating this exposure pathway. Use of statistics is practical when there are adequate data sets available for the *EXPOSURE UNITS*.

Key Considerations:

Section 1

Facility Determination

- Not applicable.

Section 2

Selection of Data For Statistical Analysis

- Samples collected for the purpose of characterizing a *FACILITY* are typically biased, based on factors such as historical information, previous sampling, disposal practices, visual impacts, and aerial photos. Once the nature and extent of contamination has been defined, it is necessary to identify and/or obtain data that will allow for appropriate comparison to criteria. There are two primary considerations in determining if data sets are adequate. First, data sets must be obtained from locations that are consistent with the exposure assumptions for the relevant land use scenario. Second, if statistics are used, data sets must contain a sufficient number of *RANDOMLY* located sample results to allow for proper statistical analysis and development of *REPRESENTATIVE CONCENTRATIONS*. Therefore, additional sampling to develop *REPRESENTATIVE CONCENTRATIONS* will often be required after the nature and extent of contamination have been defined. Some characterization data may be used in the development of a *REPRESENTATIVE CONCENTRATION* as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."

- A statistical analysis of soil data should be completed only if the nature and extent of contamination, including any *HOT SPOTS*, has been adequately defined.

- It is not appropriate to combine samples from *HOT SPOT* areas with samples from other areas of a property for statistical analysis. This is necessary to avoid averaging or diluting the samples that represent *HOT SPOTS*. *HOT SPOTS* must be addressed separately. See Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."

★ Generally only soil data from a two acre *EXPOSURE UNIT* may be used in a statistical calculation for remedial compliance unless the property is smaller than 2 acres and the *FACILITY* is confined to the property. In that case, the *EXPOSURE UNIT* size will be same as the property size.

★ Soil data from an *EXPOSURE UNIT* that reflects current human activity patterns may be used in a statistical calculation for Due Care compliance.

	Section 2: (Continued)	★ Compliance with these criteria must be demonstrated separately for surface and subsurface soils unless there is little variability between surface and subsurface data. Surface soils are typically defined as the top six inches of the soil column. However, if contamination is predominantly located at the immediate surface (such as through air deposition of hazardous substances), surface soil samples should represent the immediate surface (e.g., top one inch). ★ Subsurface soils should be evaluated in the same manner as surface soils; however, larger *EXPOSURE UNITS* and/or fewer samples may be acceptable if characterization of the property indicates that hazardous substances are predominantly at the surface. ★ *EXPOSURE UNITS* larger than the standard two acres may be used for both Due Care and Remedial Compliance if it has been demonstrated that there is little variability among concentrations of hazardous substances in the *EXPOSURE UNIT* to be evaluated.
	Section 3	**Risk Analysis – Comparison to Criteria** ★ For remedial compliance, the *FACILITY* must generally be divided into two acre *EXPOSURE UNITS* for comparison to these criteria. *EXPOSURE UNIT* size can be different for surface and subsurface soil. Areas classified as *HOT SPOTS* must be evaluated separately. A minimum of nine *RANDOMLY* located samples per *EXPOSURE UNIT* (considering surface soil and subsurface soil separately) are required to conduct the statistical analysis. This number is based on statistical considerations only. Additional samples may be necessary to adequately characterize and represent spatial variability in the *EXPOSURE UNIT* depending on such factors as soil type, and size of the *EXPOSURE UNIT*. ★ *EXPOSURE UNITS* for Due Care should be based on exposures currently occurring and reasonably likely to occur based on human activity patterns at the *FACILITY*. If activities are concentrated in an area smaller than the standard *EXPOSURE UNIT*, *EXPOSURE UNITS* smaller than two acres should be used. • Statistical analyses must include an evaluation of the underlying statistical distribution of the data (i.e., normal, lognormal, or neither) and the level of censoring (i.e., proportion of the data below the detection limit). See the tabbed section titled, "Statistical Methods." This evaluation must be completed for each hazardous substance. The statistical methods used to compare *FACILITY* data to criteria must be selected based on statistical distribution and level of censoring. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for determining *BACKGROUND* concentrations will vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods." • Statistical analysis of *FACILITY* data is not allowed for hazardous substances present above Csat screening levels without further evaluation of risk and the extent of the area exceeding Csat. • Statistical analysis of *FACILITY* data is not allowed for hazardous substances that have criteria based on acute toxicological effects and/or physical hazards.

	Section 4	**Verification of Remediation or Closure** • **No Action Needed**: If the data evaluation completed under Sections 2 and 3 demonstrated that there are no exceedances of cleanup criteria, no remedial action is required for this pathway and consequently no additional sampling or data analysis is required under Section 4. • **Excavation**: Numbers and locations of samples collected for verifying remediation of soil can be selected in accordance with either the tabbed section titled, "Sampling Strategies" (Sections 1.3 or 2.3 as appropriate based on size of excavation), or a DEQ-approved sampling plan when a person is seeking DEQ approval of the response activity. Analytical results from verification sampling must be compared to Part 201 criteria on a point-by-point basis* unless a minimum of nine *RANDOMLY* located samples are available within the *EXPOSURE UNIT(S).* If a statistical analysis is used analytical results from verification sampling must be compared to Part 201 criteria as described in Sections 2 and 3. • **In situ/Ex situ Treatment**: Plans for verifying remediation or closure must be made on a case-by-case basis and must demonstrate how treatment is effective in meeting cleanup criteria. These plans may or may not depend on statistical analysis of data. • **Cover/Containment**: Generally soil sampling will not be used to verify Limited or Site-specific remediation or closure that relies on a cover or containment. Instead, verification of remediation will involve verifying the integrity of the cover or containment structure on an ongoing basis. Verification of remediation in areas outside the cover/containment structure will be done using the options above. • If *BACKGROUND* concentrations in soil are greater than criteria, soil data may be compared to *BACKGROUND* instead. Statistical methods for determining *BACKGROUND* concentrations will vary depending on which type of *BACKGROUND* is being considered. See Statistical Guidesheet 10 and Chapter 4 of the tabbed section titled, "Statistical Methods."

Additional Information:	Criteria Application Guidesheets 27, 28 & 29
Recommended Statistical Methods for Comparison to Criteria:	Compare *FACILITY* data to criteria using a 95% upper confidence limit (UCL) for the mean concentration (see Chapter 3 of the tabbed section titled, "Statistical Methods"). Other statistical methods may be acceptable on case-by-case basis.

*Professional judgment is required to interpret the significance of exceedances that are very close to criteria, or that may be associated with insignificant quantities of hazardous substances.

Tab 6.0

Due Care

USE OF STATISTICS IN ASSESSING "DUE CARE" COMPLIANCE

USE OF STATISTICS IN ASSESSING "DUE CARE" COMPLIANCE

Staff and *FACILITY* owner/operators may need to evaluate data to assess compliance with Section 7a ("Due Care") and the Part 10 rules. Generally, the applicability of statistics will be the same in the Due Care context for the other purposes described in the Statistical Guidesheets (e.g., verification of remediation). Therefore, if the Applicability of Statistics box on the Statistical Guidesheet for an exposure pathway or condition denotes YES, it is appropriate to use statistics in a Due Care evaluation, if the data are sufficient. If Applicability is denoted as GNP, it is important to determine whether an adequate data set is available for evaluation of Due Care. The minimum data requirements are the same for Due Care as for other applications (e.g., number of samples per *EXPOSURE UNIT*, need for data to reflect *REPRESENTATIVE CONCENTRATIONS*).

The goal of Section 7a(1)(b) is protection of public health and safety. Compliance with this Section requires that response activity be undertaken to mitigate unacceptable exposure to hazardous substances and fire and explosion hazards. Recall that under Rule 1003(4)(a)(i), Due Care compliance is evaluated for the exposure pathways that are complete or likely to be complete in light of the intended use of the property. Not all exposure pathways and conditions to consider are relevant to Due Care. For example, the drinking water ingestion pathway is not relevant when drinking water is provided from a municipal supply that is unaffected by contamination from the *FACILITY*. The GSI pathway is generally not relevant for Due Care. Also, the intended use at a *FACILITY* may limit exposure to contaminated media, such that only a portion of the contaminated media needs to evaluated. For example, if planned activities at a *FACILITY* would not result in excavation below the top 12 inches of soil, the direct contact pathway would not need to be evaluated for soil more than 12 inches deep.

The following table summarizes how Due Care compliance may vary from evaluation in the remedial action context.

Statistical Guidesheet	Pathway	How Due Care and Use of Statistics to Evaluate Compliance May Be Different than Remedial Compliance
A	Abandoned substances not yet dispersed & free phase liquids	Source control may contribute to preventing or mitigating unacceptable exposures. Statistics generally not practical in defining or assessing effectiveness of source control activities because this is typically a qualitative evaluation.
B	Polluted soil runoff to surface water	Generally not relevant to Due Care compliance.
C	Aquatic flora/fauna/food chain hazards/ aesthetics	Generally not relevant to Due Care compliance.
D	Acute toxic impacts/physical hazards	This condition may need to be addressed as part of Due Care compliance to mitigate unacceptable exposures or fire and explosion hazards. Statistics generally not practical for evaluating compliance because of the acute nature of the hazards.
E	Terrestrial flora/fauna/food chain hazards/ aesthetics	Generally not relevant to Due Care compliance.

F	Asbestos	Asbestos may need to be addressed to mitigate unacceptable exposure. Relevant to Due Care in areas and through exposure pathways where asbestos exposures may occur. Use of statistics in those areas would be the same as described in the Statistical Guidesheet for the relevant exposure pathways.
1	Groundwater: Drinking water usage (Res)	Relevant to Due Care compliance if groundwater is being used for drinking water. Statistics not applicable for evaluating Due Care compliance.
2	Groundwater: Drinking water usage (C/I)	Relevant to Due Care compliance if groundwater is being used for drinking water. Statistics not applicable for evaluating Due Care compliance.
3	Groundwater: Hazards to surface waters (All)	Generally not relevant to Due Care compliance except for conditions in venting groundwater that could result in unacceptable human exposure at GSI (e.g., very high or low pH) or if there is a drinking water intake close to point of venting.
4	Groundwater: Indoor air hazards (chronic /systemic) (Res)	Relevant to Due Care compliance if volatile contaminants are present in groundwater under existing or planned structures. Use of statistics is the same as described in the Statistical Guidesheet. Due Care compliance can be based on size of existing or planned structure, and can take into account building characteristics (e.g., ventilation rates) that are different from generic assumptions. Data needs for *REPRESENTATIVE CONCENTRATION* and minimum number of data points per building footprint/*EXPOSURE UNIT* are the same as for remedial compliance. *HOT SPOTS* must be evaluated separately to determine if they represent an unacceptable risk.
5	Groundwater: Indoor air hazards (chronic /systemic) (C/I)	Relevant to Due Care compliance if volatile contaminants are present in groundwater under existing or planned structures. Use of statistics is the same as described in the Statistical Guidesheet. Due Care compliance can be based on size of existing or planned structure, and can take into account building characteristics (e.g., ventilation rates) that are different from generic assumptions. Data needs for *REPRESENTATIVE CONCENTRATION* and minimum number of data points per building footprint/*EXPOSURE UNIT* are the same as for remedial compliance. *HOT SPOTS* must be evaluated separately to determine if they represent an unacceptable risk.
6	Groundwater: Dermal exposures such as by utility workers (All)	Relevant to Due Care compliance if contact with groundwater is reasonably likely to occur given intended use of property. Area evaluated can be limited to location of likely groundwater contact, in light of existing features. Use of statistics is the same as described in the Statistical Guidesheet. Data needs for *REPRESENTATIVE CONCENTRATION* and minimum number of data points per building footprint/*EXPOSURE UNIT* are the same as for remedial compliance. *HOT SPOTS* must be evaluated separately to determine if they represent an unacceptable risk.

7	Groundwater: Water Solubility (All)	Relevant to Due Care if a generic cleanup criterion for an exposure pathway or condition that is relevant defaults to water solubility. Use of statistics is the same as described in the Statistical Guidesheet for the relevant pathway.
8	Groundwater: Flammability / Explosivity (All)	This condition may need to be addressed as part of Due Care compliance to mitigate unacceptable fire and explosion hazards. Statistics generally not practical for evaluating compliance because of the acute nature of the hazards.
9	Groundwater: Acute Inhalation Risks (All)	This condition may need to be addressed as part of Due Care compliance to mitigate unacceptable exposures. Statistics generally not practical for evaluating compliance because of the acute nature of the hazards.
10	Background (All)	*BACKGROUND* may be relevant in evaluating Due Care compliance if an applicable cleanup criterion defaults to *BACKGROUND*. Use of statistics is the same as described in the Statistical Guidesheet for the relevant exposure pathway.
11	Soil: Injury to drinking water use of aquifer (Res)	Generally not relevant to Due Care compliance.
12	Soil: Causes groundwater to be hazardous to surface water (All)	Generally not relevant to Due Care compliance.
13	Soil: Risk from contact (utility work) with groundwater (All)	Generally not relevant to Due Care compliance.
14	Soil: Indoor air inhalation hazards (Res)	Relevant to Due Care compliance if volatile contaminants are present in soil under existing or planned structures. Use of statistics is the same as described in the Statistical Guidesheet. Due Care compliance can be based on size of an existing or planned structure, and can take into account building characteristics (e.g., ventilation rates) that are different from generic assumptions. Data needs for *REPRESENTATIVE CONCENTRATION* and minimum number of data points per building footprint/*EXPOSURE UNIT* are the same as for remedial compliance. *HOT SPOTS* must be evaluated separately to determine if they represent an unacceptable risk.
15, 16, 17	Soil: Ambient air inhalation hazards (Volatile) (All)	Relevant to Due Care compliance if volatile contaminants are present in soil. Use of statistics is the same as described in the Statistical Guidesheet. *EXPOSURE UNIT* size may be modified from generic size if appropriate to the activity patterns on the property. *EMISSION SOURCE AREA* the same as for remedial compliance. Data needs for *REPRESENTATIVE CONCENTRATION* and minimum number of data points per *EXPOSURE UNIT* or *EMISSION SOURCE AREA* are the same as for remedial compliance. *HOT SPOTS* must be evaluated separately to determine if they represent an unacceptable risk.

18	Soil: Ambient air inhalation hazards (Particulate) (C/I)	Relevant to Due Care compliance. Use of statistics is the same as described in the Statistical Guidesheet. Depth of soil evaluated can be limited if activity at property will not result in disturbance of existing surface soils. Data needs for *REPRESENTATIVE CONCENTRATION* and minimum number of data points per *EXPOSURE UNIT* or *EMISSION SOURCE AREA* are the same as for remedial compliance. *HOT SPOTS* must be evaluated separately to determine if they represent an unacceptable risk.
19	Hazards due to direct contact (Res)	Relevant to Due Care compliance. Use of statistics is the same as described in the Statistical Guidesheet. Depth of soil evaluated can be limited if activity at property will not result in disturbance of existing surface soils. *EXPOSURE UNIT* size can be based on existing and planned activity patterns, rather than standard size. Data needs for *REPRESENTATIVE CONCENTRATION* and minimum number of data points per *EXPOSURE UNIT* are the same as for remedial compliance. *HOT SPOTS* must be evaluated separately to determine if they represent an unacceptable risk.
20	Soil Saturation	Relevant to Due Care if a generic cleanup criterion for an exposure pathway or condition that is relevant defaults to Csat. Use of statistics is the same as described in the Statistical Guidesheet. Data needs for *REPRESENTATIVE CONCENTRATION* and minimum number of data points per building footprint/*EXPOSURE UNIT* are the same as for remedial compliance. *HOT SPOTS* must be evaluated separately to determine if they represent an unacceptable risk.
21	Soil: Injury to drinking water use of aquifer (C/I)	Generally not relevant to Due Care compliance.
22	Soil: Indoor air inhalation hazards (C/I)	Relevant to Due Care compliance if volatile contaminants are present in soil under existing or planned structures. Use of statistics is the same as described in the Statistical Guidesheet. Due Care compliance can be based on size of existing or planned structure, and can take into account building characteristics (e.g., ventilation rates) that are different from generic assumptions. Data needs for *REPRESENTATIVE CONCENTRATION* and minimum number of data points per building footprint/*EXPOSURE UNIT* are the same as for remedial compliance. *HOT SPOTS* must be evaluated separately to determine if they represent an unacceptable risk.

23, 24, 25	Soil: Ambient air inhalation hazards (Volatile) (C/I)	Relevant to Due Care compliance if volatile contaminants are present in soil. Use of statistics is the same as described in the Statistical Guidesheet. *EXPOSURE UNIT* size may be modified from generic size if appropriate to the activity patterns on the property. *EMISSION SOURCE AREA* the same as for remedial compliance. Data needs for *REPRESENTATIVE CONCENTRATION* and minimum number of data points per *EXPOSURE UNIT* or *EMISSION SOURCE AREA* are the same as for remedial compliance. *HOT SPOTS* must be evaluated separately to determine if they represent an unacceptable risk.
26	Soil: Ambient air inhalation hazards (Particulate) (C/I)	Relevant to Due Care compliance. Use of statistics is the same as described in the Statistical Guidesheet. Depth of soil evaluated can be limited if activity at property will not result in disturbance of existing surface soils. Data needs for *REPRESENTATIVE CONCENTRATION* and minimum number of data points per *EXPOSURE UNIT* or *EMISSION SOURCE AREA* are the same as for remedial compliance. *HOT SPOTS* must be evaluated separately to determine if they represent an unacceptable risk.
27, 28, 29	Soil: Hazards due to direct contact (C/I)	Relevant to Due Care compliance. Use of statistics is the same as described in the Statistical Guidesheet. Depth of soil evaluated can be limited if activity at property will not result in disturbance of existing surface soils. *EXPOSURE UNIT* size can be based on existing and planned activity patterns, rather than standard size. Data needs for *REPRESENTATIVE CONCENTRATION* and minimum number of data points per *EXPOSURE UNIT* are the same as for remedial compliance. *HOT SPOTS* must be evaluated separately to determine if they represent an unacceptable risk.

Key: Res – Residential and Commercial I Land Use Categories
C/I – Commercial II, III, IV and Industrial Land Use Categories
All – All Land Use Categories

STATISTICAL METHODS FOR COMPARING FACILITY DATA TO PART 201 CRITERIA

Tab 7.0

Statistical Methods

STATISTICAL METHODS TABLE OF CONTENTS

INTRODUCTION **7.6**

CHAPTER 1: STATISTICAL DISTRIBUTIONS **7.9**

Section 1.1 IDENTIFICATION OF APPROPRIATE DATA SETS 7.9

Section 1.2 DISTRIBUTION TYPES 7.9

Section 1.3 METHODS FOR EVALUATING STATISTICAL DISTRIBUTIONS 7.13

Section 1.3.1 Coefficient of Variation (CV) 7.15

Section 1.3.2 Coefficient of Skewness 7.18

Section 1.3.3 Normal Probability Plots 7.20

Section 1.3.4 Box Plots 7.26

Section 1.3.5 Shapiro-Wilk Test for Normality ($n \leq 50$) 7.27

Section 1.3.6 Shapiro-Francia Test for Normality ($n > 50$) 7.32

Section 1.3.7 D'Agostino Test for Normality ($n > 50$) 7.37

Section 1.4 EVALUATING STATISTICAL DISTRIBUTIONS WHEN DATA CONTAIN > 50% NONDETECTS 7.37

CHAPTER 2: IDENTIFICATION AND TREATMENT OF OUTLIERS **7.42**

Section 2.1 STATISTICAL METHODS FOR IDENTIFICATION OF OUTLIERS 7.43

Section 2.1.1 Probability Plots 7.44

Section 2.1.2 Box Plots 7.46

Section 2.1.3 Grubbs' Test 7.47

Section 2.1.4 Dixon's Test 7.50

Section 2.1.5 Rosner's Test 7.53

Section 2.1.6 Informal Iterative Approach to Outlier Testing When Data Set is Not Normal or Lognormal 7.56

Section 2.1.7 Walsh's Test 7.57

Section 2.1.8 Evaluating for Outliers when Data Contain >50% Nondetects 7.57

Section 2.2 TREATMENT OF OUTLIERS 7.57

CHAPTER 3: CALCULATION OF A 95% UPPER CONFIDENCE LIMIT (UCL) FOR THE MEAN CONCENTRATION 7.62

Section 3.1 STEPS FOR CALCULATING AN UPPER CONFIDENCE LIMIT FOR THE MEAN 7.63

Section 3.1.1 UCL for the Mean of a Normally Distributed *RANDOM* Variable (Students t) 7.65

Section 3.1.2 UCL for the Mean of a Lognormally Distributed *RANDOM* Variable (Land's Method) 7.67

Section 3.1.3 Alternate Methods for Calculating UCLs for the Mean 7.70

Section 3.1.3.1 Large Sample Methods 7.70

Section 3.1.3.2 Alternative Methods for Small Data Sets and Data Sets With ≥ 50% Nondetects 7.70

Section 3.2 NUMBER OF SAMPLES 7.71

Section 3.2.1 Normal Distributions 7.72

Section 3.2.1.1 Lambda Test 7.72

Section 3.2.1.2 SW-846 Method 7.73

Section 3.2.2 Lognormal Distributions 7.73

Section 3.3 LOWER CONFIDENCE LIMITS FOR THE MEAN 7.74

CHAPTER 4: COMPARISON OF *FACILITY* DATA TO *BACKGROUND* 7.80

Section 4.1 *STATEWIDE DEFAULT BACKGROUND* CONCENTRATIONS 7.81

Section 4.1.1 Point-by-Point Comparison of *FACILITY* Data to *STATEWIDE DEFAULT BACKGROUND* Concentrations 7.81

Section 4.1.2 Statistical Comparison of *FACILITY* Data to *STATEWIDE DEFAULT BACKGROUND* Concentrations, When Appropriate 7.81

Section 4.2 *REGIONAL BACKGROUND* CONCENTRATIONS 7.82

Section 4.2.1 Point-by-Point Comparison of *FACILITY* Data to *REGIONAL BACKGROUND* Data 7.83

Section 4.2.2 Statistical Comparison of *FACILITY* Data to *REGIONAL BACKGROUND* Data, When Appropriate 7.83

Section 4.3 *FACILITY-SPECIFIC BACKGROUND* CONCENTRATIONS 7.83

Section 4.3.1 Point-by-Point Comparison of *FACILITY* Data to *FACILITY-SPECIFIC BACKGROUND* Data 7.83

Section 4.3.1.1 Normal or Lognormal Distributions 7.84

Section 4.3.1.2 Alternate Methods for Calculating *FACILITY-SPECIFIC BACKGROUND* Concentrations 7.86
Section 4.3.2 Statistical Comparison of *FACILITY* Data to *FACILITY-SPECIFIC BACKGROUND* Data, When Appropriate 7.86
Section 4.3.2.1 Parametric Methods for Comparing *FACILITY-SPECIFIC BACKGROUND* and *FACILITY* Data Sets 7.87
Section 4.3.2.2 Nonparametric Methods for Comparing *FACILITY-SPECIFIC BACKGROUND* and *FACILITY* Data Sets 7.89
Section 4.4 *BACKGROUND* CONCENTRATIONS FOR GROUNDWATER 7.89

CHAPTER 5: CENSORED DATA 7.91

EXAMPLES

Example 1.1 Sample Calculation of the Coefficient of Variation 7.17
Example 1.2 Sample Calculation of the Coefficient of Skewness 7.18
Example 1.3 Sample Construction of a Probability Plot 7.24
Example 1.4 Sample Shapiro-Wilk Test for Normality 7.30
Example 1.5 Sample Shapiro-Francia Test for Normality 7.35
Example 2.1 Sample Probability Plots 7.45
Example 2.2 Sample Box and Whisker Plots 7.46
Example 2.3 Sample Calculation of Grubb's Test 7.48
Example 2.4 Sample Calculation of Dixon's Test 7.52
Example 2.5 Sample Calculation of Rosner's Test 7.55
Example 3.1 Sample Calculation of a Student's t 95% Upper Confidence Limit for the Mean of a Normally Distributed *RANDOM* Variable 7.65
Example 3.2 Sample Calculation of 95% UCL for the Mean of a Lognormally Distributed *RANDOM* Variable using Land's Method 7.69
Example 4.1 Sample Calculation of a *FACILITY-SPECIFIC BACKGROUND* Concentration 7.84

FIGURES

Figure 1.1 Standard Normal Distribution 7.10
Figure 1.2a Two Normal Distributions (Different Means, Equal Variances) 7.11
Figure 1.2b Two Normal Distributions (Equal Means, Different Variances) 7.11
Figure 1.3 Lognormal Distribution 7.12
Figure 1.4 Normal Probability Plot of Zinc Data 7.22

Figure 1.5 Normal Probability Plot of Lead Data 7.22
Figure 1.6 Normal Probability Plot of Log-Transformed (Ln) Lead Data 7.22
Figure 1.7 Normal Probability Plot of Zinc Data with Potential Outlier 7.23
Figure 1.8 Normal Probability Plot of Log-Transformed Zinc Data with Potential Outlier 7.23
Figure 1.9 Normal Probability Plot of Raw Nickel Data (Plotted Using Microsoft Excel) 7.25
Figure 1.10 Normal Probability Plot of Log-Transformed Nickel Concentrations (Plotted Using Microsoft Excel) 7.25
Figure 1.11 Box and Whisker Plot 7.26
Figure 1.12 Side-by-Side Box Plots 7.26
Figure 2.1 Probability Plot of Lead Data 7.45
Figure 2.2 Probability Plot of Log-Transformed (Ln) Lead Data 7.45
Figure 2.3 Box Plot of Lead Data 7.46
Figure 2.4 Box Plot of Log-Transformed (Ln) Lead Data 7.46
Figure 2.5 Probability Plot of Arsenic Data Set 7.48
Figure 2.6 Probability Plot of Arsenic Data Set After Correcting Data-Entry Error 7.49
Figure 2.7 Normal Probability Plot for Cyanide Data Set 7.52
Figure 2.8 Probability Plot of Log-Transformed (Ln) Cadmium 7.55
Figure 3.1 Spreadsheet Calculations for a 95% UCL for the Mean 7.65
Figure 3.2 Spreadsheet Calculations for a 95% UCL Using Land's Method 7.69
Figure 4.1 Data and Calculations for Determining the *FACILITY-SPECIFIC BACKGROUND* Concentration and Evaluating for Exceedances 7.84
Figure 4.2 Selection of Appropriate Two-Sample Test for Comparison of *FACILITY* Data to *FACILITY-SPECIFIC BACKGROUND* Data, When Appropriate 7.88

PROCEDURES

Procedure 1.1 Calculation of the Coefficient of Variation 7.16
Procedure 1.2 Calculation of the Coefficient of Skewness 7.19
Procedure 1.3 Construction of a Normal Probability Plot 7.21
Procedure 1.4 Shapiro-Wilk Test for Normality ($n \leq 50$) 7.28
Procedure 1.5 Shapiro-Francia Test for Normality ($n > 50$) 7.33
Procedure 2.1 Grubbs' Test for Single Outliers ($3 < n < 100$) 7.47
Procedure 2.2 Dixon's Test for Single or Multiple Outliers ($n < 25$) 7.51
Procedure 2.3 Rosner's Test for Multiple Outliers ($n > 25$) 7.54

Procedure 3.1 Student's t Upper (1-α)% Confidence Limit for the Mean of a Normally Distributed *RANDOM* Variable 7.66
Procedure 3.2 Land's Method for Calculating a (1-α)% UCL for the Mean of a Lognormally Distributed *RANDOM* Variable 7.68
Procedure 4.1 Determining a *FACILITY-SPECIFIC BACKGROUND* Concentration 7.85

TABLES

Table 1.1 Coefficients (a_i) for the Shapiro-Wilk Test for Normality for Various Sample Sizes (n) 7.38
Table 1.2 Critical Values (sw_α, α = 0.05 and α = 0.10) for the Shapiro-Wilk Test for Normality 7.40
Table 1.3 Critical Values (sf_α, α = 0.05) for the Shapiro-Francia Test for Normality 7.41
Table 2.1 Grubbs' Test Critical Values (T_α, α = 0.05) 7.59
Table 2.2 Critical Values for Dixon's Test ($T_{\alpha,}$ α = 0.05) 7.60
Table 2.3 Rosner's Test Critical Values. (R_α, α = 0.05 for Various Levels of *n* and *k*) 7.61
Table 3.1 Values of $t_{1-\alpha, n-1}$, α = 0.05, 0.10 ..... 7.76
Table 3.2 Land's Method Values for $H_{0.95}$ 7.77
Table 3.3 Land's Method Values for $H_{0.90}$ 7.78
Table 3.4 Number of Observations for t-Test of the Mean 7.79

INTRODUCTION

"[Statistics are] the only tools by which an opening can be cut through the formidable thicket of difficulties that bars the path of those who pursue the science of man."
-Sir Francis Galton

"By a small sample, we may judge of the whole piece."
-Miguel de Cervantes from Don Quixote

“Data! Data! Data! I can't make bricks without clay!”
-Sherlock Holmes

Use of this Document

Statistics provide important tools for describing and understanding the characteristics of data. Without statistics, quantifying the properties of a data set and drawing conclusions about the population from which the data were sampled is impossible. The following document has grown out of a need for a simple, yet comprehensive, approach to analyzing environmental data sets. It was composed with the intent of providing a clear, easy-to-use summary of the statistical methods available for various uses and how to implement these methods. Rather than providing a cookbook of statistical techniques where you just look up what you need and then “plug-and-chug” with the appropriate numbers and formulas, this document was meant to be used as a whole. Analyzing any data set is a process with several steps, not just one. This document is intended to provide a simple description and rationale behind those steps.

Common uses of statistics in Michigan’s Part 201 program include:

1) comparison of *FACILITY* data to the risk-based Part 201 criteria, and
2) comparison of *FACILITY* data to *FACILITY-SPECIFIC BACKGROUND*, *STATEWIDE DEFAULT BACKGROUND*, or *REGIONAL BACKGROUND* concentrations.

Statistical methods needed for these tasks are presented in the order that they are typically completed in conducting these statistical analyses. Chapter 1 provides recommended methods for evaluating the statistical distribution of a data set. Data sets will typically include either *FACILITY* data within a specified area (e.g., an *EXPOSURE UNIT*) or *FACILITY-SPECIFIC BACKGROUND* data. Chapter 2 describes methods for evaluating and recommendations for handling statistical outliers. Chapter 3 presents acceptable methods for comparing *FACILITY* data to Part 201 criteria. Chapter 4 provides statistical methods for comparing *FACILITY* data to the various types of *BACKGROUND* data that may be used. Recommendations for handling data below the detection limit or nondetects (generally substituting 1/2 of the detection limit) are provided throughout. Handling nondetects, including alternative methods, is discussed in more detail in Chapter 5.

For each method described herein, the following are provided: background information, assumptions underlying the method and their verification, a description including procedures for implementing the method, and an example analysis illustrating the steps that are required.

The approaches described in this document include use of summary statistics, graphical techniques, and formal statistical tests. Summary statistics help the user to understand characteristics of the data. Graphical techniques allow the user to view the data and greatly enhance the user’s understanding of the data. Formal statistical tests provide an objective

framework for making decisions about the data. Used together, these methods provide a strong framework for making decisions about and understanding the data.

Use of professional judgment is also an integral part of any statistical analysis. Statistics is a tool that may be used to help make decisions about Part 201 *FACILITIES*. However, used incorrectly, the decisions that are made may not reflect reality. Consequently, professional judgment must be used throughout in evaluating the data, selecting the appropriate statistical test, and drawing conclusions about a *FACILITY* based on a statistical analysis.

The statistical methods described herein are generally acceptable without approval when conducted within the framework described throughout the S^3TM. Alternative statistical methods are acceptable on a case-by-case basis. If departmental approval for a response action is being sought, alternative methods must be *PROPOSED* for approval by the DEQ statistician. The terms "*PROPOSE,*" "*PROPOSED,*" and *"PROPOSAL"* are used throughout the S^3TM to describe the process through which a statistical analysis of data is submitted to and reviewed by the department for approval, when necessary. Self-implemented response activities using statistics to support determinations must be documented in a manner that fully and clearly addresses the three questions outlined in the tabbed section titled, "Introduction."

Use of Computers in Statistical Analyses

Use of computer programs such as statistical software or spreadsheets is recommended to the extent possible when conducting statistical analyses. Calculation of statistical quantities by hand can not only be tedious, but is prone to error. Although formulas for calculating these quantities are provided herein, use of statistical software and/or spreadsheets is described and recommended throughout.

To highlight when a computer can be used to assist in an analysis, a computer icon is shown wherever computer "short-cuts" are provided. Microsoft Excel formulas are provided, where applicable, in the form:

=function(data range)

where "function" refers to the operation applied to the data (e.g., "average" or "stdev") and "data range" refers to the range over which the data to be evaluated appear on the spread sheet (e.g., A1:A20).

Occasionally a statistical method is a bit too complicated to conduct using a spreadsheet and a more powerful statistical software package is required. The DEQ has developed a customized statistical software package called "Statistical Interface for Part 201 Evaluations." This package was developed using a statistical software package called "S-PLUS StatServer 6" (StatServer) and many of the specialized statistical functions necessary for environmental data analysis provided by EnvironmentalStats for S-PLUS. This software is accessible to all staff in the department as well as the public through the Internet.

Interpretation of Statistical Results and Use of Professional Judgment

To aid understanding and comprehension, this document includes examples for each method presented. At the end of each example, interpretation of the results is discussed. The icon to the left is shown to highlight where information on interpretation of the statistical results can be found.

As stated above, use of professional judgment is an integral part of any statistical analysis and must be used when interpreting statistical results. The results of any statistical analysis should be carefully examined. This may be particularly important if the results of a statistical analysis do not conform with expectations. For example, if hazardous substance concentrations in an area of a property are clearly above criteria, yet a statistical analysis concludes that concentrations are below criteria, the test should be reevaluated. It is also possible that a statistical test will indicate that an area is above criteria when there are only one or two marginal exceedances of criteria. Several aspects of the analysis should be checked, including:

- Characterization – Was the property adequately characterized? (See the tabbed section titled, "Sampling Strategies.")

- Applicability of statistics – For exposure pathways/conditions in which use of statistics is "Generally Not Practical" (GNP), was it appropriate to conduct a statistical analysis of the data given the above? (See the appropriate Statistical Guidesheet.)

- Data set – Was the data set selected to represent a single population within an appropriate area (e.g., an *EXPOSURE UNIT*)? (See Sections 2 and 3 of the appropriate Statistical Guidesheet and the tabbed section titled, "Sampling Strategies.")

- Statistical test – Was the appropriate statistical test selected? Were the assumptions of the statistical test adequately evaluated? Were there any questions or uncertainties in whether the assumptions were met? Should an alternate statistical test be *PROPOSED*?

It is important that the above issues are addressed in any statistical analysis. If the entire S^3TM is followed through the course of an analysis, these issues will be addressed up front. However, unexpected or questionable conclusions may still be reached. It is possible that the original expectations about a data set or a *FACILITY* were incorrect and that the statistical analysis shed new insight on conditions at the *FACILITY*. However, the likelihood that a correct conclusion is drawn as well as a user's level of comfort with a statistical analysis can only be improved by scrutinizing statistical results.

CHAPTER 1: STATISTICAL DISTRIBUTIONS

Common uses of statistics in Michigan's Part 201 program include:

1) comparison of *FACILITY* data to Part 201 cleanup criteria, and
2) comparison of *FACILITY* data to *FACILITY-SPECIFIC BACKGROUND*, *STATEWIDE DEFAULT BACKGROUND*, or *REGIONAL BACKGROUND* concentrations.

Chapters 3 and 4 of Statistical Methods describe recommended statistical methods for these uses, respectively. However, before proceeding to these chapters, it is important to evaluate *FACILITY* data and, when available, *FACILITY-SPECIFIC BACKGROUND* data as described in Chapters 1 and 2 in order to select an appropriate statistical method for comparison.

1.1 IDENTIFICATION OF APPROPRIATE DATA SETS

Before utilizing statistics to compare *FACILITY* data to Part 201 criteria or *BACKGROUND* concentrations, it is important to first select the data set(s) you want to evaluate and the associated population(s). It is a relatively straightforward matter to enter numbers into formulas, but meaningful results and accurate conclusions are not likely unless careful consideration is given to the data being used in the analysis and the manner in which they were collected.

Proper identification of data sets for statistical analysis relies on adequate site characterization information. (See Sections 1.3 and 2.3 of the tabbed section titled, "Sampling Strategies.") Once a *FACILITY* has been adequately characterized, appropriate data sets must be selected as described in Parts 2 and 3 of the appropriate Statistical Guidesheets. Information on *HOT SPOTS* is also provided in Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies." In addition, instructions for obtaining *RANDOM* samples is described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies." This section also describes the importance of *RANDOM* sampling when comparing *FACILITY* data to Part 201 criteria, as well as recommendations on how to incorporate *FACILITY* characterization data into the data set for statistical analysis.

1.2 DISTRIBUTION TYPES

Before selecting between the various statistical methods provided in Chapters 3 and 4 for comparing *FACILITY* data to Part 201 risk-based criteria or *BACKGROUND* concentrations, respectively, it is important to understand the underlying assumptions for each method. Many statistical methods are based on an assumption that the data being evaluated come from a normal probability distribution. (The concepts of probability distributions and the normal distribution are described below.) If this assumption is not accurate, alternative methods may be required. Consequently, once an appropriate data set has been selected according to the considerations described in Section 1.1, the next step is to evaluate the data to determine its underlying statistical distribution.

In statistics, a probability distribution is mathematic rule or formula that gives the probability associated with obtaining various observations from a population. Values that have a high probability will be observed in *RANDOM* samples more frequently than values with low probability. Similarly, values with equal probability will show up in *RANDOM* samples with roughly the same frequency. As an example, for a fair coin toss there is a 50% chance of obtaining a "head" and a 50% chance of obtaining a "tail." This 50/50 chance of obtaining a head or a tail is an example of a simple probability distribution.

The most commonly known probability distribution is the normal distribution. The normal distribution can be illustrated by the familiar bell-shaped curve (Figure 1.1). The mean and variance determine the location and shape, respectively, of different normal curves. For example, Figure 1.2a illustrates the difference between two normal distributions with differing means, but the same variance. The shapes of these curves are the same, but the locations on the x-axis differ. Figure 1.2b shows two normal distributions with the same mean value, but differing variances. Although these curves are centered at the same location, the shapes of the curves are different. The curve with the larger variance is wider than the other curve, illustrating that there is a larger amount of variability in the distribution of the data. Many statistical methods are based on an assumption of normality (i.e., the data being evaluated come from a normal distribution). Alternate statistical methods may be needed if the data under evaluation are not normal.

The normal distribution can be used to describe positive-valued data, negative-valued data, or both. Because negative values are frequently not plausible for environmental data (e.g., negative concentrations), the normal distribution has some limitations in use.

Figure 1.1 Standard Normal Distribution

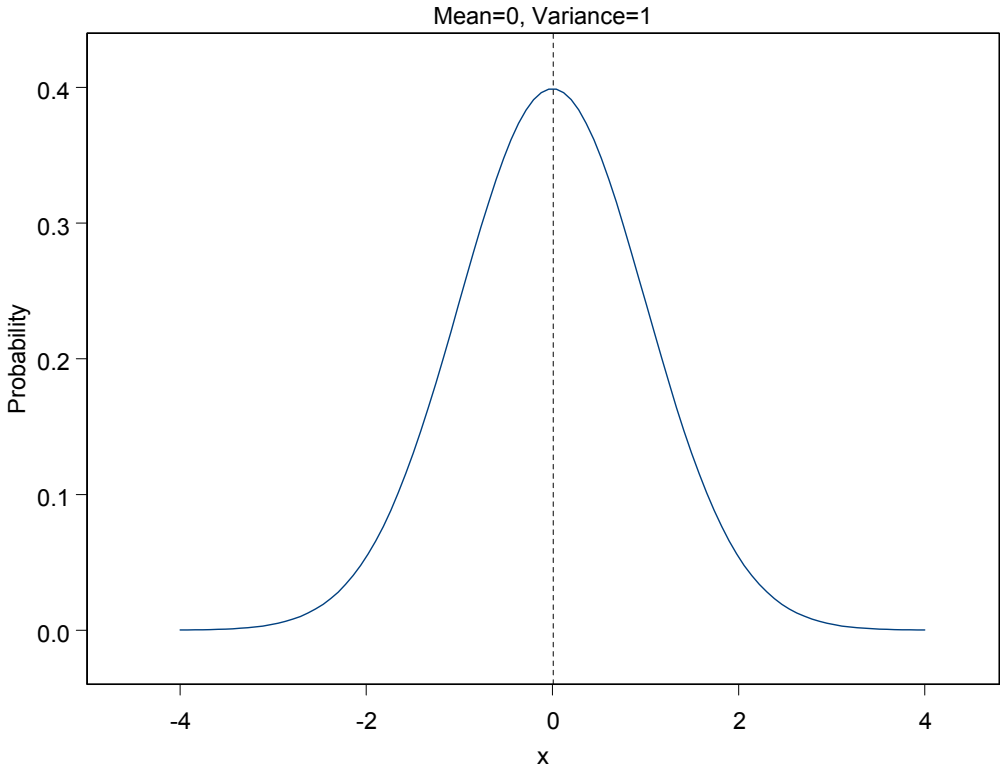


Figure 1.2a Two Normal Distributions (Different Means, Equal Variances)

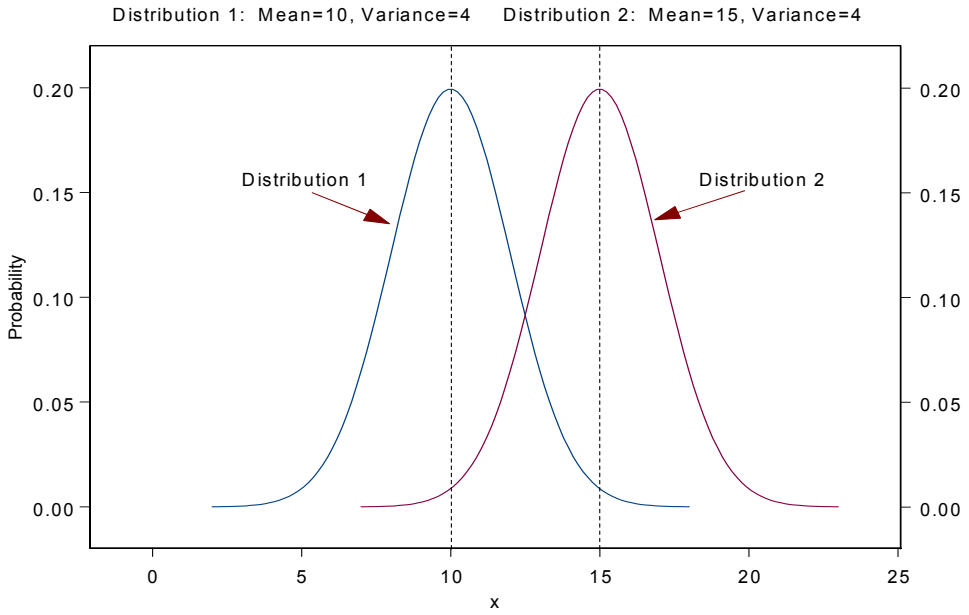
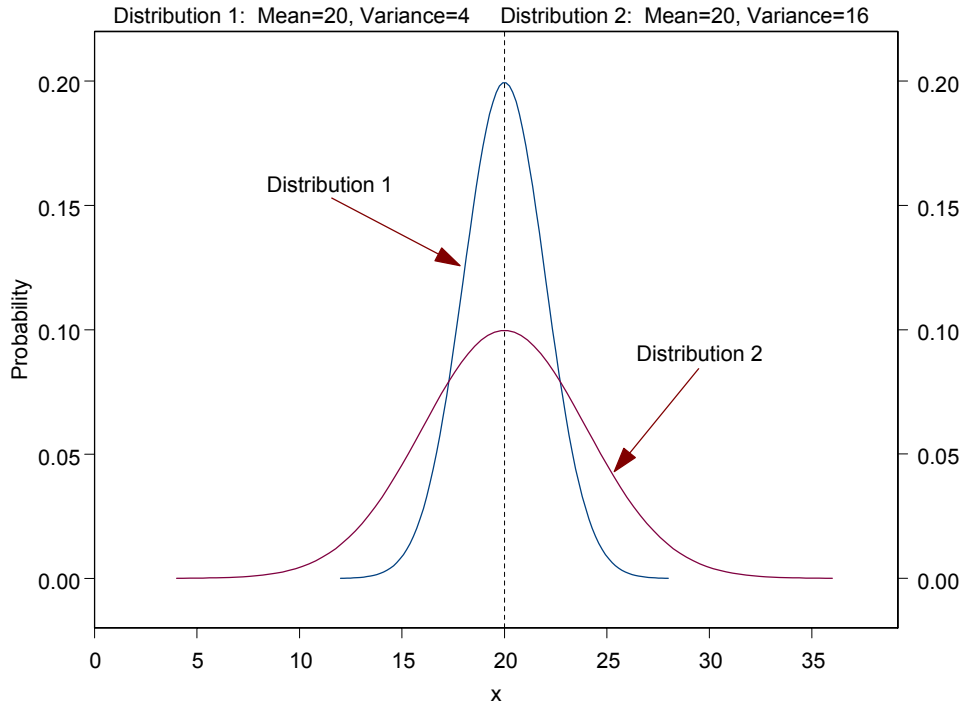


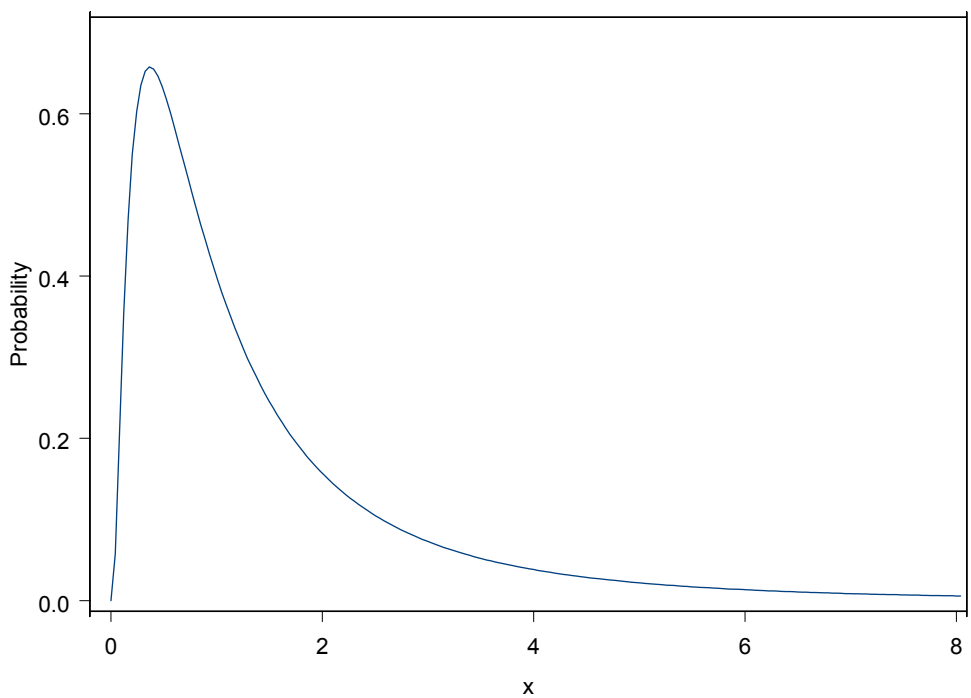
Figure 1.2b Two Normal Distributions (Equal Means, Different Variances)



Another common distribution used to model environmental data is the lognormal distribution (Figure 1.3). The lognormal distribution is characterized by a lower bound of zero and a right-skewed density function (i.e., the shape of the distribution is asymmetric with a long right tail). Because of the zero lower bound, the lognormal distribution can only be used to describe positive-valued data. These distributional characteristics often make the lognormal model a better candidate for describing environmental data sets. This idea is supported by Ott (1990) who demonstrates that there is a theoretical basis for the common occurrence of the lognormal distribution in environmental data.

Figure 1.3 Lognormal Distribution

Meanlog=0, Varlog=1



As their names might suggest, there is a close relationship between the normal and lognormal distributions. Simply put, if a set of data $x_1, x_2, ..., x_n$ are lognormally distributed, then the set $y_1, y_2, ..., y_n$ representing the natural logs of the original observations (i.e., $y_i = \ln(x_i)$) will be normally distributed. In this case, log-transforming the original data set results in a normally-distributed data set.

Calculating the natural logs of the data is an example of a transformation of the original data set to achieve a normally-distributed data set. Transformations are used for changing the scale and range of data to obtain better statistical properties. Other methods for transforming data to normality are available (e.g., the Box-Cox family of transformations *PROPOSED* by Box and Cox (1964)); however, these methods are outside of the scope of this document. Transforming data to other scales often results in additional complexities when interpreting statistical results. Because of this and the common occurrence of the lognormal distribution in environmental data, the EPA (1992c) generally recommends testing for normality and lognormality only. Alternate methods for transforming data may be *PROPOSED* for review by the DEQ statistician.

Various statistical guidance documents suggest using a default assumption of normality or lognormality (i.e., test first for normality or lognormality; if the data pass a test for the default distribution, no further testing is recommended). **However, it is recommended here that all data be evaluated for *both* the normal and lognormal distributions. The results of these evaluations should be compared to determine which distribution provides a better fit to the data and, as a result, which methods are most appropriate.**

Experience has shown that some data sets do not conform to either distribution type. This may be due to many reasons, including:

- the presence of one or more outliers (see Chapter 2),
- the combination of data from multiple populations (e.g., *HOT SPOT* and non- *HOT SPOT* data) into a single data set, or
- the proportion of concentrations below the detection limit is too large (> 50%) to adequately evaluate the underlying distribution.

Appropriate selection of data sets as described in the Statistical Guidesheets should lessen problems associated with the first two points above. When the percent of concentrations below the detection limit is > 50%, it is generally not possible to evaluate the statistical distribution as described in Section 1.3. In some cases, alternate statistical methods are described for evaluating data sets with 50% or more of values below the detection limit. Consultation with a professional statistician is advised. In any case, alternate statistical methods may be *PROPOSED* for approval by the DEQ statistician.

1.3 METHODS FOR EVALUATING STATISTICAL DISTRIBUTIONS

Several methods are available for evaluating the statistical distribution of a data set. These methods include summary statistics, graphical techniques and formal tests. Most of these methods can be used to evaluate data for both normality and lognormality.

For each of these methods, it is recommended that a minimum of nine samples be used to evaluate for statistical distribution. A minimum of nine samples was selected in an effort to balance costs of sampling and analysis with statistical rigor. Tests for normality can be completed using as few as three samples (EPA 2000); however, the statistical power to conclude that the data are not normal (or lognormal) is low. Other sources recommend that sample sizes of 20 or more are required to attain reasonable power in tests of normality (e.g., EPA 1992a, EPA 1992c). Recognizing that this minimum number of samples must be collected from each *EXPOSURE UNIT* or area for which a statistical analysis is completed, the recommended minimum of samples was selected to represent the lower end of the range cited in literature. Because use of a relatively small sample size results in reduced power in tests of normality, a variety of techniques for evaluating distribution are recommended.

If it can be reasonably concluded that concentrations from multiple *EXPOSURE UNITS* or areas can be modeled by the same statistical distribution (e.g., due to placement of homogeneous fill materials over a large area), it may be appropriate to pool data from these areas when testing for distribution in order to increase sample size. If this approach is considered, a *PROPOSAL* should be submitted for review by the DEQ statistician. Consultation with a professional statistician is advised when developing this approach.

In some cases, it may be difficult to determine which distribution is most appropriate. **A final choice of statistical distribution should be made based on evaluation of the collective results of the different methods described below.**

A number of methods are provided in this section to evaluate data for a normal or lognormal distribution. These methods are summarized below:

Type of Method	Method	Section
Summary Statistic	Coefficient of Variation	1.3.1
Summary Statistic	Coefficient of Skewness	1.3.2
Graphical Technique	Probability Plots	1.3.3
Graphical Technique	Box Plots	1.3.4
Formal Test	Shapiro-Wilk Test ($n \leq 50$)	1.3.5
Formal Test	Shapiro-Francia Test ($n > 50$)	1.3.6
Formal Test	D'Agostino's Test ($n > 50$)	1.3.7

Summary statistics provide a simple way to evaluate the distribution of data. Summary statistics include descriptive values like the mean and standard deviation. These values are called summary statistics, or descriptive statistics, because they summarize the information contained in the data set and describe certain properties of the data set, such as central tendency and variability. The coefficient of variation and the coefficient of skewness are two more examples of summary statistics. The coefficient of variation measures the relative variability of the data set and provides a rough indication of the likelihood that the data are normal. The coefficient of skewness provides a measure of symmetry or asymmetry (i.e., skewness) of the data.

Graphical techniques provide a visual depiction of the data and are an excellent tool for inspecting data and their resemblance to a particular distribution. For example, a data set may fail a formal test of normality due to the presence of an outlier (i.e., without the outlier, the data would be normally distributed). This may not be apparent based on inspection of summary statistics or formal test results. Upon graphing the data, the cause for non-normality (an outlier, in this case) may be evident, allowing for possible modifications to the data (e.g., correction of an erroneous analytical result) and/or statistical approach. Note that identification and treatment of outliers is discussed in detail in Chapter 2. Because interpretation of graphical results may be somewhat subjective, decisions regarding statistical distribution should not be made using graphical methods alone.

Formal testing provides an objective framework for making decisions about the statistical distribution since a data set will either pass or fail a test for normality or lognormality. Subjectivity is largely absent when conducting a formal test and interpreting the result. Thus, formal tests provide the benefit of an objective framework for making decisions about data. However, as noted above, if a data set fails a formal test for normality or lognormality, the formal test results alone may not provide insight as to why a particular data set failed.

Used together, formal tests, graphical techniques, and summary statistics provide a strong framework for making decisions about and understanding the data. Consequently, a final choice of statistical distribution should be made based on evaluation of the collective results of the methods described below. **At a minimum, all statistical reports or *PROPOSALS* should include calculation of summary statistics, normal and lognormal probability plots, and**

the Shapiro-Wilk or Shapiro-Francia Tests for each contaminant in order to evaluate both normality and lognormality. Alternative methods for evaluating statistical distributions may be *PROPOSED* for review by the DEQ statistician.

1.3.1 Coefficient of Variation (CV)

The CV has been used historically by the DEQ (formerly the Department of Natural Resources [DNR]) as well as the Environmental Protection Agency (EPA) to evaluate the assumption of normality (DNR, 1994; EPA, 1989c). However, questions have been raised about the usefulness of using the CV for this purpose (EPA 1992c). The CV is sensitive to biased estimates of the mean should be used cautiously for censored data. As a measure of symmetry or asymmetry, the coefficient of skewness (Section 1.3.2) provides a more reliable tool. Furthermore, the Shapiro-Wilk and Shapiro-Francia tests (Sections 1.3.5 and 1.3.6, respectively) provide a better assessment of normality. **Consequently, it is recommended that the CV be calculated and interpreted together with the other methods presented below. Decisions regarding statistical distribution should not be made based solely on the CV.**

Procedure 1.1 Calculation of the Coefficient of Variation

To evaluate for normality, calculate the CV using the following equations. To evaluate for lognormality, first define y = ln(x) and use these y (log-transformed) values in place of the x values in the equations below. For nondetects, substitute 1/2 of the detection limit up to 50% nondetects.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad \text{Equation 1.1}$$

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}} \qquad \text{Equation 1.2}$$

$$CV = \frac{s}{\bar{x}} \qquad \text{Equation 1.3}$$

Where n represents the sample size, x_i represents the i th observed value, s represents the sample standard deviation, and $\bar{x}$ represents the sample mean. Note: The CV is often reported as a percentage (i.e., 100 times the CV calculated above).

It should not be necessary to calculate the above equations by hand considering the availability of basic statistical computations in statistical software packages and most spreadsheet packages. Most statistical software packages provide the CV as well as the sample standard deviation (s) and the sample mean ($\bar{x}$) together with other common summary statistics. Alternatively, Microsoft Excel can be used to obtain s and $\bar{x}$ for use in Equation 1.3. The Excel functions that should be used to obtain s and $\bar{x}$, respectively, are:

=STDEV(data range)

=AVERAGE(data range)

Note: The Excel function =STDEVP(data range) provides the population standard deviation (denominator = n) rather than the sample standard deviation (denominator = n-1). The population standard deviation is only appropriate for use with census data, which represent every unit of a population. In practice, census data are almost never available and the true standard deviation must be estimated. The sample standard deviation is an unbiased estimate of the true standard deviation (i.e., it does not consistently underestimate or overestimate the true standard deviation) and should be used throughout this document in all calculations calling for an estimate of the standard deviation.

Interpretation: If the data come from a normal distribution, then the CV will generally be less than one (EPA, 1989c). However, a CV < 1 does not automatically imply that the data are normal. The other methods described in this chapter must be considered to determine if the normal distribution is appropriate for the data. If the CV > 1, the normal distribution may not provide an adequate model for the data. If the data come from a lognormal or some other distribution, then the CV will likely be greater than one. A log-transformation of the data set will decrease the CV if the data come from a lognormal distribution.

Example 1.1 Sample Calculation of the Coefficient of Variation

At a *FACILITY*, 20 soil samples were collected for analysis of nickel concentrations. The results are shown below in parts per billion (ppb).

	A	B	C	D
1	Observation	Nickel concentration (ppb)	Ln (Nickel conc.)	
2	1	58.8	4.074	← =LN(B2)
3	2	1.0	0.000	← =LN(B3)
4	3	262.0	5.568	← =LN(B4)
5	4	56.0	4.025	⋮
6	5	8.7	2.163	
7	6	19.0	2.944	
8	7	81.5	4.401	
9	8	331.0	5.802	
10	9	14.0	2.639	
11	10	64.4	4.165	
12	11	39.0	3.664	
13	12	151.0	5.017	
14	13	27.0	3.296	
15	14	21.4	3.063	
16	15	578.0	6.360	
17	16	3.1	1.131	
18	17	942.0	6.848	
19	18	85.6	4.450	
20	19	10.0	2.303	
21	20	637.0	6.457	
22				
23	n:	20	20	
24	Mean:	169.5	3.9	
25	Std. Dev:	259.72	1.80	
26	CV:	1.53	0.46	
27	Skewness:	2.00	-0.27	
28				
29				
30		=count(B2:B21)	=count(C2:C21)	
31		=average(B2:B21)	=average(C2:C21)	
32		=stdev(B2:B21)	=stdev(C2:C21)	
33		=B25/B24	=C25/C24	
34		=skew(B2:B21)	=skew(C2:c21)	

Coefficients of variation were calculated for both the raw data and the log-transformed data. First, the averages and standard deviations were calculated using the Microsoft Excel functions shown above. The CV was then calculated by dividing the standard deviations by their respective mean concentrations, which may be denoted CV_{Raw} and CV_{Ln}, respectively.

Since the CV for the raw nickel concentrations is greater than 1 (CV_{Raw}=1.53), this indicates that the data set may not be normally distributed. The CV for the log-transformed data set is less than 1 (CV_{Ln}=0.46), suggesting that it is more appropriate to assume that the data come from a lognormally distributed population. A final decision regarding the distribution of the data set will be made after considering the results of other methods presented throughout this section.

1.3.2 Coefficient of Skewness

The coefficient of skewness (Skew; also denoted γ_1) measures the skewness or asymmetry of a data set with respect to the mean. It is relatively easy to compute and it can be useful in evaluating symmetry.

The following coefficients of skewness may be expected for the various types of distributions:

Distribution Type	Coefficient of Skewness
Symmetric (e.g., normal distribution)	Zero (i.e., Skew = 0)
Right-skewed (with a long right tail)	Positive (i.e., Skew > 0)
Left-skewed (with a long left tail)	Negative (i.e., Skew < 0)

Right-skewed distributions are common in environmental data analysis (i.e., Skew > 0).

Procedure 1.2 (following page) describes the method for calculating the coefficient of skewness and recommendations for interpretation.

Example 1.2 Sample Calculation of the Coefficient of Skewness

Nickel concentrations from 20 soil samples collected at a *FACILITY* were presented in Example 1.1.

The coefficient of skewness was calculated for both the raw and log-transformed data using the Excel function shown in Example 1.1. The results obtained were as follows:

$$Skew_{Raw} = 2.00$$

$$Skew_{Ln} = -0.27$$

$Skew_{Raw}$ is a positive number, indicating that the data set is positively or right skewed, as is common with environmental data sets. Because $Skew_{Raw}$ is greater than 1, the data may not be normally distributed.

Since $-1 < Skew_{Ln} < 1$, the data may be lognormally distributed.

Procedure 1.2 Calculation of the Coefficient of Skewness

To evaluate for normality, the coefficient of skewness may be calculated using the following equation. To evaluate for lognormality, first define y = ln(x) and use these y (log-transformed) values in place of the x values in the equation below. For nondetects, substitute 1/2 of the detection limit up to 50% nondetects.

$$Skew = \frac{\frac{n}{(n-1)(n-2)}\sum_{i=1}^{n}(x_i - \bar{x})^3}{s^3} \qquad \text{Equation 1.4}$$

Where n represents the sample size, x_i represents the i th observation, $\bar{x}$ represents the arithmetic mean (Equation 1.1), and s represents the sample standard deviation (Equation 1.2).

Most statistical software packages calculate the coefficient of skewness. Alternatively, Microsoft Excel can be used to obtain the coefficient of skewness, as follows:

=SKEW(data range)

Interpretation: Small degrees of skewness may not affect the results of an analysis conducted using an assumption of normality; however, a large coefficient of skewness may lead to inaccurate results. In general, if -1 < Skew < 1, the normal distribution may provide a reasonable approximation of the data. If Skew > 1 or Skew < -1, the data may not be normally distributed. When calculating the coefficient of skewness for both the raw data set and the log-transformed (Ln) data set, the results (which may be denoted $Skew_{Raw}$ and $Skew_{Ln}$, repsectively) may be interpreted as follows:

- If $Skew_{Raw} > 1$ and $Skew_{Ln} > 1$, the data set is highly skewed and may not represent either a normal or lognormal distribution.
- If $Skew_{Raw} > 1$ but $-1 < Skew_{Ln} < 1$, the raw data are right-skewed, but the log-transformed data are approximately symmetric. This is evidence for the assumption of lognormality for the raw data set.
- If $-1 < Skew_{Raw} < 1$ and $-1 < Skew_{Ln} < 1$, but $|Skew_{Raw}| > |Skew_{Ln}|$, the log-transformed data set is more symmetric. Consequently, an assumption of lognormality may be more appropriate for the data. (Note: $|Skew_{Raw}|$ denotes the absolute value of the skewness of the raw, non-transformed data.)

It is also possible to obtain a Skew < -1. This may be due to the presence of one or more low outliers or simply sampling variability. If a data set is negatively skewed, a log-transformation of the data will not improve the symmetry. If Skew < -1 and the raw data fail a formal test of normality, a conclusion regarding the distribution cannot be drawn. It may be necessary to consult a professional statistician and/or *PROPOSE* an alternate statistical method to compare *FACILITY* data (see Chapter 3).

1.3.3 Normal Probability Plots

One of the best tools for evaluating a data set for normality (or lognormality) is the normal probability plot. This tool allows for visual inspection of the data as well as an assessment of the fit to a specific probability distribution. Irregularities in the data when compared to a known probability distribution are easy to identify.

Normal probability plots are typically constructed by plotting concentration measurements sorted in increasing order along the y-axis versus corresponding quantiles or "z-scores" of a standard normal distribution (i.e., a normal distribution with a mean of zero and a standard deviation of one, also denoted N(0,1)) on the x-axis. If the data are normal, the plotted data points will approximate a straight line. If the data are not normal, departures from normality may be evident as bends or curves in the plotted points. In addition, unusual values, such as outliers, are often identifiable on the resulting plot.

Normal probability plots may also be used to evaluate a data set for lognormality by constructing a probability plot using a natural log transformation of the analytical results instead of the raw (untransformed) analytical results. **It is recommended that probability plots be constructed for both raw (untransformed) and log-transformed (Ln) data and compared to identify the best-fitting distribution.**

Because interpretation of probability plots may be somewhat subjective, conclusions should not be drawn regarding statistical distributions based on probability plots alone. Probability plots should be used in combination with the other methods described in this chapter.

Many statistical packages can create normal probability plots at the click of a button. (The axes may be reversed or may differ slightly from those described below; however, they may be interpreted in the same manner.) Different statistical software packages may refer to these plots by alternate names, such as "normal probability plots," "normal quantile-quantile plots," or "QQ normal plots." For those without access to a statistical package, spreadsheets provide an alternative means to construct probability plots. The instructions are straightforward and are provided in Procedure 1.3.

Procedure 1.3 Construction of a Normal Probability Plot

To evaluate for normality, complete the steps below using the raw data. To evaluate for lognormality, first define y = ln(x) and use these y (log-transformed) values in place of the x values below. For nondetects, substitute 1/2 of the detection limit. Probability plots may be constructed using data with more than 50% nondetects; however, as the percent nondetects increases, the amount of information provided by the plot decreases.

1. Order the data from the smallest to the largest value ($x_{(i)}$, i = 1, …, n).

2. Calculate the cumulative probabilities corresponding to each $x_{(i)}$ (representing the proportion of values less than or equal to $x_{(i)}$) as follows:

3.

$$p_i = \frac{i}{n+1} \qquad \text{Equation 1.5}$$

Where n represents the sample size and i represents the rank of the i th ordered concentration.

4. Determine the quantiles or z-scores from the standard normal distribution corresponding to the cumulative probabilities in Step 2.

5.

$$z_i = \Phi^{-1}(p_i) \qquad \text{Equation 1.6}$$

where Φ^{-1} denotes the inverse of the cumulative standard normal distribution. These values are easily calculated using Excel (see below).

6. Plot z_i (z-scores) versus $x_{(i)}$ (the ordered concentrations for each sample).

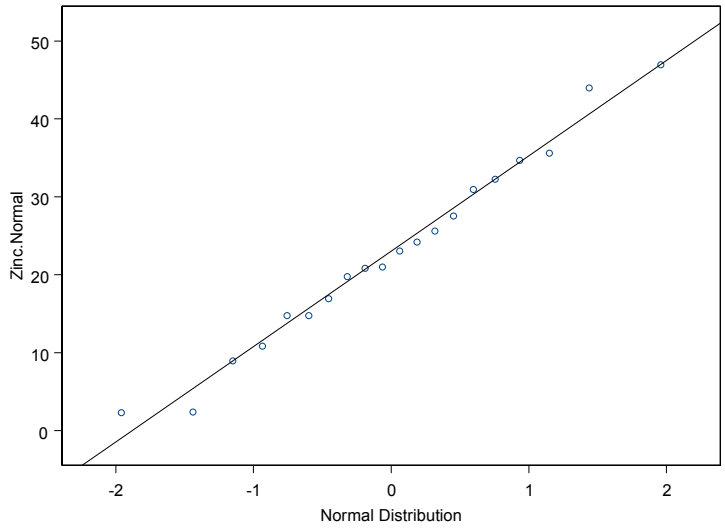
Microsoft Excel can be used to plot the above results as well as obtain z-scores (Equation 1.6) for each probability p_i using the following function:

=NORMSINV(p_i)

Interpretation: If a data set is approximately normal, the plotted points should fall on or near a straight line. Curves or bends in the line indicate that the data are not normally distributed. Lognormality of the data set can be evaluated by plotting the log-transformed y-values in place of the x-values above. If the data set is approximately lognormal and the probability plot is constructed using log-transformed data, the plotted points should fall on or near a straight line.

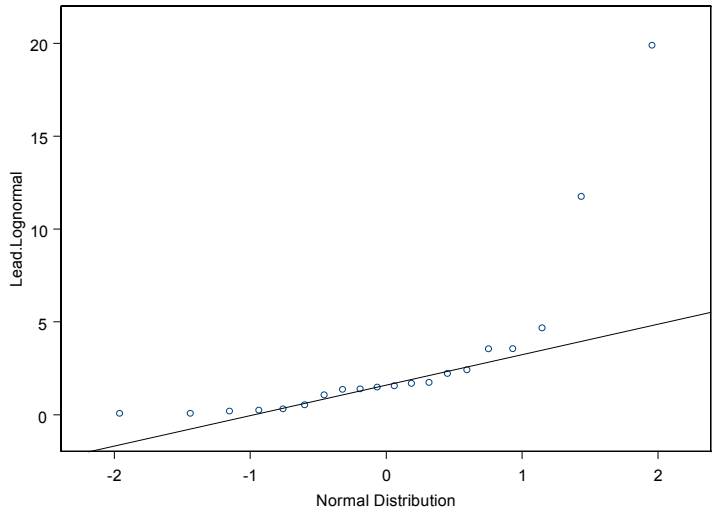
Sample plots are shown on Figures 1.4 through 1.8 to illustrate typical patterns that may be observed on probability plots. Interpretations are provided to the right of each plot. Figures 1.4 through 1.8 were created using the statistical software package S-PLUS. Figures 1.9 and 1.10 (Example 1.3) were constructed using Microsoft Excel.

Figure 1.4 Normal Probability Plot of Zinc Data



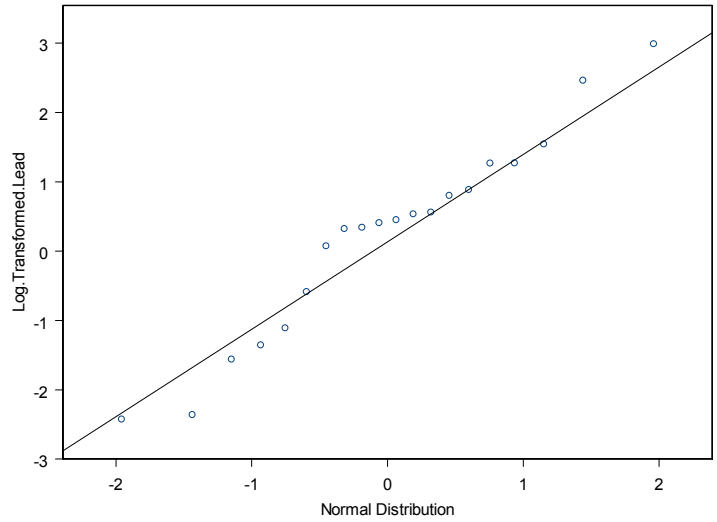
Using raw (untransformed) data, the points fall approximately on a straight line. Therefore, the data set appears to be approximately normally distributed.

Figure 1.5 Normal Probability Plot of Lead Data



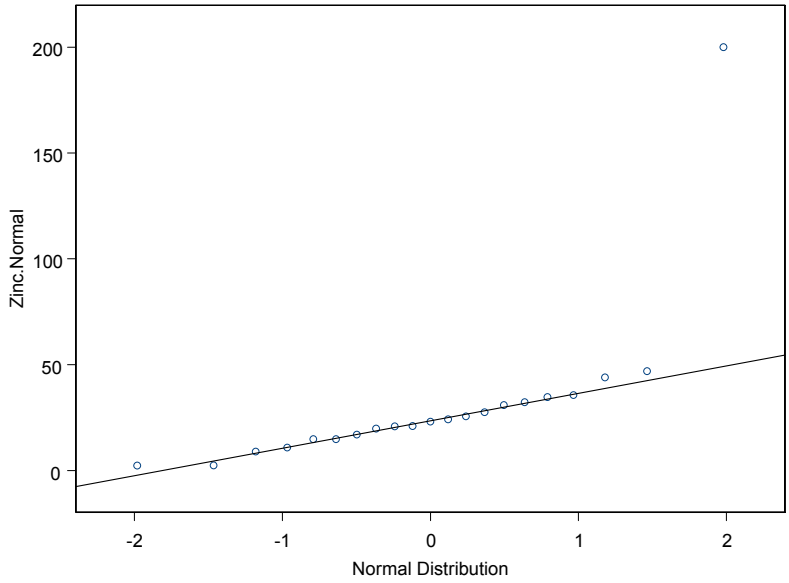
Using raw lead data, the points curve about the straight line. This may indicate that the data are approximately lognormal instead. Compare to the plot constructed using log-transformed data below.

Figure 1.6 Normal Probability Plot of Log-Transformed (Ln) Lead Data



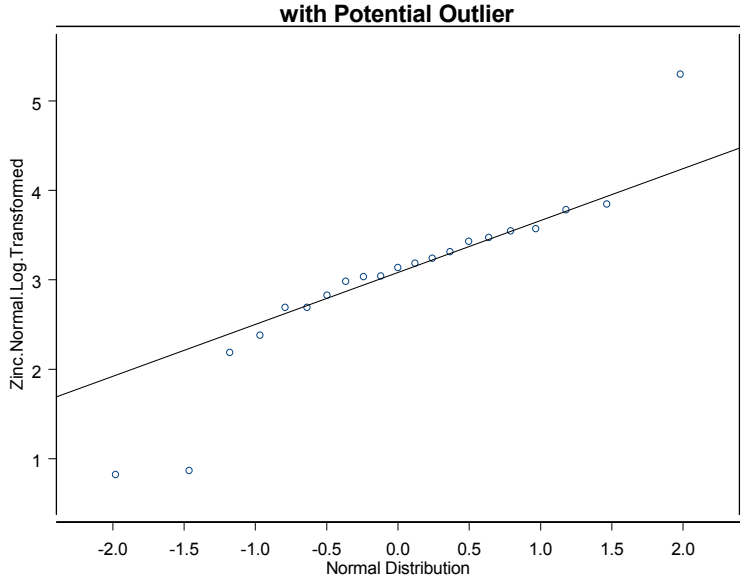
Using log-transformed lead data, the points fall approximately on a straight line. Because the log-transformed data are approximately normal, it can be concluded that the raw (untransformed) data set is approximately lognormal.

Figure 1.7 Normal Probability Plot of Zinc Data with Potential Outlier



Although one might initially guess this data set is lognormally distributed, this plot does not illustrate the characteristic curve of a data set that is lognormally distributed. Most of the data fall on or near a straight line; however, one outlying value is evident. This indicates that the data may be normally distributed with the exception of a single outlier.

Figure 1.8 Normal Probability Plot of Log-Transformed Zinc Data with Potential Outlier



The data shown in Figure 1.7 were log-transformed to illustrate that log-transformations do not always solve problems with high outliers. The high value still stands out as a potential outlier in this plot. Furthermore, note that two low values now appear to be outlying results as well.

The data set shown in Figures 1.7 and 1.8 are evaluated further in Chapter 2 on identification of outliers.

Example 1.3 Sample Construction of a Probability Plot

The nickel data set from Example 1.1 was used to create probability plots for both the raw nickel concentrations and the log-transformed concentrations. Microsoft Excel was used to complete the calculations described in Procedure 1.3 (calculations shown below) and to plot the results. Column D was plotted versus Column C to create the probability plot for the raw (untransformed) data set (Figure 1.9). Column E was plotted versus Column C to create the normal probability plot for log-transformed (Ln) data (Figure 1.10).

	A	B	C	D	E
1			Normal		
2	Order (i)	i / (n+1)	quantile	Nickel conc. (ppb)	Ln (Nickel conc.)
3	1	0.05	-1.67	1.0	0.000
4	2	0.10	-1.31	3.1	1.131
5	3	0.14	-1.07	8.7	2.163
6	4	0.19	-0.88	10.0	2.303
7	5	0.24	-0.71	14.0	2.639
8	6	0.29	-0.57	19.0	2.944
9	7	0.33	-0.43	21.4	3.063
10	8	0.38	-0.30	27.0	3.296
11	9	0.43	-0.18	39.0	3.664
12	10	0.48	-0.06	56.0	4.025
13	11	0.52	0.06	58.8	4.074
14	12	0.57	0.18	64.4	4.165
15	13	0.62	0.30	81.5	4.401
16	14	0.67	0.43	85.6	4.450
17	15	0.71	0.57	151.0	5.017
18	16	0.76	0.71	262.0	5.568
19	17	0.81	0.88	331.0	5.802
20	18	0.86	1.07	578.0	6.360
21	19	0.90	1.31	637.0	6.457
22	20	0.95	1.67	942.0	6.848
23					
24					
25		=A3/21	=NORMSINV(B3)		=LN(D3)
26		=A4/21	=NORMSINV(B4)		=LN(D4)
27		⋮	⋮		⋮

Figure 1.9 Normal Probability Plot of Raw Nickel Data (Plotted Using Microsoft Excel)

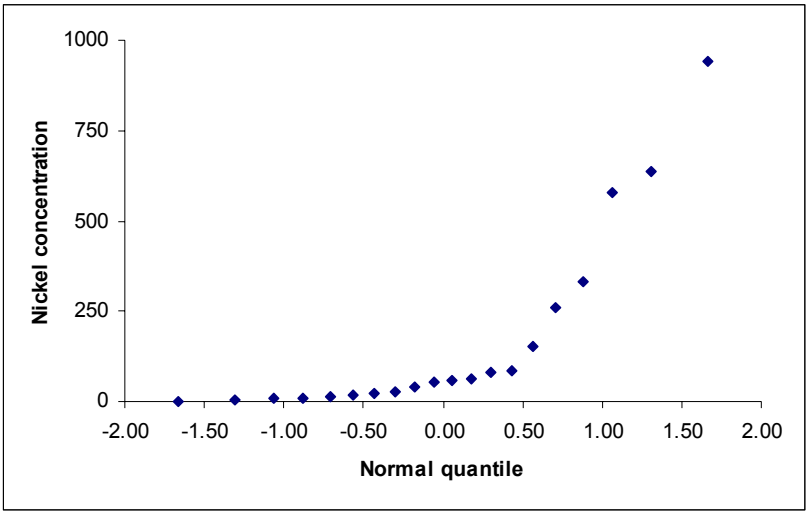
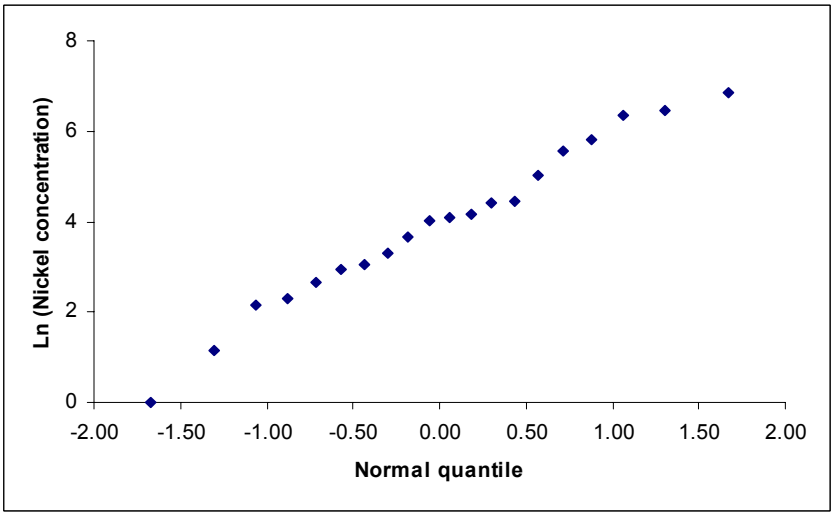


Figure 1.10 Normal Probability Plot of Log-Transformed Nickel Concentrations (Plotted Using Microsoft Excel)



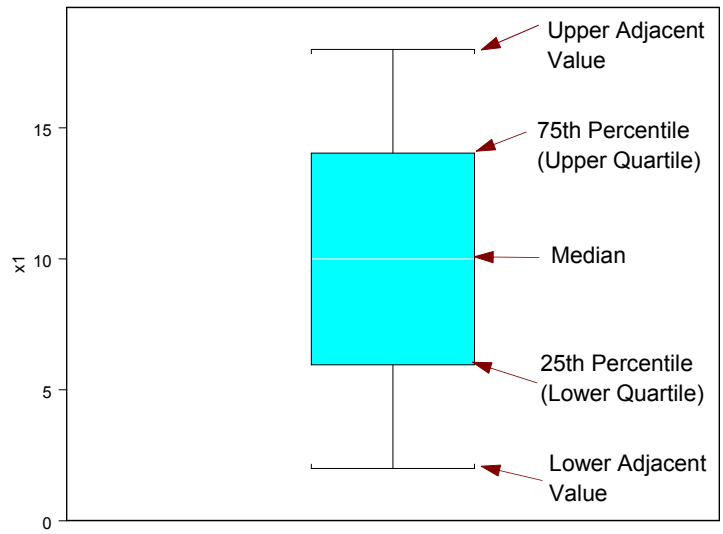
Review of the probability plots indicates that the lognormal distribution provides a better fit to the nickel concentrations than the normal distribution. The plot of the raw data in Figure 1.9 illustrates the distinct curve often seen when the data are better approximated by the lognormal distribution. However, the plot of the log-transformed data closely approximates a straight line. This indicates that the log-transformed nickel concentrations are approximately normal, thus the raw data are approximately lognormal. These findings are consistent with the conclusions drawn in Examples 1.1 and 1.2.

1.3.4 Box Plots

Box plots are another way to graphically examine the characteristics of a data set (see Figure 1.11). The 25th and 75th percentiles of the data set define the lower and upper ends of the box, respectively. A line across the center of the box denotes the median (50th percentile, or middle value). The length of the box, or distance from the 25th to the 75th percentile, is called the interquartile range (IQR).

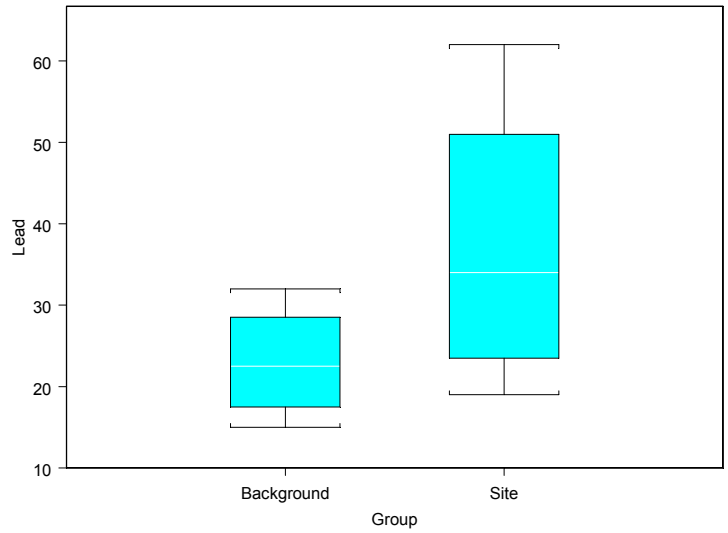
Vertical lines extending from the ends of the box (whiskers) may be constructed in various ways. Two common methods for drawing whiskers are described here. The simplest method involves drawing vertical lines from the upper edge of the box to the maximum concentration and from the lower edge of the box to the minimum concentration.

Figure 1.11 Box and Whisker Plot



A second method involves drawing vertical lines from the upper edge of the box to the next larger value within one step (i.e., the upper adjacent value) and from the 25th percentile down to the next smaller value within one step (i.e., the lower adjacent value). A step is traditionally defined as 1.5 times the IQR. This step size is useful in that the outside values shown as asterisks or horizontal lines beyond the whiskers are potential outliers, though formal verification as described in Chapter 2 is required. This screening criteria can be made more or less strict by changing the step size.

Figure 1.12 Side-by-Side Box Plots



Box plots are particularly useful when comparing two or more data sets. Side-by-side box plots can be inspected for differences between the data sets (Figure 1.12).

Since interpretation of box plots can be somewhat subjective, box plots should only be used in combination with other methods for determining the distribution of a data set, not as a sole determining factor.

Although Microsoft Excel does not currently have capabilities to produce box plots, most statistical software packages (e.g., S-Plus, Minitab, Statistica, Systat, SPSS, and SAS) can easily produce box plots with the click of a button or a few command lines of code.

Interpretation: Box plots provide another useful tool for examining the statistical distributions of data sets. The horizontal line dividing the box graphically shows the median or middle value of a data set. The length of the box provides information on the variability or spread in the data set (similar to the CV). Skewness (i.e., symmetry versus asymmetry) can be inferred by examining the relative lengths of the box halves. For example, if the portion of the box and/or whiskers above the median are longer than the portion of the box and/or whiskers below the median, the data set is right-skewed (i.e., asymmetric, with a long right tail).

Box plots also provide an easy way to identify any unusual values (e.g., potential outliers) in the data set since outside values are often shown as asterisks or horizontal lines beyond the whiskers.

1.3.5 Shapiro-Wilk Test for Normality ($n \leq 50$)

The Shapiro-Wilk (SW) Test for normality (Shapiro and Wilk, 1965) is recommended as a formal test of normality when the data set contains 50 or fewer results. As noted by the EPA (1992c), the SW Test is considered to be one of the very best tests of normality available (Miller, 1986; Madansky, 1988). Essentially, the SW Test for normality provides a measure of the degree to which a probability plot approximates a straight line. When the probability plot shows a nearly straight line, the SW Test statistic will be large. Conversely, when the probability plot shows substantial bends or curves, the SW Test statistic will be small.

As previously discussed, various statistical guidance documents provide recommendations to consider default assumptions of normality or lognormality (i.e., test first for normality or lognormality; if the data pass a test for the default distribution, no further testing is recommended). **However, it is recommended here that the SW Test be completed both on the raw data and on the log-transformed (Ln) data. The results of these two tests should be compared to determine which distribution provides a better fit to the data.**

Most statistical software packages include tests of statistical distributions; although not all include the SW Test. Of those that include this test, not all include the same version of the test. Consequently, care should be exercised. EnvironmentalStats for S-PLUS provides this test along with several supplemental graphics that are available with a few clicks of a button. For those without access to a statistical package, spreadsheets provide an alternative means for completing the SW Test. Instructions for Microsoft Excel are provided in Procedure 1.4.

Procedure 1.4 Shapiro-Wilk Test for Normality (n ≤ 50)

To test for normality, follow the steps below. To test for lognormality, first define y = ln(x) and use these y (transformed) values in place of the x values below. For nondetects, substitute 1/2 of the detection limit up to 50% nondetects.

1. Order the data from the smallest to the largest value, where $x_{(1)}$ is the smallest value (also called the first order statistic), $x_{(2)}$ is the next largest value, …, and $x_{(n)}$ is the largest value.

2. Set *k* equal to the largest integer less than or equal to (*n*/2), where n represents the sample size.

3. Calculate the differences $[x_{(n-i+1)} - x_{(i)}]$ for each *i* = 1, 2, …, *k*.

4. Find the coefficients a_i for i = 1, 2, …, *k* using Table 1.1. Coefficients are provided in this table for samples sizes from *n* = 3 to *n* = 50.

5. Calculate *b* as follows:

$$b = \sum_{i=1}^{k} b_i = \sum_{i=1}^{k} a_{n-i+1}(x_{(n-i+1)} - x_{(i)})$$

Equation 1.7

6. Calculate the sample standard deviation (*s*) of the data set (Equation 1.2).

Microsoft Excel can be used to obtain an estimate of the sample standard deviation (*s*) using the following function:

=STDEV(data range)

7. Calculate the Shapiro-Wilk test statistic as follows:

$$SW = \left[\frac{b}{s\sqrt{n-1}}\right]^2$$

Equation 1.8

8. Using Table 1.2 and a significance level of α = 0.05, determine the critical value (sw_α) based on *n* observations and compare to *SW*.

Interpretation: The value SW will tend to be large when a probability plot of the data approximates a straight line. SW will tend to be small when a probability plot shows substantial departures from a straight line (e.g., bends, curves, or outliers). Specifically:

- If $SW \geq sw_\alpha$ conclude that the data set is approximately normal (lognormal, if calculated using y values).
- If $SW < sw_\alpha$ conclude that the data set is **not** normally (lognormally) distributed.

***p*-Values:** Some statistical software packages provide *p*-values instead of the *SW* and sw_α values described above. The *p*-value may be interpreted as the probability that the given data set and the corresponding *SW* value would be obtained if the sampled population (i.e., the population that was sampled to obtain the data set) were truly normally distributed (or lognormally distributed, if testing for lognormality). For example, if a raw or untransformed data set was tested for normality and the resulting *p*-value was small, it is unlikely that the data set was obtained from a normal distribution. When the significance level is set at $\alpha = 0.05$ (the recommended level of significance for most situations), the p-value should be compared directly to this value. That is:

If $p \geq 0.05$, conclude that the data set is approximately normal (lognormal, if obtained using y values).

If $p < 0.05$, conclude that the data set is **not** normally (lognormally) distributed.

As previously noted, the SW Test should be completed for both the raw data set and the log-transformed (Ln) data set to test for normality and lognormality, respectively. If the results indicate that the data pass both tests, the test resulting in the higher *SW* value (or *p*-value) should be relied upon to draw conclusions about the distribution of the data.

A review of plots and summary statistics should also be completed to confirm the results of the SW Test.

In some cases, data sets fail both tests for normality and lognormality. When the SW Test results in a conclusion that a data set is not normal or lognormal, it does not indicate which characteristic(s) of the data, say skewness to a heavy-tailed distribution (or both) was responsible for the lack of normality or lognormality. Inspection of the histogram, box plot, and particularly the probability plot, may provide some insight as to why this occurred. It may be clear that the data set is highly skewed, even when log-transformed. If there is a potential outlier in the data set, see Chapter 2 of this section for specific recommendations. The presence of a true outlier(s) may be an indication of an unsuspected *HOT SPOT*. *HOT SPOTS* generally represent a separate population and must be addressed separately. If there is no clear reason for the data to fail tests of normality and lognormality, it may be necessary to proceed to an alternate statistical method for comparing *FACILITY* data to Part 201 criteria or *BACKGROUND*, as described in Chapters 3 and 4. Consultation with a professional statistician is advised.

Example 1.4 Sample Shapiro-Wilk Test for Normality

Based on the evaluations presented in Examples 1.1, 1.2, and 1.3, the nickel concentrations in soil appear to fit a lognormal distribution better than a normal distribution pattern. To formally test this, the SW Test was conducted on both the raw data and the log-transformed data.

Calculations for the Shapiro-Wilk Test of Normality (Raw Data)

	A	B	C	D	E	F	G
1	i	$x_{(i)}$	$x_{(n-i+1)}$	$x_{(n-i+1)} - x_{(i)}$	$a_{(n-i+1)}$	$b_{(i)}$	
2	1	1.0	942.0	941.0	0.4734	445.4694	← =D2*E2
3	2	3.1	637.0	633.9	0.3211	203.5453	← =D3*E3
4	3	8.7	578.0	569.3	0.2565	146.0255	← =D4*E4
5	4	10.0	331.0	321.0	0.2085	66.9285	⋮
6	5	14.0	262.0	248.0	0.1686	41.8128	
7	6	19.0	151.0	132.0	0.1334	17.6088	
8	7	21.4	85.6	64.2	0.1013	6.5035	
9	8	27.0	81.5	54.5	0.0711	3.8750	
10	9	39.0	64.4	25.4	0.0422	1.0719	
11	10	56.0	58.8	2.8	0.0140	0.0392	
12	11	58.8	56.0		b:	932.880	
13	12	64.4	39.0			=SUM(F2:F11)	
14	13	81.5	27.0				
15	14	85.6	21.4				
16	15	151.0	19.0				
17	16	262.0	14.0				
18	17	331.0	10.0				
19	18	578.0	8.7				
20	19	637.0	3.1				
21	20	942.0	1.0				
22							
23	Std. Dev:	259.7	← =STDEV(B2:B21)				
24	n:	20	← =COUNT(B2:B21)				
25	k:	10					

$$W = \left[\frac{932.9}{259.7\sqrt{19}}\right]^2 = 0.679$$

Calculations for the Shapiro-Wilk Test of Normality (Log-Transformed Data)

	A	B	C	D	E	F	G
1	i	$x_{(i)}$	$x_{(n-i+1)}$	$x_{(n-i+1)} - x_{(i)}$	$a_{(n-i+1)}$	$b_{(i)}$	
2	1	0.0	6.8	6.8	0.4734	3.2418	← =D2*E2
3	2	1.1	6.5	5.3	0.3211	1.7100	← =D3*E3
4	3	2.2	6.4	4.2	0.2565	1.0763	← =D4*E4
5	4	2.3	5.8	3.5	0.2085	0.7297	⋮
6	5	2.6	5.6	2.9	0.1686	0.4939	
7	6	2.9	5.0	2.1	0.1334	0.2765	
8	7	3.1	4.4	1.4	0.1013	0.1404	
9	8	3.3	4.4	1.1	0.0711	0.0785	
10	9	3.7	4.2	0.5	0.0422	0.0212	
11	10	4.0	4.1	0.0	0.0140	0.0007	
12	11	4.1	4.0		b:	7.769	
13	12	4.2	3.7			=SUM(F2:F11)	
14	13	4.4	3.3				
15	14	4.4	3.1				
16	15	5.0	2.9				
17	16	5.6	2.6				
18	17	5.8	2.3				
19	18	6.4	2.2				
20	19	6.5	1.1				
21	20	6.8	0.0				
22							
23	Std. Dev:	1.8	← =STDEV(B2:B21)				
24	n:	20	← =COUNT(B2:B21)				
25	k:	10					

$$W = \left[\frac{7.769}{1.8\sqrt{19}}\right]^2 = 0.980$$

From Table 1.2, it can be seen that the critical value sw_α, given a sample size of 20, is 0.905 at the α = 0.05 level. The SW statistic calculated from the raw nickel data (SW_{Raw}) is equal to 0.679. The SW statistic calculated using the log-transformed data (SW_{Ln}) is equal to 0.980. Because $SW_{Raw} < sw_\alpha$ (0.679 < 0.905), it can be concluded that the data are not normally distributed. However, because $SW_{Ln} > sw_\alpha$ (0.980 > 0.905), it can be concluded that the data are approximately lognormally distributed.

The results of the SW Test confirm our initial conclusions based on use of summary statistics and plots. Consequently, we can be more confident in our conclusion that the lognormal model provides a better approximation to the data. Inference made under the assumption of lognormality is expected to be more reliable than under the assumption of normality.

1.3.6 Shapiro-Francia Test for Normality (*n* > 50)

When a data set is large (i.e., data sets with more than 50 observations), the Shapiro-Francia (SF) Test for normality is appropriate (Shapiro and Francia, 1972). Similar to the SW Test, the SF Test statistic will be a large when a probability plot of the data shows a nearly straight line.

EnvironmentalStats for S-PLUS provides the SF Test for normality (or lognormality) along with several supplemental graphics that are available with a few clicks of a button. For those without access to a statistical package, spreadsheets provide an alternative means for completing the SF Test. Instructions for Microsoft Excel are provided in Procedure 1.5.

The SF Test should be completed for both the raw data set and the log-transformed (Ln) data set to test for normality and lognormality, respectively. If the results indicate that the data pass both tests, the test resulting in the higher SF value should be relied upon to draw conclusions about the distribution of the data.

A review of plots and summary statistics should also be completed to confirm the results of the SF Test.

In some cases, data sets fail both tests for normality and lognormality. When the SF Test results in a conclusion that a data set is not normal or lognormal, it does not indicate which characteristic(s) of the data, say skewness to a heavy-tailed distribution (or both) was responsible for the lack of normality or lognormality. Inspection of the histogram, box plot, and particularly the probability plot, may provide some insight as to why this occurred. It may be clear that the data set is highly skewed, even when log-transformed. If there is a potential outlier in the data set, see Chapter 2 of this section for specific recommendations. The presence of a true outlier(s) may be an indication of an unsuspected *HOT SPOT*. *HOT SPOTS* generally represent a separate population and must be addressed separately. If there is no clear reason for the data to fail tests of normality and lognormality, it may be necessary to proceed to an alternate statistical method for comparing *FACILITY* data to Part 201 criteria or *BACKGROUND*, as described in Chapters 3 and 4. Consultation with a professional statistician is advised.

Procedure 1.5 Shapiro-Francia Test for Normality (n > 50)

To test for normality, follow the steps below. To test for lognormality, first define y = ln(x) and use these y (transformed) values in place of the x values below. Substitute 1/2 of the detection limit for nondetects for up to 50% nondetects.

1. Order the data from the smallest to the largest value, where $x_{(1)}$ is the smallest value (also called the first order statistic), $x_{(2)}$ is the next largest value, …, and $x_{(n)}$ is the largest value.

2. Calculate the sample standard deviation (s^2) using Equation 1.2 and squaring the result.

Microsoft Excel can be used to obtain an estimate of the sample variance (s^2) using the following function:

=VAR(data range)

3. Calculate m_i, or *i* th ordered normal quantiles (z-scores) using:

$$m_i = \Phi^{-1}\left(\frac{i}{n+1}\right) \qquad \text{Equation 1.9}$$

Where Φ^{-1} denotes the inverse of the cumulative standard normal distribution.

Microsoft Excel can be used to obtain z-scores (m_i) for each value using the following function:

$$m_i = \text{NORMSINV}\left(\frac{i}{n+1}\right)$$

4. The SF Test statistic is calculated using the following formula:

$$SF = \left[\sum_{i=1}^{n} m_i x_{(i)}\right]^2 \Bigg/ \left[(n-1)s^2 \sum_{i=1}^{n} m_i^{\,2}\right] \qquad \text{Equation 1.10}$$

5. Using Table 1.3 and a significance level of α = 0.05, determine the critical value (sf_α) based on *n* observations and compare to *SF*.

Interpretation: Similar to the SW statistic, the value of the SF statistic will tend to be large when a probability plot of the data approximates a straight line. SF will tend to be small when a probability plot shows substantial departures from a straight line (e.g., bends, curves, or outliers). Specifically:

- If $SF \geq sf_\alpha$ conclude that the data set is approximately normal (lognormal, if calculated using y values).
- If $SF < sf_\alpha$ conclude that the data set is **not** normally (lognormally) distributed.

***p*-Values:** Some statistical software packages provide *p*-values instead of the *SF* and sf_α values described above. The *p*-value may be interpreted as the probability that the given data set and the corresponding *SF* value would be obtained if the sampled population (i.e., the population that was sampled to obtain the data set) were truly normally distributed (or lognormally distributed, if testing for lognormality). For example, if a raw or untransformed data set was tested for normality and the resulting *p*-value was small, it is unlikely that the data set was obtained from a normal distribution. When the significance level is set at $\alpha = 0.05$ (the recommended level of significance for most situations), the p-value should be compared directly to this value. That is:

If $p \geq 0.05$, conclude that the data set is approximately normal (lognormal, if obtained using y values).

If $p < 0.05$, conclude that the data set is **not** normally (lognormally) distributed.

As previously noted, the SF Test should be completed for both the raw data set and the log-transformed (Ln) data set to test for normality and lognormality, respectively. If the results indicate that the data pass both tests, the test resulting in the higher *SF* value (or *p*-value) should be relied upon to draw conclusions about the distribution of the data.

Example 1.5 Sample Shapiro-Francia Test for Normality

Fifty-two samples of soil dioxin (in ppb) were collected at a hypothetical *FACILITY*. Probability plots, the coefficient of skewness, and the CV all suggested that the data were lognormally distributed. A SF Test was then conducted to formally test whether the data were lognormally distributed.

The results were SF_{Ln} = 0.9763 and SF_{Raw} = 0.7682 (only the calculations for the log-transformed data set are shown in the figure). The sf_{α} for n = 52 and α = 0.05 is 0.955. Since $SF_{Ln} > sf_{\alpha}$, we conclude that the dioxin data set is lognormally distributed.

Calculations for Shapiro-Francia Test on Example Data Set

	A	B	C	D	E	F	G	H	I	J
1	Observation	Ln (Dioxin)	i / (n + 1)	Quantiles (m_i)	$m_i * x_{(i)}$	m_i^2				
2	1	0.07	0.02	-2.08	-0.14	4.32		n:	52	
3	2	0.36	0.04	-1.78	-0.64	3.16			=COUNT(B2:B53)	
4	3	0.41	0.06	-1.58	-0.65	2.51				
5	4	0.61	0.08	-1.44	-0.88	2.06		s^2:	0.83	
6	5	0.69	0.09	-1.31	-0.91	1.73			=VAR(B2:B53)	
7	6	0.73	0.11	-1.21	-0.89	1.46				
8	7	0.79	0.13	-1.12	-0.88	1.25		SF:	0.9763	
9	8	0.86	0.15	-1.03	-0.89	1.07		= E54^2 / (51 * I5 * F54)		
10	9	0.92	0.17	-0.95	-0.88	0.91				
11	10	1.04	0.19	-0.88	-0.92	0.78				
12	11	1.18	0.21	-0.81	-0.97	0.66				
13	12	1.27	0.23	-0.75	-0.95	0.56				
14	13	1.36	0.25	-0.69	-0.94	0.48				
15	14	1.42	0.26	-0.63	-0.90	0.40				
16	15	1.45	0.28	-0.57	-0.83	0.33				
17	16	1.48	0.30	-0.52	-0.77	0.27				
18	17	1.51	0.32	-0.47	-0.70	0.22				
19	18	1.57	0.34	-0.41	-0.65	0.17				
20	19	1.61	0.36	-0.36	-0.58	0.13				
21	20	1.62	0.38	-0.31	-0.50	0.10				
22	21	1.70	0.40	-0.26	-0.45	0.07				
23	22	1.71	0.42	-0.21	-0.37	0.05				
24	23	1.72	0.43	-0.17	-0.29	0.03				
25	24	1.73	0.45	-0.12	-0.20	0.01				
26	25	1.73	0.47	-0.07	-0.12	0.01				
27	26	1.75	0.49	-0.02	-0.04	0.00				
28	27	1.76	0.51	0.02	0.04	0.00				
29	28	1.77	0.53	0.07	0.13	0.01				
30	29	1.82	0.55	0.12	0.22	0.01				
31	30	1.86	0.57	0.17	0.31	0.03				
32	31	1.94	0.58	0.21	0.42	0.05				
33	32	1.94	0.60	0.26	0.51	0.07				
34	33	1.98	0.62	0.31	0.62	0.10				
35	34	2.02	0.64	0.36	0.73	0.13				
36	35	2.10	0.66	0.41	0.87	0.17				
37	36	2.18	0.68	0.47	1.02	0.22				
38	37	2.40	0.70	0.52	1.25	0.27				
39	38	2.51	0.72	0.57	1.44	0.33				
40	39	2.57	0.74	0.63	1.62	0.40				
41	40	2.65	0.75	0.69	1.83	0.48				
42	41	2.68	0.77	0.75	2.01	0.56				
43	42	2.82	0.79	0.81	2.30	0.66				
44	43	2.90	0.81	0.88	2.56	0.78				
45	44	2.96	0.83	0.95	2.82	0.91				
46	45	3.01	0.85	1.03	3.10	1.07				
47	46	3.09	0.87	1.12	3.45	1.25				
48	47	3.25	0.89	1.21	3.93	1.46				
49	48	3.30	0.91	1.31	4.34	1.73				
50	49	3.44	0.92	1.44	4.94	2.06				
51	50	3.48	0.94	1.58	5.51	2.51				
52	51	3.65	0.96	1.78	6.48	3.16				
53	52	3.78	0.98	2.08	7.86	4.32				
54					43.34	45.44				
55					=SUM(E2:E53)	=SUM(F2:F53)				
56										
57				=NORMSINV(C2)						
58				=NORMSINV(C3)						
59				=NORMSINV(C4)						
60				⋮						
61										

$$SF = \left[\sum_{i=1}^{n} m_i x_{(i)}\right]^2 \Big/ \left[(n-1)s^2 \sum_{i=1}^{n} m_i^2\right]$$

1.3.7 D'Agostino Test for Normality (*n* > 50)

Some EPA statistical guidance documents recommend the D'Agostino Test (D'Agostino, 1971) to test for normality when the sample size is between 50 and 1000. The D'Agostino's test and the Shapiro-Francia test tend to provide similar results and therefore can be considered roughly equivalent. EnvironmentalStats for S-PLUS does not provide a function that performs the D'Agostino Test for normality, but the necessary calculations can easily be performed using a spreadsheet. Both Gibbons (1994) and Gilbert (1987) describe the method and provide the necessary tables. Although the SF Test is preferred, analyses using the D'Agostino Test are acceptable.

1.4 EVALUATING STATISTICAL DISTRIBUTIONS WHEN DATA CONTAIN > 50% NONDETECTS

When the proportion of concentrations below the detection limit is > 50%, evaluation of the probability distribution of the data is not recommended. Therefore, the analyses described in this chapter are generally not needed. However, these methods may still provide some insight, in particular the graphical methods, to the extent that the data contain some detectable concentrations (e.g., a data set with only slightly more than 50% nondetects).

Table 1.1 Coefficients (a_i) for the Shapiro-Wilk Test for Normality for Various Sample Sizes (n). From Shapiro and Wilk, 1965.

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	-	0.0000	0.1677	0.2413	0.2806	0.3031	0.3164	0.3244	0.3291
3	-	-	-	0.0000	0.0875	0.1401	0.1743	0.1976	0.2141
4	-	-	-	-	-	0.0000	0.0561	0.0947	0.1224
5	-	-	-	-	-	-	-	0.0000	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	0.0000	0.0303	0.0539	0.0727	0.0880	0.1005	0.1109	0.1197	0.1271	0.1334
7	-	-	0.0000	0.0240	0.0433	0.0593	0.0725	0.0837	0.0932	0.1013
8	-	-	-	-	0.0000	0.0196	0.0359	0.0496	0.0612	0.0711
9	-	-	-	-	-	-	0.0000	0.0163	0.0303	0.0422
10	-	-	-	-	-	-	-	-	0.0000	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	0.0000	0.0122	0.0228	0.0321	0.0403	0.0476	0.0540	0.0598	0.6500	0.0697
12	-	-	0.0000	0.0107	0.0200	0.0284	0.0358	0.0424	0.0483	0.0537
13	-	-	-	-	0.0000	0.0094	0.0178	0.0253	0.0320	0.0381
14	-	-	-	-	-	-	0.0000	0.0084	0.0159	0.0227
15	-	-	-	-	-	-	-	-	0.0000	0.0076

Table 1.1 (*continued*) Coefficients (a_i) for the Shapiro-Wilk Test for Normality for Various Sample Sizes (n). From Shapiro and Wilk, 1965.

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	0.3989	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	0.2462	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	0.1505	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	0.0812	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	0.0000	0.0068	0.0131	0.0187	0.0239	0.0287	0.0331	0.0372	0.0409	0.0444
17	-	-	0.0000	0.0062	0.0119	0.0172	0.0220	0.0264	0.0305	0.0343
18	-	-	-	-	0.0000	0.0057	0.0110	0.0158	0.0203	0.0244
19	-	-	-	-	-	-	0.0000	0.0053	0.0101	0.0146
20	-	-	-	-	-	-	-	-	0.0000	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	0.9980	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	0.0765	0.0783	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	0.0000	0.0045	0.0087	0.0126	0.0163	0.0197	0.0229	0.0259	0.0288	0.0314
22	-	-	0.0000	0.0042	0.0081	0.0118	0.0153	0.0185	0.0215	0.0244
23	-	-	-	-	0.0000	0.0039	0.0076	0.0111	0.0143	0.0174
24	-	-	-	-	-	-	0.0000	0.0037	0.0071	0.0104
25	-	-	-	-	-	-	-	-	0.0000	0.0035

Table 1.2 Critical Values (sw_α, α = 0.05 and α = 0.10) for the Shapiro-Wilk Test for Normality. From Shapiro and Wilk, 1965.

n	$sw_{0.05}$	$sw_{0.10}$
3	0.767	0.789
4	0.748	0.792
5	0.762	0.806
6	0.788	0.826
7	0.803	0.838
8	0.818	0.851
9	0.829	0.859
10	0.842	0.869
11	0.850	0.876
12	0.859	0.883
13	0.866	0.889
14	0.874	0.895
15	0.881	0.901
16	0.887	0.906
17	0.892	0.910
18	0.897	0.914
19	0.901	0.917
20	0.905	0.920
21	0.908	0.923
22	0.911	0.926
23	0.914	0.928
24	0.916	0.930
25	0.918	0.931
26	0.920	0.933
27	0.923	0.935
28	0.924	0.936
29	0.926	0.937
30	0.927	0.939
31	0.929	0.940
32	0.930	0.941
33	0.931	0.942
34	0.933	0.943
35	0.934	0.944
36	0.935	0.945
37	0.936	0.946
38	0.938	0.947
39	0.939	0.948
40	0.940	0.949
41	0.941	0.950
42	0.942	0.951
43	0.943	0.951
44	0.944	0.952
45	0.945	0.953
46	0.945	0.953
47	0.946	0.954
48	0.947	0.954
49	0.947	0.955
50	0.947	0.955

Table 1.3 Critical Values (sf_α, α = 0.05) for the Shapiro-Francia Test for Normality. From Shapiro and Francia, 1972.

Sample Size	$sf_{0.05}$
50	0.953
51	0.954
53	0.957
55	0.958
57	0.961
59	0.962
61	0.963
63	0.964
65	0.965
67	0.966
69	0.966
71	0.967
73	0.968
75	0.969
77	0.969
79	0.970
81	0.970
83	0.971
85	0.972
87	0.972
89	0.972
91	0.973
93	0.973
95	0.974
97	0.975
99	0.976

CHAPTER 2: IDENTIFICATION AND TREATMENT OF OUTLIERS

Prior to statistically comparing *FACILITY* data to Part 201 risk-based criteria (Chapter 3) or *BACKGROUND* concentrations (Chapter 4), it is first necessary to evaluate the underlying statistical distribution (Chapter 1) and screen for outliers. In addition, if *FACILITY-SPECIFIC BACKGROUND* data are obtained, these data must also be evaluated as described in Chapter 1 prior to screening for outliers.

The importance of outlier testing is noted by Gilbert (1987), who states that, "statistical tests for outliers are one part of the data validation process wherein data are screened and examined in various ways before being placed in a data bank and used for estimating population parameters or making decisions."

Outliers are typically thought of as values that are extreme with respect to other data values. As stated by Millard and Neerchal (2001), "an outlier can be defined as an observation that is 'far away' from the rest of the observations."

An outlier can occur for various reasons:

- It may be an incorrect value due to errors in sampling, laboratory analysis, data entry or transcription.

- It may be an accurate result that was sampled from a different population than the one previously identified for investigation. For example, a population may be identified as soil concentrations in a 1/4 acre *EXPOSURE UNIT* used to evaluate direct contact exposures. These soil concentrations must representative of a single statistical distribution. If an outlier is identified in a sample collected from this *EXPOSURE UNIT*, it may reflect a different statistical distribution and possibly a *HOT SPOT* that was previously unidentified. Additional characterization may be necessary.

- It may be an accurate but extreme value sampled from the originally identified population.

- It may be an accurate value that appears to be extreme with respect to the remaining values in the data set due to failure to obtain a representative sample. This may occur because an insufficient number of samples was collected to reflect the true variability in the population or possibly because biased sampling was conducted rather than *RANDOM* sampling of the population.

In practice, true outliers can be difficult to identify because rarely do we know the parameter values of the population from which our data were sampled. Generally, the parameters must be estimated from the data, thus introducing uncertainty to outlier analysis.

Statistical methods are available for identifying outliers, as presented in Section 2.1. However**, it is important to note that classification of an observation as an outlier does not automatically imply that the observation should be removed from the data set**. This is supported by Gilbert (1987) and EPA (1992c), among others. Outlier testing simply provides methods for quantitatively identifying observations that need to be investigated further and checked for possible errors. Often, outliers provide important information that should not be casually dismissed. As noted by Millard (1998), the hole in the ozone layer over Antarctica

could have been discovered earlier; however it was delayed as a result of “flagging” low-level outliers in the data (Stolarski et al., 1986).

Recommended treatment of outliers depends on the possible cause of the outlier and the context of the evaluation. Specific recommendations are provided in Section 2.2.

HOT SPOT Identification

Outlier testing may serve as a way to quantitatively assess for the presence of *HOT SPOTS*. *HOT SPOTS,* discussed in Section 2.2.1.1 of the tabbed section titled, “Sampling Strategies,” are defined as “two or more adjacent sample locations in reasonably close proximity at which concentrations are sufficiently above criteria and surrounding locations (i.e., spatially correlated concentrations sufficiently above criteria) to indicate that they: 1) represent a different statistical population, or 2) pose a potential risk that should not be masked by a statistical analysis.” Professional judgment may generally be used to determine whether the magnitude of concentrations and/or the number and proximity of spatially correlated samples above criteria are sufficient to classify an area as a *HOT SPOT*. Spatially correlated concentrations below criteria may also exist; however, these will not be classified as *HOT SPOTS* for the purpose of statistical analysis.

Because outlier testing provides a quantitative approach for evaluating whether elevated measurements are significantly different from a sampled population, it may be considered as a tool for identifying potential *HOT SPOTS* within an area such as an *EXPOSURE UNIT*. However, outlier testing does not take into consideration the spatial distribution of the data or the proximity of concentrations to criteria. For example, a result that is below criteria may be classified as an outlier simply because it is significantly higher than the remaining concentrations in the data set. This value would not represent a *HOT SPOT* as defined above since it is below criteria. Therefore, outlier testing may be *PROPOSED* as a tool, but it may not be used solely in identification of *HOT SPOTS*.

2.1 STATISTICAL METHODS FOR IDENTIFICATION OF OUTLIERS

Formal testing for outliers should be completed only if the presence of one or more outliers is suspected, as recommended by EPA (1992c). Many of the methods described in Chapter 1 of Statistical Methods serve as screening tools for identification of outliers. For example, outliers may be suspected if either a high coefficient of variation (Section 1.2.1) or a coefficient of skewness (Section 1.2.2) far from zero is observed, particularly if these conditions exist when calculated using both the raw and log-transformed data. Furthermore, potential outliers can be easily identified on graphs such as probability plots (Section 1.2.3) and box plots (Section 1.2.4). Since plots are often of greater utility than summary statistics for identifying potential outliers, graphical techniques are always recommended as outlier screening tools.

Once a potential outlier is identified (i.e., through visual inspection of tabulated data or use of other screening tools), formal testing should be completed before classifying the observation as an outlier. Three formal tests are provided for this purpose. In addition, an informal, iterative approach is described.

Type of Method	Method	Section
Graphical Technique	Probability Plots	2.1.1
Graphical Technique	Box Plots	2.1.2
Formal Test	Grubbs' Test (single outlier)	2.1.3
Formal Test	Dixon's Test (multiple outliers, $n \leq 25$)	2.1.4
Formal Test	Rosner's Test (multiple outliers, $n > 25$)	2.1.5
Iterative Approach	Retesting with methods described in Chapter 1	2.1.6

It should be mentioned that each of the formal tests for outliers shown above assumes that the data under consideration are normally distributed. Formal outlier testing should be completed only in conjunction with tests for normality to ensure that this assumption is met. This is important since values that appear to be anomalous on the original scale may no longer appear inconsistent when transformed to the log scale. Consequently, the following recommendations are made:

- If a data set is concluded to be **normally distributed**, formal outlier testing should be completed on the raw (untransformed) data.

- If a data set is concluded to be **lognormally distributed**, formal outlier testing should be completed on the log-transformed (natural log) data.

The presence of outliers will sometimes cause a data set to fail tests for normality and lognormality. Therefore, if a data set is found to be **neither normal nor lognormal** and graphical techniques indicate the presence of a potential outlier, an iterative approach using methods described in Chapter 1 may be taken, as described in Section 2.1.6.

For data sets with 50% or more of the values below the detection limit, it is generally not possible to identify the statistical distribution of the data. Consequently, neither formal testing nor the iterative approach can be applied to the data. Therefore, it is necessary to identify outliers qualitatively using the graphical techniques shown above.

2.1.1 Probability Plots

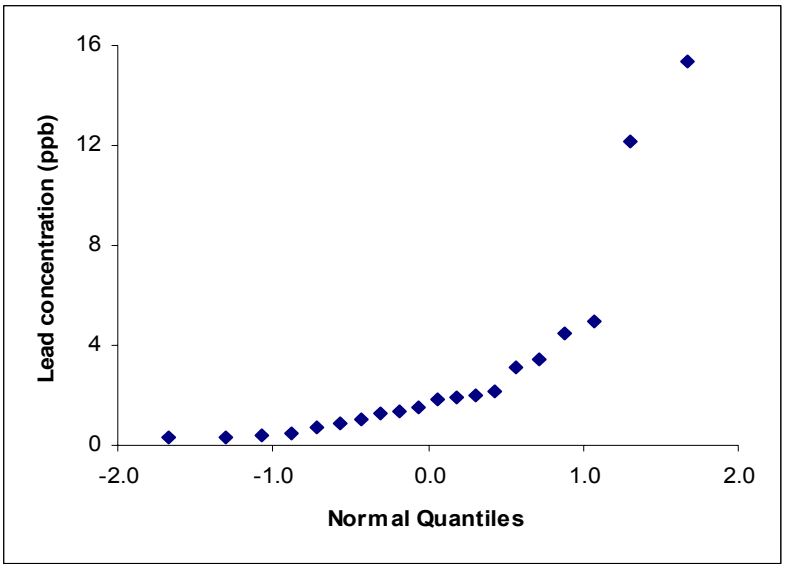
As previously mentioned, one of the first steps in analyzing data is to determine the underlying statistical distribution. Chapter 1 outlines several methods for evaluating and identifying the underlying distribution of a data set. Probability plots provide an excellent tool not only for graphically assessing the distribution of a data set, but also for identifying potential outliers. See Procedure 1.3 for a description of how to construct a probability plot.

Interpretation: On a probability plot, potential outliers will appear as isolated points away from the other points. The other points may form a pattern, such as a line, with potential outliers deviating from this pattern. A probability plot can indicate whether and how many potential outliers there may be, but further testing should be

conducted before classifying the observations as outliers. In addition, some of the formal tests for outliers presented in this chapter (e.g., Rosner's Test) require an initial estimate of the number of outliers in the data set. A probability plot may be used to select this number.

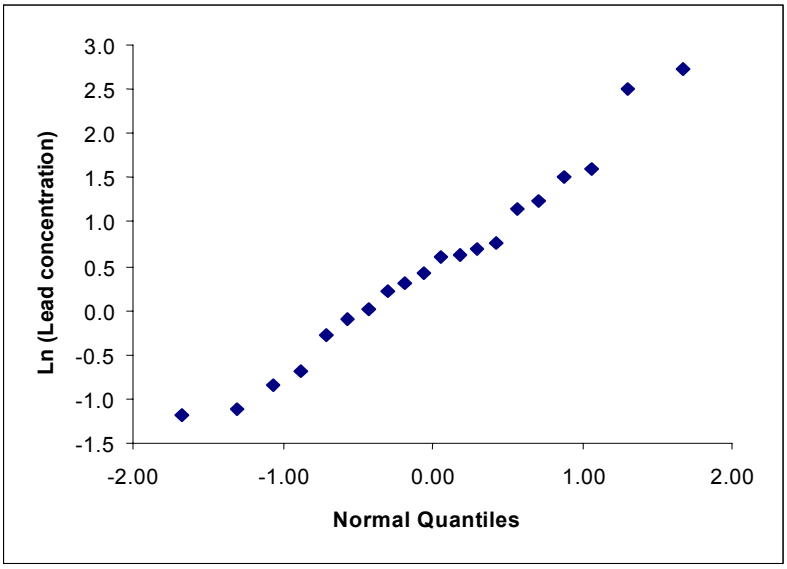
Example 2.1 Sample Probability Plots

Figure 2.1 Probability Plot of Lead Data



This probability plot, constructed using raw (untransformed) lead data, indicates the presence of two potential outliers. A probability plot of log-transformed (Ln) values should be reviewed before identifying these as potential

Figure 2.2 Probability Plot of Log-Transformed (Ln) Lead Data



This probability plot of log-transformed (Ln) lead concentrations does not clearly indicate the presence of potential outliers. Although the two highest values still stand out somewhat, they now fall relatively close to the straight line. Consequently, formal testing for outliers is not clearly necessary. Testing may be completed, however, based on professional judgment.

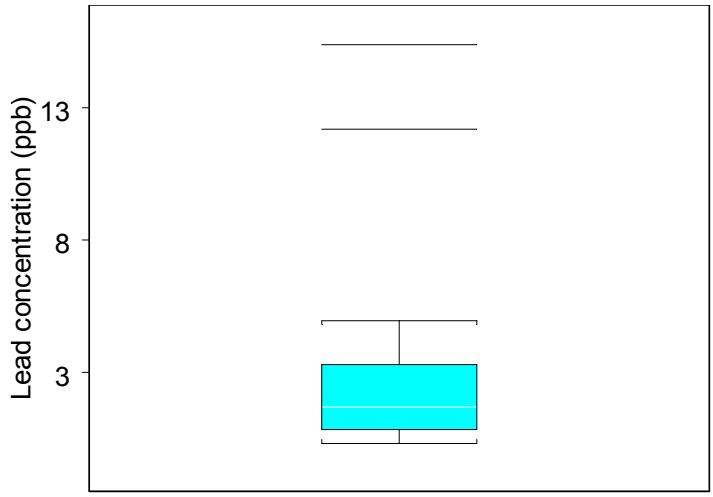
2.1.2 Box Plots

Box plots are another way to represent data graphically. Box plots were presented and described in Section 1.2.5.

Interpretation: On a box plot, potential outliers will appear as points (typically represented as asterisks or horizontal lines) beyond the whiskers of the plot. As with probability plots, box plots may be used to identify if potential outliers are present and, if so, how many. Formal testing should be completed before classifying these values as outliers.

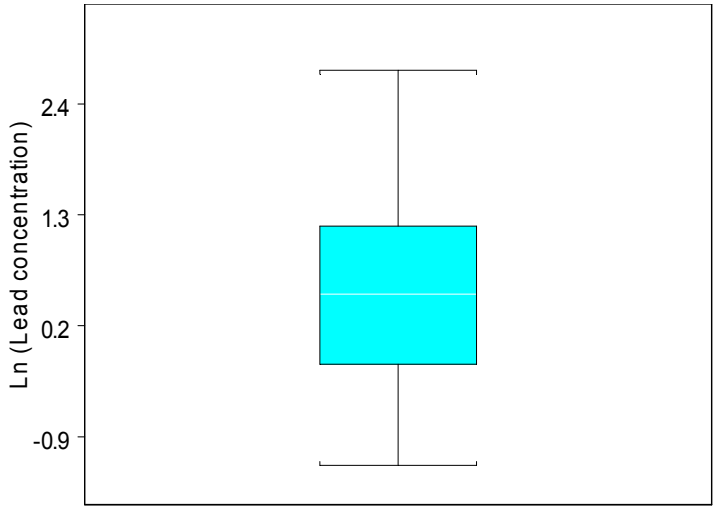
Example 2.2 Sample Box and Whisker Plots

Figure 2.3 Box Plot of Lead Data



This box plot, constructed using raw (untransformed) lead data, indicates the presence of two potential outliers. A box plot of log-transformed (Ln) values should be reviewed before identifying these as potential outliers.

Figure 2.4 Box Plot of Log-Transformed (Ln) Lead Data



This box plot of log-transformed (Ln) lead concentrations does not indicate the presence of any potential outliers. Consequently, formal testing for outliers may not be necessary.

2.1.3 Grubbs' Test

Grubbs' Test (Grubbs 1950, 1969) can be used to identify single outliers in most data sets with sample sizes ranging from small to relatively large (3 < *n* < 100). The test makes an assumption of normality, so the data set should first be evaluated for statistical distribution (Chapter 1). If the data are lognormally distributed, log-transform the data and conduct Grubbs' Test on the transformed values. Although Grubbs' Test can be used in an iterative fashion to evaluate whether there are multiple outliers, the procedure below describes only how to determine whether a single, large observation is an outlier. Other tests (e.g., Dixon's Test and Rosner's Test) should be used in cases where multiple outliers are suspected.

Procedure 2.1 Grubbs' Test for Single Outliers (3 < n < 100)

To test for outliers when the underlying distribution is normal, complete this procedure using the raw (untransformed) data, substituting 1/2 of the detection limit for nondetects up to 50% nondetect. To test for outliers when the underlying distribution is lognormal, first define y = ln(x) and use the y (log-transformed) values in place of the x values in the procedure below.

1. Calculate the sample mean ($\bar{x}$) and sample standard deviation (*s*) using all values, including the suspected outlier. (Equations 1.1 and 1.2 are reproduced below for convenience.)

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

2. Denote the maximum value (the suspected outlier) by x_n and calculate T_G using the following equation:

$$T_G = (x_n - \bar{x}) / s \qquad \text{Equation 2.1}$$

3. Compare the value of T_G to the critical value T_α in Table 2.1 based on the sample size (*n*) and a 95% level of confidence (i.e., α=0.05).

4. If $T_G \geq T_\alpha$, conclude that the observation x_n is an outlier. Follow the guidelines presented in Section 2.2 regarding the treatment of outliers.

Statistical software packages may be used to obtain some of the calculated values shown above. Most of these packages provide the sample standard deviation (s), the sample mean ($\bar{x}$), and the maximum value together with other common summary statistics. Alternatively, Microsoft Excel can be used to obtain *s*, $\bar{x}$, and the maximum for use in Equation 1.3. The Excel functions that should be used to obtain these values, respectively, are:

=STDEV(data range)

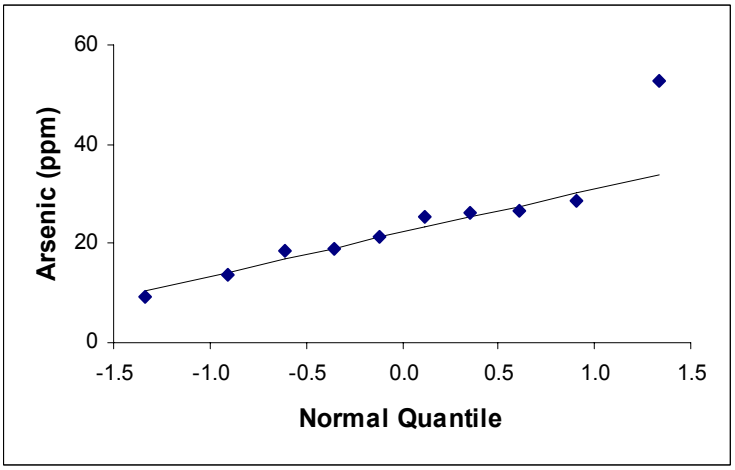
=AVERAGE(data range)

=MAX(data range)

Example 2.3 Sample Calculation of Grubbs' Test

At a hypothetical *FACILITY*, 10 samples for arsenic were collected. The measurements were 21.2, 26.0, 9.1, 28.7, 13.6, 52.6, 18.8, 25.5, 18.5, and 26.4 ppm. Suppose for this example that an evaluation as described in Chapter 1 indicated that the data were normally distributed, except for one potential outlier. Based on a normal probability plot (Figure 2.5), the largest observation (52.6 ppm) was suspected to be an outlier.

Figure 2.5 Probability Plot of Arsenic Data Set



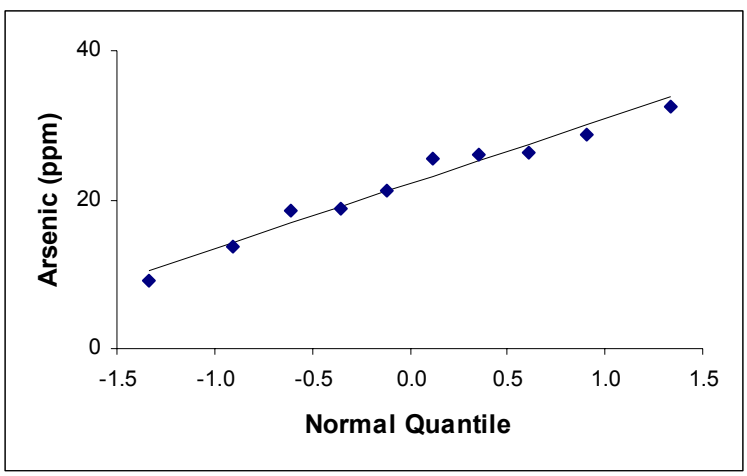
Spreadsheet Calculations for Grubbs' Test on the Arsenic Data Set

	A	B	C	D	E
1	Observation	Arsenic (ppm)			
2	1	9.1		**n:**	10
3	2	13.6		=COUNT(B2:B11)	
4	3	18.5			
5	4	18.8		**Average:**	24.0
6	5	21.2		=AVERAGE(B2:B11)	
7	6	25.5			
8	7	26.0		**Max:**	52.6
9	8	26.4		=MAX(B2:B11)	
10	9	28.7			
11	10	52.6		**Std. Dev:**	11.8
12				=STDEV(B2:B11)	
13					
14				**Grubb's T**	2.42
15				=(E8-E5)/E11	

As shown above, the full data set was used to compute Grubbs' Test. The calculated value for T_G was 2.42 and the critical value T_α for a sample size of 10 at the α = 0.05 level is 2.176 (Table 2.1). Because $T_G > T_\alpha$ (2.42 > 2.176), we conclude that the 52.6 ppm observation is a statistical outlier.

Suppose that upon review of the data sheets, a data-entry error was found and the 52.6 ppm observation was actually measured as 32.6 ppm. After making this correction, we see that the probability plot of the raw data (Figure 2.6) now appears linear. Therefore, we would conclude that there are no outliers in the data set.

Figure 2.6 Probability Plot of Arsenic Data Set After Correcting Data-Entry Error



2.1.4 Dixon's Test

Dixon's Test (Dixon 1953) is used for identifying outliers in relatively small data sets $(n \leq 25)$. Essentially, the test statistic is formed by a ratio, with the numerator representing the relative distance from the outlier to the next highest value and the denominator representing the spread of the data set (i.e., the range).

Dixon's Test is based on an assumption that the data are normally distributed. Therefore, the data set should first be evaluated for statistical distribution to make sure it conforms to this assumption (Chapter 1). If the data are lognormally distributed, log-transform the data and conduct Dixon's Test on the transformed values.

The test was initially developed for testing whether an individual observation is an outlier, but can be modified to accommodate testing for multiple outliers (Gibbons 1994). Consequently, if the data set is smaller than 25 and more than one outlier is suspected, Dixon's test is appropriate and can be used as follows:

Evaluate the *least extreme* observation first, temporarily excluding the more extreme observations from the data set. If the least extreme observation is identified as an outlier, then the more extreme observations can be classified as outliers as well. If the smallest potential outlier is not classified as such, then the next largest observation may be tested using the same procedure. This procedure, which is described in more detail in Procedure 2.2, may be continued until a set of outliers has been identified or until the test finds no outliers in the data set.

If more than one outlier is suspected and the sample size is greater than 25, Rosner's Test (Section 2.1.5) should be considered as an alternative to Dixon's Test. For more than 25 samples, Rosner's Test has the advantage of testing for both high and low outliers simultaneously. Dixon's Test can be used to test for high or low outliers, but no procedure has been established for testing for both high and low outliers simultaneously. DEQ recommends that Dixon's Test be used to test for high outliers with sample sizes less than 25. If sample sizes are less than 25 and low outliers or both high and low outliers are suspected, consultation with a professional statistician is advised.

Procedure 2.2 Dixon's Test for Single or Multiple Outliers (n < 25)

To test for outliers when the underlying distribution is normal, complete this procedure using the raw (untransformed) data, substituting 1/2 of the detection limit for nondetects up to 50% nondetects. To test for outliers when the underlying distribution is lognormal, first define y = ln(x) and use the y (log-transformed) values in place of the x values in the procedure below.

1. Order the data set from least to greatest and label the observations $x_{(1)}, x_{(2)}, \ldots, x_{(n)}$ where $x_{(1)}$ is the smallest observation and $x_{(n)}$ is the largest.

2. Based on the sample size (*n*), use the appropriate equation below to calculate the test statistic T_D:

n	Dixon's Test Statistic (T_D)	
3 - 7	$(x_{(n)} - x_{(n-1)})/(x_{(n)} - x_{(1)})$	Equation 2.2
8 - 10	$(x_{(n)} - x_{(n-1)})/(x_{(n)} - x_{(2)})$	Equation 2.3
11 - 13	$(x_{(n)} - x_{(n-2)})/(x_{(n)} - x_{(2)})$	Equation 2.4
14 - 25	$(x_{(n)} - x_{(n-2)})/(x_{(n)} - x_{(3)})$	Equation 2.5

3. Obtain the critical value for Dixon's test (T_α) based on the sample size (*n*) and a 95% level of confidence (i.e., α = 0.05) in Table 2.2.

4. Compare T_D to T_α. If $T_D > T_\alpha$, the value (and all potential outliers higher than this value) may be classified as outliers. Follow the recommendations for dealing with outliers (Section 2.2).

Microsoft Excel can be used to obtain each of the values for use in the above equations. The Excel functions that should be used to obtain the *k* th largest or smallest values, respectively, are:

=LARGE(data range,k)

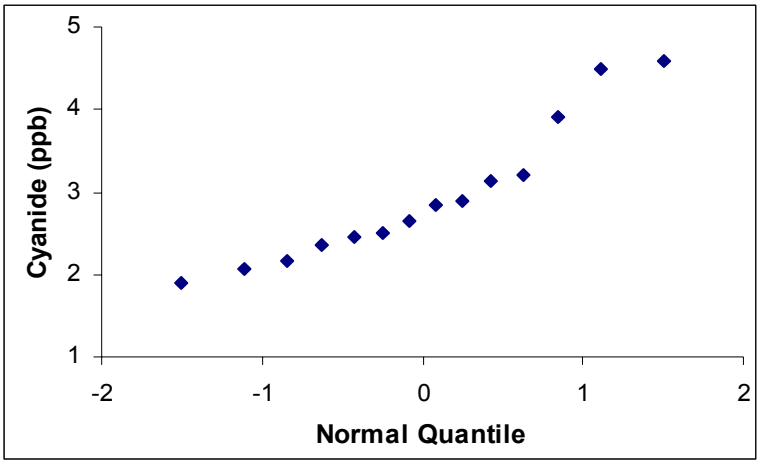
=SMALL(data range,k)

Where k denotes the *k* th largest or *k* th smallest value, respectively, in the data set.

Example 2.4 Sample Calculation of Dixon's Test

At a hypothetical *FACILITY*, 14 measurements for cyanide were collected. The values were 2.5, 4.5, 2.9, 1.9, 2.1, 3.9, 2.2, 2.4, 2.5, 4.6, 2.7, 2.8, 3.1, and 3.2 ppb. Suppose for this example that an evaluation as described in Chapter 1 indicated that the data were normally distributed, except for three potential outliers. Construction of a normal probability plot reveals that the three largest observations (3.9, 4.5, and 4.6 ppb) may be outliers (Figure 2.7).

Figure 2.7 Normal Probability Plot for Cyanide Data Set



Dixon's Test Calculations

	A	B	C	D	E	F
1	Observation	Cyanide				
2	1	1.9		Evaluating **3.9** :		
3	2	2.1			$X_{(12)}$:	3.9
4	3	2.2			$X_{(10)}$:	3.1
5	4	2.4			$X_{(2)}$:	2.1
6	5	2.5				
7	6	2.5			T_D:	0.444
8	7	2.7			= (3.9-3.1) / (3.9-2.1)	
9	8	2.8				
10	9	2.9			T (n=12):	0.546
11	10	3.1				
12	11	3.2		Evaluating **4.5**:		
13	12	**3.9**			$x_{(13)}$:	4.5
14	13	**4.5**			$x_{(11)}$:	3.2
15	14	**4.6**			$x_{(2)}$:	2.1
16						
17					T_D:	0.542
18					= (4.5-3.2) / (4.5-2.1)	
19						
20					T (n=13):	0.521

Because multiple outliers are suspected and the data set has less than 25 observations, Dixon's Test is appropriate. The least extreme potential outlier is evaluated first (3.9). The larger observations (4.5 and 4.6) are temporarily excluded from the data set, thus changing the sample size to 12 for the purposes of this test. With a sample size of 12, Equation 2.4 is used.

For n=12, the calculated value for T_D is 0.444 and the critical value for T based on a sample size of 12 is 0.546 (Table 2.2). Because 0.444 < 0.546, we conclude that 3.9 **is not an outlier**.

Next we move on to the 4.5 ppb observation. The 4.6 observation is temporarily excluded from the data set, changing the sample size to 13 for the purposes of this test. The calculated value for T_D is 0.542 (Figure 2.9) and the critical value for T based on a sample size of 13 is 0.521 (Table 2.2). Because 0.542 > 0.521, we conclude that the 4.5 ppb observation **is an outlier**. And because the 4.6 ppb observation is greater than the 4.5 ppb observation (which was just determined to be an outlier), we **consider both observations to be outliers**. Next we would follow the procedures outlined in Section 2.2 for dealing with these two outliers.

2.1.5 Rosner's Test

Rosner's Test (Rosner 1983) is an effective method for identifying outliers in moderate to large-sized data sets (i.e., n > 25). Potential outliers are tested in groups.

Similar to Grubbs' and Dixon's Tests, Rosner's Test assumes that the sampled population is normally distributed. Therefore, the data set should first be evaluated for statistical distribution to make sure it conforms to this assumption (Chapter 1). If the data are lognormally distributed, log-transform the data and conduct Rosner's Test on the transformed values.

Before completing Rosner's Test, the total number of potential outliers (k) must be identified. Probability plots, box plots, or a visual inspection of the tabulated data should be completed to screen first for potential outliers.

Rosner's Test procedure is iterative. As described in Procedure 2.3, the mean, standard deviation and maximum values are calculated first with the entire data set and again excluding potential outliers one by one, from largest to smallest, until all potential outliers have been removed. Then the first test statistic is calculated to test whether all k values are outliers. If the result is significant, all k observations are classified as outliers. If not significant, the group of possible outliers under evaluation is reduced by one (i.e., the smallest potential outlier is placed back in the data set) and the test statistic is recalculated considering the remaining k - 1 possible outliers. This process is repeated until a group of outliers is identified or until the test finds no outliers in the data set.

Procedure 2.3 Rosner's Test for Multiple Outliers (n > 25)

To test for outliers when the underlying distribution is normal, complete this procedure using the raw (untransformed) data, substituting 1/2 of the detection for nondetects up to 50% nondetect. To test for outliers when the underlying distribution is lognormal, first define y = ln(x) and use the y (log-transformed) values in place of the x values in the procedure below.

1. Order the data set from smallest to largest and denote the values as $x_{(1)}, x_{(2)}, \ldots x_{(n)}$. From plots or examination of the tabulated data, identify the number (*k*) of possible outliers.

2. Set *i* = 0 and use the following formulas

$$\bar{x}^{(i)} = (x_1 + x_2 + \ldots x_{n-i})/(n-i) \qquad \text{Equation 2.6}$$

$$s^{(i)} = \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + \ldots + (x_{n-i} - \bar{x})^2}{n-i}} \qquad \text{Equation 2.7}$$

Calculate the sample mean $(\bar{x})$ and sample standard deviation (s) for the full data set (i.e., when *i* = 0, the full data set is included in the above equations). Denote these values as $\bar{x}^{(0)}$ and $s^{(0)}$. Determine the value of the measurement furthest from $\bar{x}^{(0)}$ and denote it as $y^{(0)}$.

3. Remove the observation $y^{(0)}$ from the data set and recalculate the mean and standard deviation, denoting them as $\bar{x}^{(1)}$ and $s^{(1)}$ (i.e., set *i* = 1). Determine the value of the measurement furthest from $\bar{x}^{(1)}$ and denote it as $y^{(1)}$.

4. Remove the observation $y^{(1)}$ from the data set and recalculate the mean and standard deviation, denoting them as $\bar{x}^{(2)}$ and $s^{(2)}$ (i.e., set *i* = 2). Note that *i* refers to the number of observations that have been removed from the data set.

5. Repeat steps 3 and 4 until k potential outliers have been removed. This should provide a set of results similar to:

$$\left[\bar{x}^{(0)}, s^{(0)}, y^{(0)}\right], \left[\bar{x}^{(1)}, s^{(1)}, y^{(1)}\right], \ldots, \left[\bar{x}^{(k-1)}, s^{(k-1)}, y^{(k-1)}\right]$$

6. Evaluate the test for all k possible outliers first. To test for k outliers, compute the test statistic:

$$R_k = \left| y^{(k-1)} - \bar{x}^{(k-1)} \right| \Big/ s^{(k-1)} \qquad \text{Equation 2.8}$$

(Continued on next page)

Procedure 2.3 Rosner's Test (continued)

7. Obtain the critical value (R_α) from Table 2.3 given the sample size (*n*) and a 95% level of confidence (α = 0.05). If $R_k > R_\alpha$, conclude that there are k outliers. If not, repeat the procedure testing for $k-1$ outliers. Continue in this fashion until a group of outliers has been identified or until the test finds no outliers in the data set.

8. If one or more outliers are identified, see Section 2.2 regarding treatment of outliers.

In most cases, it should not be necessary to calculate Equations 2.6 through 2.8 by hand. Most statistical software packages provide the sample standard deviation (s) and the sample mean ($\bar{x}$) together with other common summary statistics. Alternatively, Microsoft Excel can be used to obtain *s* and $\bar{x}$ for use in Equation 2.8. The Excel functions that should be used to obtain these values, respectively, are:

=STDEV(data range)

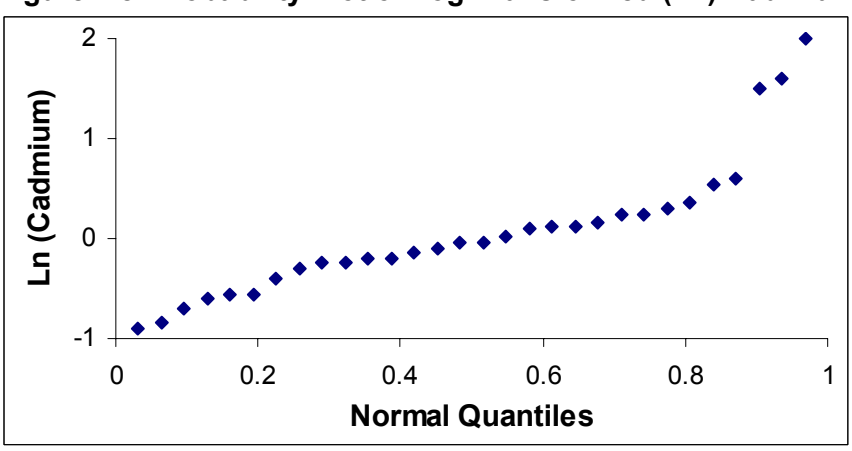
=AVERAGE(data range)

Where the data range should be modified as necessary for each iteration described above.

Example 2.5 Sample Calculation of Rosner's Test

Suppose that 30 observations for cadmium are collected at a site. For the purpose of this example, further suppose that the data were concluded to be lognromally distributed using the methods described in Chapter 1. Based on a probability plot of the log-transformed (Ln) data, the data appeared to contain three possible outliers (Figure 2.10).

Figure 2.8 Probability Plot of Log-Transformed (Ln) Cadmium



Calculations for Rosner's Test With the Cadmium Data Set

	A	B	C	D	E	F	G	H	I	J
1	Observation	Ln (Cadmium)								
2	1	-0.90		i	n-i	$\bar{y}^{(i)}$	$s_y^{(i)}$	$y^{(i)}$	R	$R_{crit.}$
3	2	-0.85		0	30	0.06	0.68	2.00	2.87	2.91
4	3	-0.70		1	29	0.00	0.58	1.60	2.77	2.89
5	4	-0.59		2	28	-0.06	0.50	1.50	3.13	2.88
6	5	-0.57								
7	6	-0.57				=AVERAGE(B2:B31)	=STDEV(B2:B31)	=MAX(B2:B31)	=ABS(H3-F3)/G3	
8	7	-0.40				=AVERAGE(B2:B30)	=STDEV(B2:B30)	=MAX(B2:B30)	=ABS(H4-F4)/G4	
9	8	-0.29				=AVERAGE(B2:B29)	=STDEV(B2:B29)	=MAX(B2:B29)	=ABS(H5-F5)/G5	
10	9	-0.23								
11	10	-0.23								
12	11	-0.20								
13	12	-0.19								
14	13	-0.13								
15	14	-0.10								
16	15	-0.03								
17	16	-0.03								
18	17	0.03								
19	18	0.10								
20	19	0.11								
21	20	0.13								
22	21	0.16								
23	22	0.25								
24	23	0.25								
25	24	0.30								
26	25	0.36								
27	26	0.55								
28	27	0.60								
29	28	1.50								
30	29	1.60								
31	30	2.00								

The three highest observations were evaluated using Rosner's Test. By equation 2.8, to test for three outliers, we must calculate R_3. The result of this calculation was 3.13 and the critical value for R (with n = 30 and i = 3) was 2.88 (Table 2.3). Because 3.13 > 2.88, we conclude that there are three outliers in the cadmium data set (1.5, 1.6, and 2.0).

2.1.6 Informal Iterative Approach to Outlier Testing When Data Set is Not Normal or Lognormal

As previously noted, the presence of outliers will sometimes cause a data set to fail tests for normality and lognormality. If a data set is found to be neither normal nor lognormal and graphical techniques indicate the presence of a potential outlier, an iterative approach using methods described in Chapter 1 may be taken, as described below.

- If one outlier is suspected, remove the potential outlier and reevaluate for normality and lognormality using the remaining observations and the methods described in Section 1. If the data pass a test for normality or lognormality without the suspected outlier, classify the anomalous value as an outlier.

- If multiple outliers are suspected, exclude them one by one and repeat the above step until the data pass a test of normality or lognormality or all of the potential outliers have been removed.

2.1.7 Walsh's Test

The formal outlier tests presented in this chapter have relied on an assumption of normality. Walsh's Test (Walsh 1958) provides a nonparametric alternative for evaluating potential outliers. Unfortunately, rather large sample sizes are required. For example, $n > 60$ is necessary to obtain a significance level of $\alpha = 0.10$ and $n > 220$ to obtain a significance level of $\alpha = 0.05$. Because of the large sample sizes necessary, it is doubtful that Walsh's Test can be applied to most environmental data sets and therefore a detailed procedure for conducting the test is not provided. However, if enough samples have been collected and the distribution appears to be neither normal nor lognormal, then Walsh's Test may be appropriate and can be *PROPOSED* for review by the DEQ statistician.

2.1.8 Evaluating for Outliers when Data Contain >50% Nondetects

As previously stated, for data sets with > 50% nondetects, it is generally not possible to identify the statistical distribution of the data (Helsel, 1990). Consequently, neither formal testing nor the iterative approach can be applied to the data. In this case, it will be necessary to evaluate for and identify outliers qualitatively using the graphical techniques described in Sections 2.1.1 and 2.1.2.

2.2 TREATMENT OF OUTLIERS

All values classified as outliers through formal testing (Section 2.1) should be thoroughly investigated before deciding how to treat them. The "chain of custody" records for the outlier should be reviewed as a check of the steps of the sampling and analysis up to this point. Each of the possible causes for outliers described in the introductory portion of this chapter should be considered.

Once all outliers have been investigated, one of the following actions should be taken:

1. If a transcription error is found and the correct value can be determined, replace the outlier with the correct value and conduct statistical analyses with the corrected value. The procedures described in Chapters 1 and 2 should be completed again with the revised data set.

2. If the observation can be proven erroneous, but the correct value cannot be determined, the outlier can be deleted and subsequent analyses conducted on the reduced data set. If a value is deleted from the data set, this fact must be reported with the statistical results.

3. If no error in the value can be found, the outlier should be regarded as a true, but extreme, observation. If this is the case, one of the following courses of action should be taken, depending on the general location of the sample containing the outlier.

   - ***FACILITY-SPECIFIC BACKGROUND* samples collected off of the property of interest:** If samples from the data set of interest were collected from off-site locations for the purpose of determining *FACILITY-SPECIFIC BACKGROUND* concentrations *and* the

outlier is not believed to represent naturally occurring *BACKGROUND* concentrations, the outlying value should be removed from the data set and documented as such. If the value is believed to be representative of *BACKGROUND* conditions, the value should be retained in the data set. Alternate statistical methods and/or additional sampling may be necessary.

- ***FACILITY-SPECIFIC BACKGROUND* samples collected on the property of interest:** If *FACILITY-SPECIFIC BACKGROUND* samples were collected from locations on the property of interest and the outlier is not believed to represent naturally occurring *BACKGROUND* concentrations, the outlying value may represent a previously unidentified area of contamination. The outlying result should be compared to the appropriate Part 201 criteria to determine if it represents a *FACILITY*. Additional characterization may be necessary in this area.

- ***FACILITY* samples:** If samples from the data set of interest were collected from locations within a *FACILITY*, the outlying value may represent a previously unidentified *HOT SPOT* if the concentration is sufficiently above criteria. Additional characterization may be necessary to determine if a *HOT SPOT* exists.

Table 2.1 Grubbs' Test Critical Values (T_α, α = 0.05). From Grubbs and Beck, 1972.

n	T_α	n	T_α	n	T_α
3	1.153	51	2.964	101	3.210
4	1.463	52	2.971	102	3.214
5	1.672	53	2.978	103	3.217
6	1.822	54	2.986	104	3.220
7	1.938	55	2.992	105	3.224
8	2.032	56	3.000	106	3.227
9	2.110	57	3.006	107	3.230
10	2.176	58	3.013	108	3.233
11	2.234	59	3.019	109	3.236
12	2.285	60	3.025	110	3.239
13	2.331	61	3.032	111	3.242
14	2.371	62	3.037	112	3.245
15	2.409	63	3.044	113	3.248
16	2.443	64	3.049	114	3.251
17	2.475	65	3.055	115	3.254
18	2.504	66	3.061	116	3.257
19	2.532	67	3.066	117	3.259
20	2.557	68	3.071	118	3.262
21	2.580	69	3.076	119	3.265
22	2.603	70	3.082	120	3.267
23	2.624	71	3.087	121	3.270
24	2.644	72	3.092	122	3.274
25	2.663	73	3.098	123	3.276
26	2.681	74	3.102	124	3.279
27	2.698	75	3.107	125	3.281
28	2.714	76	3.111	126	3.284
29	2.730	77	3.117	127	3.286
30	2.745	78	3.121	128	3.289
31	2.759	79	3.125	129	3.291
32	2.773	80	3.130	130	3.294
33	2.786	81	3.134	131	3.296
34	2.799	82	3.139	132	3.298
35	2.811	83	3.143	133	3.302
36	2.823	84	3.147	134	3.304
37	2.835	85	3.151	135	3.306
38	2.846	86	3.155	136	3.309
39	2.857	87	3.160	137	3.311
40	2.866	88	3.163	138	3.313
41	2.877	89	3.167	139	3.315
42	2.887	90	3.171	140	3.318
43	2.896	91	3.174	141	3.320
44	2.905	92	3.179	142	3.322
45	2.914	93	3.182	143	3.324
46	2.923	94	3.186	144	3.326
47	2.931	95	3.189	145	3.328
48	2.940	96	3.193	146	3.331
49	2.948	97	3.196	147	3.334
50	2.956	98	3.201		
		99	3.204		
		100	3.207		

Table 2.2 Critical Values for Dixon's Test (T_α, α = 0.05). From Dixon, 1953.

n	T
3	0.941
4	0.765
5	0.642
6	0.560
7	0.507
8	0.554
9	0.512
10	0.477
11	0.576
12	0.546
13	0.521
14	0.546
15	0.525
16	0.507
17	0.490
18	0.475
19	0.462
20	0.450
21	0.440
22	0.430
23	0.421
24	0.413
25	0.406

Table 2.3 Rosner's Test Critical Values (R_α, α = 0.05 for Various Levels of *n* and *k*). From Rosner, 1983.

n	k	Rα	n	k	Rα	n	k	Rα
25	1	2.82	35	1	2.98	45	1	3.09
	2	2.80		2	2.97		2	3.08
	3	2.78		3	2.95		3	3.07
	4	2.76		4	2.94		4	3.06
	5	2.73		5	2.92		5	3.05
	10	2.59		10	2.84		10	2.99
26	1	2.84	36	1	2.99	46	1	3.09
	2	2.82		2	2.98		2	3.09
	3	2.80		3	2.97		3	3.08
	4	2.78		4	2.95		4	3.07
	5	2.76		5	2.94		5	3.06
	10	2.62		10	2.86		10	3.00
27	1	2.86	37	1	3.00	47	1	3.10
	2	2.84		2	2.99		2	3.09
	3	2.82		3	2.98		3	3.09
	4	2.80		4	2.97		4	3.08
	5	2.78		5	2.95		5	3.07
	10	2.65		10	2.88		10	3.01
28	1	2.88	38	1	3.01	48	1	3.11
	2	2.86		2	3.00		2	3.10
	3	2.84		3	2.99		3	3.09
	4	2.82		4	2.98		4	3.09
	5	2.80		5	2.97		5	3.08
	10	2.68		10	2.91		10	3.03
29	1	2.89	39	1	3.03	49	1	3.12
	2	2.88		2	3.01		2	3.11
	3	2.86		3	3.00		3	3.10
	4	2.84		4	2.99		4	3.09
	5	2.82		5	2.98		5	3.09
	10	2.71		10	2.91		10	3.04
30	1	2.91	40	1	3.04	50	1	3.13
	2	2.89		2	3.03		2	3.12
	3	2.88		3	3.01		3	3.11
	4	2.86		4	3.00		4	3.10
	5	2.84		5	2.99		5	3.09
	10	2.73		10	2.92		10	3.05
31	1	2.92	41	1	3.05	60	1	3.20
	2	2.91		2	3.04		2	3.19
	3	2.89		3	3.03		3	3.19
	4	2.88		4	3.01		4	3.18
	5	2.86		5	3.00		5	3.17
	10	2.76		10	2.94		10	3.14
32	1	2.94	42	1	3.06	70	1	3.26
	2	2.92		2	3.05		2	3.25
	3	2.91		3	3.04		3	3.25
	4	2.89		4	3.03		4	3.24
	5	2.88		5	3.01		5	3.24
	10	2.78		10	2.95		10	3.21
33	1	2.95	43	1	3.07	80	1	3.31
	2	2.94		2	3.06		2	3.30
	3	2.92		3	3.05		3	3.30
	4	2.91		4	3.04		4	3.29
	5	2.89		5	3.03		5	3.29
	10	2.80		10	2.97		10	3.26
34	1	2.97	44	1	3.08	100	1	3.38
	2	2.95		2	3.07		2	3.38
	3	2.94		3	3.06		3	3.38
	4	2.92		4	3.05		4	3.37
	5	2.91		5	3.04		5	3.37
	10	2.82		10	2.98		10	3.35

CHAPTER 3: CALCULATION OF A 95% UPPER CONFIDENCE LIMIT (UCL) FOR THE MEAN CONCENTRATION

A goal of sampling environmental media is often to identify characteristics and/or draw conclusions about a defined population. An example of a typical population of interest under the Part 201 program would be concentrations of a hazardous substance in surface soil within a 1/4 acre *EXPOSURE UNIT*. One characteristic of the population that is useful to identify is the mean concentration. The mean, which is a measure of centrality, represents an average value. Other measures of centrality include the median (i.e., the middle value) and the mode (i.e., the most frequently occurring value). The mean and the median are more commonly used than the mode in environmental applications.

It is the MDEQ's policy that a mean rather than a median or other measure of centrality be used to estimate concentrations of hazardous substances for the purpose of comparison to Part 201 criteria. In terms of exposure to hazardous substances, the mean provides the best representation of average exposure levels at a *FACILITY* because it incorporates the magnitude of all observations. This is consistent with EPA guidance, which recommends for purposes of risk assessment that the mean concentration be used to estimate risks through exposure to a hazardous substance (EPA, 1992a). **Due to uncertainty in estimating the true mean concentration based on sample data, a UCL for the mean must generally be used to compare concentration data to Part 201 criteria, as described below.**

The true mean, also referred to as the population mean, is typically estimated by collecting data and using these data to calculate a sample mean. A sample mean is an example of a point estimate. It provides a single value to estimate the population mean; it does not represent the variability or uncertainty associated with the estimate. Confidence intervals around the sample mean are used to represent the range of uncertainty or variability associated with this estimate of the mean.

Confidence intervals can also be used to conduct a statistical test of the mean. For example, a UCL for the mean can be compared to a fixed value, such as a Part 201 criterion, to test whether a sample mean concentration is below the Part 201 criterion. This corresponds directly with EPA's recommendation that a UCL for the mean be used to estimate a reasonable maximum exposure (RME) concentration for Superfund risk assessments (EPA, 1992a). The RME "is intended to account for both uncertainty in the hazardous substance concentration and variability in exposure parameters (e.g., exposure frequency, averaging time)."

Use of a UCL for the mean to compare *FACILITY* data to Part 201 criteria corresponds to the following null and alternative hypotheses:

Hypothesis 1

H_o: The mean hazardous substance concentration in a given *EXPOSURE UNIT* is greater than or equal to the Part 201 criterion

H_a: The mean hazardous substance concentration in a given *EXPOSURE UNIT* is less than the Part 201 criterion

The null hypothesis (H_o) represents the condition that is assumed to be true. The alternative hypothesis (H_a), also known as the research hypothesis (H_R), is the converse of the null hypothesis. The alternative hypothesis will be concluded only if the sample data provide sufficient evidence that the null hypothesis is incorrect.

Practically speaking, the baseline assumption stated above in Hypothesis 1 is that the mean concentration is at or above its respective criterion unless the sample data provide sufficient evidence to conclude otherwise. Use of this baseline assumption is consistent with EPA's recommendations in the context of their cleanup programs (e.g., the Superfund program and RCRA Corrective Action) as described in many EPA statistical guidance documents (1989a, 1989b, 1992a, 1992b, 1993, 1996a, 1996b, 1999).

Further, EPA (1992b) recommends:

> *Make an assumption about the concentrations which you would like to disprove (e.g., the average population measure of a contaminant is greater than the cleanup standard of 2.0 ppm). This cleanup standard represents your initial or null hypothesis about the current situation.*

By setting the null hypothesis as something one wants to disprove, the motivation is to conduct a proper and rigorous statistical analysis in order to disprove this condition. In other words, be skeptical that concentrations meet criteria until evidence proves otherwise. Conversely, if the null hypothesis is set as something one wants to prove (e.g., hazardous substance concentrations are below Part 201 criteria), there is no motivation to obtain sufficient data or to utilize statistical rigor to disprove this assumption.

When calculating a UCL for the mean for the purpose of comparing *FACILITY* data to Part 201 criteria, a significance level of $\alpha = 0.05$ should be used. A significance level of $\alpha = 0.10$ may be used for the purpose of waste characterization (SW-846 Chapter 9; EPA 1986). See the tabbed section titled, "Waste Characterization" for further detail.

3.1 STEPS FOR CALCULATING AN UPPER CONFIDENCE LIMIT FOR THE MEAN

A minimum of nine *RANDOMLY* located samples per *EXPOSURE UNIT* is required if statistics are to be used to compare *FACILITY* data to Part 201 criteria. (For waste characterization purposes, a minimum of nine *RANDOM* samples is required if statistics are to be used to compare characterization data to regulatory thresholds.) This minimum number is necessary to evaluate the underlying statistical distribution of the data set, as described in Chapter 1. The necessity of evaluating the distribution of the data set is discussed below and described in detail in Chapter 1.

The following methods for calculating UCLs for the mean are presented or discussed in this chapter:

Method	**Section**
Student's t (recommended for normally distributed data)	3.1.1
Land's Method (recommended for lognormally distributed data)	3.1.2

Alternate methods for data sets which are neither normal nor lognormal (may be *PROPOSED* on a case-by-case basis)	3.1.3

Assumptions

Each of the statistical methods described in this chapter was developed based on certain underlying assumptions. For example, all of the methods described in this chapter require an assumption that the data are statistically independent (i.e., there are no trends in the data and obtained through *RANDOM* sampling) and representative of a single statistical distribution. Data should therefore be plotted on a map to identify spatial trends and or *HOT SPOTS* before conducting a statistical analysis. Furthermore, Statistical Guidesheets must be referred to for key considerations on the selection of an appropriate data set for development of a *REPRESENTATIVE CONCENTRATION*. Additional considerations and recommendations are presented in the tabbed section titled, "Sampling Strategies." (See Sections 1.2 and 2.2 on *FACILITY* Characterization and Section 2.4 on demonstrating compliance with Part 201 criteria using statistics.)

A second assumption required by many statistical methods is that the data were obtained from a specified underlying statistical distribution. Statistical methods requiring knowledge of the statistical distribution are called parametric methods. The method for constructing a UCL for the mean presented in Section 3.1.1 is based on an assumption that the data follow a normal distribution. Section 3.1.2 presents a method that was designed for data assumed to be lognormally distributed (Gilbert, 1987; EPA, 1992a).

Steps for Constructing a UCL for the Mean

The following procedure describes the selection of an appropriate method for calculating a UCL for the mean:

1) Determine the percent of data below the detection limit (e.g., a data set with nine samples, three of which are below the detection limit, contains 33% nondetects).

2) For data sets with < 50% nondetects, evaluate and identify the underlying statistical distribution of the data using the methods presented in Chapter 1. This step is not required for data sets with ≥ 50% nondetects, although the methods presented in Chapter 1 may still provide some insight into the data to the extent that detectable concentrations are contained in the data set.

3) All data sets should be evaluated for outliers as described in Chapter 2 whenever *FACILITY* data are being statistically compared to Part 201 criteria. Many of the methods for calculating UCLs for the mean concentration presented in this chapter are sensitive to outliers. As noted in Chapter 2, formal testing for outliers is recommended only if initial screening of the data (i.e., a review of tabulated data and/or plots) indicates the presence of one or more potential outliers. For data sets with ≥ 50% nondetects, the data should be qualitatively evaluated for outliers using the graphical techniques presented in Chapter 2.

4) Select the appropriate formula for calculation of a 95% UCL for the mean:
   - Data sets with < 50% nondetects that are approximately normal: see Section 3.1.1.
   - Data sets with < 50% nondetects that are approximately lognormal: see Section 3.1.2.

- Data sets with ≥ 50% nondetects and/or are neither normal nor lognormal: see Section 3.1.3.

Unfortunately, widely accepted methods are not available to calculate UCLs for the mean of data sets that contain ≥ 50% nondetects and/or are neither normal nor lognormal. Consequently, alternative methods for statistically comparing *FACILITY* data to Part 201 criteria must be *PROPOSED* if departmental approval of a response activity is being sought. Section 3.1.3 describes some alternative methods that may be considered, including nonparametric (i.e., distribution-free methods) and large sample approximations.

The importance of evaluating the underlying assumptions for each method can not be over-stated if accurate conclusions are to be drawn. Therefore, it is necessary to identify the underlying assumptions of each method up front and evaluate these assumptions as described above before calculating UCLs for the mean concentration for comparison to Part 201 criteria.

3.1.1 UCL for the Mean of a Normally Distributed *RANDOM* Variable (Student's t)

When a data set is normally distributed, a UCL for the mean may be calculated based on the Student's t distribution for comparison to Part 201 criteria. Procedure 3.1 describes the calculation of a UCL for the mean of a normal distribution using the Student's t distribution.

Assumptions

The assumption underlying this method is that the data set is approximately normal in its distribution. Although this method is somewhat robust to slight deviations from normality, this assumption should be evaluated using the methods described in Chapter 1.

Example 3.1 Sample Calculation of a Student's t 95% Upper Confidence Limit for the Mean of a Normally Distributed *RANDOM* Variable

Suppose that we have 10 observations of lead concentrations and they are 4.4, 2.4, 5.5, 7.6, 7.4, 8.5, 0.6, 4.5, 7.2, and 2.8 ppb. An evaluation of the data as described in Chapter 1 indicates that the data set is approximately normal. The calculations necessary to calculate a 95% UCL for the mean are presented in Figure 3.1 using Microsoft Excel. For this data set, the 95% UCL for the mean is 6.59 ppb.

Figure 3.1 Spreadsheet Calculations for a 95% UCL for the Mean

	A	B	C	D	E
1	Observation	Lead			
2	1	4.4		n:	10
3	2	2.4			=COUNT(B2:B11)
4	3	5.5			
5	4	7.6		$\bar{x}$:	5.09
6	5	7.4			=AVERAGE(B2:B11)
7	6	8.5			
8	7	0.6		s:	2.58
9	8	4.5			=STDEV(B2:B11)
10	9	7.2			
11	10	2.8		t (0.95, 9):	1.83
12					=TINV(0.1,9)
13					
14				95% UCL:	6.59
15				= E5 + E8 * E11 / SQRT(10)	

Procedure 3.1 Student's t Upper (1-α)% Confidence Limit for the Mean of a Normally Distributed *RANDOM* Variable

The Student's t method for calculating a UCL for the mean relies on having normal or nearly normal data. First evaluate the statistical distribution of the data using the methods described in Chapter 1. Outlier testing (Chapter 2) should be completed if suspect values are identified based on review of the data and/or graphs described in Chapter 1.

1. Calculate the sample mean ($\bar{x}$) and the sample standard deviation (*s*). (Equations 1.1 and 1.2 are reproduced below for convenience.)

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

where x_i represents the *i* th observed value, *s* represents the sample standard deviation, and $\bar{x}$ represents the sample mean and *n* is the number of samples in the data set. Substitute ½ of the detection limit for nondetects up to 50% nondetects. Additional options for handling nondetects are described in Chapter 5.

2. Using Table 3.1, look up the Student's t value for a (1-α)% level of confidence (α = 0.05 for Part 201 applications; α = 0.10 may be considered for waste characterization) and *n-1* degrees of freedom. This value is denoted $t_{1-\alpha,n-1}$.

3. Calculate the one-sided (1-α)% UCL for the mean as follows:

$$UCL_{1-\alpha} = \bar{x} + t_{1-\alpha,n-1}\frac{s}{\sqrt{n}} \qquad \text{Equation 3.1}$$

In most cases, it should not be necessary to calculate the above equations by hand. Most statistical software packages provide the sample standard deviation (s) and the sample mean ($\bar{x}$) with other common summary statistics. Alternatively, Microsoft Excel can be used to obtain *s*, $\bar{x}$, and the tabled value of $t_{1-\alpha,n-1}$. The Excel functions that can be used to obtain these values, respectively, are:

=STDEV(data range)
=AVERAGE(data range)
=TINV(2α,*n* -1)

Note that a value of 2 times α (e.g., 0.10 for α = 0.05 or 0.20 for α = 0.10 is used in the =TINV() function rather than α. This is because Excel automatically provides t-values for two-sided intervals, rather than one-sided intervals. Using α = 0.1 in this function will yield the correct t-value for a one-sided 95% UCL for the mean. This may be necessary for many of the statistical software packages as well.

Interpretation: If $UCL_{1-\alpha}$ > criterion, conclude that the mean concentration is above the criterion. If $UCL_{1-\alpha}$ < criterion, conclude that the mean concentration is below the criterion.

Note that a more correct statement of the interpretation would be to conclude that the mean is at or above the criterion if the UCL for the mean is greater than or equal to the criterion. However, because the data being evaluated are measured on a continuous scale, the probability of obtaining a UCL for the mean that is exactly equal to a given criterion is essentially zero. Therefore, the interpretation stated above will be relied upon for these comparisons.

3.1.2 UCL on the Mean of a Lognormally Distributed *RANDOM* Variable (Land's Method)

In cases where the data are lognormally distributed, Land's method can be used to calculate a UCL for the mean (Land, 1971; Gilbert, 1987; EPA, 1992a). Procedure 3.2 describes the calculation of a (1-α)% UCL for the mean using Land's method.

Land's method is sensitive to departures from lognormality. For example, a right-skewed data set (i.e., asymmetric with a long right tail) may be concluded to be lognormal based on an analysis as described in Chapter 1. However, the data set may be more highly skewed than a true lognormal distribution and/or contain one or more outliers. The resulting UCL for the mean may be inappropriately high. This is more likely to be the case when the sample size is small and/or highly variable. If this occurs, consider increasing the sample size until a more reasonable value is obtained. Alternative statistical methods may also be *PROPOSED*. Suggested methods for consideration include a method described by Parkin, et. al. (1990) or the methods described in Section 3.1.3.

Assumptions

Land's method is based on an assumption that the sampled population is lognormally distributed. Even slight deviations from lognormality may result in unreasonably high UCLs for the mean. The methods outlined in Section 1 should be used to evaluate this assumption.

Procedure 3.2 Land's Method for Calculating a (1-α)% UCL for the Mean of a Lognormally Distributed *RANDOM* Variable

Land's method is intended for lognormally distributed data only. Use Chapter 1 to ensure that this is the case before using Land's method. Outlier testing (Chapter 2) should be completed if suspect values are identified based on review of the data and/or graphs described in Chapter 1.

1. For nondetects, substitute 1/2 of the detection limit up to 50% nondetects. (See Chapter 5 for additional options for handling nondetects.) Then calculate the natural logarithm (Ln) of each observation in the data set (i.e., log-transform the data set). Define y = ln(x).

2. Calculate the mean $(\bar{y})$ and standard deviation (s_y) of the log-transformed data set using the y values in place of the x values in Equations 1.1 and 1.2. (Equations 1.1 and 1.2 are reproduced below for convenience.)

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

3. Look up the value for $H_{1-\alpha}$ in Table 3.2 for α = 0.05 (Part 201 applications) or Table 3.3 for α = 0.10 (for some waste characterization applications). This value is dependent upon the sample size (*n*) and the standard deviation of the log-transformed data (s_y). If the correct number of samples and standard deviation are not represented on the table, it will be necessary to interpolate between adjacent points. It may be necessary to interpolate in both directions. The details of a double linear interpolation are described in Box 4-31 of EPA (2000), provided in Appendix A of the tabbed section titled, Appendices." The interpolation is illustrated using Table A-10 of EPA (2000). Double linear interpolation can be done in the same manner on Tables 3.2 and 3.3.

4. Calculate the (1-α)% UCL of the mean using the following equation:

$$UCL_{1-\alpha} = \exp\left[\bar{y} + \frac{s_y^{\,2}}{2} + \frac{s_y H_{1-\alpha}}{\sqrt{n-1}}\right] \qquad \text{Equation 3.2}$$

Microsoft Excel can be used to take natural logarithms and exponentiate, as well as calculate s_y, $s_y^{\,2}$, and $\bar{y}$. The Excel functions that should be used to obtain these values, respectively, are:

=LN(cell)	=EXP(cell)
=STDEV(data range)	=VAR(data range)
=AVERAGE(data range)	

Interpretation: If the resulting *UCL* > criterion, conclude that the mean concentration is at or above the criterion. If *UCL* < criterion, conclude that the mean concentration is below the criterion.

Note that a more correct statement of the interpretation would be to conclude that the mean is at or above the Part 201 criterion if the UCL for the mean is greater than or equal to the criterion. However, because the data being evaluated are measured on a continuous scale, the probability of obtaining a UCL for the mean that is exactly equal to a given criterion is essentially zero. Therefore, the interpretation stated above will be relied upon for these comparisons.

Example 3.2 Sample Calculation of 95% UCL for the Mean of a Lognormally Distributed *RANDOM* Variable Using Land's Method

Fifteen soil samples were collected for analysis of arsenic concentrations. Using the methods described in Chapter 1, the data were concluded to be lognormally distributed. Figure 3.2 shows the data set, the log-transformed data set, and the calculations involved in determining a 95% UCL for the mean using Land's method. For this data set, the calculated values were $\bar{y}$ = 1.92, s_y^2 = 0.76, s_y = 0.87, and $H_{0.95}$ = 2.545. Using Equation 3.2, the 95% UCL for the mean arsenic concentration was 18.2 ppb. Note that this value is below three of the individual concentrations in the data set.

Figure 3.2 Spreadsheet Calculations of a 95% UCL Using Land's Method

	A	B	C	D	E	F	G	H
1	Observation	Arsenic	Ln (Arsenic)					
2	1	3.20	1.16		**n:**	15		
3	2	27.70	3.32			=COUNT(C2:C16)		
4	3	2.57	0.94					
5	4	9.98	2.30		**$\bar{y}$:**	1.92		
6	5	6.38	1.85			=AVERAGE(C2:C16)		
7	6	2.12	0.75					
8	7	2.80	1.03		**s_y^2:**	0.76		
9	8	12.11	2.49			=VAR(C2:C16)		
10	9	6.92	1.93					
11	10	5.32	1.67		**s_y:**	0.87		
12	11	23.19	3.14			=STDEV(C2:C16)		
13	12	7.02	1.95					
14	13	7.32	1.99		**$H_{0.95}$:**	2.545		
15	14	28.62	3.35			Interpolated value from Table 3.1		
16	15	2.59	0.95					
17				**Square bracket:**		2.90		
18			=LN(B2)			= F5 + F8 / 2 + F11 * F14 / SQRT(14)		
19			=LN(B3)					
20			⋮		**95% UCL:**	18.2		
21						=EXP(F17)		

3.1.3 Alternate Methods for Calculating UCLs for the Mean

As previously noted, the Student-t method and Land's method rely on assumptions of normality and lognormality, respectively. For data sets which are neither normal nor lognormal, alternative methods must be *PROPOSED* if departmental approval of a response activity is being sought.

3.1.3.1 Large Sample Methods

The Central Limit Theorem states that, for large sample sizes, the mean will tend to be normally distributed regardless of the distribution of the sampled population. A large sample method for computing a UCL for the mean is presented by Gilbert (1987, pg. 139). Large sample methods for calculating UCLs for the mean perform better as the number of samples increases. For smaller data sets with significant skewness, the method does not tend to perform well (Singh, et al. 1997). As an alternative, Chen (1995) describes a UCL that uses the Central Limit Theorem and incorporates an adjustment factor based on the skewness of the data set. This method is also described by Singh, et al. (1997). Because this method accounts for possible skewness in the data, it may provide more reasonable and accurate results than the standard large sample method presented by Gilbert for data sets that are right skewed.

However, for data sets that are highly skewed, Singh, et al. (1999) have found that these large sample methods do not provide adequate coverage for the mean (i.e., they may underestimate the mean concentration). Therefore, they should not be considered in this case unless the number of samples is sufficiently large. Gilbert (1987) suggests that, for highly skewed distributions, a sample size of 50 or more may be required. As always, it is important that the data set be identified as described in the appropriate Statistical Guidesheet (i.e., the data should be from samples within an appropriate *EXPOSURE UNIT* and should not include data representing *HOT SPOTS*).

Since these methods involve calculation of a mean and standard deviation, they should not be used for data sets with ≥ 50% nondetects.

Large sample methods for calculating UCLs for the mean concentration must be *PROPOSED* for review and approval if departmental approval of a response activity is being sought.

3.1.3.2 Alternative Methods for Small Data Sets and Data Sets With ≥ 50% Nondetects

For most *FACILITIES*, the number of samples in a given area (e.g., *EXPOSURE UNIT*) will generally be too small to consider the large sample methods described above. Statistical methods for calculating UCLs for the mean are generally not available for small data sets that are neither normally nor lognormally distributed. Consequently, additional samples may be collected according to a DEQ-approved sampling plan or alternate statistical methods may be *PROPOSED* to compare *FACILITY* data to Part 201 criteria.

For small data sets and for data sets with ≥ 50% nondetects, UCLs for a percentile may be considered in place of UCLs for a mean. Two methods for selecting a percentile are described below:

1) **Select a percentile that will provide an estimate of the mean of the distribution.** Since the goal is to estimate the mean concentration in a given area, a specific percentile (generally higher than the 50th percentile or median) may be selected on a case-by-case basis that will provide an estimate of the mean concentration. Parkin, et. al. (1990) describe a method for identifying a percentile to estimate the mean of a lognormal distribution. This method may be *PROPOSED* for right-skewed data sets that are approximately lognormal. Parkin's method may provide a useful alternative to Land's method for evaluating data sets that are concluded to be lognormal, but result in unreasonably high UCLs for the mean using the Land's method.

2) **Select a percentile that is higher than the percent of data below the detection limit.** For highly censored data sets, EPA (2000) suggests considering a percentile higher than the percent of data below the detection limit. For example, if 67% of the data are below the detection limit, EPA recommends consideration of a UCL for the 70th or 75th percentile to statistically compare data to a given criterion. This method, and a specified percentile for comparing data to criteria, may be *PROPOSED* if department approval of a response action is being sought.

Once a percentile has been selected, a nonparametric UCL for the percentile can be calculated to compare *FACILITY* data to Part 201 criteria. The method described by Gilbert (1987, pg. 141) may be *PROPOSED* for data sets with greater than 20 samples. Alternatively, for data sets with 20 or fewer samples, the procedure described by Conover (1980, pg. 112) may be *PROPOSED*.

Note: Past EPA guidance (1989c, 1992c) recommended use of a UCL for the median (i.e., the 50th percentile) when comparing data sets that are neither normal nor lognormal to fixed criteria. For populations with symmetric distributions, such as the normal distribution, the median and the mean are equivalent. However, the lognormal distribution is more commonly used to describe environmental data. This is because many environmental data sets have asymmetric distributions with a long right tail representing high concentration levels (i.e., right-skewed distributions).

For data sets which are lognormally distributed, the mean is always greater than the median. The median will underestimate the mean when the distribution of the data is right-skewed. Consequently, the selected percentile must generally be higher than the median, as described above. This recommendation is supported by more recent EPA guidance (2000), which recommends use of an upper percentile higher than the median for data sets with a CV > 0.5, particularly if the proportion of data below the detection limit is high (i.e., greater than 30 %).

3.2 NUMBER OF SAMPLES

When obtaining samples to characterize soils or waste materials, it is important to assure that the analytical results obtained will provide an accurate estimation of the nature of the entire area/volume under consideration. The location and number of discrete samples to be collected at a particular site depend on many factors: the degree of accuracy desired, the spatial and temporal variability of the media being sampled (e.g., soils, treated media, waste, etc.) to be sampled, and the costs involved. An important objective in any sampling program is to obtain the most accurate and representative data possible while minimizing the associated costs. One method to

accomplish this goal is to use statistically valid sampling strategies. The appropriate sample size can be estimated and the sampling locations can be chosen without bias.

Sample size, that is the number of samples to be collected, is a critical issue for determining compliance using UCLs for the mean. Larger numbers of samples result in lower UCLs for the mean. Although sample size analysis is not strictly necessary, it may be useful for demonstrating compliance.

The DEQ recommends a minimum of nine samples per *EXPOSURE UNIT*. However, when the sample mean concentration is close to the cleanup criterion, it may be beneficial to collect additional samples with the goal of lowering the UCL for the mean to demonstrate compliance. Following are three methods that can be considered during planning for sample collection.

3.2.1 Normal Distributions

When the underlying statistical distribution of the data set has been determined to be normal the appropriate number of samples required for waste characterization can be calculated by either of the following methods. Additional methods may also be *PROPOSED*.

3.2.1.1 Lambda Test

If the preliminary data indicate that more samples are needed to make a statistical comparison to Michigan's cleanup or waste classification criteria (e.g., the UCL for the mean is greater than the criterion, but the mean concentration is below), the Lambda (λ) relationship may be used to identify the number of samples necessary to demonstrate compliance. The total number of samples necessary to demonstrate compliance (assuming that the initial data were representative) can be estimated by use of the Lambda (λ) relationship and then consulting a table of values. A step by step approach to calculating the appropriate sample size follows:

1. Using data from the *n* initial samples, calculate λ

$$\lambda = \frac{C - \overline{X}}{s} \qquad \text{Equation 3.3}$$

Where:

C = the Part 201 criterion (or regulatory threshold for waste characterization),
$\overline{X}$ = the arithmetic mean of the data, and
s = the sample standard deviation.

The lower the resulting value for λ, the more samples are required to maintain a certain level of confidence. Also, as $\overline{X}$ approaches C, λ becomes smaller, and therefore a greater sample size is indicated for a certain level of confidence.

2. Refer to Table 3.4 to obtain the appropriate total sample size (n_{total}) from the table of values based on the resulting value for λ and a one-sided α at the desired significance level (α = 0.05 for comparison to Part 201 criteria). The resulting number of samples (n_{total}) reflects the total number of samples necessary to demonstrate compliance.

3. Determine the number of additional samples necessary (n_{total}-n). Collect the additional samples using the same sampling and analytical procedures as the first n samples. All field and laboratory procedures should be kept as consistent as possible to lower the amount of variability in the data.

4. Evaluate the spatial distribution of the combined data to determine if any new *HOT SPOTS* have been identified. If *HOT SPOTS* are present, these must be addressed separately.

5. Reevaluate the combined data (excluding *HOT SPOTS*) for statistical distribution as described in Chapter 1 and outliers (if apparent) as described in Chapter 2. Use all data values to calculate a new $\overline{X}$ and s.

6. If the new $\overline{X} \geq$ C, then a 95% UCL for the mean will clearly be above C and collection of additional samples is not likely to result in a UCL for the mean that is below C. Therefore, it can be concluded that the contaminant is present at an unacceptable concentration and the study would be complete.

7. If the new $\overline{X}$ < C, recalculate the 95% UCL for the mean as described in Section 3.1. If the new 95% UCL for the mean is below C, it can be concluded that the mean concentration is below the criterion (C) with 95% confidence. However, if the new 95% UCL for the mean is above C, either conclude that contaminant concentrations are unacceptable or start again at step 1.

3.2.1.2 SW-846 Method

An appropriate number of samples can also be calculated for a data set displaying the characteristics of a normal distribution by using the formula obtained from SW-846. This formula uses the t-statistic at the α level of significance with n-1 degrees of freedom.

$$n_{total} = \frac{t^2_{n-1,\alpha} s^2}{\Delta^2} \qquad \text{Equation 3.4}$$

Where:

Δ = C - $\overline{x}$
C = the Part 201 criterion or the regulatory threshold for waste characterization,
$\overline{x}$ = the arithmetic mean of the data set,
s^2 = the sample variance of the data set,
$t_{n-1,\alpha}$ = the appropriate t-statistic derived using degrees of freedom of n-1, and
n = the number of samples previously collected, and
n_{total} = the total number of samples to be collected.

For Part 201 comparisons table 3.1 is used with α = 0.05. When characterizing waste, the t-statistic is found by entering table 3.1 with α = 0.10. This method directly calculates the number of samples required (n_{total}) at the selected confidence level.

3.2.2 Lognormal Distributions

For a lognormal distribution, no simple established sample size formula, such as those presented above for normal distributions, is available which can be used to establish the number of samples necessary to achieve a specified error limit (EPA 1999). The use of the

Land's Method is recommended to define the confidence limit. Other methods may be *PROPOSED* to determine the appropriate sample size for lognormal distributions.

Sample Size Determination Using Land's Procedure for Lognormal Data

When data can be shown to be lognormally distributed, Land's procedure can be applied to calculate UCLs for the mean (Land, 1971 and 1975). For lognormally distributed populations, a UCL for the mean is (Gilbert 1987):

$$UCL = e^{\left(\bar{y}+\frac{s^2}{2}+\frac{sH}{\sqrt{n-1}}\right)} = \hat{X}e^{\left(\frac{sH}{\sqrt{n-1}}\right)}$$

To attain a UCL for the mean with 100*d*% relative error for the mean we require that:

$$\frac{UCL-\hat{X}}{\hat{X}} = e^{\left(\frac{sH}{\sqrt{n-1}}\right)} - 1 < d$$

Solving for *n*, a sample size formula to insure that Land's procedure results in confidence limits with 100xd% precision is given by

$$n_{total} \cong \frac{s^2 H_{1-\alpha}{}^2}{\left(\ln(1+d)\right)^2} + 1 \qquad \text{Equation 3.5}$$

Where:

s_y^2 = the variance of the log transformed data,
α = the significance level (α = 0.05 or 0.10), and
$H_{1-\alpha}$ = tabled value that can be obtained from Table 3.2 for α = 0.05 or Table 3.3 for α = 0.10,
n = the number of samples previously collected, and
n_{total} = the total number of samples to be collected.

For example, with s=0.2 and n ranging from 10 to 51, H ≈ 1.8. For d=0.1,

$$n = (0.2)^2(1.8)^2 / \log\left((1.1)\right)^2 + 1 = 15.3$$

Rounding up, the total sample n_{total} would be 16.

It should be noted that relative error term (d) must be specified in the original untransformed scale.

3.3 LOWER CONFIDENCE LIMITS FOR THE MEAN

Lower confidence limits (LCLs) for the mean provide a lower bound for the true mean concentration. When used to statistically compare *FACILITY* data to Part 201 criteria, the LCL for the mean corresponds to the following null and alternative hypotheses:

Hypothesis 2

H_o: The mean hazardous substance concentration in a given *EXPOSURE UNIT* is less than or equal to the Part 201 criterion

H_a: The mean hazardous substance concentration in a given *EXPOSURE UNIT* is greater than the Part 201 criterion

The baseline assumption in Hypothesis 2 is that the mean hazardous substance concentration is at or below its respective criterion unless the sample data provide sufficient evidence to conclude that the mean concentration is significantly above the criterion. Because the Part 201 cleanup program pertains to sites of environmental contamination, this set of assumptions generally does not apply. Furthermore, a review EPA statistical guidance documents indicates that EPA's recommendations regarding the use of LCLs for the mean are limited to the context of RCRA compliance monitoring (1989c, 1992c). As stated in the introduction to this chapter, UCLs for the mean are generally recommended by the EPA in the context of their cleanup programs (e.g., the Superfund program and RCRA Corrective Action).

Consequently, the baseline assumption under Hypothesis 2 will be justifiable only in limited circumstances under Michigan's Part 201 program. For example, an LCL for the mean may be justified for comparing hazardous substance concentrations to Part 201 criteria for the purpose of a *FACILITY* determination if there is no evidence to suggest that there has been a *RELEASE* anywhere on the property. Because of the limited utility of LCLs for the mean in demonstrating compliance with Part 201 criteria, this statistical method is not described in detail.

Table 3.1 Values of $t_{1-\alpha, n-1}$, α = 0.05, 0.10

Cumulative t Distribution

	α	0.10	0.05
	1	3.078	6.314
	2	1.886	2.920
	3	1.638	2.353
	4	1.533	2.132
	5	1.476	2.015
	6	1.440	1.943
	7	1.415	1.895
	8	1.397	1.860
	9	1.383	1.833
	10	1.372	1.812
	11	1.363	1.796
	12	1.356	1.782
	13	1.350	1.771
	14	1.345	1.761
	15	1.341	1.753
	16	1.337	1.746
	17	1.333	1.740
	18	1.330	1.734
df	19	1.328	1.729
(n-1)	20	1.325	1.725
	21	1.323	1.721
	22	1.321	1.717
	23	1.319	1.714
	24	1.318	1.711
	25	1.316	1.708
	26	1.315	1.706
	27	1.314	1.703
	28	1.313	1.701
	29	1.311	1.699
	30	1.310	1.697
	40	1.303	1.684
	60	1.296	1.671
	120	1.289	1.658
		1.282	1.645

Table 3.2 Land's Method Values for $H_{0.95}$. From Land (1975).

	n									
sy	3	5	7	10	12	15	21	31	51	101
0.10	2.750	2.035	1.886	1.802	1.775	1.749	1.722	1.701	1.684	1.670
0.20	3.295	2.198	1.992	1.881	1.843	1.809	1.771	1.742	1.718	1.697
0.30	4.109	2.402	2.125	1.977	1.927	1.882	1.833	1.793	1.761	1.733
0.40	5.220	2.651	2.282	2.089	2.026	1.968	1.905	1.856	1.813	1.777
0.50	6.495	2.947	2.465	2.220	2.141	2.068	1.989	1.928	1.876	1.830
0.60	7.807	3.287	2.673	2.368	2.271	2.181	2.085	2.010	1.946	1.891
0.70	9.120	3.662	2.904	2.532	2.414	2.306	2.191	2.102	2.025	1.960
0.80	10.43	4.062	3.155	2.710	2.570	2.443	2.307	2.202	2.112	2.035
0.90	11.74	4.478	3.420	2.902	2.738	2.589	2.432	2.310	2.206	2.117
1.00	13.05	4.905	3.698	3.103	2.915	2.744	2.564	2.423	2.306	2.205
1.25	16.33	6.001	4.426	3.639	3.389	3.163	2.923	2.737	2.580	2.447
1.50	19.60	7.120	5.184	4.207	3.896	3.612	3.311	3.077	2.881	2.713
1.75	22.87	8.250	5.960	4.795	4.422	4.081	3.719	3.437	3.200	2.997
2.00	26.14	9.387	6.747	5.396	4.962	4.564	4.141	3.812	3.533	3.295
2.50	32.69	11.67	8.339	6.621	6.067	5.557	5.013	4.588	4.228	3.920
3.00	39.23	13.97	9.945	7.864	7.191	6.570	5.907	5.388	4.947	4.569
3.50	45.77	16.27	11.56	9.118	8.326	7.596	6.815	6.201	5.681	5.233
4.00	52.31	18.58	13.18	10.38	9.469	8.630	7.731	7.024	6.424	5.908
4.50	58.85	20.88	14.80	11.64	10.62	9.669	8.652	7.854	7.174	6.590
5.00	65.39	23.19	16.43	12.91	11.77	10.71	9.579	8.688	7.929	7.277
6.00	78.47	27.81	19.68	15.45	14.08	12.81	11.44	10.36	9.449	8.661
7.00	91.55	32.43	22.94	18.00	16.39	14.90	13.31	12.05	10.98	10.05
8.00	104.60	37.06	26.20	20.55	18.71	17.01	15.18	13.74	12.51	11.45
9.00	117.70	41.68	29.46	23.10	21.03	19.11	17.05	15.43	14.05	12.85
10.00	130.800	46.31	32.73	25.66	23.35	21.22	18.93	17.13	15.59	14.26

Table 3.3 Land's Method Values for $H_{0.90.}$ From Land (1975).

	n									
s_y	3	5	7	10	12	15	21	31	51	101
0.10	1.686	1.438	1.381	1.349	1.338	1.328	1.317	1.308	1.301	1.295
0.20	1.885	1.522	1.442	1.396	1.380	1.365	1.348	1.335	1.324	1.314
0.30	2.156	1.627	1.517	1.453	1.432	1.411	1.388	1.370	1.354	1.339
0.40	2.521	1.755	1.607	1.523	1.494	1.467	1.437	1.412	1.390	1.371
0.50	2.990	1.907	1.712	1.604	1.567	1.532	1.494	1.462	1.434	1.409
0.60	3.542	2.084	1.834	1.696	1.650	1.606	1.558	1.519	1.485	1.454
0.70	4.136	2.284	1.970	1.800	1.743	1.690	1.631	1.583	1.541	1.504
0.80	4.742	2.503	2.119	1.914	1.845	1.781	1.710	1.654	1.604	1.560
0.90	5.349	2.736	2.280	2.036	1.955	1.880	1.797	1.731	1.672	1.621
1.00	5.955	2.980	2.450	2.167	2.073	1.985	1.889	1.812	1.745	1.686
1.25	7.466	3.617	2.904	2.518	2.391	2.271	2.141	2.036	1.946	1.866
1.50	8.973	4.276	3.383	2.896	2.733	2.581	2.415	2.282	2.166	2.066
1.75	10.48	4.944	3.877	3.289	3.092	2.907	2.705	2.543	2.402	2.279
2.00	11.98	5.619	4.380	3.693	3.461	3.244	3.005	2.814	2.648	2.503
2.50	14.99	6.979	5.401	4.518	4.220	3.938	3.629	3.380	3.163	2.974
3.00	18.00	8.346	6.434	5.359	4.994	4.650	4.270	3.964	3.697	3.463
3.50	21.00	9.717	7.473	6.208	5.778	5.370	4.921	4.559	4.242	3.965
4.00	24.00	11.09	8.516	7.062	6.566	6.097	5.580	5.161	4.796	4.474
4.50	27.01	12.47	9.562	7.919	7.360	6.829	6.243	5.769	5.354	4.989
5.00	30.01	13.84	10.61	8.779	8.155	7.563	6.909	6.379	5.916	5.508
6.00	36.02	16.60	12.71	10.50	9.751	9.037	8.248	7.607	7.048	6.555
7.00	42.02	19.35	14.81	12.23	11.35	10.52	9.592	8.842	8.186	7.607
8.00	48.03	22.11	16.91	13.96	12.96	12.00	10.94	10.08	9.329	8.665
9.00	54.03	24.87	19.02	15.70	14.56	13.48	12.29	11.32	10.48	9.725
10.00	60.04	27.63	21.12	17.43	16.17	14.97	13.64	12.56	11.62	10.79

Table 3.4 Number of Observations for t-Test of the Mean

Level for *t* Test (α)

One-sided / Two-sided	α = 0.005 / = 0.01					α = 0.01 / = 0.02					α = 0.025 / = 0.05					α = 0.05 / = 0.1				
λ	β= 0.01	0.05	0.1	0.2	0.5	0.01	0.05	0.1	0.2	0.5	0.01	0.05	0.1	0.2	0.5	0.01	0.05	0.1	0.2	0.5
0.05																				
0.10																				
0.15																				122.0
0.20										139.0					99.0					70.0
0.25					110.0					90.0				128.0	64.0			139.0	101.0	45.0
0.30				134.0	78.0				115.0	63.0			119.0	90.0	45.0		122.0	97.0	71.0	32.0
0.35			125.0	99.0	58.0			109.0	85.0	47.0		109.0	88.0	67.0	34.0		90.0	72.0	52.0	24.0
0.40		115.0	97.0	77.0	45.0		101.0	85.0	66.0	37.0	117.0	84.0	68.0	51.0	26.0	101.0	70.0	55.0	40.0	19.0
0.45		92.0	77.0	62.0	37.0	110.0	81.0	68.0	53.0	30.0	93.0	67.0	54.0	41.0	21.0	80.0	55.0	44.0	33.0	15.0
0.50	100.0	75.0	63.0	51.0	30.0	90.0	66.0	55.0	43.0	25.0	76.0	54.0	44.0	34.0	18.0	65.0	45.0	36.0	27.0	13.0
0.55	83.0	63.0	53.0	42.0	26.0	75.0	55.0	46.0	36.0	21.0	63.0	45.0	37.0	28.0	15.0	54.0	38.0	30.0	22.0	11.0
0.60	71.0	53.0	45.0	36.0	22.0	63.0	47.0	39.0	31.0	18.0	53.0	38.0	32.0	24.0	13.0	46.0	32.0	26.0	19.0	9.0
0.65	61.0	46.0	39.0	31.0	20.0	55.0	41.0	34.0	27.0	16.0	46.0	33.0	27.0	21.0	12.0	39.0	28.0	22.0	17.0	8.0
0.70	53.0	40.0	34.0	28.0	17.0	47.0	35.0	30.0	24.0	14.0	40.0	29.0	24.0	19.0	10.0	34.0	24.0	19.0	15.0	8.0
0.75	47.0	36.0	30.0	25.0	16.0	42.0	31.0	27.0	21.0	13.0	35.0	26.0	21.0	16.0	9.0	30.0	21.0	17.0	13.0	7.0
0.80	41.0	32.0	27.0	22.0	14.0	37.0	28.0	24.0	19.0	12.0	31.0	22.0	19.0	15.0	9.0	27.0	19.0	15.0	12.0	6.0
0.85	37.0	29.0	24.0	20.0	13.0	33.0	25.0	21.0	17.0	11.0	28.0	21.0	17.0	13.0	8.0	24.0	17.0	14.0	11.0	6.0
0.90	34.0	26.0	22.0	18.0	12.0	29.0	23.0	19.0	16.0	10.0	25.0	19.0	16.0	12.0	7.0	21.0	15.0	13.0	10.0	5.0
0.95	31.0	24.0	20.0	17.0	11.0	27.0	21.0	18.0	14.0	9.0	23.0	17.0	14.0	11.0	7.0	19.0	14.0	11.0	9.0	5.0
1.00	28.0	22.0	19.0	16.0	10.0	25.0	19.0	16.0	13.0	9.0	21.0	16.0	13.0	10.0	6.0	18.0	13.0	11.0	8.0	5.0
1.1	24.0	19.0	16.0	14.0	9.0	21.0	16.0	14.0	12.0	8.0	18.0	13.0	11.0	9.0	6.0	15.0	11.0	9.0	7.0	
1.2	21.0	16.0	14.0	12.0	8.0	18.0	14.0	12.0	10.0	7.0	15.0	12.0	10.0	8.0	5.0	13.0	10.0	8.0	6.0	
1.3	18.0	15.0	13.0	11.0	8.0	16.0	13.0	11.0	9.0	6.0	14.0	10.0	9.0	7.0		11.0	8.0	7.0	6.0	
1.4	16.0	13.0	12.0	10.0	8.0	14.0	11.0	10.0	9.0	6.0	12.0	9.0	8.0	7.0		10.0	8.0	7.0	5.0	
1.5	15.0	12.0	11.0	9.0	7.0	13.0	10.0	9.0	8.0	6.0	11.0	8.0	7.0	6.0		9.0	7.0	6.0		
1.6	13.0	11.0	10.0	8.0	6.0	12.0	10.0	9.0	7.0	5.0	10.0	8.0	7.0	6.0		8.0	6.0	6.0		
1.7	12.0	10.0	9.0	8.0	6.0	11.0	9.0	8.0	7.0		9.0	7.0	6.0	5.0		8.0	6.0	5.0		
1.8	12.0	10.0	9.0	8.0	6.0	10.0	8.0	7.0	7.0		8.0	7.0	6.0			7.0	6.0			
1.9	11.0	9.0	8.0	7.0	6.0	10.0	8.0	7.0	6.0		8.0	6.0	6.0			7.0	5.0			
2.0	10.0	8.0	8.0	7.0	5.0	9.0	7.0	7.0	6.0		7.0	6.0	5.0			6.0				
2.1	10.0	8.0	7.0	7.0		8.0	7.0	6.0	6.0		7.0	6.0				6.0				
2.2	9.0	8.0	7.0	6.0		8.0	7.0	6.0	5.0		7.0	6.0				6.0				
2.3	9.0	7.0	7.0	6.0		8.0	6.0	6.0			6.0	5.0				5.0				
2.4	8.0	7.0	7.0	6.0		7.0	6.0	6.0			6.0									
2.5	8.0	7.0	6.0	6.0		7.0	6.0	6.0			6.0									
3.0	7.0	6.0	6.0	5.0		6.0	5.0	5.0			5.0									
3.5	6.0	5.0	5.0			5.0														
4.0	6.0																			
						99% confidence										95% confidence				

CHAPTER 4: COMPARISON OF *FACILITY* DATA TO *BACKGROUND*

As stated in Rule 701(c), the term *BACKGROUND* is defined as:

> *the concentration or level of a hazardous substance which exists in the environment at or regionally proximate to a site that is not attributable to any release at or regionally proximate to the site.*

According to Section 20a(11), when *BACKGROUND* concentrations of a hazardous substance are greater than the corresponding Part 201 risk-based criterion, *BACKGROUND* becomes the Part 201 criterion. Consequently, consideration of applicable Part 201 criteria is necessary before comparing *FACILITY* data to *BACKGROUND*. In general, *FACILITY* data will be compared to *BACKGROUND* concentrations only when *BACKGROUND* concentrations are greater than the applicable risk-based criterion.

When *BACKGROUND* concentrations are being considered, the objective becomes to determine whether the *FACILITY* concentrations are significantly higher than *BACKGROUND* concentrations for a hazardous substance. This determination may or may not involve a statistical comparison to *BACKGROUND*, depending on: 1) the type of *BACKGROUND* being considered, and 2) whether a statistical analysis of *FACILITY* data for comparison to *BACKGROUND* is appropriate.

The types of *BACKGROUND* that will generally be considered include: 1) *STATEWIDE DEFAULT BACKGROUND*, 2) *REGIONAL BACKGROUND*, and 3) *FACILITY-SPECIFIC BACKGROUND*. Additional information on each type of *BACKGROUND* is provided below.

In most cases, *FACILITY* data will be compared to *BACKGROUND* on a point-by-point basis. That is, concentrations of each hazardous substance in each *FACILITY* sample will be compared to directly to the *BACKGROUND* concentration and individual exceedances will be noted. When point-by-point comparisons are made, professional judgment is required to interpret the significance of exceedances that are very close to criteria or *BACKGROUND*, or that may be associated with insignificant quantities of a hazardous substance.

Statistical analysis of *FACILITY* data for comparison to *BACKGROUND* may be appropriate. Statistical Guidesheets for the applicable pathways/conditions should be consulted to determine the applicability of statistics for comparing *FACILITY* data to Part 201 criteria and key considerations for selection of the appropriate data set(s). Recommendations provided in the Statistical Guidesheets apply to all Part 201 criteria, including *BACKGROUND*. A statistical analysis of *FACILITY* data for comparison to *BACKGROUND* will most likely be appropriate for pathways/conditions categorized as **YES**, or for those categorized as **GNP** for which a statistical analysis is demonstrated to be appropriate.

Recommended methods for comparing *FACILITY* data to *BACKGROUND* are provided in the following sections:

Type of *BACKGROUND*	**Statistical Analysis of *FACILITY* Data Appropriate?**	**Method for Comparing *FACILITY* Data to *BACKGROUND***
STATEWIDE DEFAULT BACKGROUND	No	Section 4.1.1
	Yes	Section 4.1.2
REGIONAL BACKGROUND	No	Section 4.2.1
	Yes	Section 4.2.2
FACILITY-SPECIFIC BACKGROUND	No	Section 4.3.1
	Yes	Section 4.3.2

Where the column "Statistical Analysis of *FACILITY* Data Appropriate?" is "No," a point-by-point comparison of *FACILITY* data to *BACKGROUND* concentrations is necessary.

If departmental approval of a response action is being sought, alternate statistical methods for comparing *FACILITY* data to *BACKGROUND* data may be *PROPOSED* on a case-by-case basis. Self-implemented response activities using statistics to support determinations must be documented in a manner that fully and clearly addresses the three questions outlined in the tabbed section titled, "Introduction."

4.1 *STATEWIDE DEFAULT BACKGROUND* CONCENTRATIONS

STATEWIDE DEFAULT BACKGROUND concentrations are provided in Operational Memorandum #15 for naturally occurring metals. (See Appendix B of the tabbed section titled, "Appendices.") For the purpose of statistical comparisons with *FACILITY* concentrations, the MDEQ considers these criteria to be fixed values, rather than statistically-derived numbers.

4.1.1 Point-by-Point Comparison of *FACILITY* Data to *STATEWIDE DEFAULT BACKGROUND* Concentrations

When the *BACKGROUND* concentration being used is a *STATEWIDE DEFAULT BACKGROUND* concentration, *FACILITY* concentrations will generally be compared to this value on a point-by-point basis. Therefore, in general, simply compare each individual *FACILITY* concentration to the *STATEWIDE DEFAULT BACKGROUND* value and note individual exceedances.

4.1.2 Statistical Comparison of *FACILITY* Data to *STATEWIDE DEFAULT BACKGROUND* Concentrations, When Appropriate

When comparing *FACILITY* data to a *STATEWIDE DEFAULT BACKGROUND* concentration and a statistical analysis of *FACILITY* data is documented to be appropriate, a 95% UCL for the mean of the *FACILITY* data set may be calculated for comparison to the *STATEWIDE DEFAULT BACKGROUND* concentration. This is the same approach taken for statistical comparison of *FACILITY* data to risk-based criteria since these criteria are also treated as fixed values.

Procedures for calculating a UCL for the mean are presented in Chapter 3. The first step is to determine the distribution of the *FACILITY* data set (Chapter 1) and whether outliers are present (Chapter 2). If the data are normally distributed, use Procedure 3.1 to calculate a 95% UCL for the mean ($UCL_{0.95}$) using the Student's t method and compare this value to the *STATEWIDE DEFAULT BACKGROUND* concentration. If the data are lognormally distributed, use Procedure 3.2 to calculate $UCL_{0.95}$ based on Land's method and compare this value to the *STATEWIDE DEFAULT BACKGROUND* concentration. Alternate methods may be *PROPOSED* on a case-by-case basis, if departmental approval of a response action is being sought.

Interpretation: If $UCL_{0.95}$ > *STATEWIDE DEFAULT BACKGROUND* value, conclude that the mean *FACILITY* concentration is above this value. If $UCL_{0.95}$ < *STATEWIDE DEFAULT BACKGROUND* value, conclude that the mean *FACILITY* concentration is below the *STATEWIDE DEFAULT BACKGROUND* concentration.

Note that a more correct statement of the interpretation would be to conclude that the mean is <u>at or above</u> the *STATEWIDE DEFAULT BACKGROUND* value if the 95% UCL for the mean is greater than <u>or equal to</u> the *BACKGROUND* value. However, because the data being evaluated are measured on a continuous scale, the probability of obtaining a 95% UCL for the mean that is exactly equal to the *STATEWIDE DEFAULT BACKGROUND* value is essentially zero. Therefore, the interpretation stated above will be relied upon for these comparisons.

4.2 *REGIONAL BACKGROUND* CONCENTRATIONS

REGIONAL BACKGROUND concentrations may be *PROPOSED* on a case-by-case basis for comparison to *FACILITY* data. *REGIONAL BACKGROUND* data are typically considered in one of two manners:

1) **Development of a *REGIONAL BACKGROUND* concentration:** Data provided in sources such as the 1991 Michigan *BACKGROUND* Soil Survey (MBSS) can be *PROPOSED* to develop a *REGIONAL BACKGROUND* concentration. The MBSS should not generally be used as the only source of information for this purpose because the data in this survey do not equally represent all areas in Michigan (i.e., large numbers of *BACKGROUND* samples were collected at some locations, but small numbers or no samples in others). This yields a disproportionate weight to the locations with large numbers of samples. Other potential sources of data include approved *FACILITY-SPECIFIC BACKGROUND* data for *FACILITIES* in the nearby region, data published by the United States Geological Survey or other approved sources. Once a regional data set has been compiled, the statistical method for calculating a *REGIONAL BACKGROUND* concentration must also be *PROPOSED* on a case-by-case basis if departmental approval of a response action is being sought.

2) **Use of Professional Judgment:** In some cases, professional judgment based on general knowledge of *BACKGROUND* conditions in the region is used rather than the more rigorous approach described above. For example, if *FACILITY* concentrations are generally within the range of *BACKGROUND* concentrations that have been approved at other *FACILITIES* or are known to be present nearby within the region, it could be concluded that the *FACILITY* concentrations comply with *REGIONAL BACKGROUND* concentrations.

4.2.1 Point-by-Point Comparison of *FACILITY* Data to *REGIONAL BACKGROUND* Data

The method for establishing a *REGIONAL BACKGROUND* concentration and the *REGIONAL BACKGROUND* data used for this purpose must generally be *PROPOSED* on a case-by-case basis if departmental approval of a response action is being sought.

When a *BACKGROUND* concentration has been established as a *REGIONAL BACKGROUND* concentration, *FACILITY* concentrations will generally be compared to the *REGIONAL BACKGROUND* concentration on a point-by-point basis. Therefore, in general, simply compare each *FACILITY* concentration to the *REGIONAL BACKGROUND* concentration and note individual exceedances.

4.2.2 Statistical Comparison of *FACILITY* Data to *REGIONAL BACKGROUND* Data, When Appropriate

When the *BACKGROUND* concentration has been established as a *REGIONAL BACKGROUND* concentration and a statistical analysis of *FACILITY* data is appropriate, a statistical analysis of *FACILITY* data may be conducted for comparison to *REGIONAL BACKGROUND.* The method for comparing *FACILITY* data to *REGIONAL BACKGROUND* data must be *PROPOSED* on a case-by-case basis if departmental approval of a response action is being sought.

4.3 *FACILITY-SPECIFIC BACKGROUND* CONCENTRATIONS

Comparison of *FACILITY* data to *FACILITY-SPECIFIC BACKGROUND* concentrations has historically been completed using the mean plus three standard deviations calculated using *FACILITY-SPECIFIC BACKGROUND* data. This method of deriving *BACKGROUND* concentrations is still allowable in certain circumstances, as described in Section 4.3.1. However, it should be noted that this upper limit statistically represents the expected variability of sample results in an uncontaminated area, not a mean concentration; consequently, **only <u>individual</u> *FACILITY* concentrations may be compared to the mean plus three standard deviations**. **It is not appropriate to compare a mean concentration or a UCL for the mean concentration to an upper limit for *BACKGROUND* calculated as the mean plus three standard deviations.**

If a statistical analysis of *FACILITY* data is demonstrated to be appropriate for comparison to *BACKGROUND*, an alternative to the mean plus three standard deviation approach may be taken to compare *FACILITY* concentrations to *FACILITY-SPECIFIC BACKGROUND* concentrations, as described in Section 4.3.2. The recommended methods described in this section may be used to statistically compare the two populations represented by *FACILITY* concentrations and *FACILITY-SPECIFIC BACKGROUND* concentrations.

4.3.1 Point-by-Point Comparison of *FACILITY* Data to *FACILITY-SPECIFIC BACKGROUND* Data

When a *BACKGROUND* concentration has been established as a *FACILITY-SPECIFIC BACKGROUND* concentration, *FACILITY* concentrations will generally be compared to the *FACILITY-SPECIFIC BACKGROUND* concentration on a point-by-point basis. Therefore, in general, simply compare each individual *FACILITY* concentration to the *FACILITY-SPECIFIC BACKGROUND* concentration and note individual exceedances.

4.3.1.1 Normal or Lognormal Distributions

A *FACILITY-SPECIFIC BACKGROUND* concentration may be established as described in Procedure 4.1. This procedure is recommended for *FACILITY-SPECIFIC BACKGROUND* data sets that are either normally or lognormally distributed. If departmental approval of a response action is being sought, *PROPOSALS* must be made to calculate *FACILITY-SPECIFIC BACKGROUND* concentrations using alternative approaches.

Before calculating the *FACILITY-SPECIFIC BACKGROUND* concentration, it is still necessary to evaluate the data set for underlying statistical distribution (i.e., normal, lognormal, or neither) and the presence of outliers using the methods described in Chapters 1 and 2, respectively. If potential outliers are identified based on a review of the tabulated data and/or graphs of the data, formal outlier testing should be completed as described in Chapter 2, taking into account the underlying statistical distribution of the data.

Figure 4.1 Data and Calculations for Determining the *FACILITY-SPECIFIC BACKGROUND* Concentration and Evaluating for Exceedances

	A	B	C	D	E	F	G
1							
2		Background	Facility				
3	Observation	Conc.	Conc.	Exceeds?			
4	1	24.4	25.0	No		BG average:	25.1
5	2	22.4	29.7	No			=AVERAGE(B4:B13)
6	3	25.5	31.1	No			
7	4	27.6	28.4	No		BG stdev:	2.6
8	5	27.4	23.8	No			=STDEV(B4:B13)
9	6	28.5	34.2	Yes			
10	7	20.6	24.3	No	Facility-specific BG conc:		32.8
11	8	24.5	26.4	No			= G4 + 3 * G7
12	9	27.2	42.6	Yes			
13	10	22.8	30.5	No			
14	11		31.0	No			
15	12		30.9	No			

Example 4.1 Sample Calculation of a *FACILITY-SPECIFIC BACKGROUND* Concentration

Suppose that 10 *FACILITY-SPECIFIC BACKGROUND* observations and 12 *FACILITY* observations of lead concentrations were collected. The data are provided in the spreadsheet below (Figure 4.1). No apparent outliers were present in the *FACILITY-SPECIFIC BACKGROUND* data. Using the methods outlined in Procedure 4.1, the average *BACKGROUND* concentration was estimated as 25.1 ppm and the standard deviation was 2.6 ppm. The resulting *FACILITY-SPECIFIC BACKGROUND* concentration was 32.8 ppm. Two exceedances were noted (34.2 and 42.6 ppm) as shown below.

Procedure 4.1 Determining a *FACILITY-SPECIFIC BACKGROUND* Concentration

1. For less than 50% nondetects, calculate the sample mean ($\bar{x}$) and sample standard deviation (*s*) using the following equation and substituting 1/2 of the detection limit for nondetects. (Equations 1.1 and 1.2 are reproduced below for convenience.)

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

2. For less than 50% nondetects, use the above values for $\bar{x}$ and s to calculate the *FACILITY-SPECIFIC BACKGROUND* concentration as:

$$\bar{x} + 3s$$

   For 50% nondetects or more, calculate the *FACILITY-SPECIFIC BACKGROUND* concentration using a nonparametric upper tolerance limit (EPA 1992c). This value should be determined as the maximum detected concentration in the *FACILITY-SPECIFIC BACKGROUND* data set.

3. Compare the *FACILITY* concentrations to the *FACILITY-SPECIFIC BACKGROUND* concentration on a point-by-point basis* and note exceedances.

In most cases, it should not be necessary to calculate the above equations by hand considering the availability of basic statistical computations in statistical software packages and most spreadsheet packages. Most statistical software packages provide the sample mean ($\bar{x}$) and the sample standard deviation (s). Alternatively, Microsoft Excel can be used to obtain $\bar{x}$ and *s*. The Excel functions that should be used to obtain these values, respectively, are:

=AVERAGE(data range)
=STDEV(data range)

* When point-by-point comparisons are made, professional judgment is required to interpret the significance of exceedances that are very close to criteria or *BACKGROUND*, or that may be associated with insignificant quantities of a hazardous substance.

4.3.1.2 Alternate Methods for Calculating *FACILITY-SPECIFIC BACKGROUND* Concentrations

Alternate methods are available for calculating *FACILITY-SPECIFIC BACKGROUND* concentrations. These methods include upper tolerance limits and upper prediction limits, among others. Upper tolerance limits and upper prediction limits are described in many documents and texts, including those by EPA (1992c), Gibbons (1994), Gibbons and Coleman (2001), Helsel and Hirsch (1992), and Millard and Neerchal (2001).

Use of alternate methods must be *PROPOSED* if departmental approval of a response action is being sought.

4.3.2 Statistical Comparison of *FACILITY* Data to *FACILITY-SPECIFIC BACKGROUND* Data, When Appropriate

If a statistical analysis of the *FACILITY* data is appropriate, statistical testing may be conducted to evaluate whether the population represented *FACILITY* data is signficantly greater than the population represented by *FACILITY-SPECIFIC BACKGROUND* data. A statistical comparison of two populations is referred to as a "two-sample test." Recommended two-sample tests (EPA 2000) include: 1) Student's t-test, 2) Satterthwaite's t-test, or 3) Wilcoxon Rank Sum test followed by the Quantile test. Selection of the appropriate test depends upon an evaluation of the underlying assumptions of these tests, as described below.

Two-sample testing is an alternative to the approach described in Section 4.3.1 because the focus is no longer on individual exceedances of a *BACKGROUND* value. Rather, two-sample tests typically compare some parameter of the population distributions, such as the mean. The Student t-test and Satterthwaite's t-test both provide methods for identifying differences in mean concentrations. The Wilcoxon Rank Sum test can be conducted to test for differences in the median concentration. The EPA (2000) recommends that the Wilcoxon Rank Sum test be conducted and interpreted together with the Quantile test. The Quantile test allows for detection of instances where only parts of the data set are different, rather than a complete shift in the data set. The EPA (2000) recommends this "tandem testing" approach since the combined tests are most powerful for detecting true differences between two population distributions.

Because EPA's *Guidance for Data Quality Assessment* (EPA, 2000) contains detailed explanations of the procedures for conducting the two-sample tests recommended in this section, this EPA document has been referenced as a source for descriptions of these tests. Excerpts from EPA (2000) are provided in Appendix A of the tabbed section titled, "Appendices."

Regardless of whether a statistical analysis is appropriate to compare *FACILITY* data to risk-based criteria, it is necessary to compute a *FACILITY-SPECIFIC BACKGROUND* concentration as described in Procedure 4.1 to determine if *BACKGROUND* is higher than the corresponding risk-based criteria. If the resulting *BACKGROUND* mean plus three standard deviations is greater than the risk-based criterion for a given hazardous substance, then this value becomes the Part 201 criterion for that hazardous substance. However, if the resulting *BACKGROUND* mean plus three standard deviations is not greater than the risk-based criterion, *BACKGROUND* does not become the Part 201 criterion and no further comparisons to *FACILITY-SPECIFIC BACKGROUND* are relevant.

4.3.2.1 Parametric Methods for Comparing *FACILITY-SPECIFIC BACKGROUND* and *FACILITY* Data Sets

First, determine the percent of nondetects in the combined data set. That is, combine the *FACILITY-SPECIFIC BACKGROUND* and *FACILITY* data sets determine the percent nondetect. If the percent nondetect in the combined data sets is ≥ 15%, proceed to Section 4.3.2.2.

If the combined data set is < 15% nondetect, determine the distribution of the *FACILITY-SPECIFIC BACKGROUND* and *FACILITY* data sets separately (Chapter 1). That is, complete the methods described in Chapter 1 for both data sets individually.

Next, evaluate each data set for potential outliers. If outliers are suspected, formal testing should be completed as described in Chapter 2. If sufficient data remain to allow for a valid statistical analysis, proceed as follows:

If both data sets are normally distributed, or both data sets are lognormally distributed, conduct Levene's test for equality of variances between the two data sets. The procedure for conducting Levene's test can be found in Box 4-26 on page 4-37 and an example can be found in Box 4-27 on page 4-38 of EPA (2000). These pages are provided in Appendix A of the tabbed section titled, "Appendices."

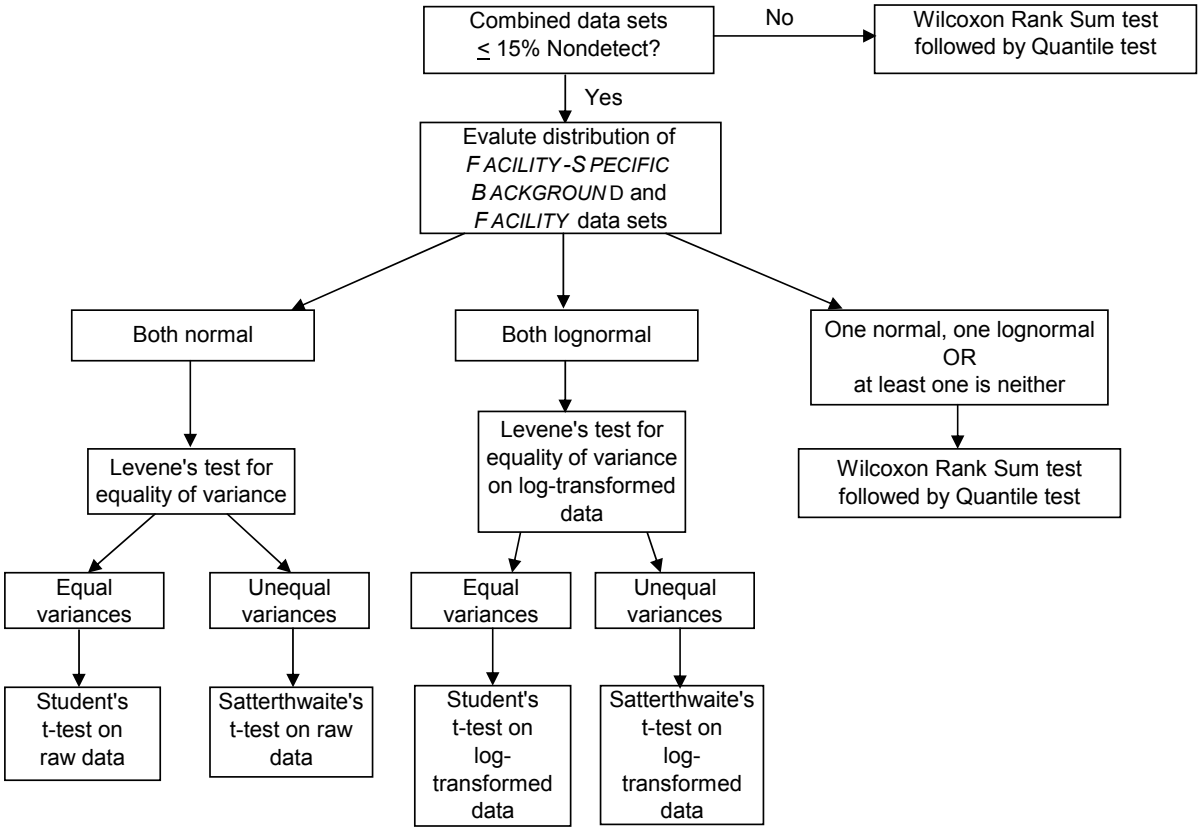
- If both data sets are normal and Levene's test indicates that variances of the data sets are equal, conduct the Student's t-test using the raw, untransformed data. Equality of variance is necessary since the Student's t-test assumes that both populations have equal variance. If both data sets are lognormal and the variances of the data sets are concluded to be equal, conduct the Student's t-test using log-transformed data. The procedure for conducting the Student's t-test and an example can be found in Box 3-14 on page 3-24 and Box 3-15 on page 3-25 of EPA (2000), respectively. These pages are provided in Appendix A of the tabbed section titled, Appendices."

- If both data sets are found to be normal and Levene's tests indicates that data sets do not have equal variances, conduct Satterthwaite's t-test using the raw, untransformed data. Satterthwaite's t-test provides an alternative to the Student's t-test when the populations being compared have unequal variances. If both data sets are lognormal and the variances of the data sets are not equal, conduct Satterthwaite's t-test using log-transformed data. Details for conducting Satterthwaite's t-test and an example can be found in Box 3-16 on page 3-26 and Box 3-17 on page 3-27 in EPA (2000), respectively. These pages are provided in Appendix A of the tabbed section titled, "Appendices." As noted by Millard and Neerchal (2001), it is important to decide whether it makes sense to focus on a difference in mean concentrations if you already know there is a difference in the variances. If this is the case, consider evaluating the data using the methods described in Section 4.3.2.2.

- If one data set is found to be normal and the other is found to be lognormal or if either data set is found to be neither normal nor lognormal, compare the data sets using the Wilcoxon Rank Sum Test followed by the Quantile Test, as described in Section 4.3.2.2.

See Figure 4.2 for a flowchart describing selection of the appropriate two-sample test.

Figure 4.2 Selection of Appropriate Two-Sample Test for Comparison of *FACILITY* Data to *FACILITY-SPECIFIC BACKGROUND* Data, When Appropriate



4.3.2.2 Nonparametric Methods for Comparing *FACILITY-SPECIFIC BACKGROUND* and *FACILITY* Data Sets

Nonparametric (i.e., distribution-free) methods for comparing *FACILITY-SPECIFIC BACKGROUND* data to *FACILITY* data are recommended when:

- One data set is found to be normal and the other is found to be lognormal, or
- Either data set is found to be neither normal nor lognormal, or
- The percent of nondetects in the combined data set is ≥ 15% (EPA 1992c).

The recommended nonparametric method involves comparing the data sets using the Wilcoxon Rank Sum Test followed by the Quantile Test. Directions for conducting a Wilcoxon Rank Sum Test can be found in Box 3-20 on page 3-32 and an example can be found in Box 3-21 on page 3-33 of EPA (2000). A large sample approximation to the Wilcoxon Rank Sum Test is provided in Box 3-22 on page 3-34 of EPA (2000) for comparing data sets each containing 20 or more samples. The Quantile Test is discussed on page 3-35 of EPA (2000). Directions for conducting a modified Quantile test can be found in Box 3-23 on page 3-36 and an example can be found in Box 3-24 on page 3-37 of EPA (2000). Each of these pages is provided in Appendix A of the tabbed section titled, "Appendices."

Although the Wilcoxon Rank Sum test can be done using a spreadsheet, the Quantile test is rather difficult to compute. S-PLUS contains functions that can perform both of these tests.

4.4 *BACKGROUND* CONCENTRATIONS FOR GROUNDWATER

Some issues particular to calculating *BACKGROUND* groundwater concentrations deserve special consideration. Careful consideration should be given to the selection of an appropriate *BACKGROUND* groundwater data set. First, *BACKGROUND* groundwater data should adequately represent *BACKGROUND* conditions. A sufficient number of groundwater samples should be collected over a time frame that will reflect seasonal variation (e.g., quarterly samples for two years). When *BACKGROUND* groundwater concentrations are established using upgradient wells, the number of wells should be sufficient to represent natural spatial variability.

BACKGROUND groundwater data should be closely evaluated for natural spatial variability and between-well variability before pooling data from upgradient wells for calculation of *BACKGROUND* concentrations. A *BACKGROUND* data set should represent a single population that can be described by a single statistical distribution (e.g., a normal distribution with a mean of 3.6 and a standard deviation of 0.78). *BACKGROUND* groundwater data should, therefore, be evaluated to determine if more than one population or distribution is present (e.g., due to the presence of multiple aquifers or significant spatial variability across an aquifer). This evaluation can be completed through a general review of the data or by using graphical techniques such as probability plots, side-by-side box plots, and/or stiff diagrams. It is generally not appropriate to combine data from different aquifers or from significantly differing areas, if present within an aquifer. Inappropriately combining data across wells can result in inflated *BACKGROUND* concentrations due to the large overall variability.

BACKGROUND groundwater data should be independent. In general, this means that: 1) the data should be *RANDOMLY* obtained, and 2) there should be no trends in the data. For groundwater monitoring purposes, samples are typically collected at fixed time intervals from wells which have been located based on professional judgment. Consequently, groundwater samples are not generally *RANDOM* with respect to space or time. However, it is important that

time intervals between samples be spaced far enough apart, considering groundwater flow rates, that groundwater samples are independent (i.e., the same groundwater is not sampled each time). Furthermore, data used to establish *BACKGROUND* groundwater concentrations should be non-trending. Use of trending data to establish *BACKGROUND* groundwater concentrations will result in inflated *BACKGROUND* concentrations.

Once *BACKGROUND* groundwater concentrations have been established, it may be necessary to reevaluate and/or update the *BACKGROUND* concentrations on a periodic basis. Revisions to *BACKGROUND* groundwater concentrations must be *PROPOSED* for DEQ approval.

The statistical methods described in Chapter 1 (evaluating statistical distributions) and Chapter 2 (evaluating for outliers) of this tabbed section are also appropriate for evaluating *BACKGROUND* groundwater data. In addition, the methods presented in Section 4.3.1 of Chapter 4 for calculating upper limits based on *FACILITY-SPECIFIC BACKGROUND* data are generally appropriate and can be used for calculating *BACKGROUND* groundwater concentrations.

Additional information and detail will be forthcoming in future statistics training materials. Any questions or reviews regarding statistic analyses of groundwater data for Part 201 applications should be submitted to the Department Statistician.

CHAPTER 5: CENSORED DATA

Contaminant concentrations often lie below the detection limits of the equipment used to estimate the concentrations of the contaminants. For these samples, instead of reporting an actual concentration, the detection limit of the equipment is typically reported (e.g., less than 7 ppb). The true concentration at the sampled location is likely below this detection limit, but how far below the limit is left to speculation. These types of data are termed **censored**.

Censored data can be rather difficult to deal with statistically. As one person put it, "censored data is like holding on to a tail and being unsure whether the other end is connected to an elephant or a mouse." This analogy gets at the heart of the difficulty that censored data presents. As you might imagine, if we have a five quantified observations above and five censored observations below some detection limit, then determining a "good" estimate of the mean, variance, or even the type of distribution (e.g., normal or lognormal) can be difficult.

Censored data can either be singly or multiply censored. Singly censored means that the data set contains only one censoring level or detection limit (e.g., < 7 ppb). A multiply-censored data set contains multiple censoring levels or detection limits (e.g., data may be reported at < 7 ppb, < 5 ppb, and < 3 ppb). A singly-censored data set is much easier to deal with than a multiply censored data set.

Recommendation

A simple approach for dealing with censored data has been to simply replace the censored observations with half of their respective detection limits. This method was found to perform adequately when calculating upper confidence limits (UCLs) for the mean concentration based on simulation studies conducted during the preparation of the draft document, Statistical Analysis of Ground-Water Monitoring Data at RCRA *FACILITIES* – Unified Guidance.

After substituting 1/2 of the detection limit for concentrations below the limit of detection, proceed with the analysis as usual by evaluating the distribution of the resulting data set (Chapter 1), examining for outliers (Chapter 2), and calculating UCLs for the mean when appropriate (Chapter 3).

This approach is recommended only for data sets with less than 50% nondetects.

When calculating a *FACILITY-SPECIFIC BACKGROUND* concentration as the mean plus three standard deviations for comparison to *FACILITY* data (Chapter 4), 1/2 of the detection limit may also be substituted for *FACILITY-SPECIFIC BACKGROUND* concentrations below the detection limit up to 50% nondetect. For greater than 50% nondetects, nonparametric upper tolerance limits may be used to obtain a *FACILITY-SPECIFIC BACKGROUND* concentration. As described by EPA (1992c), the upper limit may be established as the maximum concentration in the *FACILITY-SPECIFIC BACKGROUND* data set.

When conducting two-sample tests, such as those used to compare two populations (i.e., *FACILITY* concentrations and *FACILITY-SPECIFIC BACKGROUND* concentrations), nonparametric procedures should be used in place of parametric procedures when the percent of concentrations below the detection limit is greater than 15% in either data set, as recommended by EPA (1992c). The nonparametric procedure recommended in Chapter 4 is the Wilcoxon Rank Sum Test followed by the Quantile Test.

Alternate Methods

Several alternate methods are available for estimating the mean and standard deviation of censored data sets. Two of these are Cohen's method and Aitchison's method (EPA, 1992c). Cohen's method is based on the assumption that the censored observations belong to the same continuous distribution as the detected observations, except that they are censored at the detection limit (Cohen, 1991). Aitchison's method is based on the assumption that censored observations actually represent zero concentrations and detected values arise from some other distribution (Aitchison, 1955). These methods may be *PROPOSED*; however, it is necessary to evaluate the underlying assumptions and justify the choice between the two methods.

Censored and detects-only probability plots may be used to determine if Cohen's method or Aitchison's method is more appropriate for a given data set. These plots are described in detail in EPA (1992c). If the censoring appears to be of the Aitchison type, the data set should be evaluated further to determine whether two populations were being sampled (i.e., one represented by zero values and another represented by detected values) before proceeding with Aitchinson's method for handling nondetects. This could be achieved by examining the spatial distribution of the samples and their associated values.

Additional statistical methods for dealing with censored data are available and may be *PROPOSED* on a case-by-case basis, where departmental approval of a response action is being sought. These methods are generally too complex to implement using spreadsheet software. EnvironmentalStats for S-PLUS has several built-in functions that can be used to estimate a mean, variance, or even a UCL for the mean based on a singly or multiply censored data set.

Unfortunately, there are only a few studies that examine the performance of the various methods for calculating UCLs for the mean with censored data. Schmee et al. (1985) provides exact confidence limits, using maximum likelihood, for the parameters of a normal or lognormal distribution for various sample sizes and levels of single censoring. Millard and Neerchal (2001) provide the results of simulations examining confidence interval coverage probabilities using various sample sizes, levels of censoring, types of distributions, and methods of estimation using the functions within EnvironmentalStats for S-PLUS. As mentioned earlier, this software package contains several methods for calculating a UCL for the mean with censored data. Consult with a statistician to choose among the available methods and determine which is most appropriate for the situation at hand.

SOLID AND HAZARDOUS WASTE CHARACTERIZATION

SOLID AND HAZARDOUS WASTE CHARACTERIZATION

1.0 WASTE CHARACTERIZATION

For the purpose of waste characterization, it is assumed that there is no knowledge of the origin, process of generation or history of the material to be characterized and that the characteristics and waste class need to be determined through sampling and analysis. If sufficient knowledge of the material exists, sampling and/or statistical analysis may be reduced or eliminated.

The considerations presented here apply to any waste characterization required under the NREPA (Part 111, for Hazardous Waste Management or Part 115, Solid Waste Management). The appropriate DEQ staff must be consulted for an inertness designation for solid wastes (Part 115) and de-list petitions for listed hazardous wastes (Part 111). Other methods of determining waste classifications are available, but must be reviewed and approved by the appropriate DEQ staff.

Before statistical methods can be considered for comparing data to the appropriate criteria, the nature (waste process origin) and extent (the horizontal and vertical extent of the material) of the waste media in question, must first be defined. This information will aid in designing the sampling strategy to adequately characterize the material (i.e., identify if there is a single, homogeneous population that can be described by a single statistical distribution or whether there are *HOT SPOTS* present). Refer to the tabbed section titled, "Sampling Strategies" for more details on sampling options.

Each unique waste type must be characterized independently due to the heterogeneous nature of the waste material and the potential for stratification.

In general, compositing of samples is not recommended under any circumstances, but for volatile organic sampling it is never acceptable. Use of composite samples should be discussed with the appropriate DEQ staff.

2.0 IDENTIFICATION OF SAMPLING STRATEGIES

When obtaining samples to characterize a material, it is important to insure that the analytical results obtained will provide an accurate estimation of the nature of the entire area/volume under consideration. The location and number of samples to be taken of a particular material depend on many factors: the degree of accuracy desired, the spatial and temporal variability of the material to be sampled, and the costs involved. An important objective in any sampling program is to obtain the most accurate data possible while minimizing the associated costs. One method to accomplish this goal is to use statistically valid sampling strategies. The appropriate sample number can be estimated and the sampling intervals (which may be based on volume, location depth or time) can be chosen without bias.

A combination of sampling strategies may be necessary when characterizing wastes. The nature and extent of the material (boundaries) must be adequately defined. Biased sampling should generally be used to determine whether the material is **homogeneous** (i.e. origin with little variability), **heterogeneous** (i.e. origin with a great deal of variability) and/or **stratified**. Each unique waste type must be characterized independently. Biased sampling results may be sufficient to characterize a waste material depending on: 1) whether the biased sampling results adequately represent the waste materials, and 2) whether any individual sample result

exceeds the regulatory threshold of interest. If one or more samples exceed the regulatory threshold, a more extensive sampling may be pursued to apply a statistical analysis to compare the new characterization data to the regulatory threshold.

If a statistical analysis is to be used to compare characterization data to a regulatory threshold, it will be necessary to reevaluate data needs. Additional data will often be necessary for the purpose of calculating an upper confidence limit (UCL) for the mean concentration. These data should be obtained through statistical or *RANDOM* sampling.

If several materials on a site are under investigation, it is advisable to evaluate them separately. This is especially true if information does not exist to indicate that the materials contain similar constituents or that they were placed at the same time period.

2.1 Biased Sampling

"Biased" sampling strategies generally involve use of judgment to collect samples from areas most likely to contain contamination. Often, biased sampling is utilized for smaller areas (e.g., less than a 1/4 acre) and/or smaller volumes of materials. However, biased sampling also plays a role when characterizing large volumes of materials. In this case, biased sampling may be used to initially determine the homogeneity or heterogeneity of waste materials.

Use of biased sampling is premised on enough detailed information on which to base selection of sample locations. The sample locations are purposefully chosen based on the goal of identifying localized areas or volumes in which contaminant concentrations are elevated (i.e., *HOT SPOTS*). With sufficient knowledge of existing conditions, historic activities, or field indicators (e.g., visual, olfactory, or field screening instrumentation), these areas can be focused on reliably.

Any biased sampling plan requires use of professional judgment. A thorough justification must be documented for each sample location explaining the rationale used to select the location. Without this important detail, biased sampling alone will not be adequate.

Analytical results from biased sampling must generally be compared to regulatory thresholds on a point-by-point basis. A statistical analysis of data generated from biased sampling is generally not appropriate. This is due to the underlying assumptions of most statistical methods used to compare characterization data to regulatory thresholds. One underlying assumption is that the data being evaluated were obtained through *RANDOM* sampling of a single, homogeneous population that can be described by a single statistical distribution (e.g., a normal distribution with a mean of 3.6 and a standard deviation of 0.78). Biased sampling can be used to help identify if this is the case or if differing populations (e.g., *HOT SPOTS*) are present.

If statistical sampling is completed in addition to biased sampling, it may be appropriate to combine analytical results from the statistical sampling with some or even all of the biased sampling results in a statistical analysis. However, there are several key considerations which must first be addressed, as described in Section 3.2.

Biased sampling strategies require collection of discrete soil samples. Compositing of samples is not accepted without prior DEQ approval.

2.1.1 Sampling Process Streams

Although sampling is generally thought to occur on a pile of material or over an area of treated soil, other schemes are possible. Process wastes are commonly sampled at the point of generation. This is the preferred method, since it is most representative of the material under study. The lack of exposure to elements that might cause chemical degradation and/or leaching will result in material most indicative of actual conditions. A sampling point along the material conveyor that can be fairly easily and safely reached should be chosen. It should be in an area where the entire belt can be accessed for sampling. Sampling intervals can be assigned by specific process intervals, by generated volume (see Table 2.1 below) or by a timed interval that would represent key process time/volume.

When biased sampling is conducted for the purpose of waste characterization, it should account for process variability. Ideally, the entire active time of the waste process stream would be represented in the sampling scheme, but selected times and volumes should be identified for specific sampling (i.e., to provide a basis for biased sampling).

2.1.2 Sampling Ex Situ/Waste Piles

The number of samples to be collected from a waste pile should be based on the volume of the waste pile. The following table provides recommended numbers of samples for waste characterization using biased sampling.

Table 2.1 Number of Biased Samples for Waste Piles

Volume (cubic yards)	0-25	26-100	101-500	501-1,000	1,001-2,000	> 2,000
Number of samples (depending on basis of bias)	3-4	6-8	8-10	10-12	13-15	15 + 3 for every additional 500 cubic yards

Specific considerations for biasing sample locations are described in detail in Section 1.2.1 of the tabbed section titled, “Sampling Strategies” under *FACILITY* characterization. The fundamental approaches for biasing sample location are basically the same; however, the biased sampling is now focused on waste characterization.

2.2 Statistical Sampling

Statistical sampling, also referred to as unbiased or probabilistic sampling, is based on the theory of *RANDOM* chance probabilities in order to choose samples which are representative of a given area or volume. The probability of selecting any sampling location is equal. Because sampler bias is not of concern, the error in data accuracy of a *RANDOM* sampling scheme can be objectively measured. Furthermore, knowledge of the waste distribution is not always necessary depending on the purpose for collecting samples.

In some cases it is preferable to choose statistical sampling strategies over biased sampling strategies since they can be used to produce increased data accuracy while eliminating sampler bias. This will depend on the amount of available information with which to bias sampling. In some cases, a combination of approaches will yield the most comprehensive information.

Several statistical sampling strategies can be used to produce an unbiased, representative sampling program. The principles behind the three basic types of *RANDOM* sampling and the situations for which they are best suited are described below. To achieve true *RANDOM* sampling, composite sampling is not acceptable.

1. ***Simple RANDOM sampling*** is a method that requires little or no prior knowledge of material distribution. It relies on *RANDOM* chance probability theory – where each sampling location has an equal and known probability of being selected. In this way, sampling error can be accurately estimated. Often, the area of interest is sectioned into a two- or three-dimensional grid pattern and *RANDOM* coordinates are chosen for sampling.

2. ***Systematic RANDOM sampling*** is an extension of simple *RANDOM* sampling that may produce a more efficient sampling survey. It can be more efficient by reducing the sampling error while maintaining the sample number, or by reducing the number of samples needed to achieve a specified sampling error, or by reducing the cost of collection. This method also requires little or no knowledge about the waste distribution, but bias and imprecision can be introduced if unseen trends or cycles exist. Two methods used to select sample locations under this method follow.

    A) *RANDOMLY* select a transect or transects and sample at pre-selected intervals.

    B) Pre-select both the transect or transects and the sampling interval and starting from a *RANDOMLY* selected point. This is the method used most throughout this chapter.

3. ***Stratified RANDOM sampling*** requires some knowledge about the waste distribution. When stratification is known or suspected, sampling efficiency can be improved by dividing the material into strata that are more homogeneous than the total area. Simple or systematic *RANDOM* sampling techniques can then be used to sample each stratum independently. Each stratum is divided into a grid pattern and the sampling points are selected *RANDOMLY*. If the area is vertically stratified, the sampling points in each stratum are selected *RANDOMLY* and then selected depths are sampled. If the area is horizontally stratified, the sampling points within each stratum are selected *RANDOMLY*, but the total depth is sampled. An analysis of variance (ANOVA) may be done on the analytical results to determine if the strata differ significantly. This can help evaluate whether use of stratified *RANDOM* sampling was necessary and statistically valid. When the volumes of the strata differ or the number of samples within each stratum differs, the results must be weighed appropriately to avoid bias if the data are to be combined in order to draw conclusions.

Of these methods, Systematic *RANDOM* sampling is generally recommended. This approach is often the most efficient since it involves collection of samples at equal intervals, simplifying the collection of samples. Furthermore, systematic *RANDOM* sampling can serve many purposes. When samples are collected on a regular grid interval, conclusions can be drawn about the size of a *HOT SPOT* likely to be identified (or missed), as described in Section 2.1 of the tabbed section titled, "Sampling Strategies." Furthermore, because the sampling locations are *RANDOMIZED* through systematic *RANDOM* sampling (i.e., by *RANDOMLY* selecting transects and/or the initial

sampling point), it may be appropriate to include the analytical results in a statistical analysis for the purpose of comparison to regulatory thresholds. However, the considerations described in Section 3.2 of this tabbed section must first be addressed.

The number of samples needed to conduct a statistical evaluation will depend on the volume of the material being characterized and the homogeneity of the material. In all cases, a population sufficiency test must be completed and passed to satisfy the number of samples required for the statistical test used. See Section 4.0 of this tabbed section and Section 3.2 of the tabbed section titled, “Statistical Methods.”

For further discussion on sampling strategies and sample collection methods, see "Test Methods for Evaluating Solid Waste," SW846 Volume II: Field Methods, November 1986, Third Edition, USEPA.

2.2.1 Sampling a Process Stream

As noted in Section 2.1.1, process wastes are commonly sampled at the point of generation. This is the preferred method, since it is most representative of the material under study. The lack of exposure to elements that might cause chemical degradation and/or leaching will result in material most indicative of actual conditions. A sampling point along the material conveyor that can be fairly easily and safely reached should be chosen. It should be in an area where the entire belt can be accessed for sampling.

When statistical sampling is conducted to reflect temporal rather than spatial variability, time strata should be established over the course of the process day. The time strata should be established to account for process variability. Ideally, the entire active time of the line should be included in the sampling scheme. Once time strata are chosen, *RANDOM* numbers can be selected to establish sampling times. When the appropriate sampling time arrives, the identified material would be collected.

For example, in a four hour period, a point somewhere on the table would be chosen and numbers greater than 0 but less than 240 would be selected until the number of samples for that strata were obtained. The *RANDOM* numbers would represent time in minutes. These numbers would be added to the starting time for each stratum to determine the time of sampling.

The Microsoft Excel function =RANDBETWEEN(L,U) can be used to select a *RANDOM* number between a specified range of numbers where L is the lower bound of the range and U is the upper bound. In the example above, the function =RANDBETWEEN(0,240) would be used.

If the time strata chosen are of unequal lengths, the number of samples chosen from any one stratum should reflect the percentage contribution that stratum makes to the time frame as a whole. If, for example, a 24 hour operating time is divided such that stratum one is four hours and stratum two is eight hours, stratum two should have twice as many samples as stratum one.

When the appropriate sampling time arrives, the material from the conveyor belt point that had been identified would be sampled.

2.2.2 Sampling Ex Situ/Waste Piles

This section assumes that an adequate investigation has been completed and the volume of the material to be characterized has been confirmed to represent a single, homogeneous population

that can be described by a single statistical distribution (e.g., a normal distribution with a mean of 3.6 and a standard deviation of 0.78).

Samples collected from a waste pile or some ex situ soils may need to be located using a three dimensional gridding method. Characterizations involving soils, piles and/or wastes with a significant vertical component should be evaluated in **three dimensions** (volume evaluation). Examples of such characterizations would be ex situ soil characterization or waste pile characterization involving several cubic feet of soil and/or waste. A grid would be superimposed on the area and a vertical component added at each node.

Establishing Grid Intervals

Statistical sampling strategies often employ the use of gridding to facilitate the unbiased selection of sampling points and the use of accepted statistical tools for evaluating the resultant data.

The equations and tables provided in Section 2.2.1.2 of the tabbed section titled, "Sampling Strategies" can be used to identify grid intervals. Use of these methods facilitate unbiased selection of sampling points and sample coverage proportional to the area of the pile or material being characterized. Other methods can be *PROPOSED* for DEQ approval.

Sampling of the Grid

A minimum of nine samples or 25%, whichever is greater, of the total grid stations should be sampled and analyzed initially to allow a large enough data pool for the statistical analysis. Extra samples should be taken and kept under proper chain of custody and handling procedures at the time of initial sampling. If the statistical analysis indicates that two or three more samples are needed, an additional trip to the field may not be necessary. This may also avoid the need to reestablish the grid pattern at a later date.

Stratified *RANDOM* Sampling

Stratified *RANDOM* Sampling requires some knowledge about the waste distribution. When stratification is known or suspected, sampling efficiency can be improved by dividing the material into strata that are more homogeneous than the total area. Simple or systematic *RANDOM* sampling techniques can then be used to sample each stratum independently.

If the area is vertically stratified, the sampling points in each stratum are selected *RANDOMLY* and then selected depths are sampled. Typically, layers in a stratified material will be between two and five feet thick. Any material over five feet thick must be vertically (as well as horizontally) sampled.

If the area is horizontally stratified, the sampling points within each stratum should be selected *RANDOMLY*, but the total depth sampled. An analysis of variance (ANOVA) may be done on the analytical results to determine if the strata differ significantly. This would assure that the use of stratified *RANDOM* sampling was statistically valid. When the volume of the strata differs or the number of samples within each stratum differs, the results must be weighed appropriately to avoid bias.

3.0 COMPARISON TO REGULATORY THRESHOLDS

Regulatory thresholds for solid waste characterization are found in R 299.4115. Regulatory thresholds for the hazardous waste toxicity characteristic characterization are found in

Part 111 R 299.9217. To determine if environmental media contain a listed hazardous waste, characterization data should be compared to the Type B criteria under the NREPA as found in MERA Memo 8: Revision 3.

3.1 Comparing Characterization Data to Regulatory Thresholds on a Point-by-Point Basis

Analytical data generated using biased sampling strategies must generally be compared to regulatory thresholds on a point-by-point basis. If all samples are below the regulatory threshold and sampling of the waste materials is believed to be adequately representative, no additional samples are warranted. Adequate documentation of all sample locations must be provided based on sufficient knowledge of the waste materials.

If one or more samples contain contaminant concentrations above regulatory thresholds, additional sampling may be necessary to better understand the exceedance (e.g., if the waste materials were expected to be homogeneous and no exceedances were expected), and possibly a change in sampling strategy from biased to statistical. Vertical and horizontal delineation of elevated concentrations in the area of the biased sample location may be necessary.

Statistical analyses of data from biased sampling is generally not appropriate. This is due to the underlying assumptions of most statistical methods used to compare *FACILITY* data to cleanup criteria. One underlying assumption is that the data being evaluated were obtained through *RANDOM* sampling of a single population that can be described by a single statistical distribution (e.g., a normal distribution with a mean of 3.6 and a standard deviation of 0.78).

However, if statistical sampling is completed, use of a statistical analysis to compare characterization data to regulatory thresholds may be appropriate. It is first necessary to evaluate the considerations described below in Section 3.2.

3.2 Comparing Characterization Data to Regulatory Thresholds Using Statistics

Before assembling a data set and conducting a statistical analysis, it is important to give careful consideration to the following:

Population to be sampled

Adequate knowledge of contaminant distribution and the presence of *HOT SPOTS* is essential due to assumptions underlying the statistical methods used to compare characterization data to regulatory thresholds (i.e., 95% UCLs for the mean concentration). Adherence to these assumptions is necessary if an accurate statistical conclusion is to be drawn. One key assumption is that the data are independently and identically distributed (iid). For this assumption to be true, the following are generally necessary:

- Samples must be *independent* and representative of the area included in the analysis. In statistical terms, this means that the data were collected *RANDOMLY*.

- For the data to be identically distributed, each data point must have been drawn from the same *identical* statistical distribution (e.g., a normal distribution with a mean of 3.6 ppm and a standard deviation of 0.78 ppm). Data from a *HOT SPOT* area would be represented by a different statistical distribution than data from non-*HOT SPOT* areas. In

other words, the mean concentration in a *HOT SPOT* area would be higher than in the non-*HOT SPOT* areas and the standard deviation would likely differ as well.

Consequently, identification of *HOT SPOTS* is necessary before an appropriate statistical analysis can be conducted.

Once defined, *HOT SPOTS* should not be included in a statistical analysis for comparison to regulatory thresholds. *HOT SPOTS* must be characterized separately. This is necessary to avoid combining data from different statistical distributions and violating the assumptions of the statistical methods.

Selecting the Appropriate Statistical Method for Comparison to Criteria

A UCL for the mean should be utilized to compare characterization data to regulatory thresholds. Various methods are available for calculating UCLs for the mean concentration. These methods are presented in Chapter 3 of the tabbed section titled, "Statistical Methods."

Selection of the appropriate method for calculating a UCL for the mean requires an evaluation of the assumptions underlying each method. One of these assumptions is the statistical distribution of the data set (i.e., normal, lognormal, or neither). Consequently, each data set must be evaluated for the best-fitting statistical distribution. Chapter 1 of the tabbed section titled, "Statistical Methods" provides several techniques to accomplish this task. As described in Chapter 1, these techniques should be used in combination to best evaluate the statistical distribution.

Chapter 2 of the tabbed section titled, "Statistical Methods" provides techniques for identifying whether suspect data points are statistical outliers. Recommendations for treatment of outliers, once identified, are also provided in Chapter 2.

For the purpose of hazardous waste determinations, a 10% level of significance ($\alpha = 0.10$) may be used. For solid waste determinations, a significance level of 5% ($\alpha = 0.05$) must be used.

4.0 STATISTICAL VALIDATION

It is suggested that a minimum of one sample be collected for any container (55 gallon drum or smaller). A minimum of nine *RANDOMLY* located, discrete samples should be collected per layer/stratification for waste piles or ex situ material if statistics are to be used to compare characterization data to regulatory thresholds. The rationale for this minimum number of samples is described in Section 1.3 of the tabbed section titled, "Statistical Methods."

Further evaluation of the sample size used for waste characterization must be conducted on the data to show that a sufficient number of samples had been collected to use the chosen statistical method. Section 3.2 of the tabbed section titled, "Statistical Methods" provides statistical methods to address this issue, including the Lambda Test.

ACRONYMS / GLOSSARY

ACRONYMS

ANOVA	Analysis of Variance
BCCs	Bioaccumulative Contaminants of Concern
BEA	Baseline Environmental Assessment
CCTM	Cleanup Criteria Training Material
CFR	Code of Federal Regulations
Csat	Soil Saturation Concentration
CV	Coefficient of Variation
DCC	Direct Contact Criteria
DNAPL	Dense Non-Aqueous Phase Liquids
DWC	Drinking Water Criteria
EU	Exposure Units
FIELDS	Fully-Integrated Environmental Location Decision Support
GCC	Groundwater Contact Criteria
GI	Grid Interval
GNP	Generally Not Practical
GPS	Global Positioning System
GSI	Groundwater Surface Water Interface
GVIIC	Groundwater Volatilization to Indoor Air Inhalation Criteria
IQR	Interquartile Range
LCL	Lower Confidence Limit
Ln	Log-transformed
MBSS	Michigan Background Soil Survey
MERA	Michigan Environmental Response Act
MDEQ (DEQ)	Michigan Department of Environmental Quality
MDNR (DNR)	Michigan Department of Natural Resources
MZB	Mixing Zone-Based
NDs	Non-Detects
NREPA	Natural Resources and Environmental Protection Act
ppb	parts per billion
PSIC	Particulate Soil Inhalation Criteria
RME	Reasonable Maximum Exposure
RCRA	Resource Conservation and Recovery Act

SF	Shapiro-Francia
S^3TM	Sampling Strategies and Statistics Training Materials
SVIIC	Soil Volatilization to Indoor Air Inhalation Criteria
SW	Shapiro-Wilk
TCE	Trichloroethene
U.S.EPA (EPA)	United States Environmental Protection Agency
UCL	Upper Confidence Limit
UTL	Upper Tolerance Limit
VSIC	Volatile Soil Inhalation Criteria
VSP	Visual Sampling Plan
VSR	Verification of Soil Remediation
WET	Whole Effluent Toxicity

GLOSSARY

AVERAGING AREA: The cross sectional area of the contaminated plume used to estimate the discharge rate of venting groundwater in the request for a mixing zone determination, generally the cross sectional area with concentrations greater than the generic GSI criterion.

***BACKGROUND*:** The concentration or level of a hazardous substance which exists in the environment at or regionally proximate to a site that is not attributable to any release at or regionally proximate to the site. [See Statistical Guidesheet 10 for information on each type of *BACKGROUND* described below.

> ***STATEWIDE DEFAULT BACKGROUND*:** The concentrations provided in the September 30, 1993, Michigan Environmental Response Act (MERA) Operational Memorandum #15: Default Type A Cleanup Criteria (Op Memo #15) which represent acceptable *BACKGROUND* concentrations at all *FACILITIES*. [See Appendix A and Chapter 4 of the tabbed section titled, "Statistical Methods."]
>
> ***FACILITY-SPECIFIC BACKGROUND:*** The *BACKGROUND* concentrations in soil at or adjacent to a *FACILITY*. According to Op Memo #15, it is acceptable to establish *BACKGROUND* concentrations higher than the *STATEWIDE DEFAULT BACKGROUND* concentrations for a *FACILITY*. [See Chapter 4 of the tabbed section titled, "Statistical Methods."]
>
> ***REGIONAL BACKGROUND:*** The *BACKGROUND* concentrations in soil that are found regionally proximate to a *FACILITY.* According to Op Memo #15, use of regionally proximate background values higher than the *STATEWIDE DEFAULT BACKGROUND* concentrations may be established for a *FACILITY*. *REGIONAL BACKGROUND* values must be *PROPOSED* on a case-by-case basis.
>
> ***NON-RELEASE ANTHROPOGENIC BACKGROUND:*** *BACKGROUND* concentrations that are affected by anthropogenic compounds which are excluded from the definition of a *RELEASE (*e.g., compounds present in the soil resulting from historic widespread application of pesticides for insect control if applied in accordance with label directions).

***EMISSION SOURCE SIZE/EMISSION SOURCE AREA*:** A term specific to the generic soil inhalation criteria for ambient air that is defined as the horizontal and vertical extent of soil contamination with detectable concentrations.

***EXPOSURE UNIT*:** The area over which an individual is expected to move *RANDOMLY*, such that equivalent amounts of time are assumed to be spent at each location. This area should be logical and generally regular in shape.

FACILITY: Any area, place, or property where a hazardous substance is in excess of the concentrations which satisfy the requirements of Section 20120a(1)(a) or (17) of the cleanup criteria for unrestricted residential use under Part 213, Leaking Underground Storage Tanks, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), has been *RELEASED*, deposited, disposed of, or otherwise comes to be located. *FACILITY* does not include any area, place, or property at which response activities have been completed which satisfy the cleanup criteria for the residential category provided for in Section 20120a(1)(a) and (17) or at which corrective action has been completed under Part 213 which satisfies the cleanup criteria for unrestricted residential use.

***FACILITY-SPECIFIC BACKGROUND*:** See *BACKGROUND* definition.

GSI MONITORING WELLS: Vertical wells placed along and near the surface water body, no closer than the ordinary high water mark, that are used to monitor groundwater venting to surface water.

***HOT SPOT*:** Two or more adjacent sample locations in reasonably close proximity at which concentrations are sufficiently above cleanup criteria and sample concentrations from the surrounding area (i.e., spatially correlated concentrations sufficiently above criteria) to indicate that they: 1) represent a different statistical population, and 2) pose a potential risk that should not be masked by a statistical analysis. Judgment must be used to determine whether concentrations are sufficiently above cleanup criteria and surrounding location. [See Section 2.2.1.1 of the tabbed section titled, "Sampling Strategies."]

***INTERIM RESPONSES*:** Cleanup or removal of hazardous substances from the environment or performing other actions prior to the selection of a remedial action that is necessary to prevent, minimize, or mitigate injury to the public health, safety, or welfare, the environment, or natural resources, which injury might otherwise result from a release of a hazardous substance.

NON-RELEASE ANTHROPOGENIC BACKGROUND: See *BACKGROUND* definition.

***ONE ACUTE TOXIC UNIT*:** A value calculated as $100/LC_{50}$, where the LC_{50} is determined from a whole effluent toxicity (WET) test which produces a result that is statistically or graphically estimated to be lethal to 50% of the test organisms.

PROPOSAL/PROPOSE/ PROPOSED: A plan describing the use and, in some cases, justifying the applicability of statistics under the Part 201 program. *PROPOSALS* will typically be submitted for the following:

1. comparison of *FACILITY* data to Part 201 cleanup criteria,
2. development of *REGIONAL BACKGROUND* concentrations, or
3. use of statistical methods not described in the tabbed section titled, "Statistical Methods."

PROPOSALS are necessary only if departmental approval is being sought for a response activity. Self-implemented approaches using statistics to support determinations must be documented in a manner that address the three objectives described in the tabbed section titled, "Introduction."

PROPOSALS for comparison of *FACILITY* data to Part 201 cleanup criteria must include a justification for the use of statistics for this purpose that addresses the issues described in the Statistical Guidesheet corresponding to the pathway/condition. These issues generally relate to the practicality of obtaining enough data within limited areas and/or the complexity of the pathway/condition considering contaminant distribution and transport to the point of exposure. These proposals must also include a description of the statistical methods to be used in the analysis and the basis for their selection (e.g., consideration of the appropriate statistical distribution and proportion of concentrations below the detection limit).

PROPOSALS for development of *REGIONAL BACKGROUND* concentrations must include a description of the *REGIONAL BACKGROUND* data to be used as well as the statistical method to be used to develop the *REGIONAL BACKGROUND* concentrations.

PROPOSALS for the use of statistical methods not described in the tabbed section titled, "Statistical Methods" must provide a basis for use of the alternative methods (e.g., consideration of the appropriate statistical distribution and proportion of concentrations below the detection limit) as well as a reference for the alternative method and/or the actual document. Consultation with a professional statistician is advised.

RANDOM/RANDOMIZATION/RANDOMIZED/RANDOMIZING/RANDOMLY: A method utilized to sample *EXPOSURE UNITS*, excluding areas identified as *HOT SPOTS*, such that each location in the *EXPOSURE UNIT* has an equal likelihood of being sampled. [See Section 2.4.2 of the tabbed section titled, "Sampling Strategies."]

REGIONAL BACKGROUND: See *BACKGROUND* definition.

RELEASE: Part 201 Section 1(bb) states in part: "*RELEASE*" includes, but is not limited to, any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance into the environment, or the abandonment or discarding of barrels, containers, and other closed receptacles containing a hazardous substance. For exceptions to this definition, see Part 201 Section 1(bb).

REPRESENTATIVE CONCENTRATION: The concentration of a hazardous substance derived from a statistical analysis of *FACILITY* data obtained from sample locations representing: 1) the exposure pathway and land use category in question and 2) contaminant concentrations within a specified *EXPOSURE UNIT*. *RANDOM* sampling within the *EXPOSURE UNIT* (or other area for pathway conditions without default *EXPOSURE UNITS*) is necessary to obtain unbiased, representative samples; however, biased samples collected for the purpose of site characterization may be used in some circumstances, as described in Section 2.4.2 of the tabbed section titled, "Sampling Strategies."

SOURCE SIZE MODIFIER: A multiplier for adjusting the generic soil inhalation criteria for ambient air to correspond to the *EMISSION SOURCE SIZE/EMISSION SOURCE AREA* determined for the *FACILITY*.

***STATEWIDE DEFAULT BACKGROUND*:** See *BACKGROUND* definition.

GLOSSARY OF COMMON STATISTICAL TERMS

μ – Lowercase Greek letter pronounced "mu." Commonly used to represent the population mean of a distribution which, in practice, is usually unknown. The arithmetic mean is an estimate of μ.

σ^2 – Lowercase Greek letter sigma, squared. Commonly used to represent the population variance. The variance describes the width or spread of a distribution and is usually unknown. The sample variance, s^2, is an estimate of σ^2.

σ – Lowercase Greek letter sigma. Commonly used to representthe population standard deviation, the square root of σ^2. The standard deviation is also a measure of the width or spread of a distribution and is usually unknown. The sample standard deviation, *s*, is an estimate of σ.

Bias – the amount by which an estimate differs from the "true" parameter value.

Censored – an observation without a definitive quantity associated with it. In contaminant monitoring, typically reported as an observation below some threshold detection limit (e.g., <7 ppb).

Confidence interval – an interval used to describe the uncertainty associated with a parameter of interest. It is calculated from the sample observations and believed to contain the true parameter value a particular percentage of the time (commonly 95%).

Distribution – a function describing the probability associated with obtaining a measurable quantity of interest.

Interval estimate – two estimated values used to construct an interval, which is intended to enclose a parameter of interest. Values within the interval represent possible values for the parameter of interest.

Lognormal – a distribution characterized by a left-skewed peak and a long right tail. The shape of the distribution depends on the parameters for μ and σ^2. The natural logarithms of observations from a lognormal distribution are normally distributed. The mean and median are generally not the same for a lognormal distribution. The lognormal distribution ranges in value from 0 to $+\infty$.

Mean – the average value of a population.

Median – the "middle" value of a population. Half the population is above the median and half is below.

Normal – a symmetric, bell-shaped, probability distribution. The shape and position of the distribution depends on the parameters for μ and σ^2. Many statistical methods rely upon having normally-distributed data. The mean and median for a normal distribution are the same. The normal distribution ranges in value from $-\infty$ to $+\infty$.

Outlier – a value that has been determined to be inconsistent with an assumed distribution as determined based on the remaining data using statistical methods described in Section 2.1 of Statistical Methods. Values identified as outliers must be evaluated before determining a course of action regarding treatment of the outlier.

Point estimate – a single value, or point, that estimates a parameter of interest. For example, $\bar{x}$ is a point estimate of μ.

Potential outlier – a value that has been identified through the screening measures described in Section 2.1 of Statistical Methods. A values identified as a potential outlier must be further evaluated through formal testing before classifying it as an outlier.

Prediction interval – an interval used to describe the uncertainty associated with obtaining a single new observation.

Skewness – the amount by which a distribution is shifted away from symmetry. For example, a lognormal distribution is typically a positively-skewed (or right-skewed with a long right tail) distribution in which the median is less than the mean.

Transform – a technique for changing the scale and range of data by the application of some function to obtain better statistical properties. For example, to satisfy a method's assumption of normality, the natural log transform is often applied to lognormal data to obtain a normally distributed data set.

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Tab 10.0

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APPENDICES – REFERENCE MATERIALS

A. EPA GUIDANCE FOR DATA QUALITY ASSESSMENT, PRACTICAL METHODS FOR DATA ANALYSIS, EPA QA/G-9, QA00 UPDATE, JULY 2000

- **METHOD FOR DOUBLE LINEAR INTERPOLATION**
- **SECTION 3.3: TESTS FOR COMPARING TWO POPULATIONS**
- **SECTION 3.3.1: COMPARING TWO MEANS**
- **SECTION 3.3.3: NONPARAMETRIC COMPARISONS OF TWO POPULATIONS**
- **SECTION 4.5.4: LEVENE'S TEST FOR THE EQUALITY OF TWO OR MORE VARIANCES**

B. MERA OPERATIONAL MEMORANDUM #15: DEFAULT TYPE A CLEANUP CRITERIA, SEPTEMBER 30, 1993

United States
Environmental Protection
Agency

Office of Environmental
Information
Washington, DC 20460

EPA/600/R-96/084
July, 2000

Guidance for Data Quality Assessment

Practical Methods for Data Analysis

EPA QA/G-9

QA00 UPDATE

Quality

FOREWORD

This document is the 2000 (QA00) version of the *Guidance for Data Quality Assessment* which provides general guidance to organizations on assessing data quality criteria and performance specifications for decision making. The Environmental Protection Agency (EPA) has developed a process for performing Data Quality Assessment (DQA) Process for project managers and planners to determine whether the type, quantity, and quality of data needed to support Agency decisions has been achieved. This guidance is the culmination of experiences in the design and statistical analyses of environmental data in different Program Offices at the EPA. Many elements of prior guidance, statistics, and scientific planning have been incorporated into this document.

This document is distinctly different from other guidance documents; it is not intended to be read in a linear or continuous fashion. The intent of the document is for it to be used as a "tool-box" of useful techniques in assessing the quality of data. The overall structure of the document will enable the analyst to investigate many different problems using a systematic methodology.

This document is one of a series of quality management guidance documents that the EPA Quality Staff has prepared to assist users in implementing the Agency-wide Quality System. Other related documents include:

EPA QA/G-4	*Guidance for the Data Quality Objectives Process*
EPA QA/G-4D	*DEFT Software for the Data Quality Objectives Process*
EPA QA/G-4HW	*Guidance for the Data Quality Objectives Process for Hazardous Waste Site Investigations*
EPA QA/G-9D	*Data Quality Evaluation Statistical Toolbox (DataQUEST)*

This document is intended to be a "living document" that will be updated periodically to incorporate new topics and revisions or refinements to existing procedures. Comments received on this 2000 version will be considered for inclusion in subsequent versions. Please send your written comments on *Guidance for Data Quality Assessment* to:

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Box 4-31: Double Linear Interpolation

The details of the double linear interpolation are provided to assist in the use of Table A-10 of Appendix A. The desired value for $\hat{\lambda}$ corresponds to $\gamma = 0.083$ and, h = 0.125 from Box 4-30, Step 3. The values from Table A-10 for interpolatation are:

γ	h = 0.10	h = 0.15
0.05	0.11431	0.17925
0.10	0.11804	0.18479

There are 0.05 units between 0.10 and 0.15 on the h-scale and 0.025 units between 0.10 and 0.125. Therefore, the value of interest lies (0.025/0.05)100% = 50% of the distance along the interval between 0.10 and 0.15. To linearly interpolate between tabulated values on the h axis for $\gamma = 0.05$, the range between the values must be calculated, 0.17925 - 0.11431 = 0.06494; the value that is 50% of the distance along the range must be computed, 0.06494 x 0.50 = 0.03247; and then that value must be added to the lower point on the tabulated values, 0.11431 + 0.03247 = 0.14678. Similarly for $\gamma = 0.10$, 0.18479 - 0.11804 = 0.06675, 0.06675 x 0.50 = 0.033375, and 0.11804 + 0.033375 = 0.151415.

On the γ-axis there are 0.033 units between 0.05 and 0.083 and there are 0.05 units between 0.05 and 0.10. The value of interest (0.083) lies (0.033/0.05 x 100) = 66% of the distance along the interval between 0.05 and 0.10, so 0.151415 - 0.14678 = 0.004635, 0.004635 * 0.66 = 0.003059. Therefore,

$$\hat{\lambda} = 0.14678 + 0.003059 = 0.149839.$$

4.7.2.2 Trimmed Mean

Trimming discards the data in the tails of a data set in order to develop an unbiased estimate of the population mean. For environmental data, nondetects usually occur in the left tail of the data so trimming the data can be used to adjust the data set to account for nondetects when estimating a mean. Developing a 100p% trimmed mean involves trimming p% of the data in both the lower and the upper tail. Note that p must be between 0 and .5 since p represents the portion deleted in both the upper and the lower tail. After np of the largest values and np of the smallest values are trimmed, there are n(1-2p) data values remaining. Therefore, the proportion trimmed is dependent on the total sample size (n) since a reasonable amount of samples must remain for analysis. For approximately symmetric distributions, a 25% trimmed mean (the midmean) is a good estimator of the population mean. However, environmental data are often skewed (non-symmetric) and in these cases a 15% trimmed mean performance may be a good estimator of the population mean. It is also possible to trim the data only to replace the nondetects. For example, if 3% of the data are below the detection limit, a 3% trimmed mean could be used to estimate the population mean. Directions for developing a trimmed mean are contained in Box 4-32 and an example is given in Box 4-33. A trimmed variance is rarely calculated and is of limited use.

4.7.2.3 Winsorized Mean and Standard Deviation

Winsorizing replaces data in the tails of a data set with the next most extreme data value. For environmental data, nondetects usually occur in the left tail of the data. Therefore, winsorizing can be used to adjust the data set to account for nondetects. The mean and standard deviation can then be computed on the new data set. Directions for winsorizing data (and revising the sample size) are contained in Box 4-34 and an example is given in Box 4-35

TABLE A-10: VALUES OF THE PARAMETER $\hat{\lambda}$ FOR COHEN'S ESTIMATES ADJUSTING FOR NONDETECTED VALUES

	h											
γ	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	.15	.20
.00	.010100	.020400	.030902	.041583	.052507	.063625	.074953	.08649	.09824	.11020	.17342	.24268
.05	.010551	.021294	.032225	.043350	.054670	.066159	.077909	.08983	.10197	.11431	.17925	.25033
.10	.010950	.022082	.033398	.044902	.056596	.068483	.080563	.09285	.10534	.11804	.18479	.25741
.15	.011310	.022798	.034466	.046318	.058356	.070586	.083009	.09563	.10845	.12148	.18985	.26405
.20	.011642	.023459	.035453	.047829	.059990	.072539	.085280	.09822	.11135	.12469	.19460	.27031
.25	.011952	.024076	.036377	.048858	.061522	.074372	.087413	.10065	.11408	.12772	.19910	.27626
.30	.012243	.024658	.037249	.050018	.062969	.076106	.089433	.10295	.11667	.13059	.20338	.28193
.35	.012520	.025211	.038077	.051120	.064345	.077736	.091355	.10515	.11914	.13333	.20747	.28737
.40	.012784	.025738	.038866	.052173	.065660	.079332	.093193	.10725	.12150	.13595	.21129	.29250
.45	.013036	.026243	.039624	.053182	.066921	.080845	.094958	.10926	.12377	.13847	.21517	.29765
.50	.013279	.026728	.040352	.054153	.068135	.082301	.096657	.11121	.12595	.14090	.21882	.30253
.55	.013513	.027196	.041054	.055089	.069306	.083708	.098298	.11208	.12806	.14325	.22225	.30725
.60	.013739	.027849	.041733	.055995	.070439	.085068	.099887	.11490	.13011	.14552	.22578	.31184
.65	.013958	.028087	.042391	.056874	.071538	.086388	.10143	.11666	.13209	.14773	.22910	.31630
.70	.014171	.028513	.043030	.057726	.072505	.087670	.10292	.11837	.13402	.14987	.23234	.32065
.75	.014378	.029927	.043652	.058556	.073643	.088917	.10438	.12004	.13590	.15196	.23550	.32489
.80	.014579	.029330	.044258	.059364	.074655	.090133	.10580	.12167	.13775	.15400	.23858	.32903
.85	.014773	.029723	.044848	.060153	.075642	.091319	.10719	.12225	.13952	.15599	.24158	.33307
.90	.014967	.030107	.045425	.060923	.075606	.092477	.10854	.12480	.14126	.15793	.24452	.33703
.95	.015154	.030483	.045989	.061676	.077549	.093611	.10987	.12632	.14297	.15983	.24740	.34091
1.00	.015338	.030850	.046540	.062413	.078471	.094720	.11116	.12780	.14465	.16170	.25022	.34471

	h											
γ	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70	.80	.90
.00	.31862	.4021	.4941	.5961	.7096	.8388	.9808	1.145	1.336	1.561	2.176	3.283
.05	.32793	.4130	.5066	.6101	.7252	.8540	.9994	1.166	1.358	1.585	2.203	3.314
.10	.33662	.4233	.5184	.6234	.7400	.8703	1.017	1.185	1.379	1.608	2.229	3.345
.15	.34480	.4330	.5296	.6361	.7542	.8860	1.035	1.204	1.400	1.630	2.255	3.376
.20	.35255	.4422	.5403	.6483	.7673	.9012	1.051	1.222	1.419	1.651	2.280	3.405
.25	.35993	.4510	.5506	.6600	.7810	.9158	1.067	1.240	1.439	1.672	2.305	3.435
.30	.36700	.4595	.5604	.6713	.7937	.9300	1.083	1.257	1.457	1.693	2.329	3.464
.35	.37379	.4676	.5699	.6821	.8060	.9437	1.098	1.274	1.475	1.713	2.353	3.492
.40	.38033	.4735	.5791	.6927	.8179	.9570	1.113	1.290	1.494	1.732	2.376	3.520
.45	.38665	.4831	.5880	.7029	.8295	.9700	1.127	1.306	1.511	1.751	2.399	3.547
.50	.39276	.4904	.5967	.7129	.8408	.9826	1.141	1.321	1.528	1.770	2.421	3.575
.55	.39679	.4976	.6061	.7225	.8517	.9950	1.155	1.337	1.545	1.788	2.443	3.601
.60	.40447	.5045	.6133	.7320	.8625	1.007	1.169	1.351	1.561	1.806	2.465	3.628
.65	.41008	.5114	.6213	.7412	.8729	1.019	1.182	1.368	1.577	1.824	2.486	3.654
.70	.41555	.5180	.6291	.7502	.8832	1.030	1.195	1.380	1.593	1.841	2.507	3.679
.75	.42090	.5245	.6367	.7590	.8932	1.042	1.207	1.394	1.608	1.851	2.528	3.705
.80	.42612	.5308	.6441	.7676	.9031	1.053	1.220	1.408	1.624	1.875	2.548	3.730
.85	.43122	.5370	.6515	.7781	.9127	1.064	1.232	1.422	1.639	1.892	2.568	3.754
.90	.43622	.5430	.6586	.7844	.9222	1.074	1.244	1.435	1.653	1.908	2.588	3.779
.95	.44112	.5490	.6656	.7925	.9314	1.085	1.255	1.448	1.668	1.924	2.607	3.803
1.00	.44592	.5548	.6724	.8005	.9406	1.095	1.287	1.461	1.882	1.940	2.626	3.827

The concept of a confidence interval can be shown by a simple example. Suppose a stable situation producing data without any anomalies was sampled many times. Each time the sample was taken, the mean and standard deviation was calculated from the sample and a confidence interval constructed using the method of Box 3-10.

Box 3-12: Directions for a Confidence Interval for a Mean for Simple and Systematic Random Samples

Let $X_1, X_2, \ldots, X_n$ represent a sample of size n from a population of normally distributed values.

Step 1: Use the directions in Box 2-2 to calculate the sample mean, $\overline{X}$. Use the directions in Box 2-3 to calculate the sample standard deviation, s.

Step 2: Use Table A-1 of Appendix A to find the critical value $t_{1-\alpha/2}$ such that 100(1-α/2)% of the t distribution with n - 1 degrees of freedom is below $t_{1-\alpha/2}$. For example, if α = 0.10 and n = 16, then n-1 = 15 and $t_{1-\alpha/2}$ = 1.753.

Step 3: The (1-α)100% confidence interval is: $\overline{X} - \frac{t_{1-\alpha/2}s}{\sqrt{n}}$ *to* $\overline{X} + \frac{t_{1-\alpha/2}s}{\sqrt{n}}$

Box 3-13: An Example of a Confidence Interval for a Mean for a Random or Systematic Random Samples

The effluent from a discharge point in a plating manufacturing plant was sampled 7 times over the course of 4 days for the presence of Arsenic with the following results: 8.1, 7.9, 7.9. 8.2, 8.2, 8.0,7.9. The directions in Box 3-12 will be used to develop a 95% confidence interval for the mean.

Step 1: Using Box 2-2, $\overline{X}$ =8.03. Use Box 2-3, s=0.138.

Step 2: Using Table A-1 of Appendix A and 6 *degrees of freedom,* $t_{1-\alpha/2}$ = 2.447.

Step 3: The (1-α)100% confidence interval is:

$$8.03 - \frac{2.447x0.138}{\sqrt{7}} \; to \; 8.03 + \frac{2.447x0.138}{\sqrt{7}}$$ or 7.902 to 8.158.

3.3 TESTS FOR COMPARING TWO POPULATIONS

A two-sample test involves the comparison of two populations or a "before and after" comparison. In environmental applications, the two populations to be compared may be a potentially contaminated area with a background area or concentration levels from an upgradient and a downgradient well. The comparison of the two populations may be based on a statistical parameter that characterizes the relative location (e.g., a mean or median), or it may be based on a distribution-free comparison of the two population distributions. Tests that do not assume an underlying distributions (e.g., normal or lognormal) are called distribution-free or nonparametric tests. These tests are often more useful for comparing two populations than those that assume a specific distribution because they make less stringent assumptions. Section 3.3.1 covers tests for differences in the means of two populations. Section 3.3.2 covers tests for differences in the

proportion or percentiles of two populations. Section 3.3.3 describes distribution-free comparisons of two populations. Section 3.3.4 describes tests for comparing two medians.

Often, a two-sample test involves the comparison of the difference of two population parameters to a threshold value. For environmental applications, the threshold value is often zero, representing the case where the data are used to determine which of the two population parameters is greater than the other. For example, concentration levels from a Superfund site may be compared to a background site. Then, if the Superfund site levels exceed the background levels, the site requires further investigation. A two-sample test may also be used to compare readings from two instruments or two separate populations of people.

If the exact same sampling locations are used for both populations, then the two samples are not independent. This case should be converted to a one-sample problem by applying the methods described in Section 3.2 to the differences between the two populations at the same location. For example, one could compare contaminant levels from several wells after treatment to contaminant levels from the same wells before treatment. The methods described in Section 3.2 would then be applied to the differences between the before and after treatment contaminant levels for each well.

3.3.1 Comparing Two Means

Let μ_1 represent the mean of population 1 and μ_2 represent the mean of population 2. The hypotheses considered in this section are:

Case 1: H_0: $\mu_1 - \mu_2 \leq \delta_0$ vs. H_A: $\mu_1 - \mu_2 > \delta_0$; and

Case 2: H_0: $\mu_1 - \mu_2 \geq \delta_0$ vs. H_A: $\mu_1 - \mu_2 < \delta_0$.

An example of a two-sample test for population means is comparing the mean contaminant level at a remediated Superfund site to a background site; in this case, δ_0 would be zero. Another example is a Record of Decision for a Superfund site which specifies that the remediation technique must reduce the mean contaminant level by 50 ppm each year. Here, each year would be considered a separate population and δ_0 would be 50 ppm.

The information required for these tests includes the null and alternative hypotheses (either Case 1 or Case 2); the gray region (i.e., a value $\delta_1 > \delta_0$ for Case 1 or a value $\delta_1 < \delta_0$ for Case 2 representing the bound of the gray region); the false rejection error rate α at δ_0; the false acceptance error rate β at δ_1; and any additional limits on decision errors. It may be helpful to label additional false rejection error limits as α_2 at $\delta_{\alpha 2}$, α_3 at $\delta_{\alpha 3}$, etc., and to label additional false acceptance error limits as β_2 at $\delta_{\beta 2}$, β_3 at $\delta_{\beta 3}$, etc.

3.3.1.1 Student's Two-Sample t-Test (Equal Variances)

PURPOSE

Student's two-sample t-test can be used to compare two population means based on the independent random samples $X_1, X_2, \ldots, X_m$ from the first population, and $Y_1, Y_2, \ldots, Y_n$ from the second population. This test assumes the variabilities (as expressed by the variance) of the two populations are approximately equal. If the two variances are not equal (a test is described in Section 4.5), use Satterthwaite's t test (Section 3.3.1.2).

ASSUMPTIONS AND THEIR VERIFICATION

The principal assumption required for the two-sample t-test is that a random sample of size m ($X_1, X_2, \ldots, X_m$) is drawn from population 1, and an independent random sample of size n ($Y_1, Y_2, \ldots, Y_n$) is drawn from population 2. Validity of the random sampling and independence assumptions should be confirmed by reviewing the procedures used to select the sampling points.

The second assumption required for the two-sample t-tests are that the sample means $\overline{X}$ (sample 1) and $\overline{Y}$ (sample 2) are approximately normally distributed. If both m and n are large, one may make this assumption without further verification. For small sample sizes, approximate normality of the sample means can be checked by testing the normality of each of the two samples.

LIMITATIONS AND ROBUSTNESS

The two-sample t-test with equal variances is robust to violations of the assumptions of normality and equality of variances. However, if the investigator has tested and rejected normality or equality of variances, then nonparametric procedures may be applied. The t-test is not robust to outliers because sample means and standard deviations are sensitive to outliers.

SEQUENCE OF STEPS

Directions for the two-sample t-test for a simple random sample and a systematic simple random sample are given in Box 3-14 and an example in Box 3-15.

3.3.1.2 Satterthwaite's Two-Sample t-Test (Unequal Variances)

Satterthwaite's t-test should be used to compare two population means when the variances of the two populations are not equal. It requires the same assumptions as the two-sample t-test (Section 3.3.1.1) except the assumption of equal variances.

Directions for Satterthwaite's t-test for a simple random sample and a systematic simple random sample are given in Box 3-16 and an example in Box 3-17.

Box 3-14: Directions for the Student's Two-Sample t-Test (Equal Variances) for Simple and Systematic Random Samples

This describes the steps for applying the two-sample t-tests for differences between the population means when the two population variances are equal for Case 1 (H_0: $\mu_1 - \mu_2 \le \delta_0$). Modifications for Case 2
(H_0: $\mu_1 - \mu_2 \ge \delta_0$) are given in parentheses { }.

STEP 1: Calculate the sample mean $\overline{X}$ and the sample variance s_X^2 for sample 1 and compute the sample mean $\overline{Y}$ and the sample variance s_Y^2 for sample 2.

STEP 2: Use Section 4.5 to determine if the variances of the two populations are equal. If the variances of the two populations are not equal, use Satterthwaite's t test (Section 3.3.1.2). Otherwise, compute the pooled standard deviation

$$s_E = \sqrt{\frac{(m-1)s_X^2 + (n-1)s_Y^2}{(m-1)+(n-1)}}.$$

STEP 3: Calculate $t = \dfrac{\overline{X} - \overline{Y} - \delta_0}{s_E\sqrt{1/n + 1/m}}$.

Use Table A-1 of Appendix A to find the critical value $t_{1-\alpha}$ such that 100(1-α)% of the t-distribution with (m+n-2) degrees of freedom is below $t_{1-\alpha}$.

If $t > t_{1-\alpha}$ {$t < -t_{1-\alpha}$}, the null hypothesis may be rejected. Go to Step 5.

If $t \ngtr t_{1-\alpha}$ {$t \nless -t_{1-\alpha}$}, there is not enough evidence to reject the null hypothesis. Therefore, the false acceptance error rate will need to be verified. Go to Step 4.

STEP 4: To calculate the power of the test, assume that the true values for the mean and standard deviation are those obtained in the sample and use a statistical software package like the DEFT software (EPA, 1994) or the DataQUEST software (EPA, 1996) to generate the power curve of the two-sample t-test. If only one false acceptance error rate (β) has been specified (at δ_1), it is possible to calculate the sample size which achieves the DQOs, assuming the true mean and standard deviation are equal to the values estimated from the sample, instead of calculating the power of the test. Calculate

$$m^* = n^* = \frac{2s^2(z_{1-\alpha} + z_{1-\beta})^2}{(\delta_1 - \delta_0)^2} + (0.25)z_{1-\alpha}^2$$

If $m^* \le m$ and $n^* \le n$, the false acceptance error rate has been satisfied. Otherwise, the false acceptance error rate has not been satisfied.

STEP 5: The results of the test could be:

1) the null hypothesis was rejected, and it seems $\mu_1 - \mu_2 > \delta_0$ {$\mu_1 - \mu_2 < \delta_0$};

2) the null hypothesis was not rejected, the false acceptance error rate was satisfied, and it seems $\mu_1 - \mu_2 \le \delta_0$ {$\mu_1 - \mu_2 \ge \delta_0$}; or

3) the null hypothesis was not rejected, the false acceptance error rate was not satisfied, and it seems $\mu_1 - \mu_2 \le \delta_0$ {$\mu_1 - \mu_2 \ge \delta_0$}, but this conclusion is uncertain because the sample size

Box 3-15: An Example of a Student's Two-Sample t-Test (Equal Variances) for Simple and Systematic Random Samples

At a hazardous waste site, area 1 (cleaned using an in-situ methodology) was compared with a similar (but relatively uncontaminated) reference area, area 2. If the in-situ methodology worked, then the two sites should be approximately equal in average contaminant levels. If the methodology did not work, then area 1 should have a higher average than the reference area. Seven random samples were taken from area 1, and eight were taken from area 2. Because the contaminant concentrations in the two areas are supposedly equal, the null hypothesis is H_0: $\mu_1 - \mu_2 \leq 0$ (Case 1). The false rejection error rate was set at 5% and the false acceptance error rate was set at 20% (β) if the difference between the areas is 2.5 ppb.

STEP 1:

	Sample Mean	Sample Variance
Area 1	7.8 ppm	2.1 ppm^2
Area 2	6.6 ppm	2.2 ppm^2

STEP 2: Methods described in Section 4.5 were used to determine that the variances were essentially equal. Therefore,

$$s_E = \sqrt{\frac{(7-1)2.1 + (8-1)2.2}{(7-1)+(8-1)}} = 1.4676$$

STEP 3:

$$t = \frac{7.8 - 6.6 - 0}{1.4676\sqrt{1/7 + 1/8}} = 1.5798$$

Table A-1 of Appendix A was used to find that the critical value $t_{0.95}$ with (7 + 8 - 2) = 13 degrees of freedom is 1.771.

Because $t \not> t_{1-\alpha}$ (i.e., $1.5798 \not> 1.771$), there is not enough evidence to reject the null hypothesis. The false acceptance error rate will need to be verified.

STEP 4: Assuming the true values for the mean and standard deviation are those obtained in the sample:

$$m^* = n^* = \frac{2(1.4676^2)(1.645 + 0.842)^2}{(2.5-0)^2} + (0.25)1.645^2 = 4.938, \text{ i.e., } 5.$$

Because $m^* \leq m$ (7) and $n^* \leq n$ (8), the false acceptance error rate has been satisfied.

STEP 5: The null hypothesis was not rejected and the false acceptance error rate was satisfied. Therefore, it seems there is no difference between the two areas and that the in-situ methodology worked as expected.

Box 3-16: Directions for Satterthwaite's t-Test (Unequal Variances) for Simple and Systematic Random Samples

This describes the steps for applying the two-sample t-test for differences between the population means for Case 1 (H_0: $\mu_1 - \mu_2 \le \delta_0$). Modifications for Case 2 (H_0: $\mu_1 - \mu_2 \ge \delta_0$) are given in parentheses { }.

STEP 1: Calculate the sample mean $\overline{X}$ and the sample variance s_X^2 for sample 1 and compute the sample mean $\overline{Y}$ and the sample variance s_Y^2 for sample 2.

STEP 2: Using Section 4.5, test whether the variances of the two populations are equal. If the variances of the two populations are not equal, compute:

$$s_{NE} = \sqrt{\frac{s_X^2}{m} + \frac{s_Y^2}{n}}$$

If the variances of the two populations appear approximately equal, use Student's two-sample t-test (Section 3.3.1.1, Box 3-14).

STEP 3: Calculate $= \dfrac{\overline{X} - \overline{Y} - \delta_0}{s_{NE}}$

Use Table A-1 of Appendix A to find the critical value $t_{1-\alpha}$ such that 100(1-α)% of the t-distribution with f degrees of freedom is below $t_{1-\alpha}$, where

$$f = \frac{\left[\dfrac{s_X^2}{m} + \dfrac{s_Y^2}{n}\right]^2}{\dfrac{s_X^4}{m^2(m-1)} + \dfrac{s_Y^4}{n^2(n-1)}}$$

(Round f <u>down</u> to the nearest integer.)

If $t > t_{1-\alpha}$ {$t < -t_{1-\alpha}$}, the null hypothesis may be rejected. Go to Step 5.

If $t \ngtr t_{1-\alpha}$ {$t \nless -t_{1-\alpha}$}, there is not enough evidence to reject the null hypothesis and therefore, the false acceptance error rate will need to be verified. Go to Step 4.

STEP 4: If the null hypothesis (H_0) was not rejected, calculate either the power of the test or the sample size necessary to achieve the false rejection and false acceptance error rates. To calculate the power of the test, assume that the true values for the mean and standard deviation are those obtained in the sample and use a statistical software package to generate the power curve of the two-sample t-test. A simple method to check on statistical power does not exist.

STEP 5: The results of the test could be:

1) the null hypothesis was rejected, and it seems $\mu_1 - \mu_2 > \delta_0$ {$\mu_1 - \mu_2 < \delta_0$};

2) the null hypothesis was not rejected, the false acceptance error rate was satisfied, and it seems $\mu_1 - \mu_2 \le \delta_0$ {$\mu_1 - \mu_2 \ge \delta_0$}; or

3) the null hypothesis was not rejected, the false acceptance error rate was not satisfied, and it seems $\mu_1 - \mu_2 \le \delta_0$ {$\mu_1 - \mu_2 \ge \delta_0$}, but this conclusion is uncertain because the sample

Box 3-17: An Example of Satterthwaite's t-Test (Unequal Variances) for Simple and Systematic Random Samples

At a hazardous waste site, area 1 (cleaned using an in-situ methodology) was compared with a similar (but relatively uncontaminated) reference area, area 2. If the in-situ methodology worked, then the two sites should be approximately equal in average contaminant levels. If the methodology did not work, then area 1 should have a higher average than the reference area. Seven random samples were taken from area 1, and eight were taken from area 2. Because the contaminant concentrations in the two areas are supposedly equal, the null hypothesis is H_0: $\mu_1 - \mu_2 \leq 0$ (Case 1). The false rejection error rate was set at 5% and the false acceptance error rate was set at 20% (β) if the difference between the areas is 2.5 ppb.

STEP 1:

	Sample Mean	Sample Variance
Area 1	9.2 ppm	1.3 ppm^2
Area 2	6.1 ppm	5.7 ppm^2

STEP 2: Using Section 4.5, it was determined that the variances of the two populations were not equal, and therefore using Satterthwaite's method is appropriate:

$$s_{NE} = \sqrt{1.3/7 + 5.7/8} = 0.9477$$

STEP 3:

$$t = \frac{9.2 - 6.1 - 0}{0.9477} = 3.271$$

Table A-1 was used with f degrees of freedom, where

$$f = \frac{[1.3/7 + 5.7/8]^2}{\frac{1.3^2}{7^2(7-1)} + \frac{5.7^2}{8^2(8-1)}} = 10.307\ (i.e.,\ 10\ degrees\ of\ freedom)$$

(recall that f is rounded down to the nearest integer), to find $t_{1-\alpha} = 1.812$.

Because $t > t_{0.95}$ (3.271 > 1.812), the null hypothesis may be rejected.

STEP 5: Because the null hypothesis was rejected, it would appear there is a difference between the two areas (area 1 being more contaminated than area 2, the reference area) and that the in-situ methodology has not worked as intended.

3.3.2 Comparing Two Proportions or Percentiles

This section considers hypotheses concerning two population proportions (or two population percentiles); for example, one might use these tests to compare the proportion of children with elevated blood lead in one urban area compared with the proportion of children with elevated blood lead in another area. The population proportion is the ratio of the number of elements in a subset of the total population to the total number of elements, where the subset has some specific characteristic that the rest of the elements do not. A population percentile represents the percentage of elements of a population having values less than some threshold value C.

3.3.3 Nonparametric Comparisons of Two Populations

In many cases, assumptions on distributional characteristics are difficult to verify or difficult to satisfy for both populations. In this case, several distribution-free test procedures are available that compare the shape and location of the two distributions instead of a statistical parameter (such as a mean or median). The statistical tests described below test the null hypothesis "H_0: the distributions of population 1 and population 2 are identical (or, the site is not more contaminated than background)" versus the alternative hypothesis "H_A: part of the distribution of population 1 is located to the right of the distribution of population 2 (or the site is more contaminated than background)." Because of the structure of the hypothesis tests, the labeling of populations 1 and 2 is of importance. For most environmental applications, population 1 is the area of interest (i.e., the potentially contaminated area) and population 2 is the reference area.

There is no formal statistical parameter of interest in the hypotheses stated above. However, the concept of false rejection and false acceptance error rates still applies.

3.3.3.1 The Wilcoxon Rank Sum Test

PURPOSE

The Wilcoxon rank sum test can be used to compare two population distributions based on m independent random samples $X_1, X_2, \ldots, X_m$ from the first population, and n independent random samples $Y_1, Y_2, \ldots, Y_n$ from the second population. When applied with the Quantile test (Section 3.3.3.2), the combined tests are most powerful for detecting true differences between two population distributions.

ASSUMPTIONS AND THEIR VERIFICATION

The validity of the random sampling and independence assumptions should be verified by review of the procedures used to select the sampling points. The two underlying distributions are assumed to have the same shape and dispersion, so that one distribution differs by some fixed amount (or is increased by a constant) when compared to the other distribution. For large samples, to test whether both site distributions have approximately the same shape, one can create and compare histograms for the samples.

LIMITATIONS AND ROBUSTNESS

The Wilcoxon rank sum test may produce misleading results if many data values are the same. When values are the same, their relative ranks are the same, and this has the effect of diluting the statistical power of the Wilcoxon rank sum test. Estimated concentrations should be reported for data below the detection limit, even if these estimates are negative, because their relative magnitude to the rest of the data is of importance. An important advantage of the Wilcoxon rank sum test is its partial robustness to outliers, because the analysis is conducted in

terms of rankings of the observations. This limits the influence of outliers because a given data point can be no more extreme than the first or last rank.

SEQUENCE OF STEPS

Directions and an example for the Wilcoxon rank sum test are given in Box 3-20 and Box 3-21. However, if a relatively large number of samples have been taken, it is more efficient in terms of statistical power to use a large sample approximation to the Wilcoxon rank sum test (Box 3-22) to obtain the critical values of W.

Box 3-20: Directions for the Wilcoxon Rank Sum Test for Simple and Systematic Random Samples

Let $X_1, X_2, \ldots, X_n$ represent the n data points from population 1 and $Y_1, Y_2, \ldots, Y_m$ represent the m data points from population 2 where both n and m are less than or equal to 20. For Case 1, the null hypothesis will be that population 1 is shifted to the left of population 2 with the alternative that population 1 is either the same as or shifted to the right of population 2; Case 2 will be that population 1 is shifted to the right of population 2 with the alternative that population 1 is the same as or shifted to the left of population 2; for Case 3, the null hypothesis will be that there is no difference between the two populations and the alternative hypothesis will be that population 1 is shifted either to the right or left of population 2. If either m or n are larger than 20, use Box 3-22.

STEP 1: List and rank the measurements from both populations from smallest to largest, keeping track of which population contributed each measurement. The rank of 1 is assigned to the smallest value, the rank of 2 to the second smallest value, and so forth. If there are ties, assign the average of the ranks that would otherwise have been assigned to the tied observations.

STEP 2: Calculate R as the sum of the ranks of the data from population 1, then calculate

$$W = R - \frac{n(n+1)}{2}.$$

STEP 3: Use Table A-7 of Appendix A to find the critical value w_α (or $w_{\alpha/2}$ for Case 3). For Case 1, reject the null hypothesis if $W > nm - w_\alpha$. For Case 2, reject the null hypothesis if $W < w_\alpha$. For Case 3, reject the null hypothesis if $W > nm - w_{\alpha/2}$ or $W < w_{\alpha/2}$. If the null hypothesis is rejected, go to Step 5. Otherwise, go to Step 4.

STEP 4: If the null hypothesis (H_0) was not rejected, the power of the test or the sample size necessary to achieve the false rejection and false acceptance error rates should be calculated. For small samples sizes, these calculations are too complex for this document.

STEP 5: The results of the test could be:

1) the null hypothesis was rejected and it seems that population 1 is shifted to the right (Case 1), to the left (Case 2) or to the left or right (Case 3) of population 2.

2) the null hypothesis was not rejected and it seems that population 1 is shifted to the left (Case 1) or to the right (Case 2) of population 2, or there is no difference between the two populations (Case 3).

Box 3-21: An Example of the Wilcoxon Rank Sum Test for Simple and Systematic Random Samples

At a hazardous waste site, area 1 (cleaned using an in-situ methodology) was compared with a similar (but relatively uncontaminated) reference area, area 2. If the in-situ methodology worked, then the two sites should be approximately equal in average contaminant levels. If the methodology did not work, then area 1 should have a higher average than the reference area. The null hypothesis will be that area 1 is shifted to the right of area 2 and the alternative hypothesis will be that there is no difference between the two areas or that area 1 is shifted to the left of area 2 (Case 2). The false rejection error rate was set at 10% and the false acceptance error rate was set at 20% (β) if the difference between the areas is 2.5 ppb. Seven random samples were taken from area 1 and eight samples were taken from area 2:

Area 1	Area 2
17, 23, 26, 5	16, 20, 5, 4
13, 13, 12	8, 10, 7, 3

STEP 1: The data listed and ranked by size are (Area 1 denoted by *):

Data (ppb):	3,	4,	5,	5*,	7,	8,	10,	12*,	13*,	13*,	16,	17*,	20,	23*, 26*
Rank:	1,	2,	3.5,	3.5*,	5,	6,	7,	8*,	9.5*,	9.5*	11,	12*,	13,	14*, 15*

STEP 2: R = 3.5 + 8 + 9.5 + 9.5 + 12 + 14 + 15 = 71..5. W = 71.5 - 7(7 + 1)/2 = 43.5

STEP 3: Using Table A-7 of Appendix A, $\alpha = 0.10$ and $W_\alpha = 17$. Since 43.5 > 17, do not reject the null hypothesis.

STEP 4: The null hypothesis was not rejected and it would be appropriate to calculate the probable power of the test. However, because the number of samples is small, extensive computer simulations are required in order to estimate the power of this test which is beyond the scope of this guidance.

STEP 5: The null hypothesis was not rejected. Therefore, it is likely that there is no difference between the investigated area and the reference area, although the statistical power is low due to the small sample sizes involved.

Box 3-22: Directions for the Large Sample Approximation to the Wilcoxon Rank Sum Test for Simple and Systematic Random Samples

Let $X_1, X_2, \ldots, X_n$ represent the n data points from population 1 and $Y_1, Y_2, \ldots, Y_m$ represent the m data points from population 2 where both n and m are greater than 20. For Case 1, the null hypothesis will be that population 1 is shifted to the left of population 2 with the alternative that population 1 is the same as or shifted to the right of population 2; for Case 2, the null hypothesis will be that population 1 is shifted to the right of population 2 with the alternative that population 1 is the same as or shifted to the left of population 2; for Case 3, the null hypothesis will be that there is no difference between the populations and the alternative hypothesis will be that population 1 is shifted either to the right or left of population 2.

STEP 1: List and rank the measurements from both populations from smallest to largest, keeping track of which population contributed each measurement. The rank of 1 is assigned to the smallest value, the rank of 2 to the second smallest value, and so forth. If there are ties, assign the average of the ranks that would otherwise have been assigned to the tied observations.

STEP 2: Calculate W as the sum of the ranks of the data from population 1.

STEP 3: Calculate $w_p = \frac{mn}{2} + Zp\sqrt{mn(n + m + 1)/12}$ where p = 1 - α for Case 1, p = α for Case 2, and z_p is the pth percentile of the standard normal distribution (Table A-1 of Appendix A). For Case 3, calculate both $w_{\alpha/2}$ (p = α/2) and $w_{1-\alpha/2}$ (p = 1 - α/2).

STEP 4: For Case 1, reject the null hypothesis if $W > w_{1-\alpha}$. For Case 2, reject the null hypothesis if $W < w_{\alpha}$. For Case 3, reject the null hypothesis if $W > w_{1-\alpha/2}$ or $W < w_{\alpha/2}$. If the null hypothesis is rejected, go to Step 6. Otherwise, go to Step 5.

STEP 5: If the null hypothesis (H_0) was not rejected, calculate either the power of the test or the sample size necessary to achieve the false rejection and negative error rates. If only one false acceptance error rate (β) has been specified (at δ_1), it is possible to calculate the sample size that achieves the DQOs, assuming the true mean and standard deviation are equal to the values estimated from the sample, instead of calculating the power of the test. If m and n are large, calculate:

$$m^* = n^* = \frac{2s^2(z_{1-\alpha} + z_{1-\beta})^2}{(\delta_1 - \delta_0)^2} + (0.25)z_{1-\alpha}^2$$

where z_p is the pth percentile of the standard normal distribution (Table A-1 of Appendix A). If $1.16m^* \leq m$ and $1.16n^* \leq n$, the false acceptance error rate has been satisfied.

STEP 6: The results of the test could be:

1) the null hypothesis was rejected, and it seems that population 1 is shifted to the right (Case 1), to the left (Case 2) or to the left or right (Case 3) of population 2.

2) the null hypothesis was not rejected, the false acceptance error rate was satisfied, and it seems that population 1 is shifted to the left (Case 1) or to the right (Case 2) of population 2, or there is no difference between the two populations (Case 3).

3) the null hypothesis was not rejected, the false acceptance error rate was not satisfied, and it seems that population 1 is shifted to the left (Case 1) or to the right (Case 2) of population

3.3.3.2 The Quantile Test

PURPOSE

The Quantile test can be used to compare two populations based on the independent random samples $X_1, X_2, \ldots, X_m$ from the first population and $Y_1, Y_2, \ldots, Y_n$ from the second population. When the Quantile test and the Wilcoxon rank sum test (Section 3.3.3.1) are applied together, the combined tests are the most powerful at detecting true differences between two populations. The Quantile test is useful in detecting instances where only parts of the data are different rather than a complete shift in the data. It essentially looks at a certain number of the largest data values to determine if too many data values from one population are present to be accounted for by pure chance.

ASSUMPTIONS AND THEIR VERIFICATION

The Quantile test assumes that the data $X_1, X_2, \ldots, X_m$ are a random sample from population 1, and the data $Y_1, Y_2, \ldots, Y_n$ are a random sample from population 2, and the two random samples are independent of one another. The validity of the random sampling and independence assumptions is assured by using proper randomization procedures, either random number generators or tables of random numbers. The primary verification required is to review the procedures used to select the sampling points. The two underlying distributions are assumed to have the same underlying dispersion (variance).

LIMITATIONS AND ROBUSTNESS

The Quantile test is not robust to outliers. In addition, the test assumes either a systematic (e.g., a triangular grid) or simple random sampling was employed. The Quantile test may not be used for stratified designs. In addition, exact false rejection error rates are not available, only approximate rates.

SEQUENCE OF STEPS

The Quantile test is difficult to implement by hand. Therefore, directions are not included in this guidance but the DataQUEST software (EPA, 1996) can be used to conduct this test. However, directions for a modified Quantile test that can be implemented by hand are contained in Box 3-23 and an example is given in Box 3-24.

Box 3-23: Directions for a Modified Quantile Test for Simple and Systematic Random Samples

Let there be 'm' measurements from population 1 (the reference area or group) and 'n' measurement from population 2 (the test area or group). The Modified Quantile test can be used to detect differences in shape and location of the two distributions. For this test, the significance level (α) can either be approximately 0.10 or approximately 0.05. The null hypothesis for this test is that the two population are the same (i.e., the test group is the same as the reference group) and the alternative is that population 2 has larger measurements than population 1 (i.e., the test group has larger values than the reference group).

STEP 1:	Combine the two samples and order them from smallest to largest keeping track of which sample a value came from.
STEP 2:	Using Table A-13 of Appendix A, determine the critical number (C) for a sample size n from the reference area, sample size m from the test area using the significance level α. If the Cth largest measurement of the combined population is the same as others, increase C to include all of these tied values.
STEP 3:	If the largest C measurements from the combined samples are all from population 2 (the test group), then reject the null hypothesis and conclude that there are differences between the two populations. Otherwise, the null hypothesis is not rejected and it appears that there is no difference between the two populations.

3.3.4 Comparing Two Medians

Let $\tilde{\mu}_1$ represent the median of population 1 and $\tilde{\mu}_2$ represent the median of population 2. The hypothesis considered in this section are:

Case 1: H_0: $\tilde{\mu}_1 - \tilde{\mu}_2 \leq \delta_0$ vs. H_A: $\tilde{\mu}_1 - \tilde{\mu}_2 > \delta_0$; and

Case 2: H_0: $\tilde{\mu}_1 - \tilde{\mu}_2 \geq \delta_0$ vs. H_A: $\tilde{\mu}_1 - \tilde{\mu}_2 < \delta_0$.

An example of a two-sample test for the difference between two population medians is comparing the median contaminant level at a Superfund site to the median of a background site. In this case, δ_0 would be zero.

The median is also the 50th percentile, and, therefore, the methods described in Section 3.3.2 for percentiles and proportions may be used to test hypotheses concerning the difference between two medians by letting $P_1 = P_0 = 0.50$. The Wilcoxon rank sum test (Section 3.3.3.1) is also recommended for comparing two medians. This test is more powerful than those for proportions for symmetric distributions.

to departures from normality. With long-tailed distributions, the test too often rejects equality (homogeneity) of the variances.

Bartlett's test requires the calculation of the variance for each sample, then calculation of a statistic associated with the logarithm of these variances. This statistic is compared to tables and if it exceeds the tabulated value, the conclusion is that the variances differ as a complete set. It does *not* mean that one is significantly different from the others, nor that one or more are larger (smaller) than the rest. It simply implies the variances are unequal as a group. Directions for Bartlett's test are given in Box 4-24 and an example is given in Box 4-25.

4.5.4 Levene's Test for the Equality of Two or More Variances

Levene's test provides an alternative to Bartlett's test for homogeneity of variance (testing for differences among the dispersions of several groups). Levene's test is less sensitive to departures from normality than Bartlett's test and has greater power than Bartlett's for non-normal data. In addition, Levene's test has power nearly as great as Bartlett's test for normally distributed data. However, Levene's test is more difficult to apply than Bartlett's test since it involves applying an analysis of variance (ANOVA) to the absolute deviations from the group means. Directions and an example of Levene's test are contained in Box 4-26 and Box 4-27, respectively.

Box 4-24: Directions for Bartlett's Test

Consider k groups with a sample size of n_i for each group. Let N represent the total number of samples, i.e., let $N = n_1 + n_2 + \ldots + n_k$. For example, consider two wells where 4 samples have been taken from well 1 and 3 samples have been taken from well 2. In this case, k = 2, $n_1 = 4$, $n_2 = 3$, and N = 4 + 3 = 7.

STEP 1: For each of the k groups, calculate the sample variances, s_i^2 (Section 2.2.3).

STEP 2: Compute the pooled variance across groups: $s_p^2 = \frac{1}{(N-k)} \sum_{i=1}^{k} (n_i - 1) s_i^2$

STEP 3: Compute the test statistic: $TS = (N - k) \ln(s_p^2) - \sum_{i=1}^{k} (n_i - 1) \ln(s_i^2)$

where "ln" stands for natural logarithms.

STEP 4: Using a chi-squared table (Table A-8 of Appendix A), find the critical value for χ^2 with (k-1) degrees of freedom at a predetermined significance level. For example, for a significance level of 5% and 5 degrees of freedom, $\chi^2 = 11.1$. If the calculated value (*TS*) is greater than the tabulated value, conclude that the variances are not equal at that significance level.

Box 4-26: Directions for Levene's Test

Consider k groups with a sample size of n_i for the ith group. Let N represent the total number of samples, i.e., let $N = n_1 + n_2 + \ldots + n_k$. For example, consider two wells where 4 samples have been taken from well 1 and 3 samples have been taken from well 2. In this case, k = 2, $n_1 = 4$, $n_2 = 3$, and N = 4 + 3 = 7.

STEP 1: For each of the k groups, calculate the group mean, $\bar{x}_i$ (Section 2.2.2), i.e., calculate:

$$\bar{X}_1 = \frac{1}{n_1}\sum_{j=1}^{n_1} x_{1j}, \quad \bar{X}_2 = \frac{1}{n_2}\sum_{j=1}^{n_2} x_{2j}, \quad \ldots, \quad \bar{X}_k = \frac{1}{n_k}\sum_{j=1}^{n_k} x_{kj}.$$

STEP 2: Compute the absolute residuals $z_{ij} = |X_{ij} - \bar{X}_i|$ where X_{ij} represents the jth value of the ith group. For each of the k groups, calculate the means, $\bar{z}_i$, of these residuals, i.e., calculate:

$$\bar{z}_1 = \frac{1}{n_1}\sum_{j=1}^{n_1} z_{1j}, \quad \bar{z}_2 = \frac{1}{n_2}\sum_{j=1}^{n_2} z_{2j}, \quad \ldots, \quad \bar{z}_k = \frac{1}{n_k}\sum_{j=1}^{n_k} z_{kj}.$$

Also calculate the overall mean residual as $\bar{z} = \frac{1}{N}\sum_{i=1}^{k}\sum_{j=1}^{n_i} z_{ij} = \frac{1}{N}\sum_{i=1}^{k} n_i \bar{z}_i$.

STEP 3: Compute the following sums of squares for the absolute residuals:

$$SS_{TOTAL} = \sum_{i=1}^{k}\sum_{j=1}^{n_i} z_{ij}^2 - \frac{\bar{z}}{N}, \quad SS_{GROUPS} = \sum_{i=1}^{k}\frac{\bar{z}_i^2}{n_i} - \frac{\bar{z}}{N},$$ and $SS_{ERROR} = SS_{TOTAL} - SS_{GROUPS}$.

STEP 4: Compute $f = \dfrac{SS_{GROUPS}/(k-1)}{SS_{ERROR}/(N-k)}$

STEP 5: Using Table A-9 of Appendix A, find the critical value of the F-distribution with (k-1) numerator degrees of freedom, (N-k) denominator degrees of freedom, and a desired level of significance (α). For example, if α = 0.05, the numerator degrees of freedom is 5, and the denominator degrees of freedom is 18, then using Table A-9, F = 2.77. If f is greater than F, reject the assumptions of equal variances.

Box 4-27: An Example of Levene's Test

Four months of data on arsenic concentration were collected from six wells at a Superfund site. This data set is shown in the table below. Before analyzing this data, it is important to determine if the variances of the six wells are equal. Levene's test will be used to make this determination.

STEP 1: The group mean for each well ($\bar{x}_i$) is shown in the last row of the table below.

Arsenic Concentration (ppm)						
Month	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6
1	22.90	2.00	2.0	7.84	24.90	0.34
2	3.09	1.25	109.4	9.30	1.30	4.78
3	35.70	7.80	4.5	25.90	0.75	2.85
4	4.18	52.00	2.5	2.00	27.00	1.20
Group Means	$\bar{x}_1$=16.47	$\bar{x}_2$=15.76	$\bar{x}_3$=29.6	$\bar{x}_4$=11.26	$\bar{x}_5$=13.49	$\bar{x}_6$=2.29

STEP 2: To compute the absolute residuals z_{ij} in each well, the value 16.47 will be subtracted from Well 1 data, 15.76 from Well 2 data, 29.6 from Well 3 data, 11.26 from Well 4 data, 13.49 from Well 5 data, and 2.29 from Well 6 data. The resulting values are shown in the following table with the new well means ($\bar{z}_i$) and the total mean $\bar{z}$.

Residual Arsenic Concentration (ppm)						
Month	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6
1	6.43	13.76	27.6	3.42	11.41	1.95
2	13.38	14.51	79.8	1.96	12.19	2.49
3	19.23	7.96	25.1	14.64	12.74	0.56
4	12.29	36.24	27.1	9.26	13.51	1.09
Residual Means	$\bar{z}_1$=12.83	$\bar{z}_2$=18.12	$\bar{z}_3$=39.9	$\bar{z}_4$=7.32	$\bar{z}_5$=12.46	$\bar{z}_6$=1.52
Total Residual Mean $\bar{z}$ = (1/6)(12.83 + 18.12 + 39.9 + 7.32 + 12.46 + 1.52) = 15.36						

STEP 3: The sum of squares are: SS_{TOTAL} = 6300.89, SS_{WELLS} = 3522.90, and SS_{ERROR} = 2777.99.

STEP 4: $$f = \frac{SS_{WELLS}/(k-1)}{SS_{ERROR}/(N-k)} = \frac{3522.9/(6-1)}{2777.99/(24-6)} = 4.56$$

STEP 5: Using Table A-9 of Appendix A, the F statistic for 5 and 18 degrees of freedom with α = 0.05 is 2.77. Since f=4.56 exceeds $F_{.05}$=2.77, the assumption of equal variances should be rejected.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

INTEROFFICE COMMUNICATION

September 30, 1993

TO: Environmental Response Division Staff

FROM: Alan J. Howard, Chief, Environmental Response Division

SUBJECT: MERA Operational Memorandum #15: Default Type A Cleanup Criteria

In order to facilitate cleanup decisions at sites at which naturally occurring metals may be of concern, the following acceptable default Type A soil cleanup criteria have been established. These values are based on analysis of the database for the Michigan Background Soil Survey (April 1991) which is maintained by Waste Management Division (WMD). They represent the mean plus one standard deviation for WMD data from combined clay, topsoil, and sand categories. The values are presented in two significant figures. Data should be rounded to two significant figures for comparison.

Table 1: ACCEPTABLE DEFAULT VALUES TYPE A SOIL CLEANUP CRITERIA

Substance	Acceptable Concentration (mg/Kg)	Substance	Acceptable Concentration (mg/Kg)
Aluminum	6900	Iron	12000
Arsenic	5.8	Mercury	0.13
Barium	75	Lithium	9.8
Cadmium	1.2	Manganese	440
Cobalt	6.8	Nickel	20
Chromium	18	Lead	21
(total)	32	Selenium	0.41
Copper	0.39	Silver	1.0
Cyanide		Zinc	47

The default values apply as follows:

1. If measured concentrations at a site do not exceed the values listed in Table 1, site specific samples to establish background are not required.

2. The values apply to all soil types, statewide.

3. It is acceptable to establish site-specific background concentration higher than the default values. Such sampling should be conducted according to requirements in existence before the issuance of this memorandum. Comparison of site values is made against the mean plus three standard deviations calculated from background samples as

provided for in existing ERD guidance regarding verification of soil remediation.

4. Staff also may approve Type A cleanups based on a regionally proximate background value higher than the default values. Comparison should be made as in #3, above.

This memorandum is intended to provide guidance to Division staff to foster consistent application of the Michigan Environmental Response Act (1982 PA 307, as amended) and the Administrative Rules promulgated thereunder. This document is not intended to convey any rights to any parties or create any duties or responsibilities under law. This document and matters addressed herein are subject to revision.

Any questions about this memorandum should be directed to Bill Iversen at 517-373-0907.

rev. 0
cc: Dennis Drake, Air Quality Division
Bob Miller, Surface Water Quality Division
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