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REMEDIAL INVESTIGATION
OPERABLE UNIT 2
FOR
MARINE CORPS AIR STATION
CHERRY POINT, NORTH CAROLINA

Volume I - Text, Appendices A and B

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Atlantic Division
Environmental Restoration Branch, Code 1823
Naval Facilities Engineering Command
1510 Gilbert Street
Norfolk, Virginia 23511-2699

Submitted by:
Brown & Root Environmental
993 Old Eagle School Road, Suite 415
Wayne, Pennsylvania 19087-1710

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LIST OF ACRONYMS AND ABBREVIATIONS

ABS	absorption rate; absorption efficiency
ACGIH	American Conference of Governmental Hygienists
AF	soil-to-skin adherence factor; absorption fraction
Ag	silver
Al	aluminum
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
AT	averaging time (period of exposure)
atm	atmosphere
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
B&R	Brown & Root
Ba	barium
BB	biased boring
BCF	bioconcentration factor
BEHP	bis(2-ethylhexyl)phthalate
BGS	below ground surface
BOD_5	biochemical oxygen demand (5-day)
BOQ	Base Officer's Quarters
BTEX	benzene, toluene, ethylbenzene, and xylene
BTV	Benchmark Toxicity Value
BW	body weight
C_a	air concentration
C_f	fish concentration
C_{gw}	groundwater concentration
C_{max}	maximum concentration
C_s	soil or sediment concentration
C_{sw}	surface water concentration
CAPCOA	California Air Pollution Control Officers Association
Cd	cadmium
CEC	cation exchange capacity
CERCLA	Comprehensive Environmental Restoration, Compensation, and Liability Act
CCME	Canadian Council of Minsters of the Environment
CF	conversion factor
CLP	Contract Laboratory Program
cm	centimeter
CNO	Chief of Naval Operations
CNS	central nervous system
CO_2	carbon dioxide
COC	chemical of concern
COE	U.S. Army Corps of Engineers
COPC	chemical of potential concern
cps	counts per second
Cr	chromium
CR	contact rate
CRAVE	Carcinogenic Risk Assessment Verification Endeavor
CRDL	Contract Required Detection Limit
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CTE	Central Tendency Exposure

CWA	Clean Water Act
d	day
D_s	shower duration
D_t	total time in bathroom
DBH	diameter at breast height
DCA	dichloroethane
DCB	dichlorobenzene
DCE	dichloroethene
DEX	dermally absorbed dose
DL	detection limit
DNA	deoxyribonucleic acid
DOC	dissolved organic carbon
DRMO	Defense Reutilization and Marketing Office
DWEL	Drinking Water Equivalent Level
ECAO	Environmental Criteria and Assessment Office
ECG	electrocardiograph
ECOSAR	Exotoxicity of Industrial Chemicals Based on Structure Activity Relationships
ED	exposure duration
EF	exposure frequency
EP	equilibrium partitioning
ERA	Ecological Risk Assessment
ER-L	Effects Range-Low
ER-M	Effects Range-Medium
ET	exposure time
F	food consumed
Fa	Biotranfer factor
FA	animals as percentage of diet
FAC	Facultative
FACU	Facultative Upland
FACW	Facultative Wetland
FI	fractional intake
Fi	fraction ingested
FMF	Fleet Marine Force
FOL	Field Operations Leader
FS	Feasibility Study
FSSG	Force Service Support Group
ft	feet; foot
FV	vegetation as percentage of diet
FY	fiscal year
g	gram
GC/MS	gas chromatography/mass spectrometry
GI	gastrointestinal
GW	groundwater
HA	Health Advisory
ha	hectare
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Table
Hg	mercury
HI	Hazard Index
HQ	Hazard Quotient
HNUS	Halliburton NUS Corporation
HP	Hydropunch
hr	hour
IAS	Initial Assessment of Sites

ICR	incremental cancer risk
IDW	investigation-derived waste
IEX	inhalation exposure dose; ingestional exposure dose
IR	inhalation rate; ingestion rate
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
IEUBK	Integrated Exposure Uptake Biokinetic
IWTP	Industrial Wastewater Treatment Plant
K	mass transfer coefficient
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol water partition coefficient
Kd	distribution coefficient
kg	kilogram
L	liter
LC	lethal concentration
LD	lethal dose
LOAEL	lowest-observed-adverse-effect-level
LS	leachate seep sediment; leachate seep soil
LW	leachate seep water
m	meter
MAW	Marine Aircraft Wing
MCAS	Marine Corps Air Station
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mg	milligram
min	minute
mL	milliliter
mm	millimeter
Mn	manganese
mol	mole
MSL	mean sea level
MW	monitoring well
NA	not analyzed; not available; not applicable
NAAQS	National Ambient Air Quality Standard
NADEP	Naval Aviation Depot
Navy	Department of the Navy
NB	no benchmark
NC	not calculated
NCAC	North Carolina Administrative Code
NCDEHNR	North Carolina Department of Environmental Health and Natural Resources
NCNHP	North Carolina Natural Heritage Program
ND	not detected
NEESA	Naval Energy and Environmental Support Activity
NM	not measured
NR	not regulated; not reported
NTU	nephelometric turbidity unit
NERI	Northeast Research Institute, Inc.
NIOSH	National Institute for Occupational Health and Safety
NOAL	no-observed-adverse-effect-level
NOAA	National Oceanographic and Atmospheric Administration
NOEL	no-observed-effect-level
NPL	National Priorities List
OBL	Obligate Wetland
OERR	Office of Emergency and Remedial Response

OPPTS	Office of Prevention, Pesticides, and Toxic Substances
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAH	polynuclear aromatic hydrocarbon; polycyclic aromatic hydrocarbon
PC	dermal permeability constant; predicted concentration
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PD	predicted dose
PID	photoionization detector
POL	petroleum, oil, and lubricants
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
R	rejected data
R_a	air exchange rate
RAGS	Risk Assessment Guidance for Superfund
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RFI	RCRA Facility Investigation
RGO	Remedial Goal Options
RI	Remedial Investigation
RIIR	Remedial Investigation Interim Report
ROD	Record of Decision
RME	Reasonable Maximum Exposure
RPF	Relative Potency Factor
S	volatile chemical generation rate; sulfur
SA	skin surface area available for contact; percentage of diet that equals soil
sec	second
SB	soil boring
SCS	Soil Conservation Service
SD	sediment
Se	selenium
SF	scaling factor
SG	staff gauge
SO	soil
SOP	standard operating procedure
SOW	Statement of Work
SS	surface soil
SSL	soil screening level
STP	sewage treatment plant
SW	surface water
TAL	Target Analyte List
TBC	to be considered
TCA	1,1,1-trichloroethane
TCE	trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDM	Technical Direction Memorandum
THQ	Target Hazard Quotient
TOC	total organic carbon
TOX	total organic halogens

TP	test pit
TPH	total petroleum hydrocarbons
TR	Target Risk
TSS	total suspended solids
UCL	Upper Confidence Limit
UF	uncertainty factor
UPL	Upland
USC	United States Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
V	vanadium
VOC	volatile organic compound
WI	water intake
WR	weight of receptor
yr	year
α	alpha
β	beta
δ	delta
γ	gamma
μg	microgram
^{o}C	degrees Celsius
^{o}F	degrees Fahrenheit

EXECUTIVE SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The objective of the RI/FS process is to gather and evaluate information sufficient to select the most appropriate remedy for a given site based on an informed risk management decision making process. This Remedial Investigation (RI) report is the first of two documents that will provide the basis for selecting a remedial alternative for Operable Unit (OU) 2 at Marine Corps Air Station (MCAS) Cherry Point, North Carolina. The objective of the RI was to collect adequate chemical analytical data to determine whether contaminants are present at OU2, and if so, to determine whether those contaminants present an unacceptable risk to human health or the environment. An evaluation of the analytical data and the risk assessment revealed no unacceptable risks to human health under current land uses. However, exposure to contaminated groundwater and contaminated soil presents unacceptable risks to adult and child receptors only under a hypothetical future residential scenario. In addition, groundwater contaminant concentrations exceed state groundwater quality standards. Remedial action is required at OU2 to address these potential threats to human health and the environment. The Feasibility Study (FS) will be conducted to develop and evaluate potential remedial alternatives that address unacceptable risks to human health and the environment that are identified in this RI report. The FS will focus on evaluating cleanup technologies for soil and groundwater contamination.

SITE OVERVIEW

OU2 is located in the west-central portion of MCAS Cherry Point, on the east bank of Slocum Creek, which flows to the north (Figure 1-2). OU2 consists of Site 10 - Old Sanitary Landfill, Site 44A - Former Sludge Application Area, Site 46 - Polishing Ponds No. 1 and No. 2, and Site 76 - Vehicle Maintenance Area (Hobby Shop) (Figure 1-3 and Plate 1 in Volume V).

- Site 10 is a 40-acre sanitary landfill that served as the primary disposal site at the Air Station from 1955 until the early- to mid-1980s. Site 10 is divided by Turkey Gut (a small stream), which flows westward into Slocum Creek. Former sludge impoundments that were closed in the mid-1980s are also located in the north-central portion of Site 10. A fenced, gravel area formerly used to store drums of petroleum products is also located at Site 10.

- Site 44A consists of an area in the north-central portion of Site 10 where sludge from the sewage treatment plant was applied.

- Site 46 consists of two inactive unlined ponds, approximately 12 feet deep, that were used as aeration basins for wastewater from the sewage treatment plant. The ponds are located north of Site 10.

- Site 76 is located south of Site 10 and consists of a building and parking lot where personal vehicles are repaired.

Investigations were conducted at OU2 from 1981 through 1996. Activities included reviewing aerial photographs; conducting a soil-gas survey and magnetometer and terrain conductivity studies; drilling soil borings; excavating test pits; installing permanent and temporary monitoring wells; measuring groundwater levels; and sampling and analyzing surface and subsurface soil, groundwater, surface water, sediment, and leachate seeps.

PHYSICAL FEATURES

The ground surface elevation varies from approximately 30 feet mean sea level (MSL) in the central portions of the landfill areas to approximately 1.5 feet MSL at Slocum Creek. The ground surface is relatively flat in these central areas with smaller areas of uneven terrain. The ground surface adjacent to Slocum Creek and Turkey Gut generally has moderate to steep slopes. The berms of the Site 46 polishing ponds have an elevation of approximately 22 feet MSL. The ground surface west of the ponds slopes steeply downward to approximately 5 feet MSL, then becomes flat and heavily vegetated near Slocum Creek. The ground surface south of the ponds slopes moderately towards the Site 10 landfill area. The areas east and northeast of the ponds are relatively flat. Sites 10, 44A, and 46 are inactive. The only site activities occur at Site 76, where Air Station personnel can work on their private vehicles.

GEOLOGY/HYDROGEOLOGY

Based on the site investigations, a variety of subsurface characteristics were identified. The geological and hydrogeological units that exist beneath OU2 are listed from shallowest to deepest:

- Fill material
- Undifferentiated surficial formation and surficial aquifer
- Yorktown confining unit
- Yorktown aquifer
- Pungo River confining unit
- Pungo River aquifer

- Upper Castle Hayne confining unit
- Upper Castle Hayne aquifer
- Lower Castle Hayne confining unit
- Lower Castle Hayne aquifer

The fill material consists of the waste materials that were buried. Underlying the fill material are alternating layers that consist of aquifers and confining units. In general, aquifers are permeable materials (sands) that contain groundwater that could be available for use. The confining layers are less permeable materials (silts and clays) that do not provide significant amounts of groundwater. Confining units tend to retard the vertical flow of groundwater from one aquifer to the next.

The primary unit of concern at OU2 is the surficial aquifer that underlies the fill material. Monitoring wells installed in the surficial aquifer indicate that this groundwater is impacted by OU2. Groundwater in the surficial aquifer was encountered at depths of 7 to 22 feet below the ground. Groundwater in the surficial aquifer flows toward, and discharges to, Turkey Gut and Slocum Creek (Figure 3-5; Plate 6 in Volume V). Underlying the surficial formation and surficial aquifer is the Yorktown confining unit, which separates the surficial aquifer from the Yorktown aquifer. Monitoring wells installed in the Yorktown aquifer indicate that only a few contaminants were detected. The contaminant concentrations in the Yorktown aquifer are lower than those found in the surficial aquifer. Groundwater in the Yorktown aquifer flows toward, and discharges to, Slocum Creek (Figure 3-6; Plate 7 in Volume V). None of the deeper units beneath OU2 were investigated. The Castle Hayne aquifers serve as a source of drinking water at the Air Station, so protecting this drinking water is important. The depth to this unit is approximately 195 feet below OU2. The Castle Hayne aquifers are separated from the surficial and Yorktown aquifers by the Pungo River and Upper Castle Hayne confining units.

INVESTIGATION RESULTS

Soil

Results for surface soil (0 to 2 feet deep) and subsurface soil (greater than 2 feet deep) samples are described below. Surface and subsurface soil sampling locations are shown on Figure 2-1 and Plate 2 (Volume V).

Surface Soil

The analytical results for surface soil are presented in Tables 4-3 and 4-25 and are summarized below:

- No particular patterns of surface soil contamination were noted. The maximum concentrations of individual chemicals were found at various locations scattered throughout OU2.

- Only a few volatile organic compounds were detected in surface soil at low concentrations (up to 20 μg/kg). The only detections that exceed background levels were found at Test Pit 15 in the southern portion of the landfill.

- One surface soil sample in the southeastern part of OU2 in Study Area C contained several polynuclear aromatic hydrocarbons with concentrations up to 360 μg/kg. These compounds were not detected in background samples; however, they were the only semivolatile organic compounds detected.

- Several pesticides were detected in the surface soil at locations scattered throughout OU2. Some were only detected in one sample. The maximum concentrations were found north of the Site 46 ponds, in the southeastern portion of OU2 in Study Area C, and south of Study Area E. Most of the pesticides were detected in background samples, but at lower concentrations. Polychlorinated biphenyls (PCBs) were only detected in two samples. The maximum concentration was in a sample in the southeastern portion of OU2.

- Metals were more frequently detected than organics, although many of the concentrations detected were not elevated above background. Based on a comparison with background concentrations, metals of interest include cadmium, chromium, manganese, and thallium (only detected in one sample). Maximum concentrations were detected at the following locations: Test Pit 15 in Study Area E (cadmium), near Site 76 (chromium), the southwest corner of OU2 (manganese), and at Site 44A (thallium).

Subsurface Soil

The analytical results for subsurface soil are presented in Table 4-4 and are summarized below:

- Organic compounds were not detected frequently, but were detected at high concentrations in a limited number of samples.

- Fuel-type constituents, including benzene, toluene, ethylbenzene, and xylenes (BTEX), were identified in a number of samples; however, the majority of the samples analyzed for BTEX did not contain these compounds. The primary detections were scattered throughout the site. The highest concentrations of BTEX (155,280 to 617,000 μg/kg) were found in the southern portion of the landfill in areas used for fire-training exercises. Other areas with BTEX contamination include the former sludge impoundments (5,910 to 7,000 μg/kg), one boring in Study Area E (south of Turkey Gut) (4,830 μg/kg), and Study Area B in the east-central portion of OU2 (2,174 to 10,993 μg/kg) (Figure 4-1; Plate 8 in Volume V). A correlation exists in these areas between elevated detections of these contaminants in soil and the detections of these contaminants in the surficial aquifer because these volatile compounds are relatively mobile in the environment.

- Chlorinated solvents such as tetrachloroethene (PCE), trichloroethene (TCE), dichloroethene (DCE), vinyl chloride, and trichloroethane (TCA) are also relatively mobile in the environment. While not widespread, the detections in subsurface soil correlate with detections in groundwater at the former sludge impoundments (PCE at 4,200 μg/kg; TCE at 800 to 880 μg/kg; TCA 2,500 μg/kg), Study Area E (DCE at 6 to 4,700 μg/kg; vinyl chloride at 490 μg/kg), and Study Area B (PCE at 38 μg/kg) (Figure 4-2; Plate 9 in Volume V).

- Although ketones were detected in several subsurface soil samples, they were not frequently detected in the most recent groundwater samples. The compounds with the highest concentrations in soil were 2-butanone (16,000 μg/kg at Test Pit 2 in Study Area B) and acetone (5,300 μg/kg near Test Pit 19 in the southern portion of the landfill).

- High concentrations of phenolic compounds were detected in the former sludge impoundment area. These compounds, and the maximum concentrations, include phenol (12,000 μg/kg), 2,4-dimethylphenol (4,100 μg/kg), and 4-methylphenol (27,000 μg/kg). These compounds were also detected in groundwater in this area.

- Several PAHs were detected in the southern portion of the landfill near Test Pit 19. The highest concentrations detected were for fluorene (20,000 μg/kg), phenanthrene (90,000 μg/kg), and naphthalene (39,000 μg/kg). PAHs, which are relatively immobile in the environment, were rarely detected in groundwater.

- Pesticides were not frequently detected, and there was no apparent pattern to the detections. Dieldrin and 4,4'-DDD were detected most frequently (4 samples) at maximum concentrations of 53 μg/kg (former sludge impoundment area) and 3.5 μg/kg (southern portion of the landfill near Test Pit 18), respectively.

- Many metals were detected in subsurface soil samples. Metals were not widespread or common contaminants in subsurface soil; however, a limited number of locations were found with high concentrations (hot spots). Copper, lead, and zinc were detected frequently at concentrations greater than background and were most widespread (Figures 4-3, 4-4, and 4-5; Plates 10, 11, and 12 in Volume V). No pattern was discerned to the detections of metals.

Groundwater

Results of groundwater samples, collected in 1994 and 1996 from wells screened in the surficial aquifer and the Yorktown aquifer (Figure 2-1; Plate 2 in Volume V), are described below. The state groundwater classification for both of these aquifers is Class GA (existing or potential source of drinking water for humans).

Surficial Aquifer

A summary of the analytical results for the surficial aquifer is presented in Table 4-27 and described below:

- Groundwater contains many volatile and semivolatile organic compounds and pesticides at concentrations that exceed state narrative or numerical groundwater quality standards. State narrative standards indicate that any detection is considered an exceedance of the state standard, if no numerical standard exists for a man-made chemical. Specific compounds that exceed the standards are highlighted in Table 4-27. Volatile organic contaminants are the most prevalent. Benzene, trichloroethene, and vinyl chloride were the compounds that most often exceeded the state standards. Semivolatile organic compounds were not frequently detected. A number of pesticides were detected, but many occurred only in a single sample.

- Benzene levels exceed the state standard of 1 μg/l throughout most of OU2; however, benzene was not detected in every well in this general area of contamination. Overall, benzene was detected in 21 of 40 samples. The approximate area of groundwater contamination due to

benzene is shown on Figure 4-6 and Plate 13 (Volume V). The maximum concentration of benzene detected was 230 μg/L in well 10GW09 located in the southwest corner of OU2.

- Three separate areas of solvent contamination were identified containing (with the state standard listed after each): dichloroethenes (70 μg/L), tetrachloroethene (1 μg/L), trichloroethene (2.8 μg/L), and vinyl chloride (0.015 μg/L)(see Figure 4-6; Plate 13 in Volume V). One area is located downgradient of the former sludge impoundment area and extends to the south side of Turkey Gut near Study Area E. A second area is centered on Study Area B near the eastern edge of OU2. The third area is in the southwest portion of OU2.

- Three other areas have chlorobenzene concentrations that exceed the state standard of 50 μg/L (Figure 4-6; Plate 13 in Volume V). One overlaps the solvent contamination south of Turkey Gut near Study Area E. The second area is in the upstream portion of Turkey Gut near Study Area C in the southeast portion of OU2. The third area is southwest of Study Area E.

- Semivolatile organic compounds and pesticides were not detected as frequently as many of the volatile organics. However, many detections exceed the state groundwater standard, because no numerical values exist. In general, no pattern was discerned to the detections of these compounds. However, phenolic compounds were detected in groundwater downgradient of the former sludge impoundments. The same compounds were present in soil samples from this area.

- Arsenic, cadmium, iron, and manganese were the only metals detected that exceeded the state groundwater standards.

- Iron and manganese were the metals most frequently detected at concentrations that exceeded the state groundwater standards of 300 μg/L and 50 μg/L, respectively. All results for iron exceeded the standard, while most for manganese exceeded the standard. Concentrations of arsenic exceeded the state standard of 50 μg/L in a small area southwest of the former sludge impoundments, in a small area in the southwest portion of OU2, and a larger area in the northwest portion of OU2 near Slocum Creek (Figure 4-6; Plate 13 in Volume V). Cadmium was only detected in two wells. The concentrations (5.2 to 6.0 μg/L) slightly exceeded the state standard of 5 μg/L.

Yorktown Aquifer

A summary of the analytical results for the Yorktown aquifer based on the most recent analytical results (1994) is presented in Table 4-28 and described below:

- Far fewer detections of organic compounds were found compared to the surficial aquifer groundwater. The only organics detected were low levels of chloroform (two wells at 1 to 2 μg/L), methylene chloride (one well at 1 μg/L), and bis(2-ethylhexyl)phthalate (one well at 25 μg/L). The detections of chloroform and bis(2-ethylhexyl)phthalate exceeded the state standards of 0.019 and 3 μg/L, respectively.

- The only metals that exceeded state groundwater standards were iron and manganese. The detections of iron exceeded the state standard of 300 μg/L for most wells. The detections of manganese exceeded the state standard of 50 μg/L for more than half the wells.

Surface Water

The results of surface water samples, collected in 1994 from Turkey Gut and Slocum Creek, are described below. The state surface water classification for Slocum Creek is Class SC saltwater. Class SC waters are classified as suitable for aquatic life propagation and maintenance of biological integrity, wildlife, secondary recreation, and any other usage except primary recreation or shellfishing for marketing purposes. The state surface water classification for Turkey Gut is Class C freshwater. Class C waters are classified as suitable for aquatic life propagation and maintenance of biological integrity, wildlife, secondary recreation, agriculture, and any other usage except for primary recreation or a source of water supply for drinking, culinary, or food processing purposes. Sample locations are shown on Figure 2-1 and Plate 2 (Volume V).

Turkey Gut

The most recent (1994) analytical results for Turkey Gut water are summarized in Table 4-29 and are discussed below:

- Although groundwater from OU2 discharges to Turkey Gut, only limited exceedances of state surface water standards were found there. Turkey Gut is not adversely affected by this discharge.

- Volatile, semivolatile, and pesticide organic compounds were detected in Turkey Gut, most only in a single sample. Most of these compounds were also detected in the surficial aquifer, which discharges to Turkey Gut. Exceedances of the state surface water standards for organics were only found in single samples (Table 4-29).

- Copper and iron were the only metals that exceeded the state surface water standards. Copper was only detected in a sample near Slocum Creek at a concentration of 25 μg/L, which exceeded the standard of 3 μg/L. During the most recent sampling event, copper was only detected in a single groundwater sample at a concentration of 1.7 μg/L. All detections of iron, including the most upstream location, exceeded the state standard of 1,000 μg/L.

Slocum Creek

The most recent (1994) analytical results for Slocum Creek water are summarized in Table 4-30 and are discussed below:

- Groundwater from OU2 and water from Turkey Gut discharge to Slocum Creek where only limited exceedances of state surface water standards were found. Slocum Creek is not adversely affected by these discharges.

- Fewer organics were detected in Slocum Creek than in Turkey Gut. Chloroform and DDD were detected in the sample collected upstream of OU2 and samples collected above and below the point where Turkey Gut flows into Slocum Creek. Therefore, OU2 is not the source of chloroform or DDD. DDD was the only organic compound that exceeded the state standard (Table 4-30). The standard was exceeded in all samples collected from Slocum Creek.

- Copper was the only metal that exceeded state surface water standards. All results for copper exceeded the state surface water standard (Table 4-30). The exceedances were found in all samples (upstream of OU2 and upstream and downstream of Turkey Gut); therefore, OU2 is not the source of this exceedance.

Sediment

Results of sediment samples, collected from Turkey Gut and Slocum Creek, are described below. The locations were the same as for surface water (Figure 2-1; Plate 1 in Volume V).

Turkey Gut

A summary of the most recent analytical results (1994) for Turkey Gut sediment is presented in Table 4-31 and described below:

- Pesticides and metals were the most frequently detected analytes.

- There was no apparent pattern to the detection of pesticides. For some pesticides (alpha- and gamma-chlordane, dieldrin, and heptachlor epoxide) the maximum concentration was detected near Slocum Creek. For other pesticides (4,4'-DDE, 4,4'-DDT, endosulfan II, endrin aldehyde, endrin ketone, and heptachlor), the maximum concentration was in the farthest upstream sample, which in some cases, was the only detection found. Some pesticides detected in sediment were not found in surface soil and/or groundwater, which normally would be the sources of site-related contaminants. Dieldrin and 4,4'-DDD were not detected in groundwater samples, and endrin ketone and heptachlor epoxide were not detected in groundwater or surface soil samples. The other pesticides were detected in surface soil; however, no major source area of pesticides was found at the site.

- The concentrations of metals in sediment do not indicate a major onsite source area. Many metals were found at concentrations within approximately two times the background soil concentration, which indicates that the sediment results are similar to those for natural soil.

Slocum Creek

A summary of the most recent analytical results (1994) for Slocum Creek sediment is presented in Table 4-32 and described below:

- Fewer organic compounds were detected in sediment from Slocum Creek than from Turkey Gut. Organic compounds detected were 2-butanone, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, alpha-chlordane, 4,4'-DDD, and 4,4'-DDE. Except for di-n-butylphthalate, these compounds were only detected in one sample. No apparent pattern exists to the detections of organics. The maximum concentrations of several organics (2-butanone, di-n-butylphthalate, and 4,4'-DDD) were in the sample upstream of OU2, so are not site-related. The maximum concentrations of other organics (bis[2-ethylhexyl]phthalate, alpha-chlordane, and 4,4'-DDE) were in the sample collected downstream of Turkey Gut. No major source area for these compounds was detected on site.

- No upgradient or upslope areas were identified as potential sources of metals detected in Slocum Creek sediment. As at Turkey Gut, many of the sediment concentrations were similar to levels that would be found in natural soil.

Leachate Seeps

Results of leachate seeps samples, collected in 1995 in ponded water and areas where water was discharging from the ground, are described below. Leachate seep sampling locations are shown on Figure 2-1 and Plate 2 (Volume V). The most recent analytical results (1995) are summarized in Tables 4-22 (water) and 4-23 (soil/sediment at dry seep locations) and are described below:

- Volatile organic compounds and pesticides were detected in low concentrations in leachate seep water. Each compound was only detected in one of the three samples. Three volatile organics (benzene, chloroethane, and vinyl chloride) were only detected in one sample. One volatile organic (xylene) and the pesticides (aldrin, gamma-BHC, 4,4'-DDT, dieldrin, endrin, and heptachlor) were detected in a different sample. One sample did not contain any organic compounds. The maximum concentration for volatile organics was 5 μg/L (chloroethane). The maximum concentration of pesticides was for 4,4'-DDT (0.17 μg/L)

- A low-flowing leachate seep (OU2LW01) contained the highest concentrations of metals. Many of the concentrations were higher than those detected in background groundwater samples and samples collected from the surficial aquifer. Therefore, for some analytes, the discharge has been in contact with buried waste materials and/or contaminated subsurface soil.

- The analytical results for metals from dry leachate seeps were similar to those for surface soils.

Polishing Pond Sediment

The results of sediment (sludge) samples, collected in 1994 from the Site 46 polishing ponds and soil samples from the natural material that underlies the ponds, are described below. Sampling locations are shown on Figure 2-1 and Plate 2 (Volume V). The results are summarized in Table 4-24.

- The pond sludge contains a number of organic chemicals, while the underlying soil is relatively free of organic contaminants. Pond sludge samples contained five volatile organics, five semivolatile organics, and ten pesticides; however, not every sample contained all compounds. In contrast, one volatile organic, two semivolatile organics, and two pesticides were detected,

at lower concentrations, in the underlying soil. The concentrations detected in the underlying soil were consistent with background (natural) soil concentrations.

- Metals were also detected in the pond sludge and underlying soil. The concentrations were consistently higher in the pond sludge. The concentrations in the underlying soil were similar to background soil concentrations.

RISK ASSESSMENT

The following sections present summaries of the human health risk assessment (Section 6) and the ecological risk assessment (Section 7).

Baseline Human Health Risk Assessment

A human health risk assessment was conducted using the most recent USEPA guidance. After chemicals of potential concern (COPCs) were compiled for each medium (groundwater, soil, surface water), the maximum concentrations for each were compared to background concentrations and USEPA screening levels based on protection of human health (residential setting). If the maximum concentrations exceeded background and the screening level, the chemical was selected as a COPC and retained for further evaluation. The COPCs identified at OU2 are presented in Table ES-1.

The next step was to determine potential current and future receptors and the pathway(s) by which they could be exposed to OU2 contaminants. The receptors evaluated and the associated exposure pathways follow:

- Maintenance workers and full-time employees - direct contact with surface soil.
- Trespassers - direct contact with surface soil, surface water/leachate, and sediment.
- Recreational users - direct contact with surface water and sediment, and ingestion of fish.
- Onsite adult and child residents - direct contact with groundwater and surface soil. Exposure times evaluated for adults were 6 years and 30 years.
- Construction workers - direct contact with soil and groundwater, and inhalation of fugitive dust.

TABLE ES-1

MEDIA-SPECIFIC CHEMICALS OF POTENTIAL CONCERN (COPCs)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Surface Soil (0 to 2 Feet)	All Soil (0 to 10 Feet)	Groundwater	Leachate Seeps	Surface Water	Sediment	Polishing Pond Sediment
Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Chrysene Indeno(1,2,3-cd)pyrene Aroclor-1260 Aluminum Antimony Arsenic Beryllium Cadmium Chromium Iron Manganese Thallium	Arsenic Cadmium Lead	**Surficial Aquifer:** 1,1-Dichloroethene 1,2-Dichloroethane 1,2-Dichloropropane 2-Butanone 2-Hexanone 4-Methyl-2-pentanone Benzene Chlorobenzene Chloroform Chloroethane cis-1,2-Dichloroethene Ethylbenzene Tetrachloroethene Toluene Trichloroethene Vinyl chloride 1,2-Dichlorobenzene 1,4-Dichlorobenzene 2-Methylnaphthalene 2-Methylphenol 2,4-Dimethylphenol 4-Methylphenol Bis(2-chloroethyl)ether Bis(2-ethylhexyl)phthalate Naphthalene Nitrobenzene 4,4'-DDE 4,4'-DDT Aldrin	Benzene Chloroethane Vinyl chloride 4,4'-DDT Aldrin γ-BHC Dieldrin Heptachlor Antimony Arsenic Cadmium Iron Lead Manganese Nickel Thallium	**Turkey Gut:** Bis(2-ethylhexyl)phthalate Heptachlor epoxide Arsenic **Slocum Creek:** 4,4'-DDD	**Turkey Gut:** Aluminum Antimony Arsenic Beryllium Iron Manganese **Slocum Creek:** Aluminum Antimony Arsenic Chromium Iron Manganese	None

TABLE ES-1 (Continued)
MEDIA-SPECIFIC CHEMICALS OF POTENTIAL CONCERN (COPCs)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Surface Soil (0 to 2 Feet)	All Soil (0 to 10 Feet)	Groundwater	Leachate Seeps	Surface Water	Sediment	Polishing Pond Sediment
		Surficial Aquifer: (Continued) α-BHC γ-BHC Endosulfan I Endosulfan II Endrin Aldehyde Heptachlor Heptachlor epoxide Aluminum Arsenic Barium Cadmium Iron Manganese **Yorktown Aquifer:** Chloroform Bis(2-ethylhexyl)phthalate Iron Manganese				

Cancer and noncancer risks for these receptors and exposure pathways were calculated using equations and conservative exposure assumptions derived from USEPA guidance. An incremental cancer risk (ICR) between 1E-6 (one in one million) and 1E-4 (one in ten thousand) is considered "acceptable." A cancer risk greater than 1E-4 is considered "unacceptable." For noncancer risks (toxic hazards), a Hazard Index (HI) less than 1 is considered "acceptable", and a Hazard Index greater than 1 is considered "unacceptable." Target organs (those that would be affected by a particular toxic chemical) are considered when the Hazard Index exceeds 1, because different toxic chemicals affect different parts of the body. A summary of the risks estimated for the identified receptors is presented in Table ES-2.

Risks are below or within the target range except for future adult and child residents under both the 6-year and 30-year exposure scenarios. Under the 6-year surficial aquifer exposure scenario, the majority of risk is from ingestion of groundwater containing arsenic and vinyl chloride. Under the 30-year surficial aquifer exposure scenario, the risk is from ingestion of groundwater containing arsenic and vinyl chloride and exposure to soil containing arsenic and PCBs. Under the 30-year Yorktown aquifer exposure scenario, the risk is from ingestion of groundwater containing manganese.

The "unacceptable" risks are based on future hypothetical exposure scenarios. No "unacceptable" risks exist under current land uses and exposure scenarios.

Ecological Risk Assessment

A screening-level ecological assessment was performed to assess potential risks to ecological receptors that may inhabit OU2. Maximum contaminant concentrations in surface water and sediment (in Turkey Gut and Slocum Creek) and soil were compared to media-specific benchmark values. The ratio of the concentration to the benchmark value is called the hazard quotient (HQ). If this ratio exceeded 1.0, the contaminant was retained as a COPC. The benchmark values are contaminant concentrations above which there is a potential for adverse effects to occur. Based on comparisons with maximum observed concentrations, the results of this screening are summarized below:

- For Turkey Gut water, the following chemicals had an HQ greater than 1.0: 1,1-dichloroethane (2.5), 4,4'-DDD (4.38), and manganese (5.7). DDD and 1,1-dichloroethane were only detected in single sample. Manganese was detected in all samples; however, the concentration at the farthest upstream location also exceeded the benchmark value.

TABLE ES-2

SUMMARY OF CUMULATIVE RISKS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Receptor	Exposure Pathway	Cancer Risk	Hazard Index
Maintenance Worker	Direct contact with surface soil.	1.0E-6	0.016
Construction Worker	Direct contact with soil and groundwater; inhalation of fugitive dust.	7.6E-7	0.61
Adolescent Trespasser	Direct contact with surface soil and leachate seeps	3.9E-7	0.021
	Direct contact with Slocum Creek water and sediment	2.8E-7	0.016
	Direct contact with Turkey Gut water and sediment	1.3E-7	0.0085
Adult Recreational User	Direct contact with Slocum Creek water and sediment; ingestion of fish.	4.0E-5	0.044
Full-Time Employee	Direct contact with surface soil.	6.4E-6	0.10
Adult Resident (6 year)	Direct contact with groundwater (surficial aquifer) and surface soil.	3.8E-4*(1)	22E+1*
	Direct contact with groundwater (Yorktown aquifer) and surface soil.	4.9E-6	0.55
Child/Adult Resident (30 year)	Direct contact with groundwater (surficial aquifer) and surface soil.	2.4E-3*	72*
	Direct contact with groundwater (Yorktown aquifer) and surface soil.	5.6E-5	2.4*
Child Resident	Direct contact with groundwater (surficial aquifer) and surface soil.	9.2E-4*	51*
	Direct contact with groundwater (Yorktown aquifer) and surface soil.	3.6E-5	2.8*

(1) An asterisk indicates an "unacceptable" risk.

- For Turkey Gut sediment, the following chemicals had an HQ greater than 1.0: alpha-chlordane (14.7), dieldrin (6.67), gamma-chlordane (5.18), and heptachlor epoxide (2.08). The concentrations that exceeded the benchmark valve were only detected in a single sample (OU2SD3).

- For Slocum Creek, only 4,4'-DDD (1.56) had an HQ greater than 1.0. DDD was detected in the sample upstream of OU2 and in samples collected above and below Turkey Gut at similar concentrations that exceeded the benchmark value. Therefore, OU2 is not the source of DDD in Slocum Creek.

- No COPCs were identified for Slocum Creek sediment.

- For surface soil, the following chemicals had an HQ greater than 1.0: aluminum (1.29), cadmium (1.28), selenium (1.07), thallium (1.06), 4-nitrophenol (2.24), and Aroclor-1260 (1.26). The benchmark values were exceeded only in single samples. The sample locations exceeding the benchmark values were scattered throughout OU2.

In addition to the contaminant screening for soil, surface water, and sediment, food chain modeling was performed for the eastern cottontail rabbit, red fox, and red-tailed hawk. Exposure pathways included ingestion of soil, vegetation, contaminated prey, and drinking water. The HQs for each receptor exceeded 1.0. However, the majority of the HQ value derived was from exposure to thallium and antimony. Thallium was only detected in two samples, and antimony was only detected in four samples; these metals were not widespread in OU2 soil. The ecological assessment conservatively assumed that all three receptors would live their entire life at OU2. The receptors would not be exposed to areas of soil containing these metals all the time.

There is no risk posed to ecological receptors at OU2 from contaminants in soil, Slocum Creek, or Turkey Gut based on the use of the conservative ecological screening process and specific site information and conditions. Although HQs for some chemicals exceeded 1.0, this occurs only at localized areas (i.e., single sample locations). Potential receptors would not be exposed to these areas all the time.

- Only a few COPCs were identified at OU2.

- HQs for the COPCs were relatively low.

- Detections of many of the COPCs were isolated.

- Contaminants posing potential risk from exposure to Turkey Gut sediment were also detected in background soil samples collected at the Air Station (not only at OU2) and are not migrating to Slocum Creek.

- Risk numbers generated from the food chain models were based on scattered detections of chemicals and were mainly driven by uncertainty in toxicity data, rather than actual risk.

CONCLUSIONS AND RECOMMENDATIONS

This section presents conclusions and recommendations of the RI report.

Conclusions

- Contaminant concentrations in groundwater exceed state groundwater quality standards.

- Unacceptable risks to human health were identified for adults and children only under a hypothetical future residential scenario. The majority of these risks are from ingesting groundwater from the surficial aquifer. The risks are driven by volatile organics and metals.

- The data do not indicate a risk to human health from exposure to soil contaminants except under the future residential use exposure scenario.

- The surface water and sediment data do not indicate that offsite migration of site-related soil contaminants is occurring.

- Although groundwater discharges to Turkey Gut and Slocum Creek, these streams are not adversely impacted by this discharge.

- Soil "hot spot" areas were identified. These are areas where correlation exists between elevated detections of contaminants in soil and the detections of these contaminants in the surficial aquifer. These "hot spots" and the contaminants of concern are as follows: former sludge impoundment area (BTEX, chlorinated solvents, phenols, and pesticides), southern portion of the landfill (BTEX, ketones, PAHs, and pesticides), Study Area B (BTEX, chlorinated solvents, and ketones), and Study Area E (BTEX and chlorinated solvents).

Recommendations

- A Feasibility Study (FS) should be prepared to evaluate remedial/corrective actions to address the following items:

  (1) Contaminant concentrations in groundwater exceed state groundwater quality standards.

  (2) Unacceptable risks exist to human health (adults and children) only under a hypothetical future residential exposure scenario.

  (3) "Hot spots" exist that are potential source areas for groundwater contamination. These areas include the former sludge impoundments, the southern portion of the landfill, Study Area B, and Study Area E.

- Remedial alternatives in the FS should address contamination in the surficial aquifer and soil "hot spot" areas. The impact of the leaching of soil contaminants from "hot spots" to groundwater should be assessed as part of the FS.

- Additional data may be required after the selected remedy is announced. This data would be collected during the design phase, since information needed to focus a remedy cannot be completely defined until a specific remedy is identified.

1.0 INTRODUCTION

B&R Environmental (formerly known as Halliburton NUS Corporation and NUS Corporation), under contract to the Department of the Navy, conducted this investigation for Marine Corps Air Station (MCAS) Cherry Point, North Carolina. This report contains the results for a series of investigations beginning in 1983 and continuing through 1995 for a site now known as Operable Unit 2 (OU2). Operable Unit 2 consists of four sites (Sites 10, 44A, 46, and 76) that were identified in the Initial Assessment of Sites (IAS) performed by a Navy contractor and listed in a multi-task RCRA Section 3008(h) Administrative Order on Consent signed by the Navy and the U.S. Environmental Protection Agency (USEPA) in December 1989. MCAS Cherry Point was placed on the National Priorities List (NPL) in December 1994. The sites included in this report are now managed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The RCRA Section 3008h Administrative Order on Consent is still in effect as an Applicable or Relevant and Appropriate Requirement (ARAR). This report was prepared under Navy Contract Number N62472-90-D-1298, Contract Task Order (CTO) Number 211.

1.1 PURPOSE OF THE REPORT

The purpose of this Remedial Investigation (RI) report is to provide the basis for the ultimate selection of a remedial alternative (if needed) for the site. All available information for OU2 is summarized in this report to facilitate the decision-making process.

The overall objective of the RI was to collect adequate chemical analytical data to determine whether contaminants are present at the site, and if so, to determine whether those contaminants present an unacceptable risk to human health or to the environment. Following the completion of the RI, a Feasibility Study (FS) will be conducted to develop and evaluate potential remedial alternatives for the site.

1.2 GENERAL BACKGROUND INFORMATION

General information regarding the locale of the MCAS Cherry Point, the mission of the Air Station, and the area investigated in this RI report (OU2) is provided in this section.

1.2.1 Air Station Description

The MCAS Cherry Point is part of a military installation located in southeastern Craven County, North Carolina, just north of the town of Havelock. The site is located on an 11,485-acre tract of land bounded on the north by the Neuse River, on the east by Hancock Creek, and on the south by North Carolina Highway 101. The irregular western boundary line of the Air Station lies approximately three-quarters of a mile west of Slocum Creek. The general location of the Air Station is shown on Figure 1-1. A general Air Station map is included as Figure 1-2, which identifies the location of OU2.

1.2.2 Air Station History

The MCAS Cherry Point mission is to maintain and support facilities, services, and material of a Marine Aircraft Wing, or units thereof, and other activities and units as designated by the Commandant of the Marine Corps in coordination with the Chief of Naval Operations (CNO). Occupants at the Air Station include the Second Marine Aircraft Wing (2nd MAW), the Naval Aviation Depot (NADEP), the combat Service Support Detachment 21 of the Second Force Service Support Group (2nd FSSG), the Naval Hospital, the Dental Clinic, the Naval Air Maintenance Training Group Detachment, and the Defense Reutilization and Marketing Office (DRMO). The Air Station has facilities for training and support of the Fleet Marine Force (FMF) Atlantic aviation units and is also designated as a primary aviation supply point.

The Air Station was commissioned in 1942. Continuing construction in 1943 added a massive aircraft assembly and repair shop, which later became the NADEP. During the 1950s and 1960s, the size of the Air Station increased from 7,582 acres to more than 11,000 acres (not including outlying facilities) as a result of land acquisitions. During the 1970s, commercial and residential development of the surrounding area grew substantially. In 1980, the City of Havelock annexed MCAS Cherry Point.

1.2.3 Description of Operable Unit 2

OU2 is located in the west-central portion of MCAS Cherry Point between Roosevelt Boulevard and Slocum Creek. OU2 comprises four areas referred to as Site 10 (Old Sanitary Landfill), Site 44A (Former Sludge Application Area), Site 46 (Polishing Ponds No. 1 and No. 2), and Site 76 (Vehicle Maintenance Area [Hobby Shop]). General site features are shown in Figure 1-3 and Plate 1 (Volume V).

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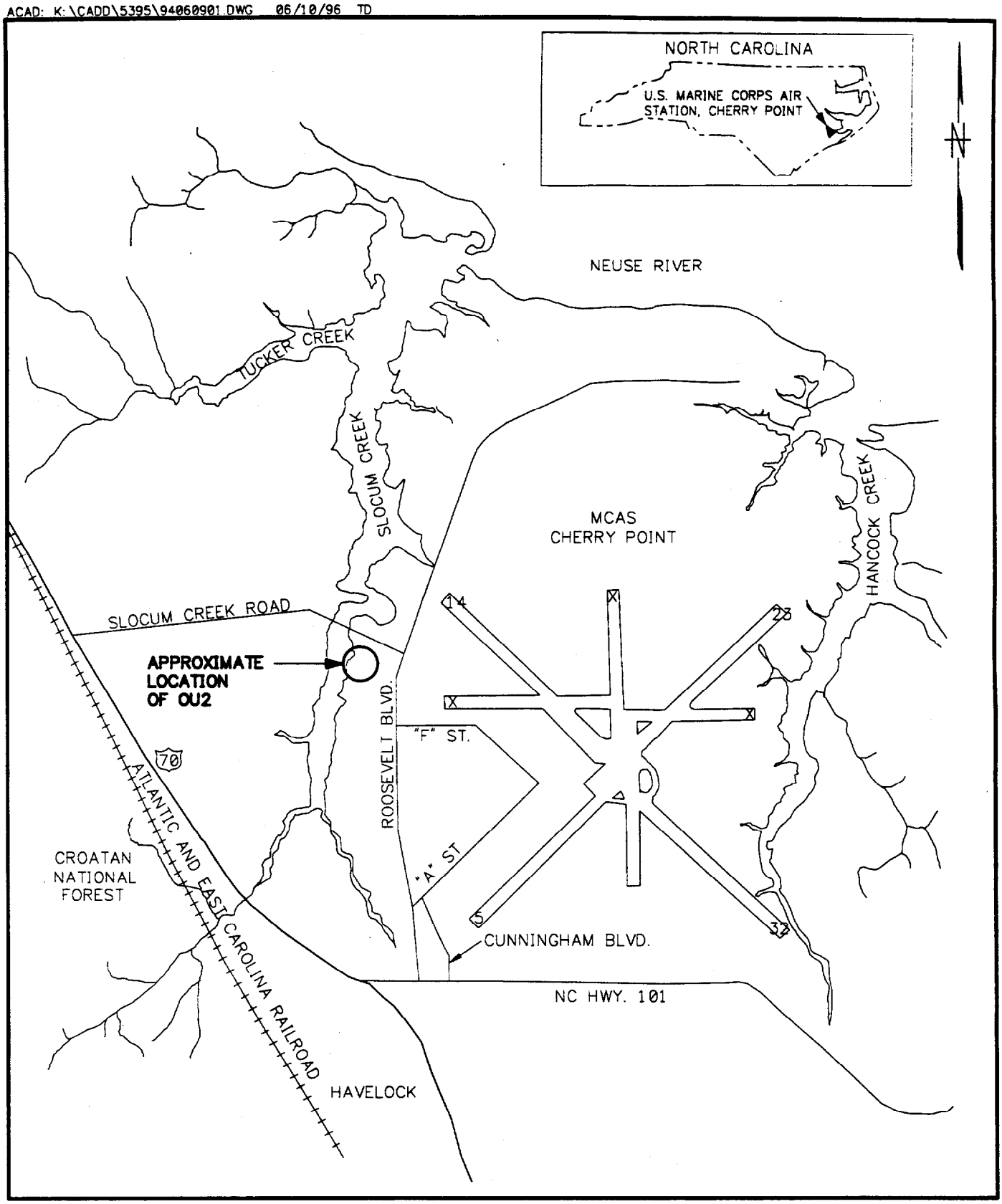

FIGURE 1-1

LOCATION MAP
MCAS CHERRY POINT, NORTH CAROLINA

0 4500 9000
SCALE IN FEET

Brown & Root Environmental

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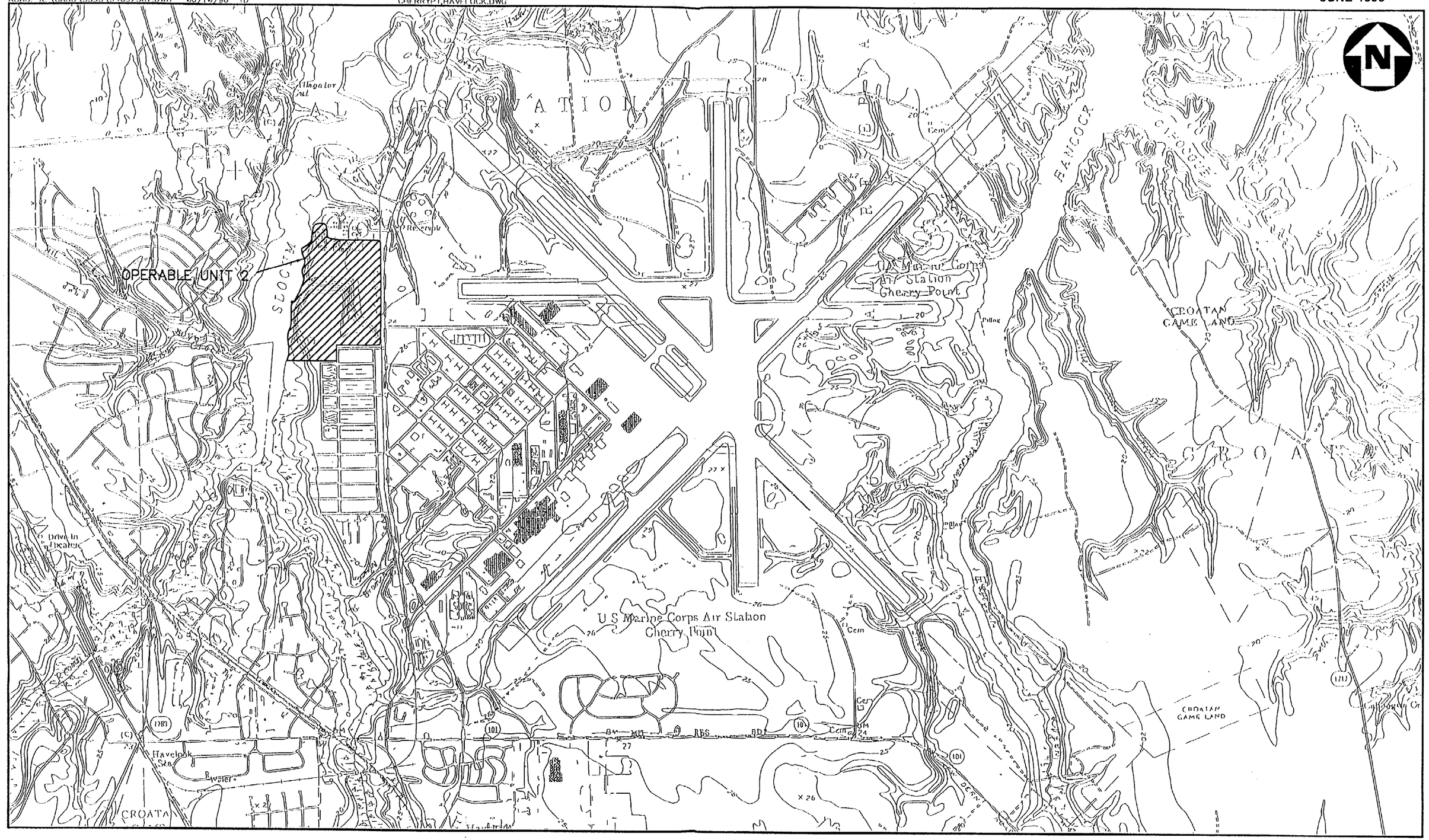
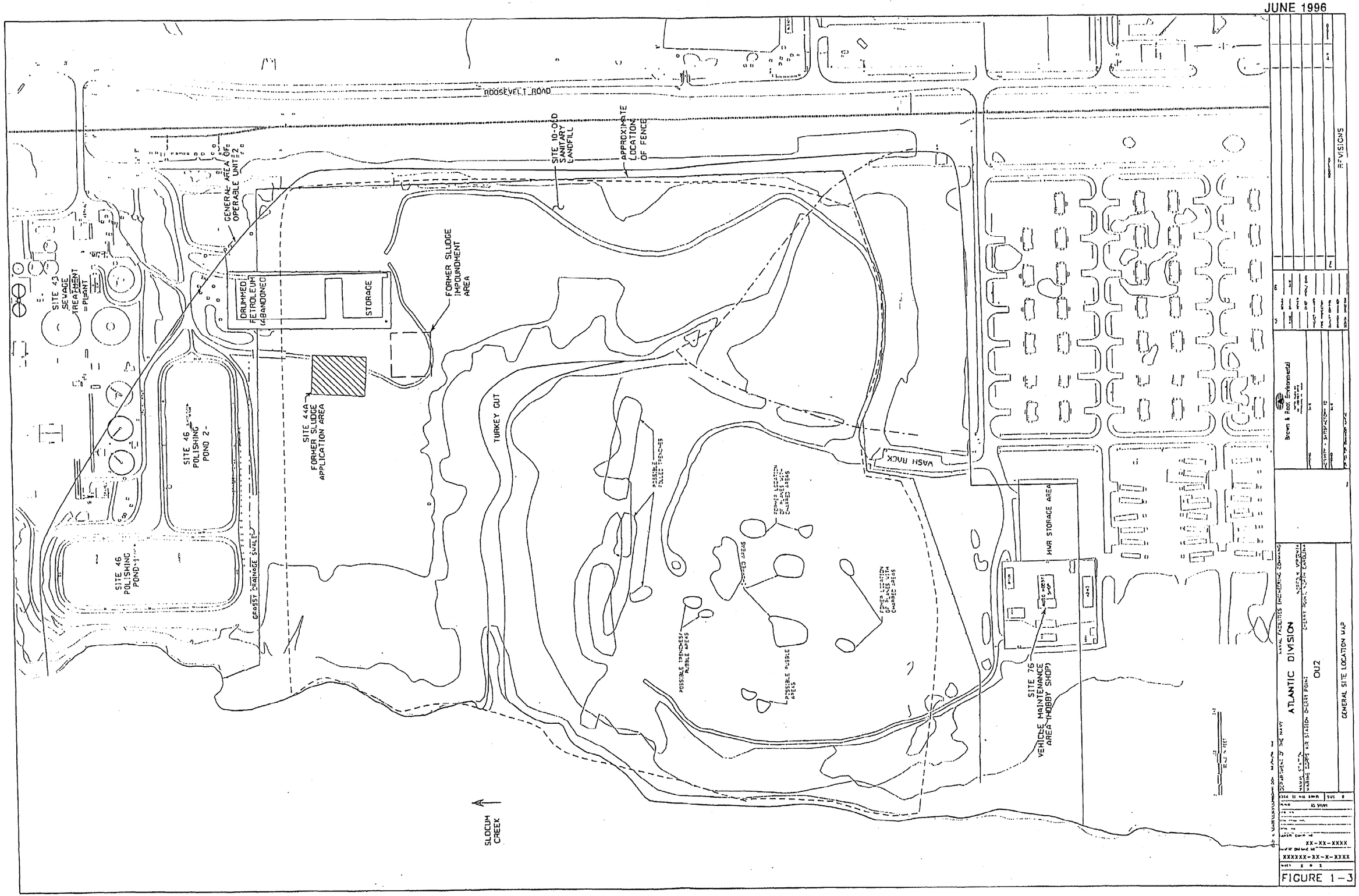


OPERABLE UNIT 2
GENERAL AIR STATION MAP
MCAS CHERRY POINT, NORTH CAROLINA

FIGURE 1-2

0 2000 4000
SCALE IN FEET

Brown & Root Environmental


ROOSEVELT ROAD
SITE 10-OLD SANITARY LANDFILL
APPROXIMATE LOCATION OF FENCE
GENERAL AREA OF OPERABLE UNIT 2
SITE 43 SEWAGE TREATMENT PLANT
DRUMMED PETROLEUM (ABANDONED)
STORAGE
FORMER SLUDGE IMPOUNDMENT AREA
SITE 44A FORMER SLUDGE APPLICATION AREA
SITE 46 POLISHING POND 2
SITE 46 POLISHING POND 1
GRASSY DRAINAGE SWALE
TURKEY CUT
WASH RACK
HWR STORAGE AREA
SITE 76 VEHICLE MAINTENANCE AREA (HOBBY SHOP)
SLOCUM CREEK
REVISIONS
Brown & Root Environmental
NAVAL FACILITIES ENGINEERING COMMAND
ATLANTIC DIVISION
OU2
GENERAL SITE LOCATION MAP
XX-XX-XXXX
XXXXXX-XX-X-XXXX
FIGURE 1-3

OU2 consists of four sites located in proximity to Site 10 - Old Sanitary Landfill. These sites have been grouped into one operable unit because of their proximity to each other (i.e., Site 44A - the Former Sludge Application Area overlies portions of the Site 10 landfill, and Site 46 - Polishing Ponds No. 1 and 2 and Site 76 - Vehicle Maintenance Area (Hobby Shop) are located adjacent to the landfill). In addition, Site 44A and Site 46 both contain the same types of suggested contamination derived from sewage treatment.

Site 10 is located west of Roosevelt Boulevard and south of Site 43 - Sewage Treatment Plant, on the east side of Slocum Creek. The site consists of a sanitary landfill approximately 40 acres in size that served as the primary disposal site at MCAS Cherry Point from 1955 until the early- to mid-1980s. Contaminated material and petroleum, oil, and lubricants (POLs) were spread on the land, burned, stored in unlined pits, and buried at the landfill. Former sludge impoundments that were closed in the mid-1980s are also located at this site. The impoundments were used to dispose of metal filings, plating sludges, paints, organic solvents, oil and grease, and miscellaneous chemicals. The sludge impoundment area is included as a hazardous waste management unit in the Air Station's RCRA Part B permit. During closure, the impoundments were excavated to approximately 9.5 feet below the existing ground surface. They were backfilled with soil and covered with 2 feet of clay and 2 feet of topsoil. A fenced, gravel area formerly used for storage of drums of petroleum products is also located at Site 10. This area is no longer used for drum storage.

Site 44 consists of two areas in which sludge from the sewage treatment plant (STP) was applied. Liquid sludge was removed from the digesters for land application every 30 days. Information provided in the Current Conditions Report (NUS Corporation, May 1991b) indicates that sludge removed between September and November 1987 was applied at Sites 10 and 21. Site 44A is located on Site 10 (OU2), and Site 44B is located on Site 21 (OU13). Site 44B is not discussed further in this report, as it is not an OU2 site. The sludge contained organic material and other constituents that are not digested during the sewage treatment process.

Site 46 consists of two inactive unlined ponds that served as aeration basins for wastewater from the STP (Site 43). The ponds are approximately 12 feet deep. The STP was recently upgraded and does not require the use of the ponds for aeration. The Air Station submitted a Closure Plan for this site to the State of North Carolina in December 1988. Final approval of the Closure Plan is pending.

Site 76 consists of a building and parking lot where personal vehicles are repaired. General auto maintenance and auto body repair are typical work activities conducted at this facility.

1.2.4 Summary of Previous Investigations

OU2 has been under investigation since the first groundwater monitoring wells were installed in 1981. The results of the various investigations have been summarized in several documents, as follows:

- Report on Hydrogeology, Contaminants Detected, and Corrective Action/Recommendations for the Former Surface Impoundments, January 1987 (NUS Corporation).
- Remedial Investigation Interim Report (RIIR), October 1988 (NUS Corporation)
- Water Resources Investigation Report 89-615, 1990 (U.S. Geological Survey [USGS])
- Water Resources Investigation Report 89-4200, 1990 (USGS)
- RCRA Facility Investigation Report: Units 5, 10, 16, and 17 (RFI). May 1991 (NUS Corporation)
- Evaluation and Recommendations: Unit 10 Former Sludge Impoundment Area, December 1991 (Halliburton NUS Corporation)
- RCRA Facility Investigation and Corrective Measures Study Final Technical Direction Memorandum for Units 10 and 16 (TDM), November 1992 (HNUS)
- RCRA Facilities Investigation - 21 Units (21 Unit RFI), June 1993 (HNUS)
- Phase II Technical Direction Memorandum for Units 10 and 16 (Phase II TDM), June 1994 (HNUS)

This section presents a chronological description of the activities conducted by B&R Environmental (Halliburton NUS and NUS) to date. The work was conducted using a phased approach that was based on the availability of funding and the prioritization of sites in terms of potential environmental impacts. The work was conducted under several environmental programs according to regulatory requirements in effect at the time. Past work conducted by other contractors and government agencies is also discussed.

Prior to the B&R Environmental investigations, the former sludge impoundment at Site 10 was closed. Prior to removal of wastes from the former sludge impoundment area, six soil borings were installed around the perimeter of the sludge pits. Samples collected from the soil borings were likely collected to confirm that

contamination did not extend laterally from the pits. After the waste was removed from the pits and as they were backfilled, confirmation testing was conducted to confirm the effectiveness of the remediation. Two borings were installed in each of the two pits, and samples were collected at 7.5 feet below the bottom of the excavated pit, at the bottom surface of the pit, and in the clay fill material 2.5 feet above the bottom of the pit.

Prior to the B&R Environmental investigations, the first monitoring wells were installed at the site. These wells were renamed and are now designated as 10EGW1, 10EGW02, 10EGW3, 10EGW5, 10EGW6, 10EGW07, 10EGW08, 10EGW13, and 10EGW20. A well designated as B-103 was not renamed. B&R Environmental investigations were initiated in 1984 as part of an overall investigation of identified waste disposal sites throughout the Air Station. This work was part of the early Installation Restoration Program (IRP) that was loosely based on the Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA). Between 1984 and 1987, 15 monitoring wells were installed at Site 10. Between January 1985 and March 1987, these wells, along with selected existing wells, were sampled up to three times depending on their date of installation in the sampling schedule. Aquifer slug tests and single well pump tests were conducted at selected monitoring wells. Concurrent with the groundwater investigation, surface water and sediment samples were collected from Slocum Creek, Turkey Gut, and leachate seeps. The results of these initial investigations were published in the RIIR (NUS Corporation, October 1988) and a report that evaluated the former sludge impoundments (NUS Corporation, January 1987).

During October and November 1987 and April 1988, the USGS installed wells in the vicinity of Site 10. Some of these USGS wells, as well as selected wells installed by others, were sampled for chemical analysis.

Following the signing of the RCRA Consent Order in 1989, the Air Station initially started work at four sites that were identified in the RIIR as having more significant environmental concerns. A soil-gas survey was performed at Site 10 in November 1989 by Northwest Research Institute, Inc. Based on the results of the soil-gas survey, 12 additional monitoring wells were installed. In addition, three monitoring wells were installed by others to investigate the potential for temporal or tidal influences on the surficial aquifer (Environmental and Safety Designs, Inc., December 1988). During 1990, a total of 35 groundwater samples were collected from the newly installed and selected existing wells. Aquifer slug tests were also performed at the 12 newly installed wells. Four borings were installed in the former sludge impoundment area to collect soil samples for chemical analysis. One subsurface composite sample from these borings was subjected to Toxicity Characteristic Leaching Procedure (TCLP) extraction and analysis. Four borings were also drilled to provide lithologic data on the presence and position of the confining unit(s) underlying the site. The newly installed monitoring wells and soil boring locations were surveyed horizontally and vertically and referenced to a USGS benchmark. During this investigation, six surface water/sediment samples were

collected from Turkey Gut and Slocum Creek. The results of these activities are discussed in the RFI report for Units 5, 10, 16, and 17 (NUS Corporation, May 1991a), as the work was conducted under the auspices of the RCRA Consent Order.

Work did not begin at Site 44A (formerly Site 45) until late 1991. At that time, two soil borings were installed. Two samples (surface and near surface) were collected for chemical analysis and Toxicity Characteristic Leaching Procedure (TCLP) testing to determine whether the soil would be classified as a RCRA hazardous waste. The results of this activity were discussed in the 21 Unit RFI Report (Halliburton NUS, June 1993), as the work was conducted under the auspices of the RCRA Consent Order.

Upon completion of the RFI at Unit 10, it was determined that additional investigation on the extent of soil contamination was required. A magnetometer survey was conducted in a grid pattern at six study areas to aid in the selection of soil sampling locations. A total of 168 magnetometer data points were measured. A total of 62 soil borings were installed during this investigation. Fifty of the borings were drilled in the six study areas based on the results of the magnetometer survey. In addition, 12 boring locations were arbitrarily chosen to establish coverage of the site. In addition, 14 test pits were excavated. A total of 79 subsurface soil samples were collected from the borings and test pits. One subsurface soil sample was collected from each test pit. In addition, one soil sample from each boring that was representative of the most contaminated soil interval (based on visual observations or organic vapor readings) was submitted for laboratory analysis. At three of the borings, two soil samples were submitted for laboratory analysis. This work is detailed in the Technical Direction Memorandum (TDM) for Units 10 and 16 (Halliburton NUS, November 1992).

Based on the results of the TDM, it was determined that additional information on soil contamination was needed in the central landfill area. Additional field work was conducted during November and December of 1993. A terrain conductivity survey was conducted in a grid pattern at the central landfill area to aid in the selection of soil sampling locations. Four soil borings were installed, and nine additional test pits were excavated. Six soil samples from the borings (collected based on visual observation or organic vapor readings) were submitted for chemical analysis. A total of 14 soil samples were collected from the test pits (based on visual observation or organic vapor readings) for chemical analysis. This work is detailed in the Phase II TDM for Units 10 and 16 (Halliburton NUS, June 1994b).

MCAS Cherry Point was placed on the NPL in December 1994. The sites included in this report are now managed in accordance with CERCLA. The RCRA Section 3008h Administrative Order on Consent is still in effect as an ARAR. The creation of several operable units from the numerous individual sites previously under investigation in accordance with the Consent Order facilitated the move to the CERCLA program. A

sampling and analysis activity was planned and conducted in the fall of 1994. This included the installation of six hydropunches (temporary monitoring wells), eight soil borings, and 12 permanent monitoring wells, and the coring of pond sediments at four locations at Polishing Ponds No. 1 and 2. In addition, borehole geophysical logging was conducted during the installation of the six monitoring wells in the Yorktown aquifer. Subsurface soil samples were collected from eight soil borings and seven monitoring wells borings for chemical and geotechnical analysis. Fifteen background soil samples were collected from five locations during the RI at Operable Units 1, 2, 3, 4, and 13. Groundwater from all new monitoring wells, new temporary wells, and selected existing wells was sampled. Surface water and sediment samples were collected from seven locations on Slocum Creek and Turkey Gut. In addition, eight sediment core samples were collected from four locations in Polishing Ponds No. 1 and 2. Three staff gauges were installed, all sample locations were surveyed, and two rounds of synoptic water-level measurements were made. All of the data collected at Sites 10, 44A, and 46 (Operable Unit 2) are compiled in this report.

It was determined that additional sampling of leachate seeps and surface soil was needed to support the human health and ecological risk assessments. This additional sampling was conducted in July 1995. Surface soil samples were collected from 11 locations. The four leachate seep sample locations identified in the RIIR, along with any newly identified seeps, were sampled. Leachate water samples were collected from areas near two of the RIIR locations and from one newly identified location. Leachate soil/sediment samples were collected from near two of the RIIR locations. All of the data collected in 1995 are also compiled in this report.

It was also determined that additional information was needed to delineate the extent of surficial aquifer groundwater contamination. This additional investigation was conducted in April 1996. Temporary monitoring wells were installed at seven locations, and groundwater samples were collected. Based on the analytical results, four of these wells were converted to permanent wells and resampled along with three existing wells. During this investigation, two soil borings were installed, and a surface and subsurface soil sample were collected from each boring. Two surface soil samples were collected from Site 76 - Vehicle Maintenance Area (Hobby Shop). Surface water samples were collected from four locations along Turkey Gut to determine the state classification of the stream. All of the data collected in 1996 are compiled in this report.

Section 4 of this report presents the results from sampling and analysis activities for all the investigations described above.

2.0 STUDY AREA INVESTIGATION

Five field investigations were conducted by B&R Environmental at Operable Unit 2 (Sites 10, 44A, 46, and 76) prior to the 1994 Remedial Investigation. Additional investigations were conducted in 1995 and 1996 to fill remaining data gaps. The first investigation (1984 through 1987) consisted of multimedia field sampling efforts discussed in the Remedial Investigation Interim Report (RIIR) (NUS Corporation, October 1988). The second (1990) investigation is discussed in the Draft Final RCRA Facility Investigation (RFI) Report - Units 5, 10, 16, and 17 (NUS Corporation, May 1991a). The third (1991) investigation, at Site 44A (formerly Site 45), is discussed in the RCRA Facilities Investigation - 21 Units report (Halliburton NUS, June 1993). The fourth (1992) investigation is discussed in the RCRA Facility Investigation and Corrective Measures Study Final Technical Direction Memorandum (TDM) for Units 10 and 16 report (Halliburton NUS, November 1992). The fifth (1993) investigation is discussed in the Final Phase II Technical Direction Memorandum for Units 10 and 16 report (Halliburton NUS, June 1994b).

The following sections give a brief description of the previous field investigations along with a detailed description of the 1994, 1995, and 1996 activities. All field procedures were conducted in accordance with the corporate and U.S. Environmental Protection Agency (USEPA) standard operating procedures (SOPs) in effect at the time of the field activity described in the Work Plans for these activities. Plate 1 (Volume V) and Figure 1-3 present the general site features of Sites 10, 44A, 46, and 76, now named Operable Unit 2 (OU2). Boring logs, well construction sheets, sample log sheets, and chain-of-custody forms from previous and current investigations are presented in Appendices A through D (Volumes I and II), respectively. All sample locations are shown on Plate 2 (Volume V) and Figure 2-1.

Prior to the B&R Environmental investigations, Schnabel Engineering Associates performed a field investigation consisting of the installation of six monitoring wells (B-101, B-102, B-103, B-104, B-105, and B-106). This field effort resulted in the 1981 Hydrogeologic and Geotechnical Engineering Analysis, Putrescible Waste Landfills, MCAS Cherry Point, North Carolina. B&R Environmental assigned new designations to five of the six Schnabel wells. Monitoring wells designated as B-101, B-104, B-105, B-106, and B-102 were changed to 10EGW1, 10EGW02, 10EGW3, 10EGW13, and 10EGW20, respectively. Monitoring well B-103 retained the Schnabel designation.

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ROOSEVELT ROAD
STUDY AREA A
STUDY AREA B
STUDY AREA C
STUDY AREA D
STUDY AREA E
STUDY AREA F
SITE 43 SEWAGE TREATMENT PLANT
SITE 44A FORMER SLUDGE APPLICATION AREA
SITE 46 POLISHING POND 2
SITE 76 VEHICLE MAINTENANCE AREA (HOBBY SHOP)
FORMER SLUDGE IMPOUNDMENT AREA
DRUMMED PETROLEUM (ABANDONED)
STORAGE
TURKEY CUT
WASH RACK
MWR STORAGE AREA
AUTO HOBBY SHOP
GRASSY DRAINAGE SWALE
SLOCUM CREEK
APPROXIMATE LOCATIONS OF FENCE
LEGEND
NOTES:
REVISIONS
Brown & Root Environmental
ACTIVITY - SATISFACTORY TO
NAVAL FACILITIES ENGINEERING COMMAND
ATLANTIC DIVISION
NORFOLK, VIRGINIA
CHERRY POINT, NORTH CAROLINA
NAVAL STATION
MARINE CORPS AIR STATION CHERRY POINT
OU2
SAMPLE LOCATION AND CROSS SECTION LOCATION MAP
DEPARTMENT OF THE NAVY
AS SHOWN
XX-XX-XXXX
XXXXXX-XX-X-XXXX
FIGURE 2-1

Prior to the B&R Environmental investigations, the earliest investigation of soil at OU2 consisted of a series of soil borings drilled for the investigation and cleanup confirmation of two sludge impoundments formerly located at Site 10. This investigation is discussed in the Draft Final Evaluation and Recommendations Unit 10 Former Sludge Impoundment Area (Halliburton NUS, December 1991).

The USGS has also investigated groundwater quality in the vicinity of OU2 (USGS, 1990a; USGS, 1990b). The USGS installed 19 monitoring wells in 1987 and 1988.

EnSafe, Inc. installed three monitoring wells (10GW33, 10GW34, and 10GW35) in 1988 as part of a groundwater assessment (Environmental and Safety Designs, Inc., December 1988).

2.1 1984 TO 1987 INVESTIGATIONS (RIIR)

This section discusses in brief the field operations and procedures used by B&R Environmental during the 1984, 1985, 1986, and 1987 field work performed at OU2 as documented in 1988 in the Remedial Investigation Interim Report (RIIR) (NUS Corporation, October 1988). The field work included the following tasks:

- Drilling and installation of 15 monitoring wells.
- Subsurface soil sampling from monitoring well borings.
- Up to 3 rounds of groundwater sampling from new and existing monitoring wells.
- Up to 3 rounds of leachate and surface water/sediment sampling from a total of 7 locations.
- Aquifer testing of monitoring wells 10GW04, 10GW09, 10GW15, 10GW22, and 10GW23

2.1.1 Drilling

Monitoring wells were installed using split-spoon and hollow-stem auger drilling or mud rotary drilling techniques. The monitoring well construction summary (Table 2-1) presents the installer, date of installation, ground elevation at the concrete pad well head, elevation at the top of the riser (where all groundwater measurements are made), total well depth (the depth of the polyvinyl chloride [PVC] well below ground surface), monitored or screened interval, and aquifer monitored. The locations of these wells are shown on Plate 2 (Volume V) and Figure 2-1. Monitoring well boring logs and well construction sheets are presented in Appendix A and Appendix B (Volume I), respectively.

Monitoring wells 10GW04, 10GW09, 19GW10, 10GW11, and 10GW12 were installed as part of the 1984 field event. These wells were located in areas where groundwater quality was unknown and to complement

TABLE 2-1

MONITORING WELL CONSTRUCTION SUMMARY
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Identification	Installation Date and Company	Ground Elevation (Feet MSL)[1]	Top of Riser Elevation (Feet MSL)	Total Well Depth (Feet BGS)[2]	Monitored Interval (Feet BGS)	Monitored Aquifer	Depth to Water (Feet BGS) April 1996
10EGW1 (B-101)	12-2-81 Schnabel	21.62	21.38	20	10-20	Upper Surficial	5.91
10EGW02 (B-104)	12-2-81 Schnabel	19.43	19.62	20	15-20	Upper Surficial	16.18
10EGW3 (B-105)	12-2-81 Schnabel	15.31	15.47	20	15-20	Upper Surficial	12.94
B-103	12-2-81 Schnabel	22.72	22.99	20	15-20	Upper Surficial	8.15
10GW04	12-10-84 HNUS	15.61	16.87	25	10-25	Upper Surficial	11.90
10EGW5	Unknown USGS	22.62	22.73	19.7	Unknown	Upper Surficial	14.46
10EGW6	Unknown USGS	22.62	22.90	33.3	Unknown	Lower Surficial	14.32
10EGW07	Unknown USGS	22.62	23.16	46.6	Unknown	Lower Surficial	14.88
10EGW08	Unknown USGS	24.46	24.62	40.75	Unknown	Lower Surficial	16.16
10GW09	12-10-84 HNUS	21.68	22.87	25	10-25	Upper Surficial	15.26
10GW10	12-11-84 HNUS	18.46	19.65	25	10-25	Upper Surficial	13.19
10GW11	12-12-84 HNUS	25.13	26.26	25	10-25	Upper Surficial	18.83
10GW12	12-12-84 HNUS	20.28	21.93	25	10-25	Upper Surficial	14.32
10EGW13 (B-106)	12-2-81 Schnabel	24.62	24.66	20.00	15-20	Upper Surficial	18.75
10GW14	4-16-86 HNUS	24.33	25.81	25	15-25	Upper Surficial	15.98
10GW15	4-18-86 HNUS	24.25	26.25	35	25-35	Lower Surficial	15.93

TABLE 2-1 (Continued)
MONITORING WELL CONSTRUCTION SUMMARY
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Identification	Installation Date and Company	Ground Elevation (Feet MSL)[1]	Top of Riser Elevation (Feet MSL)	Total Well Depth (Feet BGS)[2]	Monitored Interval (Feet BGS)	Monitored Aquifer	Depth to Water (Feet BGS) April 1996
10GW16	4-15-86 HNUS	24.52	25.01	44	34-44	Lower Surficial	16.21
10GW17	4-16-86 HNUS	24.86	27.22	24.50	14.5-24.5	Upper Surficial	16.88
10GW18	4-17-86 HNUS	21.77	22.33	25	15-25	Upper Surficial	13.81
10GW19	4-17-86 HNUS	13.92	15.00	20	10-20	Upper Surficial	6.48
10EGW20 (B-102)	12-2-81 Schnabel	23.20	23.20	20.05	15-20	Upper Surficial	11.90
10GW21	10-30-86 HNUS	13.97	15.62	30	20-30	Lower Surficial	6.65
10GW22	10-26-86 HNUS	22.06	23.55	83	73-83	Lower Yorktown	15.14
10GW23	10-27-86 HNUS	23.20	24.34	83	73-83	Lower Yorktown	16.32
10GW24	10-30-86 HNUS	13.89	15.66	70	60-70	Lower Yorktown	7.09
10GW25 (S1W2)	May 1987 USGS	23.81	25.20	38	28-38	Lower Surficial	14.06
10GW26 (S1W1A)	May 1987 USGS	23.80	24.85	76	66-76	Lower Yorktown	16.65
10GW27 (L1D)	May 1987 USGS	14.98	16.95	30	20-30	Lower Surficial	11.31
10GW28 (L1S)	March 1988 USGS	14.93	16.77	20	9.5-19.95	Upper Surficial	11.25
10GW29 (L2D)	March 1988 USGS	12.92	14.61	30	20-30	Lower Surficial	10.24
10GW30 (L2S)	March 1988 USGS	12.83	14.95	20	9.5-19.5	Upper Surficial	10.19
10GW31 (L3D)	March 1988 USGS	8.29	10.55	24	14-24	Lower Surficial	5.82
10GW32 (L3S)	March 1988 USGS	8.36	10.01	14	4-14	Upper Surficial	5.90

TABLE 2-1 (Continued)
MONITORING WELL CONSTRUCTION SUMMARY
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Identification	Installation Date and Company	Ground Elevation (Feet MSL)[1]	Top of Riser Elevation (Feet MSL)	Total Well Depth (Feet BGS)[2]	Monitored Interval (Feet BGS)	Monitored Aquifer	Depth to Water (Feet BGS) April 1996
10GW33	10-6-88 Ensafe, Inc.	24.54	26.65	81.50	70-80	Upper Yorktown	17.79
10GW34	10-4-88 Ensafe, Inc.	24.55	25.68	30.00	18-28	Upper Surficial	17.27
10GW35	10-5-88 Ensafe, Inc.	24.55	25.91	40.00	28-38	Lower Surficial	17.13
10GW36	11-11-90 HNUS	14.29	16.98	30	7-22	Upper Surficial	6.76
10GW37	11-12-90 HNUS	13.50	15.33	21	3-18	Upper Surficial	4.31
10GW38	10-26-90 HNUS	21.85	22.95	45	10-25	Upper Surficial	10.90
10GW39	11-09-90 HNUS	20.30	23.00	20	3-18	Upper Surficial	5.15
10GW40	10-27-90 HNUS	30.28	31.43	50	10-25	Upper Surficial	8.41
10GW41	11-10-90 HNUS	17.18	18.92	20	3-18	Upper Surficial	5.68
10GW42	10-24-90 HNUS	21.48	22.22	27	9-24	Upper Surficial	13.59
10GW43	11-12-90 HNUS	11.68	14.77	25	5-20	Upper Surficial	5.52
10GW44	11-9-90 HNUS	18.77	20.89	27	10-25	Upper Surficial	15.02
10GW45	10-24-90 HNUS	27.90	30.23	45	12.5-27.5	Upper Surficial	13.66
10GW46	10-25-90 HNUS	25.23	27.40	45	12.5-27.5	Upper Surficial	16.23
10GW47	10-25-90 HNUS	24.18	25.81	42	10-25	Upper Surficial	9.72
10GW48	Unknown	21.60	23.18	37	Unknown	Lower Surficial	13.65
OU2MW1	8-2-94 HNUS	27.35	29.13	27	17-27	Upper Surficial	19.51

TABLE 2-1 (Continued)
MONITORING WELL CONSTRUCTION SUMMARY
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Identification	Installation Date and Company	Ground Elevation (Feet MSL)[1]	Top of Riser Elevation (Feet MSL)	Total Well Depth (Feet BGS)[2]	Monitored Interval (Feet BGS)	Monitored Aquifer	Depth to Water (Feet BGS) April 1996
OU2MW2	8-26-94 HNUS	15.98	18.08	84	64.5-74.5	Lower Yorktown	9.60
OU2MW3	8-14-94 HNUS	15.71	16.98	82	58-68	Lower Yorktown	6.16
OU2MW4	8-23-94 HNUS	22.20	24.14	84	66-76	Lower Yorktown	15.94
OU2MW5	8-11-94 HNUS	27.49	29.66	104	92.5-102.5	Lower Yorktown	20.25
OU2MW6	8-9-94 HNUS	26.02	28.10	102	92-102	Lower Yorktown	18.86
OU2MW7	7-31-94 HNUS	23.53	25.43	98	84-94	Lower Yorktown	16.38
OU2MW8	8-3-94 HNUS	30.01	32.11	28	18-28	Upper Surficial	21.68
OU2MW9	8-2-94 HNUS	29.82	31.51	57	45-55	Lower Surficial	22.81
OU2MW10	8-15-94 HNUS	16.22	18.17	37.5	26-36	Lower Surficial	9.26
OU2MW11	8-9-94 HNUS	27.37	29.25	27.4	17.4-27.4	Upper Surficial	19.52
OU2MW12	8-8-94 HNUS	28.06	29.87	40.3	30.3-40.3	Lower Surficial	20.15
OU2MW13	4-16-96 B&R	7.7	9.67	12.5	2-12	Upper Surficial	1.0
OU2MW14	4-16-96 B&R	24.4	26.63	22.0	11-21	Upper Surficial	14.0
OU2MW15	4-16-96 B&R	24.2	26.36	14	3-13	Upper Surficial	6.09
OU2MW16	4-16-96 B&R	23.6	25.29	15	4-14	Upper Surficial	7.4
S2W1	1987 USGS	22.24	22.53	102.00	85-95	Lower Yorktown	12.09
S2W2	1987 USGS	22.20	22.86	38.00	28-38	Lower Surficial	7.91

TABLE 2-1 (Continued)
MONITORING WELL CONSTRUCTION SUMMARY
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Identification	Installation Date and Company	Ground Elevation (Feet MSL)[1]	Top of Riser Elevation (Feet MSL)	Total Well Depth (Feet BGS)[2]	Monitored Interval (Feet BGS)	Monitored Aquifer	Depth to Water (Feet BGS) April 1996
S2W3	1987 USGS	22.63	23.40	38.00	28-38	Lower Surficial	NM[3]
S4W1	1987 USGS	23.48	24.96	90.00	80-90	Lower Yorktown	16.44
S4W2	1987 USGS	23.64	24.57	30.00	20-30	Upper Surficial	11.57
S4W3	1987 USGS	23.86	24.98	30.00	20-30	Upper Surficial	11.76
S1W3	1987 USGS	23.89	24.94	38.00	28-38	Lower Surficial	14.21
S1W4	1988 USGS	23.61	26.11	88.00	58-88	Upper Yorktown	NM
S1W5	1988 USGS	24.04	26.27	28.00	18-28	Upper Surficial	NM
S1W6	1988 USGS	23.17	24.64	81.00	71-81	Upper Yorktown	NM
S1W6A	1988 USGS	23.18	26.24	74.00	64-74	Lower Yorktown	14.39
OU2HP1	08-01-94 HNUS	23.58	NA[4]	23	18-23	Upper Surficial	NM
OU2HP2	08-26-94 HNUS	19.31	NA	14.5	12.5-14.5	Upper Surficial	NM
OU2HP3	09-21-94 HNUS	3.46	NA	9	7-9	Upper Surficial	NM
OU2HP4	07-31-94 HNUS	23.41	NA	20.3	15.3-20.3	Upper Surficial	NM
OU2HP5	08-01-94 HNUS	20.12	NA	16	11-16	Upper Surficial	NM
OU2HP6	09-21-94 HNUS	6.43	NA	9	7-9	Upper Surficial	NM
OU2HP7[5]	04-05-96 B&R	7.7	NA	12.5	2-12	Upper Surficial	NM
OU2HP8[5]	04-04-96 B&R	24.4	NA	22	11-21	Upper Surficial	NM

TABLE 2-1 (Continued)
MONITORING WELL CONSTRUCTION SUMMARY
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Identification	Installation Date and Company	Ground Elevation (Feet MSL)[1]	Top of Riser Elevation (Feet MSL)	Total Well Depth (Feet BGS)[2]	Monitored Interval (Feet BGS)	Monitored Aquifer	Depth to Water (Feet BGS) April 1996
OU2HP9[5]	04-09-96 B&R	24.2	NA	14	3-13	Upper Surficial	NM
OU2HP10	04-10-96 B&R	21.7	NA	14	4-14	Upper Surficial	NM
OU2HP11[5]	04-16-96 B&R	23.6	NA	15	4-14	Upper Surficial	NM
OU2HP12	04-10-96 B&R	23.6	NA	14	3-13	Upper Surficial	NM
OU2HP13	04-09-96 B&R	22.7	NA	14	3-13	Upper Surficial	NM

(1) MSL - Mean Sea Level
(2) BGS - Below Ground Surface
(3) NM - Not measured. Well abandoned or no access.
(4) NA - Not applicable. Well removed.
(5) Converted to permanent well.

existing wells. Monitoring wells 10GW14, 10GW15, 10GW16, 10GW17, 10GW18, 10GW19, 10GW21, 10GW22, 10GW23, and 10GW24 were installed as part of the 1986 field event. These wells were located to investigate groundwater quality and hydrogeologic conditions upgradient and downgradient from the former surface sludge impoundment areas. Several of the wells were installed as clusters with screened intervals within the Upper Surficial, Lower Surficial, and Yorktown aquifers.

2.1.2 Groundwater Sampling

The groundwater at OU2 was sampled from monitoring wells using stainless-steel bailers in accordance with the Halliburton NUS SOPs and USEPA SOPs. A summary of the field measurement results is presented in Appendix C (Volume II).

Up to three rounds of groundwater samples were collected from selected existing and new monitoring wells. The first round of sampling was carried out in January 1985, the second round in October 1985, and the third round in December 1986 and February 1987. The first round analyses consisted of the groundwater contaminant indicator parameters (pH [field measurement], specific conductance [field measurement], total organic carbon [TOC], and total organic halogens [TOX]), priority pollutant volatile organic compounds, selected toxic metals (cadmium, chromium, copper, lead, nickel, silver, and zinc), and total phenolic compounds. Rounds 2 and 3 analyses consisted of the groundwater contaminant indicators, priority pollutants (including methyl ethyl ketone, methyl isobutyl ketone, and xylenes), hexavalent chromium, and ethylene dibromide. In addition, wells 10EGW5, 10EGW6, 10EGW07, 10GW14, 10GW15, 10GW16, 10GW19, and 10EGW20 were sampled during a separate field activity and analyzed for RCRA Appendix VIII constituents.

2.1.3 Surface Water/Sediment Sampling

Three surface water/sediment samples (10SW/SD03A, 10SW/SD06A, and 10SW/SD07A) were collected from Slocum Creek. 10SW/SD03A was collected approximately 200 feet upstream from the mouth of Turkey Gut, and 10SW/SD06A was collected approximately 300 feet downstream from the mouth of Turkey Gut. 10SW/SD07A is located approximately 900 feet upstream from the mouth of Turkey Gut. Two leachate water and leachate sediment samples were collected from the banks of Turkey Gut. 10LW/LS05 was collected approximately 500 feet upstream from the mouth of Turkey Gut, and 10LW/LS04 was collected approximately 50 feet upstream from the mouth of Turkey Gut. Sample locations are shown on Plate 2 (Volume V) and Figure 2-1. The chemical analysis for samples collected during Round 1 was the same as the groundwater sampling except no volatile organics analysis was conducted. Rounds 2 and 3 included a more extensive analytical program and consisted of both water and sediment samples from all seven

locations. The analytes were the complete list of groundwater contaminant indicators (specific conductance, pH, TOX, and TOC), priority pollutants, hexavalent chromium, and ethylene dibromide.

2.1.4 Aquifer Testing

Short-term pumping tests and slug tests were performed in 1986 in monitoring wells 10GW04, 10GW09, and 10GW15 to determine the hydraulic characteristics of the surifical aquifer. In addition, slug tests and laboratory permeability tests on Shelby tube samples were performed on the Yorktown confining unit during the drilling of monitoring wells 10GW22 and 10GW23. Calculations and results of pumping and slug tests are presented in Appendix F.

2.2 1990 INVESTIGATION (UNITS 5, 10, 16, and 17 RFI)

This section briefly discusses the field operations and procedures used during the 1989, 1990, and 1991 field work performed at OU2, as documented in the RCRA Facility Investigation (RFI) report of 1991 (NUS Corporation, May 1991a). The field work included the following tasks:

- Soil-gas survey
- Drilling and installation of 12 monitoring wells and 8 soil borings.
- Subsurface soil sampling and background soil sampling from 4 locations.
- Groundwater sampling from 12 new and 23 existing monitoring wells.
- Surface water/sediment sampling from 6 locations.
- Aquifer testing of 12 wells and 1 round of synoptic water-level measurements.
- Site horizontal and vertical survey

2.2.1 Soil-Gas Survey

A soil-gas survey was performed at the site in October and November of 1989 by Northeast Research Institute, Inc. (NERI). Most of the site was surveyed on an unbiased grid with 100-foot centers and a 200-foot centered grid in the southern portion of the site. Both semivolatile and volatile organic compounds were measured as relative flux and mapped. The maps are supplied in the Appendix L (Volume IV). The results from the survey were used to locate the monitoring wells.

2.2.2 Drilling

Soil borings and monitoring wells were installed using split-spoon and hollow-stem auger drilling techniques in accordance with the Halliburton SOPs and USEPA SOPs.

2.2.2.1 Soil Boring Installation

A total of eight soil borings were drilled in order to sample the subsurface soil for chemical and lithologic analysis. Borings 10B01 through 10B04 were drilled in the former sludge impoundment area to collect soil samples for chemical analysis. The sampling interval depth is designated by the last four digits of the sample identification number and ranged from 6 to 14 feet. Samples collected above a depth of 13.5 feet were from the backfill material. Deeper samples were from underlying natural soil. All samples were collected from above the water table. The sample log sheets are presented in Appendix C (Volume II). Borings 10B05 through 10B08 were drilled to provide lithologic data concerning the presence and position of the confining unit(s) underlying the site. Each boring was backfilled to the ground surface with a cement-bentonite mixture when completed.

2.2.2.2 Monitoring Well Installation

The locations of the 12 new monitoring wells were based on the soil-gas results that indicated "hot spots." Table 2-2 lists the wells and the rationale for placement. All newly installed wells were constructed of 2-inch-diameter PVC riser and screen. The well screens were 15 feet long with a 0.02-inch slot size. The sand pack material consisted of a #20-30 sand. The wells were installed such that the screened interval crossed the water table. A monitoring well construction summary is presented on Table 2-1.

2.2.3 Groundwater Sampling

A total of 35 groundwater samples were collected from newly installed and existing monitoring wells. Each groundwater sample was analyzed for Target Compound List (TCL) volatile organics, priority pollutant metals (filtered and unfiltered), and total suspended solids (TSS). Samples from existing wells 10EGW1, 10EGW4, 10GW09, 10GW12, 10GW14, 10GW19, 10GW33 and new wells 10GW36 through 10GW47 were also analyzed for TOC and 5-day biochemical oxygen demand (BOD_5). Samples from monitoring wells 10EGW3 and 10GW36 were also analyzed for TCL semivolatile organics, pesticides, and polychlorinated biphenyls (PCBs). The groundwater samples were collected using bailer methods. The sample log sheets are presented in Appendix C (Volume II).

TABLE 2-2

RATIONALE FOR PLACEMENT OF MONITORING WELLS -1990 INVESTIGATION
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well	Rationale
10GW36	South side of Turkey Gut at the most downgradient point.
10GW37	North of 10GW12 in a large PCE/TCE hot spot.
10GW38/39	Downgradient of the wash rack to monitor a hot spot of both volatiles and semivolatiles.
10GW40	At the southern most PCE/TCE hot spot.
10GW41	Near an area containing asphalt/rubble.
10GW42	Immediately downgradient of the former impoundment in a hot spot.
10GW43	On the south side of Turkey Gut in a naphthalene hot spot.
10GW44	600 feet west of the former impoundment in a PCE/TCE/ naphthalene hot spot.
10GW45/47	Within a large hot spot on the north side of Turkey Gut near what is believed to be a former drum storage area.
10GW46	East of the former petroleum storage area in a volatile hot spot.

PCE - tetrachloroethene
TCE - trichloroethene

2.2.4 Surface Water and Sediment Sampling

A total of six surface water/sediment samples were collected from the site. 10SW/SD03 (near Slocum Creek) through 10SW/SD06 (upstream location) were collected along the length of Turkey Gut. 10SW/SD01 and 10SW/SD02 were collected from Slocum Creek downstream and upstream of Turkey Gut, respectively. The sampling locations are illustrated on Plate 2 (Volume V) and Figure 2-1. The surface water samples were analyzed for TCL volatiles, Target Analyte List (TAL) metals (filtered and unfiltered), and TSS. The sediment samples were analyzed for TCL volatiles, TAL metals, and TOC.

2.2.5 Aquifer Testing

Aquifer slug tests were conducted at the 12 newly installed monitoring wells 10GW36 through 10GW47. The calculations and results are presented in Appendix F (Volume II). One round of groundwater-level measurements was carried out during the field effort. Table 2-3 presents the water-level data.

2.2.6 Surveying

Newly installed monitoring wells and soil boring locations were surveyed horizontally and vertically and referenced to a USGS benchmark.

2.3 1991 INVESTIGATION (21 UNIT RFI)

The 21-Unit RFI conducted in 1991 (HNUS, June 1993) consisted of the collection of surface and near-surface soil samples from areas where sludge was applied. These areas were actually within Units 10 and 21, and samples were collected accordingly and identified with the Unit 45 prefix.

Sample locations are shown in Plate 2 (Volume V) and Figure 2-1. Soil samples were collected from two locations, at two depths at each location. Samples 45SO01 and 45SO02 were collected from Unit 21, and samples 45SO03 and 45SO04 were collected from an area at Unit 10 that has been designated as Site 44A. Each location was sampled at depths of 0 to 0.5 foot and 2 to 3 feet. Each of the eight samples was analyzed for RCRA List 2 metals. In addition, TCLP toxicity testing was performed on each of the samples, and the leachate was analyzed for the List 2 metals. The results from Unit 21 will not be discussed in this report because Unit 21 is not located at OU2.

TABLE 2-3

GROUNDWATER ELEVATION SUMMARY - 1990
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Number	Measure Point Elevation (Feet MSL)	Water Level Information - 1990	
		Depth to Water (Feet)	Elevation (Feet MSL)
10EGW1 (B-101)	21.38	7.68	13.7
10EGW02 (B-104)	19.62	16.74	2.88
10EGW3 (B-105)	15.47	13.4	2.07
10GW04	22.87	13.09	9.78
10EGW5	22.73	15.84	6.89
10EGW6	22.9	16.02	6.88
10EGW07	23.16	16.32	6.84
10EGW08	24.62	17.40	7.22
10GW09	22.87	17.79	5.08
10GW10	19.65	15.38	4.27
10GW11	26.26	20.33	5.93
10GW12	21.93	17.17	4.76
10GW13 (B-106)	24.66	19.79	4.87
10GW14	25.81	18.60	7.21
10GW15	26.25	18.98	7.27
10GW16	25.01	17.94	7.07
10GW17	27.28	20.21	7.07
10GW18	22.33	NM	NM
10GW19	15.00	8.28	6.72
10GW20 (B-102)	23.00	13.93	9.07
10GW21	15.62	9.02	6.6
10GW22	23.55	NM	NM
10EGW23	24.34	NM	NM
10GW24	15.66	NM	NM
10GW25 (S1W2)	25.20	NM	NM

TABLE 2-3 (Continued)
GROUNDWATER ELEVATION SUMMARY - 1990
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Number	Measure Point Elevation (Feet MSL)	Water Level Information - 1990	
		Depth to Water (Feet)	Elevation (Feet MSL)
10GW26 (S1W1A)	24.85	NM	NM
10GW27 (L1D)	16.95	NM	NM
10GW28 (L1S)	16.77	NM	NM
10GW29 (L2D)	14.61	NM	NM
10GW30 (L2S)	14.95	NM	NM
10GW31 (L3D)	10.55	NM	NM
10GW32 (L3S)	10.01	NM	NM
10GW33	26.65	22.20	4.45
10GW34	25.68	19.29	6.39
10GW35	25.91	19.69	6.22
10GW36	16.98	10.05	6.93
10GW37	15.33	7.18	8.15
10GW38	22.95	14.58	8.42
10GW39	23.00	10.33	9.35
10GW40	31.43	14.06	17.37
10GW41	18.92	8.99	9.93
10GW42	22.22	15.19	7.03
10GW43	14.77	9.67	5.1
10GW44	20.89	17.63	3.26
10GW45	30.51	20.27	10.24
10GW46	27.40	19.87	7.53
10GW47	25.81	14.63	11.18
10GW48	23.18	NM	NM
B-103	22.99	NM	NM
S1W3	24.94	NM	NM
S1W6	23.36	NM	NM
S2W1	22.53	NM	NM

TABLE 2-3 (Continued)
GROUNDWATER ELEVATION SUMMARY - 1990
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Number	Measure Point Elevation (Feet MSL)	Water Level Information - 1990	
		Depth to Water (Feet)	Elevation (Feet MSL)
S2W2	22.86	NM	NM
S2W3	NM	NM	NM
S4W1	24.96	NM	NM
S4W2	24.57	NM	NM
S4W3	24.98	NM	NM

MSL - Mean Sea Level
NM - Not Measured

2.4 1992 INVESTIGATION (UNITS 10 and 16 TDM)

This section discusses in brief the field operations and procedures used during the 1992 field work performed at OU2 (HNUS, November 1992). The field work included the following tasks:

- Magnetometer survey
- Drilling of 62 soil borings.
- Excavating of 14 test pits.
- Subsurface soil sampling.

2.4.1 Magnetometer Survey

A magnetometer survey was conducted in a grid pattern at the six study areas (A through F) identified at Unit 10 (Plate 2) and Figure 2-1. A total of 168 magnetometer data points were located at 50-foot intervals using a tape measure and a hand-held "Brunton" surveying transit. Survey flagging tape wrapped around wooden stakes or pin flags were used to mark each data point location. The survey was conducted using a "Schoenstat" Heliflux magnetic locator following the operation procedures outlined in the manufacturer's manual. The Heliflux magnetic locator is a hand-held, wand-type instrument that provides the operator with audible tone readings. Areas identified as containing magnetic anomalies were investigated further with additional magnetometer readings at a closer grid spacing to help determine the approximate size of the anomaly. The readings were used to select areas for test pit excavations.

2.4.2 Drilling

A total of 62 soil borings were drilled at Operable Unit 2 using split-spoon and hollow-stem auger drilling methods in accordance with Halliburton NUS SOPs and EPA SOPs. The locations of the borings are illustrated on Plate 2 (Volume V) and Figure 2-1. The biased boring locations BB1 through BB12 were arbitrarily chosen to establish coverage of the site throughout the central and southern portions of Unit 10. Some of the locations were based on a review of past aerial photographs of the area. The remaining 50 borings were drilled within study grid areas A through F. In general, the soil borings were advanced to a depth of 10 feet or to the water table, whichever was encountered first. However, some of the borings were drilled deeper than 10 feet in landfill areas where the fill thickness was greater than 10 feet.

2.4.3 Test Pit Excavation

A total of 14 test pits were excavated at locations shown on Plate 2 (Volume V) and Figure 2-1. The test pit locations were based on the results of the magnetometer survey and a review of past aerial photographs of the area. The test pits were excavated with a rubber-tired backhoe to depths ranging from 5 to 13 feet below the ground surface. Soil samples were collected at regular depth intervals as determined by the field geologist. One soil sample from each pit was submitted for chemical analyses. The soil samples were collected from the backhoe bucket by scooping the soil sample directly into the sample jar. The sample interval that was submitted for laboratory analyses was determined in the field based on visual observations and organic vapor detector readings. If there were no indications of contamination in a specific test pit, the soil sample collected from the deepest interval was submitted for laboratory analyses. All test pits were backfilled with the excavated material and marked with a wooden stake and flagging tape for identification and surveying upon completion. Photographs were taken of each open test pit prior to backfilling. A test pit log sheet was completed for each test pit (Appendix A, Volume I).

2.4.4 Soil Sampling

A total of 79 subsurface soil samples were collected from the site. One subsurface soil sample was collected from each of the 14 test pits at depths determined by the field geologist. One of the test pit samples was collected at the water table. The remaining samples were collected from above the water table. Samples were analyzed for TCL volatile organics and priority pollutant metals. One soil sample from each of the borings that was representative of the most contaminated soil interval (based on visual observation or organic vapor readings) was submitted for laboratory analyses. The majority of the soil boring samples were collected from above the water table, except for some of the deeper borings or where shallow groundwater (less than 10 feet deep) was encountered. If no signs of contamination were evident in a given boring, then the deepest soil sample collected was submitted for laboratory analyses. However, in three of the soil borings (10SB-C1, 10SB-C27, and 10SB-C29), two soil samples were submitted for laboratory analyses. One of the samples from each of these borings was taken of the fill material, and the second sample was taken in natural material below the fill. The soil samples were collected directly from the split-barrel sampler, with the exception of soil borings 10SB-C27 and 10SB-C29. In these borings, samples of drill cuttings were collected directly from the bottom of the auger flights, since loose fill material was encountered that prohibited the collection of split-barrel samples. All soil samples (65 total) were analyzed for TCL volatile organics and priority pollutant metals. A boring log was recorded for each boring drilled and is included in Appendix A (Volume I).

2.5 1993 INVESTIGATION (10 UNIT TDM)

An investigation of 10 sites at the Air Station was conducted in April 1993. None of the sites are associated with OU2; however, groundwater samples that represent Air Station background conditions were collected. This section only discusses the collection of the background groundwater samples.

Four temporary groundwater wells were installed in areas believed to be upgradient of the Air Station sites using Hydropunch techniques. The locations of the background wells are shown on Figure 2-2 and Plate 3 (Volume V). Hydropunch techniques involve pushing a 5-foot-long, 1-inch-diameter PVC screen with a steel point into the subsurface with the hydraulic head of the drilling rig. The screen was first screwed onto a PVC rise pipe. The screen and riser pipe were then inserted into a stainless steel sleeve of the same length to act as support against collapse during installation. After the screen was pushed to the desired depth, the stainless steel sleeve was removed, leaving the PVC screen at the desired interval (typically 10 to 15 feet beneath the ground surface). A groundwater sample was collected, and the PVC screen and riser pipe were pulled from the ground with the drill rig. Each abandoned hole was backfilled with bentonite chips.

2.6 1993 INVESTIGATION (UNIT 10 AND 16 PHASE II TDM)

This section presents a description of each of the field investigation tasks that were performed between November 1 and December 14, 1993, at the Air Station to meet the objectives of the Phase II RFI (HNUS, June 1994b). The field work included the following tasks:

- Terrain conductivity survey
- Drilling of 4 soil borings
- Excavating of 9 test pits
- Soil sampling

2.6.1 Terrain Conductivity Survey

A terrain conductivity survey was conducted in a grid pattern at the central landfill area. A total of 240 terrain conductivity data points were located at 50-foot intervals using a tape measure and a hand-held "Brunton" surveying transit. Surveyors' flagging tape wrapped around wooden stakes or surveyors' pin flags were used to mark each data point location. The survey was conducted using a "Geonics EM-13" terrain conductivity meter following the operation procedures outlined in the manufacturers manual. The meter is a shoulder-mounted unit with 2 horizontal poles protruding from each end of the unit and is capable of

displaying conductivity readings in millimhos per meter. Areas identified as containing conductive anomalies were further investigated via test pit excavation and soil sampling.

2.6.2 Drilling

A total of four soil borings were drilled at Unit 10 in the former sludge impoundment area (10SISB1 through 10SISB4). The locations of the borings are shown on Plate 2 and Figure 2-1. The soil borings were drilled using hollow-stem auger drilling techniques with split-barrel soil sampling. The split-barrel sampler (2 feet long) was driven with a 140-pound drop hammer that was dropped a distance of 30 inches. The number of hammer blows that were required to drive the sampler every 6-inch interval over a total length of 2 feet was recorded for each sample. In general, split-barrel soil samples were collected continuously throughout the entire drilled interval of each boring. The depth of the soil borings ranged from 6 to 14 feet beneath the ground surface. The 6-foot depth is within the soil backfill material. The 14-foot depth is slightly (0.5 foot) beneath the backfill soil. Each boring was backfilled with a bentonite-cement grout upon completion and marked with a wooden stake and surveyors' flagging tape for subsequent identification and location.

2.6.3 Test Pit Excavations

A total of nine test pits were excavated at locations shown on Plate 2 and Figure 2-1 (TP-15 through TP-23). The test pits were excavated with a rubber-tired backhoe to depths of 10 feet below the ground surface. All test pits were backfilled with the excavated material and marked with a wooden stake and surveyors' flagging for identification and location upon completion. Photographs were taken of each open test pit prior to backfilling. A test pit log sheet was filled out for each test pit and can be found in Appendix A (Volume I). Soil sample logsheets are included in Appendix C (Volume II).

2.6.4 Soil Sampling

One or two soil samples from each of the borings (based on visual observation or organic vapor readings) were submitted for laboratory analysis for TCL volatile and semivolatile organics and TAL metals. All samples were collected from above the water table. The soil samples were collected directly from the split-barrel sampler. A boring log was recorded for each boring drilled and is included in Appendix A.

During the test pit excavation activities, soil samples were collected at regular depth intervals as determined by the field geologist. One or two soil samples were submitted for chemical analyses (TCL volatile and semivolatile organics and TAL metals) from each test pit. All samples were collected from above the water table. The soil samples were collected from the backhoe bucket by scooping the soil sample directly into

the sample jar. The sample interval that was sent to the laboratory for analyses was determined in the field based on visual observations and organic vapor detector readings. Soil sample logsheets are included in Appendix C.

2.7 1994 INVESTIGATION (RI)

This section of the report discusses in detail the field operations and procedures used during the preliminary field work performed at Operable Unit 2. The 1994 Remedial Investigation included the following tasks:

- Mobilization/demobilization
- Drilling
  - Installation of 8 soil borings.
  - Installation of 12 monitoring wells.
  - Installation of 6 temporary groundwater wells.
  - Coring of pond sediments at 4 locations.
  - Borehole geophysical logging at 6 monitoring well locations.
- Soil sampling
  - Subsurface soil sampling from 15 locations
  - Background soil sampling from 3 locations
- Groundwater sampling from temporary groundwater wells and monitoring wells.
- Surface water sampling from 7 locations, sediment sampling from 11 locations.
- Installation of 3 staff gauges.
- Survey of all sample locations
- Two rounds of synoptic water-level measurements/monitoring well inventory
- Investigation-derived waste disposal
- Quality control sampling

Details of the sample locations, sample numbers, and sample analytes are provided in the following subsections. The media investigated were sampled using procedures as described in the RI Work Plan (Halliburton NUS, June 1994a).

2.7.1 Mobilization/Demobilization

Following the approval of the Work Plan, B&R Environmental prepared specifications and obtained subcontractors for the drilling, surveying, and laboratory analyses and began mobilization activities. All field

team members reviewed the Sampling and Analysis Plan, the Heath and Safety Plan (HASP), and the Quality Assurance/Quality Control (QA/QC) sections of the Work Plan prior to the field activities.

The Field Operations Leader (FOL) coordinated the mobilization activities and made equipment purchases required to conduct the field investigation. Some of the equipment required for the field activities was loaded into a vehicle in Pittsburgh and driven to the site by the FOL and a field person; the remainder of the equipment was shipped from Pittsburgh or directly from the vendor(s) providing the equipment. After the preliminary field activities were completed, the FOL demobilized the equipment and drove the company vehicle loaded with equipment back to the Pittsburgh warehouse.

2.7.2 Drilling

Soil borings, permanent monitoring wells, temporary wells, and pond sediment coring/sampling required a variety of drilling techniques. The drilling techniques used during the field effort were split-spoon sampling/hollow-stem-auger, mud rotary, mechanically pushed, and hammer/wash methods. Borehole geophysical logging was performed at selected locations during the drilling activities. All borings were drilled in accordance with EPA SOP E.2 and logged in accordance with Halliburton NUS SOP GH-1.5 and EPA SOP E.10.

2.7.2.1 Installation of Soil Borings

A total of eight soil borings (OU2SB01, OU2SB02, OU2SB03, OU2SB04, OU2SB05, OU2SB06, OU2SB07, and OU2SB08) were installed at Operable Unit 2 using the hollow-stem-auger drilling technique. The auger flights were advanced to the water table where drilling was stopped. Continuous split-barrel soil sampling (in 2-foot increments) was conducted according to American Society for Testing and Materials (ASTM) methods from the ground surface to the total depth of each boring, and samples were screened with a photoionization detector (PID). The boring was backfilled with a cement bentonite grout upon completion. The locations of the borings are presented on Plate 2 (Volume V) and Figure 2-1. The boring logs are supplied in Appendix A (Volume I).

2.7.2.2 Installation of Permanent Monitoring Wells

A total of 12 monitoring wells were installed at the site during this investigation. Monitoring well boring logs are supplied in Appendix A, and well construction logs are presented in Appendix B (Volume I). Monitoring wells OU2MW1, OU2MW8, and OU2MW11 are upper surficial aquifer wells, with screened intervals across the water table. Monitoring wells OU2MW9, OU2MW10, and OU2MW12 are lower surficial aquifer wells, with

screened intervals just above the Yorktown confining unit (formerly the upper confining unit). Monitoring wells OU2MW2, OU2MW3, OU2MW4, OU2MW5, OU2MW6, and OU2MW7 are lower Yorktown aquifer wells, with screened intervals just above the Pungo River confining unit (formerly the lower confining unit). The locations of the monitoring wells are presented on Plate 2 (Volume V) and Figure 2-1. The monitoring wells were installed in accordance with the procedures detailed in the Work Plan. All the monitoring wells were installed using Schedule 40 PVC, 0.01-inch slot by 10-foot long screens, and Schedule 40 PVC riser, except for monitoring wells OU2MW5, OU2MW7, OU2MW9, and OU2MW12, which were installed using a 0.02-inch slot by 10-foot long screen. The monitoring well construction summary for all new and existing monitoring wells (Table 2-1) presents the date of installation, ground elevation at the concrete pad well head, elevation at the top of the riser (the point from which all groundwater-level measurements are made), total well depth (which is the depth of the PVC well below ground surface), screened interval depth, and monitored aquifer.

A 4-inch-square, black steel protective casing with a hinged locking cap was cemented in place over the riser pipe of each well. The protective casings extended approximately 2.5 feet below the ground surface, and a drain hole was drilled into the protective casing approximately 6 inches above the concrete pad at each well. All locks for the wells were keyed alike. A 5-foot-square, 6-inch-thick concrete apron was cemented in place around the well, and four bright yellow barrier posts (nominal 4-inch-diameter, 7-foot-long steel pipe filled with concrete) were cemented in at the four corners of the concrete apron. Each permanent monitoring well has an identification tag affixed to the protective casing in accordance with North Carolina well construction standards (15 NCAC 2C.0108).

The monitoring wells were developed by a vigorous air lift method, no sooner than 24 hours after the installation, and, when necessary, a final pumping with a peristaltic pump was performed. Measurements of pH, temperature, specific conductance, and turbidity were recorded in the field logbook. The wells were developed until two consecutive readings of pH, specific conductance, and temperature were similar (+/- 10 percent) and two consecutive turbidity values were 5 nephelometric turbidity units (NTUs) or less.

2.7.2.3 Installation of Temporary Groundwater Wells

A total of six temporary groundwater wells were installed at Operable Unit 2. OU2HP3 and OU2HP6 were installed with a "Bosch" rotary electric hammer, and OU2HP2 was installed using the van-mounted "Geoprobe" hydraulic equipment. Temporary wells OU2HP2, OU2HP3, and OU2HP6 were made of 1-inch-diameter mill-slotted well points. The well point and riser rods were advanced downward until the water table was encountered. The tip of each well point had a 2.5-foot-long slotted well screen connected to 3-foot lengths of riser rods. After each 3-foot section was push-driven into the soil, an electrical water-level indicator was lowered into the well point to determine whether groundwater was encountered. After

installation, the top of the well point was covered with aluminum foil and a plastic cap. Temporary wells OU2HP1, OU2HP4 and OU2HP5 were made of 2-inch-diameter by 5-foot long, Schedule 40 PVC 0.02-inch slotted well points. These temporary wells were installed using the hollow-stem-auger drilling technique, using well sand and natural cave-in material as a filter pack and by sealing the well with hydrated bentonite. However, no grout was placed in the annulus. After the well was sampled, the well screen and riser pipe were removed from the boring with the rig winch and cable. The well boring was then backfilled with bentonite grout mix.

The temporary groundwater wells were developed using a peristaltic pump and polyethylene tubing to remove silt and sand which entered the well point. A minimum of 5 gallons of water, silt, and sand were removed from each well point during development. Development consisted of inserting a length of polyethylene tubing to the bottom of the well point and agitating the tubing vertically while the pump was operating. The pump was operated at a maximum rate of approximately 2 liters per minute. After removal of settled material from the bottom of the well point, the well point was vigorously pumped at maximum capacity until the discharge water was visibly colorless and clear and no further sediments were being generated.

2.7.2.4 Coring of Pond Sediments

A total of eight sediment samples were collected from four coring locations beneath the Site 46 polishing ponds using drive casing, wash, and split-spoon techniques. One deep sample and one shallow sample were collected at each location. The pond sediment/soil sampling technique used a drilling rig mounted on two flat-bottom boats attached side by side. The rig consisted of a portable tripod with a pulley at the apex, a cathead mounted on one leg of the tri-pod, and a 140-pound hammer attached to a rope. The 140-pound hammer was used to advance flush-threaded, 5-or 10-foot long by 3-inch-diameter casing to the desired depth. The casing was then washed out using potable water prior to driving the split spoon to collect the sample.

2.7.2.5 Borehole Geophysical Logging

Borehole geophysical logging was performed during the installation of the Lower Yorktown wells (OU2MW2, OU2MW3, OU2MW4, OU2MW5, OU2MW6 and OU2MW7). The equipment was rented from COLOG, Inc., of Golden, Colorado, and operated by the B&R Environmental field personnel. The logging probe was attached to a motorized winch by a single conductor cable used to lower and withdraw the probe from the borehole. The motorized winch and probe were attached to a notebook computer that recorded the data. The probe was lowered and withdrawn from the open borehole twice. Depending on the particular well, the

first cycle ranged from 0 to 35 to 0 to 45 feet below the ground surface location. The second cycle ranged from 0 to 78 to 0 to 103 feet below the ground surface. The first logging cycle was initiated when a cohesive clayey material believed to be the Yorktown confining unit was encountered. The second cycle was initiated when the Pungo River confining unit was encountered.

Three types of geophysical logs were performed: natural gamma ray, spontaneous potential, and spot resistance. Two logging cycles were performed at the borehole location because the spontaneous potential and spot resistance logs cannot be performed through the steel casing that had to be permanently grouted into the borehole down to the Yorktown confining unit. The natural gamma ray log was performed as the probe was lowered, and the spontaneous potential and spot resistance logs were performed simultaneously as the probe was withdrawn from the open borehole. A printout of the geophysical log is supplied in Appendix A. A computer ASCII data file of the geophysical log is on file.

Natural Gamma Ray Log

The natural gamma ray log is a record of the amount of naturally occurring gamma ray radiation from the sediments in units of counts per second (cps) versus depth. Generally, clay sediments are known to have higher levels of radiation than sands. Therefore, the log can be used to distinguish between sand and clay layers. This log can be performed in a PVC- or steel-cased borehole.

Spontaneous Potential Log

The spontaneous potential log is a record of naturally occurring electrical potentials developed in the bore hole. The unit of measure is millivolts versus depth. Generally, a shale (clay) line is developed at some arbitrary value, and deviation from the line indicates a change in lithology.

Spot Resistance Log

The spot resistance log is a record of the resistance of the formation between the probe in the borehole and the surface electrode versus depth. The unit of measure is ohm versus feet. Generally, sandstone and limestone give high readings, coal gives medium to high readings, and shale gives a low reading. However, the measurement depends on the salinity of the borehole fluid.

2.7.3 Soil Sampling

Soil samples were collected using split spoons with hollow-stem-auger or mud rotary drilling techniques. The sample interval selected for chemical analysis was determined in the field by screening samples with a PID or visual observation in attempts to identify the most contaminated sample from the boring. The sample interval selected from the monitoring well borings for chemical and geotechnical analyses was predetermined in the RI Work Plan. All samples were collected from the interval near the water table. A soil sample log sheet was generated during every sample acquisition event. The log sheet includes sample identification, sample depth, date, time, analyses requested, sample data, and lithologic description. The sample log sheets are supplied in Appendix C. The portion intended for analysis of volatile organic compounds was collected first and placed immediately in the appropriate sample containers. Enough additional soil to fill all remaining containers was mixed on aluminum foil or in a stainless-steel mixing bowl, then placed in the appropriate sample containers. All sampling equipment was decontaminated in accordance with the procedures detailed in Section 2.7.6.

2.7.3.1 Subsurface Soil

A total of 21 subsurface soil samples (19 plus 2 duplicates) were collected from 8 soil borings and 7 monitoring well borings for chemical and geotechnical analysis. Eight of the 19 soil samples were collected from the soil borings SB01 through SB08 for chemical analysis, one sample per boring. The chemical analysis consisted of TCL volatile organic compounds, TCL semivolatile organic compounds, TCL pesticides and PCBs, TAL metals, and cyanide. Three of the 19 samples were collected from monitoring well boring OU2MW7 as part of a base-wide background soil sampling effort as described in Section 2.7.3.2. The locations of the soil borings and monitoring wells are shown on Plate 2 (Volume V) and Figure 2-1.

The remaining eight soil samples were collected using Shelby tube samplers from monitoring well borings OU2MW2, OU2MW3, OU2MW4, OU2MW5, OU2MW6, and OU2MW7. The geotechnical analyses included TOC, grain-size distribution, pH, moisture content, permeability, Atterberg limits, specific gravity, organic content, and cation exchange coefficient. EPA SOP 4.11 contains guidance regarding soil sampling procedures. The geotechnical analytical results are provided in Appendix E (Volume II).

2.7.3.2 Background Soil Sampling

Background soil samples were collected during the RI at Operable Units 1, 2, 3, 4, and 13. Fifteen samples and three duplicate samples were collected as background samples from five monitoring well borings. These borings were located upgradient of the various OUs being investigated. Three samples were collected

from each boring at surface, mid-level, and deep intervals. All the background and duplicate samples were analyzed for TCL volatile organic compounds, semivolatile organic compounds, pesticides, and PCBs; TPH (gasoline- and diesel-range organics and oil and grease); and TAL metals. The locations are illustrated on Plate 3 (Volume V) and Figure 2-2.

2.7.4 Groundwater Sampling

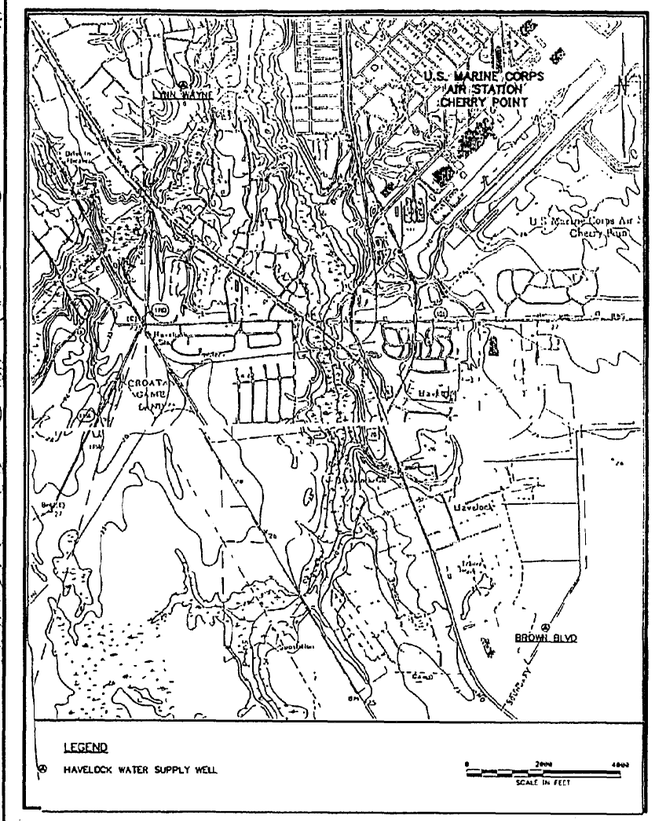
Groundwater from all new and selected existing monitoring wells and temporary wells was sampled in accordance with the low-flow sampling procedures detailed in the RI Work Plan (Halliburton NUS, June 1994a). The purging and sampling apparatus used for collecting groundwater samples consisted of a length of polyethylene tubing which was connected to a peristaltic pump. Silicon tubing was threaded through the pump, and a section of polyethylene tubing was used for discharge. Prior to sampling, the well points were purged to ensure collection of a representative groundwater sample. During purging, measurements of pH, specific conductivity, temperature, color, and turbidity were performed at five minute intervals. Groundwater sample collection was not initiated until stabilization of these parameters was observed. Stabilization was defined as ±0.1 pH units, ±10% for specific conductance, ±0.1°C for temperature, and less than 10 NTUs for turbidity.

Sample containers were first filled for the TCL semivolatile organics, pesticides/PCBs, TAL metals, and cyanide.

Samples collected for volatile organic compounds analysis were then obtained from the Teflon sample collection tube. The pump was shut off, the tubing was pinched at the top and removed from the well point, and groundwater was poured directly from the bottom of the Teflon tubing into the sample vials. Duplicate and matrix spike sample collection was performed in the same manner.

A groundwater sample log sheet was generated during every sample acquisition event and provides a record of the sampling conditions including, but not limited to, sample identification, well depth, static water level, amount of water purged, date, time, analyses requested, purge and sample data, pH, conductivity, water temperature, dissolved oxygen, turbidity, and oxidation reduction potential. The sample log sheets are supplied in Appendix C (Volume II). The groundwater samples were collected between September 20 and 27, 1994.

A total of 50 groundwater samples plus 5 field duplicate samples were collected from the 6 temporary wells, 12 newly installed monitoring wells, and 32 existing monitoring wells, as outlined in the Work Plan (Halliburton NUS, June 1994a). However, existing monitoring wells 10GW10 and 10EGW13 were dry and



NOTE:

THERE ARE TWO SUPPLY WELLS AT EACH HAVELOCK LOCATION.

INTAKE INTERVAL AT LYNN WAYNE IS UNKNOWN. THE TOTAL DEPTH IS APPROXIMATELY 280' ft BGS.

INTAKE INTERVALS AT BROWN BLVD. ARE 162 TO 192 – 258 TO 246; 168 TO 195 – 288 TO 246.

*WELL 16 HAS BEEN CONVERTED FROM A OPEN HOLE WATER SUPPLY WELL TO A 4" PVC MONITORING WELL IN THE CASTLE HAYNE AQUIFER.

HAVELOCK WATER SUPPLY WELL INFORMATION IS FROM VERBAL COMMUNIQUES WITH THE NORTH CAROLINA DEPT. OF ENVIRONMENTAL HEALTH AND NATURAL RESOURCES.

WELL DATA ARE FROM A 5/31/91 WELL STATISTIC HAND WRITEN REPORT, AND VERBAL COMMUNIQUES WITH ENVIRONMENTAL AFFAIRS DEPT. AT THE MCAS.

LEGEND

WELL # OR BLDG #
INTAKE INTERVAL (FT)BGS — DRINKING WATER SUPPLY WELL

INDUSTRIAL RAW WATER SUPPLY WELL

MONITORING WELL
SOIL BORING

SOIL SAMPLE

HYDROPUNCH SAMPLE

SOIL BORING

HAVELOCK DRINKING WATER SUPPLY WELL

REVISIONS

NO.	DESCRIPTION	DATE	APPROVED

Brown & Root Environmental

CONTRACT – SATISFACTION TO

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND — ATLANTIC DIVISION — NORFOLK, VIRGINIA

NAVAL STATION MARINE CORPS AIR STATION CHERRY POINT — CHERRY POINT, NORTH CAROLINA

OU2
BACKGROUND SOIL AND GROUNDWATER
SAMPLING LOCATIONS

CODE IDENT. NO. 80091 | SIZE D

SCALE: AS SHOWN

XX-XX-XXXX

XXXXXX-XX-X-XXXX

SHEET X OF X

FIGURE 2-2

could not be sampled. Monitoring well B-103 was incorrectly identified as 10GW45 and was sampled in lieu of well 10GW45. Sixteen of the 50 groundwater samples were analyzed for TCL volatile organic compounds, TAL metals, and cyanide. The remaining groundwater samples were analyzed for TCL volatile organic compounds, semivolatile compounds, pesticides, and PCBs; TAL metals; and cyanide.

2.7.5 Surface Water/Sediment Sampling

Surface waters were sampled in accordance with the sampling procedures detailed in the RI Work Plan (Halliburton NUS, June 1994a). All surface water/sediment sampling was conducted from downstream to upstream locations to prevent sample cross-contamination. TAL metals analyses were performed on both filtered (dissolved) and an unfiltered (total) samples. The samples were filtered prior to preservation using an in-line disposable 0.45-micron filter attached to dedicated hose and peristaltic pump. Sediment samples were collected using a stainless-steel trowel, petite ponar dredge, split-barrel sampler with drive casing, or wash drilling methods as described in Subsection 2.7.2.3.

Surface water and sediment sample log sheets were generated during every sample acquisition event. The log sheets provide a record of the applicable sampling conditions including, but not limited to, sample identification, sampling equipment, water depth, date, time, analyses requested, field sample data, pH, conductivity, water temperature, dissolved oxygen, turbidity, salinity, and oxidation reduction potential. The sample log sheets are supplied in Appendix C (Volume II).

Surface water/sediment sampling locations on Slocum Creek were reached by using a rented fishing boat. The Ordinance Point boat ramp was the access point for Slocum Creek. A gasoline motor was used to position the boat within a reasonable distance of the surface/sediment sampling points. At that time the gas motor was turned off, and the electrical motor was used to reach the final location. Sediment samples were obtained at the same locations from which the surface water samples were located.

Seven paired surface water and sediment samples plus one duplicate pair were collected at OU2. The surface water and sediment samples were analyzed for TCL volatile organic compounds, semivolatile organic compounds, pesticides, and PCBs; TAL metals; and cyanide.

OU2SW/SD1, OU2SW/SD2, and OU2SW/SD7 were collected from Slocum Creek 25 feet from shore. OU2SW/SD1 was collected approximately 1,700 feet upstream from the mouth of Turkey Gut. OU2SW/SD2 was collected approximately 950 feet upstream from the mouth of Turkey Gut. OU2SW/SD7 was collected approximately 450 feet downstream from the mouth of Turkey Gut. OU2SW/SD3, OU2SW/SD4, OU2SW/SD5 and OU2SW/SD6 were collected from Turkey Gut. OU2SW/SD3 was collected approximately

100 feet upstream in Turkey Gut. OU2SW/SD4 was collected approximately 600 feet upstream from the mouth of Turkey Gut. OU2SW/SD5 was collected 2,150 feet up stream from the mouth of Turkey Gut. OU2SW/SD6 was collected 1,500 feet upstream from the mouth of Turkey Gut.

In addition, two sediment core samples were collected from OU2SD8, OU2SD9, OU2SD10, and OU2SD11 located at Site 46. One sample was collected from an apparent sludge layer, and another sample was collected from the soil beneath the sludge layer. The sampling locations are presented on Plate 2 (Volume V) and Figure 2-1.

2.7.6 Equipment Decontamination

All nondedicated sampling equipment was decontaminated both prior to beginning field sampling and between samples. This equipment included the stainless-steel trowels, split-spoon samplers, and stainless-steel mixing bowls. The following steps were taken:

1. Potable water rinse
2. Alconox or liquinox detergent wash
3. Potable water rinse
4. Nitric acid rinse diluted with deionized water (when sampling for metals)
5. Analyte-free water rinse
6. Isopropanol rinse
7. Air dry
8. Wrap in aluminum foil

All down-hole heavy drilling equipment, including the mud pad, was decontaminated with steam between drilling points and drilling activities between the shallow aquifer and the deep aquifer at one drilling location.

Before field measurements (pH, dissolved oxygen, temperature, etc.) were made, the instrument probes were rinsed with analyte-free water. The instrument probes were then rinsed with the sample fluid to be analyzed before the probes were placed in the sample.

2.7.7 Staff Gage Installation

Three staff gauges (OU2SG1 through OU2SG3) were installed at the site; OU3SG4 is used at both the OU2 and OU3 investigations. The locations are presented on Plate 2 and Figure 2-1. SG-1 is located on Turkey Gut approximately 1,500 feet upstream from the mouth. SG2 is located 1,400 feet downstream of SG1. Staff

gauges SG1, SG2 and SG3 were installed using 4-foot-long, green, fence posts driven into the ground approximately 3 feet deep, adjacent to the water body. OU3SG4 is located on a concrete culvert in the northwest portion of the site on Slocum Creek. The staff gauges are marked permanently using either yellow highway paint or a stainless-steel stamped tag.

2.7.8 Survey of Sample Locations

All staff gauges, the perimeter of the polishing ponds, temporary wells, new and existing monitoring wells, wetlands, and all sampling points except for surface water/sediment pairs on Slocum Creek were surveyed horizontally and vertically based on North Carolina State Plane NAD 83.

2.7.9 Water-Level Measurements

Two rounds of synoptic water-level measurements were obtained from wells and staff gauges on October 8 and 31, 1994. The first round was performed on the wells that were sampled during the RI and the staff gauges. The second round was performed on all of the newly installed and existing wells on site. The water-level measurements were collected within one 24-hour period in reference to the surveyed top of the well or staff gauge and were later converted to elevations. The water-level measurements were collected with an electronic water-level indicator or using a line level at the staff gauge locations as required. The most current water-level data are presented on Table 2-4. The field crew inventoried all monitoring wells and noted any observations in regard to the integrity of the well.

2.7.10 Investigation-Derived Waste Disposal

All investigation-derived wastes (IDW), including soil, development and purge water, and decontamination fluids, were disposed of in an approved manner. Soils remaining following sample collection were containerized in 55-gallon drums at the site of generation and transported to a covered rolloff container for bulk storage and ultimate disposal. Development and purge water from monitoring well points was containerized at the point of generation and transported to a "frac" tank located at the Industrial Wastewater Treatment Plant (IWTP) to await subsequent disposal at the IWTP. The decontamination fluids were also discharged to the IWTP at the completion of field activities. The drums used to contain groundwater and decontamination fluids were double-rinsed with potable water and placed in the drum storage area at the Air Station. The rinse water was discharged to the IWTP.

Personal protective equipment (PPE) and other nonhazardous solid waste materials generated during the field investigation were disposed of in doubled plastic garbage bags, which were placed in the garbage

TABLE 2-4

GROUNDWATER ELEVATION SUMMARY - 1994
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Number	Measure Point Elevation (Feet MSL)	Water Level Information - 10/8/94		Water Level Information - 10/31/94	
		Depth to Water (Feet)	Elevation (Feet MSL)	Depth to Water (Feet)	Elevation (Feet MSL)
10EGW1 (B-101)	21.38	7.49	13.89	6.95	14.43
10EGW02 (B-104)	19.62	16.73	2.89	16.32	3.30
10EGW3 (B-105)	15.47	13.06	2.41	12.87	2.60
10GW04	16.87	NM	NM	12.77	4.10
10EGW5	22.73	15.74	6.99	NM	NM
10EGW6	22.9	15.91	6.99	15.66	7.24
10EGW07	23.16	16.34	6.82	15.90	7.26
10EGW08	24.62	NM	NM	16.98	7.64
10GW09	22.87	17.82	5.05	17.58	5.29
10GW10	19.65	NM	NM	Dry	Dry
10GW11	26.26	21.44	4.82	21.23	5.03
10GW12	21.93	17.33	4.60	17.10	4.83
10EGW13 (B-106)	24.66	NM	NM	Dry	Dry
10GW14	25.81	NM	NM	18.14	7.67
10GW15	26.25	NM	NM	18.58	7.67
10GW16	25.01	NM	NM	17.35	7.66
10GW17	27.22	NM	NM	NM	NM
10GW18	22.33	NM	NM	14.93	7.40
10GW19	15.00	NM	NM	7.96	7.04
10EGW20 (B-102)	23.20	NM	NM	NM	NM
10GW21	15.62	NM	NM	8.70	6.92
10GW22	23.55	18.51	5.04	18.13	5.42
10GW23	24.34	NM	NM	18.92	5.42
10GW24	15.66	10.71	4.95	10.33	5.33

TABLE 2-4 (Continued)
GROUNDWATER ELEVATION SUMMARY - 1994
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Number	Measure Point Elevation (Feet MSL)	Water Level Information - 10/8/94		Water Level Information - 10/31/94	
		Depth to Water (Feet)	Elevation (Feet MSL)	Depth to Water (Feet)	Elevation (Feet MSL)
10GW25 (S1W2)	25.20	NM	NM	16.51	8.69
10GW26 (S1W1A)	24.85	NM	NM	19.26	5.59
10GW27 (L1D)	16.95	13.05	3.90	12.78	4.17
10GW28 (L1S)	16.77	12.77	4.00	12.57	4.20
10GW29 (L2D)	14.61	11.45	3.16	11.14	3.47
10GW30 (L2S)	14.95	11.71	3.24	11.72	3.23
10GW31 (L3D)	10.55	7.73	2.82	7.71	2.84
10GW32 (L3S)	10.01	6.76	3.25	7.07	2.94
10GW33	26.65	NM	NM	21.22	5.43
10GW34	25.68	18.84	6.84	18.64	7.04
10GW35	25.91	19.72	6.19	19.16	6.75
10GW36	16.98	10.13	6.85	10.00	6.98
10GW37	15.33	NM	NM	6.99	8.34
10GW38	22.95	14.39	8.56	14.21	8.74
10GW39	23.00	9.98	13.02	10.58	12.42
10GW40	31.43	11.92	19.51	11.39	20.04
10GW41	18.92	9.28	9.64	8.61	10.31
10GW42	22.22	NM	NM	14.84	7.38
10GW43	14.77	9.96	4.81	9.63	5.14
10GW44	20.89	NM	NM	17.11	3.78
10GW45	30.23	NM	NM	NM	NM
10GW46	27.40	NM	NM	19.17	8.23
10GW47	25.81	14.07	9.48	13.16	12.65
10GW48	23.18	NM	NM	15.85	7.33
B-103	22.99	11.19	19.32	10.75	19.76

TABLE 2-4 (Continued)
GROUNDWATER ELEVATION SUMMARY - 1994
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Number	Measure Point Elevation (Feet MSL)	Water Level Information - 10/8/94		Water Level Information - 10/31/94	
		Depth to Water (Feet)	Elevation (Feet MSL)	Depth to Water (Feet)	Elevation (Feet MSL)
OU2MW1	29.13	21.85	7.28	21.65	7.48
OU2MW2	18.08	12.45	5.63	13.07	5.01
OU2MW3	16.98	8.92	8.06	8.68	8.30
OU2MW4	24.14	19.31	4.83	19.11	5.03
OU2MW5	29.66	24.23	5.43	23.93	5.73
OU2MW6	28.10	22.73	5.37	22.47	5.63
OU2MW7	25.43	20.07	5.36	19.76	5.67
OU2MW8	32.11	25.78	6.33	25.55	6.56
OU2MW9	31.51	26.17	5.34	26.12	5.39
OU2MW10	18.17	11.70	6.47	11.67	6.50
OU2MW11	29.25	22.12	7.13	21.99	7.26
OU2MW12	29.87	22.75	7.12	22.42	7.45
OU2SG1	10.38	1.76	8.62	1.04	9.34
OU2SG2	3.94	1.09	2.85	1.58	2.36
OU2SG3	2.59	1.60	0.99	2.15	0.44
OU3SG4	6.91	NM	NM	6.25	0.66
S1W3	24.94	NM	NM	16.30	8.64
S1W6	23.36	NM	NM	18.91	4.45
S2W1	22.53	NM	NM	16.48	6.05
S2W2	22.86	NM	NM	10.45	12.41
S2W3	NM	NM	NM	NM	NM
S4W1	24.96	19.63	5.33	19.33	5.63
S4W2	24.57	14.27	10.30	14.55	10.02
S4W3	24.98	15.41	9.57	15.15	9.83

MSL - Mean Sea Level NM - Not Measured

dumpster located behind Building 4223.

2.7.11 Quality Control Samples

In addition to regular calibration of field equipment and appropriate documentation, quality control (QC) samples were collected or generated during environmental sampling activities. QC samples include field duplicates, field blanks, trip blanks, and equipment rinsate blanks. Each type of field QC sample is defined as follows:

- Trip Blanks. Trip blanks were samples which originated from analyte-free water collected in sample vials at the laboratory. The vials were shipped with the sample containers to the sampling sites and returned to the laboratory with the volatile organic compound (VOC) samples. The trip blanks were analyzed for the same list of VOCs as the environmental samples.

- Equipment Rinsate Blanks. Equipment rinsate blanks were obtained under representative field conditions by running analyte-free water through the sampler after decontamination and placing the runoff water in the appropriate sample containers for analysis. Equipment rinsate blanks are used to assess the effectiveness of decontamination procedures. As described in NEESA guidance, every other rinsate blank delivered to the laboratory was analyzed.

- Field Blanks. Field blanks were obtained by direct pouring from the potable water source into the sample containers. Field blanks are used to assess contamination present in source water used for equipment decontamination.

- Field Duplicates. Field duplicates were generated by splitting selected samples into two portions for analysis and collected at the rate of 1 per 10 environmental samples. The field duplicates were used to assess the overall precision of the sampling and analysis program. The field duplicates were analyzed in the laboratory for the same parameters as the associated environmental samples.

Field duplicate results are averaged and presented as one sample in the appropriate matrix section of the database (Appendix H, Volume II). Details on the averaging of duplicate results are provided in Sections 4.0 and 6.0.

2.8 1995 INVESTIGATION (SUPPLEMENTAL RI)

This section of the report discusses in detail the field operations and procedures used during the supplemental field work performed at Operable Unit 2 in 1995. The additional sampling was conducted to fill data gaps needed to support the human health and ecological risk assessments. This investigation included the following tasks:

- Mobilization/demobilization
- Surface soil sampling at 11 locations
- Leachate seep water sampling at 3 locations
- Leachate seep sediment sampling at 2 locations
- Survey of all sample locations
- Investigation-derived waste disposal
- Quality control sampling

Details of the sample locations, sample numbers, and sample analytes are provided in the following subsections. The media investigated were sampled using procedures described in the Work Plan prepared for the supplemental RI (Halliburton NUS, July 1995).

2.8.1 Mobilization/Demobilization

B&R Environmental prepared specifications and obtained subcontractors for the surveying and laboratory analyses and began mobilization activities. All field team members reviewed the Sampling and Analysis Plan, the HASP, and the QA/QC sections of the Work Plan prior to the field activities.

The FOL coordinated the mobilization activities. The equipment required for the field activities was shipped from Pittsburgh or directly from the vendor providing the equipment. Some equipment was already at the field trailer that has been at the Air Station since the time of the 1994 RI. After the field activities, the FOL demobilized the equipment and shipped it back to Pittsburgh.

2.8.2 Surface Soil Sampling

Surface soil samples were collected using hand-auger and stainless-steel-trowel methods. The sampling depth was 0 to 1 foot at all locations. A soil sample log sheet was generated for each sample. The log sheet includes sample identification, sample depth, date, time, analyses requested, sample data, and lithologic description. The sample log sheets are supplied in Appendix C. The portion intended for analysis

of volatile organic compounds was collected first and placed immediately in the appropriate sample containers. Enough additional soil to fill all remaining containers was mixed on aluminum foil or in a stainless-steel mixing bowl, then placed in the appropriate sample containers. All sampling equipment was decontaminated in accordance with the procedures detailed in Section 2.7.6.

A total of 12 surface samples (11 plus 1 duplicate) were collected from 11 locations for chemical analysis. The chemical analysis consisted of TCL volatile, semivolatile, and pesticide/PCB organic compounds; TAL metals; and cyanide. The sampling locations are shown on Plate 2 (Volume V) and Figure 2-1. The chemical analytical results are provided in Appendix H (Volume II).

2.8.3 Leachate Seep Sampling

The four leachate seeps that were sampled during the RIIR (1984 to 1987) were to be sampled, along with any other seeps that were identified by the FOL. If there was no water present or if there was insufficient volume of water to collect the required volume of sample, a soil/sediment sample was collected. Water samples from leachate seeps were collected using direct fill or stainless-steel-beaker transfer methods. Soil/sediment samples were collected using the same procedures outlined in Section 2.8.2. A water or soil sample log sheet, as appropriate, was generated for each sample. The water sample log sheet includes sample identification, date, time, analysis requested, sample data, and observations of pH, temperature, color, and turbidity. The soil sample log sheet includes the same information described in Section 2.7.2. All sampling equipment was decontaminated according to the procedures detailed in Section 2.7.6.

A total of four leachate water samples (three plus one duplicate) were collected from two previously sampled and one newly identified leachate seeps. The water samples were not filtered prior to placement in the appropriate sample containers. A total of two leachate sediment samples were collected from previously sampled leachate seeps. The chemical analysis consisted of TCL volatile, semivolatile, and pesticide/PCB organics; TAL metals; and cyanide. The sampling locations are shown on Plate 2 (Volume V) and Figure 2-1. The chemical analytical results are provided in Appendix H (Volume II).

2.8.4 Equipment Decontamination

All nondedicated sampling equipment was decontaminated both prior to beginning field sampling and between samples according to the procedures outlined in Section 2.7.6.

2.8.5 Survey of Sample Locations

All sampling points were surveyed horizontally and vertically based on North Carolina State Plane NAD 83.

2.8.6 Investigation-Derived Waste Disposal

All investigation-derived wastes were disposed of according to the procedures outlined in Section 2.7.10.

2.8.7 Quality Control Samples

Quality control samples were collected as described in Section 2.7.11, except that field blank samples were not collected, and an additional rinsate blank was submitted for chemical analysis.

2.9 1996 INVESTIGATION (SUPPLEMENTAL RI)

This section of the report discusses in detail the field operations and procedures used during the supplemental field work performed at OU2 in 1996. The additional sampling was conducted to fill data gaps needed to support the nature and extent of contamination. This investigation included the following tasks:

- Mobilization/demobilization
- Drilling
  - Installation of 2 soil borings
  - Installation of 7 temporary monitoring wells
  - Installation of 4 permanent monitoring wells
- Surface soil sampling from 2 locations
- Subsurface soil sampling from 2 locations
- Groundwater sampling from temporary wells and monitoring wells
- Surface water sampling from 4 locations
- Survey of all new sample locations
- One round of synoptic water-level measurements
- Investigation-derived waste disposal
- Quality control sampling

Details of the sample locations, sample numbers, and sample analytes are provided in the following subsections. The media investigated were sampled using procedures as described in the RI Work Plan (Halliburton NUS, June 1994a).

2.9.1 Mobilization/Demobilization

B&R Environmental prepared specifications and obtained subcontractors for the drilling, surveying, laboratory analysis, and investigation-derived waste subcontractors. All field team members reviewed the Sampling and Analysis Plan, the HASP, and the QA/QC sections of the Work Plan prior to the field activities.

The FOL coordinated the mobilization activities. The equipment required for the field activities was shipped from Pittsburgh or directly from the vendor providing the equipment. Some equipment was already at the field trailer that has been at the Air Station since the time of the 1994 RI. After the field activities, the FOL demobilized the equipment and shipped it back to Pittsburgh.

2.9.2 Drilling

The drilling technique used for soil borings, temporary monitoring wells, and permanent monitoring wells was split-spoon sampling/hollow-stem auger. All borings were drilled in accordance with EPA SOP E.2 and logged in accordance with Halliburton NUS SOP GH-1.5 and EPA SOP E.10.

2.9.2.1 Installation of Soil Borings

A total of two soil borings (OU2SB09 and OU2SB10) were installed at OU2 in the area of Site 10 where fire-training exercises were conducted. The auger flights were advanced to a depth of 10 feet or to the water table, whichever was encountered first. Continuous split-barrel soil sampling (in 2-foot increments) was conducted according to ASTM methods from the ground surface to the total depth of each boring, and samples were screened with a PID. The boring was backfilled with a cement bentonite grout upon completion. The locations of the borings are presented on Plate 2 (Volume V) and Figure 2-1. The soil boring logs are supplied in Appendix A (Volume I).

2.9.2.2 Installation of Temporary Monitoring Wells

Temporary wells were installed outside the boundaries of the area of known groundwater contamination to determine whether the extent of the contaminant plume in the surficial aquifer had been adequately identified. Once the extent of the plume was known, based on samples from the temporary wells, selected temporary wells were converted into permanent monitoring wells. A total of seven temporary groundwater wells (OU2HP7 through OU2HP13) were installed at OU2 during the 1996 investigation. The temporary wells were installed in accordance with the procedures detailed in the Work Plan for permanent wells, except that no grout was placed in the annulus. All the temporary wells were installed using Schedule 40 PVC, 0.01-inch

slot by 10-foot long screens, and Schedule 40 riser. The wells were vigorously pumped at maximum capacity until the discharge water was visibly colorless and clear. After the well was sampled, it was either converted to a permanent monitoring well or removed. Based on the analytical results wells OU2HP7, OU2HP8, OU2HP9, and OU2HP11 were converted to permanent wells. The well screen and riser pipe for temporary wells OU2HP10, OU2HP12, and OU2HP13 were removed from the boring with the rig winch and cable, and the borings were then backfilled with bentonite grout mix.

Monitoring well boring logs are supplied in Appendix A (Volume I), well construction logs are presented in Appendix B (Volume I), and the locations of the wells are presented on Plate 2 (Volume V) and Figure 2-1.

2.9.2.3 Installation of Permanent Monitoring Wells

Selected temporary monitoring wells (OU2HP series) were converted to permanent wells (OU2MW series). Well OU2HP7 was converted to OU2MW13, OU2HP8 was converted to OU2MW14, OU2HP9 was converted to OU2MW15, and OU2HP11 was converted to OU2MW16. The wells were completed by placing grout in the annulus above the bentonite seal of the temporary well. The permanent wells were provided with a protective casing with locking cap, a concrete apron, and barrier posts, as described in Section 2.7.2.2. Each permanent monitoring well has an identification tag affixed to the protective casing in accordance with North Carolina well construction standards (15 NCAC 2C.0108).

Monitoring well boring logs are supplied in Appendix A (Volume I), well construction summaries are included in Appendix B (Volume I), and the locations of the wells are presented on Plate 2 (Volume V) and Figure 2-1. The monitoring well construction summary (Table 2-1) presents the date of installation, ground elevation at the concrete pad well head, elevation at the top of the riser (the point from which all groundwater-level measurements are made), total well depth (which is the depth of the PVC well below the ground surface), screened depth interval, and monitored aquifer. All of these permanent wells are screened in the surficial aquifer.

2.9.3 Soil Sampling

Soil samples were collected using split spoons with hollow-stem auger drilling techniques and hand auger and stainless steel trowel methods. A surface soil sample was collected from each boring or surface soil sampling location at the interval of 0 to 1 foot. A subsurface sample was taken from the bottom of each boring. The subsurface soil sampling interval was above the water table. A soil sample log sheet was generated for each sample. The log sheet includes sample identification, sample depth, date, time, analyses requested, sample data, and lithologic description. The sample log sheets are provided in Appendix C

(Volume II). The portion intended for analysis of volatile organic compounds was collected first and placed immediately in the appropriate sample containers. Enough additional soil to fill all remaining containers was mixed on aluminum foil or in a stainless-steel mixing bowl, then placed in the appropriate sample containers. All sampling equipment was decontaminated in accordance with the procedures detailed in Section 2.9.6.

One surface soil and one subsurface soil sample were collected from each of two boring locations for chemical analysis. The chemical analysis consisted of TCL dioxins. In addition, two surface soil samples were collected from Site 76. The sampling locations are shown on Plate 2 (Volume V) and Figure 2-1. The chemical analytical results are provided in Appendix H (Volume II).

2.9.4 Groundwater Sampling

Groundwater from new temporary wells, new permanent wells, and selected existing wells (9GW31, 10EGW20, and 10GW31) was sampled in accordance with the low-flow sampling procedures detailed in the RI Work Plan (Halliburton NUS, June 1994a) and previously described in Section 2.7.4.

A groundwater sample log sheet was generated for every sample. The log sheet provides a record of the sampling conditions including, but not limited to, sample identification, well depth, static water level, amount of water purged, date, time, analyses requested, purge and sample data, pH, conductivity, water temperature, dissolved oxygen, turbidity, and oxidation reduction potential. The sample log sheets are supplied in Appendix C (Volume II). The groundwater samples were collected between April 9 and 23, 1996.

A total of 14 groundwater samples plus one field duplicate sample were collected from the seven new temporary wells, four new permanent wells, and three existing permanent wells. All groundwater samples were analyzed for TCL volatile organic compounds, semivolatile compounds, pesticides, and PCBs; TAL metals; and cyanide.

2.9.5 Surface Water Sampling

Surface water from Turkey Gut was sampled in accordance with the sampling procedures outlined in the RI Work Plan (Halliburton NUS, June 1994a). All surface water sampling was conducted from downstream to upstream locations to prevent sample cross-contamination. The sampling locations were at or near locations OU2SW3 through OU2SW6, which were sample in 1994. The sampling locations are presented on Plate 2 (Volume V) and Figure 2-1. The 1996 samples were only analyzed for chloride to determine whether Turkey Gut would be classified as saltwater or freshwater in accordance with state surface water classifications. A surface water sample log sheet was completed for each sample. The log sheets provide

a record of the applicable sampling conditions including, but not limited to, sample identification, sampling equipment, water depth, date, time, analyses requested, field sample data, pH, conductivity, water temperature, dissolved oxygen, turbidity, and oxidation reduction potential. The sample log sheets are supplied in Appendix C (Volume II).

2.9.6 Equipment Decontamination

All nondedicated sampling equipment was decontaminated prior to beginning field sampling and between samples. This equipment included stainless steel trowels, split-spoon samplers, and mixing bowls. The following steps were taken:

1. Wash equipment with lab detergent and hot water.
2. Rinse with tap water.
3. Rinse with deionized water.
4. Rinse twice with solvent and allow to dry.
5. Wrap in aluminum foil.

All down-hole drilling equipment, including the mud pad, was decontaminated with steam between drilling points.

Before field measurements (pH, temperature, etc.) were made, the instrument probes were rinsed with analyte-free water. The instrument probes were then rinsed with the sample fluid to be analyzed before the probes were placed in the sample.

2.9.7 Survey of Sample Locations

The temporary monitoring well, permanent monitoring well, and soil boring locations were surveyed horizontally and vertically based on North Carolina State Plane NAD 83.

2.9.8 Water-Level Measurements

One round of synoptic water-level measurements were obtained from new wells, existing wells, and staff gauges on April 22 and 23, 1996. The water level measurements were collected within one 24-hour period in reference to the surveyed top of the well or staff gauge and were later converted to elevations. The water-level measurements were made with an electronic water-level indicator or using a line level at the staff gauge locations as required. The most current water-level data are presented on Table 2-5.

TABLE 2-5

GROUNDWATER ELEVATION SUMMARY - 1996
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Number	Measure Point Elevation (Feet MSL)	Water Level Information - 04/22/96	
		Depth to Water (Feet)	Elevation (Feet MSL)
10EGW1 (B-101)	21.38	5.67	15.71
10EGW02 (B-104)	19.62	16.37	3.25
10EGW3 (B-105)	15.47	13.10	2.37
10GW04	16.87	13.16	3.71
10EGW5	22.73	15.00	7.73
10EGW6	22.90	14.60	8.30
10EGW07	23.16	15.42	7.74
10EGW08	24.62	16.32	8.30
10GW09	22.87	16.45	6.42
10GW10	19.65	14.38	5.27
10GW11	26.26	19.96	6.30
10GW12	21.93	15.97	5.96
10EGW13 (B-106)	24.66	18.79	5.87
10GW14	25.81	17.46	8.35
10GW15	26.25	17.93	8.32
10GW16	25.01	16.70	8.31
10GW17	27.22	19.24	7.98
10GW18	22.33	14.37	7.96
10GW19	15.00	7.56	7.44
10EGW20 (B-102)	23.20	11.90	11.30
10GW21	15.62	8.30	7.32
10GW22	23.55	16.63	6.92
10GW23	24.34	17.46	6.88
10GW24	15.66	8.86	6.80
10GW25 (S1W2)	25.20	15.45	9.75

TABLE 2-5 (Continued)
GROUNDWATER ELEVATION SUMMARY - 1996
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Number	Measure Point Elevation (Feet MSL)	Water Level Information - 04/22/96	
		Depth to Water (Feet)	Elevation (Feet MSL)
10GW26 (S1W1A)	24.85	17.70	7.15
10GW27 (L1D)	16.95	13.28	3.67
10GW28 (L1S)	16.77	13.09	3.68
10GW29 (L2D)	14.61	11.93	2.68
10GW30 (L2S)	14.95	12.31	2.64
10GW31 (L3D)	10.55	8.08	2.47
10GW32 (L3S)	10.01	7.55	2.46
10GW33	26.65	19.90	6.75
10GW34	25.68	18.40	7.28
10GW35	25.91	18.49	7.42
10GW36	16.98	9.45	7.53
10GW37	15.33	6.14	9.19
10GW38	22.95	12.00	10.95
10GW39	23.00	7.85	15.15
10GW40	31.43	9.56	21.87
10GW41	18.92	7.42	11.50
10GW42	22.22	14.33	7.89
10GW43	14.77	8.61	6.16
10GW44	20.89	17.14	3.75
10GW45	30.23	15.99	14.33
10GW46	27.40	18.40	9.00
10GW47	25.81	11.35	14.46
10GW48	23.18	15.23	7.95
B-103	22.99	8.87	14.12
OU2MW1	29.13	21.29	7.84
OU2MW2	18.08	11.70	6.38

TABLE 2-5 (Continued)
GROUNDWATER ELEVATION SUMMARY - 1996
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Number	Measure Point Elevation (Feet MSL)	Water Level Information - 04/22/96	
		Depth to Water (Feet)	Elevation (Feet MSL)
OU2MW3	16.98	7.43	9.55
OU2MW4	24.14	17.88	6.26
OU2MW5	29.66	22.42	7.24
OU2MW6	28.10	20.94	7.16
OU2MW7	25.43	18.28	7.15
OU2MW8	32.11	23.78	8.33
OU2MW9	31.51	24.50	7.01
OU2MW10	18.17	11.21	6.96
OU2MW11	29.25	21.40	7.85
OU2MW12	29.87	21.96	7.91
OU2MW13	9.67	2.97	6.70
OU2MW14	26.63	16.23	10.40
OU2MW15	26.36	8.25	18.11
OU2MW16	25.29	9.09	16.20
OU2SG1	10.38	0.92	9.46
OU2SG2	3.94	2.33	1.61
OU2SG3	2.59	3.10	-0.51
OU3SG4	6.91	6.79	0.12
S1W3	24.94	15.26	9.68
S1W6A	26.24	17.45	8.79
S2W1	22.53	15.14	7.39
S2W2	22.86	8.57	14.29
S2W3	NM	NM	NM
S4W1	24.96	17.92	7.04
S4W2	24.57	12.50	12.07
S4W3	24.98	12.88	12.10

TABLE 2-5 (Continued)
GROUNDWATER ELEVATION SUMMARY - 1996
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Number	Measure Point Elevation (Feet MSL)	Water Level Information - 04/22/96	
		Depth to Water (Feet)	Elevation (Feet MSL)
OU3MW5	19.16	13.61	5.55
9GW12	24.48	17.27	7.21
9GW16	22.30	14.50	7.80
9GW20	28.30	17.60	10.70
9GW29	23.89	14.97	8.92
9GW30	25.67	14.72	10.95
9GW31	26.03	16.90	9.13
53GW12	27.08	8.10	18.98
53GW28	23.79	5.80	17.99

MSL - Mean Sea Level NM - Not Measured

2.9.9 Investigation-Derived Waste Disposal

All investigation-derived waste were disposed of according to the procedures outlines in Section 2.7.10, except that the tank for fluids was located at the Site 10 decontamination pad instead of at the IWTP.

2.9.10 Quality Control Samples

Quality control samples were collected as described in Section 2.7.11.

2.10 ANALYTICAL PROCEDURES

This section summarizes the analytical methodologies employed at MCAS Cherry Point from historical investigations to the 1994 RI and 1995 sampling effort. Table 2-6 lists the analytical parameters and the methods used.

2.10.1 Soil

Soil samples collected in 1983 prior to closure of the former sludge impoundment were analyzed for priority pollutant volatiles, semivolatiles, pesticides/PCBs, metals, and cyanide using various SW-846 methods. Soil samples collected in 1983 following closure of the impoundment were analyzed for selected metals, TOC, TOX, and phenols by various SW-846 methods. During the RFI (1990), soil samples were analyzed for TCL volatile, semivolatile, and pesticide/PCB organic compounds by the USEPA Contract Laboratory Program (CLP) Statement of Work (SOW) for Organic Analysis Multi-Media, Multi-Concentration (OLM01.8). These samples were also analyzed for Target Analyte List (TAL) metals via the USEPA CLP SOW for Inorganic Analysis Multi-Media, Multi-Concentration (ILM02.1). No soil samples were collected to support the RIIR (1984 to 1987). During the 21-Unit RFI (1991), soil samples were analyzed for List 2 metals by SW-846 Methods 6010 and 7000 series (see Table 2-5 for the specific analytes). Soil samples collected in 1992 in support of the TDM were analyzed for TCL volatile organic compounds via the USEPA CLP SOW OLM01.8 and priority pollutant metals. Soil samples collected in 1993 in support of the Phase II TDM were analyzed for TCL volatile organic compounds and TAL metals via USEPA CLP SOW OLM01.8 and ILM02.1, respectively. During the 1994 RI and 1995 sampling event, soil samples were analyzed for TCL volatile, semivolatile, and pesticide/PCB organic compounds via the USEPA CLP SOW OLM01.8. ILM02.1 was also used for TAL metals analyses during the 1994 and 1995 sampling events. During the 1996 sampling event, soil samples were analyzed for TCL dioxins using USEPA CLP SOW DFLM01.0; TCL volatile, semivolatile, and pesticide/PCB organic compounds using USEPA CLP SOW OLM03.1; and TAL metals and cyanide

TABLE 2-6

LABORATORY ANALYTICAL METHODS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analytical Parameter	Aqueous Analytical Method (Preparation/Analysis)	Solid Analytical Method (Preparation/Analysis)
Priority pollutant volatile, semivolatile, and pesticide/PCB organics[1]	SW-846 8240[2], 8270, and 8080	SW-846 8240, 8270, and 8080
Ketones (2-butanone and 4-methyl-2-pentanone), xylenes	SW-846 8240	SW-846 8240
TCL volatile, semivolatile, and pesticide/PCB organics[1]	USEPA CLP SOW OLM01.8, OLC02.0, and OLM03.1	USEPA CLP SOW OLM01.8, and OLM03.1
TCL dioxins	USEPA CLP SOW DFLM01.0	USEPA CLP SOW DFLM01.0
List 2 Metals		
Antimony	SW-846 3005/6010	SW-846 3050/6010
Arsenic	SW-846 7060	SW-846 3050/6010
Barium	SW-846 3005/6010	SW-846 3050/6010
Beryllium	SW-846 3005/6010	SW-846 3050/6010
Cadmium	SW-846 3005/6010	SW-846 3050/6010
Chromium	SW-846 3005/6010	SW-846 3050/6010
Cobalt	SW-846 3005/6010	SW-846 3050/6010
Copper	SW-846 3005/6010	SW-846 3050/6010
Lead	SW-846 3020/7421	SW-846 3050/7421
Nickel	SW-846 3005/6010	SW-846 3050/6010
Selenium	SW-846 7740	SW-846 3050/7740
Silver	SW-846 3005/6010	SW-846 3050/6010
Thallium	SW-846 3020/7841	SW-846 3050/7841
Vanadium	SW-846 3005/6010	SW-846 3050/6010
Zinc	SW-846 3005/6010	SW-846 3050/6010
Selected Metals - RIIR		
Arsenic	SW-846 7060	NA[3]
Cadmium	SW-846 3005/6010	NA
Chromium	SW-846 3005/6010	NA

TABLE 2-6 (Continued)
LABORATORY ANALYTICAL METHODS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analytical Parameter	Aqueous Analytical Method (Preparation/Analysis)	Solid Analytical Method (Preparation/Analysis)
Copper	SW-846 3005/6010	NA
Lead	SW-846 3020/7421	NA
Nickel	SW-846 3005/6010	NA
Silver	SW-846 3005/6010	NA
Zinc	SW-846 3005/6010	NA
Hexavalent chromium	SW-846 7196	SW-846 7196
TAL Metals/cyanide(1)	USEPA CLP SOW ILM02.1	USEPA CLP SOW ILM02.1
TCLP Metals (4)	NA	SW-846 1311 followed by 6010 and various 7000 series
Selected Metals - 1983 Impoundment Closure		
Barium	NA	SW-846 3050/6010
Cadmium	NA	SW-846 3050/6010
Chromium	NA	SW-846 3050/6010
Copper	NA	SW-846 3050/6010
Lead	NA	SW-846 3050/7421
Nickel	NA	SW-846 3050/6010
Silver	NA	SW-846 3050/6010
Zinc	NA	SW-846 3050/6010
Miscellaneous Analytes		
Cyanide	SW-846 9010	SW-846 9010
Phenols	SW-846 9065	NA
Total Organic Carbon (TOC)	CHN Analyzer(5)	MSA(6) 29-5.5.2 (1994)
Total Organic Halides (TOX)	Dohrmann(5)	NA
Moisture content	NA	ASTM D4318
Organic content	NA	ASTM D2974
Cation exchange capacity	NA	SW-846 9081
Permeability	NA	SW-846 9100
Grain size distribution	NA	ASTM D421/D422

TABLE 2-6 (Continued)
LABORATORY ANALYTICAL METHODS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analytical Parameter	Aqueous Analytical Method (Preparation/Analysis)	Solid Analytical Method (Preparation/Analysis)
pH	NA	SW-846 9045
Atterberg limits	NA	ASTM D4318
Oxidation-reduction potential (Eh)	NA	ASTM D1498
Specific gravity	NA	ASTM D854
Chloride	EPA 325.1	NA

1 Analyte lists for Target Compound List (TCL) organics, priority pollutant organics and metals, and Target Analyte List (TAL) metals contained in Appendix G.

2 SW-846 8240 does not report the following compounds: alkyl chloride, 2-picoline, and pyridine, however SW-846 8270 does.

3 NA - Not analyzed.

4 Eight toxic metals analyzed in extract.

5 Methods developed and utilized by Versar Laboratories during the 21-Unit RFI (1991).

6 Methods of Soil Analysis, Part 2 - Chemical and Microbiological Properties. Second Edition, 1994.

using USEPA CLP SOW ILM03.0.

2.10.2 Groundwater

During the RIIR (1984 to 1987), groundwater samples were analyzed for Priority Pollutant volatiles (plus 2-butanone, 4-methyl-2-pentanone, xylenes, and ethylene dibromide), semivolatiles, pesticides/PCBs, and metals; selected metals; phenol; hexavalent chromium; and cyanide by various SW-846 methods. In addition, TOC and TOX analyses were performed using analytical methods developed by Versar Laboratories. During the RFI (1990), groundwater samples were analyzed for TCL volatile, semivolatile, and pesticide/PCB organic compounds via the USEPA CLP SOW OLM01.8 and for Priority Pollutant metals by various SW-846 methods. The groundwater samples collected in 1994 (RI) were analyzed for TCL volatile, semivolatile, and pesticide/PCB organic compounds using the USEPA CLP SOW OLM01.8; TAL metals and cyanide via the USEPA CLP SOW ILM02.1; and total suspended solids (TSS). The groundwater samples collected in 1996 were analyzed for TCL volatile, semivolatile, and pesticide/PCB organic compounds using the USEPA CLP SOW OLC02.0 and OLM03.1 and TAL metals and cyanide using the USEPA CLP SOW ILM03.0.

2.10.3 Surface Water

For the RIIR (1984 to 1987), surface water samples were analyzed for priority pollutant volatiles (plus 2-butanone, 4-methyl-2-pentanone, xylenes, and ethylene dibromide), semivolatile, and pesticide/PCB organic compounds and metals; selected metals; phenols; hexavalent chromium; and cyanide by various SW-846 methods. TOC and TOX were also analyzed using methods developed by Versar Laboratories. During the RFI (1990), surface water samples were analyzed for TCL volatile organic compounds by USEPA CLP SOW OLM01.8; TAL metals by USEPA CLP SOW ILM02.1; and TSS. During the RI (1994), surface water samples were analyzed for TCL volatile, semivolatile, and pesticide/PCB organic compounds using USEPA CLP SOW OLM01.8 and TAL metals using USEPA CLP SOW ILM02.1. The surface water samples collected in 1996 were analyzed for chloride using USEPA Method 325.1.

2.10.4 Sediment

During the RIIR (1984 to 1987), sediment samples were analyzed for priority pollutant volatiles (plus 2-butanone, 4-methyl-2-pentanone, and xylenes), semivolatiles, pesticides/PCBs, and metals and hexavalent chromium using various SW-846 methods. During the RFI (1990), sediment samples were analyzed for TCL volatile organic compounds using the USEPA CLP SOW OLM01.8 and TAL metals using the USEPA CLP SOW ILM02.1. During the RI (1994), sediment samples were analyzed for TCL volatile, semivolatile, and

pesticide/PCB organic compounds using the USEPA CLP SOW OLM01.8 and TAL metals using the USEPA CLP SOW ILM02.1.

2.10.5 Leachate Water

During the RIIR (1984 to 1987), samples of water from leachate seeps were analyzed for priority pollutant volatiles (plus 2-butanone, 4-methyl-2-pentanone, xylenes, and ethylene dibromide), semivolatiles, pesticides/PCBs, and metals; selected metals; phenolics; and hexavalent chromium using various SW-846 methods. In addition, TOC and TOX analyses were performed using methods developed by Versar Laboratories. During the 1995 field investigation, leachate water samples were analyzed for TCL volatile, semivolatile, and pesticide/PCB organic compounds using the USEPA CLP SOW OLM01.8 and TAL metals using the USEPA CLP SOW ILM02.1.

2.10.6 Leachate Sediment

During the RIIR (1984 to 1987), samples of sediment from leachate seeps were analyzed for priority pollutant volatiles (plus 2-butanone, 4-methyl-2-pentanone, and xylenes), semivolatiles, pesticides/PCBs, and metals; selected metals; phenolics; and hexavalent chromium using various SW-846 methods. During the 1995 field investigation, leachate sediment samples were analyzed for TCL volatile, semivolatile, and pesticide/PCB organic compounds using the USEPA CLP SOW OLM01.8 and TAL metals using the USEPA CLP SOW ILM02.1.

2.11 DATA VALIDATION

Formal data validation performs three basic functions. It serves as an independent quality assurance check of the veracity of laboratory results; it is a means of evaluating laboratory performance and determining the impact of noncompliances on the data; and through the use of data qualifiers, it lends interpretive guidance as to the proper usage and limitations of the data. For the 21-Unit RFI (HNUS, June 1993), approximately 20 percent of the data received from the laboratory were validated by B&R Environmental personnel, at the request of the Navy. The remaining 80 percent was not validated, except for a cursory evaluation of blank contamination during the data evaluation task. For the TDM report (HNUS, June 1994b), 100 percent of the data were validated by B&R Environmental personnel. For the 1994 RI, 100 percent of the data were validated by a third-party contractor, Validata Chemical Services, Inc. For the 1995 and 1996 investigations, 100 percent of the data were validated by B&R Environmental personnel.

Formal data validation is a systematic review and evaluation of the data, which is conducted according to the following guidance:

- U.S. Navy guidance (Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program [NEESA 20.2-047B]).

- USEPA's CLP Functional Guidelines for Organic and Inorganic Data Review were mainly used for CLP analysis, as well as for some samples analyzed via SW-846 methods. Validation was completed for various chemical/physical parameters in accordance with the cited guidelines to the greatest extent practicable, in view of method-specific QA/QC requirements, and criteria outlined in the NEESA guidance document.

In accordance with the specific protocols, organic analytical data were evaluated based on the following criteria:

- Data completeness
- Holding times
- Gas Chromatography/Mass Spectrometry (GC/MS) tuning and mass calibration
- Initial and continuing calibration
- Internal standards performance
- Laboratory blank analyses
- Surrogate spike recoveries
- Matrix spike/matrix spike duplicate analyses
- Detection limits
- Sample quantitation

In accordance with the protocols, inorganic data were evaluated based on the following parameters:

- Data completeness
- Holding times
- Initial and continuing calibration verification
- Contract required detection limit (CRDL) standard analysis
- Laboratory blank analysis
- Matrix spike analysis
- Interference check sample results
- Laboratory control sample results

- Furnace atomic absorption results
- Serial dilution analysis
- Detection limits
- Sample quantitation

Results from the field quality control analyses (i.e., field blanks, trip blanks, rinsate blanks, and field duplicate samples) are also evaluated according to these protocols.

Results and conclusions drawn from the formal validation described above are submitted in the form of internal correspondence memos addressed to the B&R Environmental project manager. These data validation memos explain the findings of the data evaluation process, give interpretations of actions taken on the data, and include a summary of data qualifiers assigned to the data points. Qualified laboratory results and support documentation, consisting of photocopied pages from the data packages, are available from B&R Environmental files. The laboratory is responsible for sending a final QA/QC report to the NEESA contract representative.

Formal data validation and the subsequent memo and documentation ensures the accuracy and integrity of the analytical data. These items are also essential to the overall defensibility of the data and provide a secure platform for risk assessment decisions.

As a result of the data validation process, analytical results (presented in subsequent sections of this report and the associated appendices) may be followed by a data qualifier. The data qualifiers are briefly defined as follows:

- U - Chemical was not detected at the detection limit noted.
- J - Chemical was detected in the sample and the positive result is considered to be an estimated value.
- UJ - Chemical was not detected and detection limit is estimated.
- R - Positive result is considered to be unreliable and is rejected.
- UR - Chemical was not detected in the sample. However, the nondetected result is considered to be unreliable and is rejected.

All validated data deemed to be of sufficient quality (except those results that were rejected, qualified "R" and "UR") were used in the risk assessment.

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section contains a summary of the physical characteristics of MCAS Cherry Point and OU2. Section 3.1 discusses topography and surface features. Section 3.2 describes the climate and meteorology of the area. Section 3.3 discusses surface water hydrology, Section 3.4 discusses soil, and Section 3.5 describes regional and study area geology. Section 3.6 describes regional and study area hydrogeologic features. Section 3.7 discusses population and land use, and Section 3.8 describes ecological features and programs.

3.1 TOPOGRAPHY AND SURFACE FEATURES

MCAS Cherry Point is located within the Coastal Plain Physiographic Province. The province is characterized as an elevated sea-bottom environment with low topographic relief and is generally below 100 feet mean sea level (MSL) in elevation.

Within the Air Station, Operable Unit 2 (OU2) is bounded by the sewage treatment plant to the north, Roosevelt Boulevard to the east, a residential area to the south, and Slocum Creek to the west (Plate 1 in Volume V and Figure 1-3). OU2 consists primarily of the Site 10 Landfill. It also includes the Polishing Ponds (Site 46) north of the landfill, a former sludge application area (Site 44A formerly Site 45) located in the north-central portion of OU2, and the Vehicle Maintenance Area (Hobby Shop) (Site 76).

Site 10 consists of two areas where landfill activities have been identified. The northern area is located north of Turkey Gut and south of the sewage treatment plant. The southern area extends approximately 1,300 feet to the south of Turkey Gut. Site 10 is transected by Turkey Gut in the east and southeast portion of the site.

The ground surface elevation varies from approximately 30 feet MSL in the central portions of the landfill areas to approximately 1.5 feet MSL at Slocum Creek. The ground surface is relatively flat in these central areas with smaller areas of uneven terrain. The ground surface at the perimeter of the landfill areas adjacent to the floodplains of Slocum Creek and Turkey Gut generally form moderate to steep slopes.

The polishing ponds (Site 46) are formed by earthen berms with elevations of approximately 22 feet MSL. The ground surface west of the ponds slopes steeply from 22 feet to approximately 5 feet MSL, giving way to a flat and heavily vegetated area adjacent to Slocum Creek. The ground surface south of the ponds

slopes moderately towards the old sanitary landfill to a grass swale where standing water is common. The areas east and northeast of the ponds are relatively flat where the STP is located.

3.2 CLIMATE AND METEOROLOGY

Proximity to the Atlantic Ocean significantly influences the climate of the study area. The climate is warm and humid with short, mild winters and long, hot summers. Winter temperatures average 46°F, and summer temperatures average 77°F (NAVFACENGCOM, 1980). The average annual temperature is approximately 64°F. Periods of continuous freezing temperatures seldom last more than a few days. Precipitation is unevenly distributed, with the greatest monthly precipitation occurring during July, August, and September (6 to 8 inches per month). In the other months, rainfall averages 3 to 4 inches per month. Average annual precipitation in Craven County is approximately 55 inches (Floyd, 1969). During extreme dry years, precipitation may be as low as 35 inches, whereas rainfall may increase to 80 inches during very wet years. Tropical hurricanes pass offshore twice in an average year, but infrequently strike the coast with full force. Average annual evapotranspiration is 36.8 inches (Floyd, 1969).

3.3 SURFACE WATER HYDROLOGY

Operable Unit 2 is bounded on the west by Slocum Creek, which flows north past the site. Turkey Gut is a perennial stream that flows northwestward through the central portion of OU2 and discharges to Slocum Creek. There is a surface drainage swale between the polishing ponds and the Old Sanitary Landfill where standing water is common during wet periods. The swale drains westward discharging to Slocum Creek.

Slocum Creek is shallow, warm, and brackish. It is approximately 800 feet wide at the confluence of Turkey Gut. During the 1994 sampling event, depths ranged from 2.4 feet to 4 feet approximately 25 feet from shore. It serves as a recreational resource (e.g., boating) for military personnel and local residents. The North Carolina Department of Environmental Health and Natural Resources (NCDEHNR) has classified Slocum Creek as a Class SC tidal salt water. The SC classification is defined as suitable for fish and wildlife propagation, secondary recreation (i.e., recreational activities not involving whole-body contact), and any other usage except primary recreation or shellfishing for market purposes (15A NCAC 2B.0212).

Turkey Gut is a small channelized freshwater tributary to Slocum Creek that drains a portion of MCAS Cherry Point south of the sewage treatment plant. The stream is approximately 10 feet wide and varies in depth from 2 inches to 2 feet, based on estimates made during the ecological assessment. The width increases to approximately 50 feet when it enters Slocum Creek. Turkey Gut is classified as a Class C fresh surface water. The C classification is defined as suitable for aquatic life propagation and maintenance of biological

integrity, wildlife, secondary recreation, agriculture, and any other usage except for primary recreation or as a source of water supply for drinking, culinary, or food processing purposes (15A NCAC 2B.0211).

3.4 SOIL

The Air Station is located mainly on the Talbot Terrace Plain, which was formed by sediments deposited in a lagoon approximately 220,000 years ago. The soils have developed into medium-textured materials that are underlain by beds of sandy sediments. Soil-forming processes have produced different soils mainly because of differences in natural drainage as influenced by relief and proximity to streams. The well-drained soils near the stream valleys have light-colored topsoils that are low in organic matter and yellowish or brownish subsoils. The poorly drained soils, which are located in the interstream areas and in depressions, have dark topsoils that are higher in organic matter and grayish subsoils. Soils on this landscape are similar in some of their physical properties. They are strongly to very strongly acidic and have good workability, high available water capacity, moderate permeability, and low natural fertility. The better-drained soils are well suited for most uses. A seasonal high water table during months of low evapotranspiration (November to March) and ponding in topographic depressions are present in areas of wetter soils.

An area of the site is in the flood plains along the streams dissecting the Talbot Terrace. These poorly- to very-poorly-drained areas flood frequently. The soils are very young and are formed in stratified loamy and sandy alluvium. These flood plains merge with loamy brackish marsh areas as they near the Neuse River.

A few areas of stream terrace occur along the Neuse River and the larger creeks. These are mostly sandy soils. Some of the low lying areas are subject to flooding (Department of the Navy, December 1979).

3.5 GEOLOGY

This section provides a discussion of the regional and study area geology. The nomenclature presented for the geologic units is that developed by the U.S. Geological Survey (USGS, 1994). The boring and geophysical logs for the soil borings and monitoring wells are included in Appendix A (Volume I). The well construction diagrams for the monitoring wells are included in Appendix B (Volume I). Geotechnical laboratory test data from soil and sediment are supplied in Appendix E (Volume II).

3.5.1 Regional Geology

The Air Station is underlain by about 3,000 feet of interbedded, unconsolidated to partially consolidated sedimentary deposits of sand, silt, clay, shell, and limestone that range in age from Cretaceous to Holocene.

These deposits are part of the Coastal Plain sediments of North Carolina that, in aggregate, form a wedge-shape mass that thickens from a feather edge at the Fall Line to as much as 10,000 feet at Cape Hatteras. The Coastal Plain deposits are underlain by igneous and metamorphic basement rocks. Figure 3-1 presents the general stratigraphy at the Air Station (USGS, 1994).

3.5.2 Study Area Geology

Four types of lithologic materials were encountered during the subsurface investigation at the study area. These materials consisted of fill material, the undifferentiated surficial formation, the Yorktown Formation, and the upper portion of the Pungo River Formation. Five cross sections, A-A', B-B', C-C', D-D' and E-E', have been generated to illustrate materials encountered at those locations during the most current and previous investigations. Included on the cross sections are copies of the natural gamma-logs highlighting the clay layers (Appendix A). Cross section locations are provided on Plate 2 (Volume V) and Figure 2-1. Cross sections are provided on Plates 3 and 4 (Volume V) and Figures 3-2, 3-3, and 3-4.

Fill Material

The fill material consists of sand, silt, and clay mixed with refuse including domestic trash, wood, plastic, rubber, glass, asphalt, concrete, and metal fragments.

Generally, the fill material is at its maximum thickness in the center of the landfill area and thins gradually to the west and abruptly to the east. Refuse was encountered in the following borings and respective thicknesses:

- OU2MW12 - 20 feet
- OU2MW8 - 23 feet
- OU2MW5 - 23 feet
- OU2SB6 - 22 feet
- 10GW40 - 26 feet
- 10GW45 - 20 feet
- BB2 - 10 feet

Natural reworked material was encountered in 10EGW1 to 5 feet below ground surface. No refuse was encountered in OU2MW1; however, wood fragments were encountered, and high organic vapor analyzer field readings (greater than 1,000 ppm) were measured at the boring. Refuse was not encountered at boring locations 10-2B, 9GW31, 9GW30, 9GW23, or B-103 that mark the east and northeastern extent of the landfill

FIGURE 3-1

GENERALIZED STRATIGRAPHY AND RELATIONSHIP BETWEEN GEOLOGIC AND HYDROGEOLOGIC UNITS MCAS CHERRY POINT, NORTH CAROLINA (USGS, 1994)

Geologic Units			Hydrogeologic Units
System	Series	Formation	Aquifer and confining unit
Quaternary	Holocene Pleistocene	Undifferentiated	Surficial aquifer
Tertiary	Pliocene	Yorktown Formation	Yorktown confining unit[1] Yorktown aquifer
	Miocene	Eastover Formation[2]	Pungo River confining unit[1]
		Pungo River Formation	Pungo River aquifer
		Belgrade Formation[2]	Upper Castle Hayne confining unit
	Oligocene	River Bend Formation	Upper Castle Hayne aquifer
	Eocene	Castle Hayne Limestone	Lower Castle Hayne confining unit Lower Castle Hayne aquifer
	Paleocene	Beaufort Formation	Beaufort confining unit Beaufort aquifer
Cretaceous	Upper Cretaceous	Peedee Formation	Peedee confining unit Peedee aquifer
		Black Creek and Middendorf Formations	Black Creek confining unit Black Creek aquifer
		Cape Fear Formation	Upper Cape Fear confining unit Upper Cape Fear aquifer Lower Cape Fear confining unit Lower Cape Fear aquifer
	Lower Cretaceous[2]	Unnamed deposits[2]	Lower Cretaceous confining unit[2] Lower Cretaceous aquifer[2]
Pre-Cretaceous crystalline basement rocks			

1 Units are not continuous beneath the Air Station (USGS, 1995).

2 Geologic and hydrogeologic units not identified beneath the Air Station.

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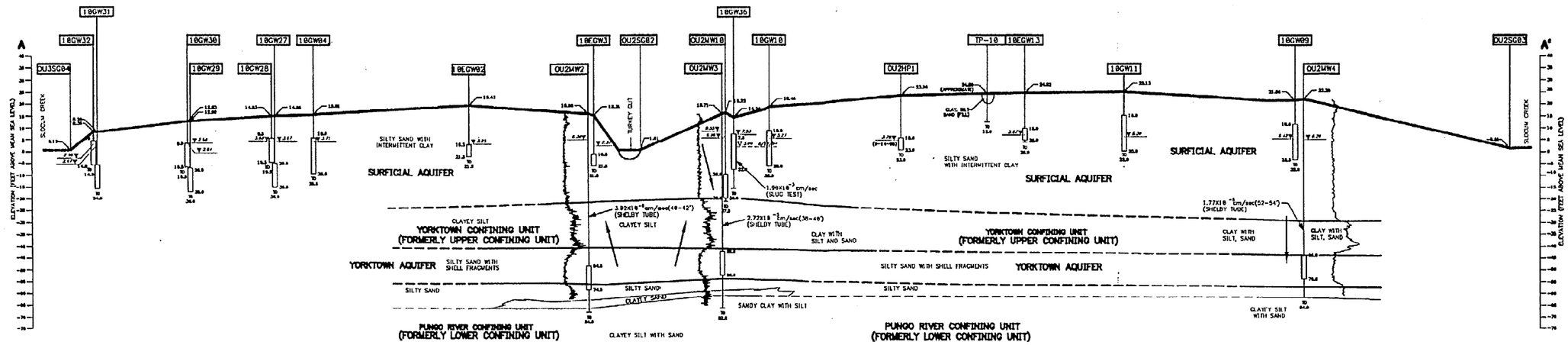
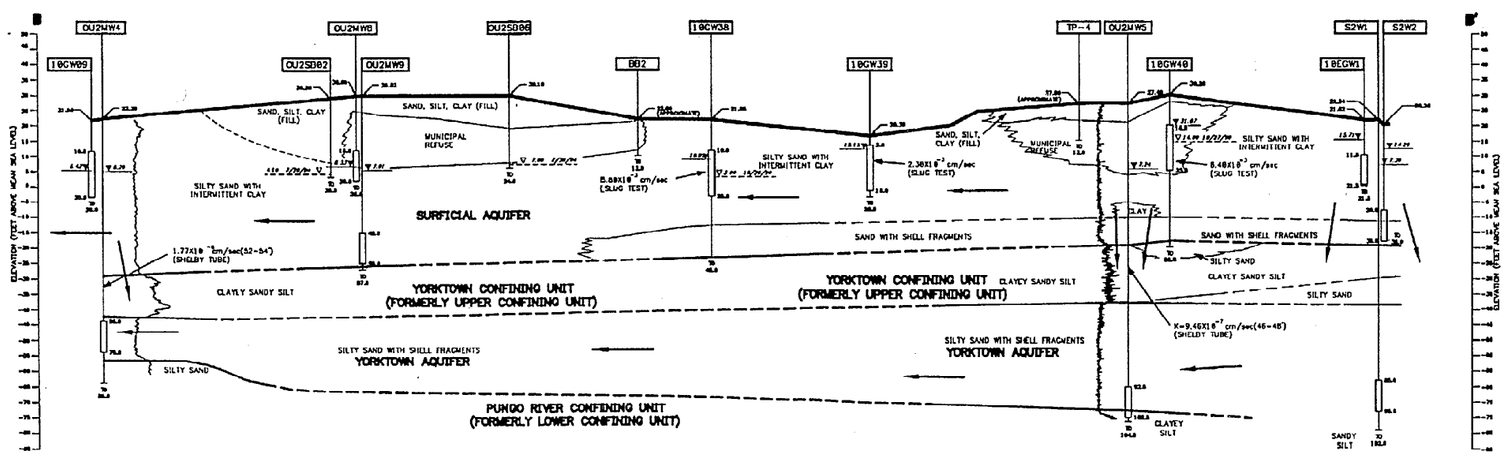
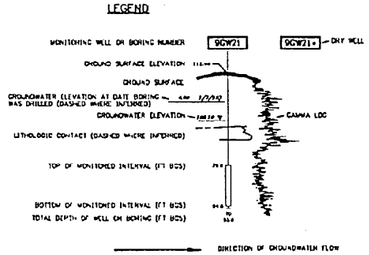


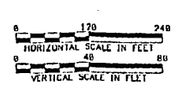


LEGEND



NOTES

WATER LEVELS COLLECTED ON 4-22-96 UNLESS OTHERWISE NOTED



REVISIONS

NO.	DESCRIPTION	DATE	APPROVED

Brown & Root Environmental

ACTIVITY – SATISFACTORY TO

DATE

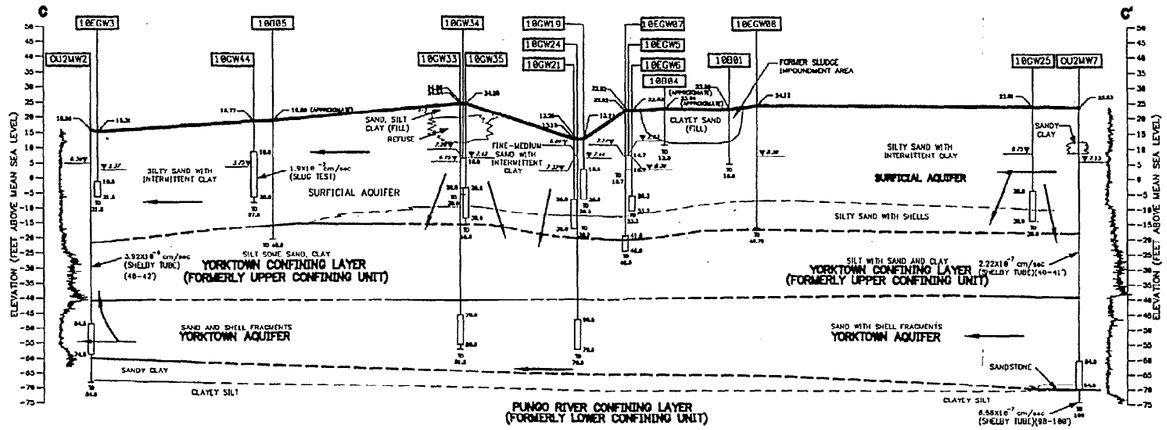
DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORFOLK, VIRGINIA
NAVAL STATION
MARINE CORPS AIR STATION CHERRY POINT
CHERRY POINT, NORTH CAROLINA

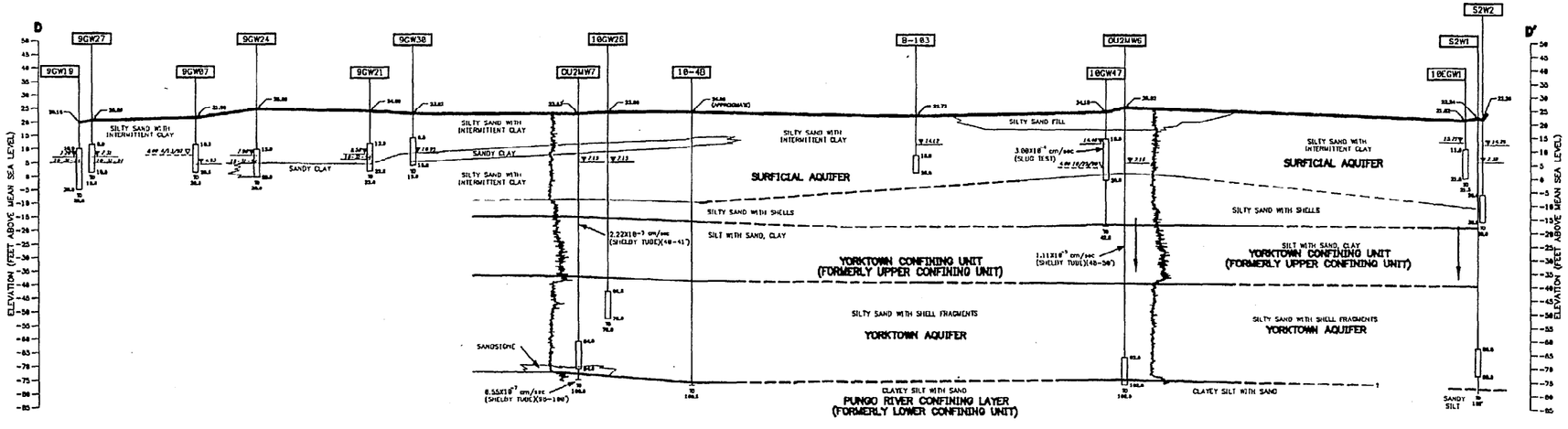
OU2

CROSS SECTION A-A' & B-B'

CODE ID. NO. 80091 SIZE D
SCALE AS SHOWN
FD NO
STA. FIELD NO
REG. NO
CADD ENTRY NO XX-XX-XXXX
NAVFAC DRAWING NO XXXXXX-XX-X-XXXX
SHEET X OF X

FIGURE 3-2





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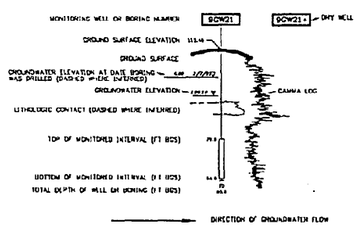
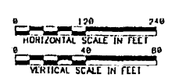


NOTES

WATER LEVELS COLLECTED ON 4-22-96 UNLESS OTHERWISE NOTED

SCREEN INTERVAL FOR 10ECW08 IS UNKNOWN



REVISIONS

Brown & Root Environmental

NAVAL FACILITIES ENGINEERING COMMAND
ATLANTIC DIVISION
NORFOLK, VIRGINIA
NAVAL STATION
CHERRY POINT, NORTH CAROLINA
OU2

CROSS SECTION C-C' & D-D'

SCALE: AS SHOWN

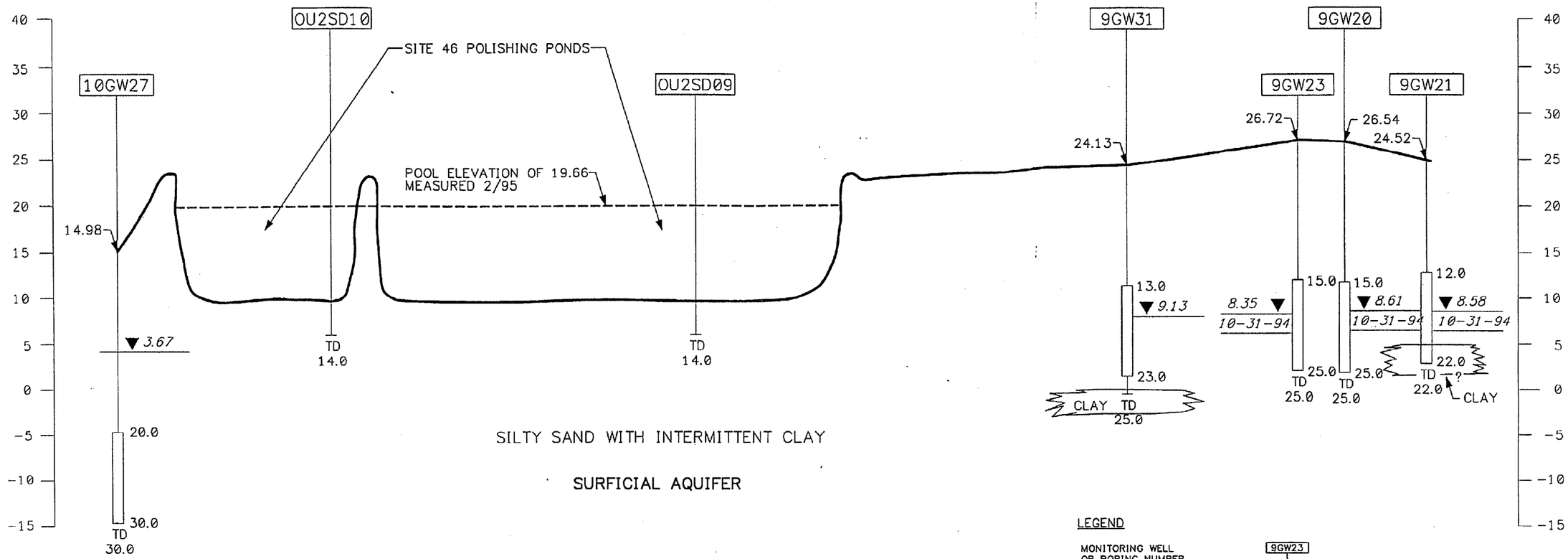
CONTRACT NO. XX-XX-XXXX

DRAWING NO. XXXXXX-XX-X-XXXX

SHEET X OF X

FIGURE 3-3

ACAD: K:\CADD\5395\5395BX03.DWG 06/10/96 TD



LEGEND

MONITORING WELL OR BORING NUMBER

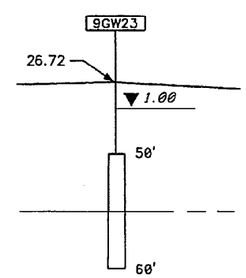
GROUND SURFACE ELEVATION

GROUNDWATER ELEVATION

TOP OF MONITORED INTERVAL (ft bgs)

LITHOLIGIC CONTACT (DASHED WHERE INFERRED)

BOTTOM OF MONITORED INTERVAL (ft bgs)



NOTE: WATER LEVELS COLLECTED ON 4-22-96 UNLESS OTHERWISE NOTED. LITHOLOGIC CONTACTS ARE INFERRED FROM GEOPHYSICAL AND BORING LOGS. ACTUAL CONDITIONS MAY VARY FROM THOSE DEPICTED.

NOTE: ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL (FT AMSL)

0 120 240
HORIZONTAL SCALE IN FEET

0 12 24
VERTICAL SCALE IN FEET

FIGURE 3-4

GENERALIZED GEOLOGIC CROSS SECTION E-E'
OPERABLE UNIT 2
MCAS, CHERRY POINT

069511/P

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CTO 211

activities. There was no refuse encountered at OU2MW4 and 10GW09; however, the toe of the slope of the landfill was observed to extend approximately 150 feet to the south and 100 feet to the southwest of monitoring well 10GW09.

The Undifferentiated Surficial Formation

The shallowest natural materials beneath Site 10 consisted of orange, yellow, and brown silty sand with trace to some amounts of clay present in localized areas. This material is present at the ground surface where fill is nonexistent or underlies the fill. This material extends to a depth of 52 feet below the ground surface in the southwest portion of the site and thins slightly to the north and northeast to approximately 38 and 40 feet respectively. It is at least 25 to 30 feet thick at the Site 46 polishing ponds. Cross-section E-E' (Figure 3-4) depicts the subsurface materials in this area. These materials correlate with the Undifferentiated Surficial Formation as described by the USGS.

The Yorktown Formation

Underlying the Undifferentiated Surficial Formation is an olive green to grayish green, dense, fine sand with varying amounts of bivalve shell fragments, clay, and silt. It is believed that this layer correlates with the hydrogeologic Yorktown confining unit (formerly named the upper confining unit) that comprises the upper portion of the Yorktown Formation. It has an average thickness of 19 feet as measured in the following Lower Yorktown monitoring well borings: OU2MW2, OU2MW3, OU2MW4, OU2MW5, OU2MW6, and OU2MW7.

Seven shelby tube samples were collected from the upper portion of the Yorktown Formation. The grain-size distribution curves indicate poorly sorted sands with little fines but with an average effective grain size of 0.029 mm diameter (silt) (Appendix E, Volume II).

Underlying the upper portion of the Yorktown Formation is a grey silty sand with varying amounts of bivalve shell fragments and correlates with the hydrogeologic unit named the Yorktown aquifer. The lower portion of the Yorktown Formation has an average thickness of approximately 35 feet in the eastern portion of the site and approximately 14 feet in the western portion of the site. Small beds of consolidated material were also encountered in the lower portion of the Yorktown Formation at OU2MW6 and OU2MW7 well borings.

The Pungo River Formation

A dark green clayey silt and clayey sand was encountered in six of the OU2 Lower Yorktown wells at depths of 69 to 100 feet below ground surface (bgs). These materials are inferred to be the upper portion of the Pungo River Formation and correlate to the hydrogeologic unit named the Pungo River confining unit (formerly the lower confining unit). Based on site investigations, the top surface of the Pungo River Formation dips to the east at approximately 0.01 percent grade. The thickness of the Pungo River confining unit was not determined because the unit was not penetrated during the drilling activities.

One shelby tube sample was collected from the upper portion of the Pungo River Formation. The grain-size distribution curve indicates poorly sorted sand with an effective grain size of 0.019 mm diameter (silt) (Appendix E, Volume II).

3.6 HYDROGEOLOGY

This section provides a discussion of the regional and study area hydrogeology for OU2. The discussion of regional hydrogeology is limited to the non-saline aquifers underlying MCAS Cherry Point. The discussion of study area hydrogeology is limited to the aquifers and confining units encountered beneath the site. Figure 3-1 presents the generalized relationship between the geologic and hydrogeologic units and includes the Paleocene and Cretaceous units that are saline aquifers underlying the Air Station. The nomenclature presented for the hydrologic units is from USGS Water Resources Investigation Report 94-4186 (USGS, 1994).

3.6.1 Regional Hydrogeology

MCAS Cherry Point is underlain by five non-saline aquifers and four confining units to a depth of approximately 500 feet. These aquifers and confining units, from the youngest to the oldest, are the surficial aquifer, the Yorktown confining unit (formerly named upper confining unit), the Yorktown aquifer, the Pungo River confining unit (formerly named lower confining unit), the Pungo River aquifer, Upper Castle Hayne confining unit, the Upper Castle Hayne aquifer, Lower Castle Hayne confining unit, and the Lower Castle Hayne aquifer. These units are described below.

- Surficial Aquifer - The surficial aquifer is the uppermost aquifer of the study area and is exposed at the ground surface and in streambeds throughout the Air Station. This aquifer consists of unconsolidated and interfingering beds of fine sand, silt, clay, shell, and peat beds, as well as

scattered deposits of coarser grained material believed to represent relic beach ridges and alluvium. The surficial aquifer has an estimated hydraulic conductivity of 10 ft/day (USGS, 1994).

- Yorktown Aquifer and Confining Unit - The Yorktown confining unit overlies the Yorktown aquifer and is composed of clay and sandy clay with locally discontinuous, thin beds of fine sand or shells. The Yorktown confining unit is not present in the southern portion of the Air Station. This hydrogeologic unit represents the uppermost sediments of the Yorktown Formation (USGS, 1994).

  The Yorktown aquifer consists of consolidated and unconsolidated fine sand, silty and clayey sand, and clay; shells and shell beds also occur in the unit and indicate a marine depositional environment. This hydrogeologic unit has an estimated hydraulic conductivity of 15 ft/day (USGS, 1994).

- Pungo River Aquifer and Confining Unit - The Pungo River aquifer and confining unit underlie the Yorktown aquifer throughout the area of the Air Station.

  The Pungo River confining unit overlies the Pungo River aquifer and is composed mostly of clay, and possibly some clay containing phosphatic sand. The unit is inferred to be missing in the southern portion of the Air Station (USGS, 1994). The Pungo River aquifer consists of fine- to medium-grained sand with some local beds of silt, clay, and phosphatic sand. A few beds of coarse sand also occur in the unit. This aquifer has an estimated hydraulic conductivity of 15 ft/day (USGS, 1994).

- Upper Castle Hayne Aquifer and Confining Unit - The Upper Castle Hayne aquifer and confining unit underlie the Pungo River aquifer everywhere beneath the Air Station. The Upper Castle Hayne confining unit overlies the Upper Castle Hayne aquifer and is composed of clay and sandy clay at the Air Station. Thin beds of sand have been documented to exist in this confining unit (USGS, 1994).

  The Castle Hayne aquifer is the principal water-supply for many domestic, municipal, and industrial users in eastern North Carolina, including the Air Station and the nearby town of Havelock. This aquifer has an estimated hydraulic conductivity of 315 ft/day (USGS, 1994).

  The Upper Castle Hayne aquifer is composed primarily of porous limestone, sandy limestone, and medium to fine sand. Thin, discontinuous beds of clay can also be present in the aquifer.

- Lower Castle Hayne Aquifer and Confining Unit - The Lower Castle Hayne aquifer and confining unit underlie the Upper Castle Hayne aquifer and are believed to be continuous beneath the Air Station. The Lower Castle Hayne confining unit overlies the Lower Castle Hayne aquifer and is composed of clay, sandy clay, and sand. The observed thickness of the confining unit ranges from about 15 to 50 feet. The confining unit is slightly thicker in the northern part of the Air Station (USGS, 1994).

  The Lower Castle Hayne aquifer is composed of limestone, sandy limestone, calcareous sand, and clay beds. Thin, discontinuous stringers of consolidated limestone also are present. The aquifer grades to progressively finer grained sediments with depth; fine sand mixed with silt and clay dominate the lower two-thirds of the unit. This aquifer has an estimated hydraulic conductivity of 50 ft/day (USGS, 1994).

The USGS has identified paleochannels and suspected stratigraphic breaks beneath and in the vicinity of the Air Station. Paleochannels filled with permeable material could act as conduits for groundwater flow or movement of contaminants between the surficial and Castle Hayne aquifer (USGS, 1995).

A total of 16 monitoring wells were installed in the Lower Yorktown aquifer at five operable units throughout the Air Station during the 1994 RI. The scope of this report does not permit a detailed discussion of the findings from the investigations at the four other operable units. The Yorktown confining unit was encountered in all 16 monitoring wells. The average elevation of the top of the Yorktown Confining Unit is -23.2 feet MSL, with a range of -14.6 to -31.3 feet MSL. The thickness of the Yorktown confining unit ranges from 5 to 30 feet, with an average of 16.75 feet. These values of thickness and elevation are consistent with the USGS report findings. The Yorktown aquifer varied in thickness from 12 to approximately 70 feet with an average thickness of 35 feet. At four of the 16 well borings, the Pungo River confining unit was not distinct, and the borings were stopped in order to avoid the penetration of the Castle Hayne aquifer. No aquifer testing was performed during the 1994 field investigation.

3.6.2 Study Area Hydrogeology

Four hydrogeologic units were encountered during the subsurface investigation at the study area. They are presented in the order at which they were encountered from top to bottom. The units are the surficial aquifer, the Yorktown confining unit (formerly the upper confining unit), the Yorktown aquifer, and the upper portion of the Pungo River confining Unit (formerly the lower confining unit). Five cross sections, A-A', B-B', C-C', D-D' and E-E', have been generated and are provided in Volume V of the report on Plates 4 and 5 and

Figures 3-2, 3-3, and 3-4. Potentiometric surface maps for the surficial and Yorktown aquifers, Plate 6 (Figure 3-5) and Plate 7 (Figure 3-6), respectively, have been generated using the most recent groundwater data (see Table 2-4). The lithology of these units has been described in the previous section.

The Surficial Aquifer

Groundwater beneath the site was encountered in the surficial aquifer at approximately 7 to 22 feet below ground surface (BGS), and water-level elevations ranged from approximately 2.6 to 22 feet mean sea level (MSL).

The groundwater in the surficial aquifer flows toward and discharges into either Slocum Creek or Turkey Gut. Polishing Ponds No. 1 and No. 2 (Site 46) are unlined and act as a recharge zone for the surficial aquifer. There are two distinct areas of water table mounding. A large mounding effect in the southeast is due to a topographic high. A small mounding effect in the central area is due to wells that are located near trenches that act as recharge zones.

The saturated thickness of the surficial aquifer tends to increase toward the southern portion of the site. The average saturated thickness is 29 feet as measured at 9 well clusters across the site, ranging from approximately 22 feet at well cluster 10GW34 in the north, to approximately 37 feet at well cluster 10GW40 in the south.

The seepage velocity (groundwater flow velocity) can be calculated using the following equation: $Vs = K(i/n)$, where "K" is the hydraulic conductivity (permeability), "n" is the effective porosity, and "i" is the average hydraulic gradient (dh/dl). Because of the varying hydraulic gradients throughout the operable unit, the seepage velocity is calculated for three areas within the site; the sanitary landfill area, the central landfill area south of Turkey Gut, and the landfill area in the southeast corner of the site.

At the northern landfill area, the hydraulic gradient "i" was estimated to be 1.1E-2 ft/ft by graphic interpretation from the potentiometric surface map. Slug tests were performed in this area in 1990 at monitoring wells 10GW42 and 10GW44 with a resulting average permeability value of 69 ft/day. The effective porosity was estimated to be 0.3 for sand. Substituting these values into the equation results in a value for seepage velocity of 2.6 ft/day (9.1E-4 cm/sec).

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ROOSEVELT ROAD
APPROXIMATE LOCATIONS OF FENCE
SITE 43 SEWAGE TREATMENT PLANT
DRUMMED PETROLEUM (ABANDONED)
STORAGE
FORMER SLUDGE IMPOUNDMENT AREA
SITE 44 FORMER SLUDGE APPLICATION AREA
SITE 46 POLISHING POND 2
SITE 46 POLISHING POND 1
TURKEY GUT
GRASSY DRAINAGE SWALE
WASH RACK
HWR STORAGE AREA
AUTO HOBBY SHOP
SITE 76 VEHICLE MAINTENANCE AREA (HOBBY SHOP)
SLOCUM CREEK
LEGEND
L3S10GW32 UPPER SURFICIAL AQUIFER MONITORING WELL AND ELEVATION
OU3SG04 STAFF GAUGE
1.0 POTENTIOMETRIC SURFACE CONTOUR
GROUNDWATER FLOW DIRECTION
INTERMITTENT STREAM
WATER LEVELS MEASURED 4-22-96
SCALE IN FEET
REVISIONS
Brown & Root Environmental
ACTIVITY - SATISFACTORY TO
DATE
PROJECT MANAGER
QCP
PROJ ENG.
QUALITY CONTROL
DESIGN MANAGER
DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORFOLK, VIRGINIA
NAVAL STATION
MARINE CORPS AIR STATION CHERRY POINT
CHERRY POINT, NORTH CAROLINA
OU2
POTENTIOMETRIC SURFACE MAP OF SURFICIAL AQUIFER
SCALE AS SHOWN
XX-XX-XXXX
XXXXXX-XX-X-XXXX
X OF X
FIGURE 3-5

ROOSEVELT ROAD
APPROXIMATE LOCATION OF FENCE
SITE 43 SEWAGE TREATMENT PLANT
DRUMMED PETROLEUM (ABANDONED)
STORAGE
FORMER SLUDGE LAGOUNDMENT AREA
SITE 44A FORMER SLUDGE APPLICATION AREA
SITE 46 POLISHING POND 2
SITE 46 POLISHING POND 1
GRASSY DRAINAGE SWALE
TURKEY GUT
WASH RACK
MWR STORAGE AREA
SITE 76 VEHICLE MAINTENANCE AREA (HOBBY SHOP)
AUTO HOBBY SHOP
SLOCUM CREEK
OU2MW7 7.16
S1W1 8.79
S1W1 (10GW26) 7.15
OU2MW6 7.6
S2W1 7.39
OU2MW5 7.29
10GW22 6.92
10GW23 6.85
10GW24 6.80
10GW33 6.75
OU2MW2 6.38
OU2MW3* 9.55
OU2MW4* 6.26
S4W1 7.04
7.00
7.20
6.80
6.60
6.40
LEGEND
S2W1 △ LOWER YORKTOWN MONITORING WELL
CROUNDWATER FLOW DIRECTION
6.60 POTENTIOMETRIC SURFACE CONTOUR
INTERMITTENT STREAM
*OU2MW3 NOT USED FOR CONTOURS DUE TO AN ANOMALOUS WATER LEVEL ELEVATION
WATER LEVELS COLLECTED 4-22-96
SCALE IN FEET
REVISIONS
Brown & Root Environmental
ACTIVITY - SATISFACTORY TO
DATE
NAVAL FACILITIES ENGINEERING COMMAND
DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL STATION
MARINE CORPS AIR STATION CHERRY POINT
N.S.F.A.K. VIRGINIA
CHERRY POINT, NORTH CAROLINA
OU2
POTENTIOMETRIC SURFACE MAP OF YORKTOWN AQUIFER
AS SHOWN
XX-XX-XXXX
XXXXXX-XX-X-XXXX
FIGURE 3-6

At the central landfill area, the hydraulic gradient "i" was estimated to be 5.1E-2 ft/ft by graphic interpretation from the potentiometric surface map in the area of monitoring well 10GW36 in the northwestern direction (Plate 6 and Figure 3-5). Slug tests were performed in the central landfill in 1990 at monitoring wells 10GW36, 10GW37, and 10GW43 with a resulting average permeability value of 8.6 ft/day. The effective porosity was estimated to be 0.3 for sand. Substituting these values into the equation results in a value for seepage velocity of 1.5 ft/day (5.2E-4 cm/sec).

At the landfill area in the southeast corner of the site the hydraulic gradient "i" was estimated to be 0.018 ft/ft by using graphic interpretation from the potentiometric surface map between monitoring wells 10GW40 and 10GW39. Slug tests were performed in this area in 1990 at monitoring wells 10GW40 and 10GW39 with a resulting average permeability value of 11 ft/day. The effective porosity was estimated to be 0.3 for sand. Substituting these values into the equation results in a value for seepage velocity of 0.66 ft/day (2.3E-4 cm/sec).

The seepage velocity was also calculated based on aquifer testing conducted in 1986 during the RIIR at wells 10GW04, 10GW09, and 10GW15 (NUS, January 1987). These wells are widely-spaced. Well 10GW04 is located near the northwest corner of the site, near the Site 46 polishing ponds. Well 10GW09 is located at the southwest corner of the site, and well 10GW15 is located near the former sludge impoundments. The average permeability was 19.3 ft/day, which was within the range of results obtained in 1990. Porosity was assumed to be the same (0.03). The average hydraulic gradient was 0.005, which is much lower than the value used based on the most recent water-level measurements. Based on the above measured values and assumptions, the resulting seepage velocity was 0.32 ft/day, below the range based on more recent data. The data provided in the preceeding paragraphs are considered to be better estimates of aquifer characteristics. The values calculated in 1986 were based on a limited number of widely-spaced data points.

The Yorktown Confining Unit and Aquifer

The Yorktown confining unit has an average thickness of approximately 19 feet as measured at six Lower Yorktown wells. The thickness ranges from approximately 12 feet at OU2MW2 in the south to approximately 22 feet at OU2MW6 located in the southeast. The Yorktown confining unit is continuous throughout OU2. Seven Shelby tube samples were collected in 1994 from the upper portion of the Yorktown confining unit for geotechnical parameters. The results indicated a geometric average permeability of 1.8E-06 cm/sec (0.005 ft/day). This permeability is likely to be a conservative value because the boring logs and the natural gamma logs indicate that the clay content increases downward within the confining unit.

The groundwater within the Yorktown aquifer beneath the site flows westward and discharges into Slocum Creek. The potentiometric surface elevation of the Yorktown aquifer ranges from approximately 6 to 9.5 feet (MSL). A 8.3-foot potentiometric surface elevation was observed at OU2MW3 (Figure 3-6 and Plate 7). This elevation is believed to be due to an unexplained localized increase in the potentiometric surface. The average elevation of the Yorktown aquifer potentiometric surface is 6.9 feet MSL. This is consistent with the USGS simulated potentiometric surface of the Yorktown aquifer (USGS, 1994).

The thickness of the aquifer increases towards the southern portion of the site. The average thickness of the Yorktown aquifer is 29 feet as measured at 9 well clusters across the site. Thickness ranges from approximately 22 feet at well cluster 10GW34 in the north, to approximately 37 feet at well cluster 10GW40 in the south.

The seepage velocity can be calculated using the same equation used for the surficial aquifer. The hydraulic conductivity value of 15 ft/day was obtained from the 1994 USGS report. The hydraulic gradient "i" was estimated to be 5.3E-4 ft/ft by graphic interpretation from the potentiometric surface map (Plate 7 and Figure 3-6). The effective porosity was estimated to be 0.3 for sand. Substituting these values into the equation results in a value for seepage velocity of 0.175 ft/day (6.2E-5 cm/sec).

Generally, the vertical hydraulic gradients between the surficial and Yorktown aquifers are upward in areas near Slocum Creek and downward in the central and eastern portion of the site. Upward gradients occur in well clusters OU2MW3 and OU2MW2. This is an area where the groundwater in the surficial aquifer is recharged by the underlying Yorktown aquifer through the Yorktown confining unit. Because of the proximity of Slocum Creek, the groundwater from the Yorktown aquifer is discharging to the creek through the surficial aquifer.

Based on the most recent water-level measurements a small (head differential of 0.16 feet) downward gradient was observed at well cluster OU2MW4. Larger (average head differential of 8.2 feet) downward gradients were observed in clusters OU2MW5, 10EGW1, OU2MW6, and OU2MW7 located in the eastern side of the site. At well cluster OU2MW7, water-level measurements were not taken at the surficial well because of inaccessibility; however, water levels were obtained from the lower surficial well 10GW25 (S1W2). Moderate downward gradients occur in the central portion of the site at well clusters 10GW19 and 10GW33.

Pungo River Confining Unit

The Pungo River confining unit was believed to be encountered in all of the six lower Yorktown Wells. One Shelby tube was collected from the upper portion of the Pungo River confining unit at OU2MW7. The

hydraulic conductivity was measured to be 6.6E-07 cm/sec. The lithology of the confining unit is described in the geology section of this report (Section 3.5).

3.6.3 Groundwater Quality and Designations

Groundwater is the major source of drinking water at the Air Station and in the City of Havelock. Groundwater use within the area includes domestic, light industrial, and industrial. The Air Station uses between 2.5 and 4.5 million gallons of water per day (USGS, 1988). This supply is derived from about 20 wells that range in depth from 195 to 330 feet. The number of wells in use at any one time varies with need. The City of Havelock obtains its water from two wells that are 144 to 150 feet deep. Air Station and Havelock water supply wells are shown on Figure 2-2 and Plate 3.

The groundwater in the vicinity of MCAS Cherry Point is classified by the state of North Carolina as Class GA. Class GA groundwaters are considered to be existing or potential sources of drinking water. Groundwater quality standards for these waters are the lesser of the following:

- Systemic threshold concentrations
- Concentration corresponding to a 10^{-6} cancer risk
- Taste threshold limit
- Odor threshold limit
- Maximum Contaminant Level
- Natural secondary drinking water standard

3.7 POPULATION AND LAND USE

MCAS Cherry Point is located within the limits of the City of Havelock, North Carolina. The area surrounding the Air Station consists of commercial and residential developments, waterways, and public lands (Croatan National Forest). It is isolated from relatively large population centers. The largest cities in the vicinity are the City of New Bern (approximately 19 miles northwest of the Air Station) and Morehead City (approximately 19 miles southeast of the Air Station). There are approximately 8,267 active military personnel and 5,946 civilian personnel living and/or working at the Air Station. In addition, approximately 27,586 dependents live on or off the station. Enlisted military personnel assigned to the Air Station typically remain for two tours of duty (a total of approximately 3 years). Officers may remain longer.

The primary military land uses at the Air Station include military operations, training, maintenance and production, supply, medical administration, troop and family housing, community support, and utilities. The

most concentrated area of development occurs in an area bounded by "A" Street, Sixth Avenue, and Roosevelt Boulevard. This area is southeast of OU2 on the opposite side of Roosevelt Boulevard. Most of the assigned personnel, both civilian and military, work in this area, and most of the enlisted men's quarters are located there.

The area between the East Prong of Slocum Creek and Roosevelt Boulevard and south of Runway 14 is generally devoted to a Community Services complex. Most housing is located within the Community Services complex in the southwest corner of the Air Station (southeast of OU2). The northwest corner and the area west of Slocum Creek are devoted to Ordnance and Survival Training areas. These areas are also northwest and west of OU2. None of the above areas have been impacted by past activities at OU2.

3.8 ECOLOGY

The Air Station has an active fish and wildlife management program, with on-staff foresters, wildlife biologists, and game wardens. The objectives of the management program are to protect all native wildlife species and their habitat, make fish and wildlife resources available on a continuing basis, enhance fish and wildlife resources, and participate in the multiple uses of Marine Corps property. A copy of the Fish and Wildlife Management Plan is included in Appendix K (Rogers, June 1990).

Most of the game species native to eastern North Carolina are present at MCAS Cherry Point. These include large game (white-tailed deer, black bear, and wild turkey), small game (grey squirrel, mourning dove, rabbits, bobwhite quail, and waterfowl), and furbearers (raccoon, grey fox, river otter, opossum, muskrat, beaver, nutria, and bobcat), as well as a variety of nongame species (amphibians, reptiles, birds, and mammals). Some of the management programs are active in maintaining population and habitat (e.g., rabbits and squirrels). Some areas of the Air Station are planted in grains to provide additional forage (e.g., doves), and some species are managed primarily by restricting hunting and providing protection from poaching (e.g., bears). Only one waterfowl species (the wood duck) actively breeds in the area, and nesting boxes are provided.

In addition, the Air Station carries out management programs for endangered and threatened species, and all actions are evaluated for the potential effects on these resources. A few endangered and threatened species are known to exist or pass through the area, as follows:

- Bald eagle - A few birds use Slocum Creek or the Neuse River during their migrations. No nests are known.

- American alligator - It is estimated that four to six alligators reside in local creeks and marshes. Young have occasionally been seen in the Jack's Branch area of Hancock Creek.

- Red-cockaded woodpecker - No active colonies have been found in the area, although the birds did exist historically. Monitoring continues, but there have been no confirmed sightings.

- Loggerhead turtle - Found in sounds and rivers adjacent to MCAS Cherry Point.

A rare species and special-interest natural areas inventory of MCAS Cherry Point was conducted by the North Carolina Natural Heritage Program (NCNHP) during 1992 and 1993. The animal and plant inventory was designed to gather data on the population and habitat characteristics of each documented rare species, to map their locations, to assess the quality and integrity of habitat, and to make management recommendations regarding species and habitat.

MCAS Cherry Point forested uplands are dominated by the Wet Pine Flatwoods community, most of which has been managed for timber production. The Tidal Freshwater Marsh community forms a fringe along the tidal creeks, and the Coastal Fringe Evergreen Forest community occupies low upland terraces along the tidal creeks. Tidal creek tributaries support the Coastal Plain Small Stream Swamp (Blackwater Subtype) community, and the Mesic Mixed Hardwood Forest community occupies the slopes adjacent to these inland streams.

Areas containing extensive amounts of one or more high quality natural community types, and which usually support critical areas for rare species, are designated as "Natural Areas". One such area was designated for MCAS Cherry Point and that was the Tucker Creek Natural Area. This area is composed primarily of the drainages of Tucker Creek and Anderson Creek and the peninsula between Anderson Creek and Neuse River. It also includes an outlying area named the Ridge and Ravine Creeks located north of Roosevelt Boulevard to the Neuse River between the road to the Officers Club and the road to the Base Officer Quarters. The Tucker Creek Natural Area contains exemplary examples or three community types and supports two rare animal species and two rare plant species.

MCAS Cherry Point has been divided into 15 critical areas, which are considered to be essential to the conservation and management of rare species. Of these 15 critical areas, only one -- Slocum Creek and tributaries -- is associated with OU2. The location of this critical area is "Slocum Creek from Anderson Creek upstream to the crossing of Southwest Prong and East Prong by road U.S. 70, including Anderson Creek, Tucker Creek, and Mill Creek". The size of the critical area is undetermined; however, the linear extent of Slocum Creek and its tributaries within the critical area is approximately 14 miles. The portion of Slocum

Creek adjacent to OU2 is part of this critical area. Maps in the NCNHP report do not include Turkey Gut within this critical area. Slocum Creek and its tributaries contain tidal freshwater marshes, coastal small stream swamps, and/or cypress-gum swamps.

MCAS Cherry Point comprises 11,700 acres, of which 6,336 acres (54 percent) are forested. The remainder is in military use for operations, training, maintenance, construction, supply, housing, support facilities, and utilities. The majority of military use facilities are located in the central and south-central portions of the Air Station. The majority of forested lands are located in the northwest, north-central, and southeast portions of the Air Station. Much of the forested land is used for training purposes. Pine is the dominant canopy tree, with Loblolly Pine (*Pinus taeda*) covering about 4,000 acres. Mixed pine and hardwoods cover about 1,200 acres. Some forested lands are managed for natural and scenic values. These include major road corridors; riparian, beach, and bluff areas along the major river and creek systems, including their tributaries; areas containing federally designated endangered, threatened, or rare species; and forests adjacent to some residential areas and the Air Station golf course. Other forested lands are managed for even-age timber production and to enhance wildlife populations, such as by maintaining wildlife food plots. Although there is a recent history of prescribed winter burning in MCAS Cherry Point forests, shrub dominance of the ground layer and the near absence of Wiregrass (*Aristida stricta*) indicate a long historical period without fire. It is also possible that land uses, such as agriculture, prior to the establishment of the Air Station contributed to loss of Wiregrass.

The game warden staff assists Federal and state authorities in enforcement of the Endangered Species Act. The Air Station also runs an active fisheries management program to provide recreational fishing for personnel and their dependents, civilian employees, and public guests. The program consists of intensive management of four freshwater ponds, as well as regulation enforcement on adjacent waters. The ponds are stocked with catfish, large-mouth bass, bluegill, and redear sunfish.

The Air Station is also working closely with the U.S. Fish and Wildlife Service on a research project on Slocum Creek (Fleming, October 1992). In 1990, a general fish health assessment was performed on three species (large-mouth bass, brown bullheads, and pumpkinseeds). Although no unusual occurrences have been noted, additional computer analysis of histopathology and stress protein data is continuing.

In 1992, fish were collected from Slocum Creek, Hancock Creek, and Goose Creek. Hancock and Goose Creeks were selected as reference (background) locations.

During the 1994 ecological assessment, fish, frogs, and aquatic insects were observed in Turkey Gut.

A number of data interpretation and statistical analysis activities are under way. The 1992 annual project report is included in Appendix K (Volume IV). These investigations provided input for the ecological assessment presented in Section 7.0.

4.0 NATURE AND EXTENT OF CONTAMINATION

This section contains a summary of the nature and extent of contamination observed in all environmental media sampled at Operable Unit 2. Section 4.1 discusses soil (both surface and subsurface) and Section 4.2 discusses groundwater. Sections 4.3 and 4.4 present information on surface water and sediment, respectively. A discussion of the leachate seeps is provided in Section 4.5, and the polishing pond samples are discussed in Section 4.6. An overall summary is contained in Section 4.7. The complete chemical analytical data base for Operable Unit 2 can be found in Appendix H (Volume II). All sampling locations are shown on Plate 2, which is contained in Volume V of this report, and Figure 2-1. Additional information on field measurements made during surface water and sediment sampling activities is presented on the sample log sheets in Appendix C (Volume II).

4.1 SOIL

This section contains a summary of the observed contamination in surface and subsurface soil samples collected from Operable Unit 2. All sampling rounds are discussed, and the data are summarized on a series of tables and plates, as appropriate.

4.1.1 Sampling and Analysis Summary

Soil samples were collected from this area in a series of investigations, beginning in 1983 and ending with the 1996 field work completed for the RI. A total of 149 soil samples (not including field duplicates) were collected from a variety of locations. Table 4-1 contains a matrix listing each soil sample that was collected and the analyses that were performed. The earliest investigations at this site focused on the potential presence of volatile organics, driven by two pieces of site history. The first is that the area was used as a fire training area, and the second is that an unlined sludge impoundment had been used for the disposal of metal filings, plating sludges, organic solvents, oil and grease, and miscellaneous chemicals collected in floor drains.

The earliest investigation of soil at OU2 (formerly Site 10) consisted of a series of soil borings drilled for the investigation and cleanup confirmation of the former sludge impoundments. These samples have "B" (impoundment perimeter samples) and "H" (confirmation samples from above and below the former pit bottom) designations in their sample nomenclature. Each of the "B" samples was collected from a depth

TABLE 4-1

SUMMARY OF SOIL SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Sample Number (Depth)	Date	Priority Pollutant Organics	Priority Pollutant Metals	Selected Metals[1]	Total Organic Carbon	Total Organic Halogens	Phenols	TCL Volatile Organics	TCL Semivolatile Organics	TCL Pesticides/ PCBs	TAL Metals	RCRA List 2 Metals[2]	Dioxins
B1-14	04/83	X	X[3]				X						
B2-14	04/83	X	X[3]				X						
B3/B4-C (14)	04/83	X	X[3]				X						
B5/B6-C (14)	04/83	X	X[3]				X						
H1(+2.5) (7)	12/83			X	X	X	X						
H1(-7.5) (17)	12/83			X	X	X	X						
H2(+2.5) (7)	12/83			X	X	X	X						
H2(-7.5) (17)	12/83			X	X	X	X						
H1/H2-C (7)	12/83			X	X	X	X						
H3(+2.5) (7)	12/83			X	X	X	X						
H3(-7.5) (17)	12/83			X	X	X	X						
H4(+2.5) (7)	12/83			X	X	X	X						
H4(-7.5) (17)	12/83			X	X	X	X						
H3/H4-C (7)	12/83			X	X	X	X						
10B01-0810	10/90				X			X			X		
10B01-1012	10/90				X			X	X	X	X		
10B02-0608	10/90				X			X			X		
10B02-1214	10/90				X			X			X		
10B03-0608	10/90				X			X			X		
10B03-0810	10/90				X			X	X	X	X		

TABLE 4-1 (Continued)
SUMMARY OF SOIL SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Sample Number (Depth)	Date	Priority Pollutant Organics	Priority Pollutant Metals	Selected Metals[1]	Total Organic Carbon	Total Organic Halogens	Phenols	TCL Volatile Organics	TCL Semivolatile Organics	TCL Pesticides/ PCBs	TAL Metals	RCRA List 2 Metals[2]	Dioxins
10B04-1012	10/90				X			X			X		
44ASO03-0000	1991												X
44ASO03-0203	1991												X
44ASO04-0000	1991												X
44ASO04-0203	1991												X
10SB-A5-0810	07/92		X					X					
10SB-A5-0810-D	07/92		X					X					
10SB-B5-0810	07/92		X					X					
10SB-C1-0406	07/92		X					X					
10SB-C1-1012	07/92		X					X					
10SB-C5-1012	07/92		X					X					
10SB-C9-1416	07/92		X					X					
10SB-C9-1416-D	07/92		X					X					
10SB-C11-2022	07/92		X					X					
10SB-C23-1012	07/92		X					X					
10SB-C25-1719	07/92		X					X					
10SB-C27-1214	07/92		X					X					
10SB-C27-CD (8-10)	07/92		X					X					
10SB-C29-1416	07/92		X					X					
10SB-C29-CD (14-16)	07/92		X					X					
10SB-C33-1921	07/92		X					X					
10SB-D1-0810	07/92		X					X					

TABLE 4-1 (Continued)
SUMMARY OF SOIL SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Sample Number (Depth)	Date	Priority Pollutant Organics	Priority Pollutant Metals	Selected Metals[1]	Total Organic Carbon	Total Organic Halogens	Phenols	TCL Volatile Organics	TCL Semivolatile Organics	TCL Pesticides/ PCBs	TAL Metals	RCRA List 2 Metals[2]	Dioxins
10SB-D3-0810	07/92		X					X					
10SB-D7-0810	07/92		X					X					
10SB-D9-0810	07/92		X					X					
10SB-D13-0810	07/92		X					X					
10SB-D13-0810-D	07/92		X					X					
10SB-D15-0810	07/92		X					X					
10SB-E1-0608	07/92		X					X					
10SB-E3-0810	07/92		X					X					
10SB-E5-0810	07/92		X					X					
10SB-E7-0810	07/92		X					X					
10SB-E15-0406	07/92		X					X					
10SB-E17-0810	07/92		X					X					
10SB-E19-1012	07/92		X					X					
10SB-E21-0810	07/92		X					X					
10SB-E29-0406	07/92		X					X					
10SB-E29-0406-D	07/92		X					X					
10SB-E31-0406	07/92		X					X					
10SB-E33-0406	07/92		X					X					
10SB-E35-0810	07/92		X					X					
10SB-E35-0810-D	07/92		X					X					
10SB-E43-0204	07/92		X					X					
10SB-E45-0810	07/92		X					X					

TABLE 4-1 (Continued)
SUMMARY OF SOIL SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Sample Number (Depth)	Date	Priority Pollutant Organics	Priority Pollutant Metals	Selected Metals[1]	Total Organic Carbon	Total Organic Halogens	Phenols	TCL Volatile Organics	TCL Semivolatile Organics	TCL Pesticides/ PCBs	TAL Metals	RCRA List 2 Metals[2]	Dioxins
10SB-E47-0810	07/92		X					X					
10SB-E49-0810	07/92		X					X					
10SB-E57-0810	07/92		X					X					
10SB-E59-0810	07/92		X					X					
10SB-E61-0810	07/92		X					X					
10SB-E63-0204	07/92		X					X					
10SB-E71-0204	07/92		X					X					
10SB-E73-0810	07/92		X					X					
10SB-E75-0406	07/92		X					X					
10SB-E77-0810	07/92		X					X					
10SB-F1-0810	07/92		X					X					
10SB-F3-0810	07/92		X					X					
10SB-F5-0810	07/92		X					X					
10SB-F11-0810	07/92		X					X					
10SB-F13-0810	07/92		X					X					
10SB-F15-0810	07/92		X					X					
10SB-F21-0810	07/92		X					X					
10SB-F23-0810	07/92		X					X					
10SB-F25-0810	07/92		X					X					
10SB-BB1-2022	07/92		X					X					
10SB-BB2-1012	07/92		X					X					
10SB-BB3-1921	07/92		X					X					

TABLE 4-1 (Continued)
SUMMARY OF SOIL SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Sample Number (Depth)	Date	Priority Pollutant Organics	Priority Pollutant Metals	Selected Metals[1]	Total Organic Carbon	Total Organic Halogens	Phenols	TCL Volatile Organics	TCL Semivolatile Organics	TCL Pesticides/ PCBs	TAL Metals	RCRA List 2 Metals[2]	Dioxins
10SB-BB3-1921-D	07/92		X					X					
10SB-BB4-0810	07/92		X					X					
10SB-BB5-1820	07/92		X					X					
10SB-BB6-0810	07/92		X					X					
10SB-BB7-0810	07/92		X					X					
10SB-BB8-0810	07/92		X					X					
10SB-BB9-0810	07/92		X					X					
10SB-BB10-1820	07/92		X					X					
10SB-BB11-0810	07/92		X					X					
10SB-BB11-0810-D	07/92		X					X					
10SB-BB12-0608	07/92		X					X					
10TP01-0709	07/92		X					X					
10TP02-0405	07/92		X					X					
10TP03-0506	07/92		X					X					
10TP04-1012	07/92		X					X					
10TP05-0608	07/92		X					X					
10TP05-0608-D	07/92		X					X					
10TP06-1012	07/92		X					X					
10TP07-1012	07/92		X					X					
10TP08-0304	07/92		X					X					
10TP09-0406	07/92		X					X					
10TP10-0204	07/92		X					X					

TABLE 4-1 (Continued)
SUMMARY OF SOIL SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Sample Number (Depth)	Date	Priority Pollutant Organics	Priority Pollutant Metals	Selected Metals[1]	Total Organic Carbon	Total Organic Halogens	Phenols	TCL Volatile Organics	TCL Semivolatile Organics	TCL Pesticides/ PCBs	TAL Metals	RCRA List 2 Metals[2]	Dioxins
10TP11-0406	07/92		X					X					
10TP12-0204	07/92		X					X					
10TP12-0204-D	07/92		X					X					
10TP13-1012	07/92		X					X					
10TP14-1214	07/92		X					X					
10TP15-0002	11/93							X	X		X		
10TP15-0810	11/93							X	X		X		
10TP16-0002	11/93							X	X		X		
10TP16-1011	11/93							X	X		X		
10TP17-0910	11/93							X	X		X		
10TP17-0910-D	11/93							X	X		X		
10TP18-0406	11/93							X	X		X		
10TP18-0910	11/93							X	X		X		
10TP19-0910	11/93							X	X		X		
10TP20-0203	11/93							X	X		X		
10TP20-0910	11/93							X	X		X		
10TP21-0910	11/93							X	X		X		
10TP22-0607	11/93							X	X		X		
10TP23-0102	11/93							X	X		X		
10TP23-0910	11/93							X	X		X		
10SISB1-1012	11/93							X	X		X		
10SISB1-1618	11/93							X	X		X		

TABLE 4-1 (Continued)
SUMMARY OF SOIL SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Sample Number (Depth)	Date	Priority Pollutant Organics	Priority Pollutant Metals	Selected Metals[1]	Total Organic Carbon	Total Organic Halogens	Phenols	TCL Volatile Organics	TCL Semivolatile Organics	TCL Pesticides/ PCBs	TAL Metals	RCRA List 2 Metals[2]	Dioxins
10SISB2-1618	11/93							X	X		X		
10SISB3-1618	11/93							X	X		X		
10SISB4-1214	11/93							X	X		X		
10SISB4-1618	11/93							X	X		X		
OU2SB01-2022	1994							X	X	X	X[3]		
OU2SB02-2426	1994							X	X	X	X[3]		
OU2SB02-2426-D	1994							X	X	X	X[3]		
OU2SB03-2022	1994							X	X	X	X[3]		
OU2SB04-2224	1994							X	X	X	X[3]		
OU2SB05-2224	1994							X	X	X	X[3]		
OU2SB06-2224	1994							X	X	X	X[3]		
OU2SB07-2224	1994							X	X	X	X[3]		
OU2SB08-2224	1994							X	X	X	X[3]		
OU2SB09-0001	1996												X
OU2SB09-0810	1996												X
OU2SB10-0001	1996												X
OU2SB10-0406	1996												X
OU2SS01-0001	1995							X	X	X	X[3]		
OU2SS02-0001	1995							X	X	X	X[3]		
OU2SS03-0001	1995							X	X	X	X[3]		
OU2SS04-0001	1995							X	X	X	X[3]		
OU2SS05-0001	1995							X	X	X	X[3]		

TABLE 4-1 (Continued)
SUMMARY OF SOIL SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Sample Number (Depth)	Date	Priority Pollutant Organics	Priority Pollutant Metals	Selected Metals[1]	Total Organic Carbon	Total Organic Halogens	Phenols	TCL Volatile Organics	TCL Semivolatile Organics	TCL Pesticides/ PCBs	TAL Metals	RCRA List 2 Metals[2]	Dioxins
OU2SS06-0001	1995							X	X	X	X[3]		
OU2SS07-0001	1995							X	X	X	X[3]		
OU2SS08-0001	1995							X	X	X	X[3]		
OU2SS09-0001	1995							X	X	X	X[3]		
OU2SS09-0001-D	1995							X	X	X	X[3]		
OU2SS10-0001	1995							X	X	X	X[3]		
OU2SS11-0001	1995							X	X	X	X[3]		
OU2SS12-0001	1996							X	X	X	X[3]		
OU2SS13-0001	1996							X	X	X	X[3]		
BACKGROUND SAMPLES													
BGSO01-000-5[4]	11/91												
BGSO01-0101-5[4]	11/91												
BGSO02-000-5[4]	11/91												
BGSO02-0101-5[4]	11/91												
BGSB01-0204	11/93							X	X		X		
BGSB01-1416	11/93							X	X		X		
OU1MW09-0002[5]	08/94							X	X	X	X[3]		
OU1MW09-0406[5]	08/94							X	X	X	X[3]		
OU1MW09-0608[5]	08/94							X	X	X	X[3]		
OU2MW7A-0002[5]	08/94							X	X	X	X[3]		
OU2MW7A-0406[5]	08/94							X	X	X	X[3]		
OU2MW7A-1012[5]	08/94							X	X	X	X[3]		

TABLE 4-1 (Continued)
SUMMARY OF SOIL SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Sample Number (Depth)	Date	Priority Pollutant Organics	Priority Pollutant Metals	Selected Metals[1]	Total Organic Carbon	Total Organic Halogens	Phenols	TCL Volatile Organics	TCL Semivolatile Organics	TCL Pesticides/ PCBs	TAL Metals	RCRA List 2 Metals[2]	Dioxins
OU2MW7A-1012-DUP2[5]	08/94							X	X	X	X[3]		
OU3MW05-0002[5]	08/94							X	X	X	X[3]		
OU3MW05-0002-DUP3[5]	08/94							X	X	X	X[3]		
OU3MW05-0406[5]	08/94							X	X	X	X[3]		
OU3MW05-0810[5]	08/94							X	X	X	X[3]		
OU4MW03-0002[5]	08/94							X	X	X	X[3]		
OU4MW03-0406[5]	08/94							X	X	X	X[3]		
OU4MW03-0810[5]	08/94							X	X	X	X[3]		
OU13MW7A-0002[5]	08/94							X	X	X	X[3]		
OU13MW7A-0406[5]	08/94							X	X	X	X[3]		
OU13MW7A-0406-DUP1[5]	08/94							X	X	X	X[3]		
OU13MW7A-1618	08/94							X	X	X	X[3]		

1 Includes barium, cadmium, chromium, copper, lead, nickel, silver, and zinc.
2 Includes antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, selenium, silver, thallium, vanadium, and zinc. Analysis included TCLP and List 2 metals for the leachate.
3 Includes cyanide.
4 List 1 and List 2 analyses (see Tables G-1, G-2, G-3; Appendix G).
5 Analyses included TPH.

Note: An "X" indicates the analytical parameter(s) for each sample. See Appendix G for lists of various analytical programs (e.g., priority pollutants, TCL, TAL).

above the water table and analyzed for priority pollutant organics and metals. The confirmatory ("H") samples were analyzed for TOC, TOX, phenols, and selected metals. The "H" samples were collected above the water table depth. Samples were obtained from the fill material and the underlying natural soil. These results are presented in detail in the Unit 10 sludge impoundment evaluation report (Halliburton NUS, December 1991). Upon completion of this activity, no further work was done until 1985, when several wells were installed as part of the initial remedial investigation (RIIR) (NUS Corporation, October 1988). However, no soil samples were collected at this time (1985-1987).

Based on historical site knowledge and the results of the RIIR groundwater assessment, this site was selected as one of four high-priority sites at the Air Station. The investigation of OU2, while still phased for funding reasons, was initiated in 1990. The next investigation of soil in this area consisted of four soil borings drilled within the former sludge impoundments to confirm that the 1983 closure was successful. During the 1983 cleanup, no analysis for specific organic compounds was conducted. Each of these samples were analyzed for Target Compound List (TCL) volatile organics, Target Analyte List (TAL) metals, and Total Organic Carbon (TOC). Two of these samples were also analyzed for TCL semivolatile organics and pesticides/PCBs. Samples were collected from the zone with the highest organic vapor readings on an HNu, and a second sample was collected from the interval immediately above the water table. One subsurface composite sample from these borings was subjected to TCLP extraction and analysis. The results of this activity were summarized in the RFI report for Units 5, 10, 16, and 17 (NUS Corporation, May 1991a) and Unit 10 sludge impoundment evaluation report (Halliburton NUS, December 1991).

In 1991, four surface and shallow subsurface soil samples were collected from a former sludge application area (Site 44A) located on top of the landfill. This sludge application area was originally designated as Site 45 in the 21-Unit RFI Report (Halliburton NUS, June 1993), which is the entire current sludge application area; however, the designation of the particular area of concern is actually identified in the RCRA Consent Order as Site 44. The area designated as this site was an area upon which sludge from the wastewater treatment plant digesters was applied between September and November 1987. Samples identified in the 21-Unit RFI Report as Site 45 samples are now identified as samples with a Site 44A designation to be consistent with the Consent Order. These samples were analyzed for the RCRA List 2 metals, as plating shop sludges were the reason this site was identified in the first place. TCLP extraction and analysis for List 2 metals was also performed on each sample.

As part of the more detailed investigation of the landfill, an extensive soil sampling program was initiated in July 1992 as part of the Phase I TDM. Magnetometer surveys were performed in several areas of concern formerly identified on the basis of known areas of groundwater contamination. These areas were gridded

and surveyed, and potential areas of concern were identified for chemical sampling and analysis via split-spoon sampling or test pitting. These samples are designated with a "10SB-alpha character" or "10TP" number, with the alpha character identifying the particular area of concern. Each of the 58 samples (including 9 duplicates) collected for laboratory analysis was analyzed for TCL volatiles and priority pollutant metals. The majority of the samples were collected above the water table, except for some of the deeper borings or where shallow groundwater (less than 10 feet deep) was encountered.

In November 1993, additional investigation was performed in areas of concern identified in the Phase I TDM. This activity consisted of test pitting in several areas identified as locations of elevated volatile organic contaminant concentrations. Fifteen soil samples, including one duplicate, were collected from nine test pits. Four soil borings were also drilled during the investigation. Six soil samples were collected from these borings. All samples were collected above the water table. Each of these samples was analyzed for TCL volatile and semivolatile organics and TAL metals. The results are summarized in the Phase II TDM for Site 10 (Halliburton NUS, June 1994b).

Another phase of investigation at OU2 was the RI field work performed in the fall of 1994. At that time, eight soil borings were drilled in areas of concern identified by the previous test pitting. One soil sample was collected from each boring and analyzed for TCL volatile and semivolatile organics, pesticides, and PCBs and for TAL metals. One duplicate sample was also collected at this time. Samples were collected when the water table was encountered.

An additional phase of investigation at OU2 was the supplemental RI field work performed in July 1995. At that time, 11 surface soil samples were collected. These samples, along with a duplicate sample, were analyzed for TCL volatile, semivolatile, pesticide, and PCB organic compounds; TAL metals; and cyanide.

The final phase of investigation at OU2 was the supplemental RI field work performed in April 1996. Two soil borings were drilled in areas at Site 10 where fire-training exercises were conducted. One surface soil sample and one subsurface soil sample were collected from each boring and analyzed for dioxins. In addition, two surface soil samples were collected from Site 76 and analyzed for TCL volatile and semivolatile organics, pesticides, and PCBs and TAL metals and cyanide.

All of the results from the investigations described above are summarized in this report.

Background soil samples were collected from several locations (shown in Plate 3 and Figure 2-2) throughout the Air Station during both the RFI, the TDM, and the RI activities. Two locations were identified during the

RFI in the north central portion of the Air Station east of Roosevelt Boulevard in undisturbed pine woodlands. Two soil samples were collected from each of the two locations (0 to 0.5 feet and 1 to 1.5 feet). These four samples, collected during the RFI, were analyzed for the List 1 and List 2 constituents (see Tables G-1, G-2, and G-3, Appendix G, Volume II). During the Phase II TDM for Sites 10 and 16 (Halliburton NUS, June 1994b), two additional soil samples were collected from a background soil boring. These samples were analyzed for TCL volatile and semivolatile organics and TAL metals. Five additional background soil samples were selected during the RI activities. One boring was drilled at each of five operable units (OU1, OU2, OU3, OU4, and OU13) from which three soil samples were collected. Three duplicate samples were also collected. Each sample was analyzed for the full TCL/TAL lists, including cyanide, as well as gasoline- and diesel-range organics and oil and grease. The analytical results for the background samples are summarized in Table 4-2 and contained in full in Appendix H.1 (Volume II).

The remainder of this section discusses the chemical analytical results for the soil samples. The complete soil analytical data base is contained in Appendix H.2 (Volume II).

4.1.2 Surface Soil

Until 1995, only five samples had been collected at this site from depths of less than 2 feet. These include three 0- to 2-foot deep samples from test pits analyzed for TCL volatile and semivolatile organics and TAL metals, and two true surface soil samples (0 to 6 inches) from the former Site 45 area (now Site 44A) analyzed for RCRA List 2 metals. For the purposes of this investigation, these are considered to be surface soil samples. In 1995, 11 additional surface soil samples were collected and analyzed for the full TCL/TAL, including cyanide. In 1996, two surface soil samples were collected and analyzed for the full TCL/TAL including cyanide, and two surface soil samples were collected and analyzed for dioxins. The analytical results for the surface soil samples are summarized in Table 4-3.

Only a few volatile organic chemicals were detected in the surface soil samples. These include single detections of 1,2-dichloroethene (20 micrograms per kilogram [μg/kg]), methylene chloride (12 μg/kg), and toluene (11 μg/kg), all of which were found in 10TP15. Xylenes were detected in five samples at concentrations of 1 to 2 μg/kg.

One surface soil sample (OU2SS04) contained several PAHs at concentrations ranging from 140 μg/kg (indeno[1,2,3-cd]pyrene) to 360 μg/kg (pyrene). This sample also contained the highest concentrations of the DDT isomers (33 to 43 μg/kg) and dieldrin (23 μg/kg). Several other pesticides were also detected in

TABLE 4-2

BACKGROUND SOIL ANALYTICAL RESULTS[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Concentration Range	Frequency of Detection	Upper 95 % Confidence Limit
Volatile Organics (μg/kg)			
Acetone	15 - 100	5/21	100[2]
2-Butanone	5	1/21	5[2]
Toluene	9.25	1/21	6.1
Ethylbenzene	4	1/21	4[2]
Xylenes	19.3	1/21	6.9
Chloroform	5	1/21	5[2]
Methylene chloride	4	1/21	4[2]
Semivolatile Organics (μg/kg)			
Bis(2-ethylhexyl)phthalate	37 - 75	5/17	75[2]
Di-n-butylphthalate	100 - 370	8/17	261.4
Pesticides/PCBs (μg/kg)			
α-Chlordane	1.4 - 1.55	4/15	1.20
γ-Chlordane	1.1 - 1.25	4/15	1.09
4,4'-DDD	1.0 - 3.1	7/15	2.36
4,4'-DDE	0.625	1/15	0.625[2]
4,4'-DDT	0.45 - 0.56	2/15	0.56[2]
Dieldrin	1.1	1/15	1.1[2]
Endosulfan I	0.43	1/15	0.43[2]
Endosulfan II	0.64	1/15	0.64[2]
Endrin aldehyde	0.82	1/15	0.82[2]
Heptachlor	0.045	1/15	0.045[2]
Methoxychlor	0.29	1/15	0.29[2]
Inorganics (mg/kg)			
Aluminum	488 - 16,900	21/21	9,268.26
Antimony	ND[1]	0/16	--
Arsenic	0.43 - 13.7	13/21	4.54
Barium	1.0 - 30.9	20/21	14.42
Beryllium	0.24 - 0.59	2/21	0.26
Boron	1.6 - 3.1	2/4	3.1[2]
Cadmium	1.35	1/21	0.65

TABLE 4-2 (Continued)
BACKGROUND SOIL ANALYTICAL RESULTS[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Concentration Range	Frequency of Detection	Upper 95 % Confidence Limit
Chromium	2.7 - 26.4	20/21	12.83
Calcium	15.5 - 1,750	18/21	692.55
Cobalt	0.88 - 6.05	3/21	1.63
Copper	0.82 - 8.15	12/21	3.08
Iron	573 - 9,055	21/21	4,959.05
Lead	0.93 - 14.9	20/21	7.92
Magnesium	27.1 - 871	20/21	382.96
Manganese	2.5 - 39.4	20/21	14.06
Mercury	0.15 - 0.235	2/17	0.11
Nickel	4.7 - 10.2	3/21	4.29
Potassium	41.4 - 958	16/17	389.58
Selenium	0.24 - 1.1	7/21	0.38
Silver	1.69	1/21	0.46
Sodium	7.3 - 72.3	10/17	59.24
Strontium	1.4 - 7.7	4/4	7.7[2]
Thallium	0.48	1/21	0.48[2]
Vanadium	1.2 - 30.45	21/21	15.52
Zinc	1.3 - 34.65	18/21	10.61
Cyanide	0.57	1/15	0.34
Miscellaneous Parameters (mg/kg)			
Chloride	20.1 - 31.4	4/4	31.4[2]
Diesel range organics	16.0	1/15	16.0
Nitrate, as nitrogen	0.0860 - 0.317	4/4	0.317[2]
Oil and grease	289 - 332	6/15	246.3
Sulfate	12.3 - 16.2	4/4	16.2[2]
Total Kjeldahl nitrogen	689 - 2,010	4/4	2,010[2]
Total organic carbon	31,900 - 61,700	4/4	61,700[2]

1 Complete data base in Appendix H.1 (Volume II). Table includes all background samples listed in Table 4-1.
2 95% UCL exceeded the maximum detection; therefore, maximum is reported.

TABLE 4-3

SOIL ANALYTICAL RESULTS (0 TO 2 FEET)[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Concentration Range	Frequency of Detection	Location of Maximum Detection
Volatile Organics (μg/kg)			
Toluene	11	1/16	10TP15-0002
Xylenes	1 - 2	5/16	OU2SS02/04/06/10-0001
1,2-Dichloroethene	20	1/16	10TP15-0002
Methylene chloride	12	1/16	10TP15-0002
Semivolatile Organics (μg/kg)			
Benzo(a)anthracene	160	1/13	OU2SS04-0001
Benzo(b)fluoranthene	170	1/13	OU2SS04-0001
Benzo(k)fluoranthene	160	1/13	OU2SS04-0001
Benzo(g,h,i)perylene	250	1/13	OU2SS04-0001
Benzo(a)pyrene	240	1/13	OU2SS04-0001
Chrysene	220	1/13	OU2SS04-0001
Di-n-octylphthalate	190	1/13	OU2SS13-0001
Fluoranthene	270	1/13	OU2SS04-0001
Indeno(1,2,3-cd)pyrene	140	1/13	OU2SS04-0001
Pyrene	360	1/13	OU2SS04-0001
Pesticides/PCBs/Dioxins/Furans (μg/kg)			
α-Chlordane	1.9 - 27	6/13	OU2-SS06-0001
γ-Chlordane	29	1/13	OU2-SS06-0001
4,4'-DDD	3.8 - 43	2/13	OU2SS04-0001
4,4'-DDE	4.2 - 33	5/13	OU2SS04-0001
4,4'-DDT	4.7 - 35	7/13	OU2SS04-0001
Dieldrin	3.8 - 11	3/12	OU2SS01-0001
Endrin aldehyde	3.0 - 27	6/12	OU2SS02-0001
Heptachlor	2.0	1/13	OU2SS06-0001

TABLE 4-3 (Continued)
SOIL ANALYTICAL RESULTS (0 TO 2 FEET)[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Concentration Range	Frequency of Detection	Location of Maximum Detection
Aroclor-1254	28 - 31	2/13	OU2SS12-00001
Aroclor-1260	630	1/13	OU2SS01-0001
OCDD	0.141 - 1.012	2/2	OU2SB10-0001
Total HpCDD	0.0265	1/2	OU2SB10-0001
Inorganics (mg/kg)			
Aluminum	1,700 - 13,000	16/16	10TP15-0002
Antimony	1.1 - 2.4	3/16	OU2SS07-0001
Arsenic	0.68 - 3.6	18/18	OU2SS02-0001
Barium	5.2 - 46.5	18/18	OU2SS08-0001
Beryllium	0.28	1/18	OU2SS03-0001
Cadmium	0.29 - 6.4	7/18	10TP15-0002
Calcium	210 - 209,000	16/16	OU2SS03-0001
Chromium	2.5 - 51.2	18/18	OU2SS08-0001
Cobalt	0.28 - 1.6	11/18	OU2SS07-0001
Copper	1.1 - 50.8	17/18	OU2SS02-0001
Iron	1,620 - 54,700	16/16	OU2SS07-0001
Lead	3.8 - 58.2	16/18	OU2SS08-0001
Magnesium	236 - 2,180	13/16	OU2SS03-0001
Manganese	3.7 - 211	16/16	OU2SS07-0001
Mercury	0.06 - 0.43	9/16	10TP23-0102
Nickel	0.46 - 5.4	13/18	10TP16-0002
Potassium	189 - 1,140	11/16	OU2SS03-0001
Selenium	0.30 - 1.2	5/18	OU2SS07-0001
Silver	0.43 - 3.7	2/18	44ASO03-0000
Sodium	40.3 - 149	7/16	OU2SS02-0001
Thallium	0.47 - 6.7	3/18	44ASO03-0000

TABLE 4-3 (Continued)
SOIL ANALYTICAL RESULTS (0 TO 2 FEET)[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Concentration Range	Frequency of Detection	Location of Maximum Detection
Vanadium	4.3 - 24.2	17/18	10TP15-0002
Zinc	6.6 - 209	17/18	10TP23-0102

1 Includes samples 44ASO03-0000, 44ASO04-0000, 10TP15-0002, 10TP16-0002, 10TP23-0102, OU2SS01-0001, OU2SS02-0001, OU2SS03-0001, OU2SS04-0001, OU2SS05-0001, OU2SS06-0001, OU2SS07-0001, OU2SS08-0001, OU2SS09-0001, OU2SS10-0001, OU2SS11-0001, OU2SS12-0001, and OU2SS13-0001.

surface soils, including chlordane, endrin aldehyde, and heptachlor. PCBs were detected in three surface soil samples. The sample from location OU2SS05 contained 28 μg/kg Aroclor-1254, the sample from locations OU2SB10-0001 contained 31 μg/kg Aroclor-1254, and the sample from location OU2SS01 contained 630 μg/kg Aroclor-1260. No other PCBs were detected in the surface soil samples.

Dioxins were detected in the two surface soil samples that were analyzed for this class of compounds (OU2SB09-0001 and OU2SB10-0001). The congeners detected include only total heptachlorodibenzo-p-dioxin (HpCDD) and octachlorodibenzo-p-dioxins (OCDD). These are the least toxic of the chlorinated dibenzo-p-dioxins. The concentrations of OCDD ranged from 0.141 to 1.012 μg/kg. Total HpCDD was only detected at location OU2SB10 at 0.0265 μg/kg. Chlorinated dibenzo-p-dioxins are evaluated using Toxicity Equivalence Factors (TEFs) relative to the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Based on a variety of approaches that generate toxicities relative to 2,3,7,8-TCDD, the USEPA developed the following TEFs: 1.0 for 2,3,7,8-TCDD; 0.01 for HpCDD; and 0.001 for OCDD. TCDD equivalent concentrations ranged from 0.0001 μg/kg (OU2SB09) to 0.001 μg/kg (OU2SB10).

Of interest in the surface soil samples were cadmium, chromium, manganese, and thallium, which were detected at the site at maximum concentrations of 6.4 milligrams per kilogram (mg/kg), 51.7 mg/kg, 211 mg/kg, and 6.7 mg/kg, respectively. No single sample location contained an overwhelming majority of the detected maxima. The maxima were split between a number of sample locations. As another item of note, the maximum detected concentration of lead (58.2 mg/kg) occurred in OU2SS8-0001.

The concentrations of metals in the surface soil samples were much lower than those reported in the subsurface soil samples, which reflect actual waste disposal. The next section discusses the subsurface soil sample analytical results.

4.1.3 Subsurface Soil

The subsurface soil sampling program was far more extensive than the surface soil program. It included 130 samples (not including field duplicates) at depths ranging from 2 to 26 feet. The chemical analytical results are summarized in Table 4-4.

The soil sampling program over much of the site was biased. An initial soil sampling program in 1990 was based on a soil-gas survey and knowledge of existing groundwater contamination. Next, the results of soil-gas surveys and aerial photos were used to define certain investigation areas, which were gridded for

TABLE 4-4

SUBSURFACE SOIL ANALYTICAL RESULTS (> 2 FEET)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Concentration Range	Frequency of Detection	Location of Maximum Detection
Volatile Organics (μg/kg)			
Acetone	4 - 5,300	24/111	OU2SB5-2224
2-Butanone	11 - 16,000	15/111	10TP02-0405
4-Methyl-2-pentanone	10 - 1,000	5/111	10TP15-0810
2-Hexanone	7 - 510	7/111	10TP01-0709
Benzene	4 - 280	7/115	OU2SB8-2224
Toluene	5 - 67,000	20/115	OU2SB7-2224
Ethylbenzene	7 - 140,000	19/115	10TP18-0910
Xylenes (total)	5 - 450,000	32/111	10TP18-0910
Chlorobenzene	14 - 520	7/115	10TP04-1012
Styrene	5	1/111	10SB-E31-0406
1,1,1-Trichloroethane	3 - 2,500	15/115	10B02-0608
1,1-Dichloroethane	9 - 69	4/115	OU2SB8-2224
1,2-Dichloroethane	13	1/115	10TP15-0810
Chloroethane	14	1/115	10TP17-0910
Tetrachloroethene	38 - 4,800	2/111	10SISB3-1618
Trichloroethene	5 - 880	7/115	10B04-1012
1,2-Dichloroethene (total)	5 - 4,700	6/111	10SB-E63-0204
Vinyl chloride	13 - 490	2/115	10SB-E63-0204
Chloroform	470 - 2,590	4/115	B1-14
Methylene chloride	4 - 190,000	16/115	10TP18-0910
Trichlorofluoromethane	4.9 - 24	4/4	B1-14
trans-1,3-Dichloropropene	98	1/115	10TP02-0405
Carbon disulfide	6 - 44	7/111	10SB-C33-1921
Semivolatile Organics (μg/kg)			
Phenol	43 - 12,000	4/20	10B03-0810
2,4-Dimethylphenol	52 - 4,100	5/20	10B03-0810
4-Methylphenol	590 - 27,000	2/16[2]	10B03-0810

TABLE 4-4 (Continued)
SUBSURFACE SOIL ANALYTICAL RESULTS (> 2 FEET)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Concentration Range	Frequency of Detection	Location of Maximum Detection
1,2-Dichlorobenzene	430 - 2,000	2/20	10SISB3-1618
Bis(2-ethylhexyl)phthalate	49 - 11,000	9/20	OU2SB8-2224
Di-n-butylphthalate	110 - 1,800	5/20	OU2SB2-2426
Diethylphthalate	55 - 160	2/20	OU2SB4-2224
Butylbenzylphthalate	140 - 2,300	2/20	OU2SB8-2224
Anthracene	1,000	1/20	10SISB3-1618
Fluoranthene	1,100	1/20	10B01-1012
Fluorene	420 - 20,000	4/20	OU2SB8-2224
2-Methylnaphthalene	140 - 230,000	8/16	OU2SB8-2224
Naphthalene	100 - 39,000	9/20	OU2SB8-2224
Phenanthrene	200 - 90,000	6/20	OU2SB8-2224
Pyrene	190	1/20	10SISB2-1618
Dibenzofuran	4,300 - 11,000	2/16	OU2SB8-2224
Pesticides/PCBs/Dioxins/Furans(μg/kg)			
Aldrin	3.6	1/14	OU2SB4-2224
δ-BHC	4.6	1/14	10B03-0810
α-Chlordane	3.9 - 630	3/9	OU2SB8-2224
γ-Chlordane	1.2 - 2.8	3/10	OU2SB5-2224
4,4'-DDD	1.4 - 3.5	4/11	OU2SB3-2022
4,4'-DDE	2.5 - 30	2/13	10B01-1012
4,4'-DDT	120 - 130	2/13	10B03-0810
Dieldrin	7.2 - 53	4/14	10B03-0810
Endosulfan I	2.2	1/14	10B01-1012
Endosulfan II	32 - 47	2/12	10B03-0810
Endosulfan sulfate	36 - 67	2/14	10B03-0810
Endrin	15 - 21	2/14	10B03-0810
Heptachlor epoxide	7.7 - 18	2/12	10B03-0810
OCDD	0.210 - 0.651	2/2	OU2SB10-0406
1,2,3,4,6,7,8-HpCDF	0.0061	1/2	OU2SB09-0810

TABLE 4-4 (Continued)
SUBSURFACE SOIL ANALYTICAL RESULTS (> 2 FEET)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Concentration Range	Frequency of Detection	Location of Maximum Detection
Total HpCDF	0.0075	1/2	OU2SB09-0810
1,2,3,4,6,7,8-HpCDD	0.0404	1/2	OU2SB10-0406
Total HpCDD	0.0404	1/2	OU2SB10-0406
Inorganics (mg/kg)			
Aluminum	467 - 18,500	32/32	10TP23-0910
Antimony	3.9 - 66.3	15/111	10SB-E19-1012
Arsenic	0.12 - 13.7	113/118	10TP17-0910
Barium	1.0 - 705	38/40	10TP23-0910
Beryllium	0.02 - 3.7	38/117	10SB-E19-1012
Cadmium	0.14 - 119.5	26/127	10TP17-0910
Calcium	49.7 - 105,000	32/32	10SISB4-1214
Chromium	1.1 - 122	120/127	H3/H4-C (10-14.5)
Cobalt	0.50 - 16.7	14/34	10TP23-0910
Copper	0.24 - 2,370	76/127	10SB-E19-1012
Iron	717 - 62,600	32/32	OU2SB4-2224
Lead	0.82 - 1,650	118/127	10TP23-0910
Magnesium	25.3 - 3,440	32/32	10TP23-0910
Manganese	2.7 - 1,170	32/32	10TP23-0910
Mercury	0.04 - 4.1	12/115	10TP17-0910
Nickel	1.0 - 176	54/127	10SB-E35-0810
Potassium	54.6 - 2,040	22/32	10TP23-0910
Selenium	0.02 - 1.5	38/117	10TP23-0910
Silver	0.09 - 90.0	11/125	10TP15-0810
Sodium	30.6 - 2,250	19/32	10TP23-0910
Thallium	0.12 - 7.4	6/117	44ASO03-0203
Vanadium	4.0- 27.2	27/34	10TP17-0910
Zinc	0.58 - 2,650	113/127	10TP23-0910

1 Includes all onsite soil samples listed in Table 4-1, except those presented on Table 4-3.
2 Results for 1993 SISB samples reported total 3- and 4-methylphenol.

geophysical surveys. When anomalous areas were identified, soil borings were used to collect subsurface soil samples. Within these areas of concern, a later test pit program during the TDM was initiated to further investigate potential source areas or areas with high concentrations of volatile organics in groundwater. The most recent (i.e., 1994 and 1996) field activities were conducted to fill known data gaps from the previous investigations.

The analytical results for the subsurface soil samples show that volatile organic compounds were not detected frequently, but were detected at notable concentrations in a limited number of samples. Only a limited number of samples were analyzed for semivolatile organics and pesticides/PCBs.

Fuel-type constituents were identified in a number of subsurface soil samples, as indicated in Table 4-4. These compounds include benzene, toluene, ethylbenzene, and xylenes (BTEX). In addition, 2-methyl-naphthalene and naphthalene are soluble polycyclic aromatics that are found in many fuels. Total concentrations of BTEX are presented in Figure 4-1 and in Plate 8 (Volume V). The vast majority of samples analyzed for BTEX did not contain these compounds at detectable levels. However, a few samples shown in bold type on this plate contained notable concentrations. The primary detections were scattered throughout the site, with the highest concentrations reported in the area used for fire training exercises in the southern portion of the landfill (see Plate 1 or Figure 1-3 for former locations of planes). The locations with the highest concentrations were OU2SB7 and 10TP18. The higher concentrations of BTEX (primarily toluene, ethylbenzene, and xylenes, with lower concentrations of benzene) ranged from 155,280 (OU2SB8 at 22 to 24 feet deep) to 617,000 μg/kg (TP-18 at 9 to 10 feet deep). The deeper sample interval (22 to 24 feet) was near the water table. All other samples were collected above the water table.

Other areas with BTEX contamination, although not at those high concentrations, were in the area of the former sludge impoundments (1,900 to 7,500 μg/kg), Study Area E/boring E63 (4,830 μg/kg), and Study Area B (2,174 to 10,993 μg/kg). All of the samples in these areas were collected from above the water table. The presence of these constituents in the soil appears to suggest potential source area(s) for BTEX in groundwater (see Section 4.2).

Another group of compounds potentially related to the observed groundwater contamination includes the chlorinated solvents such as tetrachloroethene (PCE), trichloroethene (TCE), dichloroethenes (DCE), and vinyl chloride. While not widespread in the soil, their presence also appears to correlate with observed areas of these compounds in the surficial aquifer. For instance, Figure 4-2 (Plate 9, Volume V) indicates that there are a few areas with chlorinated solvents in the soil, such as the area near TP-15 (Study Area E), the area of the former sludge impoundments, and Study Area B. All samples from these areas were collected above

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ROOSEVELT ROAD
APPROXIMATE LOCATION OF FENCE
STUDY AREA A
STUDY AREA B
STUDY AREA C
STUDY AREA D
STUDY AREA E
STUDY AREA F
SITE 43 SEWAGE TREATMENT PLANT
SITE 44A FORMER SLUDGE APPLICATION AREA
FORMER SLUDGE IMPOUNDMENT AREA
DRUMMED RETROLEUM (ABANDONED)
STORAGE
SITE 46 POLISHING POND 2
SITE 46 POLISHING POND 1
GRASSY DRAINAGE SWALE
TURKEY GUT
SLOCUM CREEK
WASH RACK
MWR STORAGE AREA
SITE 76 VEHICLE MAINTENANCE AREA (HOBBY SHOP)
LEGEND
OU2SS01 1995/1996 SURFACE SOIL SAMPLE
E59 SOIL BORING/MAGNETOMETER Data POINTS
BB12 1992 SOIL BORING
TP01 1991 PITS 1 THRU 14 DONE 1992, 15 THRU 23 DONE 1993
12B01 1990-1991 SOIL BORING
OU2SB08 1994/1996 SOIL BORING
1993 SOIL BORING
INTERMITTENT STREAM
NOTES:
1) STUDY AREAS A THROUGH F ARE FROM MAGNETOMETER STUDY GRIDS.
2) ALL MONITORING WELLS UNLESS OTHERWISE NOTED.
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NORFOLK, VIRGINIA
NAVAL STATION
CHERRY POINT
MARINE CORPS AIR STATION CHERRY POINT
CHERRY POINT, NORTH CAROLINA
OU2
BENZENE, TOLUENE, ETHYLBENZENE, AND XYLENES (BTEX) IN SOIL (ug/kg)
AS SHOWN
XX-XX-XXXX
XXXXXX-XX-X-XXXX
FIGURE 4-1

ROOSEVELT ROAD
STUDY AREA A
STUDY AREA B
STUDY AREA C
STUDY AREA D
STUDY AREA E
STUDY AREA F
APPROXIMATE LOCATION OF FENCE
SITE 43 SEWAGE TREATMENT PLANT
DRUMMED PETROLEUM (ABANDONED)
FORMER SLUDGE IMPOUNDMENT AREA
SITE 44A FORMER SLUDGE APPLICATION AREA
SITE 46 POLISHING POND 2
SITE 46 POLISHING POND 1
GRASSY DRAINAGE SWALE
TURKEY GUT
SLOCUM CREEK
WASH RACK
MWR STORAGE AREA
SITE 76 VEHICLE MAINTENANCE AREA (HOBBY SHOP)
LEGEND
PCE - TETRACHLOROETHENE
TCE - TRICHLOROETHENE
DCE - 1,2-DICHLOROETHENE
VC - VINYL CHLORIDE
TCA - 1,1,1-TRICHLOROETHANE
ND - NOT DETECTED
EXCEEDS BACKGROUND VOL
SCALE IN FEET
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NAVAL STATION
MARINE CORPS AIR STATION CHERRY POINT
CHERRY POINT, NORTH CAROLINA
OU2
CHLORINATED SOLVENTS IN SOIL (ug/kg)
DEPARTMENT OF THE NAVY
AS SHOWN
XX-XX-XXXX
XXXXXX-XX-X-XXXX
REVISIONS
FIGURE 4-2

the water table. TCE and PCE are commonly used solvents and were used at the Air Station in numerous applications. These compounds are no longer in use. PCE was detected only twice (38 μg/kg in Study Area B at TP-02 at a depth of 4 to 5 feet and 4,800 μg/kg in SISB3 at a depth of 16 to 18 feet), but TCE was detected in seven samples. The highest concentrations of TCE, which ranged from 800 to 880 μg/kg in three samples, were noted in the soil samples collected from the former sludge impoundment area and in Study Area B. One of these samples also contained the highest detected concentration of 1,1,1-trichloroethane (2,500 μg/kg).

In Study Area E, dichloroethene and vinyl chloride were detected. The concentrations observed ranged from 6 to 4,700 μg/kg for DCE with a single detection of vinyl chloride at 490 μg/kg. Vinyl chloride was detected in only one other subsurface soil sample, which was an isolated sample from TP-23.

Other compounds of note in the subsurface soil include several phenols found in the area of the former sludge impoundments. These compounds and the maximum concentrations include phenol (12,000 μg/kg), 2,4-dimethylphenol (4,100 μg/kg), and 4-methylphenol (27,000 μg/kg) at a depth of 8 to 10 feet. This depth interval is above the water table. In addition, several of the more soluble polycyclic aromatic hydrocarbons (PAHs) were detected. The highest concentrations were noted in a sample collected from a depth of 22 to 24 feet in OU2SB8, in the vicinity of TP-19. PAHs at this location include fluorene (20,000 μg/kg), phenanthrene (90,000 μg/kg), naphthalene (39,000 μg/kg), and 2-methylnaphthalene (230,000 μg/kg). Additional PAHs were detected in location OU2SB5, also near TP-19, at a depth of 22 to 24 feet. This depth interval was at the water table.

Pesticides were not frequently analyzed nor were they frequently detected. Dieldrin was one of the most commonly detected pesticides, which was found in 4 of 14 samples at a maximum concentration of 53 μg/kg. This concentration was found in the former sludge impoundment area at location 10B03 at a depth of 8 to 10 feet. Other pesticides of note were α- and γ-chlordane, found in three samples each (maximum concentration of 630 μg/kg), and 4,4'-DDD, which was found in 4 of 11 samples at a maximum concentration of 3.5 μg/kg. The maximum concentrations of these pesticides were detected at a depth of 22 to 24 feet, which is at the water table, near test pit locations TP-18 and TP-19. Many of the maximum concentrations of these and other pesticides were found at depths of 10 or more feet below ground surface, which may be indicative of soil mixing or application of pesticides for insect control when various areas were receiving waste material.

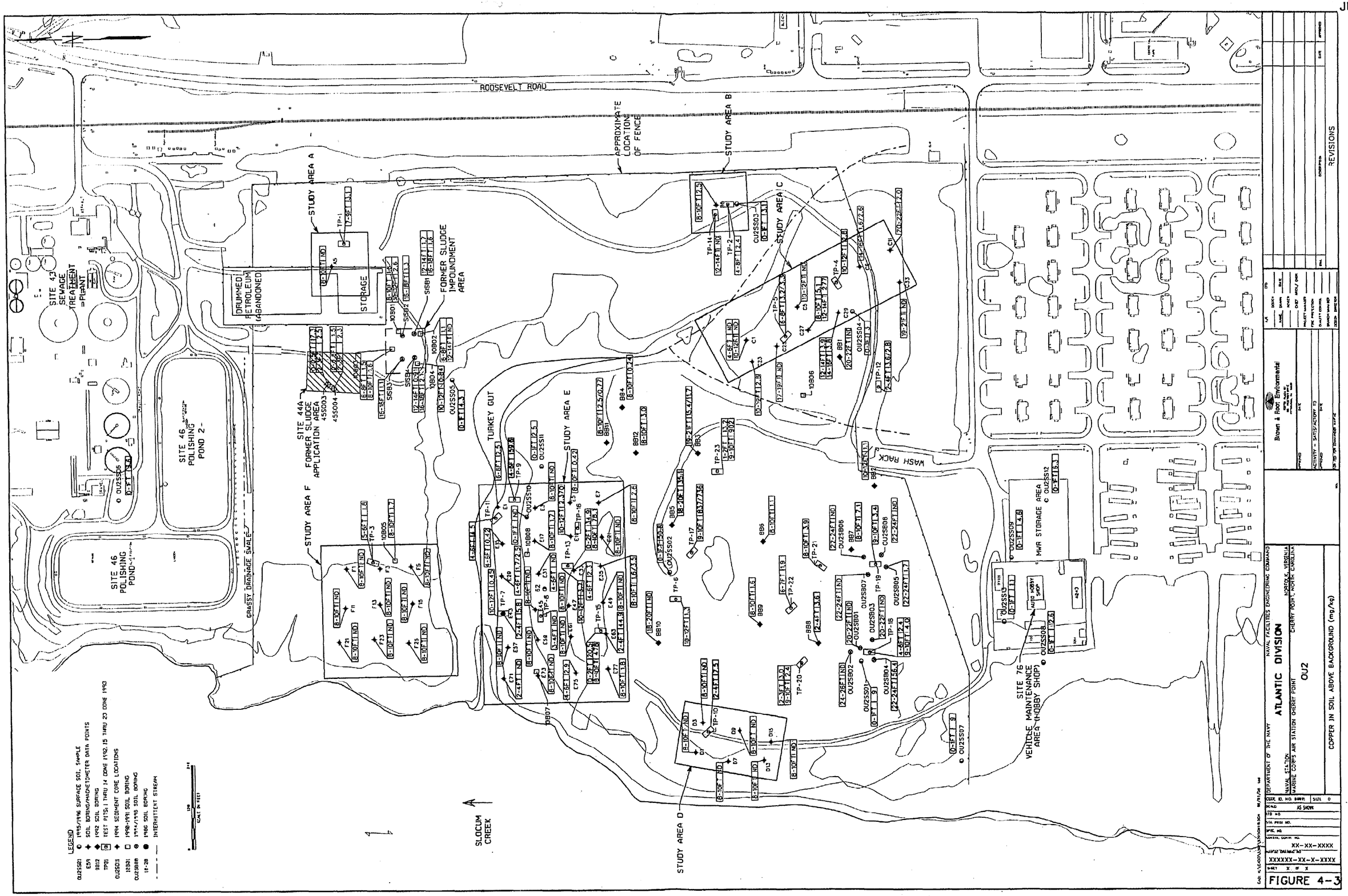
Dioxins and furans were detected in the two subsurface soil samples that were analyzed for this class of compounds (OU2SB09-0810 and OU2SB10-0406). The congeners detected include OCDD; 1,2,3,4,6,7,8-HpCDD; and 1,2,3,4,6,7,8-heptachlorodibenzo-p-furan (HpCDF). These are the least toxic of the chlorinated dibenzo-p-dioxins and furans. The concentrations of OCDD ranged from 0.210 to 0.651 μg/kg. HpCDD was only detected at location OU2SB10 at a concentration of 0.040 μg/kg. The concentrations of HpCDF at location OU2SB09 were 0.006 μg/kg (1,2,3,4,6,7,8-HpCDF) and 0.0075 μg/kg (total HpCDF). TCDD equivalent concentrations ranged from 0.0003 μg/kg (OU2SB09) to 0.0011 μg/kg (OU2SB10).

Ketones were also detected in several subsurface soil samples, at concentrations up to 16,000 μg/kg (2-butanone) in TP-02 at a depth of 4 to 5 feet (Study Area B) and 5,300 μg/kg (acetone) in OU2SB5 at a depth of 22 to 24 feet (near TP-19).

A number of metals were analyzed and detected in the subsurface soil samples. Up to 128 analyses of metals that are on both the TAL and priority pollutant list were conducted. Many metals were detected in 90 percent or more of the samples, with the following metals less frequently detected: antimony (14 percent), mercury (10 percent), beryllium (32 percent), cadmium (20 percent), cobalt (41 percent), copper (60 percent), nickel (42 percent), selenium (32 percent), silver (9 percent), thallium (5 percent), and vanadium (82 percent). Metals that were detected in at least 90 percent of the sample include aluminum, arsenic, barium, calcium, chromium, iron, lead, magnesium, and manganese. Several of the metals were detected at concentrations that are not significantly greater than background concentration ranges, including arsenic, vanadium, and zinc. The metals whose maximum detected concentrations exceeded the background upper 95 percent confidence limits by the greatest amount were antimony (not detected in background samples), barium (48 times background UCL), cadmium (184 times background UCL), copper (770 times background UCL), lead (208 times background UCL), manganese (83 times background UCL), and silver (196 times background UCL).

Figures 4-3, 4-4, and 4-5, and Plates 10, 11, and 12 (Volume V) show detections of copper, lead, and zinc, respectively, above the background UCLs. The points of comparison used in these figures are as follows:

- Copper — Background UCL = 3.08 mg/kg
- Lead — Background UCL = 7.92 mg/kg
- Zinc — Background UCL = 10.61 mg/kg


ROOSEVELT ROAD
SITE 43 SEWAGE TREATMENT PLANT
SITE 46 POLISHING POND 2
SITE 46 POLISHING POND 1
GRASSY DRAINAGE SWALE
STUDY AREA A
DRUMMED PETROLEUM (ABANDONED)
STORAGE
SITE 44A FORMER SLUDGE APPLICATION AREA
FORMER SLUDGE IMPOUNDMENT AREA
STUDY AREA F
TURKEY GUT
STUDY AREA E
STUDY AREA D
STUDY AREA B
STUDY AREA C
APPROXIMATE LOCATION OF FENCE
WASH RACK
MWR STORAGE AREA
SITE 76 VEHICLE MAINTENANCE AREA (HOBBY SHOP)
SLOCUM CREEK
LEGEND
1995/1996 SURFACE SOIL SAMPLE
SOIL BORING/MAGNETOMETER DATA POINTS
1992 SOIL BORING
TEST PITS(1 THRU 14 DONE 1992,15 THRU 23 DONE 1993
1994 SEDIMENT CORE LOCATIONS
1990-1991 SOIL BORING
1994/1995 SOIL BORING
1986 SOIL BORING
INTERMITTENT STREAM
SCALE IN FEET
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MARINE CORPS AIR STATION CHERRY POINT
CHERRY POINT, NORTH CAROLINA
OU2
COPPER IN SOIL ABOVE BACKGROUND (mg/kg)
AS SHOWN
XX-XX-XXXX
XXXXXX-XX-X-XXXX
FIGURE 4-3

ROOSEVELT ROAD
APPROXIMATE LOCATION OF FENCE
STUDY AREA A
STUDY AREA B
STUDY AREA C
STUDY AREA D
STUDY AREA E
STUDY AREA F
SITE 43 SEWAGE TREATMENT PLANT
DRUMMED PETROLEUM (ABANDONED)
STORAGE
FORMER SLUDGE IMPOUNDMENT AREA
SITE 44A FORMER SLUDGE APPLICATION AREA
SITE 46 POLISHING POND 2
SITE 46 POLISHING POND 1
GRASSY DRAINAGE SWALE
TURKEY GUT
SLOCUM CREEK
WASH RACK
MWR STORAGE AREA
SITE 76 VEHICLE MAINTENANCE AREA (HOBBY SHOP)
LEGEND
SCALE IN FEET
REVISIONS
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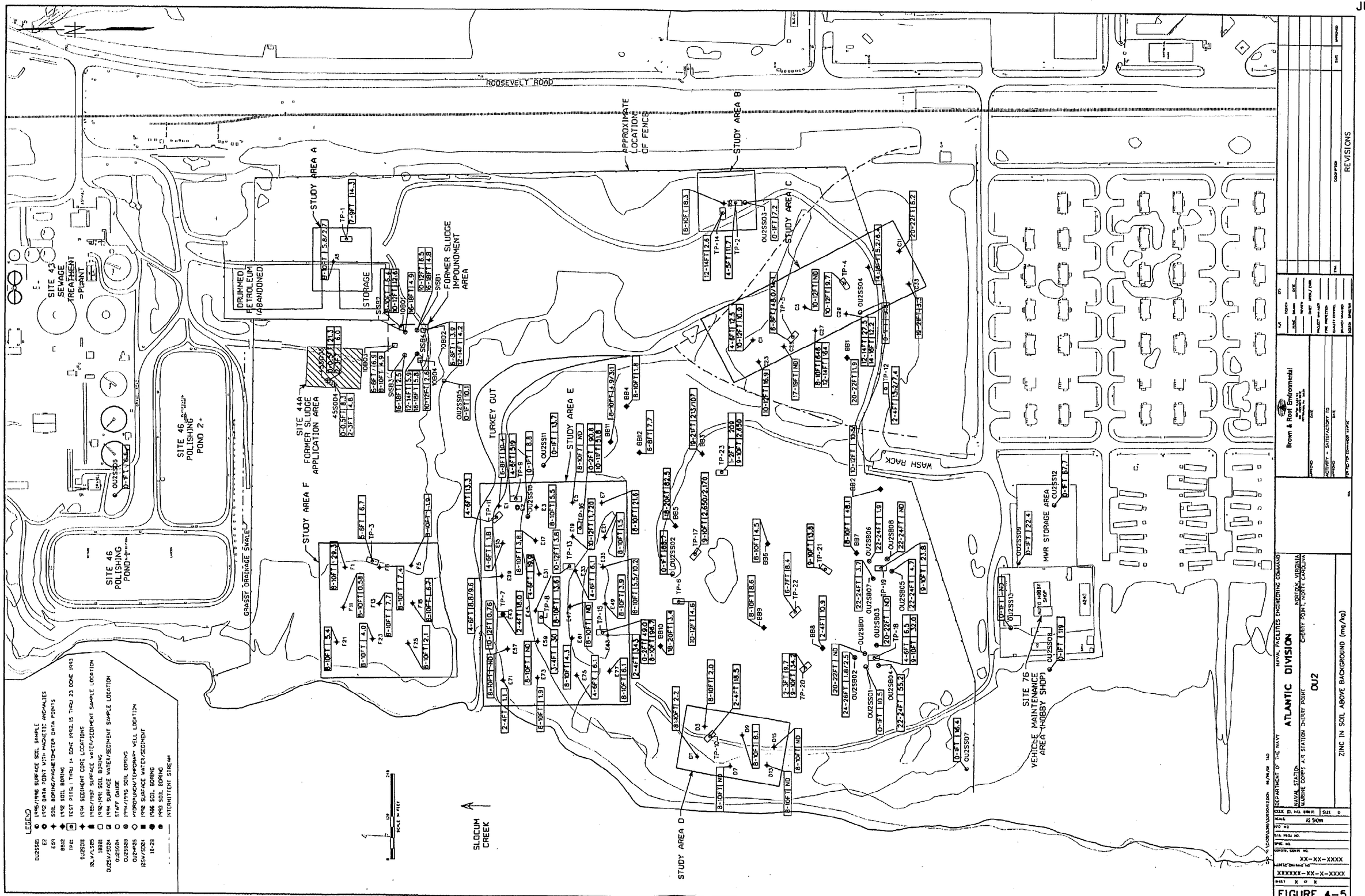
NAVAL STATION
MARINE CORPS AIR STATION CHERRY POINT
CHERRY POINT, NORTH CAROLINA
OU2
LEAD IN SOIL ABOVE BACKGROUND (mg/kg)
AS SHOWN
XX-XX-XXXX
XXXXXX-XX-X-XXXX
FIGURE 4-4


ROOSEVELT ROAD
APPROXIMATE LOCATIONS OF FENCE
STUDY AREA A
STUDY AREA B
STUDY AREA C
STUDY AREA D
STUDY AREA E
STUDY AREA F
SITE 43 SEWAGE TREATMENT PLANT
DRUMMED PETROLEUM (ABANDONED)
STORAGE
FORMER SLUDGE IMPOUNDMENT AREA
SITE 44A FORMER SLUDGE APPLICATION AREA
SITE 46 POLISHING POND 2
SITE 46 POLISHING POND 1
TURKEY GUT
GRASSY DRAINAGE SWALE
WASH RACK
MWR STORAGE AREA
SITE 76 VEHICLE MAINTENANCE AREA (HOBBY SHOP)
SLOCUM CREEK
LEGEND
REVISIONS
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CHERRY POINT, NORTH CAROLINA
OU2
ZINC IN SOIL ABOVE BACKGROUND (mg/kg)
AS SHOWN
XX-XX-XXXX
XXXXXX-XX-X-XXXX
FIGURE 4-5

Metals were not widespread or common contaminants in soil at OU2, although there are a limited number of locations with high concentrations (i.e., a "hot spots"). The three metals listed above were those that were detected frequently at concentrations greater than background and that appeared to be the most widespread. Table 4-4 lists the locations of the maxima for all metals, many of which were found in test pits TP-15, TP-17, and TP-23, all of which are located south of Turkey Gut.

4.2 GROUNDWATER

Groundwater at OU2 has been extensively studied since 1985. Both Marine Corps/Navy contractors and the USGS have installed and sampled monitoring wells in this area. This section discusses the sampling program conducted on groundwater and the chemical analytical results of these investigations. This section is divided into three parts, the first summarizing all the investigation and analytical activities, the second presenting chemical analytical results for the surficial aquifer, and the third presenting the results for the Yorktown aquifer. The complete groundwater chemical analytical database is contained in Appendix H.4 (Volume II), and the results are summarized in a series of tables in this section. Figure 2-1 and Plate 2 (Volume V) show the location of all monitoring wells at this site.

4.2.1 Sampling and Analysis Summary

Prior to 1984, several monitoring wells had been installed at this site. These wells are designated with the nomenclature "10EGW" for existing wells. Four additional wells were installed in 1984, and all were subjected to three rounds of sampling for the RIIR (NUS Corporation, October 1988) between 1985 and 1987. The first round of sampling consisted of analyses for priority pollutant volatiles, including 2-butanone, 4-methyl-2-pentanone, and xylenes, selected metals (cadmium, chromium, copper, lead, nickel, silver, and zinc), and phenolics. The second and third rounds of RIIR sampling included analyses for all priority pollutants (organics and metals) and the two ketones, xylenes, ethylene dibromide, hexavalent chromium, and groundwater indicator parameters (TOC and TOX). Nine additional wells were installed in 1986 and were included in the third round of RIIR sampling.

In October and November 1987 and April 1988, the USGS conducted two investigations at the Air Station. The earlier study included sampling six wells, and the later study involved seven wells and one duplicate sample. Each sample was analyzed for Priority Pollutant organics and metals, including barium and cobalt. These results were reported in two documents (USGS, 1990a and 1990b) and included in the database.

In 1990, as part of the RCRA Facility Investigation Report for OU2 (Site 10) and three other sites, 12 additional monitoring wells were installed (10GW36 through 10GW47) and sampled (34 existing and new wells and 4 duplicates). The twelve new wells were installed in locations determined to be potential volatile organic "hot spots" based on a soil-gas survey conducted in late 1989. All of the groundwater samples collected in 1990 were analyzed for TCL volatile organics and priority pollutant metals. Two samples were also analyzed for TCL semivolatiles and pesticides/PCBs. Miscellaneous water quality parameters were also measured [e.g., TSS, TOC, and/or BOD].

As part of a follow-on field activity conducted after the 21 Unit RFI (the 10 Unit TDM, HNUS, August 1993), four background groundwater samples were collected. These samples were collected from four Hydropunch installations around the air station in areas known to be free of waste disposal and industrial activities, as shown in Plate 3 and Figure 2-2. The wells were samples in March 1993 and analyzed for both total and dissolved TAL metals using the low-flow purging and sampling techniques.

Groundwater sampling and analysis conducted in 1994 was part of the RI field work conducted specifically for this report. This work consisted of sampling 19 existing wells, 12 new wells (designated with the "OU2" nomenclature), and three Hydropunch installations for TCL organics (volatiles, semivolatiles, and pesticides/PCBs) and TAL metals. In addition, three Hydropunch installations and 12 existing wells were sampled and analyzed only for TCL volatile organics and TAL metals.

The final groundwater sampling and analysis activity was conducted in April 1996 to determine if the extent of contamination in the surficial aquifer had been adequately defined. Seven temporary monitoring wells were installed to the south and east of the area of groundwater contamination. These wells were sampled and analyzed for TCL organics (volatiles, semivolatiles, and pesticides/PCBs), TAL metals, and cyanide. The results of quick-turnaround (24-hour) laboratory analysis indicated that the temporary wells were outside the area of contamination. Four of the temporary wells were then converted to permanent monitoring wells. These new wells, along with three existing wells located north of the area of groundwater contamination, were sampled and analyzed for TCL organics, TAL metals, and cyanide.

Table 4-5 presents the complete summary of the groundwater sampling and analysis program for OU2. The wells that were sampled in duplicate are also indicated on this table.

TABLE 4-5

SUMMARY OF GROUNDWATER SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well	Sample Date	Priority Pollutant Volatiles[1]	Selected Metals[2]	Phenolics	Priority Pollutant Organics	Priority Pollutant Metals	Cr+6	TCL Volatiles	Other TCL Organics	TAL Metals	TSS	TOC/ TOX	TOC/ BOD
10EGW1	01/85	X	X	X								X	
10EGW1	10/85			X	X[3]	X[4]	X					X	
10EGW1	03/87			X	X[3]	X[4]	X					X	
10EGW1	1990					X		X			X		X
10EGW1	1994							X	X	X[4]			
10EGW02	01/85	X	X	X								X	
10EGW02	10/85			X	X[3]	X[4]	X					X	
10EGW02	03/87			X	X[3]	X[4]	X					X	
10EGW02	1990					X		X			X		
10EGW02	1994							X	X	X[4]			
10EGW3	01/85	X	X	X								X	
10EGW3	10/85			X	X[3]	X[4]	X					X	
10EGW3	03/87			X	X[3]	X[4]	X					X	
10EGW3	1990					X		X	X		X		
10EGW3-D	1990					X		X			X		
10EGW3	1994							X	X	X[4]			
10EGW3-D	1994							X	X	X[4]			
10GW04	01/85	X	X	X								X	
10GW04	10/85			X	X[3]	X[4]	X					X	

TABLE 4-5 (Continued)
SUMMARY OF GROUNDWATER SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well	Sample Date	Priority Pollutant Volatiles[1]	Selected Metals[2]	Phenolics	Priority Pollutant Organics	Priority Pollutant Metals	Cr+6	TCL Volatiles	Other TCL Organics	TAL Metals	TSS	TOC/ TOX	TOC/ BOD
10GW04	03/87			X	X[3]	X[4]	X					X	
10GW04	1990					X		X			X		X
10EGW5	01/85	X	X	X								X	
10EGW5	10/85			X	X[3]	X[4]	X					X	
10EGW5	03/87			X	X[3]	X[4]	X					X	
10EGW5	1990					X		X					
10EGW5	1994							X	X	X[4]			
10EGW6	01/85	X	X	X								X	
10EGW6	10/85			X	X[3]	X[4]	X					X	
10EGW6	03/87			X	X[3]	X[4]	X					X	
10EGW6	1990					X		X					
10EGW6	1994							X	X	X[4]			
10EGW07	01/85	X	X	X								X	
10EGW07	10/85			X	X[3]	X[4]	X					X	
10EGW07	03/87			X	X[3]	X[4]	X					X	
10EGW07	1990					X		X					
10EGW07	1994							X	X	X[4]			
10EGW08	01/85	X	X	X								X	
10EGW08	10/85			X	X[3]	X[4]	X					X	
10EGW08	03/87			X	X[3]	X[4]	X					X	
10EGW08	1990					X		X					

TABLE 4-5 (Continued)
SUMMARY OF GROUNDWATER SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well	Sample Date	Priority Pollutant Volatiles[1]	Selected Metals[2]	Phenolics	Priority Pollutant Organics	Priority Pollutant Metals	Cr+6	TCL Volatiles	Other TCL Organics	TAL Metals	TSS	TOC/ TOX	TOC/ BOD
10GW09	01/85	X	X	X								X	
10GW09	10/85			X	X[3]	X[4]	X					X	
10GW09	03/87			X	X[3]	X[4]	X					X	
10GW09	1990					X		X			X		X
10GW09	1994							X		X[4]			
10GW10	01/85	X	X	X								X	
10GW10	10/85			X	X[3]	X[4]	X					X	
10GW10	03/87			X	X[3]	X[4]	X					X	
10GW10	1990					X		X					
10GW11	01/85	X	X	X								X	
10GW11	10/85			X	X[3]	X[4]	X					X	
10GW11	03/87			X	X[3]	X[4]	X					X	
10GW11	1990					X		X					
10GW11-D	1990					X		X					
10GW11	1994							X		X[4]			
10GW12	01/85	X	X	X								X	
10GW12	10/85			X	X[3]	X[4]	X					X	
10GW12	03/87			X	X[3]	X[4]	X					X	
10GW12	1990					X		X			X		X
10GW12	1994							X		X[4]			
10GW14	03/87			X	X[3]	X[4]	X					X	

TABLE 4-5 (Continued)
SUMMARY OF GROUNDWATER SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well	Sample Date	Priority Pollutant Volatiles[1]	Selected Metals[2]	Phenolics	Priority Pollutant Organics	Priority Pollutant Metals	Cr+6	TCL Volatiles	Other TCL Organics	TAL Metals	TSS	TOC/ TOX	TOC/ BOD
10GW14	1990					X		X			X		X
10GW15	03/87			X	X[3]	X[4]	X					X	
10GW15	1990					X		X					
10GW16	03/87			X	X[3]	X[4]	X					X	
10GW16	1990					X		X					
10GW17	03/87			X	X[3]	X[4]	X					X	
10GW17	1990					X		X					
10GW18	03/87			X	X[3]	X[4]	X					X	
10GW19	03/87			X	X[3]	X[4]	X					X	
10GW19	1990					X		X			X		X
10EGW20	03/87			X	X[3]	X[4]	X					X	
10EGW20	1990					X		X			X		
10EGW20	1996							X	X	X[4]			
10EGW20-D	1996							X	X	X[4]			
10GW21	03/87			X	X[3]	X[4]	X					X	
10GW21	1990					X		X					
10GW22	12/86			X	X	X[4]						X	
10GW22	1994							X	X	X[4]			
10GW23	12/86			X	X	X[4]						X	
10GW23	1994							X	X	X[4]			
10GW24	12/86			X	X	X[4]						X	

TABLE 4-5 (Continued)
SUMMARY OF GROUNDWATER SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well	Sample Date	Priority Pollutant Volatiles[1]	Selected Metals[2]	Phenolics	Priority Pollutant Organics	Priority Pollutant Metals	Cr+6	TCL Volatiles	Other TCL Organics	TAL Metals	TSS	TOC/ TOX	TOC/ BOD
10GW24	1994							X	X	X[4]			
10GW25	10/87				X	X[4,5]							
10GW25	04/88				X	X[4,5]							
10GW26	10/87				X	X[4,5]							
10GW27	04/88				X	X[4,5]							
10GW27	1994							X		X[4]			
10GW28	04/88				X	X[4,5]							
10GW28	1994							X		X[4]			
10GW29	04/88				X	X[4,5]							
10GW29	1994							X	X	X[4]			
10GW30	04/88				X	X[4,5]							
10GW30-D	04/88				X	X[4,5]							
10GW30	1994							X	X	X[4]			
10GW31	04/88				X	X[4,5]							
10GW31	1994							X		X[4]			
10GW31	1996							X	X	X[4]			
10GW32	04/88				X	X[4,5]							
10GW32	1994							X		X[4]			
10GW33	1990					X		X			X		X
10GW33-D	1990					X		X			X		X
10GW34	1990					X		X					

TABLE 4-5 (Continued)
SUMMARY OF GROUNDWATER SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well	Sample Date	Priority Pollutant Volatiles[1]	Selected Metals[2]	Phenolics	Priority Pollutant Organics	Priority Pollutant Metals	Cr+6	TCL Volatiles	Other TCL Organics	TAL Metals	TSS	TOC/ TOX	TOC/ BOD
10GW34	1994							X	X	X[4]			
10GW35	1990					X		X					
10GW35	1994							X	X	X[4]			
10GW36	1990					X		X	X		X		X
10GW36-D	1990					X		X	X		X		X
10GW36	1994							X	X	X[4]			
10GW37	1990					X		X			X		X
10GW38	1990					X		X			X		X
10GW38	1994							X		X[4]			
10GW39	1990					X		X			X		X
10GW39	1994							X		X[4]			
10GW39-D	1994							X		X[4]			
10GW40	1990					X		X			X		X
10GW40	1994							X		X[4]			
10GW41	1990					X		X			X		X
10GW41	1994							X		X[4]			
10GW42	1990					X		X			X		X
10GW43	1990					X		X			X		X
10GW43	1994							X	X	X[4]			
10GW44	1990					X		X			X		X
10GW45	1990					X		X			X		X

TABLE 4-5 (Continued)
SUMMARY OF GROUNDWATER SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well	Sample Date	Priority Pollutant Volatiles[1]	Selected Metals[2]	Phenolics	Priority Pollutant Organics	Priority Pollutant Metals	Cr+6	TCL Volatiles	Other TCL Organics	TAL Metals	TSS	TOC/ TOX	TOC/ BOD
10GW45[6]	1994							X	X	X[4]			
10GW46	1990					X		X			X		X
10GW47	1990					X		X			X		X
10GW47	1994							X	X	X[4]			
10GW48	1994							X	X	X[4]			
OU2MW1	1994							X	X	X[4]			
OU2MW2	1994							X	X	X[4]			
OU2MW3	1994							X	X	X[4]			
OU2MW4	1994							X		X[4]			
OU2MW5	1994							X		X[4]			
OU2MW6	1994							X	X	X[4]			
OU2MW7	1994							X	X	X[4]			
OU2MW8	1994							X	X	X[4]			
OU2MW9	1994							X	X	X[4]			
OU2MW10	1994							X	X	X[4]			
OU2MW10-D	1994							X	X	X[4]			
OU2MW11	1994							X	X	X[4]			
OU2MW11-D	1994							X	X	X[4]			
OU2MW12	1994							X	X	X[4]			
OU2MW13	1996							X	X	X[4]			
OU2MW14	1996							X	X	X[4]			

TABLE 4-5 (Continued)
SUMMARY OF GROUNDWATER SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well	Sample Date	Priority Pollutant Volatiles[1]	Selected Metals[2]	Phenolics	Priority Pollutant Organics	Priority Pollutant Metals	Cr+6	TCL Volatiles	Other TCL Organics	TAL Metals	TSS	TOC/ TOX	TOC/ BOD
OU2MW15	1996							X	X	X[4]			
OU2MW16	1996							X	X	X[4]			
OU2HP1	1994							X	X	X[4]			
OU2HP2	1994							X	X	X[4]			
OU2HP3	1994							X	X	X[4]			
OU2HP4	1994							X		X[4]			
OU2HP4-D	1994							X		X[4]			
OU2HP5	1994							X		X[4]			
OU2HP6	1994							X		X[4]			
OU2HP7	1996							X	X	X[4]			
OU2HP8	1996							X	X	X[4]			
OU2HP9	1996							X	X	X[4]			
OU2HP10	1996							X	X	X[4]			
OU2HP11	1996							X	X	X[4]			
OU2HP12	1996							X	X	X[4]			
OU2HP13	1996							X	X	X[4]			
S1W3	10/87				X	X[4,5]							
S1W5	04/88				X	X[4,5]							
S4W1	10/87				X	X[4,5]							
S4W1	1994							X	X	X[4]			
S4W2	10/87				X	X[4,5]							

TABLE 4-5 (Continued)
SUMMARY OF GROUNDWATER SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well	Sample Date	Priority Pollutant Volatiles[1]	Selected Metals[2]	Phenolics	Priority Pollutant Organics	Priority Pollutant Metals	Cr+6	TCL Volatiles	Other TCL Organics	TAL Metals	TSS	TOC/ TOX	TOC/ BOD
S4W2	1994							X	X	X[4]			
S4W3	10/87				X	X[4,5]							
S4W3	1994							X	X	X[4]			
9GW31	1996							X	X	X[4]			

1 Includes 2-butanone, 4-methyl-2-pentanone, and xylenes
2 Includes cadmium, chromium, copper, lead, nickel, silver, and zinc
3 Includes ethylene dibromide, 2-butanone, 4-methyl-2-pentanone, and xylenes
4 Includes cyanide
5 Includes barium and cobalt
6 Monitoring well B-103 was incorrectly identified as 10GW45 and was sampled in lieu of well 10GW45.

Note: An "X" indicates the analytical parameters for each sample. See Appendix G for lists of various analytical programs (e.g., priority pollutants, TCL, TAL).

4.2.2 Background Groundwater Quality

This section contains a summary of the background groundwater quality from four background locations identified during 1993 (Figure 2-2 and Plate 3, Volume V). All the background locations are in the surficial aquifer. The analytical results are summarized in Table 4-6. The Hydropunch installations were only sampled and analyzed for metals, as their intended use was to defined naturally-occurring metals in groundwater.

Groundwater samples from the RI well installations used to determine background soil characteristics were not used as indicators of background groundwater quality. While the soil may not be directly affected by waste disposal or industrial activities, the groundwater originates elsewhere, and the results may reflect upgradient contaminant contributions.

The results indicate that the concentrations of most metals are fairly consistent throughout the Air Station. Barium, calcium, iron, magnesium, manganese, and sodium were detected in almost all samples at roughly similar concentrations in the correlated filtered and unfiltered samples. There were some isolated detections of arsenic (3.3 micrograms per liter [μg/L], HP-4), chromium (9.7 μg/L, HP-4), lead (5.0 μg/L, HP-4), and aluminum (194 μg/L, HP-3). In addition, zinc was detected in all unfiltered samples at concentrations ranging from 2.6 to 14.0 μg/L.

4.2.3 Surficial Aquifer

A total of 60 permanent wells at OU2 are screened in the surficial aquifer. Six Hydropunch installations and seven temporary wells were also screened in the surficial aquifer. Four of the temporary wells were converted into permanent monitoring wells. The other temporary wells and Hydropunch installations have been removed. The chemical analytical database for permanent wells and Hydropunch installations is summarized in Table 4-7. Results for temporary wells that were not converted into permanent wells are not included because they were only installed and sampled to select locations for permanent wells. This table includes information on all chemicals detected in any well at any time, the frequency of detection, the average of the positive detections, and the location and date of the maximum occurrence. As an overview, the most commonly detected contaminants were the monocyclic aromatic fuel constituents (e.g., benzene, toluene, ethylbenzene, and xylenes), halogenated aliphatics (chlorinated solvents and breakdown products such as tetrachloroethene (PCE), trichloroethene (TCE), dichloroethenes (DCE), vinyl chloride, 1,1,1-trichloroethane (TCA), dichloroethanes (DCA), and chloroethane), and chlorinated monocyclic aromatics (e.g., chlorobenzene [a solvent] and dichlorobenzenes [used in deodorizers/mothballs]).

TABLE 4-6

BACKGROUND GROUNDWATER ANALYTICAL RESULTS ($\mu g/L$)[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	HP-1[2] (3/93)		HP-2 (3/93)		HP-3 (3/93)		HP-4 (3/93)	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Aluminum	ND(87.9)[3]	ND(76.1)	ND(65.4)	ND(28.5)	194	ND(31.2)	2500	ND(28.7)
Antimony	ND(24.0)	ND(24.0)	ND(24.0)	ND(24.0)	ND(24.0)	ND(24.0)	ND(24.0)	ND(24.0)
Arsenic	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	3.3	ND(1.0)
Barium	34.6	32.5	20.2	17.9	4.5	3.9	43.7	27.6
Beryllium	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)
Cadmium	ND(4.0)	ND(4.0)	ND(4.0)	ND(4.0)	ND(4.1)	ND(4.0)	ND(4.5)	ND(4.1)
Calcium	2275	2305	1550	1410	ND(650)	744	ND(1210)	1130
Chromium	ND(4.0)	ND(4.0)	ND(4.0)	ND(4.0)	ND(4.0)	ND(4.0)	9.7	ND(4.0)
Cobalt	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(3.5)	ND(2.0)
Copper	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)
Iron	63.3	47.8	772	715	97.2	ND(19.0)	4370	1850
Lead	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	5.0	ND(1.0)
Magnesium	2255	2295	1450	1390	709	733	1420	1270
Manganese	20.05	21.05	7.4	8.7	5.3	7.4	35.8	15.9
Mercury	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)	ND(0.20)
Nickel	ND(13.0)	ND(13.0)	ND(13.0)	ND(13.0)	ND(13.0)	ND(13.0)	ND(13.0)	ND(13.0)
Potassium	855	1315	ND(1080)	ND(1080)	ND(1080)	ND(1080)	ND(1080)	ND(1080)
Selenium	ND(1.2)	ND(1.8)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)

TABLE 4-6 (Continued)
BACKGROUND GROUNDWATER ANALYTICAL RESULTS (μg/L)[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	HP-1[2] (3/93)		HP-2 (3/93)		HP-3 (3/93)		HP-4 (3/93)	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Silver	ND(4.0)	ND(4.0)	ND(4.0)	ND(4.0)	ND(4.0)	ND(4.0)	ND(4.0)	ND(4.0)
Sodium	6355	6495	7540	7560	2130	2200	2460	2560
Thallium	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)
Vanadium	ND(2.1)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(4.9)	ND(2.0)
Zinc	2.7	ND(3.1)	2.6	ND(2.1)	4.9	ND(6.8)	14.0	ND(2.8)
Cyanide	NA[4]	NA	NA	NA	NA	NA	NA	NA

1 Complete data base in Appendix H.3 (HP data).
2 Results reported are the arithmetic average of duplicate sample results calculated using one-half the sample quantitation limit for nondetects.
3 ND - Not detected at the detection limit reported in parentheses.
4 NA - Not analyzed.

TABLE 4-7

GROUNDWATER ANALYTICAL RESULTS - SURFICIAL AQUIFER[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Concentration Range (μg/L)	Frequency of Detection	Average of Positive Detections	Location of Maximum Detection	Date of Maximum Occurrence	NC GA Standard[2]
Volatile Organics						
Acetone	7 - 32	3/43	19	OU2MW11	1994	700
2-Butanone*	8 - 730	6/92	152	10EGW5	1985	170
4-Methyl-2-pentanone*	3 - 64	5/124	17	OU2MW1	1994	>DL[4]
2-Hexanone*	1	1/80	1	OU2MW10	1994	>DL
Benzene*	0.15 - 230	55/136	19.5	10GW09	1994	1
Toluene*	2 - 1,100	24/136	84.2	10GW10	1985	1,000
Ethylbenzene*	1 - 120	16/136	26.5	10GW10	1990	29
Chlorobenzene*	0.15 - 200	47/138	49.6	10GW10	1987	50
Xylenes, total*	2 - 230	31/132	46.6	10GW40	1990	530
1,1,2,2-Tetrachloroethane*	0.4	1/136	0.4	10GW27	1988	>DL
1,1,1-Trichloroethane	0.6 - 160	15/136	30.4	10EGW5	1985	200
1,1-Dichloroethane	0.15 - 1,000	58/136	74.4	10EGW5	1985	700
1,2-Dichloroethane*	0.6 - 16	6/136	6.1	10EGW02	1990	0.38
Chloroethane*	1 - 2,500	38/136	122	10EGW5	1985	>DL
Tetrachloroethene*	0.2 - 280	20/136	25.0	10GW12	1985	0.7
Trichloroethene*	0.2 - 650	41/136	72.6	10EGW08	1985	2.8
1,1-Dichloroethene*	2 - 70	5/136	21.6	10EGW5	1985	7
cis-1,2-Dichloroethene*	0.2 - 140	22/89	21.4	10EGW5	1994	70
trans-1,2-Dichloroethene*	0.75 - 1,900	26/103	188	10EGW5	1985	70
1,2-Dichloroethene (total)*	3 - 205	15/33	54.9	10EGW3	1990	70
Vinyl chloride*	1 - 2,600	25/136	132	10GW10	1985	0.015
Bromodichloromethane*	0.3	1/132	0.3	10GW27	1988	>DL
Dibromochloromethane*	0.4	1/136	0.4	10GW25	1988	>DL
Chloroform*	0.2 - 22	5/136	5.8	10EGW5	1990	0.19
Dichlorodifluoromethane	2	1/12	2	10GW28	1988	1,400
Methylene chloride*	0.5 - 560	19/128	100	10EGW5	1985	5
Chloromethane*	2 - 56	2/133	29	10EGW5	1985	>DL
1,2-Dichloropropane*	1 - 2	5/136	1.2	OU2MW11	1994	0.56
cis-1,3-Dichloropropene*	0.5	1/136	0.5	10GW27	1988	>DL
trans-1,3-Dichloropropene*	0.3	1/136	0.3	10GW27	1988	>DL
1,3-Dichloropropene (total)*	0.8	1/13	0.8	10GW27	1988	>DL
Carbon tetrachloride*	4	1/136	4	10GW34	1990	0.3

TABLE 4-7 (Continued)
GROUNDWATER ANALYTICAL RESULTS - SURFICIAL AQUIFER
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Concentration Range (μg/L)	Frequency of Detection	Average of Positive Detections	Location of Maximum Detection	Date of Maximum Occurrence	NC GA Standard[2]
Semivolatile Organics						
Phenol	3 - 150	6/78	33.8	10EGW5	1985	300
2-Methylphenol*	6 - 11	2/34	8.5	10EGW5	1994	>DL
4-Methylphenol*	3 - 65	5/34	32.7	10EGW5	1994	>DL
2,4-Dimethylphenol*	4 - 280	4/74	77.3	OU2HP3	1994	>DL
2-Nitrophenol*	6	1/78	6	10GW28	1988	>DL
Bis(2-ethylhexyl) phthalate*	4 - 66	7/78	34.4	10GW34	1994	3
Di-n-octylphthalate	8	1/78	8	10GW30	1988	140
Diethylphthalate	4 - 53	16/78	20.0	OU2HP1	1994	5,000
1,2-Dichlorobenzene[3]	0.35 - 28	20/124	7.5	OU2HP1	1994	620
1,3-Dichlorobenzene[3]	0.2 - 2	5/125	1.0	OU2HP1	1994	620
1,4-Dichlorobenzene[3]	0.2 - 40	35/125	10.7	OU2HP1	1994	75
Nitrobenzene*	5 - 7	2/78	6	10GW31	1988	>DL
Naphthalene*	3 - 131	12/78	33.1	10EGW5	1987	21
2-Methylnaphthalene*	4 - 18	4/34	8.3	10EGW5	1994	>DL
Phenanthrene	15	1/78	15.0	10GW32	1988	210
Bis(2-chloroethyl)ether*	3	1/78	3	OU2HP3	1994	>DL
Pesticides/PCBs						
Aldrin*	0.0034	1/77	0.0034	10GW35	1994	>DL
α-BHC*	0.0089 - 0.0098	2/75	0.0094	10GW43	1994	>DL
β-BHC*	0.34	1/76	0.34	10EGW6	1985	>DL
γ-BHC (Lindane)	0.0089 - 0.040	2/73	0.0245	OU2HP1	1994	0.2
α-Chlordane	0.0054 - 0.014	5/31	0.0090	OU2HP3	1994	0.027
γ-Chlordane	0.0085	1/27	0.0085	OU2HP1	1994	0.027
4,4'-DDE*	0.0092	1/75	0.0092	OU2HP1	1994	>DL
4,4'-DDT*	0.010	1/76	0.01	S4W2	1994	>DL
Diazinon*	0.020 - 0.030	3/12	0.03	10GW28/ 10GW30	1988	>DL
Endosulfan I*	0.0090	1/77	0.0090	OU2HP3	1994	>DL
Endosulfan II*	0.0033 - 0.050	3/71	0.02	OU2HP1	1994	>DL
Endrin	0.010 - 0.020	2/77	0.015	OU2HP3	1994	2
Endrin aldehyde*	0.020 - 0.97	5/73	0.22	OU2MW11	1994	>DL
Heptachlor	0.0055	1/76	0.0055	10GW43	1994	0.008
Heptachlor epoxide*	0.0033 - 0.020	2/75	0.0117	OU2HP2	1994	0.004
Methyl parathion*	0.01 - 0.03	2/12	0.02	10GW28	1988	>DL
Methyl trithion*	0.02	2/12	0.02	10GW27/ 10GW28	1988	>DL
Parathion*	0.01	3/12	0.01	10GW28/ 10GW31/ 10GW32	1988	>DL

TABLE 4-7 (Continued)
GROUNDWATER ANALYTICAL RESULTS - SURFICIAL AQUIFER
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Concentration Range (μg/L)	Frequency of Detection	Average of Positive Detections	Location of Maximum Detection	Date of Maximum Occurrence	NC GA Standard[2]
Trithion*	0.01	1/12	0.01	10GW28	1988	>DL
Inorganics						
Aluminum	150 - 4,840	30/47	339	OU2GW15	1996	NR[5]
Antimony	0.75 - 91.5	10/124	18.4	10EGW02	1990	NR
Arsenic*	1.0 - 146	75/127	33.9	10GW19	1990	50
Barium	16.0 - 306	45/47	77.9	10GW41	1994	2,000
Beryllium	1.0 - 18.6	8/124	3.5	10GW10	1990	NR
Cadmium*	1.0 - 9.0	12/136	4.4	10GW46	1990	5
Calcium	1,170 - 93,850	46/46	32,170	10GW39	1994	NR
Chromium*	3.0 - 135	35/135	39.5	10GW30	1988	50
Cobalt	8.7 - 81.0	11/47	34.2	10GW27	1994	NR
Copper	1.7 - 200	28/136	17.5	10GW32	1988	1,000
Iron*	69.9 - 100,500	44/47	34,118	OU2MW11	1994	300
Lead*	0.75 - 79.9	46/136	11.8	10GW10	1990	15
Magnesium	1,080 - 34,900	47/47	7,991	OU2HP2	1994	NR
Manganese*	5.4 - 3540	47/47	467	10GW31	1994	50
Mercury	0.38 - 0.70	5/123	0.52	10EGW02	1985	1.1
Nickel*	5.0 - 104	31/135	31.5	10GW10	1990	100
Potassium	923 - 36,900	47/47	7,427	10GW40	1994	NR
Silver*	1.0 - 101	29/137	13.1	10GW10	1990	18
Sodium	1,070 - 95,900	47/47	27,622	10GW12	1994	NR
Tin	25.0	1/9	25.0	10GW32	1988	NR
Vanadium	1.9 - 38.0	6/55	10.6	10GW32	1988	NR
Zinc	6.0 - 320	84/136	44.8	10GW32	1988	2,100
Cyanide	5.0 - 93.0	10/91	22.3	10GW21	1987	154

1 Includes samples from wells listed in Table 4-5, except for 10GW22, 10GW23, 10GW24, 10GW26, 10GW33, OU2MW2, OU2MW3, OU2MW4, OU2MW5, OU2MW6, OU2MW7, and S4W1, which monitor the Yorktown aquifer. Asterisk of chemical name indicates exceedance of state standard.
2 15A NCAC 2L.0200
3 Reported by laboratory in volatile and semivoltile fractions.
4 Greater than detection limit. Any detection is considered an exceedance of the standard.
5 NR - Not regulated.

Several items are of note in discussing the nature and extent of contamination. First, there is widespread contamination of groundwater with organic chemicals. Those chemicals listed in the preceding paragraph are the most prevalent, both historically and during the most recent groundwater sampling events (1994 and 1996). Second, the maximum detected concentrations of many compounds have declined over the years. Third, while no distinct plumes are visible based on the most recent sampling event, several areas of overall contamination can be outlined as general areas of concern (i.e., areas where certain contaminants exceed state and/or federal groundwater or drinking water standards). This section elaborates on these issues.

Table 4-8 illustrates historical trends for several chlorinated solvents and benzene in several shallow wells. The compounds presented in this table are some of the more prevalent contaminants that play a significant role in the risk assessment. While all of these illustrations show a general decline over time, there are several wells that show no overall decrease in contaminant concentrations, but rather a fluctuating pattern, and in some cases even an increase in certain compounds. Additional tables showing historical concentration trends are provided in Appendix H.4 (Volume II). Detailed analytical results for each well and each sampling round can also be found in Appendix H.4.

Wells 10EGW3 and 10EGW5 are located north of Turkey Gut. They are associated with an area of contamination by chlorinated solvents, with the former sludge impoundments as the most obvious source area. Since the source material (i.e., the sludge) has been removed, no significant source material remains, and plume washout is indicated by these data points that show a general decrease in contaminant concentrations over time (see Table 4-8).

Wells 10GW10 and 10GW12 are located on the south side of Turkey Gut. Several additional wells and Hydropunches were installed later in this area to further investigate volatile organic contamination. These two wells have the most historic data.

Based on the most recent sampling event in a number of surficial aquifer wells (either 1990, 1994, or 1996 data, only), a number of compounds are found at concentrations that exceed state groundwater quality standards. Those exceedances are highlighted in Table 4-9. Only compounds that had at least one exceedance during the most recent sampling round for a particular well are presented in this table. The complete database in Appendix H.4 (Volume II) contains all results.

Benzene, TCE, and vinyl chloride were the compounds that exceeded the state groundwater quality standards most often. Figure 4-6 and Plate 13 (Volume V) show general areas of groundwater

TABLE 4-8

CONCENTRATION TRENDS IN SELECTED SURFICIAL AQUIFER WELLS (μg/L)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Well Number	Chemical	Date Sampled				
		01/85	10/85	03/87	1990	1994
10EGW3	Benzene	ND[1]	ND	ND	4	5.5
	Trichloroethene	ND	ND	88	180	10
	Vinyl chloride	ND	ND	150	64	7
10EGW5	1,1-Dichloroethane	1,000	890	500	140	72
	Trichloroethene	410	220	110	49	11
	1,2-Dichloroethene	1,900	280	ND	110	142
10GW10	1,2-Dichloroethene	1,300	170	ND	ND	NA[2]
	Vinyl chloride	2,600	190	ND	ND	NA
10GW12	Tetrachloroethene	280	81	ND	6	3
	Trichloroethene	180	55	ND	12	4

1 ND - Not detected
2 NA - Not analyzed. Well not sampled in 1994.

TABLE 4-9

SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)		10EGW1 1994	10EGW02 1994	10EGW3 1994	10GW04 1990	10EGW5 1994	10EGW6 1994	10EGW07 1994	10EGW08 1990	10GW09 1994
Volatile Organics (μg/L)										
Benzene	(1)	ND(1)	17*[1]	5.5*	ND(5)	6*	ND(1)	ND(1)	6*	230*
Ethylbenzene	(29)	ND(1)	ND(5)	ND(1)	ND(5)	4	ND(1)	ND(1)	ND(5)	10
Chlorobenzene	(50)	ND(1)	5	ND(1)	ND(5)	ND(1)	ND(1)	ND(1)	ND(5)	26
1,2-Dichloroethane	(0.38)	ND(1)	ND(5)	ND(1)	ND(5)	2*	ND(1)	ND(1)	ND(5)	ND(1)
1,2-Dichloroethene (total)	(70)	ND(1)	100*	16.5	ND(5)	142*	11	2	10	1
1,2-Dichloropropane	(0.56)	ND(1)	ND(5)	ND(1)	ND(5)	1*	ND(1)	ND(1)	ND(5)	ND(1)
Methylene chloride	(5)	ND(2)	ND(10)	ND(2)	ND(4)	ND(2)	ND(2)	ND(2)	14*	R[3]
Tetrachloroethene	(0.7)	ND(1)	8*	ND(1)	ND(5)	3*	ND(1)	ND(1)	4*	ND(1)
Trichloroethene	(2.8)	ND(1)	ND(5)	10*	ND(5)	11*	ND(1)	ND(1)	5*	ND(1)
Vinyl chloride	(0.015)	ND(1)	26*	*7	ND(10)	14*	ND(1)	ND(1)	14*	3*
Chloroethane	(>DL)[6]	ND(1)	90*	6*	ND(10)	19*	ND(1)	ND(1)	ND(10)	15*
2-Hexanone	(>DL)	ND(5)	ND(25)	ND(5)	ND(10)	ND(5)	ND(5)	ND(5)	ND(10)	ND(5)
4-Methyl-2-pentanone	(>DL)	ND(5)	ND(25)	ND(5)	ND(10)	4*	ND(5)	ND(5)	ND(10)	ND(5)
Chloroform	(0.019)	ND(1)	ND(5)	ND(1)	ND(5)	ND(1)	ND(1)	ND(1)	ND(5)	ND(1)
Chloromethane	(>DL)	ND(1)	ND(5)	ND(1)	ND(10)	ND(1)	ND(1)	ND(1)	ND(10)	ND(1)
Dibromochloromethane	(>DL)	ND(1)	ND(5)	ND(1)	ND(5)	ND(1)	ND(1)	ND(1)	ND(5)	ND(1)
Semivolatile Organics (μg/L)										
Bis(2-ethylhexyl)phthalate	(3)	ND(12)	ND(10)	ND(14.5)	NA	ND(16)	ND(13)	ND(13)	NA	NA
Naphthalene	(21)	ND(10)	4	ND(10)	NA	33*	ND(10)	ND(10)	NA	NA
Bis(2-chloroethyl)ether	(>DL)	ND(10)	ND(10)	ND(10)	NA	ND(10)	ND(10)	ND(10)	NA	NA
2,4-Dimethylphenol	(>DL)	ND(10)	ND(10)	ND(10)	NA	19*	ND(10)	ND(10)	NA	NA

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)		10EGW1 1994	10EGW02 1994	10EGW3 1994	10GW04 1990	10EGW5 1994	10EGW6 1994	10EGW07 1994	10EGW08 1990	10GW09 1994
2-Methylnaphthalene	(>DL)	ND(10)	ND(10)	ND(10)	NA	18*	ND(10)	ND(10)	NA	NA
2-Methylphenol	(>DL)	ND(10)	ND(10)	ND(10)	NA	11*	ND(10)	ND(10)	NA	NA
4-Methylphenol	(>DL)	ND(10)	ND(10)	ND(10)	NA	65*	ND(10)	ND(10)	NA	NA
Nitrobenzene	(>DL)	ND(10)	ND(10)	ND(10)	NA	ND(10)	ND(10)	ND(10)	NA	NA
Pesticides (μg/L)										
Heptachlor expoxide	(0.004)	ND(0.05)	R	R	NA	ND(0.05)	ND(0.05)	ND(0.05)	NA	NA
Aldrin	(>DL)	ND(0.05)	ND(0.05)	ND(0.05)	NA	ND(0.05)	ND(0.05)	ND(0.05)	NA	NA
alpha-BHC	(>DL)	ND(0.05)	R	ND(0.05)	NA	0.0089*	ND(0.05)	ND(0.05)	NA	NA
4,4'-DDE	(>DL)	ND(0.1)	ND(0.1)	R	NA	ND(0.1)	ND(0.1)	ND(0.1)	NA	NA
4,4'-DDT	(>DL)	ND(0.1)	ND(0.1)	ND(0.1)	NA	ND(0.1)	ND(0.1)	ND(0.1)	NA	NA
Endosulfan I	(>DL)	ND(0.05)	ND(0.05)	ND(0.05)	NA	ND(0.05)	ND(0.05)	ND(0.05)	NA	NA
Endosulfan II	(>DL)	ND(0.1)	R	R	NA	ND(0.1)	ND(0.1)	ND(0.1)	NA	NA
Endrin aldehyde	(>DL)	ND(0.1)	R	0.01*	NA	ND(0.1)	ND(0.1)	ND(0.1)	NA	NA
Metals (μg/L)										
Arsenic	(50)	ND(2)	106*	126.5*	26.9	50.8*	44.4	ND(2.0)	ND(10.2)	43.6
Cadmium	(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5.0)	ND(5.0)	ND(5)	ND(5)
Iron	(300)	263	90,400*	72,800*	NA	84,700*	42,500*	2,310*	NA	64,100*
Lead	(15)	1.1	ND(1.0)	ND(1.0)	7.4	ND(1.0)	ND(1.0)	ND(1.0)	34.5*	ND(1.0)
Manganese	(50)	25	2,370*	9,915*	NA	107*	1,530*	126*	NA	95.0*
Nickel	(100)	ND(20)	ND(20.0)	ND(20.0)	17.9	ND(20.0)	ND(20.0)	ND(20.0)	22.7	ND(20.0)
Silver	(18)	ND(3)	ND(3.0)	ND(3.0)	5.3	ND(3.0)	ND(3.0)	ND(3.0)	6.2	ND(3.0)

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)	10GW10 1990	10GW11 1994	10GW12 1994	10GW14 1990	10GW15 1990	10GW16 1990	10GW17 1990	10GW18 1997	10GW19 1990	10EGW20 1996
Volatile Organics (μg/L)										
Benzene (1)	29*	5*	6*	ND(5)	ND(5)	ND(5)	8*	ND	5*	ND(1)
Ethylbenzene (29)	120*	ND(2)	ND(1)	ND(5)	ND(5)	ND(5)	ND(5)	ND	ND(5)	ND(1)
Chlorobenzene (50)	140*	25	42	ND(5)	ND(5)	ND(5)	ND(5)	ND	ND(5)	ND(1)
1,2-Dichloroethane (0.38)	ND(5)	ND(2)	ND(1)	ND(5)	ND(5)	ND(5)	ND(5)	ND	ND(5)	ND(1)
1,2-Dichloroethene (total) (70)	ND(5)	ND(2)	ND(1)	3	ND(5)	ND(5)	32	ND	6	ND(1)
1,2-Dichloropropane (0.56)	ND(5)	ND(2)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND	ND(5)	ND(1)
Methylene chloride (5)	6*	ND(4)	ND(2)	ND(5)	ND(5)	4	8*	ND	ND(5)	ND(2)
Tetrachloroethene (0.7)	ND(5)	ND(2)	3*	ND(5)	ND(5)	ND(5)	6*	ND	ND(5)	ND(1)
Trichloroethene (2.8)	ND(5)	ND(2)	4*	ND(5)	ND(5)	ND(5)	24*	ND	ND(5)	ND(1)
Vinyl chloride (0.015)	ND(10)	ND(2)	2*	ND(10)	ND(10)	ND(10)	ND(10)	ND	ND(10)	ND(1)
Chloroethane (>DL)[6]	ND(20)	ND(2)	4*	ND(10)	ND(10)	ND(10)	7*	ND	42*	ND(1)
2-Hexanone (>DL)	ND(20)	ND(10)	ND(5)	ND(10)	ND(10)	ND(10)	ND(20)	NA	ND(10)	ND(5)
4-Methyl-2-pentanone (>DL)	ND(10)	ND(10)	ND(5)	ND(10)	ND(10)	ND(10)	ND(20)	NA	ND(10)	ND(5)
Chloroform (0.019)	ND(10)	ND(2)	ND(1)	ND(5)	ND(5)	ND(5)	ND(10)	ND	ND(5)	ND(1)
Chloromethane (>DL)	ND(20)	ND(2)	ND(1)	ND(10)	ND(10)	2*	ND(20)	ND	ND(10)	ND(1)
Dibromochloromethane (>DL)	ND(10)	ND(2)	ND(1)	ND(5)	ND(5)	ND(5)	ND(10)	ND	ND(5)	ND(1)
Semivolatile Organics (μg/L)										
Bis(2-ethylhexyl)phthalate (3)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(10)
Naphthalene (21)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(10)
Bis(2-chloroethyl)ether (>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(10)
2,4-Dimethylphenol (>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(10)

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)		10GW10 1990	10GW11 1994	10GW12 1994	10GW14 1990	10GW15 1990	10GW16 1990	10GW17 1990	10GW18 1987	10GW19 1990	10EGW20 1996
2-Methylnaphthalene	(>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(10)
2-Methylphenol	(>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(10)
4-Methylphenol	(>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(10)
Nitrobenzene	(>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(10)
Pesticides (μg/L)											
Heptachlor expoxide	(0.004)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(0.05)
Aldrin	(>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(0.05)
alpha-BHC	(>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(0.05)
4,4'-DDE	(>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(0.1)
4,4'-DDT	(>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(0.1)
Endosulfan I	(>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(0.05)
Endosulfan II	(>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(0.1)
Endrin aldehyde	(>DL)	NA	NA	NA	NA	NA	NA	NA	ND	NA	ND(0.1)
Metals (μg/L)											
Arsenic	(50)	22.2	98.0*	38.8	ND(5.4)	ND(8.7)	ND(3)	22.2	4.0	146.0*	ND(2)
Cadmium	(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND	ND(5)	ND(2)
Iron	(300)	NA	43,600*	65,000*	NA	NA	NA	NA	NA	NA	8,705*
Lead	(15)	79.9*	ND(1.0)	ND(1.0)	3.9	11.4	ND(1)	11.0	ND	1.7	ND(2)
Manganese	(50)	NA	30.0	108*	NA	NA	NA	NA	NA	NA	82.5
Nickel	(100)	104*	ND(20)	ND(20)	ND(13)	18.5	ND(13)	ND(13)	ND	16.6	ND(15)
Silver	(18)	101*	ND(3.0)	ND(3.0)	ND(3)	ND(3)	ND(3)	5.9	ND	20.3*	ND(5)

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)	10GW21 1990	10GW25 1988	10GW27 1994	10GW28 1994	10GW29 1994	10GW30 1994	10GW31 1996	10GW32 1994	10GW33 1990
Volatile Organics (µg/L)									
Benzene (1)	ND(5)[2]	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(5)
Ethylbenzene (29)	ND(5)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(5)
Chlorobenzene (50)	7	0.3	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(5)
1,2-Dichloroethane (0.38)	ND(5)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(5)
1,2-Dichloroethene (total) (70)	ND(5)	ND(0.2)	13	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(5)
1,2-Dichloropropane (0.56)	ND(5)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(5)
Methylene chloride (5)	26*	0.5	ND(2)	ND(2)	ND(1)	ND(2)	ND(2)	ND(2)	ND(5)
Tetrachloroethene (0.7)	ND(5)	ND(0.2)	1*	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(5)
Trichloroethene (2.8)	ND(5)	ND(0.2)	2	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(5)
Vinyl chloride (0.015)	ND(10)	ND(0.2)	6*	3*	ND(1)	ND(1)	ND(1)	ND(1)	ND(10)
Chloroethane (>DL)[6]	ND(20)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(10)
2-Hexanone (>DL)	ND(20)	NA	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(10)
4-Methyl-2-pentanone (>DL)	ND(20)	NA	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(10)
Chloroform (0.019)	ND(10)	0.2*	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(5)
Chloromethane (>DL)	ND(20)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(10)
Dibromochloromethane (>DL)	ND(10)	0.4*	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(5)
Semivolatile Organics (µg/L)									
Bis(2-ethylhexyl)phthalate (3)	NA	ND(5)	NA	NA	ND(10)	ND(10)	ND(10)	NA	NA
Naphthalene (21)	NA	ND(5)	NA	NA	ND(10)	ND(10)	ND(10)	NA	NA
Bis(2-chloroethyl)ether (>DL)	NA	ND(5)	NA	NA	ND(10)	ND(10)	ND(10)	NA	NA
2,4-Dimethylphenol (>DL)	NA	ND(5)	NA	NA	ND(10)	ND(10)	ND(10)	NA	NA

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)		10GW21 1990	10GW25 1988	10GW27 1994	10GW28 1994	10GW29 1994	10GW30 1994	10GW31 1996	10GW32 1994	10GW33 1990
2-Methylnaphthalene	(>DL)	NA	NA	NA	NA	ND(10)	ND(10)	ND(10)	NA	NA
2-Methylphenol	(>DL)	NA	NA	NA	NA	ND(10)	ND(10)	ND(10)	NA	NA
4-Methylphenol	(>DL)	NA	NA	NA	NA	ND(10)	ND(10)	ND(10)	NA	NA
Nitrobenzene	(>DL)	NA	ND(5)	NA	NA	ND(10)	ND(10)	ND(10)	NA	NA
Pesticides (μg/L)										
Heptachlor expoxide	(0.004)	NA	ND(0.01)	NA	NA	ND(0.05)	ND(0.05)	ND(0.05)	NA	NA
Aldrin	(>DL)	NA	ND(0.01)	NA	NA	ND(0.05)	ND(0.05)	ND(0.05)	NA	NA
alpha-BHC	(>DL)	NA	ND(0.01)	NA	NA	ND(0.05)	ND(0.05)	ND(0.05)	NA	NA
4,4'-DDE	(>DL)	NA	ND(0.01)	NA	NA	ND(0.1)	ND(0.1)	ND(0.1)	NA	NA
4,4'-DDT	(>DL)	NA	ND(0.01)	NA	NA	ND(0.1)	ND(0.1)	ND(0.1)	NA	NA
Endosulfan I	(>DL)	NA	ND(0.01)	NA	NA	ND(0.05)	ND(0.05)	ND(0.05)	NA	NA
Endosulfan II	(>DL)	NA	ND(0.01)	NA	NA	ND(0.1)	ND(0.1)	ND(0.1)	NA	NA
Endrin aldehyde	(>DL)	NA	ND(0.01)	NA	NA	ND(0.1)	ND(0.1)	ND(0.1)	NA	NA
Metals (μg/L)										
Arsenic	(50)	67.8*	5.0	118*	66.5*	8.8	67.0*	ND(2.0)	48.0	ND(10)
Cadmium	(5)	ND(5)	ND(1)	ND(5)	ND(5)	ND(5.0)	ND(5)	ND(2.0)	ND(5.0)	ND(5)
Iron	(300)	NA	NA	58,100*	38,500*	13,000*	29,300*	3,920*	21,100*	NA
Lead	(15)	41.7*	ND(5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(2.0)	ND(1.0)	20*
Manganese	(50)	NA	NA	2,030*	149*	1,500*	156*	3,270*	294*	NA
Nickel	(100)	ND(13.0)	22	ND(20.0)	ND(20.0)	ND(20.0)	ND(20.0)	ND(9.0)	ND(20.0)	14.5
Silver	(18)	9.1	1.0	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(5.0)	ND(3.0)	ND(10)

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)	10GW34 1994	10GW35 1994	10GW36 1994	10GW37 1990	10GW38 1994	10GW39 1994	10GW40 1994	10GW41 1994	10GW42 1990	10GW43 1994
Volatile Organics (μg/L)										
Benzene (1)	8*	3*	ND(5)	9*	ND(1)	ND(1)	8*	5*	ND(5)	4*
Ethylbenzene (29)	ND(1)	ND(2)	ND(5)	ND(5)	ND(1)	ND(1)	ND(1)	ND(5)	ND(5)	ND(2)
Chlorobenzene (50)	2	ND(2)	58*	120*	4	23	180*	89*	ND(5)	45
1,2-Dichloroethane (0.38)	ND(1)	ND(2)	ND(5)	ND(5)	12*	ND(1)	ND(1)	ND(5)	ND(5)	ND(2)
1,2-Dichloroethene (70) (total)	14	24	ND(5)	ND(5)	ND(1)	ND(1)	ND(1)	ND(5)	9	ND(2)
1,2-Dichloropropane (0.56)	1*	ND(2)	ND(5)	ND(5)	ND(1)	ND(1)	ND(1)	ND(5)	ND(5)	ND(5)
Methylene chloride (5)	ND(2)	ND(4)	ND(10)	ND(5)	ND(2)	ND(2)	ND(2)	ND(10)	ND(5)	ND(5)
Tetrachloroethene (0.7)	ND(1)	ND(2)	ND(5)	ND(5)	ND(1)	ND(1)	ND(1)	ND(5)	ND(5)	ND(2)
Trichloroethene (2.8)	4*	8*	ND(5)	ND(5)	ND(1)	ND(1)	ND(1)	ND(5)	3*	ND(2)
Vinyl chloride (0.015)	7*	5*	ND(5)	ND(10)	ND(1)	ND(1)	ND(1)	ND(5)	ND(10)	ND(2)
Chloroethane (>DL)[6]	ND(1)	ND(2)	ND(5)	ND(10)	8*	ND(1)	ND(10)	ND(5)	ND(10)	ND(2)
2-Hexanone (>DL)	ND(5)	ND(10)	ND(25)	ND(10)	ND(5)	ND(5)	ND(5)	ND(25)	ND(10)	ND(12)
4-Methyl-2-pentanone (>DL)	ND(5)	ND(10)	ND(25)	ND(10)	ND(5)	ND(5)	ND(5)	ND(25)	ND(10)	ND(12)
Chloroform (0.19)	ND(1)	ND(2)	ND(5)	ND(5)	ND(1)	ND(1)	ND(1)	ND(5)	ND(5)	ND(2)
Chloromethane (>DL)	ND(1)	ND(2)	ND(5)	ND(10)	ND(1)	ND(1)	ND(1)	ND(5)	ND(10)	ND(2)
Dibromochloromethane (>DL)	ND(1)	ND(2)	ND(5)	ND(5)	ND(1)	ND(1)	ND(1)	ND(5)	ND(5)	ND(2)
Semivolatile Organics (μg/L)										
Bis(2-ethylhexyl) phthalate (3)	66*	29*	ND(10)	NA	NA	NA	NA	NA	NA	ND(14)

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)	10GW34 1994	10GW35 1994	10GW36 1994	10GW37 1990	10GW38 1994	10GW39 1994	10GW40 1994	10GW41 1994	10GW42 1990	10GW43 1994
Naphthalene (21)	ND(10)	ND(10)	ND(10)	NA	NA	NA	NA	NA	NA	ND(10)
Bis(2-chloroethyl) ether (>DL)	ND(10)	ND(10)	ND(10)	NA	NA	NA	NA	NA	NA	ND(10)
2,4-Dimethylphenol (>DL)	ND(10)	ND(10)	ND(10)	NA	NA	NA	NA	NA	NA	ND(10)
2-Methylnaphthalene(>DL)	ND(10)	ND(10)	ND(10)	NA	NA	NA	NA	NA	NA	ND(10)
2-Methylphenol (>DL)	ND(10)	ND(10)	ND(10)	NA	NA	NA	NA	NA	NA	ND(10)
4-Methylphenol (>DL)	ND(10)	ND(10)	ND(10)	NA	NA	NA	NA	NA	NA	ND(10)
Nitrobenzene (>DL)	5*	ND(10)	ND(10)	NA	NA	NA	NA	NA	NA	ND(10)
Pesticides (μg/L)										
Heptachlor epoxide (0.004)	0.0033	ND(0.05)	ND(0.05)	NA	NA	NA	NA	NA	NA	ND(0.05)
Aldrin (>DL)	ND(0.05)	0.0034*	ND(0.05)	NA	NA	NA	NA	NA	NA	ND(0.05)
alpha-BHC (>DL)	ND(0.05)	ND(0.05)	ND(0.05)	NA	NA	NA	NA	NA	NA	0.0098*
4,4'-DDE (>DL)	R	ND(0.1)	ND(0.1)	NA	NA	NA	NA	NA	NA	ND(0.1)
4,4'-DDT (>DL)	ND(0.1)	ND(0.1)	ND(0.1)	NA	NA	NA	NA	NA	NA	ND(0.1)
Endosulfan I (>DL)	ND(0.05)	ND(0.05)	ND(0.05)	NA	NA	NA	NA	NA	NA	ND(0.05)
Endosulfan II (>DL)	0.0033*	ND(0.1)	R	NA	NA	NA	NA	NA	NA	R
Endrin aldehyde (>DL)	ND(0.1)	ND(0.1)	R	NA	NA	NA	NA	NA	NA	ND(0.1)
Metals (μg/L)										
Arsenic (50)	29.8	4.6	27.0	24.3	ND(2.0)	6.15	ND(2)	15.3	18.6	3.9
Cadmium (5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5.0)	ND(5.0)	ND(5)	ND(5)	ND(5)	ND(5)
Iron (300)	106,000*	66,100*	84,800*	NA	3,720*	33,050*	69,300*	57,400*	NA	74,400*
Lead (15)	ND(1.0)	ND(1.0)	ND(1.0)	5.3	ND(1.0)	ND(1.0)	7.3	1.5	90.8*	ND(1.0)

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)		10GW34 1994	10GW35 1994	10GW36 1994	10GW37 1990	10GW38 1994	10GW39 1994	10GW40 1994	10GW41 1994	10GW42 1990	10GW43 1994
Manganese	(50)	52.0*	135*	341*	NA	37.0	210*	145*	121*	NA	65.0*
Nickel	(100)	ND(20.0)	ND(20.0)	22.0	ND(13.0)	ND(20.0)	ND(20.0)	ND(20.0)	ND(20.0)	ND(13.0)	ND(20.0)
Silver	(18)	ND(3.0)	ND(3.0)	ND(3.0	7.1	ND(3.0)	ND(3.0)	ND(3.0	ND(3.0)	11.4	ND(3.0)

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)		10GW44 1990	10GW45 (B-103)[5] 1994	10GW46 1990	10GW47 1994	10GW48 1994	OU2MW1 1994	OU2MW8 1994	OU2MW9 1994	OU2MW10 1994	OU2MW11 1994	OU2MW12 1994
Volatile Organics												
Benzene	(1)	10*	ND(1)	7*	2*	ND(1)	4*	7*	ND(1)	3.5*	7*	ND(1)
Ethylbenzene	(29)	16	ND(1)	26	22	ND(1)	ND(1)	14	ND(1)	ND(1)	2.5	ND(1)
Chlorobenzene	(50)	ND(5)	ND(1)	3	2	ND(1)	ND(1)	11	ND(1)	24.5	3.5	ND(1)
1,2-Dichloroethane	(0.38)	9*	ND(1)	ND(5)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	5*	ND(1)	ND(1)
1,2-Dichloroethene (total)	(70)	90*	ND(1)	22	13	ND(1)	23	ND(1)	ND(1)	7.5	100*	1
1,2-Dichloropropane	(0.56)	ND(5)	ND(1)	ND(5)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	2*	ND(1)
Methylene chloride	(5)	ND(5)	ND(2)	ND(5)	ND(1)	ND(2)	ND(3)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)
Tetrachloroethene	(0.7)	ND(5)	ND(1)	ND(5)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	8.5*	ND(1)
Trichloroethene	(2.8)	11*	ND(1)	ND(5)	38*	ND(1)	3*	ND(1)	ND(1)	3.5*	40*	ND(1)
Vinyl chloride	(0.015)	ND(10)	ND(1)	ND(10)	3*	ND(1)	8*	ND(1)	ND(1)	17*	19*	ND(1)
Chloroethane	(>DL)[6]	42*	ND(1)	30*	ND(1)	ND(1)	14*	ND(1)	ND(1)	ND(1)	2*	ND(1)
2-Hexanone	(>DL)	ND(10)	ND(5)	ND(10)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	1*	ND(5)	ND(5)
4-Methyl-2-pentanone	(>DL)	ND(10)	ND(5)	ND(10)	ND(5)	ND(5)	64*	ND(5)	7*	ND(5)	7*	3*
Chloroform	(0.19)	ND(5)	ND(1)	ND(5)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Chloromethane	(>DL)	ND(10)	ND(1)	ND(10)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Dibromochloromethane	(>DL)	ND(5)	ND(1)	ND(5)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Semivolatile Organics												
Bis(2-ethylhexyl)phthalate	(3)	NA	4*	NA	ND(54)	ND(10)	ND(24)	ND(24)	ND(10)	ND(10)	ND(19.5)	ND(10)
Naphthalene	(21)	NA	ND(10)	NA	41*	ND(10)	3	8	ND(10)	ND(10)	4	ND(10)
Bis(2-chloroethyl)ether	(>DL)	NA	ND(10)	NA	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
2,4-Dimethylphenol	(>DL)	NA	ND(10)	NA	ND(10)	ND(10)	ND(10)	6*	ND(10)	ND(10)	ND(10)	ND(10)
2-Methylnaphthalene	(>DL)	NA	ND(10)	NA	7*	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	4*	4*
2-Methylphenol	(>DL)	NA	ND(10)	NA	ND(10)	ND(10)	ND(10)	ND(10)	6*	ND(10)	ND(10)	ND(10)

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)		10GW44 1990	10GW45 (B-103)[5] 1994	10GW46 1990	10GW47 1994	10GW48 1994	OU2MW1 1994	OU2MW8 1994	OU2MW9 1994	OU2MW10 1994	OU2MW11 1994	OU2MW12 1994
4-Methylphenol	(>DL)	NA	ND(10)	NA	57*	ND(10)	ND(10)	ND(10)	18*	ND(10)	20*	ND(10)
Nitrobenzene	(>DL)	NA	ND(10)	NA	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
Pesticides												
Heptachlor expoxide	(0.004)	NA	ND(0.05)	NA	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)
Aldrin	(>DL)	NA	ND(0.05)	NA	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)
alpha-BHC	(>DL)	NA	ND(0.05)	NA	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)
4,4'-DDE	(>DL)	NA	ND(0.1)	NA	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
4,4'-DDT	(>DL)	NA	ND(0.1)	NA	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Endosulfan I	(>DL)	NA	ND(0.05)	NA	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)
Endosulfan II	(>DL)	NA	ND(0.1)	NA	ND(0.1)	ND(0.1)	ND(0.1)	R	ND(0.1)	ND(0.1)	R	ND(0.1)
Endrin aldehyde	(>DL)	NA	ND(0.1)	NA	ND(0.1)	ND(0.1)	R	0.05*	ND(0.1)	ND(0.1)	0.97*	ND(0.1)
Metals												
Arsenic	(50)	42.7	ND(2)	72.7*	12.9	ND(2.3)	28.0	32.7	ND(2.0)	ND(2)	18.05	ND(2.0)
Cadmium	(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5.0)	ND(5)	ND(5)	ND(5.0)	ND(5)	5.25*	ND(5.0)
Iron	(300)	NA	519*	NA	31,800*	3,250*	81,200*	50,800*	2,200*	5,700*	100,500*	6,660*
Lead	(15)	16.4	ND(1.0)	22.8	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	0.75	ND(1.0)	ND(1.0)
Manganese	(50)	NA	32.0	NA	132*	296*	368*	40.0	52.0*	440.5*	141*	1,230*
Nickel	(100)	ND(13.0)	ND(20.0)	28.9	ND(20.0)	ND(20.0)	ND(30.0)	ND(20.0)	ND(20.0)	ND(20.0)	ND(30.0)	ND(30.0)
Silver	(18)	18.2*	ND(3.0)	23.7*	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)	OU2MW13 1996	OU2MW14 1996	OU2MW15 1996	OU2MW16 1996	OU2HP1 1994	OU2HP2 1994	OU2HP3 1994	OU2HP4 1994	OU2HP5 1994	OU2HP6 1994
Volatile Organics										
Benzene (1)	ND(1)	ND(1)	ND(1)	ND(1)	6*	23*	48*	10*	4*	ND(1)
Ethylbenzene (29)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	38*	ND(2)	ND(1)	ND(1)	ND(1)
Chlorobenzene (50)	ND(1)	ND(1)	ND(1)	ND(1)	170*	6	31	135*	47	1
1,2-Dichloroethane (0.38)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	4*	ND(2)	ND(1)	ND(1)	ND(1)
1,2-Dichloroethene (total) (70)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	5	ND(2)	ND(1)	ND(1)	ND(1)
1,2-Dichloropropane (0.56)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	1*	ND(2)	ND(1)	ND(1)	ND(1)
Methylene chloride (5)	ND(2)	ND(2)	ND(2)	ND(2)	ND(2)	ND(4)	ND(4)	ND(2)	ND(2)	ND(2)
Tetrachloroethene (0.7)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(2)	ND(1)	ND(1)	21*
Trichloroethene (2.8)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(2)	ND(1)	ND(1)	1
Vinyl chloride (0.015)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	9*	ND(2)	3*	1*	ND(1)
Chloroethane (>DL)[6]	ND(1)	ND(1)	ND(1)	ND(1)	84*	76*	ND(2)	ND(1)	8*	ND(1)
2-Hexanone (>DL)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(10)	ND(5)	ND(5)	ND(5)
4-Methyl-2-pentanone (>DL)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)	ND(10)	ND(5)	ND(5)	ND(5)
Chloroform (0.19)	ND(1)	3*	ND(1)	1*	ND(1)	ND(1)	ND(2)	ND(1)	ND(1)	ND(1)
Chloromethane (>DL)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(2)	ND(1)	ND(1)	ND(1)
Dibromochloromethane (>DL)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)	ND(2)	ND(1)	ND(1)	ND(1)
Semivolatile Organics										
Bis(2-ethylhexyl)phthalate (3)	ND(10)	ND(10)	ND(10)	ND(10)	ND(33)	ND(10)	ND(20)	NA	NA	NA
Naphthalene (21)	ND(10)	ND(10)	ND(10)	ND(10)	8	16	ND(10)	NA	NA	NA
Bis(2-chloroethyl)ether (>DL)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	3*	NA	NA	NA
2,4-Dimethylphenol (>DL)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	4*	280*	NA	NA	NA
2-Methylnaphthalene (>DL)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	NA	NA	NA
2-Methylphenol (>DL)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	NA	NA	NA
4-Methylphenol (>DL)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	NA	NA	NA
Nitrobenzene (>DL)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	NA	NA	NA

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)		OU2MW13 1996	OU2MW14 1996	OU2MW15 1996	OU2MW16 1996	OU2HP1 1994	OU2HP2 1994	OU2HP3 1994	OU2HP4 1994	OU2HP5 1994	OU2HP6 1994
Pesticides											
Heptachlor expoxide	(0.004)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	0.024*	R	NA	NA	NA
Aldrin	(>DL)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	NA	NA	NA
alpha-BHC	(>DL)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	R	NA	NA	NA
4,4'-DDE	(>DL)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	0.0092*	R	ND(0.1)	NA	NA	NA
4,4'-DDT	(>DL)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	R	NA	NA	NA
Endosulfan I	(>DL)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)	0.009*	NA	NA	NA
Endosulfan II	(>DL)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	0.05*	0.01*	R	NA	NA	NA
Endrin aldehyde	(>DL)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	0.05*	0.02*	0.02*	NA	NA	NA
Metals											
Arsenic	(50)	ND(2)	ND(2)	6.2	ND(2)	56.0*	50.8*	ND(2)	12.2	29.8	ND(2)
Cadmium	(5)	ND(2)	ND(2)	ND(2)	ND(2)	6.0*	ND(5)	ND(5)	ND(5)	ND(5)	ND(5)
Iron	(300)	ND(12)	ND(12)	3.160*	69.9	58,200*	175,000*	122,000*	73,450*	49,406*	1,420*
Lead	(15)	2.6	ND(2)	3.1	ND(2)	ND(1.0)	ND(1.0)	ND(1.0)	5.1	ND(1.0)	ND(1.0)
Manganese	(50)	9.3	5.4	38	30.8	231*	660*	94.0*	93.0*	127*	296*
Nickel	(100)	ND(9)	ND(9)	ND(9)	ND(9)	ND(30.0)	ND(20.0)	ND(20.0)	ND(20.0)	ND(20.0)	ND(20.0)
Silver	(18)	ND(5)	ND(5)	ND(5)	ND(5)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)		S1W3 1987	S1W5 1988	S4W2 1994	S4W3 1994	9GW06 1994	9GW31 1996
Volatile Organics							
Benzene	(1)	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
Ethylbenzene	(29)	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
Chlorobenzene	(50)	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
1,2-Dichloroethane	(0.38)	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
1,2-Dichloroethene (total)	(70)	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
1,2-Dichloropropane	(0.56)	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
Methylene chloride	(5)	ND(0.2)	ND(0.2)	ND(2)	ND(2)	ND(2)	ND(2)
Tetrachloroethene	(0.7)	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
Trichloroethene	(2.8)	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
Vinyl chloride	(0.015)	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
Chloroethane	(>DL)[8]	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
2-Hexanone	(>DL)	NA	NA	ND(5)	ND(5)	ND(5)	ND(5)
4-Methyl-2-pentanone	(>DL)	NA	NA	ND(50	ND(5)	ND(5)	ND(5)
Chloroform	(0.19)	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
Chloromethane	(>DL)	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
Dibromochloromethane	(>DL)	ND(0.2)	ND(0.2)	ND(1)	ND(1)	ND(1)	ND(1)
Semivolatile Organics							
Bis(2-ethylhexyl)phthalate	(3)	14*	ND(5)	ND(10)	ND(10)	ND(10)	ND(10)
Naphthalene	(21)	ND(5)	ND(5)	ND(10)	ND(10)	ND(10)	ND(10)
Bis(2-chloroethyl)ether	(>DL)	ND(5)	ND(5)	ND(10)	ND(10)	ND(10)	ND(10)
2,4-Dimethylphenol	(>DL)	NA	ND(5)	ND(10)	ND(10)	ND(10)	ND(10)
2-Methylnaphthalene	(>DL)	NA	NA	ND(10)	ND(10)	ND(10)	ND(10)
2-Methylphenol	(>DL)	NA	NA	ND(10)	ND(10)	ND(10)	ND(10)
4-Methylphenol	(>DL)	NA	NA	ND(10)	ND(10)	ND(10)	ND(10)
Nitrobenzene	(>DL)	ND(5)	ND(5)	ND(10)	ND(10)	ND(10)	ND(10)

TABLE 4-9 (Continued)
SURFICIAL AQUIFER ANALYTICAL RESULTS - MOST RECENT SAMPLING ROUND
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)		S1W3 1987	S1W5 1988	S4W2 1994	S4W3 1994	9GW06 1994	9GW31 1996
Pesticides							
Heptachlor expoxide	(0.004)	ND(0.01)	ND(0.01)	ND(0.05)	ND(0.05	ND(0.05)	ND(0.05)
Aldrin	(>DL)	ND(0.01)	ND(0.01)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)
alpha-BHC	(>DL)	ND(0.01)	ND(0.01)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)
4,4'-DDE	(>DL)	ND(0.01)	ND(0.01)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
4,4'-DDT	(>DL)	ND(0.01)	ND(0.01)	0.01*	ND(0.1)	ND(0.1)	ND(0.1)
Endosulfan I	(>DL)	ND(0.01)	ND(0.01)	ND(0.05)	ND(0.05)	ND(0.05)	ND(0.05)
Endosulfan II	(>DL)	ND(0.01)	ND(0.01)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Endrin aldehyde	(>DL)	ND(0.01)	ND(0.01)	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)
Metals							
Arsenic	(50)	11.0	ND(1)	ND(2.0)	ND(2.0)	54.5*	ND(2)
Cadmium	(5)	3.0	ND(1)	ND(5.0)	ND(5.0)	ND(5.0)	ND(2)
Iron	(300)	580*	NA	2,440*	1,350*	102,000*	329*
Lead	(15)	5	ND(5)	ND(1.0)	ND(1.0)	ND(1.0)	ND(2)
Manganese	(50)	47	NA	1,080*	1,300*	65.0*	17.3
Nickel	(100)	7	11	ND(20.0)	ND(20.0)	ND(20.0)	15.3
Silver	(18)	ND(1.0)	1	ND(3.0)	ND(3.0)	ND(3.0)	ND(5)

1 Exceedances identified by asterisk.
2 ND - Not detected at detection limit noted in parentheses.
3 R - Rejected data.
4 NA - Not analyzed.
5 Well B-103 was incorrectly identified as 10GW45 and was sampled in lieu of well 10GW45.
6 >DL - Greater than detection limit. Any detection is considered exceedance of standard.

Note: If an analyte is not listed, it was not detected at a concentration exceeding the state standard during the most recent sampling round for a particular well. Complete analytical results are provided in Appendix H.

ROOSEVELT ROAD
SITE 43
SEWAGE TREATMENT PLANT
SITE 46
POLISHING POND 2
SITE 46
POLISHING POND 1
DRUMMED PETROLEUM (ABANDONED)
STORAGE
SITE 44
FORMER SLUDGE APPLICATION AREA
FORMER SLUDGE IMPOUNDMENT AREA
TURKEY GUT
APPROXIMATE LOCATION OF FENCE
APPROXIMATE AREA OF GROUNDWATER CONTAMINATION
WASH RACK
MWR STORAGE AREA
AUTO HOBBY SHOP
SITE 76
VEHICLE MAINTENANCE AREA (HOBBY SHOP)
SLOCUM CREEK
SCALE IN FEET
LEGEND
UPPER SURFICIAL AQUIFER MONITORING WELL
LOWER SURFICIAL AQUIFER MONITORING WELL
HYDROPUNCH/TEMPORARY WELL LOCATION
INTERMITTENT STREAM
CHLOROBENZENE >50 ppb
BENZENE >1 ppb
CHLORINATE ORGANICS (EXCEPT 1)
ARSENIC >50 ppb
BIS(2-ETHYLHEXYL)PHTHALATE
NOTE: RESULTS BASED ON MOST RECENT SAMPLING EVENT FOR EACH WELL
REVISIONS
Brown & Root Environmental
ACTIVITY - SATISFACTORY TO
ATLANTIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORFOLK, VIRGINIA
DEPARTMENT OF THE NAVY
NAVAL STATION
MARINE CORPS AIR STATION CHERRY POINT
CHERRY POINT, NORTH CAROLINA
OU2
SURFICIAL AQUIFER APPROXIMATE AREAS OF GROUNDWATER CONTAMINATION
AS SHOWN
XX-XX-XXXX
XXXXXX-XX-X-XXXX
FIGURE 4-6

contamination defined by exceedances of state standards for class GA groundwaters based on the most recent sampling event (generally 1994 or 1990). The plate indicates that over almost the entire area, the concentration of benzene exceeds the state standard of 1 μg/L. Within this general area of benzene contamination, three areas of solvent contamination were identified. One area is located west (downgradient) of the former sludge impoundments and extends to the south side of Turkey Gut in the area identified as Study Area E. Another area is centered on the Study Area B on the eastern edge of the landfill, and the third area is located in the southwest portion of OU2. This area may be associated with the fire training areas and potential use of solvents there or in the adjacent vehicle maintenance area (Site 76).

Several areas have chlorobenzene concentrations exceeding the state standard of 50 μg/L. These areas are as follows: (1) coincident with the solvent contamination area south of Turkey Gut, (2) an area in the upstream area of Turkey Gut (Study Area C) originally identified using soil-gas surveys, (3) the areas surrounding OU2HP1, which is located southwest of Study Area E.

Metals are not significant groundwater contaminants at this site. Only four metals (arsenic, cadmium, iron and manganese) were found during the most recent sampling event at concentrations that exceeded state standards (50 μg/L, 5 μg/L, 50 μg/L, and 300 μg/L, respectively). Several areas of arsenic exceedances are also identified on Figure 4-6 and Plate 13.

There is no significant difference between the analytical results for wells screened in the upper and lower portions of the surficial aquifer. These results, therefore, do not indicate a great potential for nonaqueous-phase liquids at this site. Table 4-10 presents information on the ranges of detections, the frequencies of detection, and the average of all positive detections for the 1994 and 1996 data in both portions of the aquifer. Older data are not included in this table, as it is intended to reflect current site conditions.

Additional details on the analytical results for individual wells can be found in Appendix H.4 (Volume II).

4.2.4 Yorktown Aquifer

A total of 16 wells have been installed in the Yorktown aquifer. The chemical analytical results for all sampling events are summarized in Table 4-11. The results indicate that metals are not significant contaminants in the Yorktown aquifer except for iron and manganese. Iron exceeded the state groundwater standard in most Yorktown aquifer wells, and manganese exceeded the standard in more than 50 percent

TABLE 4-10

COMPARISON OF UPPER AND LOWER SURFICIAL AQUIFER CONTAMINATION - 1994 AND 1996 DATA
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)[3]	Upper Surficial Aquifer			Lower Surficial Aquifer		
	Frequency of Detection	Range of Detections (μg/L)	Average of Positive Detections (μg/L)	Frequency of Detection	Range of Detections (μg/L)	Average of Positive Detections (μg/L)
Volatile Organics						
Acetone (700)	2/7	18 - 32	25	1/4	7	7
2-Butanone (170)	2/13	69 - 83	76	ND[1]	--	--
4-Methyl-2-pentanone* (>DL)[4]	3/36	4 - 64	25	2/11	3 - 7	5
2-Hexanone* (>DL)	ND	--	--	1/11	1	1
Benzene* (1)	19/36	2 - 230	21.3	2/11	3 - 3.5	3.25
Toluene (1,000)	6/36	2 - 110	48	1/11	3	3
Ethylbenzene* (29)	7/36	1 - 38	13.1	ND	--	--
Xylenes (530)	9/36	4 - 180	60.4	2/11	2 - 3	2.5
Chlorobenzene* (50)	21/36	1 - 180	43.2	1/11	24.5	24.5
1,2-Dichlorobenzene[2] (620)	13/60	1 - 28	10.2	2/20	1 - 3	2
1,3-Dichlorobenzene[2] (620)	2/60	2	2	ND	--	--
1,4-Dichlorobenzene[2] (75)	24/60	2.5 - 40	11.4	2/20	3 - 3.5	3.25
1,1,1-Trichloroethane (200)	2/36	3 - 5	4	ND	--	--
1,1-Dichloroethane (700)	13/36	1 - 79.5	37	5/11	2 - 28	10
1,2-Dichloroethane* (0.38)	2/36	2 - 4	3	1/11	5	5
Chloroethane* (>DL)	12/36	1 - 90	27.3	ND	--	--
Tetrachloroethene* (0.7)	5/36	3 - 21	8.7	1/11	1	1
Trichloroethene* (2.8)	8/36	1 - 40.5	13.9	3/11	2 - 8	4.5
1,1-Dichloroethene (7)	1/36	2	2	ND	--	--

TABLE 4-10 (Continued)
COMPARISON OF UPPER AND LOWER SURFICIAL AQUIFER CONTAMINATION - 1994 AND 1996 DATA
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)[3]		Upper Surficial Aquifer			Lower Surficial Aquifer		
		Frequency of Detection	Range of Detections (μg/L)	Average of Positive Detections (μg/L)	Frequency of Detection	Range of Detections (μg/L)	Average of Positive Detections (μg/L)
Chloroform*	(0.19)	2/36	1-3	2	ND	--	--
cis-1,2-Dichloroethene*	(70)	10/36	1 - 140	40.9	6/11	1 - 24	9.75
trans-1,2-Dichloroethene	(70)	6/36	0.75 - 3	1.8	ND	--	--
Vinyl chloride*	(0.015)	13/36	1 - 26	8	3/11	5 - 17	9.3
1,2-Dichloropropane*	(0.56)	5/36	1 - 2	1.2	ND	--	--
Methlyene chloride	(5)	3/35	1 - 2	1.5	ND	--	--
Semivolatile Organics							
Phenol	(300)	3/24	3 - 16	8	1/9	9	9
2-Methylphenol*	(>DL)	1/24	11	11	1/9	6	6
4-Methylphenol*	(>DL)	4/24	3 - 65	36.4	1/9	18	18
2,4-Dimethylphenol*	(>DL)	4/24	4 - 280	77.3	ND	--	--
Bis(2-chloroethyl)ether*	(>DL)	1/24	3	3	ND	--	--
Bis(2-ethylhexyl)phthalate*	(3)	2/24	4 - 66	35	1/9	29	29
Diethylphthalate	(5,000)	9/24	4 - 53	18.2	ND	--	--
Naphthalene*	(21)	8/24	3 - 41	14.6	ND	--	--
2-Methylnaphthalene*	(>DL)	3/24	4 - 18	9.7	1/9	4	4
Nitrobenzene*	(>DL)	1/24	5	5	ND	--	--
Pesticides/PCBs							
Aldrin*	(>DL)	ND			1/9	0.0034	0.0034
α-BHC*	(>DL)	2/21	0.0089 - 0.0098	0.0094	ND	--	--
γ-BHC (Lindane)	(0.2)	2/19	0.0089 - 0.041	0.0250	ND	--	--
α-Chlordane	(0.027)	5/21	0.0054 - 0.014	0.0102	ND	--	--

TABLE 4-10 (Continued)
COMPARISON OF UPPER AND LOWER SURFICIAL AQUIFER CONTAMINATION - 1994 AND 1996 DATA
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)[3]		Upper Surficial Aquifer			Lower Surficial Aquifer		
		Frequency of Detection	Range of Detections (μg/L)	Average of Positive Detections (μg/L)	Frequency of Detection	Range of Detections (μg/L)	Average of Positive Detections (μg/L)
γ-Chlordane	(0.027)	1/22	0.0085	0.0085	ND	--	--
4,4'-DDE*	(>DL)	1/21	0.0092	0.0092	ND	--	--
4,4'-DDT*	(>DL)	1/22	0.017	0.017	ND	--	--
Endosulfan I*	(>DL)	1/23	0.0090	0.0090	ND	--	--
Endosulfan II*	(>DL)	3/17	0.0033 - 0.056	0.0258	ND	--	--
Endrin	(2)	3/23	0.0007 - 0.020	0.0129	ND	--	--
Endrin aldehyde*	(>DL)	5/20	0.02 - 0.97	0.221	ND	--	--
Heptachlor	(0.008)	1/22	0.0055	0.0055	ND	--	--
Heptachlor epoxide*	(0.004)	2/21	0.0033 - 0.024	0.0137	ND	--	--
Inorganics							
Aluminum	NR[5]	23/36	15.0 - 4840	419	7/11	29.0 - 117	75.4
Arsenic*	(50)	23/36	3.9 - 127	42.3	4/11	4.6 - 119	44.2
Barium	(2,000)	34/36	18.0 - 306	83.4	11/11	16.0 - 152	60.9
Beryllium	(NR)	ND	--	--	1/11	1.0	1.0
Cadmium*	(5)	2/36	5.25 - 6.0	5.63	ND	--	--
Calcium	(NR)	36/36	1170 - 93,850	29,477	10/10	10,400 - 89,800	41,865
Cobalt	(NR)	7/36	8.6 - 44.0	21.5	4/11	23.0 - 81.0	56.4
Copper	(1,000)	2/36	1.75 - 10.6	6.10	ND	--	--
Iron*	(300)	33/36	69.9 - 100,500	39,380	11/11	2,200 - 66,100	18,331
Lead	(15)	8/36	1.1 - 7.3	3.3	1/11	1.0	1.0
Magnesium	(NR)	36/36	1,080 - 34,900	9,257	11/11	1,640 - 8,350	3,846
Manganese*	(50)	36/36	5.4 - 2,370	217	11/11	52.0 - 3,540	1,286

TABLE 4-10 (Continued)
COMPARISON OF UPPER AND LOWER SURFICIAL AQUIFER CONTAMINATION - 1994 AND 1996 DATA
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (NC GA Standard)[3]		Upper Surficial Aquifer			Lower Surficial Aquifer		
		Frequency of Detection	Range of Detections (μg/L)	Average of Positive Detections (μg/L)	Frequency of Detection	Range of Detections (μg/L)	Average of Positive Detections (μg/L)
Nickel	(100)	2/36	15.3 - 22.0	18.6	ND	--	--
Potassium	(NR)	36/36	923 - 36,900	8,368	11/11	1,070 - 12,400	4,347
Sodium	(NR)	36/36	1,070 - 95,900	28,677	11/11	6,990 - 42,450	24,167
Vanadium	(NR)	4/36	1.05 - 9.0	6.0	ND	--	--
Zinc	(2,100)	11/36	6.0 - 90.5	24.0	3/11	13.0 - 22.1	18.4
Cyanide	(154)	1//36	28.0	28.0	ND	--	--

1 ND - Not detected.
2 Analyzed in both volatile and semivolatile fraction.
3 15A NCAC 2L.0200. Exceedance of standard indicated by asterisk.
4 Greater than detection limit.
5 NR - Not regulated.

TABLE 4-11
GROUNDWATER ANALYTICAL RESULTS - YORKTOWN AQUIFER[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Concentration Range (µg/L)	Frequency of Detection	Average of Positive Detections	Location of Maximum Detection	Date of Maximum Occurrence	NC GA Standard[2]
Volatile Organics						
Toluene	0.5	1/16	0.5	S4W1	1987	1,000
Trichloroethene	1	1/16	1	S4W1	1987	2.8
Methylene chloride	3	1/16	3	OU2MW6	1994	5
Chloroform*	1 - 2	2/16	1.5	OU2MW6	1994	0.19
Semivolatile Organics						
Bis(2-ethylhexyl)phthalate*	14 - 25	2/13	19.5	10GW24	1994	3
Inorganics						
Aluminum	25.0 - 936	6/10	198	OU2MW3	1994	NR[3]
Arsenic	1.0 - 2.0	4/16	1.75	10GW23/ 10GW26/S4W1	1986/1987 /1987	50
Barium	2.0 - 44.0	10/11	18.1	OU2MW7	1994	2,000
Calcium	49,500 - 68,600	10/10	61,930	OU2MW2	1994	NR
Chromium	7.0 - 24.3	3/16	14.8	10GW33	1990	50
Copper	3.6 - 13.0	3/16	9.9	10GW26/S4W1	1987	1,000
Iron*	279 - 2,010	9/10	827	10GW22	1994	300
Lead*	1.2 - 18.0	5/16	10.7	10GW26	1987	15
Magnesium	783 - 2,380	10/10	1,700	OU2MW5	1994	NR
Manganese*	12.0 - 90.0	10/10	50.9	OU2MW5	1994	50
Nickel	10.0 - 11.9	3/16	10.6	10GW33	1990	100
Potassium	858 - 7,510	10/10	2,238	OU2MW7	1994	NR
Sodium	1,280 - 32,000	10/10	10,409	OU2MW3	1994	NR
Zinc	10.0 - 60.0	3/16	26.7	S4W1	1987	2,100

1 Includes samples from wells 10GW22, 10GW23, 10GW24, 10GW26, 10GW33, OU2MW2, OU2MW3, OU2MW4, OU2MW5, OU2MW6, OU2MW7, and S4W1. Asterisk next to analyte indicates exceedence of state standard.
2 NCAC T15A: 2L.0200 (October 25, 1994).
3 Not regulated.

of the wells. The only other exceedance was for lead in wells 10GW26 (18 μg/L in 1987) and 10GW33 (17 μg/L in 1990).

A few Yorktown aquifer wells exhibited exceedances of state groundwater standards for organics, including 10GW24 [25 μg/L bis(2-ethylhexyl)phthalate in 1994], 10GW26 [14 μg/L bis(2-ethylhexyl)phthalate in 1987], and OU2MW3 and OU2MW6 (1 and 2 μg/L, respectively, of chloroform in 1994). No other exceedances were noted, and all wells, with the exception of 10GW26 (last sampled in 1987) and S1W4 (locked), were last sampled in either 1990 (TCL volatiles and TAL metals) or 1994 (full TCL/TAL). Figure 4-7 and Plate 14 (Volume V) contain graphical presentations of state groundwater standard exceedances in the Yorktown aquifer wells based on the most recent sampling event (generally 1994 or 1990). Table 4-12 contains a summary of the standard exceedances for all Yorktown wells in which an exceedance was noted.

Another item of note in the Yorktown aquifer wells is that the highest concentrations of many of the toxic metals (e.g., arsenic, lead, mercury, silver, etc.) were measured between 1985 and 1990, prior to the implementation of the low flow purging and sampling technique, which reduced the sediment load in the groundwater samples. This methodology results in a more representative sample of dissolved (not suspended) and mobile metals.

4.3 SURFACE WATER

Surface waters from both Turkey Gut and Slocum Creek have been sampled at this site on several occasions. Table 4-13 contains a summary of the surface water sampling and analysis program at OU2. The complete chemical analytical database is presented in Appendix H.5 (Volume II), and the results are summarized in a series of tables in this section. All sampling locations are shown in Figure 2-1 and Plate 2 (Volume V).

Beginning in January 1985, one surface water sample was collected from the mouth of Turkey Gut (10SW03A) and analyzed for selected metals (cadmium, chromium, copper, lead, nickel, silver, and zinc), total phenolics, TOC, and TOX. This location was resampled in October 1985, at which time analyses were conducted for all priority pollutants organics, including 2-butanone, 4-methyl-2-pentanone, xylenes, and ethylene dibromide, as well as priority pollutant metals and hexavalent chromium.

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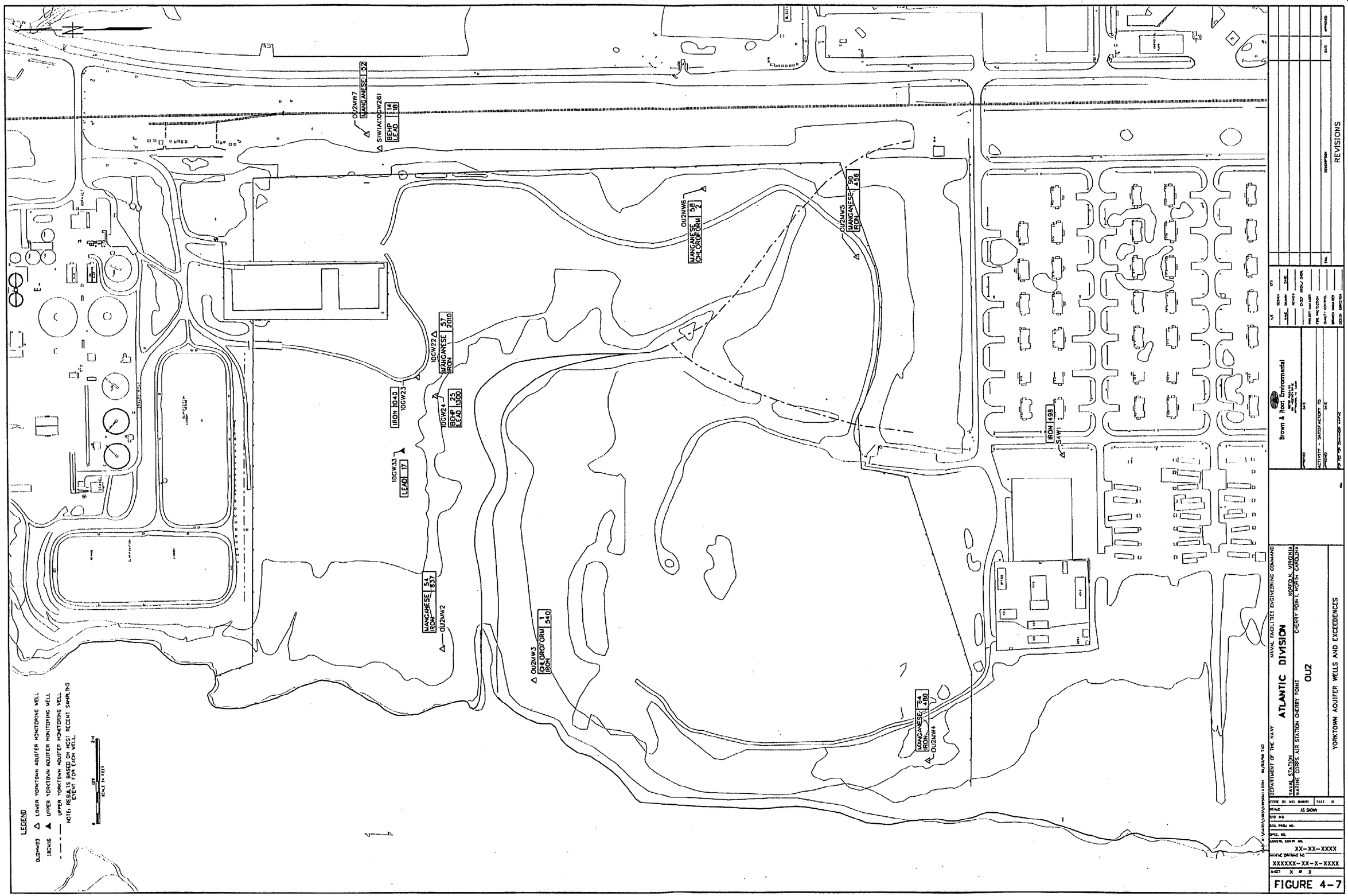
OU2MW7
MANGANESE 32
S1W1A(10)(W261)
BERYLLIUM 14
LEAD 8
OU2MW6
MANGANESE 58
CHLOROFORM 2
OU2MW5
MANGANESE 90
IRON 456
10GW22
MANGANESE 57
IRON 2010
10GW23
IRON 1040
10GW24
BERYLLIUM 25
LEAD 1300
10GW33
LEAD 17
MANGANESE 54
IRON 837
OU2MW2
OU2MW3
CHLOROFORM 1
IRON 540
MANGANESE 84
IRON 480
OU2MW4
S1W1
IRON 498
LEGEND
OU2MW23 LOWER YORKTOWN AQUIFER MONITORING WELL
1BGW16 UPPER YORKTOWN AQUIFER MONITORING WELL
UPPER YORKTOWN AQUIFER MONITORING WELL
NOTE: RESULTS BASED ON MOST RECENT SAMPLING EVENT FOR EACH WELL
SCALE IN FEET
REVISIONS
Brown & Root Environmental
ACTIVITY - SATISFACTORY TO
NAVAL FACILITIES ENGINEERING COMMAND
ATLANTIC DIVISION
DEPARTMENT OF THE NAVY
NAVAL STATION
MARINE CORPS AIR STATION CHERRY POINT
NORFOLK, VIRGINIA
CHERRY POINT, NORTH CAROLINA
OU2
YORKTOWN AQUIFER WELLS AND EXCEEDENCES
AS SHOWN
XX-XX-XXXX
XXXXXX-XX-X-XXXX
FIGURE 4-7

TABLE 4-12

EXCEEDANCES OF STATE GROUNDWATER STANDARDS - YORKTOWN AQUIFER (μg/L)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte (Standard)	10GW22 1994	10GW23 1994	10GW24 1994	10GW26 1987	10GW33 1990	OU2MW2 1994
Organics						
Chloroform (0.19)	ND(1)[1]	ND(1)	ND(1)	ND(0.2)	ND(5)	ND(1)
Bis(2-ethylhexyl)phthalate (3)	ND(10)	ND(10)	25*	14*	NA	ND(13)
Inorganics						
Iron (300)	2,010*[2]	1,040*	1,300*	NA[3]	NA	837*
Lead (15)	ND(1)	ND(1)	1.2	18*	17*	ND(1)
Manganese (50)	57*	49	46	NA	NA	54*

Analyte (Standard)	OU2MW3 1994	OU2MW4 1994	OU2MW5 1994	OU2MW6 1994	OU2MW7 1994	S4W1 1994
Organics						
Chloroform (0.19)	1*	ND(1)	ND(1)	2*	NA(1)	NA(1)
Bis(2-ethylhexyl)phthalate (3)	ND(12)	NA	NA	ND(10)	ND(30)	ND(17)
Inorganics						
Iron (300)	540*	480*	456*	ND(199)	279	498*
Lead (15)	1.2	ND(1)	ND(1)	ND(1)	ND(1)	ND(1)
Manganese (50)	27	64*	90*	58*	52*	12

1 ND - Not detected at detection limit shown in parentheses.
2 Exceedances indicated by an asterisk.
3 NA - Not analyzed.

TABLE 4-13

SUMMARY OF SURFACE WATER SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Sample Number	Date	Selected Metals[1]	Phenolics	Priority Pollutants[2]	Ketones[3]	TOC / TOX	Cr+6	TCL Volatiles	Other TCL Organics	TAL Metals	TSS	Chloride
10SW03A	01/85	X	X			X						
10SW03A	10/85		X	X[4]	X	X	X					
10SW03A	03/87		X	X[4]	X	X	X					
10SW06A	03/87			X[4]	X	X	X					
10SW07A	03/87			X[4]	X	X	X					
10SW01	1990							X		X	X	
10SW02	1990							X		X	X	
10SW03	1990							X		X	X	
10SW03-D	1990							X		X	X	
10SW04	1990							X		X	X	
10SW05	1990							X		X	X	
10SW06	1990							X		X	X	
OU2SW1	1994							X	X	X[4]		
OU2SW2	1994							X	X	X[4]		
OU2SW3	1994							X	X	X[4]		
OU2SW4	1994							X	X	X[4]		
OU2SW5	1994							X	X	X[4]		
OU2SW6	1994							X	X	X[4]		
OU2SW7	1994							X	X	X[4]		
OU2SW3	1996											X
OU2SW4	1996											X
OU2SW5	1996											X
OU2SW6	1996											X

TABLE 4-13 (Continued)
SUMMARY OF SURFACE WATER SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

1 Includes cadmium, chromium, copper, lead, nickel, silver, and zinc.
2 Includes ethylene dibromide and xylenes.
3 Includes 2-butanone and 4-methyl-2-pentanone.
4 Includes cyanide.
Note: An "X" indicates the analytical parameters for each sample. See Appendix G for lists of various analytical programs (e.g., priority pollutants, TCL, TAL).

The final round of sampling in the RIIR, conducted in March 1987, included two additional locations in Slocum Creek (10SW06A and 10SW07A), as well as resampling location 10SW03A. These three samples were analyzed for the same parameters as were analyzed in October 1985. These results were summarized and discussed in the RIIR (NUS, October 1988).

As part of the TDM conducted for Sites 10 and 16 in 1990, six additional surface water samples were collected at this site. Locations included 10SW03 through 10SW06 in Turkey gut, from downstream to upstream, as well as 10SW01 (Slocum Creek downstream from the mouth of Turkey Gut) and 10SW02 (Slocum Creek upstream from the mouth of Turkey Gut). Each of these six samples was analyzed for TCL volatile organics, TAL metals, and Total Suspended Solids (TSS). The analytical results for these samples were presented in the Sites 10 and 16 TDM (Halliburton NUS, June 1994b).

In 1994, an additional round of surface water sampling was conducted at this site. Seven surface water samples were collected. From downstream to upstream in Turkey Gut, the following samples were collected: OU2SW3, OU2SW4, OU2SW6, and OU2SW5. Sample location OU2SW1 was the most upstream location in Slocum Creek, just offshore from the Site 76 Vehicle Maintenance Area (Hobby Shop). Sample location OU2SW2 was located approximately 800 feet downstream from OU2SW1, along the landfill boundary. Sample OU2SW7 was collected in Slocum Creek approximately 500 feet downstream of the mouth of Turkey Gut. These samples were analyzed for TCL volatile and semivolatile organics, TCL pesticides and PCBs, TAL metals, and cyanide.

In 1996, four surface water samples from Turkey Gut were collected near locations OU2SW3, OU2SW4, OU2SW5, OU2SW6. The samples were analyzed for chloride to determine whether Turkey Gut would be classified by the state as saltwater or freshwater.

4.3.1 Turkey Gut

Turkey Gut is classified as a Class C freshwater because chloride concentrations were below 500 mg/L. A total of nine locations in Turkey Gut have been sampled over the years. The results are summarized in Table 4-14 along with Class C surface water standards. Volatile organic compounds were detected in several samples, at concentrations of 12 μg/L or less. Several compounds were detected at their highest concentrations in 1990 (benzene, ethylbenzene, chlorbenzene, 1,1-dichloroethane, and chloroethane), while others were only detected in 1994 in single samples (1,4-dichlorobenzene, cis-1,2-dichloroethene, and vinyl chloride). These compounds most likely originated in onsite source areas, as the same compounds were also detected in onsite groundwaters and some subsurface soil samples. Pesticides and PCBs were analyzed in surface waters only in the 1994 RI sampling event. γ-BHC, 4,4'-DDD, and heptachlor epoxide

TABLE 4-14

SUMMARY OF ANALYTICAL RESULTS - TURKEY GUT SURFACE WATER[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Unfiltered				Filtered				NC Class C Standard/ Criteria[4]
	Concentration Range	Frequency of Detection	Average of Positive Detections	Location of Maximum/Date	Concentration Range	Frequency of Detection	Average of Positive Detections	Location of Maximum/Date	
Volatile Organics (µg/L)									
Benzene	1 - 3.75	2/10	2.4	10SW03/1990	NA[2]	--	--	--	71.4
Ethylbenzene	2.75 - 4	2/10	3.4	10SW05/1990	NA	--	--	--	325
Chlorobenzene	7 - 10.5	3/10	9.2	10SW03/1990	NA	--	--	--	21,000
1,4-Dichlorobenzene	2	1/10	2	OU2SW4/1994	NA	--	--	--	2,600
1,1-Dichloroethane	2 - 6	4/10	3.9	10SW04/1990	NA	--	--	--	19.8
Chloroethane	3 - 12	5/10	6.4	10SW04/1990	NA	--	--	--	860
cis-1,2-Dichloroethene	1	1/4	1	OU2SW4/1994	NA	--	--	--	7.0
Vinyl chloride	1	1/10	1	OU2SW4/1994	NA	--	--	--	525
Semivolatile Organics (µg/L)									
Bis(2-ethylhexyl)phthalate*	4 - 6	2/6	5	OU2SW6/1994	NA	--	--	--	5.9
Pesticides/PCBs (µg/L)									
γ-BHC (Lindane)	0.0016 - 0.0081	2/6	0.0049	OU2SW4/1994	NA	--	--	--	0.01
4,4'-DDD*	0.028	1/6	0.028	OU2SW3/1994	NA	--	--	--	0.00084
Heptachlor epoxide*	0.0019	1/6	0.0019	OU2SW4/1994	NA	--	--	--	0.00011
Inorganics (µg/L)									
Aluminum	29.0 - 1,010	3/4	380	OU2SW5/1994	ND[3]	--	--	--	NR[5]
Antimony	ND	--	--	--	11.5	1/4	11.5	OU2SW3/1994	4,300
Arsenic	2.95 - 10.0	3/10	6.55	10SW03A/1987	ND	--	--	--	50

TABLE 4-14 (Continued)
SUMMARY OF ANALYTICAL RESULTS - TURKEY GUT SURFACE WATER[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Unfiltered				Filtered				NC Class C Standard/ Criteria[4]
	Concentration Range	Frequency of Detection	Average of Positive Detections	Location of Maximum/Date	Concentration Range	Frequency of Detection	Average of Positive Detections	Location of Maximum/Date	
Barium	40.5 - 90.0	4/4	57.1	OU2SW5/1994	39.0 - 86.0	4/4	54.5	OU2SW3/1994	NR
Calcium	21,400 - 135,000	4/4	63,750	OU2SW3/1994	22,100 - 139,000	4/4	64,550	OU2SW3/1994	NR
Copper*	ND	--	--	--	25.0	1/4	25.0	OU2SW3/1994	7
Iron*	1,435 - 11,600	4/4	4,391	OU2SW4/1994	727 - 5,580	3/4	2,526	OU2SW4/1994	1,000
Lead	2.23 - 7.5	4/11	4.78	OU2SW5/1994	ND	--	--	--	25
Magnesium	3,125 - 393,000	4/4	102,719	OU2SW3/1994	3,115 - 387,000	4/4	101,246	OU2SW3/1994	NR
Manganese	80.5 - 458	4/4	268	OU2SW4/1994	71.5 - 447	4/4	232	OU2SW4/1994	NR
Potassium	1,840 - 123,000	4/4	33,176	OU2SW3/1994	1,890 - 116,000	4/4	31,430	OU2SW3/1994	NR
Silver*	3.4	1/11	3.4	10SW04/1990	ND	--	--	--	0.06
Sodium	3,170 - 3,030,000	4/4	766,645	OU2SW3/1994	3,200 - 3,150,000	4/4	796,685	OU2SW3/1994	NR
Zinc	10.0 - 20.0	3/11	15.7	10SW03A/1985	12.0	1/4	12.0	OU2SW5/1994	50

1 Includes samples from locations 10SW03A, 10SW03, 10SW04, 10SW05, 10SW06, OU2SW3, OU2SW4, OU2SW5, and OU2SW6. Asterisk next to analyte indicates exceedance of state standard.
2 NA - Not analyzed.
3 ND - Not detected.
4 Reid, 1996.
5 NR - Not regulated; no standard.

were detected. The maximum detected concentration was 0.028 μg/L for 4,4'-DDD. Bis(2-ethylhexyl)phthalate was also detected in two samples, at a maximum concentration of 6 μg/L.

Unfiltered water samples were collected in all sampling events, but in 1994, filtered samples were also collected. The results of both types of samples are also summarized in Table 4-14 along with Class C surface water standards. Antimony and copper were only detected in single filtered samples. Other metals were detected in higher concentrations in the unfiltered samples (e.g., aluminum, arsenic, iron, lead, silver, and zinc). There were several more soluble metals whose concentrations were similar in the unfiltered and filtered samples, such as barium, calcium, magnesium, manganese, potassium, and sodium. Exceedances of state surface water quality standards, except for iron, were only noted at single sample locations. Bis(2-ethylhexyl)phthalate, detected at OU2SW6 at 6 μg/L, barely exceeded the standard of 5.9 μg/L. 4,4'-DDD, detected at 0.028 μg/L at OU2SW3, exceeded the standard of 0.00084 μg/L. Heptachlor epoxide, detected at 0.0019 μg/L at OU2SW4, exceeded the standard of 0.00011 μg/L. Copper, detected at 25 μg/L at OU2SW3, exceeded the standard of 3 μg/L. Iron concentrations routinely exceeded the standard of 1,000 μg/L. Silver, detected at 3.4 μg/L at 10SW04, exceeded the standard of 0.1 μg/L. Based on all data collected for Turkey Gut, these were the only exceedances of state surface water quality standards.

4.3.2 Slocum Creek

Seven locations were sampled during the environmental investigation of surface water quality in Slocum Creek, which is a Class SC tidal salt water (Table 4-13, Plate 2 and Figure 2-1). None of the locations were sampled multiple times. The results are summarized in Table 4-15 along with Class SC surface water standards. Eight volatile organic compounds were detected at maximum concentrations of 12 μg/L or less. Five of the eight volatile organics were only detected in the sample collected from location 10SW01 in 1990, as follows:

- Chlorobenzene (4 μg/L)
- 1,1-Dichloroethane (6 μg/L)
- Trichloroethene (4 μg/L)
- 1,2-Dichloroethene (total) (8 μg/L)
- Vinyl chloride (12 μg/L)

TABLE 4-15

SUMMARY OF ANALYTICAL RESULTS - SLOCUM CREEK SURFACE WATER[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Unfiltered				Filtered				NC Class SC Standard/ Criteria[4]
	Concentration Range	Frequency of Detection	Average of Positive Detections	Location of Maximum/Date	Concentration Range	Frequency of Detection	Average of Positive Detections	Location of Maximum/Date	
Volatile Organics (µg/L)									
Acetone	3	1/3	3	OU2SW7/1994	NA[2]	--	--	--	NR[6]
Chlorobenzene	4	1/7	4	10SW01/1990	NA	--	--	--	21,000
1,1-Dichloroethane	6	1/7	6	10SW01/1990	NA	--	--	--	19.8
Trichloroethene	4	1/7	4	10SW01/1990	NA	--	--	--	81
1,2-Dichloroethene (total)	8	1/2	8	10SW01/1990	NA	--	--	--	NR
cis-1,2-Dichloroethene	1 - 2	2/3	1.5	OU2SW1/1994	NA	--	--	--	NR
Vinyl chloride	12	1/5	12	10SW01/1990	NA	--	--	--	525
Chloroform	1	3/7	1	OU2SW1/2/7/ 1994	NA	--	--	--	470
Pesticides/PCBs (µg/L)									
4,4'-DDD*	0.027 - 0.039	3/5	0.033	OU2SW1/1994	NA	--	--	--	0.00084
Inorganics (µg/L)									
Antimony	ND[3]	--	--	--	7.4	1/3	7.4	OU2SW7/1994	4,300
Arsenic	5.0 - 6.0	3/7	5.6	10SW06A/1987	ND	--	--	--	50
Barium	37.0 - 60.0	3/3	51.0	OU2SW2/1994	28.0 - 37.0	3/3	32.0	OU2SW7/1994	NR[5]
Cadmium*	5.9	1/7	5.9	10SW01/1990	ND	--	--	--	5
Calcium	132,000 - 135,000	3/3	134,000	OU2SW2/7/1994	138,000 - 144,000	3/3	140,333	OU2SW7/1994	NR
Copper*	28.0	1/7	28.0	OU2SW7/1994	23.0 - 37.0	3/3	27.7	OU2SW7/1994	3
Iron	106 - 158	2/3	132	OU2SW7/1994	ND	--	--	--	NR

TABLE 4-15 (Continued)
SUMMARY OF ANALYTICAL RESULTS - SLOCUM CREEK SURFACE WATER[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Unfiltered				Filtered				NC Class SC Standard/ Criteria[4]
	Concentration Range	Frequency of Detection	Average of Positive Detections	Location of Maximum/Date	Concentration Range	Frequency of Detection	Average of Positive Detections	Location of Maximum/Date	
Lead	4.0	1/7	4.0	10SW02/1990	ND	--	--	--	25
Magnesium	379,000 - 407,000	3/3	396,000	OU2SW2/1994	395,000 - 414,000	3/3	401,667	OU2SW7/1994	NR
Manganese	350 - 432	3/3	383	OU2SW1/1994	6.0	2/3	6.0	OU2SW1/7/ 1994	NR
Mercury*	0.21	1/7	0.21	10SW02/1990	ND	--	--	--	0.025
Nickel*	20.2	1/7	20.2	10SW01/1990	ND	--	--	--	8.3
Potassium	116,000 - 123,000	3/3	120,333	OU2SW7/1994	116,000 - 124,000	3/3	119,000	OU2SW7/1994	NR
Sodium	2,950,000 - 3,150,000	3/3	3,073,333	OU2SW2/1994	3,090,000 - 3,210,000	3/3	3,140,000	OU2SW7/1994	NR
Zinc	ND	--	--	--	7.0	1/3	7.0	OU2SW1/1994	86
Cyanide*	140	1/5	140	10SW06A/ 1987	NA	--	--	--	1.0

1 Includes samples from locations 10SW06A, 10SW07A, 10SW01, 10SW02, OU2SW1, OU2SW2, and OU2SW7. Asterisk next to analyte indicates exceedance of state standard.
2 NA - Not analyzed.
3 ND - Not detected.
4 Reid, 1996.
5 NR - Not regulated; no standard.

Location 10SW01 is immediately downgradient of the confluence with Turkey Gut and in the vicinity of Study Areas E and F. The other volatile organics detected (acetone, cis-1,2-dichloroethene, and chloroform) were detected at maximum concentrations not exceeding 3 μg/L. It should be noted that two volatile organic compounds (cis-1,2-dichloroethene [2 μg/L] and chloroform [1 μg/L]) were detected at location OU2SW01, which is upstream of the study areas of concern. Semivolatile organic compounds were not detected in any of the surface water samples collected to date.

Although surface water samples collected during the 1994 sampling event were analyzed for pesticides and PCBs, 4,4'-DDD was the only targeted pesticide/PCB detected. 4,4'-DDD was noted in 3 of 5 samples analyzed at a concentration range of 0.027 to 0.039 μg/L. The maximum reported concentration was detected in a sample from location OU2SW1, the most upstream sampling location along Slocum Creek.

The results of the metals analysis of unfiltered and filtered surface water samples are included in Table 4-14. Filtered surface water samples were collected only during the 1994 sampling event. With the exception of the macronutrients (e.g., calcium), antimony, copper, and zinc, the maximum and average concentrations reported for the unfiltered samples exceed those reported for the filtered samples. This may reflect the metals content of suspended particulates in the unfiltered samples. Most of the maximum metals concentrations reported for the filtered samples were noted in a sample collected from location OU2SW7. Location OU2SW7 is approximately 500 feet downstream of the confluence with Turkey Gut and in the vicinity of Study Area F. Most of the heavy or toxic metals were detected at maximum concentrations in unfiltered samples from sampling locations in the vicinity of/ or downstream from the confluence with Turkey Gut. Most toxic heavy metals (e.g., arsenic, lead, cadmium, mercury, nickel, chromium) were not detected in the unfiltered or filtered surface water samples collected from the most upstream location on Slocum Creek (OU2SW1) sampled during the 1994 field event.

The surface water quality standard for 4,4'-DDD (0.00084 μg/L) was exceeded in all samples collected in 1994 (0.027 to 0.039 μg/L), including the sample location upstream of OU2. The standard for cadmium (5 μg/L) was only exceeded in one unfiltered sample (10SW01 at 5.9 μg/L in 1990). The standard for copper (3 μg/L) was exceeded in one unfiltered sample (OU2SW7 at 28 μg/L in 1994) and all filtered samples (23 to 37 μg/L in 1994). There were single exceedances of the standards for mercury (10SW02 in 1990), nickel (10SW01 in 1990), and cyanide (10SW06A in 1987). These were the only exceedences based on all historical data.

4.4 SEDIMENT

A sediment sampling program was conducted in parallel with the surface water sampling program at this site. The analytical program is summarized in Table 4-16. Appendix H.6 contains the complete sediment analytical data base, and the results are summarized in this section. All sample locations are shown in Plate 2 and Figure 2-1.

4.4.1 Turkey Gut

Table 4-17 presents the results of the analysis of sediment samples collected from Turkey Gut throughout all investigations of this site. Six volatile organic compounds and one semivolatile organic compound (di-n-butyl phthalate) were detected at a maximum concentration of 75 μg/kg, except for 2-butanone (maximum concentration [C_{max}] = 540 μg/kg) and di-n-butyl phthalate (C_{max}= 640 μg/kg). Volatile/semivolatile organics were detected at maximum concentrations at either location 10SD04 or location 10SD05, which are downgradient or in the vicinity of Study Areas B, C, and E. The following four volatile organic compounds were detected in one sample only:

- Ethylbenzene (11 μg/kg)
- 1,1-Dichloroethane (19 μg/kg)
- Chloroethane (75 μg/kg)
- Carbon disulfide (20 μg/kg)

Xylene, 2-butanone, and di-n-butyl phthalate were the only volatile/semivolatile organics detected in more than one sample analyzed. As discussed in Section 4.3.1, ethylbenzene, 1,1-dichloroethane, and chloroethane were also detected in surface water samples collected from Turkey Gut. However, with the exception of di-n-butyl phthalate, volatile/semivolatile organic compounds were not detected in sediment samples collected during the 1994 field sampling event.

In contrast to the surface water results presented for Turkey Gut (three low-concentration positive detections only), eleven pesticides were detected in sediment samples collected from four locations during the 1994 sampling event. The pesticides detected in 1994 and their maximum concentrations are as follows: α-chlordane (25 μg/kg), γ-chlordane (8.8 μg/kg), 4,4'-DDD (3.4 μg/kg), 4,4'-DDE (1.4 μg/kg), 4,4'-DDT (0.2 μg/kg), dieldrin (22 μg/kg), endosulfan II (0.24 μg/kg), endrin aldehyde (0.40 μg/kg), endrin ketone (1.2 μg/kg), heptachlor (0.15 μg/kg), and heptachlor epoxide (16 μg/kg). None of the pesticides listed in Table 4-17 were detected at maximum concentrations exceeding 25 μg/kg. Four of the pesticides listed

TABLE 4-16

SUMMARY OF SEDIMENT SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Sample Number	Date	Priority Pollutants[1]	Ketones[2]	Cr+6	TCL Volatiles	Other TCL Organics	TAL Metals	TOC
10SD03A	10/85	X[3]	X	X				
10SD03A	03/87	X[3]	X	X				
10SD06A	03/87	X[3]	X	X				
10SD07A	03/87	X[3]	X	X				
10SD01	1990				X		X	X
10SD02	1990				X		X	X
10SD03	1990				X		X	X
10SD03-D	1990				X			
10SD04	1990				X		X	X
10SD05	1990				X		X	X
10SD06	1990				X		X	X
OU2SD1	1994				X	X	X[3]	
OU2SD2	1994				X	X	X[3]	
OU2SD3	1994				X	X	X[3]	
OU2SD4	1994				X	X	X[3]	
OU2SD5	1994				X	X	X[3]	
OU2SD6	1994				X	X	X[3]	
OU2SD7	1994				X	X	X[3]	

1 Includes xylenes.
2 Includes 2-butanone and 4-methyl-2-pentanone.
3 Includes cyanide.
Note: An "X" indicates the analytical parameters for each sample. See Appendix G for lists of various analytical programs (e.g., priority pollutants, TCL, TAL).

TABLE 4-17

SUMMARY OF ANALYTICAL RESULTS - TURKEY GUT SEDIMENT[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection/Date
Volatile Organics (µg/kg)				
2-Butanone	3/10	191	9 - 540	10SD04/1990
Ethylbenzene	1/10	11	11	10SD05/1990
Xylenes (total)	2/10	24	5 - 43	10SD04/1990
1,1-Dichloroethane	1/10	19	19	10SD04/1990
Chloroethane	1/10	75	75	10SD04/1990
Carbon disulfide	1/8	20	20	10SD04/1990
Semivolatile Organics (µg/kg)				
Di-n-butylphthalate	4/6	494	350 - 640	OU2SD5/1994
Pesticides/PCBs (µg/kg)				
α-Chlordane	4/4	6.67	0.36 - 25	OU2SD3/1994
γ-Chlordane	4/4	3.1	0.34 - 8.8	OU2SD3/1994
4,4'-DDD	3/5	1.48	0.45 - 3.4	OU2SD4/1994
4,4'-DDE	3/5	0.87	0.42 - 1.4	OU2SD5/1994
4,4'-DDT	1/6	0.20	0.20	OU2SD5/1994
Dieldrin	3/6	7.9	0.52 - 22	OU2SD3/1994
Endosulfan II	1/6	0.24	0.24	OU2SD5/1994
Endrin aldehyde	1/6	0.40	0.40	OU2SD5/1994
Endrin ketone	1/4	1.2	1.2	OU2SD5/1994
Heptachlor	2/6	0.14	0.13 - 0.15	OU2SD6/1994
Heptachlor epoxide	1/6	16	16	OU2SD3/1994
Inorganics (mg/kg)				
Aluminum	8/8	7230	1,630 - 11,100	OU2SD3/1994
Antimony	2/9	15.0	10.0 - 20.0	10SD03A/1985
Arsenic	7/9	3.3	1.2 - 7.2	10SD05/1990
Barium	8/8	30.7	12.6 - 92.1	10SD04/1990
Beryllium	1/9	0.20	0.20	10SD03A/1985
Cadmium	2/9	2.5	1.4 - 3.6	10SD05/1990
Calcium	8/8	4208	348 - 12,000	10SD06/1990
Chromium	9/9	11.1	2.0 - 24.6	10SD05/1990
Cobalt	1/7	2.3	2.3	10SD05/1990

TABLE 4-17 (Continued)
SUMMARY OF ANALYTICAL RESULTS - TURKEY GUT SEDIMENT[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection/Date
Copper	6/9	4.0	2.0 - 6.6	10SD05/1990
Iron	8/8	8480	1,930 - 18,200	OU2SD3/1994
Lead	8/10	22.5	6.55 - 52.5	10SD05/1990
Magnesium	8/8	494	155 - 930	OU2SD3/1994
Manganese	8/8	45.1	6.4 - 182	10SD04/1990
Mercury	2/9	0.14	0.10 - 0.17	OU2SD5/1994
Nickel	2/10	9.5	4.3 - 14.7	10SD04/1990
Potassium	7/7	400	123 - 679	OU2SD6/1994
Selenium	1/9	0.70	0.70	OU2SD5/1994
Sodium	6/8	304	40.7 - 1,090	OU2SD3/1994
Vanadium	8/8	15.9	4.8 - 26.7	OU2SD6/1994
Zinc	10/10	23.5	2.0 - 73.1	10SD04/1990

1 Includes samples from locations 10SD03A, 10SD03, 10SD04, 10SD05, 10SD06, 0U2SD3, OU2SD4, OU2SD5, and OU2SD6.

(4,4'-DDT, endosulfan II, endrin aldehyde, and heptachlor) were reported at maximum concentrations below 1 μg/kg. α-Chlordane, γ-chlordane, 4,4'-DDD, 4,4'-DDE, and dieldrin were the pesticides detected most frequently. Several pesticides (4,4'-DDE, 4,4'-DDT, endosulfan II, endrin aldehyde, and endrin ketone) were reported at their maximum concentrations in the sample collected at the most upstream sampling location (OU2SD5); all other locations are downstream of OU2SD5. This suggests that the pesticides may be present as the result of the widespread use of pesticides in the environment and are not strictly the result of study area activities.

Metals concentrations in sediment samples collected from nine locations along Turkey Gut are presented in Table 4-17. Several of the heavy/toxic metals (arsenic, cadmium, chromium, cobalt, copper, and lead) were detected at maximum concentrations at location 10SD05 (1990 sample). This location is downstream of Study Areas B and C. However, maximum detections of mercury and selenium were detected at location OU2SD5, which is the most upstream sampling location on Turkey Gut. Several metals were detected in the sediment samples at maximum concentrations that were two or more times the soil background UCL concentrations. These metals were antimony, barium, cadmium, copper, lead, manganese, nickel, vanadium, and zinc. However, overall, the concentrations of most metals in the sediments of Turkey Gut were not indicative of a major contamination problem. Some metals were found at the greatest concentrations in Turkey Gut, while others were found at the highest concentrations in Slocum Creek.

4.4.2 Slocum Creek

Three volatile organic compounds (2-butanone, chlorobenzene, and methylene chloride), two semivolatile organic compounds (bis[2-ethylhexyl] phthalate and di-n-butyl phthalate), and three pesticides (α-chlordane, 4,4'-DDD, and 4,4'-DDE) were detected in Slocum Creek sediment samples. The maximum detected concentrations of volatile organics, semivolatile organics, and pesticides did not exceed 100 μg/kg, 1,000 μg/kg, and 10 μg/kg, respectively. With the exception of di-n-butyl phthalate, organics were not detected in more than one of the samples analyzed. 2-Butanone (13 μg/kg), di-n-butyl phthalate (800 μg/kg), and 4,4'-DDD (2.7 μg/kg) were detected in the sediment sample from the most upstream location on Slocum Creek (OU2SD1). It should also be noted that chlorobenzene and 4,4'-DDD were also found in the surface water samples collected from Slocum Creek.

The results of the metals analysis of sediment samples collected along Slocum Creek are included in Table 4-18. Most of the heavy or toxic metals (i.e., arsenic, lead, cadmium, mercury, nickel, chromium) were detected at maximum concentrations in samples from locations in the vicinity of or downstream of the confluence with Turkey Gut. Heavy metals concentrations at the most upstream location along Slocum Creek (OU2SD1) are generally lower than those noted at downstream sampling locations. A number of

TABLE 4-18

SUMMARY OF ANALYTICAL RESULTS - SLOCUM CREEK SEDIMENT[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection/Date
Volatile Organics (µg/kg)				
2-Butanone	1/7	13	13	OU2SD1/1994
Chlorobenzene	1/7	61	61	10SD02/1990
Methylene chloride	1/7	16	16	10SD06A/1987
Chloromethane	1/7	16	16	10SD006/1987
Semivolatile Organics (µg/kg)				
Bis(2-ethylhexyl)phthalate	1/5	430	430	OU2SD7/1994
Di-n-butylphthalate	3/5	430	190 - 800	OU2SD1/1994
Pesticides/PCBs (µg/kg)				
α-Chlordane	1/3	1.5	1.5	OU2SD7/1994
4,4'-DDD	1/4	2.7	2.7	OU2SD1/1994
4,4'-DDE	1/5	2.8	2.8	OU2SD7/1994
Inorganics (mg/kg)				
Aluminum	5/5	2,289	382 - 8,760	OU2SD7/1994
Antimony	1/7	10.6	10.6	10SD01/1990
Arsenic	5/7	8.1	0.30 - 32.7	10SD01/1990
Barium	5/5	10.6	1.1 - 35.8	OU2SD7/1994
Calcium	5/5	1,732	136 - 6,540	OU2SD7/1994
Chromium	3/7	21.7	1.7 - 57.5	OU2SD7/1994
Cobalt	1/5	3.4	3.4	OU2SD1/1994
Copper	2/7	10.9	3.9 - 17.9	OU2SD7/1994
Iron	5/5	11,122	932 - 32,600	10SD01/1990
Lead	4/7	13.5	1.2 - 37.7	OU2SD7/1994
Magnesium	4/5	1,036	93.7 - 2,650	OU2SD7/1994
Manganese	5/5	111	3.3 - 394	OU2SD7/1994
Mercury	1/7	0.60	0.60	OU2SD7/1994
Nickel	1/7	3.0	3.0	10SD06A/1987
Potassium	3/5	444	93.6 - 956	OU2SD7/1994
Selenium	1/7	0.89	0.89	OU2SD7/1994
Sodium	5/5	3,006	155 - 8,250	OU2SD7/1994
Vanadium	2/5	3.5	1.7 - 5.2	10SD01/1990
Zinc	6/7	26.1	1.0 - 113	OU2SD7/1994

1 Includes samples from locations 10SD06A, 10SD07A, 10SD01, 10SD02, OU2SD1, OU2SD2, and OU2SD7.

metals were detected at maximum concentrations in Slocum Creek that were two or more times higher than the background soil UCL concentrations. These metals were antimony, arsenic, barium, chromium, cobalt, copper, lead, manganese, mercury, and zinc. These results indicate that Slocum Creek sediment has been affected by discharges of metals, but since metals were not significant surface soil contaminants, the source may not be related to OU2.

4.5 LEACHATE SEEPS

Water and sediment from several leachate seeps were sampled and analyzed during the RIIR. Three locations (10LW/LS01, 10LW/LS02, and 10LW/LS04) were identified and sampled in January and October 1985 and March 1987. A fourth location (10LW/LS05) was sampled only during the last two events.

In January 1985, the leachate seep water and sediment were analyzed for selected metals (cadmium, chromium, copper, lead, nickel, silver, and zinc) and total phenolics. In addition, the leachate water samples were analyzed for TOC and TOX. In October 1985 and March 1987, the analytical list was expanded. The four seep water and sediment samples were analyzed for priority pollutant organics and metals, 2-butanone, 4-methyl-2-pentanone, xylenes, ethylene dibromide, and hexavalent chromium.

As part of the final RI sampling activities conducted in 1995, additional leachate water and sediment samples were collected. Samples were collected of water (if present) or sediment (if not water present) from near four locations sampled during the RIIR. Each of these samples (OU2LW01, OU2LW02, OU2LW02-D, OU2LS04, and OU2LS05) along with a water sample from a new location (OU2LW06) were analyzed for the full TCL/TAL, including cyanide.

Leachate seep water and sediment (soil at dry seep location) were again sampled in July 1995. Soil/sediment samples were collected at locations OU2-LS04 and OU2-LS05, which are close to locations 10LW/LS04 and 10LW/LS05. Water samples were collected at locations OU2-LW01, OU2-LW02, and OU2-LW06. Locations OU2-LW01 and OU2-LW02 are near locations 10LW/LS01 and 10LW/LS02.

Table 4-19 contains a summary of the analytical program for the leachate seep water and sediment samples. All sample locations are presented in Figure 2-1 and Plate 2, and the complete chemical analytical data base is contained in Appendix H.7.

Tables 4-20 and 4-21 summarize the results of the leachate seep sampling conducted in 1985 through 1987 and 1995. The results indicate that several volatile organics were detected in 10LW01 and 10LW05, which were located near the 10GW09/OU2MW4 well cluster at the upstream portion of Slocum Creek and in the slope near Study Area F on the north side of Turkey Gut, respectively. In addition, some high

TABLE 4-19
SUMMARY OF LEACHATE SEEP SAMPLING PROGRAM
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Sample Number	Sample Date	Selected Metals[1]	Phenolics	TOC/ TOX	Priority Pollutants	Ketones[2]	Cr+6	TCL Organics[6]	TAL Metals
Leachate Water									
10LW01	01/85	X	X	X					
10LW01	10/85		X	X	X[3,4]	X	X		
10LW01	03/87		X	X	X[3,4]	X	X		
10LW02	01/85	X	X	X					
10LW02	10/85		X	X	X[3,4]	X	X		
10LW02	03/87		X	X	X[3,4]	X	X		
10LW04	01/85	X	X	X					
10LW04	10/85		X	X	X[3,4]	X	X		
10LW04	03/87		X	X	X[3,4]	X	X		
10LW05	10/85		X	X	X[3,4]	X	X		
10LW05	03/87		X	X	X[3,4]	X	X		
OU2LW01	07/95							X	X[4]
OU2LW02	07/95							X	X[4]
OU2LW02-D	07/95							X	X[4]
OU2LW06	07/95							X	X[4]
Leachate Sediment									
10LS01	01/85	X	X						
10LS01	10/85		X		X[4,5]	X	X		
10LS01	03/87		X		X[4,5]	X	X		
10LS02	01/85	X	X						
10LS02	10/85		X		X[4,5]	X	X		
10LS02	03/87		X		X[4,5]	X	X		
10LS04	01/85	X	X						
10LS04	10/85		X		X[4,5]	X	X		
10LS04	03/87		X		X[4,5]	X	X		
10LS05	10/85		X		X[4,5]	X	X		
10LS05	03/87		X		X[4,5]	X			
OU2LS04	07/95							X	X[4]
OU2LS05	07/95							X	X[4]

1 Includes cadmium, chromium, copper, lead, nickel, silver, and zinc.
2 Includes 2-butanone and 4-methyl-2-pentanone.
3 Includes xylenes and ethylene dibromide.
4 Includes cyanide.
5 Includes xylenes.
6 Volatiles, semivolatiles, and pesticides/PCBs.
Note: An "X" indicates the analytical parameters for each sample. See Appendix G for lists of various analytical programs (e.g., priority pollutants, TCL, TAL).

TABLE 4-20

SUMMARY OF ANALYTICAL RESULTS - LEACHATE SEEP WATER (1985-1987)[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection
Volatile Organics (µg/L)				
Benzene	2/7	40	12 - 68	10LW01
Chlorobenzene	1/7	72	72	10LW05
1,1-Dichloroethane	2/7	20	13 - 26	10LW01
Chloroethane	1/7	23	23	10LW01
Semivolatile Organics (µg/L)				
2,4-Dimethylphenol	1/8	14	14	10LW05
Inorganics (µg/L)				
Arsenic	7/11	41.1	1.0 - 260	10LW01
Copper	1/11	40.0	40.0	10LW05
Zinc	6/11	32.5	5.0 - 130	10LW01
Cyanide	2/11	40.5	7.0 - 74.0	10LW05

1 Includes samples 10LW01 (01/85, 10/85, 03/87); 10LW02 (01/85, 10/85, 03/87); 10LW04 (01/85, 10/85, 03/87); 10LW05 (10/85, 03/87).

TABLE 4-21

SUMMARY OF ANALYTICAL RESULTS - LEACHATE SEEP SEDIMENT (1985-1987)[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection
Volatile Organics (µg/kg)				
Chlorobenzene	1/8	560	560	10LS05
Methylene chloride	1/14	8	8	10LS02
Pesticides/PCBs (µg/kg)				
Aroclor-1254	2/8	555	300 - 810	10LS05
Inorganics (mg/kg)				
Antimony	6/8	35.0	10.0 - 70.0	10LS01
Arsenic	8/8	3.7	0.40 - 11.3	10LS05
Beryllium	3/8	0.47	0.40 - 0.50	10LS04
Cadmium	8/11	1.3	0.80 - 2.0	10LS02
Chromium	10/11	13.5	2.0 - 46.0	10LS05
Chromium +6	4/7	0.58	0.30 - 1.0	10LS01
Copper	11/11	14.5	2.0 - 39.0	10LS05
Lead	8/11	49.2	0.31 - 140	10LS05
Mercury	2/8	0.10	0.10	10LS05
Nickel	6/11	10.2	5.0 - 18.0	10LS05
Silver	3/11	1.67	1.0 - 2.0	10LS05
Thallium	1/6	10.0	10.0	10LS05
Zinc	10/11	36.3	7.0 - 92.0	10LS02

1 Includes samples 10LS01 (01/85, 10/85, 03/87); 10LS02 (01/85, 10/85, 03/87); 10LS04 (01/85, 10/85, 03/87); 10LS05 (10/85, 03/87).

concentrations of metals were observed in the leachate water samples. These results appear to indicate that contaminated groundwater from the landfill area is discharging to the ground surface and reaching surface water bodies via overland flow (in addition to direct groundwater discharge to the creeks).

The leachate sediment samples notably contained PCBs (in samples 10LS05 [810 μg/kg] and 10LS02 [300 μg/kg]). However, PCBs were not detected in subsurface soils or groundwater samples collected at this site. While these may be considered somewhat anomalous, the metals concentrations may not be. The concentrations of metals in the leachate seep sediments were similar to the ranges reported in the onsite subsurface soil samples. The chemical analytical results indicate that there is little difference between the leachate seep sediments and the natural surface soil at the site.

Tables 4-22 and 4-23 summarize the results of the leachate water and sediment samples collected in 1995. Samples OU2LW01 was collected from a true seep on the slope of the landfill. This sample contained several volatile organics at low concentrations (2 μg/L benzene, 3 μg/L vinyl chloride, and 5 μg/L chloroethane. This sample location, again, is a trickle of water located near wells 10GW09 and OU2MW4, and the chemical results are fairly consistent with those reported in the 1980s, although the concentrations are somewhat lower.

Samples OU2LW02 and OU2LW06 were collected from two areas of ponded water. One of a pair of duplicate samples contained xylenes (2 μg/L) and several pesticides at concentrations below 0.3 μg/L. None of these analytes were detected in the other of the pair. No organic analyte were detected in sample OU2LW06.

Sample OU2LW01 contained the highest concentrations of all detected metals except thallium. This result would be expected, given that it was collected from an actual seep (versus ponded water). Many of the metals found in the leachate sample OU2LW01 were present at concentrations that exceeded state groundwater standards and/or federal drinking water standards (cadmium, iron, and manganese).

The sediment samples collected from previously identified (but now dry) leachate seep locations were similar in concentration to surface soil samples discussed in Section 4.1. Only a few organic compounds were detected (monocyclic aromatics, trihalomethanes, phthalate esters, and pesticides) at low concentrations. The organic compounds detected at the highest concentrations in these samples were 4,4'-DDE (69 μg/kg), di-n-octylphthalate (67 μg/kg), and toluene (42 μg/kg). The concentrations of all other organics ranged from 7.6 μg/kg (endosulfan I) to 25 μg/kg (γ-chlordane).

TABLE 4-22

SUMMARY OF ANALYTICAL RESULTS - LEACHATE SEEP WATER (1995)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	OU2LW01	OU2LW02[1]	OU2LW06
Volatile Organics (μg/L)			
Benzene	2	ND[2]	ND
Xylenes	ND	2	ND
Chloroethane	5	ND	ND
Vinyl chloride	3	ND	ND
Pesticides/PCBs (μg/L)			
Aldrin	ND	0.0625	ND
γ-BHC	ND	0.0725	ND
4,4'-DDT	ND	0.17	ND
Dieldrin	ND	0.155	ND
Endrin	ND	0.165	ND
Heptachlor	ND	0.0775	ND
Inorganics (μg/L)			
Aluminum	1,310	360.5	495
Antimony	9.4	ND	ND
Arsenic	3.9	2.3	2.2
Barium	76.8	5.2	11.7
Cadmium	24.2	0.8	3.1
Calcium	36,500	3,705	8,350
Chromium	5.6	0.85	5.0
Cobalt	6.5	ND	ND
Copper	62.6	3.3	9.3
Iron	40,400	1,015.5	558
Lead	24.1	3.9	5.3
Magnesium	2,580	681	944
Manganese	494	62.65	80.2
Nickel	97.9	0.85	1.2

TABLE 4-22 (Continued)
SUMMARY OF ANALYTICAL RESULTS - LEACHATE SEEP WATER (1995)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	OU2LW01	OU2LW02[1]	OU2LW06
Potassium	4,470	1,860	2,770
Selenium	2.6	2.3	ND
Sodium	5,640	1,240	1,900
Thallium	ND	1.95	ND
Vanadium	6.0	2.15	2.3
Zinc	813	26.3	58.2

1 Results reported are the average of duplicate sample results calculated using one-half the detection limit for non-detects.
2 ND - Not detected.

TABLE 4-23

SUMMARY OF ANALYTICAL RESULTS - LEACHATE SEEP SEDIMENT (1995)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	OU2LS04-0001	OU2LS05-0001
Volatile Organics (μg/kg)		
Toluene	ND[1]	42
Xylenes	ND	11
Chloroform	ND	9
Semivolatile Organics (μg/kg)		
2,4-Dinitrophenol	850	ND
4-Nitrophenol	850	ND
Di-n-octylphthalate	67	ND
Pesticides/PCBs (μg/kg)		
α-Chlordane	ND	12
γ-Chlordane	ND	25
4,4'-DDE	ND	69
Dieldrin	ND	20
Endosulfan I	ND	7.6
Inorganics (mg/kg)		
Aluminum	1,190	5,030
Antimony	ND	3.6
Arsenic	1.1	17.1
Barium	3.3	103
Cadmium	ND	1.8
Calcium	54.4	2,220
Chromium	2.2	7.1
Cobalt	0.22	1.0
Copper	0.79	16.0
Iron	1,520	40,500
Lead	3.1	76.5

TABLE 4-23 (Continued)
SUMMARY OF ANALYTICAL RESULTS - LEACHATE SEEP SEDIMENT (1995)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	OU2LS04-0001	OU2LS05-0001
Magnesium	64.2	1,770
Manganese	3.8	23.3
Mercury	ND	1.0
Nickel	0.35	4.6
Potassium	ND	1,090
Selenium	ND	3.1
Silver	ND	1.0
Sodium	ND	424
Vanadium	3.2	16.6
Zinc	4.8	80.8

1 ND - Not detected.

The concentrations of metals in these two leachate seep sediment samples were also similar to those reported in the surface soils. However, some metals were found at higher concentrations in OU2LS05 than in the surface soils, while others were found at lower concentrations. Overall, for the sake of contamination assessment, they may be considered as one sample set. Some of the more notable metals detections in the leachate seep sediments include arsenic (17.1 mg/kg), lead (76.5 mg/kg), and zinc (80.8 mg/kg). For many of the metals, the higher concentrations were identified at location 10LS05, the same as was reported in the 1985-1987 data (Table 4-20).

4.6 POLISHING POND SEDIMENT

Eight sediment and soil samples were collected from the polishing ponds in 1994. These samples, designated OU2SD08 through OU2SD11, were each sampled at two depths. The uppermost sample (10 to 12 feet deep) was collected from the pond sediments, and the deeper sample (12 to 14 feet deep) was collected from the underlying natural soil material. All samples were analyzed for TCL organics, TAL metals, and cyanide. The analytical results are summarized in Table 4-24.

The data indicate that the sediments in the ponds contain a number of organic chemicals, while the underlying soil contains fewer organics at lower concentrations. For instance, the pond sediments contain ketones, monocyclic aromatics, phthalate esters, PAHs, and pesticides at concentrations ranging from 0.063 μg/kg (γ-BHC) to 13,000 μg/kg [bis(2-ethylhexyl)phthalate]. Sample OU2SD09-1012 contained the majority of the organic chemicals.

The underlying natural soil material contained 4 μg/kg chloroform, 130 μg/kg bis(2-ethylhexyl)phthalate, 255 μg/kg di-n-butylphthalate, 0.10 μg/kg α-chlordane, and up to 0.14 μg/kg heptachlor.

In general, it can be stated that the pond sediments contain higher concentrations of metals than the underlying soils. These data probably reflect the nature of the wastewaters treated in the polishing ponds. The concentrations of metals in the underlying soil are comparable with background soil results.

4.7 SUMMARY

This summary contains an overview of the chemical analytical data for various media at OU2. The focus is on surface soil (0 to 2 feet deep) and surface/subsurface soil (the top 10 feet, which are used in the risk assessment), the surficial and Yorktown aquifer data from 1994 and 1996 only (selected as that which is most representative of current site conditions), surface water and sediment data from both Turkey Gut and

TABLE 4-24

SUMMARY OF ANALYTICAL RESULTS - POLISHING POND SEDIMENT/SOIL
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Sediments[1]			Soil[2]		
	Concentration Range	Average of Positive Detections	Frequency of Detection	Concentration Range	Average of Positive Detections	Frequency of Detection
Volatile Organics (μg/kg)						
Acetone	1,300	1,300	1/4	ND[3]	--	--
2-Butanone	11 - 80	34.3	3/4	ND	--	--
Toluene	26	26	1/4	ND	--	--
Ethylbenzene	42	42	1/4	ND	--	--
Xylenes	44	44	1/4	ND	--	--
Chloroform	ND	--	--	4	4	1/4
Semivolatile organics (μg/kg)						
Bis(2-ethylhexyl)phthalate	120 - 13,000	3,590	4/4	130	130	1/4
Di-n-butylphthalate	180 - 350	250	4/4	200 - 290	255	4/4
Phenol	260	260	1/4	ND	--	--
Fluoranthene	250	250	1/4	ND	--	--
2-Methylnaphthalene	130	130	1/4	ND	--	--
Pesticides/PCBs (μg/kg)						
Aldrin	0.28 - 3.8	2.0	2/4	ND	--	--
γ-BHC	0.063 - 1.2	0.63	2/4	ND	--	--
α-Chlordane	0.66 - 15	7.8	2/4	0.10	0.10	1/4
γ-Chlordane	2.6	2.6	1/3	ND	--	--
4,4'-DDD	13	13	1/2	ND	--	--

TABLE 4-24 (Continued)
SUMMARY OF ANALYTICAL RESULTS - POLISHING POND SEDIMENT/SOIL
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Sediments[1]			Soil[2]		
	Concentration Range	Average of Positive Detections	Frequency of Detection	Concentration Range	Average of Positive Detections	Frequency of Detection
4,4'-DDE	0.19 - 16	5.5	3/3	ND	--	--
Dieldrin	0.53 - 9.4	5.0	2/4	ND	--	--
Endosulfan I	5.1	5.1	1/4	ND	--	--
Heptachlor	0.11	0.11	1/3	0.068 - 0.14	0.099	3/3
Methoxychlor	0.44	0.44	1/3	ND	--	--
Inorganics (mg/kg)						
Aluminum	5,330 - 9,810	8,040	4/4	2,920 - 4,410	3,580	4/4
Arsenic	2.3 - 3.3	2.8	2/4	1.3 - 2.3	1.9	4/4
Barium	10.2 - 25.6	15.8	4/4	5.0 - 7.2	5.75	4/4
Beryllium	0.34	0.34	1/4	ND	--	--
Cadmium	1.7 - 4.1	2.9	2/4	ND	--	--
Calcium	319 - 1,180	636	4/4	73.3 - 295	185	4/4
Chromium	14.0 - 78.5	32.4	4/4	3.8 - 11.7	7.55	4/4
Copper	2.3 - 17.4	6.7	4/4	1.2 - 1.6	1.47	3/4
Iron	3,340 - 14,500	8,312	4/4	2,690 - 6,720	4,368	4/4
Lead	3.2 - 7.1	5.0	4/4	1.9 - 3.7	2.4	4/4
Magnesium	264 - 514	417.4	4/4	148 - 220	184	4/4
Manganese	9.5 - 20.4	14.2	4/4	4.3 - 10.2	6.5	4/4
Mercury	0.12 - 0.85	0.485	2/4	ND	--	--
Nickel	10.3	10.3	1/4	ND	--	--
Potassium	328 - 616	453	4/4	244 - 262	235.5	4/4
Selenium	0.18 - 0.26	0.22	2/4	ND	--	--

TABLE 4-24 (Continued)
SUMMARY OF ANALYTICAL RESULTS - POLISHING POND SEDIMENT/SOIL
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Sediments[1]			Soil[2]		
	Concentration Range	Average of Positive Detections	Frequency of Detection	Concentration Range	Average of Positive Detections	Frequency of Detection
Silver	0.97 - 4.1	2.54	2/4	ND	--	--
Vanadium	14.8 - 36.8	23.3	4/4	8.5 - 13.0	9.9	4/4
Zinc	7.08 - 55.3	27.9	3/4	ND	--	--
Cyanide	1.8	1.8	1/4	ND	--	--

1 Includes sample OU2SD08-1012, OU2SD09-1012, OU2SD10-1012, OU2SD10-1012-D, and OU2SD11-1012. Duplicate sample resutls are averaged and counted as one sample.
2 Includes samples OU2SD08-1214, OU2SD09-1214, OU2SD10-1214, and OU2SD11-1214.
3 ND - Not detected.

Slocum Creek (1994 data only), and the leachate seep data. A series of data summary tables are included in this section to illustrate the nature and extent of contamination in each of these media.

4.7.1 Surface Soil and Dry Leachate Seep Soil

Surface soil analytical results are summarized in Table 4-25. The table incorporates the following samples:

- Two surface soil samples (0 to 6 inches) collected from Site 44A sludge application area
- Three surface soil samples (0 to 2 feet) collected during 1993 confirmation test pit sampling in hot spots
- Eleven surface soil samples (0 to 1 foot) collected in 1995
- Two leachate sediment samples (0 to 1 foot) collected in 1995
- Four surface soil samples (0 to 1 foot) collected in 1996.

All of these represent soils to which a casual site visitor could be exposed. Earlier leachate seep sediment samples are not included because the results were roughly similar and would not alter conclusions reached regarding levels of contamination.

Volatile organics were not frequently detected, nor were they found at high concentrations. Xylenes were the most frequently detected volatile organics (in 7 of 18 samples) and were found at a maximum concentration of 11 μg/kg. Toluene was the volatile organic found at the highest concentration (42 μg/kg). These low concentrations are typical in areas with warm temperatures and sandy soil. Any volatile organics released directly to surface soils would readily volatilize or migrate to the subsurface soils.

Several PAHs were detected in a single sample (OU2SS04-0001), at concentrations ranging from 140 μg/kg [indeno(1,2,3-cd)pyrene] to 360 μg/kg (pyrene). These chemicals may indicate the presence of an area where something was burned. In addition, one of the leachate sediment samples (OU2LS04) contained 67 μg/kg di-n-octylphthalate, and one of the surface soil samples (OU2SS13-0001) contained 190 μg/kg of the same phthalate. No other semivolatile organics were detected in surface soils at OU2. Again, this pattern is not unexpected at a landfill site that was most likely covered with clean soil.

The samples collected in 1995 and 1996 were the only samples analyzed for pesticides/PCBs. Several pesticides were also detected in the surface soils in concentrations generally below 30 μg/kg. A few pesticides were detected at higher concentrations (e.g., 4,4'-DDD and 4,4'-DDT), with a maximum reported concentration of 69 μg/kg (4,4'-DDE). The maximum concentrations of pesticides were found in various samples throughout the site.

TABLE 4-25

SUMMARY OF ANALYTICAL RESULTS - SURFACE SOIL AND DRY LEACHATE SEEP SOIL[1] (0 TO 2 FEET) - OPERABLE UNIT 2 MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection
Volatile Organics (μg/kg)				
Toluene	3/18	21.7	11 - 42	OU2LS05-0001
Xylenes	7/18	3.7	1 - 11	OU2LS05-00001
1,2-Dichloroethene (total)	1/18	20	20	10TP15-0002
Methylene chloride	1/18	12	12	10TP15-0002
Chloroform	1/18	9	9	OU2LS05-0001
Semivolatile Organics (μg/kg)				
2,4-Dinitrophenol	1/15	850	850	OU2LS04-0001
4-Nitrophenol	1/15	850	850	OU2LS04-0001
Di-n-octylphthalate	2/15	128.5	67 - 190	OU2SS13-0001
Benzo(a)anthracene	1/15	160	160	OU2SS04-0001
Benzo(b)fluoranthene	1/15	170	170	OU2SS04-0001
Benzo(k)fluoranthene	1/15	160	160	OU2SS04-0001
Benzo(g,h,i)perylene	1/15	250	250	OU2SS04-0001
Benzo(a)pyrene	1/15	240	240	OU2SS04-0001
Chrysene	1/15	220	220	OU2SS04-0001
Fluoranthene	1/15	270	270	OU2SS04-0001
Indeno(1,2,3-cd)pyrene	1/15	140	140	OU2SS04-0001
Pyrene	1/15	360	360	OU2SS04-0001
Pesticides/PCBs/Dioxins/Furans (μg/kg)				
α-Chlordane	7/15	8.9	1.9 - 27	OU2SS06-0001
γ-Chlordane	2/15	20.5	12 - 29	OU2SS06-0001
4,4'-DDD	2/15	23.4	3.8 - 43	OU2SS04-0001
4,4'-DDE	6/15	22.9	4.2 - 69	OU2LS05-0001
4,4'-DDT	7/15	14.4	4.7 - 35	OU2SS04-0001
Dieldrin	4/14	10.7	3.8 - 20	OU2LW05-0001
Endosulfan I	2/15	4.7	1.8 - 7.6	OU2LS05-0001
Endrin aldehyde	6/14	10.7	3.0 - 27	OU2SS02-0001

TABLE 4-25 (Continued)
SUMMARY OF ANALYTICAL RESULTS - SURFACE SOIL AND DRY LEACHATE SEEP SOIL[1]
(0 TO 2 FEET) - OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection
Heptachlor	1/15	2.0	2.0	OU2SS06-0001
Aroclor-1254	2/15	29.5	28 - 31	OU2SS12-0001
Aroclor-1260	1/15	630	630	OU2SS01-0001
OCDD	2/2	0.58	0.14 - 1.0	OU2SB10-0001
Total HpCDD	1/2	0.03	0.03	OU2SB10-0001
Inorganics (mg/kg)				
Aluminum	18/18	4,541	1190 - 13,000	10TP15-0002
Antimony	4/18	2.3	1.1 - 3.6	OU2LS05-0001
Arsenic	20/20	2.4	0.68 - 17.1	OU2LS05-0001
Barium	20/20	24.7	3.3 - 103	OU2LS05-0001
Beryllium	1/20	0.28	0.28	OU2SS03-0001
Cadmium	8/20	2.0	0.29 - 6.4	10TP15-0002
Calcium	17/18	20,416	210 - 209,000	OU2SS03-0001
Chromium	20/20	14.0	2.2 - 51.2	OU2SS08-0001
Cobalt	13/20	0.73	0.22 - 1.6	OU2SS07-001
Copper	18/20	11.0	1.51 - 50.8	OU2SS02-0001
Iron	18/18	8,552	1,520 - 54,700	OU2SS07-0001
Lead	17/20	29.3	3.8 - 76.5	OU2LS05-0001
Magnesium	14/18	678	236 - 2,180	OU2SS03-0001
Manganese	18/18	37.3	3.7 - 211	OU2SS07-0001
Mercury	10/18	0.30	0.06 - 1.0	OU2LS05-0001
Nickel	15/20	2.2	0.35 - 5.4	10TP16-0002
Potassium	12/18	578	189 - 1140	OU2SS03-0001
Selenium	6/20	0.98	0.30 - 3.1	OU2LS05-0001
Silver	2/20	2.1	0.43 - 3.7	44ASO03-0000
Sodium	8/18	124	40.3 - 424	OU2LS05-0001
Thallium	3/20	2.6	0.47 - 6.7	44ASO03-0000

TABLE 4-25 (Continued)
SUMMARY OF ANALYTICAL RESULTS - SURFACE SOIL AND DRY LEACHATE SEEP SOIL[1]
(0 TO 2 FEET) - OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection
Vanadium	19/20	9.7	3.2 - 24.2	10TP15-0002
Zinc	19/20	43.1	4.8 - 209	10TP23-0102

1 Includes samples 10TP15-0002, 10TP16-0002, 10TP23-0102, 44ASO03-0000, 44ASO04-0004, OU2SS01-0001 through OU2SS13-0001, OU2LS04-0001, OU2LS05-0001, OU2SB09-0001, and OU2SB10-0001 (22 samples).

Several metals were detected in these soil and leachate seep sediment samples at maximum concentrations that exceed twice the maximum background concentration, including barium, cadmium, chromium, copper, iron, lead, magnesium, manganese, selenium, sodium, thallium, and zinc.

Metals were more frequently detected, although the concentrations were not notably elevated above background levels. No particular patterns of contamination were noted; the maximum concentrations of individual metals were found in various locations.

4.7.2 Surface Soil, Subsurface Soil, and Dry Leachate Seep Soil (0 to 10 feet)

The earlier sections on soil (4.1.2 and 4.1.3) discussed all surface and subsurface soil sample results, respectively. This section focuses on samples collected from depths of 0 to 10 feet, which are the samples used in the human health risk assessment for exposure scenarios involving soil disturbance. Data from soil at dry leachate seeps is also included. Data on the deeper samples (i.e., more than 10 feet) are included in Section 4.1.3.

Table 4-26 indicates that a number of volatile organic compounds were detected in the soil samples collected from depths of 0 to 10 feet. Those compounds found at the greatest frequency were ketones and monocyclic aromatics. A soil sample collected from test pit 10TP18, located in the southern portion of the site near the area where fire training exercises were conducted, contained the highest concentrations of fuel-type (toluene, ethylbenzene, and xylenes) contaminants. This sample was collected from a depth of 9 to 10 feet, which is the zone immediately above the water table.

Another area that contained volatile organic contaminants was centered around boring 10SB-E63 and test pit 10TP15, on the south side of Turkey Gut in Study Area E. These samples contained the highest concentrations of 4-methyl-2-pentanone (1,000 μg/kg), 1,2-dichloroethane (13 μg/kg), benzene (130 μg/kg), 1,2-dichloroethene (4,700 μg/kg), vinyl chloride (490 μg/kg), and carbon disulfide (29 μg/kg).

Only one subsurface soil sample from this depth interval of 2 to 10 feet was analyzed for semivolatile organic compounds. This sample (10B03-0810) was found to contain phenol (12,000 μg/kg), 4-methylphenol (27,000 μg/kg), and 2,4-dimethylphenol (4,100 μg/kg). These compounds were found in the sludges removed from the former impoundment and were also detected in some of the groundwater samples from wells in this area. The remaining detections of semivolatile organics were limited to single detections in surface soil and dry leachate seep soil.

TABLE 4-26

SUMMARY OF ANALYTICAL RESULTS - SURFACE SOIL, SUBSURFACE SOIL, AND DRY LEACHATE SEEP SOIL (0 TO 10 FEET)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection
Volatile Organics (μg/kg)				
Acetone	19/90	295	4 - 2,300	10TP01-0709
2-Butanone	10/90	1,952	11 - 16,000	10TP02-0405
4-Methyl-2-pentanone	5/90	247	10 - 1,000	10TP15-0810
2-Hexanone	6/90	218	7 - 510	10TP01-0709
Benzene	6/90	35	4 - 130	10SB-E63-0204
Toluene	14/90	3,028	7.5 - 27,000	10TP18-0910
Ethylbenzene	11/90	14,073	7 - 140,000	10TP18-0910
Xylenes	25/90	20,232	1 - 450,000	10TP18-0910
Chlorobenzene	3/90	27	22 - 34	10TP23-0910
Styrene	1/90	5	5	10SB-E31-0406
1,1,1-Trichloroethane	9/90	286	3 - 2,500	10B02-0608
1,1-Dichloroethane	3/90	38.3	9 - 68	10SB-B5-0810
1,2-Dichloroethane	1/90	13	13	10TP15-0810
Chloroethane	1/90	14	14	10TB17-0910
Tetrachloroethene	1/90	38	38	10TP02-0405
Trichloroethene	5/90	367	5 - 860	10B02-0608
1,2-Dichloroethene (total)	7/90	923	5 - 4,700	10SB-E63-0204
Vinyl chloride	2/90	252	13 - 490	10SB-E63-0204
Methylene chloride	7/90	36,214	4 - 190,000	10TP18-0910
Chloroform	1/90	9	9	OU2LS05-0001
trans-1,3-Dichloropropene	1/90	98	98	10TP02-0405
Carbon disulfide	4/90	16.0	9 - 29	10SB-E63-0204
Semivolatile Organics (μg/kg)				
Phenol	1/16	12,000	12,000	10B03-0810
4-Methylphenol	1/16	27,000	27,000	10B03-0810
2,4-Dimethylphenol	1/16	4,100	4,100	10B03-0810
2,4-Dinitrophenol	1/16	850	850	OU2LS05-0001
4-Nitrophenol	1/16	850	850	OU2LS04-0001
Benzo(a)anthracene	1/16	160	160	OU2SS04-0001

TABLE 4-26 (Continued)
SUMMARY OF ANALYTICAL RESULTS - SURFACE SOIL, SUBSURFACE SOIL, AND DRY LEACHATE SEEP SOIL (0 TO 10 FEET)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection
Benzo(b)fluoranthene	1/16	170	170	OU2SS04-0001
Benzo(k)fluoranthene	1/16	160	160	OU2SS04-0001
Benzo(g,h,i)perylene	1/16	250	250	OU2SS04-0001
Benzo(a)pyrene	1/16	240	240	OU2SS04-0001
Chrysene	1/16	220	220	OU2SS04-0001
Fluoranthene	1/16	270	270	OU2SS04-0001
Indeno(1,2,3-cd)pyrene	1/16	140	140	OU2SS04-0001
Pyrene	1/16	360	360	OU2SS04-0001
Di-n-octylphthalate	2/16	128	67 - 190	OU2LS04-0001
Pesticides/PCBs/Dioxins/Furans (μg/kg)				
δ-BHC	1/16	4.6	4.6	10B03-0810
α-Chlordnae	7/16	8.9	1.9 - 27	OU2SS06-0001
γ-Chlordane	2/16	20.5	12 - 29	OU2SS06-0001
4,4'-DDD	2/16	23.4	3.8 - 43	OU2SS04-0001
4,4'-DDE	6/16	22.9	4.2 - 69	OU2LS05-0001
4,4'-DDT	8/16	28.9	4.7 - 130	10B03-0810
Dieldrin	5/15	19.2	3.8 - 53	10B03-0810
Endosulfan I	2/16	4.7	1.8 - 7.6	OU2LS05-0001
Endosulfan II	1/16	47	47	10B03-0810
Endosulfan sulfate	1/16	67	67	10B03-0810
Endrin	1/16	21	21	10B03-0810
Endrin aldehyde	6/14	10.7	3 - 27	OU2SS02-0001
Heptachlor	1/16	2	2	OU2SS06-0001
Heptachlor epoxide	1/15	18	18	10B03-0810
Aroclor-1254	2/16	29.5	28 - 31	OU2SS12-0001
Aroclor-1260	1/16	630	630	OU2SS01-0001
1,2,3,4,6,7,8-HpCDD	1/4	0.040	0.040	OU2SB10-0406
1,2,3,4,6,7,8-HpCDF	1/4	0.006	0.006	OU2SB9-0810
OCDD	4/4	0.5035	0.141 - 1.012	OU2SB10-0001
Total HpCDD	2/4	0.0335	0.026 - 0.040	OU2SB10-0406

TABLE 4-26 (Continued)
SUMMARY OF ANALYTICAL RESULTS - SURFACE SOIL, SUBSURFACE SOIL, AND DRY LEACHATE SEEP SOIL (0 TO 10 FEET)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection
Total HpCDF	1/4	0.0075	0.0075	OU2SB9-0810
Inorganics (mg/kg)				
Aluminum	32/32	7,083	1,190 - 18,500	10TP23-0910
Antimony	9/87	15.9	1.1 - 58.3	10TP23-0910
Arsenic	92/95	2.5	0.24 - 17.1	OU2LS05-0001
Barium	37/38	40.3	1.0 - 705	10TP23-0910
Beryllium	30/94	0.19	0.0925 - 0.49	10TP23-0910
Cadmium	25/100	9.0	0.29 - 119.5	10TP17-0910
Calcium	31/32	13,334	76.1 - 209,000	OU2SS03-0001
Chromium	97/100	15.1	1.2 - 122	H3/H4-C
Cobalt	19/36	2.1	0.22 - 16.7	10TP23-0910
Copper	64/100	43.3	0.24 - 902	10TP23-0910
Iron	32/32	9,148	1,190 - 54,700	OU2SS07-0001
Lead	91/100	54.9	0.82 - 1,650	10TP23-0910
Magnesium	28/32	760	236 - 3,440	10TP23-0910
Manganese	32/32	97.7	3.7 - 1,170	10TP23-0910
Mercury	19/90	0.69	0.06 - 4.1	10TP17-0910
Nickel	51/100	11.9	0.35 - 176	10SB-E35-0810
Potassium	21/32	698	189 - 2,040	10TP23-0910
Selenium	28/94	0.43	0.11 - 3.1	OU2LS05-0001
Silver	8/98	17.9	0.43 - 90.0	10TP15-0810
Sodium	16/32	319	38.5 - 2,250	10TP23-0910
Thallium	5/94	3.1	0.12 - 7.4	44ASO03-0203
Vanadium	35/36	12.6	3.2 - 27.2	10TP17-0910
Zinc	92/100	98.3	0.58 - 2,650	10TP23-0910

Pesticides were also analyzed in only one subsurface soil sample (10B03-0810). The remaining detections were found in surface soil and dry leachate seep soil. These compounds were not detected at concentrations that indicate a major waste disposal problem, but rather the past application of pesticides to soil now buried or indicate disposal of materials containing small residues of pesticides. The maximum detected concentration of pesticides in soils from 0 to 10 feet deep was 130 μg/kg 4,4'-DDT, followed by 67 μg/kg endosulfan sulfate. All other detected concentrations of pesticides were 53 μg/kg or less.

The concentrations of metals in these samples were certainly greater than those measured in the background soil samples. Metals that would be considered to be elevated over background UCL concentrations include antimony (not detected in background samples), barium, lead, manganese, nickel, and zinc. These metals were found at maximum concentrations an order of magnitude greater than the UCL background soil concentrations. The maximum concentrations of most metals were found in 10TP23 at a depth of 9 to 10 feet below ground surface. This test pit is located in the northeastern corner of an unnamed study area between A, D, and E. The concentrations in surrounding borings BB3, BB5, and BB6 were much lower.

4.7.3 Surficial Aquifer

Analytical results from the most recent groundwater sampling event (1994 and 1996) in the surficial aquifer are summarized in Table 4-27 along with the state groundwater standard. This table indicates that the shallow groundwater at this site contains a number of volatile organic compounds at concentrations that exceed both Federal drinking water standards and state groundwater standards. The particular compounds of concern include several monocyclic aromatics and halogenated aliphatics. Some of the more prevalent contaminants identified in the shallow aquifer are benzene (detected in 21 of 46 samples at a maximum concentration of 230 μg/L), chlorobenzene (detected in 22 of 46 samples at a maximum concentration of 180 μg/L), 1,2- and 1,4-dichlorobenzene (15 of 76 and 26 of 79 samples, respectively, including detections in both the volatile and semivolatile fractions), 1,1-dichloroethane (18 of 46 samples at a maximum concentration of 79 μg/L), vinyl chloride, and cis-1,2-dichloroethene (16 of 46 samples at maximum concentrations of 26 and 140 μg/L, respectively), and trichloroethene (11 of 46 samples at a maximum concentration of 40 μg/L). The maximum detections of individual volatiles were found in a number of wells throughout the entire site.

Semivolatile organic compounds detected included several phenols, phthalate esters, and some of the more soluble PAHs (naphthalene and 2-methylnaphthalene). Nitrobenzene and bis(2-chloroethyl)ether were each detected in only one well. Well 10EGW5, which is located immediately downgradient of the former sludge

TABLE 4-27

SUMMARY OF ANALYTICAL RESULTS - SURFICIAL AQUIFER (1994 AND 1996)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection	NC Class GA Standard[4]
Volatile Organics (µg/L)					
Acetone	3/9	19.0	7 - 32	OU2MW11	700
2-Butanone	2/17	76.0	69 - 83	OU2MW11	170
2-Hexanone*[5]	1/46	1	1	OU2MW10	> DL[6]
4-Methyl-2-pentanone*	5/46	17.0	3 - 64	OU2MW1	> DL
Benzene*	21/46	19.6	2 - 230	10GW09	1
Toluene	7/46	41.6	2 - 110	10GW47	1,000
Ethylbenzene*	7/46	13.0	1 - 38	OU2HP2	29
Xylenes	11/46	49.9	2 - 180	OU2HP3	530
Chlorobenzene*	22/46	42.3	1 - 180	10GW40	50
1,2-Dichlorobenzene[1]	15/76	8.5	0.75 - 28	OU2HP1	620
1,3-Dichlorobenzene[1]	2/79	2	2	OU2HP1	620
1,4-Dichlorobenzene[1]	26/79	10.7	2.5 - 40	OU2HP1	75
1,1,1-Trichloroethane	2/46	4	3 - 5	10EGW5	200
1,1-Dichloroethane	18/46	27.6	1 - 79	OU2MW11	700
1,2-Dichloroethane*	3/46	3.7	2 - 5	OU2MW10	0.38
Chloroethane*	12/46	27.3	1 - 90	10EGW02	> DL
Tetrachloroethene*	6/46	7.4	1 - 21	OU2HP6	0.7
Trichloroethene*	11/46	11.3	1 - 40	OU2MW11	2.8
1,1-Dichloroethene	1/46	2	2	OU2MW11	7
cis-1,2-Dichloroethene*	16/46	29.2	1 - 140	10EGW5	70
trans-1,2-Dichloroethene	6/46	1.8	0.75 - 3	OU2HP2	70
Vinyl chloride*	16/46	8.3	1 - 26	10EGW02	0.015
Methylene chloride	3/45	1.5	1 - 2	OU2MW16	5
1,2-Dichloropropane*	5/46	1.2	1 - 2	OU2MW11	0.56
Chloroform*	2/46	2	1 - 3	OU2MW14	0.19
Semivolatile Organics (µg/L)					
Phenol	4/33	8.3	3 - 16	10EGW5	300
2-Methylphenol*	2/33	8.5	6 - 11	10EGW5	> DL
4-Methylphenol*	5/33	32.7	3 - 65	10EGW5	> DL
2,4-Dimethylphenol*	4/33	77.3	4 - 280	OU2HP3	> DL
Bis(2-ethylhexyl)phthalate*	3/33	33.0	4 - 66	10GW34	3
Diethylphthalate	9/33	18.2	4 - 53	OU2HP1	5,000
2-Methylnaphthalene*	4/33	8.3	4 - 18	10EGW5	> DL
Naphthalene*	8/33	14.6	3 - 41	10GW47	21
Nitrobenzene*	1/33	5	5	10GW34	> DL
Bis(2-chloroethyl)ether*	1/33	3	3	OU2HP3	> DL

TABLE 4-27 (Continued)
SUMMARY OF ANALYTICAL RESULTS - SURFICIAL AQUIFER (1994 AND 1996)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection	NC Class GA Standard
Pesticides/PCBs (µg/L)					
Aldrin*	1/32	0.0034	0.0034	10GW35	> DL
α-BHC*	2/30	0.0094	0.0089 - 0.0098	10GW43	> DL
γ-BHC (Lindane)	2/28	0.024	0.0089 - 0.041	OU2HP1/HP3	0.2
α-Chlordane	5/30	0.0009	0.0054 - 0.014	OU2HP3	0.027
γ-Chlordane	1/31	0.0085	0.0085	OU2HP1	0.027
4,4'-DDE*	1/30	0.0092	0.0092	OU2HP1	> DL
4,4'-DDT*	1/31	0.01	0.01	S4W2	> DL
Endosulfan I*	1/32	0.0090	0.0090	OU2HP3	> DL
Endosulfan II*	3/26	0.021	0.0033 - 0.056	OU2HP1	> DL
Endrin	2/32	0.015	0.01 - 0.020	OU2HP3	2
Endrin aldehyde*	5/29	0.22	0.02 - 0.97	OU2MW11	> DL
Heptachlor	1/31	0.0055	0.0055	10GW43	0.008
Heptachlor epoxide*	2/30	0.012	0.0033 - 0.024	OU2HP2	0.004
Inorganics (µg/L)					
Aluminum	29/46	347	15.0 - 4,840	OU2MW15	NR[7]
Arsenic*	27/46	42.6	3.9 - 126	10EGW3	50
Barium	44/46	78.5	16.0 - 306	10GW41	2,000
Cadmium*	2/46	5.6	5.2 - 6.0	OU2HP1	5
Calcium	45/45	32,502	1,170 - 93,850	10GW39	NR
Cobalt	10/46	32.5	8.6 - 81.0	10GW27	NR
Copper	2/46	6.2	1.7 - 10.6	9GW31	1,000
Iron*	43/46	34,774	69.9 - 100,500	OU2MW11	300
Lead	9/46	2.8	0.75 - 7.3	10GW40	15
Magnesium	46/46	8,116	1,080 - 34,900	OU2HP2	NR
Manganese*	46/46	400	5.4 - 3,270	10GW31	50
Nickel	2/46	18.6	15.3 - 22.0	10GW36	100
Potassium	46/46	7,526	923 - 36,900	10GW40	NR
Sodium	46/46	27,452	1,070 - 95,900	10GW12	NR
Vanadium	4/46	6.0	1.8 - 9.0	OU2HP1	NR
Zinc	14/46	22.8	6.0 - 90.5	OU2HP4	2,100
Cyanide	1/46	28.0	28.0	10GW34	154
pH (units)*	37/37	5.95[2]	3.22 - 7.28	NA[3]	6.5 - 8.5

1 Measured in both volatile and semivolatile fraction.
2 Geometric average.
3 NA - Not applicable.
4 15A NCAC 2L.0200.
5 Asterisk next to analyte indicates exceedance of state standard.
6 > DL - Greater than detection limit. Any detection is considered an exceedance of the standard.
7 NR - Not regulated; no standard.

impoundments, contained the highest concentrations of several of the phenol compounds, and the wastes that were emplaced in that impoundment was known to contain such compounds.

A number of pesticides were detected in the samples from the surficial aquifer, but many were only found in single samples. The highest concentration of pesticides was 0.97 μg/L of endrin aldehyde, which was also the most frequently detected pesticide, found in 5 of 29 samples. Most pesticides were found at maximum concentrations of 0.02 μg/L or less.

Several metals were also detected at concentrations that exceeded either Federal drinking water standards or State groundwater standards. These metals include arsenic and cadmium (although the exceedances are neither widespread nor numerous), iron, and manganese.

The most recent data clearly indicate that volatile organics are the major concern in groundwater. Other contaminants, while detected, are not found frequently, nor are they found frequently at concentrations that exceed standards.

4.7.4 Yorktown Aquifer

Ten groundwater samples were collected from wells screened in the Yorktown aquifer during the 1994 sampling event. These results are summarized in Table 4-28 along with the state groundwater standard. The organic contaminants detected (chloroform, methylene chloride, and bis[2-ethylhexyl]phthalate) are all common laboratory contaminants, while BEHP is a commonly used plasticizer. However, none of these compounds were found in QA/QC blanks at levels that would affect the data. Chloroform was detected at concentrations of 1 μg/L (OU2MW3) and 2 μg/L (OU2MW6), methylene chloride at a concentration of 3 μg/L (OU2MW6), and BEHP at a concentration of 25 μg/L (10GW24). Chloroform and bis(2-ethylhexyl)phthalate exceeded the state standards.

The concentrations of all metals found in the Yorktown samples were below drinking water standards or State groundwater standards, except for iron and manganese, both of which have only secondary standards for aesthetic reasons.

4.7.5 Surface Water

Four samples were collected from Turkey Gut in 1994, and three samples were collected from Slocum Creek. The analytical results for these samples are summarized in Tables 4-29 and 4-30, respectively, along with state surface water standards. These tables indicate that volatile organics are detected in several

TABLE 4-28

SUMMARY OF ANALYTICAL RESULTS - YORKTOWN AQUIFER (1994)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection	NC Class GA Standard[3]
Volatile Organics (μg/L)					
Chloroform*[4]	2/10	1.5	1 - 2	OU2MW6	0.019
Methylene chloride	1/10	3	3	OU2MW6	5
Semivolatile Organics (μg/L)					
Bis(2-ethylhexyl)phthalate*	1/8	25	25	10GW24	3
Inorganics (μg/L)					
Aluminum	6/10	198	25.0 - 936	OU2MW3	NR[5]
Barium	10/10	18.1	2.0 - 44.0	OU2MW7	2,000
Calcium	10/10	61,930	49,500 - 68,600	OU2MW2	NR
Iron*	9/10	827	279 - 2,010	10GW22	300
Lead	2/10	1.2	1.2	10GW24/ OU2MW3	15
Magnesium	10/10	1,700	783 - 2,380	OU2MW5	NR
Manganese*	10/10	50.9	12.0 - 90.0	OU2MW5	50
Potassium	10/10	2,238	858 - 7,510	OU2MW7	NR
Sodium	10/10	23,081	7,410 - 128,000	OU2MW7	NR
Zinc	1/10	10.0	10.0	OU2MW3	2,100
pH (units)*	10/10	7.42[1]	6.99 - 8.59	NA[2]	6.5 - 8.5

1 Geometric average.
2 NA - Not applicable.
3 15A NCAC 2L.0200.
4 Asterisk next to analyte indicates exceedance of state standard.
5 NR - Not regulated; no standard.

TABLE 4-29

SUMMARY OF ANALYTICAL RESULTS - TURKEY GUT SURFACE WATER (1994)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection	NC Class C Standard/ Criteria[4]
Volatile Organics (µg/L)					
Benzene	1/4	1	1	OU2SW4	71.4
Chlorobenzene	1/4	10	10	OU2SW4	21,000
1,4-Dichlorobenzene[1]	1/8	2	2	OU2SW4	2,600
1,1-Dichloroethane	1/4	2	2	OU2SW4	19.8
Chloroethane	1/4	3	3	OU2SW4	860
cis-1,2-Dichloroethene	1/4	1	1	OU2SW4	7.0
Vinyl chloride	1/4	1	1	OU2SW4	525
Semivolatile Organics (µg/L)					
Bis(2-ethylhexyl)phthalate*	2/4	5	4 - 6	OU2SW6	5.9
Pesticides/PCBs (µg/L)					
γ-BHC (Lindane)	2/4	0.0049	0.0016 - 0.0081	OU2SW4	0.01
4,4'-DDD*	1/4	0.028	0.028	OU2SW3	0.00084
Heptachlor epoxide*	1/4	0.0019	0.0019	OU2SW4	0.00011
Inorganics (µg/L)					
Aluminum	3/4	380	29.0 - 1,010	OU2SW5	NR[5]
Arsenic	1/4	2.95	2.95	OU2SW6	50
Barium	4/4	57.1	40.5 - 90.0	OU2SW5	NR
Calcium	4/4	63,750	21,400 - 135,000	OU2SW3	NR
Iron*	4/4	4,391	1,435 - 11,600	OU2SW4	1,000
Lead	1/4	7.5	7.5	OU2SW5	25
Magnesium	4/4	102,719	3,125 - 393,000	OU2SW3	NR
Manganese	4/4	268	80.5 - 458	OU2SW4	NR
Potassium	4/4	33,176	1,840 - 123,000	OU2SW3	NR
Sodium	4/4	766,645	3,170 - 3,030,000	OU2SW3	NR
Zinc	1/4	17.0	17.0	OU2SW5	50
pH (units)	4/4	6.52[2]	6.01 - 6.95	NA[3]	6 - 9
Inorganics - Filtered (µg/L)					
Antimony	1/4	11.5	11.5	OU2SW3	4,300
Barium	4/4	54.5	39.0 - 86.0	OU2SW5	NR
Calcium	4/4	64,550	22,100 - 139,000	OU2SW3	NR
Copper*	1/4	25.0	25.0	OU2SW3	7

TABLE 4-29 (Continued)
SUMMARY OF ANALYTICAL RESULTS - TURKEY GUT SURFACE WATER (1994)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection	NC Class C Standard/ Criteria[4]
Iron*	3/4	2,526	727 - 5,580	OU2SW4	1,000
Magnesium	4/4	101,246	3,115 - 387,000	OU2SW3	NR
Manganese	4/4	232	71.5 - 447	OU2SW4	NR
Potassium	4/4	31,430	1,890 - 116,000	OU2SW3	NR
Sodium	4/4	796,685	3,200 - 3,150,000	OU2SW3	NR
Zinc	1/4	12.0	12.0	OU2SW5	50

1 Measured in both volatile and semivolatile fractions.
2 Geometric mean.
3 NA - Not applicable.
4 Reid, 1996. Asterisk next to analyte indicates exceedance of standard.
5 NR - Not regulated, no standard.

TABLE 4-30

SUMMARY OF ANALYTICAL RESULTS - SLOCUM CREEK SURFACE WATER (1994)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection	NC Class SC Standard/Criteria[3]
Volatile Organics (µg/L)					
Acetone	1/1	3	3	OU2SW7	NR[5]
cis-1,2-Dichloroethene	2/3	1.5	1 - 2	OU2SW1	NR
Chloroform	3/3	1	1	OU2SW1/2/7	470
Pesticides/PCBs (µg/L)					
4,4'-DDD*[6]	3/3	0.033	0.027 - 0.039	OU2SW1	0.00084
Inorganics (µg/L)					
Barium	3/3	51.0	37.0 - 60.0	OU2SW2	NR
Calcium	3/3	134,000	132,000 - 135,000	OU2SW2/7	NR
Copper*	1/3	28.0	28.0	OU2SW7	3
Iron	2/3	132	106 - 158	OU2SW7	NR
Magnesium	3/3	396,000	379,000 - 407,000	OU2SW2	NR
Manganese	3/3	383	350 - 432	OU2SW1	NR
Potassium	3/3	120,333	116,000 - 123,000	OU2SW7	NR
Sodium	3/3	3,073,333	2,950,000 - 3,150,000	OU2SW2	NR
pH (units)	3/3	7.74[1]	7.55 - 7.87	NA[2]	6.8 - 8.5
Inorganics - Filtered (µg/L)					
Antimony	1/3	7.4	7.4	OU2SW7	4,300
Barium	3/3	32.0	28.0 - 37.0	OU2SW7	NR
Calcium	3/3	140,333	138,000 - 144,000	OU2SW7	NR
Copper*	3/3	27.7	23.0 - 37.0	OU2SW7	3
Magnesium	3/3	401,667	395,000 - 414,000	OU2SW7	NR
Manganese	2/3	6.0	6.0	OU2SW1/7	NR
Potassium	3/3	119,000	116,000 - 124,000	OU2SW7	NR
Sodium	3/3	3,140,000	3,090,000 - 3,210,000	OU2SW7	NR
Zinc	1/3	7.0	7.0	OU2SW1	86

1 Geometric average.
2 NA - Not applicable.
3 Reid, 1996.
4 For protection of aquatic life.
5 NR - Not regulated; no standard.
6 Asterisk indicates exceedance of standard for analyte.

surface water samples, and that the suite of contaminants detected is similar to the types and classes of compounds detected in the onsite groundwater. The surface water concentrations were generally lower than those detected in groundwater.

In Turkey Gut, sample OU2SW4, which was located just upstream of an identifiable leachate seep (in 1985), contained benzene, chlorobenzene, 1,4-dichlorobenzene, 1,1-dichloroethane, chloroethane, cis-1,2-dichloroethene, and vinyl chloride. Most detections were 1 to 3 μg/L, although chlorobenzene was detected at a concentration of 10 μg/L in this sample.

In Slocum Creek, chloroform was consistently detected at a concentration of 1 μg/L in all three samples. While chloroform was not detected in the surficial aquifer samples, another compound (cis-1,2-dichloroethene), which was consistently found on site, was detected in Slocum Creek. Therefore, it may be assumed that contaminated groundwater is discharging to Slocum Creek. The sample in which cis-1,2-dichloroethene was detected is at the downgradient end of a contaminant plume emanating from the former sludge impoundment.

Pesticides were detected in several surface water samples, although their presence may be related to suspended sediment material in the samples rather than actually dissolved in the surface waters. Pesticides were detected at low concentrations in a number of groundwater samples, although no plume or significant soil source area could be identified that could result in the presence of these pesticides in either Turkey Gut or Slocum Creek. The source of these pesticides is most likely the prior or current application of these materials throughout the watershed, followed by runoff.

It is notable that manganese, which was a prevalent groundwater contaminant at concentrations that exceeded standards, was also found in Turkey Gut. This is an additional indication of discharge of shallow groundwater to Turkey Gut. Manganese was found only in one Slocum Creek sample at a concentration of 6 μg/L. Note also that sodium concentrations are high, particularly in Slocum Creek and the mouth of Turkey Gut.

There were a few exceedances of state surface water quality standards in Turkey Gut and Slocum Creek. Bis(2-ethylhexyl)phthalate slightly exceeded the standard in one sample from Turkey Gut. There were also single exceedances of the state standards for 4,4'-DDD and heptachlor epoxide in Turkey Gut samples. The standard for copper was exceeded in one Turkey Gut sample. The standard for iron was exceeded in all samples from Turkey Gut. The standards for 4,4'-DDD and copper were exceeded in all three samples from Slocum Creek, including the sample location upstream of OU2.

There is no general pattern or trend in contaminant distribution in either Slocum Creek or Turkey Gut.

4.7.6 Sediment

Sediment analytical results from 1994 are summarized in Tables 4-31 (Turkey Gut) and 4-32 (Slocum Creek). The results indicate that pesticides and metals are the most frequently detected analytes.

In Turkey Gut, the concentrations of pesticides were found generally in an upstream sample (OU2SD5) or in a sample collected from near the mouth of the Gut (OU2SD3). A wide variety of pesticides were detected in the Gut, and several of the identified compounds (4,4'-DDD, 4,4'-DDE, endrin aldehyde, endrin ketone, and heptachlor) were detected in the sediment and not in any onsite soil samples (to a depth of 10 feet). Therefore the data appear to indicate that the source of these pesticides may not be site-related.

Similarly, the only pesticides detected in Slocum Creek were not found in onsite soils. This evidence particularly points to offsite sources of other insoluble sediment constituents (e.g., metals).

The concentrations of metals in both water bodies do not appear to indicate the presence of a major onsite source area. Many of the metals are found at concentrations within about two times the background soil UCL concentrations, and although this comparison is not totally valid (i.e., soils are not the same as sediments), the fact still has some credence in identifying whether onsite soils may be contributing to the observed sediment contamination. The maximum concentrations of individual metals were found at all of the four Turkey Gut sample locations, but all maxima in Slocum Creek were found in the most downstream location (OU2SD7). No upgradient/upslope areas could be identified as potential sources of these metals in Slocum Creek.

4.7.7 Leachate Seeps

The 1995 chemical analytical results for one leachate seep (LW01) and two areas of ponded water (LW02 and LW06) are summarized in this section and in Table 4-33. The results for the most recent leachate seep sediment sampling (1995) were incorporated in the summary discussion of surface soils (Section 4.7.1).

The actual leachate seep (OU2LW01) contained several volatile organic compounds that were also detected in the surficial aquifer (benzene, chloroethane, and vinyl chloride). These data are consistent with what might be expected to be found in a leachate seep. One of the areas of ponded surface water (OU2LW02) contained the only other detections of organic chemicals (xylenes at 2 μg/L and several pesticides at concentrations ranging from 0.0625 μg/L to 0.17 μg/L). The pesticides are not typically considered to be

TABLE 4-31

SUMMARY OF ANALYTICAL RESULTS - TURKEY GUT SEDIMENT (1994)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection
Semivolatile Organics (μg/kg)				
Di-n-butylphthalate	4/4	494	350 - 640	OU2SD5
Pesticides/PCBs (μg/kg)				
α-Chlordane	4/4	6.7	0.36 - 25	OU2SD3
γ-Chlordane	4/4	3.1	0.34 - 8.8	OU2SD3
4,4'-DDD	3/3	1.5	0.45 - 3.4	OU2SD4
4,4'-DDE	3/3	0.87	0.42 - 1.4	OU2SD5
4,4'-DDT	1/4	0.20	0.20	OU2SD5
Dieldrin	3/4	7.9	0.52 - 22	OU2SD3
Endosulfan II	1/4	0.24	0.24	OU2SD5
Endrin aldehyde	1/4	0.40	0.40	OU2SD5
Endrin ketone	1/4	1.2	1.2	OU2SD5
Heptachlor	2/4	0.14	0.13 - 0.15	OU2SD6
Heptachlor epoxide	1/4	16	16	OU2SD3
Inorganics (mg/kg)				
Aluminum	4/4	8,048	1,630 - 11,100	OU2SD3
Arsenic	3/4	2.6	1.2 - 3.7	OU2SD3
Barium	4/4	23.3	12.6 - 36.1	OU2SD5
Calcium	4/4	1,481	348 - 3,570	OU2SD4
Chromium	4/4	12.7	5.5 - 19.6	OU2SD6
Copper	1/4	5.5	5.5	OU2SD3
Iron	4/4	7,824	1,930 - 18,200	OU2SD3
Lead	4/4	14.3	6.6 - 28.8	OU2SD3
Magnesium	4/4	495	155 - 930	OU2SD3
Manganese	4/4	30.6	6.4 - 97.4	OU2SD3
Mercury	2/4	0.14	0.10 - 0.17	OU2SD5
Potassium	4/4	428	123 - 679	OU2SD6
Selenium	1/4	0.71	0.71	OU2SD5
Sodium	2/4	628	166 - 1,090	OU2SD3
Vanadium	4/4	16.3	4.8 - 26.7	OU2SD6
Zinc	4/4	14.7	6.8 - 27.4	OU2SD3

TABLE 4-32

SUMMARY OF ANALYTICAL RESULTS - SLOCUM CREEK SEDIMENT (1994)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection
Volatile Organics (μg/kg)				
2-Butanone	1/3	13	13	OU2SD1
Semivolatile Organics (μg/kg)				
Bis(2-ethylhexyl)phthalate	1/3	430	430	OU2SD7
Di-n-butylphthalate	3/3	430	190 - 800	OU2SD1
Pesticides/PCBs (μg/kg)				
α-Chlordane	1/3	1.5	1.5	OU2SD7
4,4'-DDD	1/2	2.7	2.7	OU2SD1
4,4'-DDE	1/3	2.8	2.8	OU2SD7
Inorganics (mg/kg)				
Aluminum	3/3	3,414	382 - 8,760	OU2SD7
Arsenic	2/3	2.7	1.8 - 3.6	OU2SD7
Barium	3/3	13.8	1.1 - 35.8	OU2SD7
Calcium	3/3	2,675	304 - 6,540	OU2SD7
Chromium	2/3	31.8	6.0 - 57.5	OU2SD7
Copper	1/3	17.9	17.9	OU2SD7
Iron	3/3	7,221	932 - 18,200	OU2SD7
Lead	2/3	23.2	8.7 - 37.7	OU2SD7
Magnesium	3/3	1,350	261 - 2,650	OU2SD7
Manganese	3/3	176	15.1 - 394	OU2SD7
Mercury	1/3	0.6	0.6	OU2SD7
Potassium	3/3	444	93.6 - 956	OU2SD7
Selenium	1/3	0.89	0.89	OU2SD7
Sodium	3/3	4,890	1,590 - 8,250	OU2SD7
Zinc	3/3	47.2	6.1 - 113	OU2SD7

TABLE 4-33

SUMMARY OF ANALYTICAL RESULTS - LEACHATE SEEP WATER (1995)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection
Volatile Organics (μg/L)				
Benzene	1/3	2	2	OU2LW01
Xylenes	1/3	2	2	OU2LW02
Chloroethane	1/3	5	5	OU2LW01
Vinyl chloride	1/3	3	3	OU2LW01
Pesticides/PCBs (μg/L)				
Aldrin	1/3	0.0625	0.0625	OU2LW02
γ-BHC	1/3	0.0725	0.0725	OU2LW02
4,4'-DDT	1/3	0.17	0.17	OU2LW02
Dieldrin	1/3	0.155	0.155	OU2LW02
Endrin	1/3	0.165	0.165	OU2LW02
Heptachlor	1/3	0.0775	0.0775	OU2LW02
Inorganics				
Aluminum	3/3	721.8	360.5 - 1,310	OU2LW01
Antimony	1/3	9.4	9.4	OU2LW01
Arsenic	3/3	2.8	2.2 - 3.9	OU2LW01
Barium	3/3	31.2	5.2 - 76.8	OU2LW01
Cadmium	3/3	9.4	0.8 - 24.2	OU2LW01
Calcium	3/3	16,185	3,705 - 36,500	OU2LW01
Chromium	3/3	3.8	0.85 - 5.6	OU2LW01
Cobalt	1/3	6.5	6.5	OU2LW01
Copper	3/3	25.1	3.3 - 62.6	OU2LW01
Iron	3/3	13,991	558 - 40,400	OU2LW01
Lead	3/3	11.1	3.9 - 24.1	OU2LW01
Magnesium	3/3	1,401.7	681 - 2,580	OU2LW01

TABLE 4-33 (Continued)
SUMMARY OF ANALYTICAL RESULTS - LEACHATE SEEP WATER (1995)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Frequency of Detection	Average of Positive Detections	Range of Positive Detections	Location of Maximum Detection
Manganese	3/3	212.3	62.5 - 494	OU2LW01
Nickel	3/3	33.3	0.85 - 97.9	OU2LW01
Potassium	3/3	3,033.3	1,860 - 4,470	OU2LW01
Selenium	2/3	2.45	2.3 - 2.6	OU2LW01
Sodium	3/3	2,926.7	1,240 - 5,640	OU2LW01
Thallium	1/3	1.95	1.95	OU2LW02
Vanadium	3/3	3.5	2.15 - 6.0	OU2LW01
Zinc	3/3	299.2	26.3 - 813	OU2LW01
pH	3/3	6.11[1]	6.09 - 6.15	NA[2]

1 Geometric average.
2 NA - Not applicable.

soluble compounds; therefore, their presence might be reflective of suspended sediment entrained in the sample.

The leachate seep (OU2LW01) contained the highest concentrations of many of the metals (except thallium). The low flow of this seep may have resulted in entrainment of surface soil/sediment material in the sample bottles.

In several cases, the concentrations of metals in OU2LW01 exceeded the maximum detection in the surficial aquifer collected in 1994 using the low flow techniques. These instances include antimony, cadmium, chromium, copper, lead, nickel, selenium, and zinc. For all other metals, the concentrations in groundwater exceed the leachate concentrations. The low flow rate of this seep makes it unlikely that leachate water would migrate to groundwater and cause an exceedance of a groundwater standard. In addition, this leachate seep may be an area of groundwater discharge.

4.7.8 Polishing Pond Sediment

During 1994, samples were collected from the pond sediments and the underlying natural soil. The analytical results were summarized in Table 4-24.

The data indicate that the sediments in the ponds contain a number of organic chemicals, while the underlying soil contains fewer organic chemicals at lower concentrations. For instance, the pond sediments contain ketones, monocyclic aromatics, phthalate esters, PAHs, and pesticides at concentrations ranging from 0.063 μg/kg (γ-BHC) to 13,000 μg/kg [bis(2-ethylhexyl)phthalate]. Sample OU2SD09-1012 contained the majority of the organic chemicals. The underlying natural soil material contained 4 μg/kg chloroform, 130 μg/kg bis(2-ethylhexyl)phthalate, 255 μg/kg di-n-butylphthalate, 0.10 μg/kg α-chlordane, and up to 0.14 μg/kg heptachlor.

In general, it can be stated that the pond sediments contain higher concentrations of metals than the underlying soils. These data probably reflect the nature of the wastewaters treated in the polishing ponds.

The concentration of metals in the underlying soil are comparable to background soil results.

5.0 CONTAMINANT FATE AND TRANSPORT

This section contains information on contaminant fate and transport and the properties affecting contaminant migration at OU2. Section 5.1 contains a discussion of the chemical and physical properties of the analytes detected in all media. Section 5.2 presents brief discussions of contaminant persistence. Section 5.3 presents a summary of contaminant migration.

5.1 CHEMICAL AND PHYSICAL PROPERTIES

Various chemical and physical properties of the compounds detected on site are presented and discussed in this section. These parameters are used to estimate the environmental behavior of site chemicals. Physical and chemical properties of the organic chemicals detected at MCAS Cherry Point OU2 are provided in Table 5-1.

Empirically determined literature values of the water solubility, octanol/water partition coefficient, organic carbon partition coefficient, vapor pressure, Henry's law constant, bioconcentration factor, and specific gravity are presented, when available. Calculated values, which were obtained using approximation methods, are presented when literature values are not available. A discussion of the environmental significance of each of these parameters follows.

5.1.1 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. Its primary use is to determine whether a contaminant will have a tendency to float or sink in water if it is present as a pure compound or at very high concentrations. Contaminants with a specific gravity greater than 1 will tend to sink, whereas contaminants with a specific gravity less than 1 will tend to float. This parameter becomes important in discussions regarding the potential presence of free product or non-aqueous phase liquids.

Of the commonly detected chemicals at OU2, the ketones and many monocyclic aromatics have specific gravities less than 1. The halogenated aliphatics, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), phthalate esters, and pesticides have specific gravities greater than 1.

TABLE 5-1

CHEMICAL AND PHYSICAL PROPERTIES OF DETECTED ORGANIC CHEMICALS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Molecular Weight (g/mol)[1]	Specific Gravity @ 20/4°C[1]	Vapor Pressure @ 25°C (mm Hg)[1]	Solubility @ 25°C (mg/L)[1]	Log Organic Carbon Partition Coefficient (Koc)[2]	Log Octanol Water Partition Coefficient (Kow)[1]	Henry's Law Constant @ 25°C (atm-m^3/mol)[1]	Bioconcentration Factor (L/kg)[2]
KETONES								
Acetone	58.08	0.7899	2.66E+2	miscible	0.73[3]	-0.24	4.276E-5	6.9E-1[4]
2-Butanone	72.11	0.8054	1E+2	2.75E+5 (20°C)	0.646[5]	0.26	4.66E-5	9.3E-1[6]
4-Methyl-2-pentanone	100.16	0.7978	1.0E+1 (30°C)	1.91E+4	0.88[13]	1.09	1.49E-5	3.97E+0[6]
2-Hexanone	100.16	0.8113	2E+0 (20°C)	3.5E+4 (20°C)	1.17[13]	1.38	1.75E-3	6.6E+0
MONOCYCLIC AROMATICS								
Benzene	78.11	0.8765	9.5E+1	1.78E+3 (20°C)	1.81	2.13	5.55E-3	3.7E+1
Ethylbenzene	106.17	0.8670	1.0E+1 (25.9°C)	1.52E+2 (20°C)	3.04	3.15	8.043E-3	4.7E+2
Chlorobenzene	112.56	1.1058	1.18E+1	4.88E+2	2.52	2.84	3.93E-3	1.64E+2
Nitrobenzene	123.11	1.2037	1.5E-1 (20°C)	1.9E+3 (20°C)	1.56	1.85	2.38E-5	2.2E+1
Toluene	92.14	0.8669	2.8E+1	5.15E+2 (20°C)	2.48	2.69	5.92E-3	1.48E+2
Xylenes (total)	106.17	0.86104 -0.8801	1.0E+1 (27.3-32.1°C)	1.6E+2 - 1.75E+2[7]	1.68 - 2.41[7]	2.77 - 3.20	4.184E-3 - 6.662E-3	7.5E+1 - 1.59E+2[6]
Styrene	104.15	0.906	5E+0 (20°C)	3E+2 (20°C)	2.95[13]	3.16	2.633E-3	1.48E+2
1,2-Dichlorobenzene	147.00	1.3048	1.5E+0	1.45E+2	3.23	3.38	2.951E-3	7.3E+2
1,3-Dichlorobenzene	147.00	1.2884	1.0E+0 (12.2°C)	1.23E+2	3.23	3.38	3.241E-3	7.3E+2
1,4-Dichlorobenzene	147.00	1.2475	1.8E+0 (30°C)	7.9E+1	3.23	3.39	4.328E-3	7.3E+2
Phenol	94.11	1.0576	3.5E-1	8E+4	1.15	1.46	1.3E-6	9.4E+0

TABLE 5-1 (Continued)
CHEMICAL AND PHYSICAL PROPERTIES OF DETECTED ORGANIC CHEMICALS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Molecular Weight (g/mol)[1]	Specific Gravity @ 20/4°C[1]	Vapor Pressure @ 25°C (mm Hg)[1]	Solubility @ 25°C (mg/L)[1]	Log Organic Carbon Partition Coefficient (Koc)[2]	Log Octanol Water Partition Coefficient (Kow)[1]	Henry's Law Constant @ 25°C (atm-m³/mol)[1]	Bioconcentration Factor (L/kg)[2]
2-Methylphenol	108.14	1.0273	2.4E-1	3.1E+4 (40°C)	1.74[13]	1.95	8.41E-7 (20°C)	1.79E+1[6]
4-Methylphenol	108.14	1.0178	1.1E-1	2.4E+4 (40°C)	1.71[13]	1.92	3.92E-7 (20°C)	1.7E+1[6]
2-Nitrophenol	139.11	1.485 (14°C)	1E+0 (49.3°C)	2.1E+3 (20°C)	1.43	1.79	3.5E-6	1.7E+1
2,4-Dimethylphenol	122.17	0.9650	9.8E+1 (104°C)	7.868E+3	1.98	2.42	6.55E-6	7.5E+1
HALOGENATED ALIPHATICS								
1,1,2,2-Tetrachloroethane	167.85	1.5953	4E+0	2.9E+3 (20°C)	2.07	2.39	3.8E-4 (20°C)	9.1E+1
1,1,1-Trichloroethane	133.40	1.3390	1.0E+2 (20°C)	4.4E+3 (20°C)	2.18	2.47	4.08E-3	8.1E+1
1,1-Dichloroethane	98.96	1.1757	2.34E+2	5.5E+3 (20°C)	1.48	1.79	5.871E-3	1.9E+1
1,2-Dichloroethane	98.96	1.2351	7.9E+1	8.69E+3 (20°C)	1.15	1.45	1.178E-3	9E+0
Chloroethane	64.51	0.8978	1.011E+3 (20°C)	5.74E+3 (20°C)	1.17	1.43	6.919E-3 (20°C)	9.8E+0
Tetrachloroethene	165.83	1.6227	1.9E+1	1.5E+2	2.56	2.53	2.68E-2	2.52E+2
Trichloroethene	131.39	1.4642	7.7E+1	1.1E+3	2.10	2.53	1.17E-2	9.7E+1
1,1-Dichloroethene	96.94	1.218	5.91E+2	2.1E+2	1.81	1.48	2.286E-2	5.3E+1
1,2-Dichloroethene (cis)	96.94	1.2837	2.02E+2	8E+2 (20°C)	2.09[14]	NA	4.08E-3 (24.8°C)	NA
1,2-Dichloroethene (trans)	96.94	1.2565	3.31E+2	6E+2 (20°C)	1.77	1.48	6.67E-3	4.8E+1
Vinyl chloride	62.50	0.9106	2.58E+3 (20°C)	1.1E+3	0.91	0.60	2.78E-2	5.7E+0
Chloroform	119.38	1.4832	1.60E+2 (20°C)	9.3E+3	1.64	1.97	3.39E-3	2.6E+1
Bromodichloromethane	163.83	1.980	5.0E+1 (20°C)	4.5E+3 (0°C)	1.78	1.88	2.12E-3	3.5E+1

TABLE 5-1 (Continued)
CHEMICAL AND PHYSICAL PROPERTIES OF DETECTED ORGANIC CHEMICALS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Molecular Weight (g/mol)[1]	Specific Gravity @ 20/4°C[1]	Vapor Pressure @ 25°C (mm Hg)[1]	Solubility @ 25°C (mg/L)[1]	Log Organic Carbon Partition Coefficient (Koc)[2]	Log Octanol Water Partition Coefficient (Kow)[1]	Henry's Law Constant @ 25°C (atm-m³/mol)[1]	Bioconcentration Factor (L/kg)[2]
Chlorodibromomethane	208.28	2.451	1.5E+1 (10.5°C)	NA	1.92	2.09	7.83E-4	4.7E+1
Methylene chloride	84.93	1.3266	4.29E+2	1.67E+4	0.94	1.25	3.19E-3	6.0E+0
Chloromethane			3.76E+3 (20°C)[2]	6.45E+3 (20°C)[2]	0.63	0.94[2]	4.0E-2[2]	3.2E+0
Dichlorodifluoromethane	120.91	1.1834 (57°C)	4.25E+3 (20°C)	2.8E+2	1.76	2.16	3.904E-1	3.3E+1
Trichlorofluoromethane	137.38	1.494 (17.2/4°C)	6.87E+2 (20°C)	1.1E+3	2.20	2.53	5.83E-2	8.4E+1
1,2-Dichloropropane	112.99	1.1560	4.2E+1 (200°C)	2.7E+3 (20°C)	1.71	2.28	2.675E-3	3.0E+1
1,3-Dichloropropene (cis)	110.97	1.217	4.3E+1	2.7E+3	1.75[5]	1.41	3.55E-3	6.9E+0[6]
1,3-Dichloropropene (trans)	110.97	1.224	3.4E+1	2.8E+3	1.74[5]	NA	NA	NA
PHTHALATE ESTERS								
Bis(2-ethylhexyl)phthalate	390.54	0.99 (20/20°C)	1.2E+0 (200°C)	4E-1	9.30	5.3	3E-7 (20°C)	2.3E+8
Di-n-butylphthalate	278.35	1.047 (20/20°C)	1E-1 (115°C)	4E+2	5.23	5.2	2.8E-7	4.7E+4
Di-n-octylphthalate	390.57	0.978	<2E-1 (150°C)	3E+0	9.56	9.2	1.41E-12	3.9E+8
Diethylphthalate	222.24	1.1175	5E-2 (70°C)	1.08E+3	2.15	2.96	8.46E-7	1.07E+2
Butylbenzylphthalate	312.4	1.1 (25/25°C)	8.6E-6 (20°C)	2.9E+0 (20°C)	5.23	4.78	8.3E-6[2]	4.7E+4
POLYCYCLIC AROMATIC HYDROCARBONS								
Benzo(a)anthracene	228.29	1.274	5E-9 (20°C)	1.0E-2 (24°C)	5.30	5.61	6.6E-7 (20°C)	5.3E+4
Benzo(b)fluoranthene	252.32	NA	5E-7 (20°C)	1.2E-3	5.74	6.57	1.2E-5	1.4E+5
Benzo(k)fluoranthene	252.32	NA	9.59E-11 (20°C)	5.5E-4	5.74	6.84	1.04E-3	1.4E+5
Benzo(g,h,i)perylene	276.34	NA	1E-10 (20°C)	2.6E-4	6.20	7.23	1.4E-7	3.5E+5

TABLE 5-1 (Continued)
CHEMICAL AND PHYSICAL PROPERTIES OF DETECTED ORGANIC CHEMICALS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Molecular Weight (g/mol)[1]	Specific Gravity @ 20/4°C[1]	Vapor Pressure @ 25°C (mm Hg)[1]	Solubility @ 25°C (mg/L)[1]	Log Organic Carbon Partition Coefficient (Koc)[2]	Log Octanol Water Partition Coefficient (Kow)[1]	Henry's Law Constant @ 25°C (atm-m³/mol)[1]	Bioconcentration Factor (L/kg)[2]
Benzo(a)pyrene	252.32	1.351	5E-9 (20°C)	3.8E-3	6.74	5.98	4.9E-7	1.4E+5
Chrysene	228.29	1.274 (20°C)	6.3E-9	6E-3	5.30	5.61	1.05E-6	5.3E+4
Fluoranthene	202.26	1.252	5.0E-6	2.65E-1	4.58	5.33	6.5E-6	1.2E+4
Fluorene	166.22	1.202	1E+1 (146°C)	1.9E+0	3.86	4.18	1.17E-4	3.8E+3
Indeno(1,2,3-cd)pyrene	276.34	NA	1E-10	6.2E-2 (20°C)	6.20	7.66	6.95E-8	3.5E+5
2-Methylnaphthalene	142.20	1.0058	1.0E+1 (105°C)	2.6E+1	2.86[5]	3.86	4.99E-4	5.1E+2[6]
Naphthalene	128.17	1.162	8.2E-2	3E+1	2.97	3.37	4.83E-4	4.2E+2
Phenanthrene	178.23	0.9800 (4°C)	1E+0 (118.2°C)	8.16E-1 (21°C)	4.15	4.46	3.93E-5	4.7E+3
Pyrene	202.26	1.271 (23/4°C)	2.5E+0 (200°C)	1.6E-1 (26°C)	4.58	5.18	5.1E-6	1.2E+4
HALOGENATED ETHERS								
Bis(2-chloroethyl)ether	143,01	1.2199	7.1E-1 (20°C)	1.02E+4	1.14	1.58	1.3E-5 (20°C)	9.2E+0
PESTICIDES/PCBs								
Aldrin	364.91	1.70	2.3E-5 (20°C)	1.7E-2	4.98	5.11	4.96E-4	2.8E+2
α-BHC	290.83	~1.87	6E-2 (40°C)	1.63E+0	3.58	3.81	5.3E-6 (20°C)	1.5E+3
β-BHC	290.83	1.89 (19°C)	1.7E-1 (40°C)	7.0E-1	3.58	3.8	2.3E-7 (20°C)	1.5E+3
γ-BHC (Lindane)	290.83	1.891 (19/4°C)	9.4E-6 (20°C)	7.0E+0 (20°C)	3.58	3.24	4.93E-7	1.5E+3
δ-BHC	290.83	~1.87	2E-2 (20°C)	2.13E+1	3.82	4.14	2.5E-7	3.5E+3
Chlordane (α,γ)	409.80	1.59 - 1.63 (25°C)	1E-5	5.6E-2 (20°C)	5.15	2.78	4.79E-5	4.0E+4
4,4'-DDD	320.05	1.476	1E-6 (30°C)	1.6E-1 (24°C)	5.89	5.99	2.16E-5	1.8E+5

TABLE 5-1 (Continued)
CHEMICAL AND PHYSICAL PROPERTIES OF DETECTED ORGANIC CHEMICALS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Molecular Weight (g/mol)[1]	Specific Gravity @ 20/4°C[1]	Vapor Pressure @ 25°C (mm Hg)[1]	Solubility @ 25°C (mg/L)[1]	Log Organic Carbon Partition Coefficient (Koc)[2]	Log Octanol Water Partition Coefficient (Kow)[1]	Henry's Law Constant @ 25°C (atm-m^3/mol)[1]	Bioconcentration Factor (L/kg)[2]
4,4'-DDE	319.03	NA	6.5E-6 (20°C)	4.0E-2 (20°C)	6.64	5.69	2.34E-5	8.9E+5
4,4'-DDT	354.49	1.56 (15/4°C)	1.5E-7 (20°C)	3.1E-3	6.59	6.19	3.89E-5	8.0E+6
Diazinon	304.3[10]	1.116[11]	8.4E-5 (20°C)[10]	6.88E+1[10]	4.65[5]	3.81[10]	1.13E-7[10]	5.68E+1[12]
Dieldrin	380.91	1.75	1.8E-7	1.86E-1 (20°C)	3.23	4.09	5.84E-5	7.1E+2
Endosulfan I	406.95	1.745	1E-5	3.2E-1 (22°C)	-2.02	3.55	1.01E-4	1.2E-2
Endosulfan II	406.95	1.745 (20/20°C)	1E-5	3.3E-1 (22°C)	-2.02	3.62	1.91E-5	1.2E-2
Endosulfan sulfate	422.92	NA	1E-5[2]	2.2E-1	3.28[5]	3.66	2.6E-5[2]	3.56E+2[2]
Endrin	380.92	1.65 (25/4°C)	2E-7	2.6E-1	3.23	5.6	4E-7	7.1E+2
Endrin aldehyde	380.92	NA	2E-7	2.6E-1	2.83	5.6	3.86E-7	3.1E+2
Endrin ketone	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	373.32	1.57 (9°C)	3E-4	5.6E-2	4.08	4.40	1.48E-3	4.4E+3
Heptachlor epoxide	389.32	NA	2.6E-6 (20°C)	3.5E-1	2.34	3.65	3.16E-5	1.1E+2
Methoxychlor	345.65	1.41 (25°C)	1.4E-6[8]	4E-2 (24°C)	4.9[8]	4.68	1.6E-5[8]	2.12E+3[8]
Methyl parathion	263.23	1.358	9.8E-6 (20°C)	5E+1	4.57[5]	2.04	1.0E-7 (20°C)	6.8E+1[12]
Methyl trithion	NA	NA	NA	NA	NA	NA	NA	NA
Parathion	291.27	1.26 (25/4°C)	3E-3 (24°C)	2.4E+1	4.40[5]	3.81	8.56E-8	1.03E+2[12]
Trithion	NA	1.275 (20/20°C)[11]	3E-7 (20°C) [11]	<4.0E+1[11]	NA	NA	NA	NA
Aroclor-1254	328.4[2]	1.495-1.555 (65/15.5°C)[8]	7.71E-5[2]	3.1E-2[2]	5.72	6.04[2]	2.6E-3[2]	1.3E+5

TABLE 5-1 (Continued)
CHEMICAL AND PHYSICAL PROPERTIES OF DETECTED ORGANIC CHEMICALS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Molecular Weight (g/mol)[1]	Specific Gravity @ 20/4°C[1]	Vapor Pressure @ 25°C (mm Hg)[1]	Solubility @ 25°C (mg/L)[1]	Log Organic Carbon Partition Coefficient (Koc)[2]	Log Octanol Water Partition Coefficient (Kow)[1]	Henry's Law Constant @ 25°C (atm-m³/mol)[1]	Bioconcentration Factor (L/kg)[2]
Aroclor-1260	375.7[2]	NA	4.05E-5[2]	2.7E-3[2]	6.83	7.15[2]	7.4E-3[2]	1.3E+6
MISCELLANEOUS COMPOUNDS								
Carbon tetrachloride	153.82	1.5940	1.13E+2	8.0E+2 (20°C)		2.73	2.93E-2	7.0E+1[6]
Carbon disulfide	76.13	1.2632	2.98E+2 (20°C)	2.9E+3 (20°C)	1.7[5]	2.16	1.921E-2	2.6E+1[6]
Dibenzofuran	168.19	1.0886 (99/4°C)	NA	1E+1 (20°C)	3.09[5]	4.12	NA	7.9E+2[6]

1 USEPA, September 1992
2 USEPA, December 1982
3 ATSDR, October 1992a
4 Howard, 1989
5 Lyman et al., 1990; Equation 4-5
6 Lyman et al., 1990; Equation 5-2
7 ATSDR, October 1989a
8 ATSDR, October 1992b
9 USEPA, October 1980
10 Howard, 1991
11 Verschueren, 1983
12 ATSDR, November 1987
13 Lyman et al., 1990; Equation 5-3

NA Not available

5.1.2 Vapor Pressure

Vapor pressure provides an indication of the rate at which a chemical volatilizes from both soil and water. It 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. Vapor pressures for ketones, monocyclic aromatics, and halogenated aliphatics are generally many times higher than vapor pressures for PAHs, pesticides, and PCBs. 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 volatile organics in surface water or surface soil. Volatilization is not significant for inorganics.

5.1.3 Solubility

The rate at which a chemical is leached from a waste deposit or soil by infiltrating precipitation is directly proportional to its water solubility. More soluble chemicals are more readily leached than less soluble chemicals. The water solubilities presented in Table 5-1 indicate that the volatile organic chemicals (ketones, monocyclic aromatics, and halogenated aliphatics) and halogenated ethers are usually several orders of magnitude more water-soluble than the PAHs, pesticides, and PCBs.

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, and other ionic species in solution (the Debye-Hückel 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.

5.1.4 Octanol/Water Partition Coefficient

The octanol/water partition coefficient (K_{ow}) is a measure of the equilibrium partitioning of chemicals between octanol and water. A linear relationship between the K_{ow} and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor) has been determined (Lyman et al., 1990). 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 volatile organics. The K_{ow} is also used to estimate bioconcentration factors in aquatic organisms.

5.1.5 Organic Carbon Partition Coefficient

The organic carbon partition coefficient (K_{oc}) indicates the tendency of a chemical to bind to soil particles containing organic carbon. Chemicals with a high K_{oc} 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) are transported in the groundwater. Chemicals such as most pesticides, PAHs, and PCBs are relatively immobile in the soil and are preferentially bound to the soil. These compounds are not subject to groundwater transport to the extent that compounds with higher water solubilities are. However, these immobile chemicals are easily transported by erosional processes when they are present in surface soils.

5.1.6 Henry's Law Constant

Both the vapor pressure and the 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 calculated 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 5E-6 atm-m^3/mole, such as pesticides and PCBs, volatilize very little and are present only in minute amounts in the atmosphere or soil gas. For chemicals with a Henry's law constant greater than 5E-3 atm-m^3/mole, such as many of the halogenated aliphatics, volatilization and diffusion in soil gas are significant.

5.1.7 Bioconcentration Factor

Bioconcentration factors (BCFs) represent 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 octanol/water coefficient. Many of the PAHs, pesticides, and PCBs will bioconcentrate at levels several orders of magnitude greater than those concentrations found in the water, whereas volatile organics and nitrogen-containing compounds are not as readily bioconcentrated.

5.1.8 Distribution Coefficient

The distribution coefficient (Kd) 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 the K_{oc} and the amount of organic carbon in the soil. For ions (e.g., metals), Kd 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 the Kd 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. Distribution coefficients for several metals are shown in Table 5-2.

5.2 CONTAMINANT PERSISTENCE

The persistence of various classes of chemicals is discussed in this section. Several transformation mechanisms affect chemical persistence, such as hydrolysis, biodegradation, photolysis, and oxidation/reduction reactions. The following general classes of compounds are discussed:

- Ketones
- Monocyclic aromatics
- Halogenated aliphatics
- PAHs
- Phthalate esters
- Pesticides
- PCBs
- Halogenated ethers
- Chlorinated dibenzo-p-dioxins and furans (CDDs and CDFs)
- Metals

5.2.1 Ketones

Ketones are highly volatile and soluble, and these two processes dominate the fate of these compounds in the environment. Hydrolysis is generally not a significant fate process for this class of chemicals, nor is bioconcentration significant, based on the low K_{ow}s (Howard, 1990).

Acetone is completely miscible in water and is unlikely to adsorb to soil or sediments or bioaccumulate. It has a high vapor pressure and once released to the air, photolysis and reaction with hydroxyl radicals result in an average half-life of 22 days (Howard, 1990).

2-Butanone will partially evaporate into the atmosphere if released to the soil, and it may also leach into the groundwater. Once in the groundwater, 2-butanone may slowly degrade. In surface water, 2-butanone has

TABLE 5-2

ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS FOR INORGANICS MCAS CHERRY POINT, NORTH CAROLINA OPERABLE UNITS

Element	Molecular Weight (g/mole)	Soil/Water Distribution Coefficient (Kd)[1] (mL/g)	Bioconcentration Factor[2] (L/kg)
Antimony	121.75	NR[3]	NR
Arsenic	74.92	1.0 - 8.3	44
Barium	137.34	NR	NR
Beryllium	9.01	NR	NR
Boron	10.81	NR	NR
Cadmium	112.4	1.3 - 27	64
Chromium III	52.0	470 - 150,000	16
Chromium VI	52.0	1.2 - 1,800	16
Cobalt	58.93	0.2 - 3,800	NR
Copper	63.54	1.4 - 333	36
Lead	207.19	4.5 - 7,640	NR
Manganese	54.93	0.2 - 10,000	NR
Mercury	200.59	NR	NR
Nickel	58.71	NR	NR
Selenium	78.96	1.2 - 8.6	4.8
Silver	107.87	10 - 1,000	0.5
Thallium	204.37	NR	116
Vanadium	50.94	NR	NR
Zinc	65.38	0.1 - 8,000	47

1 Dragun, 1988.
2 USEPA, June 14, 1991.
3 NR - Not reported.

a half-life of approximately 3 to 12 days. Hydrolysis, photolysis, bioconcentration, and adsorption are not significant fate processes for this chemical (Howard, 1990).

4-Methyl-2-pentanone is removed from soil by photolysis, volatilization, or aerobic biodegradation. In water, this compound has a volatilization half-life of 15 to 33 hours. 4-Methyl-2-pentanone is not expected to undergo chemical oxidation or hydrolysis, bioaccumulate, or adsorb to solids or sediments (Howard, 1990).

5.2.2 Monocyclic Aromatics

Monocyclic aromatic compounds such as benzene, toluene, and xylenes are not considered to be persistent in the environment, particularly in comparison to chemicals such as PCBs and pesticides. Monocyclic aromatics are subject to degradation via the action of both soil and aquatic microorganisms. The biodegradation of these compounds in the soil matrix is dependent of the abundance of microflora, macronutrient availability, soil reaction (pH), temperature, etc.

Although these compounds are amenable to microbial degradation, it is not anticipated that degradation will occur at an appreciable rate, although macronutrient availability is not known. In the event that these compounds discharge to surface water bodies, volatilization and biodegradation may occur relatively rapidly. For example, a reported first-order biodegradation rate constant for benzene is 0.11 day^{-1} in aquatic systems (Lyman et al., 1990). This corresponds to an aquatic half-life of approximately 6 days. Other monocyclic aromatics are subject to similar degradation processes in aquatic environments (USEPA, December 1982). However, chlorinated monocyclic aromatics such as chlorobenzene are not expected to be as susceptible to microbial degradation. For example, a reported first-order biodegradation rate constant for chlorobenzene is 0.0045 day^{-1} in aquatic systems (Lyman et al., 1990). This corresponds to an aquatic half-life of approximately 150 days.

Benzene in groundwater is significantly reduced by the action of aerobic bacteria. A biodegradation rate of 0.95%/day has been reported (Chiang et al., 1989). The amount of benzene, toluene, and xylenes in the groundwater was reported to be directly proportional to the availability of dissolved oxygen.

1,4-Dichlorobenzene volatilizes from soil and surface water at a relatively rapid rate. The estimated volatilization half-life in a model river is 4.3 hours, and the reported volatilization half-lives in coastal seawater ranged from 10 to 18 days. Volatilization from surface soil may be an important transport mechanism, but adsorption to soil particulates may inhibit volatilization by as much as an order of magnitude compared to the volatilization from water (ATSDR, October 1991a).

Volatilization from soil surfaces is an important transport mechanism for 1,2- and 1,3-dichlorobenzene. If released to water, 1,2- and 1,3-dichlorobenzene will adsorb to sediments or volatilize (half-lives of 4.4 and 4.1 hours are reported), although adsorption will attenuate volatilization. Aerobic biodegradation is slow, and these compounds are not affected by hydrolysis, oxidation, or direct photolysis (Howard, 1990).

Phenol and 2,4-dimethylphenol rapidly biodegrade (within days) in all media. These compounds are not persistent in the environment. 2,4-Dimethylphenol in humic waters will photooxidize as a result of reaction with alkylperoxy radicals. In the atmosphere, 2,4-dimethylphenol will react with hydroxyl radicals (Howard, 1989).

The fate of 2-methylphenol and 4-methylphenol in soil has not been extensively studied, although they are considered to be relatively mobile (i.e., soluble) in soil and undergo complete biodegradation in 7 to 8 days. Biodegradation is the dominant loss mechanism in surface waters; volatilization, bioconcentration, and adsorption are not significant. Photolysis only occurs in the surface waters of oligotrophic lakes (Howard, 1990).

Additional environmental degradation processes, such as hydrolysis and photolysis, are considered to be insignificant fate mechanisms for monocyclic aromatics in aquatic systems (USEPA, December 1982). However, some monocyclic aromatics such as benzene and toluene have been shown to undergo clay-, mineral-, and soil-catalyzed oxidation (Dragun, 1988).

5.2.3 Halogenated Aliphatics

Halogenated aliphatic hydrocarbons such as 1,1,2,2-tetrachloroethane, 1,1,1-trichloroethane, tetrachloroethene, and trichloroethene are subject to abiotic dehydrohalogenation. This process is an elimination reaction that results in the formation of an ethene from a saturated halogenated compound (Olsen and Davis, 1990). Research indicates that microbial degradation of highly chlorinated ethanes is a relatively slow process. 1,1,1-Trichloroethane has been shown to break down to 1,1-dichloroethane and chloroethane (Smith and Dragun, 1984), with half-lives reported on the order of 6 to 8 months. Hydrolysis, photolysis, and oxidation are generally not considered to be significant fate processes for the chlorinated ethanes.

Although trichloroethene is reportedly susceptible to degradation, the primary end product is reportedly vinyl chloride, which degrades slowly (Cline and Viste, 1984). It does not appear that appreciable degradation of halogenated aliphatics occurs in aerobic aquatic systems (USEPA, December 1982) or in unsaturated soils (Lyman et al., 1990).

For vinyl chloride, volatilization is the most significant mechanism in all environmental media. However, any vinyl chloride that is not rapidly volatilized will rapidly leach to groundwater. Data suggest that vinyl chloride is resistant to biodegradation in aerobic systems (Howard, 1989).

Releases of chloroform to land and water will rapidly evaporate to the atmosphere. In the atmosphere, chloroform may be transported long distances and react in the gas phase with photochemically produced hydroxyl radicals, with a reaction half-life of several months. Chloroform may leach to groundwater, from where it may discharge to surface water bodies. Half-lives for this compound in various surface water bodies range from 30 hours to 10 days (Howard, 1989).

Several other aliphatic hydrocarbons (bromodichloromethane, chlorodibromomethane, and methylene chloride) will rapidly volatilize when released to soil and water. These compounds also significantly biodegrade under aerobic conditions. Releases to the atmosphere will react with hydroxyl radicals. These reactions have estimated half-lives of several months (Howard, 1990).

Trichlorofluoromethane is a stable compound that will migrate readily through soil but will persist in groundwater. The only major sink for trichlorofluoromethane is from its slow diffusion into the stratosphere where photolysis occurs, followed by ozone-destroying reactions. If released in water or on land, trichlorofluoromethane is lost by volatilization (a half-life of 3.4 hours in a river is reported) (Howard, 1990).

1,2-Dichloropropane is removed from soil by volatilization, but some may leach to the groundwater. Volatilization half-lives of 6 hours to 10 days are reported for surface waters. Adsorption and bioconcentration are not significant fate mechanisms (Howard, 1990).

Photolysis is not considered to be a relevant degradation mechanism for this class of compounds (USEPA, December 1982). Limited hydrolysis of saturated aliphatics (i.e., alkanes) may occur, but it does not appear to be a significant degradation mechanism for unsaturated species (i.e., alkenes) (USEPA, December 1982).

Under certain conditions, volatilization is a significant fate process for these compounds. Volatilization is only significant at the air-soil or air-water interface. Adsorption should not be considered as an important fate for these types of compounds when compared to more hydrophobic compounds (PCBs for example).

5.2.4 Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs 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, whereas the high-molecular-weight PAHs [e.g., benzo(a)pyrene, benzo(a)anthracene, chrysene] 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.

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.

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 (ATSDR, October 1989b).

The most important fates of PAHs in water are photooxidation, 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. Fluorene and pyrene are reported to be resistant to photodegradation. PAHs may also be oxidized by chlorination and ozonation, and they may be metabolized by microbes under oxygenated conditions (ATSDR, October 1989b).

5.2.5 Phthalate Esters

Phthalate esters are considered to be relatively persistent chemicals in the environment. Although numerous studies have demonstrated that phthalate esters undergo biodegradation, it appears that this is a slow process in both soils and surface waters. Certain microorganisms have been shown to excrete products that increase the solubility of phthalate esters and enhance their biodegradation (Gibbons and Alexander, 1989).

Biodegradation of bis(2-ethylhexyl)phthalate and other phthalates in water is an important fate mechanism, with a half-life of 2 to 3 weeks reported for bis(2-ethylhexyl)phthalate (Howard, 1989). Bioaccumulation is also a significant fate process. Hydrolysis of phthalate esters is very slow, with calculated half-lives of 3 years (dimethylphthalate) to 2,000 years [bis(2-ethylhexyl)phthalate] (USEPA, December 1979). Similarly, photolysis and volatilization are considered to be insignificant degradation mechanisms (USEPA, December 1979; Howard, 1989).

5.2.6 Pesticides

Whether pesticides are sprayed, dusted, or applied directly to the soil, the soil is the ultimate sink for these chemicals. Runoff may carry pesticides to adjacent surface water bodies. Bioconcentration of pesticides in the food chain is another important fate mechanism. Hydrolysis, oxidation, and photolysis are not generally important fate mechanisms for pesticides in soil or water. Hydrolysis half-lives for several pesticides are reported in periods of months to years (USEPA, December 1979). Some of the more commonly detected pesticides are discussed below.

- **4,4'-DDT and its metabolites** are considered to be persistent chemicals. They undergo extensive adsorption to soil and are not highly soluble. 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, while under anaerobic conditions, DDE 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 (ATSDR, October 1992c). DDT is no longer in production in the United States.

- **Aldrin** residues in soils and plants will volatilize from surface soil or be slowly transformed to dieldrin. Aldrin is considered to be moderately persistent with a half life of 20 to 100 days.

- **Dieldrin** is an extremely persistent pesticide, but it is no longer registered for general use. 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 (Howard, 1991).

- **Heptachlor epoxide** is formed by the biological transformation of **heptachlor** in the environment. These compounds sorb strongly to soil. Heptachlor is subject to biodegradation (forming heptachlor epoxide, which is highly resistent to biodegradation) and hydrolysis. Bioconcentration of both compounds is significant, while volatilization and photolysis are very slow (Howard, 1991).

- **Methoxychlor** will remain in the soil and does not leach significantly. It degrades more rapidly under anaerobic conditions (less than 28-day half-life in sediments) than in aerobic conditions (more than 100-day half-life in sediments). In water, methoxychlor may adsorb to sediments or

it may bioaccumulate, although fish are reported to metabolize methoxychlor fairly rapidly (Howard, 1991).

- **Chlordane** is generally considered to be immobile or slightly mobile or slightly mobile in soil; however, it can be detected in groundwater. Chlordane may volatilize from moist soil surfaces to which it has been recently applied, but shallow incorporation into the soil greatly reduces volatile losses. Similarly, adsorption to sediment also reduces volatilization from surface waters. In water, hydrolysis, oxidation, and photolysis are not significant. Bioconcentration is an important fate mechanism.

- **γ-BHC (Lindane)** released to soil will result in volatilization and slow leaching to groundwater. Lindane may slowly degrade in aerobic media. It rapidly degrades under anaerobic conditions. Hydrolysis is a significant fate process in alkaline waters, with half-life of 4 days at pH 9.3. Lindane bioconcentrates slightly in fish.

- **Endosulfan** is susceptible to biodegradation and hydrolysis in alkaline soils, and if applied to the soil surface, it may photolyze. Volatilization and leaching to groundwater are not expected to be significant. In alkaline waters, hydrolysis occurs readily. In all waters, volatilization, biodegradation, photolysis, and oxidation are important.

- **Endrin** is persistent in the environment, but will photodegrade to endrin ketone. Biodegradation may occur slowly in aerobic conditions. If released to water, endrin does not hydrolyze or biodegrade, but will sorb to sediments and bioconcentrate.

5.2.7 Polychlorinated Biphenyls (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 (USEPA, December 1979). 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 (USEPA, December 1979). Base-, acid-, and neutral-promoted hydrolysis are considered to be inconsequential degradation mechanisms for PCBs (USEPA, December 1982).

5.2.8 Halogenated Ethers

Bis(2-chloroethyl)ether has a hydrolysis half-life of 40 days in water. Volatilization is important, and biodegradation may occur after several weeks of acclimation. Aqueous photolysis and photooxidation are not important. When released to soil, this compound may hydrolyze and would leach to groundwater (Howard, 1989).

5.2.9 Chlorinated Dibenzo-p-Dioxins and Furans (CDDs and CDFs)

No information is available on the fate of octachlorodibenzo-p-dioxin in the environment. However, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is expected to be fairly immobile in soil. Leaching through the soil column is possible in soils of very low organic carbon content as a result of solvation or biotic mixing by earthworms. A white rot fungus (Phanaerochaete chrysosporium) has been shown to degrade TCDD, but this process is not reported in natural soil. Additionally, photoreaction and volatilization may remove some TCDD from soil surfaces (ATSDR, November 1987). The half life of CDDs in soil has been found to vary from 130 days to several years. Hence, CDDs are persistent environmental contaminants (Clement Associates, September 1985).

5.2.10 Metals

Metals are highly persistent environmental contaminants. They do not biodegrade, photolyze, hydrolyze, etc. The major fate mechanisms for metals are adsorption to the soil matrix (as compared to being part of the soil structure) and bioaccumulation.

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 the 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.

5.3 CONTAMINANT FATE AND TRANSPORT SUMMARY

This section presents a brief overview of contaminant fate and transport issues at MCAS Cherry Point. This discussion focuses on some of the major types of contaminants found at the site. The primary contaminants at OU2 are volatile organic compounds in soil and groundwater.

Volatile organic chemicals are typically considered to be fairly soluble and have a low capacity for retention by soil organic carbon, and therefore are the organic compounds most likely to be detected in groundwater. These types of chemicals may migrate through the soil column to groundwater as infiltrating precipitation solubilizes them. Some portion of these chemicals is retained by the unsaturated soil, but most will continue migrating downward to the water table. At that time, migration is primarily laterally with the hydraulic gradient at a rate determined by the aquifer seepage velocity and chemical retardation. Again, some portion of the chemical may be retained by the saturated soil.

Several of these compounds have specific gravities less than that of water (e.g., benzene, xylenes). These compounds are typically found in fuels, and if a large enough fuel spill occurs (including using gasoline, etc., as a fuel), these compounds may move through the soil column as a bulk liquid, until they reach the water table. There, instead of going into solution, the majority of the release may remain as a discrete fuel layer on the water table surface, with some of the material going into solution at the water/fuel interface. No floating fuel product was observed in any monitoring wells. The water table over much of the study area is less than 15 feet deep.

Pesticides were widely used at the Air Station. Many of the compounds detected are no longer licensed for general sale and use in the United States. Therefore, it is assumed that much of what was detected in the soil and sediments are representative of past application for insect control. 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 occurs primarily by erosion via the action of wind or water. However, the flat terrain and thick vegetation have minimized migration of pesticides. Concentrations of pesticides in soils and sediments are generally below 50 μg/kg.

6.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The purpose of the baseline human health risk assessment is to determine whether detected concentrations of contaminants pose a significant threat to potential human receptors. The potential risks for human health at Operable Unit 2 (OU2) are estimated based on the assumption that no actions are taken to control contaminant releases.

The assessment consists of five components: (1) Data Evaluation; (2) Toxicity Assessment; (3) Exposure Assessment; (4) Risk Characterization; and (5) Uncertainty Analysis. Figure 6-1 illustrates the general step-by-step process undertaken during the baseline human health risk assessment. A brief overview of each component of the assessment is presented below.

The main purpose of Data Evaluation (Section 6.1) is to identify and select chemicals of potential concern (COPCs) that are representative of the type and magnitude of potential human health effects. A list of potential COPCs is developed for each medium by comparing the maximum detected site concentrations to risk-based concentrations and background levels. Contaminant release and environmental transport mechanisms and exposure routes are also considered in the selection process.

In the Exposure Assessment (Section 6.2), a Conceptual Site Model (CSM) is developed which defines the exposure setting. Potential human exposures either at the source area or off site are identified. Exposure routes are developed from information regarding the source area concentrations, contaminant release mechanisms, patterns of human activity, and other pertinent information. Equations and exposure assumptions used to calculate exposure concentrations and human intakes for COPCs are provided.

The Toxicity Assessment (Section 6.3) presents the available data used to define the potential for COPCs to cause adverse human health effects. Reference Doses (RfDs) and Cancer Slope Factors (CSFs) are provided for oral, inhalation, and dermal exposures. A summary of the dose-response parameters for all identified COPCs is contained in this section. Other regulatory and health-based criteria (e.g., Federal and state drinking water/groundwater standards and ambient water quality criteria) are also presented for each medium as available.

A quantitative assessment of risk is performed in the Risk Characterization (Section 6.4). Risks are characterized by combining information on estimated exposure intakes for COPCs and dose-response parameters. Risks associated with threshold (noncarcinogenic) and nonthreshold (carcinogenic) effects are

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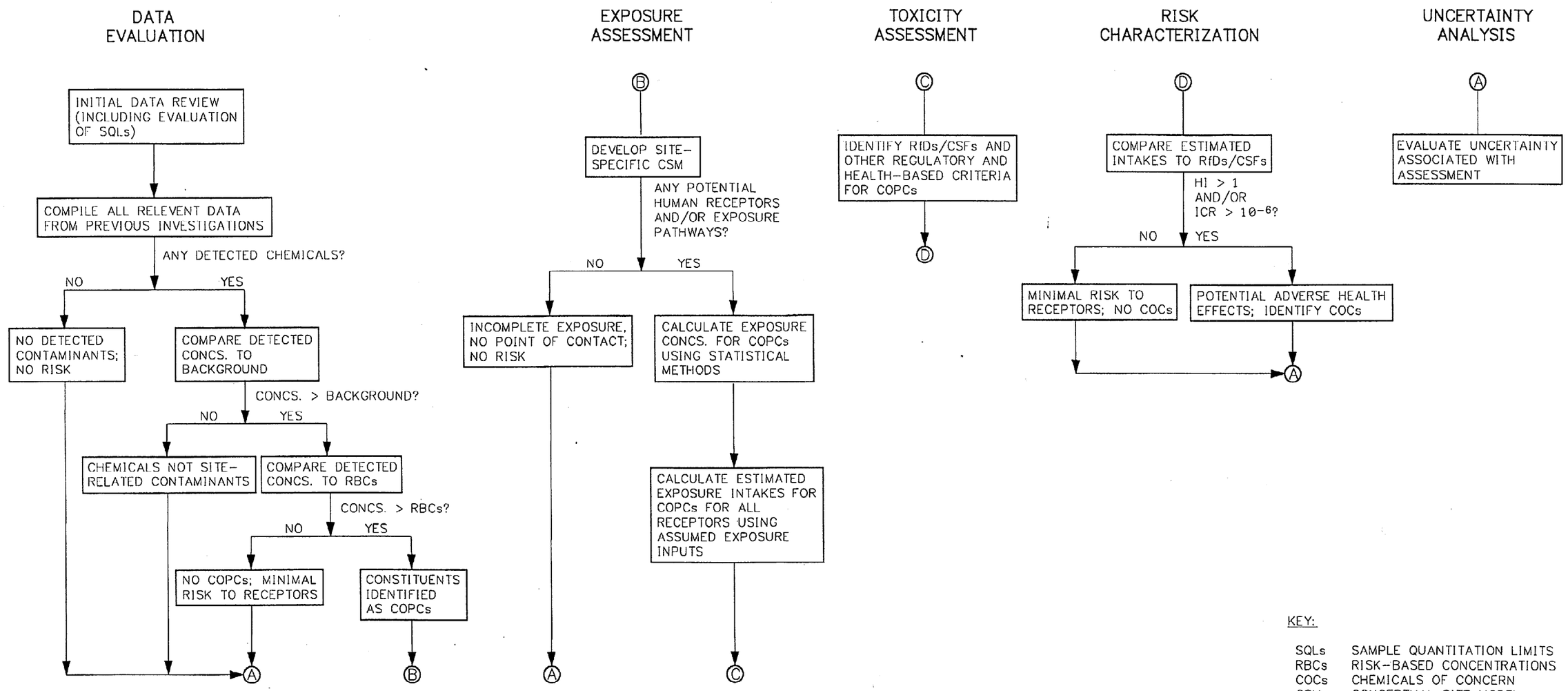

BASELINE HUMAN HEALTH RISK ASSESSMENT
GENERAL METHODOLOGY
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

FIGURE 6-1

calculated. The manner in which the risks are estimated is presented, as well as a summary and discussion of the quantitative risks.

The last component of the baseline human health risk assessment is the Uncertainty Analysis (Section 6.5). Varying degrees of uncertainty are inherent in each phase of the assessment. This section contains a discussion of the site-specific and general assumptions concerning exposure and toxicity that lead to uncertainties in the risk estimates.

The assessment was conducted in accordance with the following current USEPA risk assessment guidance and Region IV supplements:

- USEPA (U.S. Environmental Protection Agency), December 1989. Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A). EPA 540/1-89/002.

- USEPA (U.S. Environmental Protection Agency), May 1989b. Exposure Factors Handbook. EPA/600/8-89/043, Office of Health and Environmental Assessment, Washington, D.C.

- USEPA (U.S. Environmental Protection Agency), March 25, 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03, Washington, D.C.

- USEPA (U.S. Environmental Protection Agency) Region IV, April 4, 1991. Baseline Risk Assessment Guidance. Waste Management Division, Atlanta, GA.

- USEPA (U.S. Environmental Protection Agency), January 1992. Dermal Exposure Assessment: Principles and Applications, Interim Report. EPA/600/8-91/011B, Office of Research and Development, Washington, D.C.

- USEPA (U.S. Environmental Protection Agency), May 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term. OSWER Publication No. 9285.7-081, Washington, D.C.

- USEPA (U.S. Environmental Protection Agency) Region IV, November 1995. Supplemental Guidance to RAGS: Region 4 Bulletins (1-5) - Human Health Risk Assessment. Waste Management Division, Atlanta GA.

Copies of some relevant guidance documents are contained in Appendix J.2 (Volume III).

Three major aspects of chemical contamination and environmental fate and transport must be considered to evaluate potential risks: (1) contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or by human action; (2) potential exposure points must exist; and (3) human receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure. If any one of the factors listed above is absent, the exposure route is incomplete, and no potential risks to receptors are considered.

6.1 DATA EVALUATION

Data evaluation, the first component of the baseline risk assessment, involves the compilation and evaluation of analytical data. All existing data for soil and sediment were used for the assessment; only the most recent (1994-1996) data were used to evaluate potential risks for exposure to groundwater, surface water, and leachate seep water. The main objective of data evaluation is to develop a media-specific list of COPCs for OU2. The selection of COPCs is a qualitative screening process used to limit the number of chemicals quantitatively evaluated in the risk assessment to those chemicals that are site-related and contribute significantly to the overall risk.

The first step in the COPC selection process was to compare the maximum detected concentrations in each medium to appropriate background results. At this site, background data were collected for soil and groundwater only. The maximum onsite result was compared to a value representing two times the arithmetic average background result calculated using one half the detection limit for nondetects. No background comparison was performed for surface water or sediments. Leachate seep water was considered as groundwater, and leachate seep sediment was considered as soil.

Background comparisons were performed only for inorganic constituents. Although several organic compounds (e.g., PAHs, pesticides, and PCBs) were detected in background soil samples, these chemicals may be a result of anthropogenic activity and were not considered to represent "true" background levels. All detected organic compounds, therefore, were assumed to be present at concentrations above background.

A risk-based concentration screen, similar to one developed by USEPA Region III, was the used. The maximum detected concentrations in environmental samples were compared to risk-based concentrations, which correspond to a systemic Hazard Quotient of 0.1 (for noncarcinogens) or a lifetime cancer risk of 1E-6 (for carcinogens). If the maximum concentration of a particular chemical exceeded the screening level, the

chemical was retained for further evaluation. Chemicals eliminated from further evaluation, at this point, are assumed to present minimal risk to potential receptors.

Screening levels for this assessment were developed using Region III Risk-Based Concentration (RBC) Tables (USEPA Region III, May 1996) presented in Appendix J.2 (Volume III). These concentrations, which can be used, under certain circumstances, to approximate cleanup levels, are revised on a regular basis to account for changes in toxicological information and to incorporate default exposure parameters and exposure scenarios. Because Region III RBCs for noncarcinogens are back-calculated from a target Hazard Quotient (HQ) of 1.0, the associated values were divided by 10 to correspond to a systemic hazard of 0.1. RBCs for carcinogens were not modified, since these concentrations are derived from a target cancer risk of 1E-6.

RBCs for the residential exposure scenario were used to select COPCs for both surface soil and sediment. Residential criteria were used for screening COPCs even though there are no current plans to develop this site for residential uses. Subsurface soil COPSs were selected by comparing the analytical results to industrial RBCs. COPCs for groundwater and leachate seep surface water were identified using tap water RBCs. This approach results in a conservative list of COPCs because the shallow groundwater at the Air Station is not used as a drinking water supply, and routine ingestional exposures to groundwater and surface water are not expected. In the event that the site is developed as a residential area, it would be served by the Air Station's potable water supply. Finally, COPCs for surface water were identified using Water Quality Standards (WQS) for protection of human health (via ingestion of water and organisms).

RBCs could not be calculated for lead, since no toxicity values have been derived for this chemical. However, recommended contaminant levels, which are used to indicate the need for response activities, are available for lead in soil. Guidance from both the Office of Prevention, Pesticides, and Toxic Substances (OPPTS) and the Office of Solid Waste and Emergency Response (OSWER) recommend 400 mg/kg as the lowest screening level for lead-contaminated soil in a residential setting where children are frequently present (USEPA, July 14, 1994a and July 14, 1994b). OPPTS identifies 2,000 to 5,000 mg/kg as an appropriate range for areas where contact with soil by children in a residential setting is less frequent. At this time, no screening level is available for nonresidential areas involving adult exposure only; however, a value of 1,300 mg/kg has been identified by the USEPA and NCDEHNR as an appropriate screening value in an industrial setting to protect pregnant female employees. A value of 400 mg/kg is used as the screening level for surface soil at OU2, and 1,300 mg/kg is used for subsurface soil.

If a chemical was detected at a maximum concentration exceeding both two times the background concentration and the RBC/WQS (or the RBC/WQS if no background data were available), the chemical was selected as a COPC. The following are exceptions to these rules:

- If one carcinogenic PAH was selected as a COPC using the methodology described above, all other detected carcinogenic PAHs were selected as per USEPA Region IV guidance (November 1995).

- If there was no RBC/WQS available for a particular compound, the following surrogate criteria were used:

  - Naphthalene for noncarcinogenic PAHs such as 2-methylnaphthalene or benzo(g,h,i)perylene
  - Chlordane for α or γ-chlordane
  - Total PCBs value for individual congeners
  - Endosulfan value for endosulfan I and II
  - Endrin value for endrin aldehyde
  - Hydrogen cyanide value for cyanide
  - Thallic oxide value for thallium

- For arsenic, the RBCs for arsenic as a human carcinogen were used to be more conservative

- For chromium, the RBCs for hexavalent chromium were used to be more conservative

- Essential human nutrients (calcium, magnesium, potassium, and sodium) were not selected as COPCs.

Finally, the list of groundwater/leachate and surface water chemicals eliminated from consideration was compared to North Carolina Groundwater Quality Standards and Surface Water Standards for protection of human health for exceedances. Any compound that exceeded a state standard was then included as a COPC. Organic analytes found in groundwater for which the state has no standard were also selected as COPCs. In conjunction with this step, a final evaluation of the analytical results and their associated blank samples was performed to determine if additional analytes could potentially be present in the sampling; however, no additional COPCs were selected for this reason.

Media-specific tables summarizing the comparison of maximum detected concentrations to calculated risk-based screening levels and background are presented in Appendix J.3 (Volume III). A summary of the list of COPCs for human health risk assessment for each medium is provided in Table 6-1. The remainder of this section contains brief discussions of the identified COPCs.

6.1.1 Soil

As discussed in Section 4.1, several constituents, including volatile organics, PAHs, phenols, phthalate esters, pesticides, and metals, were detected in the soil at OU2. Most chemicals were detected infrequently; however, fuel-type constituents and a few chlorinated solvents were detected more frequently than other organic compounds. COCPs were selected for two soil classifications: surface soil (soil from depths of 0 to 2 feet and dry sediments from leachate seeps identified in the RIIR) and "all soil" (surface and subsurface soil and leachate seep sediments from depths of 0 to 10 feet) for the entire site. Soils to a depth of 2 feet were used in order to maximize the use of existing data; however, it should be noted that most of these samples were actually collected from depths of less than 1 foot. All historical and current (1994, 1995, and 1996) data were considered in the selection of COPCs for soil.

Nine metals (aluminum, antimony, arsenic, beryllium, cadmium, chromium, iron, manganese, and thallium), benzo(a)pyrene, and Aroclor-1260 were selected as COPCs for surface soil/leachate sediment. Five other carcinogenic PAHs were also selected because benzo(a)pyrene was selected. All other organic compounds detected in the surface soil (monocyclic aromatics, halogenated aliphatics, phenols, PAHs, phthalate esters, dioxins, and pesticides) were detected at maximum concentrations below the risk-based concentration screening values. All other detected metals not selected were below the screening values.

In "all soil", only three metals were selected as COPCs (arsenic, cadmium, and lead) based on their presence at concentrations greater than background and their maximum detected concentrations exceeding the industrial risk-based screening values. All detected organic compounds and all other metals were present at maximum concentrations below the industrial RBCs.

Risk-based screening levels were not available for several organic chemicals (e.g., 2-methylnaphthalene, phenanthrene, 2-hexanone, δ-BHC, and endrin aldehyde) detected in the soil samples because of the lack of published dose-response parameters for these compounds. Therefore, the RBCs for similar compounds were used for the COPC selection process. None of these constituents were selected as COPCs, and the exclusion of these chemicals should not add significantly to the uncertainty of the baseline human health risk assessment (Section 6.5).

TABLE 6-1

MEDIA-SPECIFIC CHEMICALS OF POTENTIAL CONCERN (COPCs)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Surface Soil (0 to 2 Feet)	All Soil (0 to 10 Feet)	Groundwater	Leachate Seeps	Surface Water	Sediment	Polishing Pond Sediment
Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Chrysene Indeno(1,2,3-cd)pyrene Aroclor-1260 Aluminum Antimony Arsenic Beryllium Cadmium Chromium Iron Manganese Thallium	Arsenic Cadmium Lead	**Surficial Aquifer:** 1,1-Dichloroethene 1,2-Dichloroethane 1,2-Dichloropropane 2-Butanone 2-Hexanone 4-Methyl-2-pentanone Benzene Chlorobenzene Chloroform Chloroethane cis-1,2-Dichloroethene Ethylbenzene Tetrachloroethene Toluene Trichloroethene Vinyl chloride 1,2-Dichlorobenzene 1,4-Dichlorobenzene 2-Methylnaphthalene 2-Methylphenol 2,4-Dimethylphenol 4-Methylphenol Bis(2-chloroethyl)ether Bis(2-ethylhexyl)phthalate Naphthalene Nitrobenzene 4,4'-DDE 4,4'-DDT Aldrin	Benzene Chloroethane Vinyl chloride 4,4'-DDT Aldrin γ-BHC Dieldrin Heptachlor Antimony Arsenic Cadmium Iron Lead Manganese Nickel Thallium	**Turkey Gut:** Bis(2-ethylhexyl)phthalate Heptachlor epoxide Arsenic **Slocum Creek:** 4,4'-DDD	**Turkey Gut:** Aluminum Antimony Arsenic Beryllium Iron Manganese **Slocum Creek:** Aluminum Antimony Arsenic Chromium Iron Manganese	None

TABLE 6-1 (Continued)
MEDIA-SPECIFIC CHEMICALS OF POTENTIAL CONCERN (COPCs)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Surface Soil (0 to 2 Feet)	All Soil (0 to 10 Feet)	Groundwater	Leachate Seeps	Surface Water	Sediment	Polishing Pond Sediment
		Surficial Aquifer: (Continued) α-BHC γ-BHC Endosulfan I Endosulfan II Endrin Aldehyde Heptachlor Heptachlor epoxide Aluminum Arsenic Barium Cadmium Iron Manganese **Yorktown Aquifer:** Chloroform Bis(2-ethylhexyl)phthalate Iron Manganese				

In addition, there are several metals for which no dose-response parameters (and therefore no RBCs) are available. These metals (calcium, magnesium, potassium, and sodium) are not selected as COPCs in any medium. These metals are all considered to be essential human nutrients, as well as significant natural components of soil and groundwater.

The detailed COPCs selection process for surface soils and "all soils" is contained in Tables J.3-1 and J.3-2, respectively, in Appendix J.3 (Volume III).

6.1.2 Groundwater

Halogenated aliphatics, monocyclic aromatics, phthalate esters, naphthalene, and metals were the constituents most commonly detected in the groundwater samples at OU2. Sporadic detections (in five or fewer samples) of a few other volatiles, semivolatiles, and pesticides were observed. A detailed discussion of the chemicals detected in this medium is provided in Section 4.2. Risk evaluation for groundwater was performed using the most recent available (1994-1996) unfiltered data. Historical data are not used for the following reasons: (1) the 1994-1996 samples were collected using the most appropriate sampling technique (low-flow purge and sample), (2) the 1994-1996 data are most representative of current site conditions, (3) the suite of analytes measured in 1994-1996 was the most comprehensive, and (4) all 1994-1996 data were subject to validation.

The list of COPCs for the surficial aquifer at OU2 includes several monocyclic aromatics (benzene; chlorobenzene; ethylbenzene; nitrobenzene; 1,2- and 1,4-dichlorobenzene; toluene; 2,4-dimethylphenol; and 2- and 4-methylphenol); and halogenated aliphatics (tetrachloroethene; trichloroethene; cis-1,2-dichloroethene; 1,1-dichloroethene; vinyl chloride; 1,2-dichloroethane; chloroethane; chloroform; and 1,2-dichloropropane). Also included as COPCs are bis(2-chloroethyl)ether; bis(2-ethylhexyl)phthalate; several ketones (2-butanone, 2 hexanone, and 4-methyl-2-pentanone) and 10 pesticides. Several of the organic COPCs were selected only because there is no state groundwater standard. The state regulations indicate that this condition is an exceedance, and therefore these compounds are of particular interest to NCDEHNR. The compounds that fall in this category include the ketones; chloroethane; 2-methylnaphthalene; 2-methylphenol; and several pesticides.

In addition, six metals (aluminum, arsenic, barium, cadmium, iron, and manganese) were also selected as COPCs. All other detected metals were below the RBCs or are considered to be essential nutrients. Details on the COPC selection process for the surficial aquifer are presented in Table J.3-3 (Appendix J.3, Volume III).

A limited number of COPCs were selected for the Yorktown aquifer. These are chloroform, bis(2-ethylhexyl)phthalate, iron, and manganese. Other detected analytes that were present at concentrations below RBCs (methylene chloride, aluminum, barium, lead, and zinc) were not selected as COPCs for this aquifer. The selection process is outlined in Table J.3-4 (Appendix J.3, Volume III).

6.1.3 Surface Water

Both unfiltered and filtered 1994 surface water data were used in the assessment, as these data are considered to be most indicative of current site conditions. Unfiltered data were used preferentially, unless a contaminant was only detected in the filtered samples. A discussion of the nature and extent of contamination in surface water is provided in Section 4.3.

Separate lists of COPCs for surface water were developed for Turkey Gut and Slocum Creek. No background data are available for this medium; therefore, COPCs were selected based on a comparison of maximum detections to WQS and state standards only. Bis(2-ethylhexyl)phthalate, heptachlor epoxide, and arsenic were retained as surface water COPCs for Turkey Gut. For Slocum Creek, the list of COPCs for surface water includes only 4,4'-DDD. Details on the COPC selection process for Turkey Gut and Slocum Creek are provided in Tables J.3-5 and J.3-6 (Volume III), respectively.

6.1.4 Sediment

As discussed in Section 4.4, pesticides and metals were commonly detected in the sediment samples at OU2. A few volatile organics and phthalate esters were also detected in several samples. All existing data (current and historical) were used to select COPCs for this medium.

Separate lists of COPCs for sediment were developed for Turkey Gut and Slocum Creek. Since background data are not available for this medium, COPCs were selected by comparing the maximum detections to residential soil risk-based screening levels. For Turkey Gut, aluminum, antimony, arsenic, beryllium, iron, and manganese were the only analytes identified as COPCs for sediment. The list of sediment COPCs for Slocum Creek consists of aluminum, antimony, arsenic, chromium, iron, and manganese. The rationale for inclusion or exclusion of each analyte is presented in Tables J.3-7 (Turkey Gut) and J.3-8 (Slocum Creek), found in Appendix J.3 (Volume III).

6.1.5 Leachate Water

Several leachate seeps were sampled during the RIIR (1985 through 1987) and in 1995. The analytical results are summarized in Section 4.5. Compounds detected include monocyclic aromatics, halogenated aliphatics, pesticides, and metals.

A list of COPCs was developed using analytical results from the most recent (1995) leachate water samples. These samples may be considered to be representative of groundwater, and therefore COPCs were selected by comparing the maximum detections to background groundwater data, tap water risk-based screening levels, and state groundwater standards. Benzene, chloroethane, vinyl chloride, and several pesticides (aldrin; 4,4'-DDT; γ-BHC; dieldrin; and heptachlor) and metals (antimony, arsenic, cadmium, iron, lead, manganese, nickel, and thallium) were selected as COPCs for leachate water using the rationale outlined in Table J.3-9 (Appendix J.3, Volume III). All other detected organics and metals were found at concentrations below the RBCs.

6.1.6 Polishing Pond Sediments

Eight samples were collected from the polishing pond bottom sediments and underlying soils. For the purposes of selecting COPCs for this medium, all samples were considered to be sediments, and therefore no background comparison was performed. The maximum detected concentrations were compared to industrial soil RBCs. No COPCs were selected. Table J.3-10 (Appendix J.3) contains additional details on the COPC selection process.

6.2 EXPOSURE ASSESSMENT

This portion of the risk assessment defines and evaluates, quantitatively or qualitatively, the type and magnitude of human exposure to the chemicals present at or migrating from OU2. The exposure assessment is designed to depict the physical setting of the site, identify potentially exposed populations and applicable exposure pathways, calculate COPC concentrations to which receptors might be exposed, and estimate chemical intakes for the identified exposure scenarios.

Actual or potential exposures at OU2 are determined based on the most likely pathways of contaminant release and transport, as well as the human and environmental activity patterns. 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 a human or environmental receptor.

6.2.1 Conceptual Site Model

The development of a detailed Conceptual Site Model (CSM), Figure 6-2, is an essential component of the exposure assessment. The model is intended to integrate information regarding the physical characteristics of the site, exposed populations, sources of contamination, and contaminant mobility (fate and transport) to identify potential exposure routes and receptors evaluated in the risk assessment.

6.2.1.1 Exposure Setting

The exposure setting consists of a general description of the physical characteristics of the site, as well as the identification of potentially exposed populations at or near the site. Exposed populations are identified with respect to both current and future land uses.

Physical Environment

A detailed description of the physical characteristics of OU2 (climate, meteorology, geology, groundwater hydrology, vegetation, and nearby surface water bodies) is provided in Section 3.0 of this report. A synopsis of the information pertinent to the assessment of potential exposure is presented below.

The climate of OU2 is best described as being warm and humid with an average annual temperature of 64°F. Winters are typically short and mild, and summers are usually long and hot. The average annual rainfall is approximately 55 inches (Floyd, 1969).

The site, which is well vegetated, is mainly flat with short, sloping banks along Slocum Creek. The entire landfill area is enclosed by a chain-link fence except along the bank of Slocum Creek.

Groundwater in the surficial aquifer at OU2 generally flows toward Slocum Creek and is not used as a potable water supply. All water supplies for the Air Station and the City of Havelock are drawn from deeper aquifers, primarily the Castle Hayne aquifer, which is approximately 110 to 300 feet below ground surface.

Slocum Creek is designated as a Class SC tidal saltwater body by the North Carolina Department of Environment, Health, and Natural Resources. These waters are suitable for fish and wildlife propagation and secondary recreational activities. Freshwater and estuarine fish inhabit the creek. Fish and wildlife habitats are protected at the Air Station by an active management program. A detailed discussion of the sensitive ecological habitats at OU2 is provided in the ecological risk assessment (Section 7.0).

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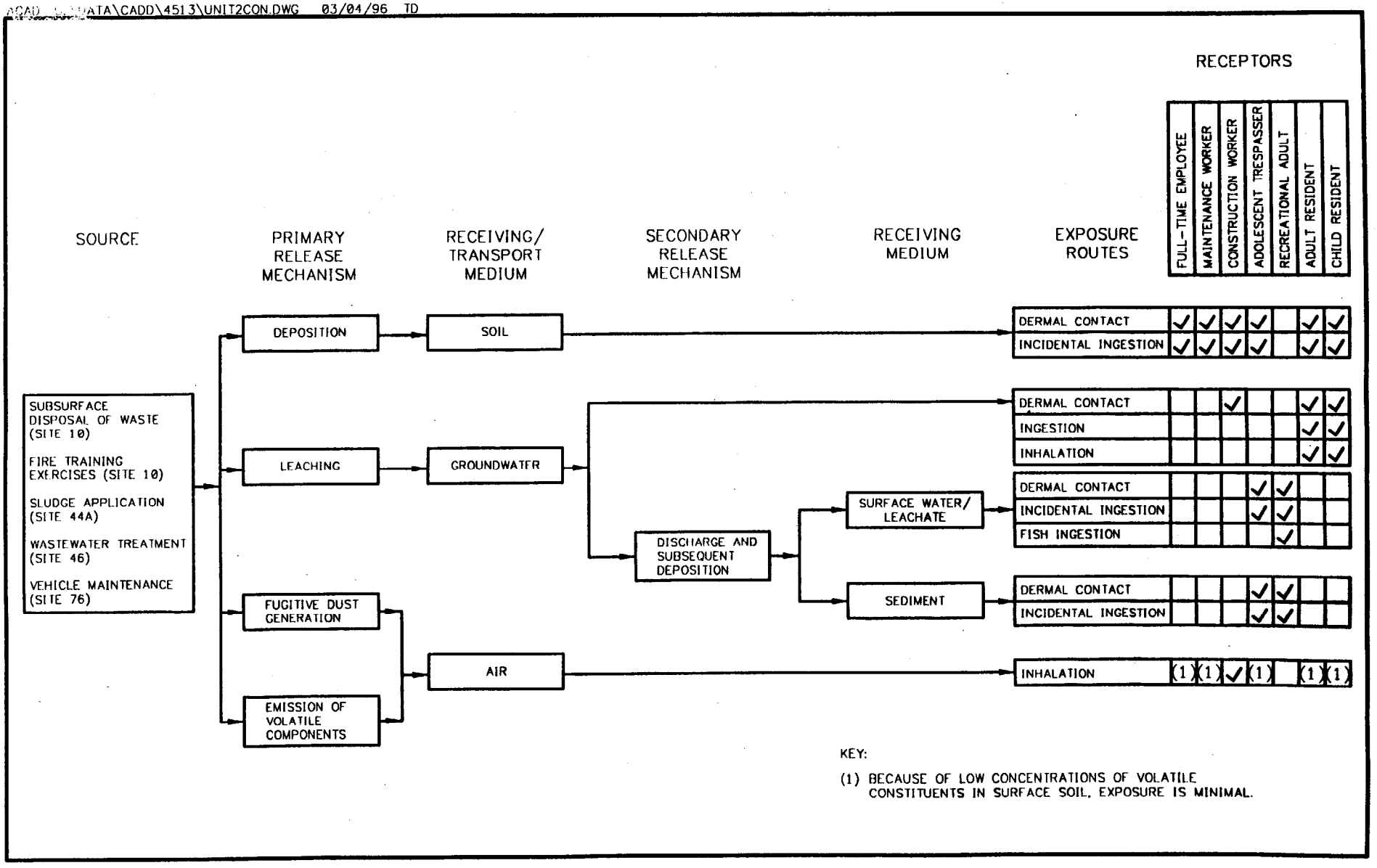

FIGURE 6-2

CONCEPTUAL SITE MODEL
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Brown & Root Environmental

Exposed Populations

In Fiscal Year 1995, the Air Station had 8,267 active military personnel and 5,946 civilian personnel living and/or working on site. Dependents, living both on and off the station, numbered 27,586. The military is a major presence in the area, with a total of 46,407 military personnel in four counties (Pamlico, Jones, Craven, and Carteret counties). An average tour of duty is approximately 3 years, with most personnel falling in a range of 2 to 6 years.

Most of the housing at MCAS Cherry Point is located in the southwest area of the Air Station. The closest housing to OU2 is situated south of the landfill, approximately 200 feet from the fenceline. Various areas of the Air Station are used as Ordnance and Survival Training Areas; OU2 is not among these designated areas.

6.2.1.2 Exposure Pathways

The course that a chemical takes from the source to the exposed individual is defined as the exposure pathway. Several factors regarding exposure (chemical sources, environmental release mechanisms, contact points, likely exposure routes, and potential receptors) are discussed in this section. The characterization of these factors is necessary so that only complete exposure pathways are evaluated in the risk assessment.

Contaminant Sources and Release Mechanisms

OU2 consists of an old sanitary landfill approximately 40 acres in size. It had served as the primary waste disposal site at the Air Station from 1955 until the early to mid-1980s. Contaminated material and POL were landspread, burned, stored in unlined pits, and buried at the landfill. A former sludge impoundment area, former sludge application areas, and surface impoundments associated with the sewage treatment plant are also components of OU2.

Chemicals from the identified sources may be released to the surrounding environment primarily though volatilization, wind erosion, and infiltration. Transportation of contaminants via surface water runoff is expected to be insignificant, since OU2 is relatively flat and well vegetated.

Constituents in the site soil may volatilize from surficial material or become airborne via wind erosion. However, the concentrations of chemicals with high vapor pressures (volatile organics) are low in the surface soil (top 2 feet). Fugitive dust may also be generated during potential future ground-intrusive activities, such

as construction or excavation. The vegetative cover that currently exists will minimize offsite transport of particulates under current site conditions. These chemicals are dispersed in the surrounding environment and transported off site to downwind locations, where they may repartition to surface soil, surface water, or sediment through gravitational settling, precipitation, and deposition. It is assumed that following any construction activity, the area would be paved, covered with a structure, revegetated, etc. Therefore, future exposures via inhalation would be limited to the construction period.

Infiltrating precipitation and/or direct subsurface burial may cause the contamination of subsurface soil and groundwater with soluble chemicals. Contaminants disposed of in the unlined pits appear to have solubilized and migrated downward into the surficial aquifer. Chemicals with a stronger tendency to adsorb to organic matter in soil (e.g., PAHs, phthalates, etc.) are expected to migrate at a slower rate than volatile organics. Upon entering the water column, a chemical is carried with the flow of groundwater to downgradient locations. Groundwater from the site eventually discharges to surface water. Contaminants may be subsequently deposited in sediment, or they may accumulate in the tissues of aquatic organisms.

Potential Receptors and Exposure Routes

A summary of the potential receptors and exposure routes selected for risk evaluation at OU2 is provided in Table 6-2. This information is presented in the context of current and future land use conditions.

The following groups are considered to be potential receptors for exposure to contaminated media at OU2:

- Onsite Residents
- Maintenance Workers
- Full-Time Employees
- Construction Workers
- Trespassers
- Recreational Users

Although the site is not frequented by military personnel, exposure to site media may intermittently occur under current land use conditions while workers are performing maintenance duties (e.g., mowing) or site inspections. Adolescents may also trespass on the site even though access to the site is restricted. Slocum Creek and its tributaries are used for recreational purposes; consequently, an adult recreational user was evaluated. Small children (6 years or younger) were not evaluated because the steep shorelines preclude wading. Construction workers and full-time employees are considered potential receptors under future land use conditions only, as no frequent activities currently occur on site. Future residents were identified as

TABLE 6-2

SUMMARY OF SELECTION OF EXPOSURE PATHWAYS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Potentially Exposed Population	Exposure Route/Pathway	Selected for Evaluation?	Rationale for Evaluation or Exclusion
Current Land Use:			
Residents	Direct contact with contaminated media	No	Access to the site is restricted. No housing currently located on site.
	Inhalation of volatile emissions and/or dust	No	Concentrations of volatiles in surface soil are low. Site is well vegetated.
Maintenance Workers	Direct contact with surface soil	Yes	Inspection/maintenance duties may be performed at the site.
	Inhalation of volatile emissions and/or dust	No	Concentrations of volatiles in surface soil are low. Site is well vegetated.
	Direct contact with groundwater, surface water, and sediment	No	Groundwater not used as a potable water supply. Exposure to surface water and sediment unlikely for adult personnel.
Trespassers	Direct contact with surface soil, surface water/leachate, and sediment	Yes	Access to the site is restricted, but adolescents may trespass on the site and in Turkey Gut.
	Inhalation of volatile emissions and/or dust	No	Concentrations of volatiles in surface soil are low. Site is well vegetated.
Recreational Users	Direct contact with surface water and sediment	Yes	Slocum Creek is used for recreational activities (i.e., fishing, swimming, waterskiing).
	Ingestion of fish	Yes	Fishing occurs in Slocum Creek.
	Direct contact with surface soil	No	Adult recreational users are not expected to leave the shore banks.

TABLE 6-2 (Continued)
SUMMARY OF SELECTION OF EXPOSURE PATHWAYS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Potentially Exposed Population	Exposure Route/Pathway	Selected for Evaluation?	Rationale for Evaluation or Exclusion
Future Land Use:			
Onsite Residents[1]	Direct contact with groundwater and surface soil	Yes	No land use restrictions are in effect. Future land use is unknown.
	Inhalation of volatile emissions and/or dust	No	Concentrations of volatiles in surface soil are low. Site is well vegetated.
Maintenance Workers/Full-Time Employees	Direct contact with surface soil	Yes	Inspection/maintenance/routine duties may be performed at the site.
	Inhalation of volatile emissions and/or dust	No	Concentrations of volatiles in surface soil are low. Site is well vegetated.
	Direct contact with groundwater, surface water, and sediment	No	Groundwater not used as a potable water supply. Exposure to surface water and sediment unlikely.
Construction Workers	Direct contact with surface/subsurface soil and groundwater (surficial aquifer)	Yes	Construction/excavation projects may be undertaken on the site.
	Inhalation of fugitive dust	Yes	Dust may be generated during construction/excavation projects.
	Direct contact with surface water and sediment	No	Exposure is unlikely.
	Inhalation of volatile emissions	No	Volatile organics are not significant or widespread soil contaminants.
Trespassers	Direct contact with surface soil, surface water/leachate, and sediment	Yes	Access to the site is restricted, but adolescents may trespass on the site and in Turkey Gut.
	Inhalation of volatile emissions and/or dust	No	Concentrations of volatiles in surface soil are low. Site is well vegetated.

TABLE 6-2 (Continued)
SUMMARY OF SELECTION OF EXPOSURE PATHWAYS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Potentially Exposed Population	Exposure Route/Pathway	Selected for Evaluation?	Rationale for Evaluation or Exclusion
Future Land Use:			
Recreational Users	Direct contact with surface water and sediment	Yes	Slocum Creek is used for recreational activities (i.e., fishing, swimming, waterskiing).
	Ingestion of fish	Yes	Fishing occurs in Slocum Creek.
	Direct contact with surface soil	No	Adult recreational users are not expected to leave the shore blanks.

1 Under future land use (construction scenario), offsite residents may also be exposed to fugitive dust. See Section 6.2.3 for order-of-magnitude exposure discussion.

potential receptors because no land use restrictions are in effect at this site.

Potential receptors can be exposed to site contaminants, directly or indirectly, via six environmental media: air, soil, groundwater, surface water, sediment, and leachate. Potential exposure routes for these media include ingestion (swallowing), dermal contact (skin or eye), and/or inhalation (through breathing passages).

Direct contact with contaminated soil or sediment can result in a dermal exposure. For example, personnel performing inspection duties at the site could get contaminated soil on their skin. Chemicals in soil are considered to be dermally absorbed to some extent. Incidental ingestion of soil can also occur following hand-to-mouth contact. Direct contact with surface soil and leachate seep sediments was evaluated for the maintenance worker, full-time employee, adolescent trespasser, and residents. No distinction was made between soil samples and sediment samples collected from former (now dry) leachate seep areas. Construction workers are assumed to be exposed to all soil (and sediment) to a depth of 10 feet. Surface soil/sediment exposures only are considered for future residents or employees, as it is assumed that after construction of housing (covering or disturbing only limited areas), undisturbed surface soil would exist over the remainder of the area. Adult recreational users are not expected to venture ashore and come in contact with site soil, although they could contact sediment in Slocum Creek during fishing, etc. In addition, adolescent trespassers could come into contact with sediment in both Turkey Gut and Slocum Creek.

Volatile emissions are not considered to be a significant route of exposure for OU2 and were not evaluated in the risk assessment. Volatile organic compounds that were retained as COPCs are not found in soils less than 2 feet deep. Higher concentrations were detected in several soil samples at depths of 20 feet or more, below the estimated depth of construction (10 feet). Therefore, no major source area exists for volatile emissions for either current or future land use conditions.

Exposure to fugitive dust is expected to be greater than the exposure to volatile emissions. This exposure route was quantitatively evaluated only for future construction workers, who may inhale contaminated airborne particulates while on site. Although the action of the wind on fine-grained surface soils can generate fugitive dust, the extent is expected to be minimal because the site is, for the most part, densely vegetated and would most likely be revegetated, paved, etc., if disturbed in the future.

Exposure to groundwater is also minimal under current site conditions. As discussed previously, this medium is not used as a potable water supply. No downgradient users exist. The only potential receptors assumed to be exposed to groundwater are the construction worker (via dermal contact with wet soil during construction) and future residents. In actuality, excavation would be unlikely to occur below the water table,

and the installation of a domestic supply well in the surficial aquifer or Yorktown aquifer is highly unlikely, as the Air Station has a separate potable water distribution system.

Exposure to surface water in Slocum Creek and Turkey Gut could occur though incidental ingestion and direct dermal contact. Exposure scenarios for this medium, were developed for adolescent trespassers (ages 8 to 16 years) for both water bodies and adult recreational users for Slocum Creek only. Contact with surface water is not expected to occur for construction and maintenance workers or residents other than those discussed above. Indirect exposures to Slocum Creek surface water may also occur via ingestion of fish by adult recreational users.

Exposure to leachate seeps could occur via incidental ingestion and dermal contact. Only adolescent trespassers playing on site were considered for this medium, as leachate seeps on the slopes of the landfill are not readily accessible by unsupervised, small children nor are they areas in which adult receptors are likely to be exposed. In addition, the same areas of ponded water would probably not exist if the site were developed for residential uses.

6.2.2 Exposure Concentrations

The exposure concentration is a reasonable maximum estimate of the chemical concentration that is likely to be contacted over time and is used to calculate estimated exposure intakes, presented in the following subsection (Section 6.2.3). The 95 percent upper confidence limit (UCL), which is based on the distribution of a data set, is considered to be the best estimate of the exposure concentration for data sets with 10 or more samples (USEPA, May 1992). For data sets with less than 10 samples, the UCL is considered to be a poor estimate of the mean. When the distribution of a data set could not be determined, the default assumption was that the data were log-normally distributed. For most compounds in most media, this default assumption results in a higher UCL and is therefore more conservative.

Details regarding the statistical methods used to determine the distribution and UCL of a particular data set are provided in Appendix J.1 (Volume III). Sample calculations, as well as general methodology, are presented. Sample and duplicate analytical results were averaged for statistical use. Nondetected data points were utilized; one-half the sample-specific detection limit was employed for these analytical results. Maximum concentrations were used as exposure concentrations for data sets with less than 10 samples and in cases where the calculated UCL exceeded the maximum detected value. This approach often results in the use of an exposure concentration (UCL) that exceeds the average of positive detections only, and is often therefore more conservative.

A summary of the exposure concentrations used to quantitate risks for each COPC is provided in Table 6-3.

6.2.3 Chemical Intake Estimates

The methodology used to estimate exposure intakes is discussed in this section. In general, intakes were calculated based on methods and models consistent with current USEPA risk assessment guidance (USEPA, December 1989 and January 1992). When available, standard default parameters were used to calculate intakes so that the resulting estimates represent the Reasonable Maximum Exposure (RME), defined as "the highest exposure that is reasonably expected to occur at a site" (USEPA, December 1989). An evaluation of the Central Tendency Exposure (CTE) is provided in Appendix J.6 (Volume III) for selected exposure scenarios.

Noncarcinogenic risks are estimated using the concept of an average annual exposure. The intake incorporates terms such as the exposure time and/or frequency which represents the number of hours per day and the number of days per year that exposure occurs. This is used with a term known as the averaging time, which converts the daily exposure frequency and duration to an annual exposure by dividing by 365 days per year of exposure.

On the other hand, carcinogenic risks are calculated as an incremental lifetime risk. The exposure intake for carcinogenic effects incorporate terms to represent the exposure duration (years) over the course of a lifetime (70 years or 25,550 days).

The methods and models applied to estimate exposure intakes for the exposure routes selected in Section 6.2.1.2 are presented below. Sample calculations for intakes can be found in Appendix J.4 (Volume III).

Exposure to Fugitive Dust

An emission model (Cowherd et al., 1984) is used to estimate the concentrations of respirable particulates in the air based on wind speed, vegetative cover, size of the source area, etc. The source area is assumed to be the area of the entire site (162,000 m^2). All of the site-specific and general assumptions made regarding the generation of fugitive dust at OU2 are presented in Appendix J.4 (Volume III).

TABLE 6-3

EXPOSURE CONCENTRATIONS FOR CHEMICALS OF POTENTIAL CONCERN (COPCs)[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Surface Soil (0 to 2 feet) (mg/kg)	All Soil (0 to 10 feet) (mg/kg)	Groundwater (mg/L)		Surface Water (mg/L)			Sediment (mg/kg)	
			Surficial Aquifer	Yorktown Aquifer	Slocum Creek	Turkey Gut	Leachate Seeps	Slocum Creek	Turkey Gut
1,1-Dichloroethene	--[2]	--	0.00077	--	--	--	--	--	--
1,2-Dichloroethane	--	--	0.00097	--	--	--	--	--	--
1,2-Dichloropropane	--	--	0.00083	--	--	--	--	--	--
2-Butanone	--	--	0.020	--	--	--	--		
2-Hexanone	--	--	0.001	--	--	--	--		
4-Methyl-2-pentanone	--	--	0.005	--	--	--	--		
Benzene	--	--	0.012	--	--	--	0.002[3]	--	--
Chlorobenzene	--	--	0.072	--	--	--	-	--	--
Chloroethane	--	--	0.0087	--	--	--	0.005[3]		
Chloroform	--	--	0.00087	0.002[3]		--	--	--	--
cis-1,2-Dichloroethene	--	--	0.015	--	--	--	--	--	--
Ethylbenzene	--	--	0.0024	--	--	--	--		
Methylene chloride	--	--	--	--	--	--	--	--	--
Tetrachloroethene	--	--	0.0015	--	--	--	--	--	--
Toluene	--	--	0.0055	--	--	--	--	--	--
Trichloroethene	--	--	0.0035	--	--	--	--	--	--
Vinyl chloride	--	--	0.0048	--	--	--	0.003[3]	--	--
1,2-Dichlorobenzene	--	--	0.0029	--	--	--	--	--	--
1,4-Dichlorobenzene	--	--	0.0082	--	--	--	--	--	--
2,4-Dimethylphenol	--	--	0.010	--	--	--	--	--	--

TABLE 6-3 (Continued)
EXPOSURE CONCENTRATIONS FOR CHEMICALS OF POTENTIAL CONCERN (COPCs)[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Surface Soil (0 to 2 feet) (mg/kg)	All Soil (0 to 10 feet) (mg/kg)	Groundwater (mg/L)		Surface Water (mg/L)			Sediment (mg/kg)	
			Surficial Aquifer	Yorktown Aquifer	Slocum Creek	Turkey Gut	Leachate Seeps	Slocum Creek	Turkey Gut
2-Methylnaphthalene	--	--	0.0057	--	--	--	--	--	--
2-Methylphenol	--	--	0.0054	--	--	--	--	--	--
4-Methylphenol	--	--	0.010	--	--	--	--	--	--
Benzo(a)anthracene	0.160[3]	--	--	--	--	--	--		
Benzo(a)pyrene	0.240[3]	--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	0.170[3]	--	--	--	--	--	--		
Benzo(k)fluoranthene	0.160[3]	--	--	--	--	--	--		
Bis(2-chloroethyl)ether	--	--	0.003[3]	--	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	--	--	0.011	0.0188	--	0.006[3]	--	--	--
Chrysene	0.220[3]	--	--	--	--	--	--		
Indeno(1,2,3-cd)pyrene	0.140[3]	--	--	--	--	--	--		
Naphthalene	--	--	0.0081	--	--	--	--	--	--
Nitrobenzene	--	--	0.005[3]	--	--	--	--	--	--
4,4'-DDD	--	--	--	--	0.000039	0.00028	--	--	--
4,4'-DDE	--	--	0.000055	--	--	--	--	--	--
4,4'-DDT	--	--	0.00001	--	--	--	0.00017[3]	--	--
Aldrin	--	--	0.0000034[3]	--	--	--	0.0000625[3]	--	--
α-BHC	--	--	0.0000098[3]	--	--	--	--	--	--
γ-BHC	--	--	0.000027	--	--	--	0.0000725[3]	--	--
Dieldrin	--	--	--	--	--	--	0.000155[3]	--	--
Endosulfan II	--	--	0.00005[3]	--	--	--	--	--	--

TABLE 6-3 (Continued)
EXPOSURE CONCENTRATIONS FOR CHEMICALS OF POTENTIAL CONCERN (COPCs)[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Surface Soil (0 to 2 feet) (mg/kg)	All Soil (0 to 10 feet) (mg/kg)	Groundwater (mg/L)		Surface Water (mg/L)			Sediment (mg/kg)	
			Surficial Aquifer	Yorktown Aquifer	Slocum Creek	Turkey Gut	Leachate Seeps	Slocum Creek	Turkey Gut
Endosulfan I	--	--	0.000009[3]	--	--	--	--	--	--
Endrin Aldehyde	--	--	0.000079	--	--	--	--	--	--
Heptachlor	--	--	0.0000055[3]	--	--	--	0.0000775[3]	--	--
Heptachlor epoxide	--	--	0.00002[3]	--	--	0.0000019[3]	--	--	--
Aroclor-1260	0.0778	--	--	--	--	--	--	--	--
Aluminum	6,470	--	0.275	--	--	--	--	8,760[3]	11,100[3]
Antimony	3.2	--	--	--	--	--	0.0094[3]	10.6[3]	20.0[3]
Arsenic	17.1[3]	2.96	0.0967	--	--	0.00295[3]	0.0039[3]	32.7[3]	7.2[3]
Barium	--	--	0.0975	--	--	--	--	--	--
Beryllium	0.15	--	--	--	--	--	--	--	0.2[3]
Cadmium	2.2[3]	1.35	0.00269	--	--	--	0.0242[3]	--	--
Chromium	24.1	--	--	--	--	--	--	57.5[3]	--
Copper	--	--	--	--	--	--	--	--	--
Iron	14,300	--	100.5	1.8	--	--	40.4[3]	32,600[3]	18,200[3]
Lead	--	35.7	--	--	--	--	0.0241[3]	--	--
Manganese	78.6	--	0.760	0.063	--	--	0.494[3]	394[3]	182[3]
Mercury	--	--	--	--	--	--	--	--	--
Nickel	--	--	---	--	--	--	0.0979[3]	--	--
Silver	--	--	--	--	--	--	--	--	--
Thallium	0.99	--	--	--	--	--	0.00195[3]	--	--

1 95 Percent upper confidence limit, unless otherwise noted 2 -- - Not a COPC for this medium 3 Maximum concentration

Chemical-specific intakes are then estimated using the following equation (USEPA, December 1989):

$$IEX = \frac{C_a \times IR \times ABS \times ET \times EF \times ED}{BW \times AT \times CF}$$

where:

IEX	=	inhalation exposure dose (mg/kg-day)
C_a	=	air concentration of chemical (μg/cubic meter [m^3])
IR	=	inhalation rate (m^3/hour)
ABS	=	absorption rate (unitless)
ET	=	exposure time (hours/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time or period of exposure (days)
CF	=	conversion factor (1E+3 μg/mg)

A fugitive dust exposure scenario was developed for construction workers involved in a short-term construction/excavation project (estimated length of project is 1 year). The total estimated intake for this scenario assumes that after the chemical is inhaled, a certain fraction of the contaminant is deposited in the lungs (12.5 percent), while another portion is subsequently ingested and accumulated in the gastrointestinal tract (62.5 percent). The inhalation rate for the construction worker was set at 4.8 m^3/hour. Constant exposure during working hours was assumed to occur (i.e., 8 hours/day for 180 days/year). Table 6-4 presents a summary of the input parameters for the fugitive dust exposure scenario.

A qualitative evaluation of fugitive dust impacts to current residents in adjacent neighborhoods may be made by comparing inhalation rates and exposure times. The exposures of current adult residents may be estimated as follows:

- Using an inhalation rate of 0.8 m^3/hr vs. 4.8 m^3/hr, the adult resident intake would be 1/6 that of the construction worker.

- Using an exposure time of 24 hr/day vs. 8 hr/day, the adult resident intake would be three times that of the construction worker.

- Therefore the combination of these parameters (1/6 times 3) would result in an intake for an adult resident of one-half that of the construction worker.

TABLE 6-4

EXPOSURE ASSUMPTIONS - FUGITIVE DUST
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Inhalation of Fugitive Dust (Construction Worker only)		
Input Variable	**Value Used**	**Brief Rationale/Reference**
Exposure Concentration (C)	95% UCL[1] (mg/kg)	Used to estimate contaminant concentration in air ($\mu g/m^3$).
Inhalation Rate (IR)	4.8 m^3/hr	Mean value for a heavy activity level (USEPA, May 1989b).
Absorption in Lungs and Gut (ABS; unitless)	0.125 - Lungs 0.625 - Gut	Schaum, 1984.
Exposure Time (ET)	8 hrs/day	Constant exposure while working; professional judgment.
Exposure Frequency (EF)	180 days/yr	Convention; 5 days/wk for 9 months; professional judgment.
Exposure Duration (ED)	1 yr	Estimated length of construction project; professional judgment.
Body Weight (BW)	70 kg	Convention; average value for adult men and women (USEPA, May 1989b).
Averaging Time (AT)	365 days/yr x ED - Noncarcinogens 365 days/yr x 70 yrs - Carcinogens	Convention (USEPA, December 1989).

1 Arithmetic Upper 95% Confidence Limit (UCL) of mean of data or log-transformed data. Maximum concentration used if 95% UCL exceeds maximum detection (USEPA, May 1992).

Similarly, for a child resident, using an inhalation rate of 0.6 m^3/hr, an exposure time of 24 hours/day, and a body weight of 15 kg (vs. 70 kg), the child resident's intake would be almost twice that of the construction worker.

Exposure to Soil/Sediment

Direct physical contact with contaminated soil or sediment can result in the dermal absorption of chemicals. Exposures resulting from the dermal route are estimated in the following manner (USEPA, December 1989):

$$DEX = \frac{C_s \times SA \times AF \times ABS \times EF \times ED}{BW \times AT \times CF}$$

where:

DEX	=	dermally absorbed dose (mg/kg-day)
C_s	=	contaminant concentration in soil or sediment (mg/kg)
SA	=	skin surface area available for contact (cm^2/day)
AF	=	soil-to-skin adherence factor (mg/cm^2)
ABS	=	absorption factor (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time or period of exposure (days)
CF	=	conversion factor (1E+6 mg/kg)

Five exposure scenarios (for maintenance, full-time employee, construction, trespassing, and residential exposure) were developed for dermal contact with soil. Construction workers and full-time employees are assumed to come in contact with soil on a daily basis (180 days/year and 250 day/yr, respectively), whereas expected exposure for maintenance workers and adolescent trespassers is assumed to be infrequent (12 days/year). Residents are assumed to be exposed daily (350 days/year). Additional exposures of adolescent trespassers (ages 8 to 16) and adult recreational users to sediment was considered, at 12 days/year and 45 days/yr, respectively, as well.

The skin surface area available for contact is receptor-specific and was estimated based on receptor activity patterns. Total exposed skin surface areas and exposed body areas for the potential receptors are, as follows:

- Maintenance worker/employee ..... 3,160 cm^2 .... head, forearms, and hands (soil)
- Construction worker ..... 4,300 cm^2 .... head, arms, and hands (soil)
- Adolescent trespasser ..... 4,570 cm^2 .... head, forearms, hands, and lower legs (soil)
- Adolescent trespasser ..... 4,140 cm^2 .... hands, forearms, feet, and lower legs (sediment)
- Adult recreational user ..... 5,170 cm^2 .... hands, forearms, feet, and lower legs (sediment)
- Adult resident ..... 5,230 cm^2 .... head, forearms, hands, and lower legs (soil)
- Child resident ..... 3,910 cm^2 .... head, forearms, hands, and lower legs (soil)

Maintenance workers and employees are expected to wear a short-sleeve shirt and pants. Although similar attire was assumed for construction workers, these receptors may roll up their shirt sleeves which can result in exposure to the total area of the arms. Adolescent trespassers and adult recreational users are assumed to be dressed in a short sleeve shirt and shorts. Adult and child residents may wear only shorts in summer, but winter months limit outdoor exposures. Therefore, clothing of short-sleeve shirts and shorts was selected to represent an overall average exposure.

An upper-bound default value of 1.0 mg/cm^2 was used as the soil-to-skin adherence factor (USEPA, January 1992). In accordance with Region IV guidance (USEPA Region IV, March 1994), dermal absorption factors of 0.01 and 0.001 were used for organic and inorganic chemicals, respectively.

Exposure to soil can also result in a minor amount of incidental ingestion after hand-to-mouth contact. Intakes through this route are estimated as follows (USEPA, December 1989):

$$IEX = \frac{C_s \times IR \times Fi \times EF \times ED}{BW \times AT \times CF}$$

where:
- IEX = ingestional exposure dose (mg/kg-day)
- C_s = exposure concentration in soil (mg/kg)
- IR = soil ingestion rate (mg/day)
- Fi = fraction ingested from source area (unitless)
- EF = exposure frequency (days/year)
- ED = exposure duration (years)

BW = body weight (kg)
AT = averaging time or period of exposure (days)
CF = conversion factor (1E+6 mg/kg)

Ingestion rates were set at 200 mg/day, 50 mg/day, 480 mg/day, and 100 mg/day, respectively, for the maintenance worker, employee, construction worker, and adolescent trespasser/adult resident/adult recreational user. Child residents are assumed to ingest 200 mg soil/day. Professional judgment was employed for the estimation of the fraction of soil ingested from the contaminated source. A conservative value of 1.0 was designated for all receptors. A summary of the soil exposure assessment assumptions for direct contact with soil at OU2 is presented in Table 6-5.

Exposure to Groundwater

Limited exposure to groundwater is expected to occur at the site, since groundwater is not used as potable water supply under current land use, and it is highly unlikely that the shallow groundwater sampled during the RI investigation would ever be used for domestic purposes under future land use. For receptors involved in ground-intrusive activities (construction workers), dermal contact with groundwater may occur. The following equation is used to assess this route of exposure (USEPA, December 1989):

$$DEX = \frac{C_{gw} \times PC \times SA \times ET \times EF \times ED}{BW \times AT \times CF}$$

where:
DEX = dermally absorbed dose (mg/kg-day)
C_{gw} = groundwater exposure concentration (mg/L)
PC = dermal permeability constant (cm/hour)
SA = skin surface area available for contact (cm^2)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time or period of exposure (days)
CF = conversion factor (1E+3 cm^3/L)

Chemical-specific permeability constants are used to estimate dermal intakes for the construction worker. The total exposed skin surface area was specified at 4,300 cm^2. The head, arms, and hands are assumed

TABLE 6-5
EXPOSURE ASSUMPTIONS - SOIL AND SEDIMENT
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Dermal Contact with Soil and Sediment		
Input Variable	**Value Used**	**Brief Rationale/Reference**
Exposure Concentration (C)	95% UCL[1] (mg/kg)	Convention (USEPA, May 1992).
Skin Surface Area Available for Contact (SA)	3160 cm^2 - Maintenance Worker/ Employee - soil 4300 cm^2 - Construction Worker - soil 4570 cm^2 - Adolescent Trespasser - soil 4140 cm^2 - Adolescent Trespasser - sediment 5170 cm^2 - Recreational Adult - sediment 5230 cm^2 - Adult Resident-soil 3910 cm^2 - Child Resident-soil	Mean values for assumed exposed body areas (USEPA, January 1992; May 1989b).
Soil to Skin Adherence Factor (AF)	1.0 mg/cm^2	Upper-end default (USEPA, January 1992); USEPA Region IV, November 1995.
Absorption Factor (ABS; unitless)	0.01 - Organics 0.001 - Inorganics	Regional defaults (USEPA Region IV, March 1994).
Exposure Frequency (EF)	12 days/yr - Maintenance Worker 250 days/yr - Employee 180 days/yr - Construction Worker 12 days/yr - Adolescent Trespasser 350 days/yr - Residents 45 days/yr - Recreational Adult	For construction, 5 days/wk for 6 months. Default values for employee (USEPA, March 25, 1991). For maintenance/ trespasser, 1 event/month for 12 months/yr; professional judgment. Routine exposure for residents (USEPA, March 25, 1991). Regional default for recreational adult (USEPA Region IV, November 1995).
Exposure Duration (ED)	25 yrs - Maintenance Worker/Employee 1 yr - Construction Worker 10 yrs - Adolescent Trespasser 6 yrs - Adult Resident 6 yrs - Child Resident 30 yrs - Recreational Adult	95th percentile time at one workplace (USEPA, March 25, 1991). Estimated length of construction project. Trespasser of 7-16 years evaluated (USEPA Region IV, November 1995). Two tours of duty (3 yr each) considered for Air Station residents[2]. 90th percentile time at one residence for recreational adult (USEPA, March 25, 1991).
Body Weight (BW)	70 kg - All Adults 45 kg - Adolescent Trespasser 15 kg - Child Resident	Average values (USEPA, May 1989b); USEPA Region IV, November 1995.

TABLE 6-5 (Continued)
EXPOSURE ASSUMPTIONS - SOIL AND SEDIMENT
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Incidental Ingestion of Soil and Sediment		
Input Variable	**Value Used**	**Brief Rationale/Reference**
Averaging Time (AT)	365 days/yr x ED - Noncarcinogens 365 days/yr x 70 yrs - Carcinogens	Convention (USEPA, December 1989).
Exposure Concentration (C)	95% UCL[1] (mg/kg)	Convention (USEPA, May 1992).
Ingestion Rate (IR)	200 mg/day - Maintenance Worker 50 mg/day - Employee 480 mg/day - Construction Worker 100 mg/day - Adolescent Trespasser, Adult Resident, Adult Recreational User 200 mg/day - Child Resident	Upper-bound values (USEPA, March 25, 1991).
Fraction Ingested from Contaminated Source (Fi; unitless)	1.0	USEPA Region IV, November 1995.
Exposure Frequency (EF)	12 days/yr - Maintenance Worker 250 days/yr - Employee 180 days/yr - Construction Worker 12 days/yr - Adolescent Trespasser 350 days/yr - Resident 45 days/yr - Adult Recreational User	For construction, 5 days/wk for 6 months; 1 event/month for 12 months/yr; professional judgment. Routine exposure for residents and employees (USEPA, March 25, 1991). Regional default for recreational adult (USEPA, March 26, 1991).
Exposure Duration (ED)	25 yrs - Maintenance Worker/ Employee 1 yr - Construction Worker 10 yrs - Adolescent Trespasser 6 yrs - Adult Resident 6 yrs - Child Resident 30 yrs - Adult Recreational User	95th percentile time at one workplace (USEPA, March 25, 1991). Estimated length of construction project. Trespasser of 7-16 years evaluated (USEPA Region IV, November 1995). Two tours of duty (3 yrs each) considered for Air Station residents. 90th percentile time at one residence for recreational adult (USEPA, March 25, 1991).

TABLE 6-5 (Continued)
EXPOSURE ASSUMPTIONS - SOIL AND SEDIMENT
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Incidental Ingestion of Soil and Sediment		
Input Variable	**Value Used**	**Brief Rationale/Reference**
Body Weight (BW)	70 kg - All Adults 45 kg - Adolescent Trespasser 15 kg - Child Resident	Average values (USEPA, May 1989b); USEPA Region IV, November 1995.
Averaging Time (AT)	365 days/yr x ED - Noncarcinogens 365 days/yr x 70 yrs - Carcinogens	Convention (USEPA, December 1989).

1 Arithmetic Upper 95% Confidence Limit (UCL) of mean of data or log-transformed data. Maximum concentration used if 95% UCL exceeds maximum detection.
2 Alternate (default) exposure duration evaluated of 6 years as a child and 24 years as an adult.

to be available for contact. The exposure time is based on professional judgment and assumes that only a portion of the work day (4 hours/day) results in actual contact with groundwater.

Future residents could also come into contact with groundwater, should a shallow well ever be installed for potable use. This scenario is highly unlikely to occur, given that the Air Station has its own potable water system supplied by wells in the Castle Hayne aquifer. However, for future land use, residential dermal contact is assumed to occur on a daily basis (350 days/yr) over the entire body surface area. All assumptions for dermal exposure to groundwater for construction workers and future residents are outlined in Table 6-6.

Residents may also be exposed to groundwater in this hypothetical scenario via ingestion and inhalation of volatiles during showering, etc. The following equation is used to estimate ingestional exposures in the home (USEPA, December 1989):

$$IEX = \frac{C_{gw} \times IR \times EF \times ED}{BW \times AT}$$

where:

IEX	=	ingestional exposure dose (mg/kg-day)
C_{gw}	=	groundwater exposure concentration (mg/L)
IR	=	ingestion rate (L/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time or period of exposure (days)

Default values for the ingestion rate and exposure frequency and duration were used. Adults were assumed to ingest 2 L/day, 350 days/year, for 6 years (two tours of duty consisting of 3 years per tour of duty), while children were assumed to ingest 1 L/day, 350 days/year, for 6 years.

Additional exposures may occur via inhalation during showering, bathing, washing dishes, etc. Inhalation exposures were estimated using a mass transfer model developed specifically for this exposure route, in combination with an air intake estimation model. The mass transfer model accounts for inhalation that occurs during a shower and after a shower while the receptor remains in the closed bathroom. The method employed is as follows (USEPA, December 1989; Foster and Chrostowski, 1987):

$$IEX = \frac{S \times IR \times K \times EF \times ED}{BW \times AT \times R_a \times CF}$$

TABLE 6-6

EXPOSURE ASSUMPTIONS - GROUNDWATER
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Dermal Contact with Groundwater		
Input Variable	**Value Used**	**Brief Rationale/Reference**
Exposure Concentration (C)	95% UCL[1] (mg/L)	Convention (USEPA, May 1992).
Skin Surface Area Available for Contact (SA)	4300 cm^3 - Construction Worker 19400 cm^3 - Adult Resident 7280 cm^3 - Child Resident	Mean value for assumed exposed body areas for construction worker; whole-body contact for residents (USEPA, January 1992; May 1989b).
Permeability Constant (PC)	Chemical-specific (cm/hr)	Dermal guidance (USEPA, January 1992).
Exposure Time (ET)	4 hrs/day - Construction Worker 12 min/day - Residents	Professional judgment; USEPA, March 25, 1991.
Exposure Frequency (EF)	180 days/yr - Construction Worker 350 days/yr - Residents	5 days/wk for 9 months (professional judgment); USEPA, March 25, 1991.
Exposure Duration (ED)	1 yr - Construction Worker 6 yrs - Adult Resident 6 yrs - Child Resident	Estimated length of construction project (professional judgment). Two tours of duty (3 yrs each) considered for Air Station residents.[2]
Body Weight (BW)	70 kg - All Adults 15 kg - Child Resident	Convention; average value for adults and children (USEPA, May 1989b).
Averaging Time (AT)	365 days/yr x ED - Noncarcinogens 365 days/yr x 70 yrs - Carcinogens	Convention (USEPA, December 1989).

TABLE 6-6 (Continued)
EXPOSURE ASSUMPTIONS - GROUNDWATER
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Ingestion of Groundwater		
Input Variable	**Value Used**	**Brief Rationale/Reference**
Exposure Concentration (C)	95% UCL[1] (mg/L)	Convention (USEPA, May 1992).
Ingestion Rate (IR)	2 L/day - Adult Resident 1 L/day - Child Resident	Convention (USEPA, March 25, 1991).
Exposure Frequency (EF)	350 days/yr - Residents	Convention (USEPA, March 25, 1991).
Exposure Duration (ED)	6 yrs - Adult Resident 6 yrs - Child Resident	Two tours of duty (3 yrs each) considered for Air Station residents[2].
Body Weight (BW)	70 kg - Adult Resident 15 kg - Child Resident	Convention (USEPA, May 1989b).
Averaging Time (AT)	365 days/yr x ED - Noncarcinogens 365 days/yr x 70 yrs - Carcinogens	Convention (USEPA, December 1989).

TABLE 6-6 (Continued)
EXPOSURE ASSUMPTIONS - GROUNDWATER
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Inhalation of Volatiles		
Input Variable	**Value Used**	**Brief Rationale/Reference**
Volatile Chemical Generation Rate (S)	Chemical-specific ($\mu g/m^3$-min-shower)	Calculated from 95% UCL (mg/L).
Inhalation Rate (IR)	10 L/min	USEPA, March 25, 1991.
Shower Duration (D_s)	12 minutes	USEPA, March 25, 1991.
Total Time in Bathroom (D_t)	20 minutes	Professional judgment.
Air Exchange Rate (R_a)	0.0083/min	Foster and Chrostowski, 1987.
Exposure Frequency (EF)	350 showers/yr	One shower/day for 350 days/yr (USEPA, March 25, 1991)
Exposure Duration (ED)	6 yrs - Adult Resident 6 yrs - Child Resident	Two tours of duty (3 yrs each) considered for Air Station residents.[2]
Body Weight (BW)	70 kg - Adult Resident 15 kg - Child Resident	Convention (USEPA, May 1989b).
Averaging Time (AT)	365 days/yr x ED - Noncarcinogens 365 days/yr x 70 yrs - Carcinogens	Convention (USEPA, December 1989).

1 Arithmetic Upper 95% Confidence Limit (UCL) of mean of data or log-transformed data. Maximum concentration used if 95% UCL exceeds maximum detection. No definable plumes.
2 Alternate (default) exposure duration evaluated for 6 years as a child and 24 years as an adult.

and

$$K = D_s + \frac{\exp(-R_a \times D_t)}{R_a} - \frac{\exp[R_a \times (D_s - D_t)]}{R_a}$$

where:

IEX	=	inhalational exposure dose (mg/kg-day)
S	=	volatile chemical generation rate (μg/m^3-min-shower)
IR	=	inhalation rate (L/min)
K	=	mass transfer coefficient (min)
EF	=	exposure frequency (showers/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time or period of exposure (days)
R_a	=	air exchange rate (min^{-1})
CF	=	conversion factor (1E+6 μg-L/mg-m^3)
D_s	=	shower duration (min)
D_t	=	total time in bathroom (min)

The volatile chemical generation rate was estimated using the Foster and Chrostowski mass transfer model, which is based on a two-phase film theory. The model employs contaminant-specific mass transfer coefficients, Henry's law constants, droplet diameter, drop time, viscosity, temperature, etc. Specific details regarding the application of this model are included in Appendix J.4 (Volume III).

The inhalation rate was specified at 10 L/min for the adult and child. The exposure frequency was specified as one shower/day, 350 days/year, and the exposure durations are 6 years for both adults and children. The air exchange rate was specified as 0.0083/min, the shower duration as 12 minutes, and the total time in the bathroom as 20 minutes. Table 6-6 also contains a summary of the inhalation and ingestion input parameters for residential exposure to groundwater.

Exposure to Surface Water

Direct contact with surface water from Slocum Creek and Turkey Gut can result in both dermal and ingestion exposures. Exposure scenarios are developed for an adolescent trespasser and adult recreational swimmer. An adolescent recreational swimmer was not evaluated because the risks to an adult would be greater. The body surface area, exposure duration, and body weight would be higher for an adult than an adolescent.

The equation used to calculate dermal exposure to surface water is the same as the one used to assess exposure to groundwater. The total skin surface area for the adolescent trespasser was set at 4,570 cm^2; exposed body areas available for contact include the head, forearms, hands, lower legs, and feet. Whole-body contact is assumed for the adult recreational user. Professional judgment was employed to set the exposure frequency for the adolescent trespasser at 12 days/year. One exposure event per month is assumed to be a reasonable estimate for this receptor. The Region IV default value for the frequency of a swimming scenario, 45 days/year (USEPA Region IV, November 1995), was used for the adult recreational user. Adults were assumed to be exposed only in Slocum Creek, whereas adolescent exposures were evaluated for both Turkey Gut and Slocum Creek.

Adolescent trespassers may also be exposed to contaminants in leachate seeps. It is assumed that they are exposed only on their hands and feet while playing, for a total of 1540 cm^2 (12 percent of total body surface area for average ages 7 to 16). The exposure frequency is 12 days/year, as for surface water.

Exposure to this medium may also result in accidental ingestion. Ingestional exposures are characterized using the following equation (USEPA, December 1989):

$$IEX = \frac{C_{sw} \times CR \times ET \times EF \times ED}{BW \times AT}$$

where:

IEX	=	ingestional exposure dose (mg/kg-day)
C_{sw}	=	surface water exposure concentration (mg/L)
CR	=	contact rate (L/hour)
ET	=	exposure time (hours/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time or period of exposure (days)

As stated previously, this scenario was developed for adolescents who may trespass on the site and adults who may be involved in recreational activities (swimming, waterskiing, etc.). Default values, presented in current guidance (USEPA, December 1989 and January 1992) were used for the contact rate (0.05 L/hr) and exposure time (1 hour/day) for both receptors. Because non-Air Station residents may participate in recreational activities on Slocum Creek, a 30-year exposure duration is considered (USEPA, March 25, 1991).

For adolescents playing in the areas of leachate seeps, an ingestion rate of 0.005 L/hr was used to represent some small increment (10 percent) of the surface water contact rate for the swimming scenario.

Input parameters are presented in Table 6-7 for exposure to surface water and leachate via dermal contact and incidental ingestion.

Exposure to Contaminated Fish

Local residents could catch and consume fish from Slocum Creek, and thereby be indirectly exposed to surface water contaminants that can accumulate in the tissues or organs of marine life. The following methods were used to estimate intakes for this exposure route (USEPA, December 1989):

$$IEX = \frac{C_f \times IR \times Fi \times EF \times ED}{BW \times AT}$$

and

$$C_f = C_{sw} \times BCF$$

where:

IEX	=	ingestional exposure dose (mg/kg-day)
C_f	=	contaminant concentration in fish (mg/kg)
IR	=	ingestion rate (kg/meal)
Fi	=	fraction ingested from contaminated source (unitless)
EF	=	exposure frequency (meals/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time or period of exposure (days)
C_{sw}	=	exposure concentration in surface water (mg/L)
BCF	=	bioconcentration factor (L/kg)

Because no actual fish samples were collected during the RI, surface water concentrations were used to predict fish tissue concentrations. The fish ingestion rate and the exposure frequency were set at 0.284 kg/meal and 48 meals/year, respectively. These default values were in accordance with USEPA guidance (USEPA, December 1989). The fraction ingested from the contaminated source was specified as 0.1, since only recreational fishing is known to occur at Slocum Creek, and persons are unlikely to fish solely in the vicinity of OU2. Table 6-8 contains the assumed input variables for the ingestion of contaminated fish.

TABLE 6-7

EXPOSURE ASSUMPTIONS - SURFACE WATER AND LEACHATE
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Dermal Contact with Surface Water and Leachate		
Input Variable	**Value Used**	**Brief Rationale/Reference**
Exposure Concentration (C)	95% UCL[1] (mg/L)	Convention (USEPA, May 1992).
Skin Surface Area Available for Contact (SA)	19400 cm^2 - Recreational Adult 4570 cm^2 - Adolescent Trespasser (surface water) 1540 cm^2 - Adolescent Trespasser (leachate)	Whole body contact for adult swimmer. For trespasser, mean value for assumed exposed body areas (USEPA, January 1992; May 1989b).
Permeability Constant (PC)	Chemical-specific (cm/hr)	Dermal guidance (USEPA, January 1992).
Exposure Time (ET)	1.0 hr/day	Upper-bound default for swimming scenario (USEPA, January 1992).
Exposure Frequency (EF)	45 days/yr - Recreational Adult 12 days/yr - Adolescent Trespasser	Regional default for swimming scenario (USEPA Region IV, November 1995). Professional judgment for trespasser; 1 day/month for 12 months/yr.
Exposure Duration (ED)	30 yrs - Recreational Adult 10 yrs - Adolescent Trespasser	For adult, 90th percentile time at one residence (USEPA, May 1989b). Trespasser of 7-16 years evaluated (USEPA Region IV, November 1995).
Body Weight (BW)	70 kg - Recreational Adult 45 kg - Adolescent Trespasser	Average value (USEPA, May 1989b); USEPA Region IV, November 1995.
Averaging Time (AT)	365 days/yr x ED - Noncarcinogens 365 days/yr x 70 yrs - Carcinogens	Convention (USEPA, December 1989).

TABLE 6-7 (Continued)
EXPOSURE ASSUMPTIONS - SURFACE WATER AND LEACHATE
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Incidental Ingestion of Surface Water and Leachate		
Input Variable	**Value Used**	**Brief Rationale/Reference**
Exposure Concentration (C)	95% UCL[1] (mg/L)	Convention (USEPA, May 1992).
Contact Rate (IR)	0.050 L/hr - surface water 0.005 L/hr - leachate	Recommended default (USEPA, December 1989). Professional judgment for leachate.
Exposure Time (ET)	1.0 hr/day	Upper-bound default for swimming scenario (USEPA, January 1992).
Exposure Frequency (EF)	45 days/yr - Recreational Adult 12 days/yr - Adolescent Trespasser	Regional default for swimming scenario (USEPA Region IV, November 1995). Professional judgment for trespasser; 1 day/month for 12 months/yr.
Exposure Duration (ED)	30 yrs - Recreational Adult 10 yrs - Adolescent Trespasser	For adult, 90th percentile time at one residence (USEPA, May 1989b). Trespasser of 7-16 years evaluated (USEPA Region IV, November 1995).
Body Weight (BW)	70 kg - Recreational Adult 45 kg - Adolescent Trespasser	Average values (USEPA, May 1989b); USEPA Region IV, November 1995.
Averaging Time (AT)	365 days/yr x ED - Noncarcinogens 365 days/yr x 70 yrs - Carcinogens	Convention (USEPA, December 1989).

1 Arithmetic upper 95% Confidence Limit (UCL) of mean of data or log-transformed data. Maximum concentration used if 95% UCL exceeds maximum detection.

TABLE 6-8

EXPOSURE ASSUMPTIONS - FISH INGESTION
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Ingestion of Finfish (Recreational Adult only)		
Input Variable	**Value Used**	**Brief Rationale/Reference**
Surface Water Concentration (C_{sw})	95% UCL[1] (mg/L)	Used to estimate contaminant concentration in fish (mg/kg).
Bioconcentration Factor (BCF)	Chemical-specific (L/kg)	Used to estimate contaminant concentration in fish (mg/kg) (USEPA, December 1982 and Lyman et al., 1990).
Ingestion Rate (IR)	0.284 kg/meal	Recommended default (USEPA, December 1989).
Fraction Ingested from Contaminated Source (Fi; unitless)	0.1	Professional judgment.
Exposure Frequency (EF)	48 meals/yr	Recommended default (USEPA, March 25, 1991).
Exposure Duration (ED)	30 yrs	90th percentile time at one residence (USEPA, May 1989b).
Body Weight (BW)	70 kg	Convention; average value for adult men and women (USEPA, May 1989b).
Averaging Time (AT)	365 days/yr x ED - Noncarcinogens 365 days/yr x 70 yrs - Carcinogens	Convention (USEPA, December 1989).

1 Arithmetic upper 95% Confidence Limit (UCL) of mean of data or log-transformed data. Maximum concentration used if 95% UCL exceeds maximum detection.

6.2.4 Exposure to Lead

Lead was identified as a COPC, only for subsurface soil at OU2. The equations and methodology discussed in the previous section cannot be used to evaluate exposure to lead because of the absence of published dose-response parameters for this chemical. Studies indicate that infants and young children are the most sensitive receptors to adverse effects from exposure to this chemical. Considerable behavioral and developmental impairments have been noted in children with elevated blood lead levels.

At this time, no guidance is available to address either infrequent or frequent adult exposure to lead. Typically, childhood exposure to lead in a residential setting is quantitatively addressed using the USEPA Integrated Exposure Uptake Biokinetic (IEUBK) Model, version 0.99D (USEPA, February 1994). This model is designed to estimate blood lead levels in children (under 7 years of age) based on either default or site-specific input values for air, water, diet, and soil exposure.

Exposure to lead in site soil is addressed only qualitatively in this section by a comparison of detected concentrations to a recommended screening level (1300 mg/kg) (USEPA and NCDEHNR verbal guidance). The appropriateness of this value was discussed in the data evaluation section, Section 6.1. The maximum detected lead concentration (1650 mg/kg) slightly exceeds the 1300 mg/kg screening value, but is below older published values of 2000-5000 mg/kg. The average of positive detections is 54.9 mg/kg, and the UCL concentration is 35.7, both well below the screening value. The uncertainties associated with the qualitative evaluation of exposure to lead are presented in Section 6.5.

Positively detected concentrations of lead in site soil samples collected from 1991 to 1994 ranged from 0.82 mg/kg to 1,650 mg/kg (10TP23; 9 to 10 feet). The highest concentrations of lead were observed in the samples collected from a test pit in the south-central portion of the landfill. The maximum concentration of lead in surface soil was 58.2 mg/kg.

Under current land use conditions, no potential human receptors are considered for lead exposure at OU2 because all surface soil concentrations are below 400 mg/kg. Under future conditions, exposure of construction workers could occur (to all soil to a depth of 10 feet only). However, because the UCL concentration of lead (146 mg/kg) is below the 400 mg/kg screening level), and because the IEUBK model only applies to children, no quantitative assessment is performed for construction workers. Exposure to the highest elevated levels of lead at OU2 would be experienced by only construction workers under future land use conditions.

6.3 TOXICITY ASSESSMENT

The objective of this section is to identify the potential health hazards associated with exposure to each COPC. A toxicity assessment characterizes the potential for a particular chemical to cause adverse health effects (carcinogenic and/or noncarcinogenic) in exposed populations.

Although various chemicals have been found to cause adverse health effects in toxicological studies, the dose-response relationship and the extent of exposure must be evaluated before potential health impacts for a COPC can be determined. A dose-response relationship correlates the magnitude of the intake of a chemical (the amount that is absorbed by a receptor) with the increased likelihood or severity of adverse effects resulting from that intake.

Dose-response relationships for numerous substances have been investigated by means of epidemiological and clinical studies. Data from human and animal studies are weighed in an effort to derive toxicity values, which are quantitative estimates of the incidence of adverse effects. The toxicity value used to evaluate noncarcinogenic health effects is the Reference Dose (RfD). Carcinogenic effects are quantified using the Cancer Slope Factor (CSF).

Toxicity values for oral and inhalation exposures have been developed by the USEPA for many organic chemicals and metals. Although RfDs and CSFs can be found in several toxicological sources, USEPA's Integrated Risk Information System (IRIS) (USEPA, May 1996) on-line database is the preferred source of toxicity values. This database is continuously updated and values presented have been verified by USEPA RfD and Carcinogenic Risk Assessment Verification Endeavor (CRAVE) work groups.

RfDs and CSFs found in literature may be expressed as administered doses; therefore, these values are considered to be inappropriate for estimating the risks associated with dermal routes of exposure. Oral dose-response parameters based on administered doses must be adjusted to absorbed doses before the comparison to estimated dermal exposure intakes is made. The adjustment to an absorbed dose was made using chemical-specific absorption efficiencies published in Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles. When absorption efficiencies were not found in ATSDR files, USEPA Region IV default absorption efficiencies for volatiles (80 percent), semivolatiles/pesticides/PCBs (50 percent), and metals (20 percent) were used (USEPA, Region IV, November 1995).

Most of the dose-response parameters used in the baseline human health risk assessment were obtained from IRIS. If information for a particular COPC was not available in IRIS, Health Effects Assessment

Summary Tables (HEAST) (USEPA, May 1995) and Environmental Criteria and Assessment Office (ECAO) documents were consulted. In some cases, toxicity values that have been withdrawn from IRIS were used to estimate risks to receptors. Dose-response parameters for COPCs at OU2 are summarized in Table 6-9 for inhalation, oral, and dermal exposures. All references are provided.

6.3.1 Cancer Slope Factors

CSFs are used to estimate the upper-bound lifetime probability (assuming a 70-year lifetime) of a human receptor developing cancer as a result of exposure to a known or potential carcinogen. A CSF is usually accompanied by a provisional weight of evidence classification, which indicates the likelihood that a chemical is a human carcinogen. Based on data collected from animal and human studies, USEPA has developed the following weight of evidence classifications:

- A - Known human carcinogen.
- B1 - Probable human carcinogen, limited human data are available to support carcinogenicity in humans.
- B2 - Probable human carcinogen; sufficient evidence is available to support carcinogenicity in animals but inadequate or no evidence is available to support carcinogenicity in humans.
- C - Possible human carcinogen.
- D - Not classifiable as to human carcinogenicity.
- E - Evidence of noncarcinogenicity in humans.

A CSF is typically reported in units of kg-day/mg and is derived through an assumed low-dosage linear relationship and an extrapolation from high to low dose responses determined from animal studies. In general, the value used in reporting the CSF is the upper 95 percent confidence limit of the slope of the dose-response curve. The estimation of CSFs is usually performed for Class A, B1, and B2 carcinogens. A Class C carcinogen may or may not have a published CSF.

Some carcinogenic toxicity values, especially for the inhalation route, are expressed as a unit risk, which is defined as "the risk per unit concentration of substance in the medium where human contact occurs" (USEPA, December 1989). Before a unit risk can be used to quantify potential risks to receptors, it is converted to a CSF (kg-day/mg) by dividing the value by the rate of exposure (an inhalation rate of 20 m^3/day or a water consumption rate of 2 L/day) and multiplying by 70 kg (assumed body weight). An additional conversion factor for units (1,000 μg/kg) may be needed if unit risks are reported in risk per

TABLE 6-9

DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF POTENTIAL CONCERN[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Chronic/Subchronic RfD (mg/kg/day)[2]			CSF(kg-day/mg)[3]			GI[4] Absorption Factor	Weight of Evidence
	Inhalation	Oral	Dermal	Inhalation	Oral	Dermal		
Volatile Organics								
1,1-Dichloroethene		7E-3 (UF=1000; liver)	9E-3	1.75E-1 (kidney)	6E-1 (adrenal tumors)	7.5E-1	0.80[5]	C
1,2-Dichloroethane		2.86E-3[9] (UF=3000; CNS, GI tract, liver, kidney)	2.3E-3	9.1E-2	9.1E-2 (hemangiosarcoma)	1.1E-1	0.80[5]	B2
1,2-Dichloropropane	1.14E-3 (UF=300; nasal hyperplasia)				6.8E-2[16] (liver)	8.5E-2	0.80[5]	B2
2-Butanone	2.86E-1 (UF=1000; birth wt)	6E-1 (UF=3000; birth wt)	4.8E-1				0.80[5]	
2-Hexanone	2.29E-2[27]	8E-2[27]	6.4E-2				0.80[5]	
4-Methyl-2-pentanone	2.29E-1, 2.29E-2[16] (UF=100/1000; liver, kidney)	8E-1, 8E-2[16] (UF=300/3000; liver, kidney)	6.4E-2				0.80[5]	
Benzene	1.71E-3[9] (UF=1000; hematopoietic system	3E-4[24]	3E-4	2.9E-2 (leukemia, neoplasia)	2.9E-2 (leukemia, neoplasia)	2.9E-2	1.0[6]	A
Chlorobenzene	5.71E-3[16] (UF=10,000; liver, kidney)	2E-2 (UF=1000; liver)	6.2E-3				0.31[10]	D
Chloroethane	2.86E+0 (UF=300; fetus)	4E-1[9]	3.2E-1				0.80[5]	
Chloroform		1E-2 (UF=1000; liver)	1E-2	8.05E-2 (liver)	6.1E-3 (kidney)	6.1E-3	1.0[11]	B2
cis-1,2-Dichloroethene		1E-2[16] (UF=3000; blood)	8E-3				0.80[5]	D

TABLE 6-9 (Continued)
DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF POTENTIAL CONCERN[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Chronic/Subchronic RfD (mg/kg/day)[2]			CSF(kg-day/mg)[3]			GI[4] Absorption Factor	Weight of Evidence
	Inhalation	Oral	Dermal	Inhalation	Oral	Dermal		
Ethylbenzene	2.86E-1 (UF=300; development)	1E-1 (UF=1000; liver, kidney)	8E-2				0.80[5]	
Methylene chloride	8.57E-1[16] (UF=100; liver)	6E-2 (UF=100; liver)	6E-2	1.64E-3 (liver; respiratory)	7.5E-3 (liver; respiratory)	7.5E-3	1.0[12]	B2
Tetrachloroethene		1E-2 (UF=1000; liver)	1E-2	2.03E-3[8] (liver)	5.2E-2[8] (liver)	5.2E-2	1.0[13]	B2/C
Toluene	1.14E-1 (UF=300; CNS; nasal mucosa)	2E-1 (UF=1000; liver, kidney)	1.6E-1				0.80[5]	D
Trichloroethene		6E-3[9]	6E-3	6.0E-3[9] (liver)	1.1E-2[26] (liver)	1.1E-2	1.0[14]	
Vinyl chloride				3.0E-1[16] (liver)	1.9E+0[16] (lung, liver)	2.38E+0	0.80[5]	A
Semivolatile Organics								
1,2-Dichlorobenzene	4E-2[16] (UF=1000; whole body)	9E-2 (UF=1000)	9E-2				1.0[6]	D
1,4-Dichlorobenzene	2.29E-1 (UF=100; liver)				2.4E-2[16] (liver)	2.4E-2	1.0[7]	B2
2,4-Dimethylphenol		2E-2 (UF=3000; lethargy, blood)	1E-2				0.50[5]	
2-Methylnaphthalene		4E-E[27]	2E-2				0.50[5]	
2-Methylphenol		5E-2 (UF=1000; body wt, neurotoxicity	2.5E-2				0.50[5]	
4-Methylphenol		5E-3[16] (UF=1000; CNS, respiratory)	2.5E-3				0.50[5]	C

TABLE 6-9 (Continued)
DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF POTENTIAL CONCERN[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Chronic/Subchronic RfD (mg/kg/day)[2]			CSF(kg-day/mg)[3]			GI[4] Absorption Factor	Weight of Evidence
	Inhalation	Oral	Dermal	Inhalation	Oral	Dermal		
Benzo(a)anthracene				3.1E-1[29]	7.3E-1[29] (liver)	3.65E-1	0.50[5]	B2
Benzo(a)pyrene				3.1E+0[25] (respiratory tract)	7.3E+0 (forestomach, liver, esophagus)	3.65E+0	0.50[5]	B2
Benzo(b)fluoranthene				3.1E-1[29]	7.3E-1[29] (liver)	3.65E-1	0.50[5]	B2
Benzo(k)fluoranthene				3.1E-2[29]	7.3E-1[29] (liver)	3.65E-2	0.50[5]	B2
Bis(2-chloroethyl)ether				1.16E+0 (hepatoma)	1.1E+0 (hepatoma)	2.2E+0	0.50[5]	B2
Bis(2-ethylhexyl)phthalate		2E-2 (UF=1000; liver)	1.1E-2		1.4E-2 (liver)	2.55E-2	0.55[15]	B2
Chrysene				3.1E-3[29]	7.3E-3[29]	3.65E-3	0.50[5]	B2
Indeno(1,2,3-cd)pyrene				3.1E-1[29]	7.3E-1[29]	3.65E-1	0.50[5]	B2
Naphthalene		4E-2[26]	2E-2				0.50[5]	D
Nitrobenzene	5.71E-4[16] (UF-10,000; blood, liver, kidney)	5E-4 (UF=10000; blood, liver, kidney)	2.5E-4				0.50[5]	D
Pesticides/PCBs								
4,4'-DDD					2.4E-1 (liver)	2.5E-1	0.80[30]	B2
4,4'-DDE					3.4E-1 (liver)	4.2E-1	0.80[30]	B2
4,4'-DDT		5E-4 (UF = 100; liver)	4E-4	3.4E-1 (liver)	3.4E-1 (liver)	4.2E-1	0.80[30]	B2
Aldrin		3E-5 (UF=1000; liver)	1.5E-5	1.71E+1 (liver)	1.7E+1 (liver)	3.4E+1	0.50[5]	B2
α-BHC				6.3E+0 (liver, kidney)	6.3E+0 (liver, kidney)	1.3E+1	0.50[5]	

TABLE 6-9 (Continued)
DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF POTENTIAL CONCERN[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Chronic/Subchronic RfD (mg/kg/day)[2]			CSF(kg-day/mg)[3]			GI[4] Absorption Factor	Weight of Evidence
	Inhalation	Oral	Dermal	Inhalation	Oral	Dermal		
γ-BHC		3E-4 (UF=1000; liver, kidney)	1.5E-4		1.3E+0[16] (liver)	2.6E+0	0.50[5]	B2/C
Dieldrin		5E-5 (UF=100; liver)	2.5E-5	1.61E+1 (liver)	1.6E+1 (liver)	3.2E+1	0.50[5]	B2
Endosulfan I		6E-3[27] (UF=100; body wt)	3E-3				0.50[5]	
Endosulfan II		6E-3[27] (UF=100; body wt)	3E-3				0.50[5]	
Endrin aldehyde		3E-4[27]	1.5E-4				0.50[5]	
Heptachlor		5E-4 (UF=300; liver)	2.5E-4	4.55E+0 (liver)	4.5E+0 (liver)	9.0E+0	0.50[5]	B2
Heptachlor epoxide		1.3E-5 (UF=1000; liver)	6.5E-6	9.1E+0 (liver)	9.1E+0 (liver)	1.82E+1	0.50[5]	B2
Aroclor-1260					7.7E+0 (liver)	1.5E+1	0.50[5]	B2
Inorganics								
Aluminum		1E+0[9]	2E-1				0.20[5]	
Antimony		4E-4 (UF=1000; whole body, blood)	8E-5				0.20[5]	
Arsenic		3E-4 (UF=3; skin)	2.85E-4	1.51E+1 (lung)	1.5E+0 (skin)	1.6E+0	0.95[17]	A
Barium	1.43E-4[16] (UF=1000; fetus)	7E-2 (UF=3; cardiovascular system)	1.4E-2				0.20[5]	
Beryllium		5E-3 (UF=100)	5E-5	8.4E+0 (lung; osteosarcomas)	4.3E+0 (lung; osteosarcomas)	4.3E+2	0.01[18]	B2

TABLE 6-9 (Continued)
DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF POTENTIAL CONCERN[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Chronic/Subchronic RfD (mg/kg/day)[2]			CSF(kg-day/mg)[3]			GI[4] Absorption Factor	Weight of Evidence
	Inhalation	Oral	Dermal	Inhalation	Oral	Dermal		
Cadmium		5E-4 (UF=10; kidney)	1.5E-5	6.3E+0 (lung; trachea)			0.03[19]	B1
Chromium VI		5E-3 (UF=500)	5E-5	4.2E+1 (lung)			0.01[20]	A
Copper		4E-2[9] (gastrointestinal system)	2.4E-2				0.60[21]	
Iron		3E-1[9] (none)	6E-2				0.20[5]	
Lead								B2
Manganese	1.43E-5 (UF=1000; CNS)	2.4E-2 (UF=3; CNS)	4.6E-3				0.20[5]	D
Mercury	8.57E-5[16] (UF=30; CNS)	3E-4[16] (UF=1000; kidney)	6E-5				0.20[5]	D
Nickel		2E-2 (UF=300; body weight)	8E-4				0.40[23]	
Silver		5E-3 (UF=3; argyria)	1E-3				0.20[5]	
Thallium		7E-5[22,26] (UF=3000; liver, blood, hair)	1.4E-5				0.20[5]	D

1 All values from USEPA, May 1996 (IRIS) unless otherwise noted
2 RfD - Reference Dose
3 CSF - Cancer Slope Factor
4 GI - Gastrointestinal
5 USEPA Region IV default value (November 1995)
6 Assumed equal to 1,4-dichlorobenzene
7 ATSDR, October 1991a
8 ATSDR, October 1991b
9 ECAO provisional value
10 ATSDR, October 1989c
11 ATSDR, October 1991c
12 ATSDR, October 1991d
13 ATSDR, October 1991e
14 ATSDR, January 1988
15 ATSDR, October 1991f
16 HEAST FY-1995 (USEPA, May 1995)
17 ATSDR, October 1991g
18 ATSDR, October 1991h
19 ATSDR, October 1991i
20 ATSDR, October 1991j
21 ATSDR, October 1989d
22 Thallic oxide; HEAST FY-1990 (USEPA, January 1990)

TABLE 6-9 (Continued)
DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF POTENTIAL CONCERN[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

24 USEPA Region IV provisional value identified in comments received. Uncertainty factor and target organs not available.
25 Provisional value listed in USEPA Region IV, November 1995.
26 Withdrawn from IRIS.
27 Surrogate value provided.
28 Other USEPA document referenced in USEPA Region III, May 1996.
29 Based on USEPA Region IV Toxicity Equivalence Factors (TEFs; USEPA Region IV, November 1995).
30 ATSDR 1992.

$\mu g/m^3$ or risk per $\mu g/L$. Recognizing that this approach is not always technically correct, it can provide workable toxicity parameters where they are not otherwise available.

Arsenic is one example of the conversion of a unit risk to a CSF. No oral CSF is available for this chemical in IRIS. The recommended drinking water risk for the human ingestion of inorganic arsenic is 5E-5 per $\mu g/L$ (USEPA, June 21, 1988; see Appendix J.2, Volume III). Using the methodology presented in the previous paragraph, a toxicity value of 1.75 kg-day/mg is calculated to evaluate the carcinogenic effects from oral exposure to this chemical.

As stated previously, CSFs for the dermal exposure route are derived using chemical-specific absorption efficiencies. The following equation is employed to convert an oral CSF (based on an administered dose) to a dermal CSF:

$$CSF_{dermal} = \frac{CSF_{oral}}{ABS_{GI}}$$

where: ABS_{GI} = Absorption efficiency in the gastrointestinal tract

The resulting dermal CSF is considered to be more appropriate in estimating the cancer risk associated with an absorbed dose.

6.3.2 Reference Doses

RfDs, which are usually expressed in units of mg/kg-day, are developed by the USEPA for chronic and/or subchronic human exposure to hazardous chemicals and are solely based on the noncarcinogenic health effects imparted by a chemical. For the purposes of this risk assessment, chronic RfDs were used to estimate risk to potential receptors.

An RfD is generally derived by dividing a no-observed-(adverse)-effect-level (NOEL or NOAEL) or a lowest-observed-adverse-effect-level (LOAEL) by an appropriate uncertainty factor. NOELs, NOAELs, and LOAELs are determined from laboratory or epidemiological studies. The uncertainty factor used in the RfD estimation process is based on the availability of toxicity data.

Uncertainty factors are applied as multiples of 10 to represent specific areas of uncertainty in the available data. A factor of 10 is used to account for variations in the general population (to protect sensitive subpopulations) when extrapolating test results from animals to human (to account for interspecies

variability), when a NOAEL derived from a subchronic study (instead of a chronic study) is used to develop the RfD, and when a LOAEL is used instead of a NOAEL. In addition, the USEPA reserves the use of a modifying factor or up to 10 for professional judgement of uncertainties in the database that have not already been accounted for. The default value of the modifying factor is 1.

The RfD incorporates the surety of the evidence for chronic human health effects. Even if applicable human data exist, the RfD (as diminished by the uncertainty factor) still maintains a margin of safety so that chronic human health effects are not underestimated. Thus, the RfD is an acceptable guideline for evaluation of noncarcinogenic risk, although the associated uncertainties preclude its use for precise risk quantitation.

Toxicity values for inhalation exposures are typically expressed as Reference Concentrations (RfCs). These values are reported in units of mg/m^3 and can be converted to RfDs by multiplying the RfC by 20 m^3/day (inhalation rate) and dividing by 70 kg (body weight).

As indicated previously, most dose-response parameters are based on administered doses. Dermal RfDs are calculated from oral RfDs in the following manner:

$$RfD_{dermal} = RfD_{oral} \times ABS_{GI}$$

where: ABS_{GI} = Absorption efficiency in the gastrointestinal tract

The adjustment for absorption efficiency must be made before the potential risks for dermal exposures can be estimated.

6.3.3 Other Regulatory and Human Health-Based Criteria

The intent of this section is to provide media-specific regulatory and human health criteria for COPCs (other than dose-response parameters). This can be used to indicate the potential for adverse health effects in human receptors. Applicable or Relevant and Appropriate Requirements (ARARs) and criteria To Be Considered (TBC) values are presented for soil/sediment, groundwater, and surface water. ARARs are cleanup standards and other environmental protection requirements and criteria promulgated under Federal or state law. TBCs are nonpromulgated, nonenforceable standards or criteria that are helpful in determining what concentration of a particular chemical is protective of human health.

6.3.3.1 Soil

Currently, no state or Federal ARARs are available to assess chemical contamination in soil. For the purpose of this risk assessment, USEPA Region III Risk-Based Concentrations (RBCs) and USEPA draft Soil Screening Levels (SSLs) were identified as TBCs. Values are presented in Table 6-10 for those substances selected as COPCs for soil.

RBCs (USEPA Region III, May 1996) are risk-based presumptive levels that are calculated using specific exposure assumptions for ingestion of soil. The levels are derived for carcinogenic and noncarcinogenic health effects; the lower of the two calculated values is defined as the RBC for a chemical. The RBC for noncarcinogenic effects is estimated using a Target Hazard Quotient (THQ) of 1.0. However, the screening value used for selection of COPCs was based on a HQ of 0.1. A Target Risk (TR) of 1E-6 is used for carcinogenic effects. Based on the identified current and future potential land uses at OU2, RBCs for the industrial exposure scenario are considered to be the most appropriate TBCs for the assessment of adverse health effects.

Draft SSLs (USEPA, December 1994) are risk-based chemical concentrations in soil which, if exceeded, can represent a level of contamination that may be considered a potential concern. They are available for three exposure pathways: direct ingestion of soil, inhalation of volatiles and fugitive dust, and migration to groundwater. Values for inhalation and migration to groundwater are also presented in Table 6-10; SSLs for ingestion are not provided, since they are similar to Region III RBCs. Because SSLs are based on residential exposure assumptions only, they are conservative TBCs for assessing potential health effects at OU2.

Lead was selected as a COPC for subsurface soil at OU2. RBCs and SSLs could not be calculated for this chemical, as no dose-response parameters are available for lead. However, recommended levels which are used to indicate the need for response activities are published for lead in soil. These levels were discussed in Section 6.1 (Data Evaluation). A value of 400 mg/kg was used for this assessment. At this time, no screening level is available for nonresidential areas involving adult exposure only. An additional value of 1,300 mg/kg is presented by the USEPA and NCDEHNR for industrial areas.

Based on the values presented in Table 6-10, the 95 percent UCL concentrations determined as the exposure concentrations at OU2 exceed the residential scenario RBCs for benzo(a)pyrene, arsenic, and beryllium. Other metals were found at concentrations above background, but the UCL concentrations did not exceed the residential scenario RBCs.

TABLE 6-10

OTHER CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN (mg/kg) - SOIL AND SEDIMENT
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Maximum Exposure Concentration			Industrial RBC[1]	Residential RBC[1]	Draft Soil Screening Levels (SSLs)[2]	
	Surface Soil	All Soil	Stream Sediment			Inhalation	Groundwater Migration[3]
Benzo(a)anthracene	0.16	—	—	7.8	0.88	27	0.7
Benzo(b)fluoranthene	0.17	—	—	7.8	0.88	23	4
Benzo(k)fluoranthene	0.16	—	—	78	8.8	NA[4]	4
Chrysene	0.22	—	—	780	88	3.6	1
Indeno(1,2,3-cd)pyrene	0.14	—	—	7.8	0.88	280	35
Benzo(a)pyrene	0.24	0.24	—	0.78	0.088	11	4
Aroclors	0.0778	—	—	0.74	0.083	NA	8.2
Aluminum	6470	—	11,100	1E+6	78,000	NA	NA
Antimony	3.2	—	20.0	820	31	NA	NA
Arsenic	17.1	2.96	32.7	3.8	0.43	380	15
Beryllium	0.15	—	0.20	1.3	0.15	690	180
Cadmium	2.2	1.35	—	1,000	39	920	6
Chromium (VI)	24.1	—	57.5	10,000	390	140	19
Iron	14,300	—	32,600	6.1E+5	23,000	NA	NA
Lead	—	35.7	—	1,300[6]	400[5]	NA	NA
Manganese	78.6	—	394	47,000	1800	NA	NA
Thallium	0.99	—	—	140[7]	5.5[7]	NA	0.4

1 USEPA Region III, May 10, 1996; based on Hazard Quotient of 1.0 and cancer risk of 1E-6.
2 USEPA Region III, May 10, 1996; some values may be calculated by the Region.
3 Based on a Dilution and Attenuation Factor (DAF) of 10.
4 NA - Not available.
5 USEPA, July 14, 1994a,b.
6 USEPA/NCDEHNR recommended value.
7 Thallic oxide.
RBC Risk-Based Concentration

The concentrations of arsenic, chromium, and thallium in soil also exceed the draft SSLs for protection of groundwater. These and other analytes were detected in groundwater samples.

6.3.3.2 Groundwater/Leachate

Table 6-11 presents human health ARARs and TBCs for groundwater (and surface water) COPCs. State and Federal standards are provided. The only ARARs available for this medium are state groundwater standards and Federal Maximum Contaminant Levels (MCLs), which are used to assess the drinking water quality of a resource. No state MCLs are available; the State of North Carolina has adopted the Federal drinking water standards. Criteria designated as TBCs for groundwater at OU2 are Maximum Contaminant Level Goals (MCLGs), Health Advisories (HAs), and Region III RBCs (for tap water).

Federal MCLs are promulgated under the Safe Drinking Water Act (40 CFR, Parts 141 and 142). MCLs can be risk-based standards derived from laboratory or epidemiology studies; however, these values may also reflect the technical feasibility of removing the contaminant. Federal MCLs are applicable to all community and non-transient water supplies. Since groundwater at the site is not used as a potable water supply, the use of Federal MCLs as enforceable ARARs is not entirely appropriate. However, these values can be used conservatively to infer potential human health impacts.

North Carolina groundwater standards are also ARARs for this medium. Groundwater at the site is designated with a GA classification, which is "intended for those groundwaters in which chloride concentrations are equal to or less than 250 mg/L, and which are considered suitable for drinking in their natural state, but which may require treatment to improve quality to natural conditions" (15A NCAC 2L.0201). State standards associated with Class GA groundwaters are presented in Table 6-11.

MCLGs are nonenforceable guidelines (TBCs) established entirely on health effects and are generally specified as zero for carcinogenic chemicals. These values are based on the assumption of nonthreshold toxicity. MCLGs do not consider either the technical or economic feasibility of achieving the specific goal.

HAs are guidelines developed by the USEPA Office of Drinking Water for regulated and nonregulated contaminants in drinking water. These values are designed to consider only threshold effects and, as such, are not used to set acceptable levels of known or probable human carcinogens. HAs are generally available for acute (1-day), subchronic (10-day), and chronic (longer-term or lifetime) exposures.

Region III RBCs for the consumption of tap water were also used as TBCs in the assessment. As previously stated, RBCs are risk-based levels that are estimated for noncarcinogenic and carcinogenic effects using

TABLE 6-11

OTHER HUMAN HEALTH CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN - WATER (mg/L)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Federal Standards					North Carolina Standards		Maximum Exposure Concentration	
	MCL[1]	MCLG[1]	Health Advisories[1]	AWQC[2]	Tap Water RBC[3]	Class GA Groundwater[4]	Class SC Saltwater/Class C Freshwater[5]	Ground-water/ Leachate	Surface Water
Volatiles									
1,1-Dichloroethene	0.007	0.007	1-Day Child: 2 10-Day Child: 1 Longer-term Child: 1 Longer-term Adult: 4 Lifetime: 0.007 DWEL[8] 0.4	0.000057	0.000044	0.007	NA[9]	0.00077*	---[12]
1,2-Dichloroethane	0.005	0	1-Day Child: 0.7 10-Day Child: 0.7 Longer-term Child: 0.7 Longer-term Adult: 2.6	0.00038	0.00012	0.00038	NA	0.00097*	---
1,2-Dichloropropane	0.005	0	10-Day Child: 0.09	0.00052	0.00016	0.00056	NA	0.00083*	---
2-Butanone	NA	NA	NA	NA	1.9	0.17	NA	0.020	---
2-Hexanone	NA	NA	NA	NA	NA	>DL	NA	0.001*	---
4-Methyl-2-pentanone	NA	NA	NA	NA	2.9	>DL	NA	0.005*	---
Benzene	0.005	0	1-Day Child: 0.2 10-Day Child: 0.2	0.0012	0.00036	0.001	0.0714	0.012*	---
Chlorobenzene	0.1	0.1	1-Day Child: 2 10-Day Child: 2 Longer-term Child: 2 Longer-term Adult: 7 Lifetime: 0.1 DWEL: 0.7	0.68	0.039	0.05	NA	0.072*	---
Chloroethane	NA	NA	NA	NA	8.6	>DL	NA	0.0087*	---

TABLE 6-11 (Continued)
OTHER HUMAN HEALTH CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN - WATER (mg/L)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Federal Standards					North Carolina Standards		Maximum Exposure Concentration	
	MCL[1]	MCLG[1]	Health Advisories[1]	AWQC[2]	Tap Water RBC[3]	Class GA Groundwater[4]	Class SC Saltwater/Class C Freshwater[5]	Ground-water/ Leachate	Surface Water
Chloroform	0.1[6,7]	0	1-Day Child: 4 10-Day Child: 4 Longer-term Child: 0.1 Longer-term Adult: 0.4 DWEL: 0.4	0.0057	0.00015	0.00019	NA	0.002*	---
cis-1,2-Dichloroethene	0.07	0.07	1-Day Child: 4 10-Day Child: 3 Longer-term Child: 3 Longer-term Adult: 11 Lifetime: 0.07 DWEL: 0.4	NA	0.061	0.07	NA	0.015	---
Ethylbenzene	0.7	0.7	1-Day Child: 30 10-Day Child: 3 Longer-term Child: 1 Longer-term Adult: 3 Lifetime: 0.7 DWEL: 3	3.1	1.3	0.029	NA	0.0024	---
Tetrachloroethene	0.005	0	1-Day Child: 2 10-Day Child: 2 Longer-term Child: 1 Longer-term Adult: 5 DWEL: 0.5	0.0008	0.0011	0.0007	NA	0.0015*	---
Toluene	1	1	1-Day Child: 20 10-Day Child: 2 Longer-term Child: 2 Longer-term Adult: 7 Lifetime: 1 DWEL: 7	6.8	0.750	1.0	NA	0.0055	---
Trichloroethene	0.005	0	DWEL: 0.3	0.0027	0.0016	0.0028	NA	0.0035*	---

TABLE 6-11 (Continued)
OTHER HUMAN HEALTH CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN - WATER (mg/L)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Federal Standards					North Carolina Standards		Maximum Exposure Concentration	
	MCL[1]	MCLG[1]	Health Advisories[1]	AWQC[2]	Tap Water RBC[3]	Class GA Groundwater[4]	Class SC Saltwater/Class C Freshwater[5]	Ground-water/ Leachate	Surface Water
Vinyl chloride	0.002	0	1-Day Child: 3 10-Day Child: 3 Longer-term Child: 0.01 Longer-term Adult: 0.05	0.002	0.000019	0.000015	0.525	0.0048*	---
Semivolatiles									
1,2-Dichlorobenzene	0.6	0.6	1-Day Child: 9 10-Day Child: 9 Longer-term Child: 9 Longer-term Adult: 30 Lifetime: 0.6 DWEL: 3	2.7	0.270	0.62	NA	0.0029	---
1,4-Dichlorobenzene	0.075	0.075	1-Day Child: 10 10-Day Child: 10 Longer-term Child: 10 Longer-term Adult: 40 Lifetime: 0.075 DWEL: 4	0.4	0.00044	0.075	NA	0.0082*	---
2-Methylnaphthalene	NA	NA	NA	NA	NA	>DL	0.0000311	0.0057*	---
2-Methylphenol	NA	NA	NA	NA	1.8	>DL	NA	0.0054*	---
2,4-Dimethylphenol	NA	NA	NA	0.54	0.73	>DL	NA	0.01*	---
4-Methylphenol	NA	NA	NA	NA	0.18	>DL	NA	0.01*	---
Bis(2-chloroethyl)ether	NA	NA	NA	0.000031	9.2E-6	>DL	NA	0.003*	---
Bis(2-ethylhexyl)phthalate	0.006	0	DWEL: 0.7	0.0018	0.0048	0.003	NA	0.011*	0.006*
Naphthalene	NA	NA	1-Day Child: 0.5 10-Day Child: 0.5 Longer-term Child: 0.4 Longer-term Adult: 1 Lifetime: 0.02 DWEL: 0.1	NA	1.5	0.021	0.0000311	0.0081	---

TABLE 6-11 (Continued)
OTHER HUMAN HEALTH CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN - WATER (mg/L)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Federal Standards					North Carolina Standards		Maximum Exposure Concentration	
	MCL[1]	MCLG[1]	Health Advisories[1]	AWQC[2]	Tap Water RBC[3]	Class GA Groundwater[4]	Class SC Saltwater/Class C Freshwater[5]	Ground-water/ Leachate	Surface Water
Nitrobenzene	NA	NA	NA	0.017	0.0034	>DL	NA	0.005*	---
Pesticides/PCBs									
4,4'-DDE	NA	NA	NA	5.9E-7	0.2	>DL	NA	5.5E-5*	---
4,4'-DDD	NA	NA	NA	8.3E-7	0.28	>DL	NA	---	0.28*
4,4'-DDT	NA	NA	NA	5.9E-7	0.2	>DL	5.91E-7	0.00001*	---
Aldrin	NA	NA	1-Day Child: 0.0003 10-Day Child: 0.0003 Longer-Term Child: 0.0003 Longer-Term Adult: 0.0003 DWEL: 0.001	1.3E-7	4E-6	>DL	1.36E-7	6.25E-5*	---
α-BHC	NA	NA	NA	3.9E-6	0.000011	>DL	NA	9.8E-6*	---
γ-BHC	0.0002	0.0002	1-Day Child: 1 10-Day Child: 1 Longer-Term Child: 0.03 Longer-Term Adult: 0.1 Lifetime: 0.0002 DWEL: 0.01	0.000019	0.000052	0.0002	NA	7.25E-5*	---
Dieldrin	NA	NA	1-Day Child: 0.0005 10-Day Child: 0.0005 Longer-Term Child: 0.0005 Longer-Term Adult: 0.002 DWEL: 0.002	1.4E-7	4.2E-6	>DL	1.44E-7	0.000155*	---
Endosulfan I	NA	NA	NA	0.00093	NA	>DL	NA	0.00005*	---
Endosulfan II	NA	NA	NA	0.00093	NA	>DL	NA	9E-6*	---
Endrin aldehyde	NA	NA	NA	0.00076	NA	>DL	NA	0.000079*	---

TABLE 6-11 (Continued)
OTHER HUMAN HEALTH CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN - WATER (mg/L)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Federal Standards					North Carolina Standards		Maximum Exposure Concentration	
	MCL[1]	MCLG[1]	Health Advisories[1]	AWQC[2]	Tap Water RBC[3]	Class GA Groundwater[4]	Class SC Saltwater/Class C Freshwater[5]	Ground-water/ Leachate	Surface Water
Heptachlor	0.0004	0	1-Day Child: 0.01 10-Day Child: 0.01 Longer-term Child: 0.005 Longer-term Adult: 0.005 DWEL: 0.02	2.1E-7	2.3E-6	8E-6	2.14E-7	7.75E-5*	---
Heptachlor epoxide	0.0002	0	1-Day Child: 0.01 Longer-term Child: 0.0001 Longer-term Adult: 0.0001 DWEL: 0.02	1.0E-7	1.2E-6	4E-6	NA	2E-5*	1.9E-6*
Inorganics									
Aluminum	NA	NA	NA	NA	37	NA	NA	0.275	---
Antimony	0.006	0.006	1-Day Child: 0.01 10-Day Child: 0.01 Longer-Term Child: 0.01 Longer-Term Adult: 0.015 Lifetime: 0.003 DWEL: 0.01	0.014	0.015	NA	NA	0.0094*	---
Arsenic	0.05[10]	NA	NA	0.000018	0.000045	0.05	NA	0.0967*	0.00295*
Barium	2	2	Lifetime: 2 DWEL: 2	NA	2.6	2.0	NA	0.0975	---
Cadmium	0.005	0.005	1-Day Child: 0.04 10-Day Child: 0.04 Longer-Term Child: 0.005 Longer-Term Adult: 0.02 Lifetime: 0.005 DWEL: 0.02	0.016	0.018	0.005	NA	0.0242*	---
Iron	0.3[14]	NA	NA	NA	11	0.3	NA	100.5*	---
Lead	0.015[11]	0	NA	0.05	NA	0.015	NA	0.0241*	---
Manganese	0.05[14]	NA	NA	NA	0.84	0.05	NA	0.76*	---

TABLE 6-11 (Continued)
OTHER HUMAN HEALTH CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN - WATER (mg/L)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Federal Standards					North Carolina Standards		Maximum Exposure Concentration	
	MCL[1]	MCLG[1]	Health Advisories[1]	AWQC[2]	Tap Water RBC[3]	Class GA Groundwater[4]	Class SC Saltwater/Class C Freshwater[5]	Ground-water/ Leachate	Surface Water
Nickel	0.1	0.1	1-Day Child: 1 10-Day Child: 1 Longer-Term Child: 0.5 Longer-Term Adult: 1.7 Lifetime: 0.1 DWEL: 0.6	0.61	0.73	0.1	NA	0.0979*	---
Thallium	0.002	0.0005	1-Day Child: 0.007 10-Day Child: 0.007 Longer-Term Child: 0.007 Longer-Term Adult: 0.02 Lifetime: 0.0004 DWEL: 0.002	0.0017	0.0026[13]	NA	NA	0.00195	---

1 USEPA, February 1996.
2 USEPA 1991. Values for protection of human health from ingestion of water and organisms are presented.
3 USEPA Region III, March 7, 1995.
4 NCAC, October 25, 1994.
5 NCAC, June 1, 1994 and Reid, 1996.
6 Total trihalomethanes.
7 1994 proposed rule - total trihalomethane cannot exceed 0.08.
8 Drinking Water Equivalent Level.
9 NA - Not available (no standard) or not applicable (not a COPC for medium).
10 MCL under review.
11 Action level.
12 --- Not detected or not a COPC for medium.
13 Thallic oxide.
14 Secondary MCL.
MCL - Maximum Contaminant Level.
MCLG - Maximum Contaminant Level Goal.
AWQC - Ambient Water Quality Criteria.
RBC - Risk-Based Concentration.
>DL - Greater than detection limit.
*Exposure concentration exceeds one or more relevant criteria.

residential land use exposure assumptions. Water is assumed to be ingested at a rate of 2 L/day. RBCs are calculated using a THQ of 1.0 and a TR of 1E-6. The noncarcinogenic RBCs shown in Table 6-11 are divided by 10 to derive an RBC based on a THQ of 0.1 for use in selection of COPCs. The use of the RBCs in assessing potential health effects at OU2 results in an extremely conservative analysis, since groundwater investigated at the site is not used as a potable water supply.

The 95 percent UCL concentrations for COPCs detected in groundwater/leachate are also shown on Table 6-11. Almost all of the organic compounds selected as COPCs in groundwater/leachate (i.e., those present at concentrations that correlate to a cancer risk greater than 1E-6 and a Hazard Index of 0.1) are present at concentrations that exceed MCLs/MCLGs, USEPA Region III RBCs for tap water, and/or the North Carolina standards for GA waters. In addition, several metals exceed one or more of the criteria (antimony, arsenic, and manganese).

Based on this comparison, it can be inferred that the groundwater at OU2 is not suitable for direct human consumption on a routine basis (i.e., residential land use scenario). The development of the surficial or Yorktown aquifers for potable supply is highly unlikely, given the existence of the Air Station's supply system. In addition, the groundwater at this site discharges to Slocum Creek or Turkey Gut; therefore, no downgradient users of groundwater exist now or would exist in the future.

6.3.3.3 Surface Water

ARARs and TBCs for the selected COPCs for surface water are also outlined in this section. State water quality standards (for protection of human health) were used as ARARs; Federal Ambient Water Quality Criteria (AWQC) for the protection of human health from ingestion of water and fish were used as TBCs. Ecological issues are discussed in Section 7.0 of this report.

Slocum Creek is classified by the state as a Class SC tidal saltwater body that is meant to be suitable for propagation of aquatic life, fishing, wildlife, and secondary recreation (15A NCAC 2B.0212). Water quality standards for protection of human health are presented in Table 6-11.

Turkey Gut is classified as a fresh surface water that is meant to be suitable for aquatic life propagation and maintenance of biological integrity, wildlife, secondary recreation, and any other usage except for primary recreation or as a source of water supply for drinking, culinary, or food processing purposes (15A NCAC 2B.0211). Water quality standards are presented in Table 6-11. The Class SC and Class C standards are the same for many COPCs.

Neither stream would be suitable as a source of drinking water.

Federal AWQC (USEPA, May 1980) are nonenforceable guidelines and are mainly used to assess the potential for toxic effects in aquatic organisms. However, they may also be used to identify the potential for human health risks. AWQC presented in Table 6-11 are for ingestion of water and aquatic organisms (6.5 g/day). Region IV screening values for surface water (USEPA Region IV, November 16, 1992) were not included in the assessment, since these values are similar to federal AWQC.

The following COPCs exceeded state and/or Federal standards for the protection of human health: bis(2-ethylhexyl)phthalate, 4,4'-DDD, heptachlor epoxide, arsenic, and thallium.

The criteria presented in this section are those for protection of human health. Comparisons to all state surface water standards, including those for protection of aquatic life, were made in Section 4.

6.4 RISK CHARACTERIZATION

Potential risks for human receptors resulting from the exposures outlined in the exposure assessment (Section 6.2) are characterized quantitatively in this section. Risk quantification methods are discussed for carcinogenic and noncarcinogenic effects. This discussion is followed by the presentation of the calculated risks for potential receptors at OU2.

6.4.1 Risk Estimation Methods

Quantitative estimates of risk are calculated according to risk assessment methods outlined in current guidance (USEPA, December 1989). Lifetime cancer risks are expressed in the form of dimensionless probabilities based on CSFs. Noncarcinogenic risk estimates are presented in the form of Hazard Quotients (or Hazard Indices) that are determined through a comparison of intakes with published reference doses (RfDs).

Incremental cancer risk (ICR) estimates are generated for each COPC using estimated exposure intakes and published CSFs, as follows:

$$ICR = \textit{Estimated Exposure Intake} \times CSF$$

If the above equation results in a risk greater than 0.01, the following equation is used:

$$ICR = 1 - [\exp(\textit{Estimated Exposure Intake} \times CSF)]$$

The resulting risk is a unitless expression of an individual's likelihood of developing cancer from exposure to carcinogenic chemicals. An incremental cancer risk of 1E-6 indicates that the exposed receptor has a one-in-one-million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons.

The calculated cancer risks should be recognized as an upper-limit estimate of potential risk. CSFs are the upper 95 percent confidence limit of a dose-response curve, which is generally derived from animal studies. Actual human risk, while not identifiable, is not expected to exceed the upper limit based on the CSFs and, in fact, may be lower.

The USEPA has defined the range of 1E-4 to 1E-6 as the "target range" for most hazardous waste facilities addressed under CERCLA. Typically, individual or cumulative ICRs greater than 1E-4 are not considered to be protective of human health, while ICRs below 1E-6 are.

Noncarcinogenic risks are assessed using the concept of Hazard Quotients (HQs) and Hazard Indices (HIs). The HQ for a COPC is the ratio of the estimated intake to the RfD, as follows:

$$HQ = \frac{\textit{Estimated Exposure Intake}}{RfD}$$

An HI is generated by summing the individual HQs for the COPCs. If the value of the HI exceeds unity (1.0), there is a potential noncarcinogenic health risk associated with exposure to that particular chemical mixture (USEPA, September 24, 1986). At that time, particular attention should be paid to the target organs associated with exposure to each chemical as not all noncarcinogenic health effects are considered to be additive. The HI is not a mathematical prediction of the severity of toxic effects and, therefore, is not a true "risk." It is simply a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects. If the ratio of the intake and the RfD for any individual chemical exceeds unity, toxic effects would also be expected.

6.4.2 Calculated Risks

A summary of the carcinogenic and noncarcinogenic risks for potential receptors at OU2 is provided in Tables 6-12 and 6-13. Risks are presented for individual exposure routes; a cumulative risk for noncarcinogens and carcinogens across all applicable exposure routes is also calculated for each receptor. The risks associated with particular chemicals are presented in spreadsheets in Appendix J.5 (Volume III). Sample calculations for the risk characterization are contained in Appendix J.4 (Volume III).

6.4.2.1 Carcinogenic Risks

Carcinogenic risks for each current and future potential receptor are discussed in this section. Receptors considered under current land use conditions are maintenance workers, adolescent trespassers, and adult recreational users. Under future land use conditions, adolescent trespassers, construction workers, hypothetical full-time employees, and adult/child residents are considered.

Maintenance Workers

Under current and future conditions, the total incremental cancer risk for maintenance workers exposed only to surface soil is 1.0E-6. This risk is within the risk range goal of 1E-4 to 1E-6 for cancer risks; therefore, adverse health effects would be minimal for maintenance workers at this site.

Adolescent Trespassers

Under current land use conditions, adolescent trespassers could be exposed to surface soil (ingestion and dermal contact) and leachate seep water (ingestion and dermal contact) while actually on site. In addition, these receptors may also be exposed to surface water and sediment in both Slocum Creek and Turkey Gut. Both ingestion and dermal contact are considered for these media as well.

Risks for adolescent trespassers on site are an ICR of 3.9E-7. This value is below the USEPA risk range goal of 1E-4 to 1E-6.

In Turkey Gut and Slocum Creek, the risks for the adolescent trespasser are below 1E-6. Therefore, the infrequent exposures of this receptor (12 days/yr in each water body) are not expected to result in any adverse health effects.

TABLE 6-12

CUMULATIVE RISKS[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Exposure Route	Maintenance Worker	Adolescent Trespasser	Construction Worker	Onsite Adult Resident	Onsite Child Resident	Full-Time Employee
Incremental Cancer Risk						
Inhalation of Fugitive Dust	NA[2]	NA	8.7E-9	NA	NA	NA
Dermal Contact with Soil	6.0E-8	5.4E-8	2.0E-9	7.0E-7	2.4E-6	1.3E-6
Incidental Ingestion of Soil	9.7E-7	3.0E-7	2.1E-7	3.4E-6	3.2E-5	5.1E-6
Dermal Contact with Leachate	NA	2.4E-8	NA	NA	NA	NA
Incidental Ingestion of Leachate	NA	8.6E-9	NA	NA	NA	NA
Dermal Contact with Groundwater (surficial aquifer)	NA	NA	5.4E-7	1.4E-6	2.5E-6	NA
Ingestion of Groundwater (surficial aquifer)	NA	NA	NA	3.7E-4	8.7E-4	NA
Inhalation of Volatiles in Groundwater (surficial aquifer)	NA	NA	NA	1.8E-6	8.2E-6	NA
Total:	**1.0E-6**	**3.9E-7**	**7.6E-7[3]**	**3.8E-4[4]**	**9.2E-4**	**6.4E-6**
Hazard Index						
Inhalation of Fugitive Dust	NA	NA	0.00051	NA	NA	NA
Dermal Contact with Soil	0.0016	0.0036	0.003	0.078	0.27	0.034
Incidental Ingestion of Soil	0.014	0.011	0.042	0.2	1.9	0.071
Dermal Contact with Leachate	NA	0.0052	NA	NA	NA	NA
Incidental Ingestion of Leachate	NA	0.0013	NA	NA	NA	NA
Dermal Contact with Groundwater (surficial aquifer)	NA	NA	0.56	0.22	0.38	NA
Ingestion of Groundwater (surficial aquifer)	NA	NA	NA	21	48	NA
Inhalation of Volatiles in Groundwater (surficial aquifer)	NA	NA	NA	0.16	0.77	NA
Total:	**0.016**	**0.021**	**0.61[3]**	**22[4]**	**51**	**0.10**

1 Chemical-specific risks presented in Appendix J.5 (Volume III).
2 NA - Not applicable. Exposure route not evaluated for this receptor.
3 No additional risks associated with exposure to Polishing Pond sediments (No COPCs).
4 Risks associated a 30-yr child/adult residential exposure scenario are ICR = 2.4E-3 and HI = 72.

TABLE 6-13

CUMULATIVE RISKS - SURFACE WATER AND SEDIMENT EXPOSURES[1]
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Exposure Route	Slocum Creek		Turkey Gut
	Adult Recreational User	Adolescent Trespasser	Adolescent Trespasser
Incremental Cancer Risk			
Dermal Contact with Sediment	2.0E-7	2.3E-8	4.2E-8
Incidental Ingestion of Sediment	1.8E-6	2.6E-7	6.1E-8
Dermal Contact with Surface Water	4.0E-8	1.3E-9	4.9E-9
Incidental Ingestion of Surface Water	3.5E-10	4.9E-11	2.4E-8
Ingestion of Fish	3.8E-5	NA[2]	NA
Total:	**4.0E-5**	**2.8E-7**	**1.3E-7**
Hazard Index			
Dermal Contact with Sediment	0.019	0.0063	0.002
Incidental Ingestion of Sediment	0.025	0.010	0.0056
Dermal Contact with Surface Water	(3)	(3)	0.00048
Incidental Ingestion of Surface Water	(3)	(3)	0.00038
Ingestion of Fish	(3)	NA	NA
Total:	**0.044**	**0.016**	**0.0085**

1 Chemical-specific risks presented in Appendix J.5 (Volume III).
2 NA - Not applicable. Exposure route not evaluated for this receptor.
3 No dose-response parameters available for COPCs.

Construction Worker

The estimated incremental cancer risk for the construction worker is 7.6E-7 which is below the USEPA risk range goal. Therefore, adverse health effects would be minimal for a construction worker.

Future Full-Time Employee

This receptor is based on the supposition that some facility could be built on site to house full-time personnel. These persons are assumed to be exposed to surface soil only (via ingestion and dermal contact). The risks for this receptor are 6.4E-6, which is within the USEPA's risk range goal of 1E-4 to 1E-6. This risk is almost exclusively due to the evaluation of arsenic (88% of total risk) at its maximum detected concentrations of 17.1 mg/kg. The status of arsenic as a human carcinogen via ingestion is discussed in Section 6.5.3.

Future Onsite Residents

The most likely residential exposure scenario, as long as the Air Station remains active, is a 6-year exposure duration, as described in Section 6.2.1.1. The carcinogenic risks for both adult and child receptor exceed 1E-4. The risks are more than 95 percent attributable to potential ingestion of groundwater. More than 90 percent of the ingestion risk is attributable to the presence of arsenic (evaluated at a concentration of 96.7 μg/L, versus an overall average of positive detections of 42.6 μg/L which is below the MCL/State groundwater standard) and 6 percent to vinyl chloride. The uncertainty associated with evaluating arsenic as a carcinogen is discussed in Section 6.5.3.

If groundwater use is not considered (i.e., future residents use the Air Station's potable water supply), the cancer risks are within the USEPA's risk range goal. Under this scenario, arsenic which was evaluated at its maximum concentration, and beryllium contribute about 88 percent of the total soil risks.

An alternate residential exposure scenario was also evaluated, incorporating the USEPA default exposure duration of 6 years as a child and 24 years as an adult (USEPA, March 25, 1991). The total risks under this scenario are 2.4E-3, which is an order of magnitude higher than for the 6-year adult exposure. Arsenic and vinyl chloride again are the major risk drivers for groundwater, and arsenic and beryllium drive the soil risks.

Adult Recreational Users

Adult recreational users exposed orally and dermally to water and sediment in Slocum Creek, as well as via fish ingestion, would experience an incremental cancer risk of 4.0E-5, which is within the USEPA's risk range goal. Therefore, these exposures could be considered to result in minimal adverse health effects.

6.4.2.2 Noncarcinogenic Hazards

Noncarcinogenic hazards are presented in this section for each of the defined receptor groups. The USEPA considers Hazard Indices over 1.0 for any target organ to be indicative of the potential for onset of adverse health effects.

Maintenance Workers

The Hazard Index for maintenance workers was estimated to be 0.016. Because this value is below 1.0, adverse health effects would not be expected in this receptor population.

Adolescent Trespassers

HIs for all adolescent trespasser scenarios (soil/leachate exposures, Turkey Gut exposures, and Slocum Creek exposures) are all below 1.0, ranging from 0.0085 to 0.021. Therefore, toxic effects would not be expected to occur.

Construction Worker

The total HI for construction workers is estimated at 0.61. Because this value is below 1.0, adverse health effects would not be expected.

Future Full-Time Employee

A full-time employee exposed to surface soil at this site would have an HI of 0.10. Therefore, no adverse toxic effects are anticipated for this receptor.

Future Onsite Residents

The HIs for both adult and child residents exceed 1.0 (22 and 51, respectively). These hazards are due almost solely (more than 85 percent) to ingestion of groundwater containing iron (44 percent) and arsenic (42 percent). Individually, these metals have HIs greater than 1.0. These HIs make the potential domestic use of water in the surficial aquifer unacceptable.

Adult Recreational User

The estimated HI for the adult recreational user of Slocum Creek is 0.044. Therefore, no adverse, noncarcinogenic health effects would be expected.

6.4.2.3 Health Effects Associated with Exposure to Lead

Lead was identified as a COPC for subsurface soil at OU2 because detected concentrations in several soil samples exceeded 400 mg/kg. However, it should be noted that since the future residential land use scenario does not consider exposure to deep subsurface soil that actually no child receptors are considered for lead exposure. All surface soil lead concentrations were below 400 mg/kg (maximum was 76.5 mg/kg); therefore, lead exposures were not estimated for future child residents.

6.4.3 Summary

Quantitative carcinogenic and noncarcinogenic risks for the RME were estimated for maintenance workers, adolescent trespassers, construction workers, full-time employees, future residents, and adult recreational users at OU2. With the exception of future potential exposure to groundwater in a residential setting, all carcinogenic risks for all receptors were within the USEPA's target risk range. The maximum risk is reported as 9.2E-4 for the future child resident exposed to arsenic in shallow groundwater. The risks for future residents (children and adults) both exceed 1E-4, which is the upper end of the USEPA's target risk range.

For future residents (using the 6-year residence period typical of military installations), several analytes have individual cancer risks greater than 1E-6, making them chemicals of concern (COCs) for groundwater. The following analytes were determined to be COCs:

- 1,1-Dichloroethene
- 1,4-Dichlorobenzene
- Benzene

- Vinyl chloride
- Bis(2-chloroethyl)ether
- Heptachlor epoxide
- Arsenic

In addition, there were several noncarcinogenic analytes in the surficial aquifer with HIs greater than 0.1, which also makes them COCs. These analytes are as follows:

- Chlorobenzene
- 4-Methylphenol
- Nitrobenzene
- Heptachlor epoxide
- Arsenic
- Cadmium
- Iron
- Manganese

In addition to the future potential exposure to the surficial aquifer, potential potable use of the Yorktown aquifer was also considered. The spreadsheets detailing these exposures are also included in Appendix J.5.5 (Volume III). These risks were not included in the risk summary tables, as the use of the surficial aquifer and the Yorktown would be mutually exclusive. However, they are provided below:

Receptor	Incremental Cancer Risk	Hazard Index
Adult residents - 6 yr	8.2E-7	0.27
Adult residents - 30 yr	5.4E-6	0.91
Child residents	2.1E-6	0.63

The risks associated with use of the Yorktown aquifer fall within the USEPA's target risk range.

Exposure to soil at OU2 results in unacceptable risks (HIs) only for future child residents. All other soil exposures result in ICRs below 1E-4 or HIs below 1. There are, however, several COPCs that contributed individual ICRs greater than 1E-6 for residential or full-time employee exposures, as follows:

- Arsenic
- Beryllium

Several COCs are identified for soil where they contribute HIs greater than 0.1 for one or more receptor and/or exposure route, as follows:

- Antimony
- Arsenic
- Chromium
- Iron
- Thallium

No other COCs were identified in soil. In addition, no individual compounds in either the surface waters or sediments would be considered as COCs.

An evaluation of average-case or central-tendency exposure (CTE) risks was also conducted for full-time employees. A discussion of CTE is provided in Appendix J.6.

6.5 UNCERTAINTY ANALYSIS

The intent of this section is to identify important uncertainties and limitations associated with the baseline human health risk assessment. The uncertainties related to each component of the assessment (e.g., data evaluation, exposure assessment, toxicity assessment, and risk characterization) are presented below. In addition, the effect of a particular uncertainty on the outcome of the assessment (i.e., risk estimates) is also indicated, where possible.

6.5.1 Data Evaluation

The most significant uncertainty associated with this section is in the actual selection of COPCs considered to be representative of site contamination. Both measured background concentrations and risk-based screening concentrations were used to identify COPCs.

Some degree of uncertainty is associated with the use of established background values, since the background database is limited by the amount of samples collected and the locations (i.e., lithology) sampled. Actual concentrations of naturally occurring inorganics may in fact be lower or higher, although 21 background soil samples have been collected throughout the years at the Air Station.

The use of single-route, risk-based screening concentrations may lead to the underestimation of risks, since they do not account for the additive effects across various exposure pathways. The resultant effects of the

risks are not considered significant because conservative values, derived from a target HI of 0.1 for noncarcinogens and a target risk of 1E-6 for carcinogens, were employed. In addition, screening concentrations for groundwater (which were used for surface water) are overly conservative, since they assume direct ingestion occurs at a rate of 2 L/day.

Additionally, the chemical analytical database also has some limitations regarding the representativeness of the laboratory results, the inclusion of nondetected data, data gaps, number of samples collected, and heterogeneity of sample data. The effects of these limitations on the results of the risk assessment are varied. However, every effort was made to collect and use samples that reflect actual site conditions. Nondetected results were treated using one-half the detection limit in all statistical functions. These actions should minimize uncertainty in the database, although the size of the OU precluded a completely unbiased (grid) soil sampling program.

6.5.2 Exposure Assessment

Major uncertainties related to the estimates of exposure are, as follows:

- The likelihood of the occurrence of the defined exposure scenarios. Identified land use and activity patterns at the Air Station are limited to the observations made during the field investigation and known land uses in the surrounding area.

- The use of upper-bound input parameters. Receptor characteristics, such as age, body weight, and exposure duration, are based on published ranges and default values. Some parameters are based on professional judgment.

- The limitation of using various models and/or equations to estimate exposure doses or contaminant concentrations. For example, the use of modeled concentrations (i.e., generated fugitive dust concentrations) in place of monitored values may not be indicative of actual site conditions during a future potential construction project.

- The use of maximum detected concentrations as representative exposure concentrations.

In general, the underestimation of risks was prevented using conservative exposure assumptions and exposure concentrations. Although maximum concentrations are not a reasonable estimate of the concentration expected to be experienced by a receptor over time, the use of these values does provide a highly conservative estimate of risk to potential receptors.

6.5.3 Toxicity Assessment

The toxicologic data used as the basis for all risk assessments contain uncertainty in the following areas:

- The extrapolation of nonthreshold (carcinogenic) effects from the high doses administered to laboratory animals to the low doses received under more common human exposure scenarios.
- The extrapolation of the results of laboratory animal studies to human or environmental receptors.
- The interspecies variation in toxicological endpoints used in characterizing potential health effects resulting from exposure to a chemical.
- The variations in sensitivity among individuals of any particular species.
- The use of short-term toxicological studies to predict long-term effects.

As discussed in Section 6.3.2, established RfDs have an inherent amount of uncertainty. Uncertainty factors for RfDs used in the assessment were presented in Table 6-9.

Also, the fact that toxicity information is not available for all COPCs is in itself a limitation. Because RfDs, CSFs, and other toxicity criteria are not available for all identified chemicals, it is impossible to qualitatively or quantitatively assess the risks associated with exposure to some substances. This may lead to the under-estimation of risks. Several chemicals that do not have published dose-response parameters were detected in the environmental media at the Air Station. Some of these chemicals (calcium, iron, magnesium, sodium, and potassium) are essential human nutrients and are abundant elements in soil and were, therefore, not selected as COPCs. Other compounds were not selected as COPCs based on screening values for similar compounds (e.g., naphthalene RBC for benzo(g,h,i)perylene and endrin RBC for endrin ketone); therefore, the cumulative effect of these compounds is not likely to be significant.

Furthermore, no toxicity values are available for lead. This chemical was selected as a COPC for "all" soil. A qualitative evaluation of exposure to this chemical, as well as a quantitative evaluation using the USEPA IEUBK model, was provided. Calculated risks associated with exposure to soil, presented in Section 6.4.2, are underestimated, since the risks associated with lead could not be performed in the same manner.

Some uncertainty is associated with the evaluation of the carcinogenic effects from oral exposure to arsenic. Although the carcinogenicity of this chemical has been extensively reviewed, no published oral Cancer Slope Factor (CSF) is available. The CSF used in this assessment was calculated using a proposed drinking water unit risk (USEPA, June 21, 1988), derived from Taiwanese data. The uncertainties associated with the ingestion of arsenic are high, such that estimated risks for this chemical may be overestimated by as much as an order of magnitude. Several factors contributing to the uncertainties include the assumption that the dose-response curve is linear, evidence in animal studies suggesting that arsenic may be a necessary nutrient, the observation that oral exposure to arsenic results in non-lethal type of cancer (skin cancer), and the fact that the development of the CSF does not account for differences in population groups.

6.5.4 Risk Characterization

Incremental cancer risks and Hazard Indices are summed for all potential COPCs and for all applicable routes of exposure. Summing the cancer risks implies that no antagonistic or synergistic effects exist between chemicals. It also assumes that similar mechanisms of action and metabolism are prevalent. Therefore, the use of this approach may either underestimate or underestimate the risks, depending on the chemical-specific interactions, which cannot be predicted. The direction of the uncertainty cannot be defined, but the methodology used is according to current USEPA guidance.

Risks to any individual may also be overestimated by summing multiple assumed exposure pathway risks for any single receptor. Although every effort was made to develop reasonable scenarios, not all individual receptors may be exposed via all pathways considered.

6.5.5 Summary

In summary, noncarcinogenic hazards and carcinogenic health risks are estimated using various assumptions. Consequently, the values presented contain an inherent amount of uncertainty. The extent to which health risks can be characterized is primarily dependent upon the accuracy with which the toxicity of a chemical can be estimated and the accuracy of the exposure scenario assumptions.

6.6 HUMAN HEALTH RISK ASSESSMENT SUMMARY

This section provides a summary of the carcinogenic and noncarcinogenic risks for each current and future potential receptor. Receptors considered under current land use conditions are maintenance workers, adolescent trespassers, and adult recreational users. Additional receptors for the future land use conditions are construction workers, full-time employees, and adult and child residents. For some receptors multiple

exposure scenarios were evaluated. The USEPA risk range goal for carcinogens is 1E-4 to 1E-6. The USEPA risk goal for noncarcinogens is a Hazard Index (HI) less than 1.

6.6.1 Carcinogenic Risks

The estimated incremental cancer risks for each receptor and exposure scenario are as follows:

- Maintenance worker (surface soil): 1.0E-6
- Adolescent trespasser (surface soil and leachate seep water): 3.9E-7
- Adolescent trespasser (Slocum Creek water and sediment): 2.8E-7
- Adolescent trespasser (Turkey Gut water and sediment): 1.3E-7
- Adult recreational user (Slocum Creek water, sediment, and fish): 4.0E-5
- Construction worker (soil and groundwater): 7.6E-7
- Full-time employee (surface soil): 6.4E-6
- Adult resident (soil and surficial aquifer groundwater for 6 years): 3.8E-4
- Child resident (soil and surficial aquifer groundwater): 9.2E-4
- Adult/child resident (soil and surficial aquifer groundwater for 30 years): 2.4E-3
- Adult resident (soil and Yorktown aquifer groundwater for 6 years): 4.9E-6
- Child resident (soil and Yorktown aquifer groundwater): 3.6E-5
- Adult/child resident (soil and Yorktown aquifer groundwater for 30 years): 5.6E-5

Except for future adult and child residents exposed to soil and surficial aquifer groundwater, all estimated incremental cancer risks were below or within the target risk range of 1E-4 to 1E-6.

6.6.2 Noncarcinogenic Risks

The estimated HI for each receptor and exposure scenario are as follows:

- Maintenance worker (surface soil): 0.016
- Adolescent trespasser (surface soil and leachate seep water): 0.021
- Adolescent trespasser (Slocum Creek water and sediment): 0.016
- Adolescent trespasser (Turkey Gut water and sediment): 0.0085
- Adult recreational user (Slocum Creek water, sediment, and fish): 0.044
- Construction worker (soil and groundwater): 0.61
- Full-time employee (surface soil): 0.10
- Adult resident (soil and surficial aquifer groundwater for 6 years): 22

- Child resident (soil and surficial aquifer groundwater): 51
- Adult/child resident (soil and surficial aquifer groundwater for 30 years): 72
- Adult resident (soil and Yorktown aquifer groundwater for 6 years): 0.55
- Child resident (soil and Yorktown aquifer groundwater): 2.8
- Adult/child resident (soil and Yorktown aquifer groundwater for 30 years): 2.4

Except for all future residents exposed to soil and surficial aquifer groundwater, and child and adult/child residents exposed to soil and Yorktown aquifer groundwater (30-year), all estimated HIs were below the target of 1.0.

6.6.3 Remedial Goal Options

The USEPA Region IV requires, as part of the risk assessment, an estimation of Remedial Goal Options (RGOs) for three risk range levels for any receptor for which any individual chemical has a cancer risk greater than 1E-6 or a Hazard Index greater than 1. Tables 6-14 and 6-15 contain a summary of preliminary RGOs for the future 6-year resident exposure to soil and groundwater, respectively. Tables 6-16 and 6-17 contains RGOs for the future 30-year resident exposure to soil and groundwater respectively. Table 6-18 contains RGOs for future full-time employee exposure to soil. The 30-year (worst case) future resident has the most stringent (lowest) RGOs, and the employee has the least stringent (highest) RGOs. No other exposure scenarios would require this step under the Region IV guidelines. These preliminary RGOs will be used in the Feasibility Study to evaluate the effectiveness of various remedial alternatives.

TABLE 6-14

REMEDIAL GOAL OPTIONS - SOIL (mg/kg)
6-YEAR RESIDENT (CHILD OR ADULT)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Cancer Risk			Hazard Index		
	1E-6	1E-5	1E-4	0.1	1	10
Antimony	NA	NA	NA	2.9	29	290
Arsenic	0.51	5.1	51	2.3	23	230
Beryllium	0.072	0.72	7.2	13.3	133	1,330
Chromium VI	0.84	8.4	84	13.3	133	1,330
Iron	NA	NA	NA	2,140	21,400	214,000
Thallium	NA	NA	NA	0.5	5.0	50

NA Not applicable. No cancer slope factor or Reference Dose for this chemical.

TABLE 6-15

REMEDIAL GOAL OPTIONS - GROUNDWATER (mg/L)
6-YEAR RESIDENT (CHILD OR ADULT)
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Cancer Risk			Hazard Index		
	1E-6	1E-5	1E-4	0.1	1	10
1,1-Dichloroethene	0.00025	0.0025	0.025	-	-	-
1,4-Dichlorobenzene	0.0069	0.069	0.69	3.4	34	340
Benzene	0.0038	0.038	0.38	0.0044	0.044	0.44
Chlorobenzene	NA	NA	NA	0.026	0.26	2.6
Vinyl chloride	0.000086	0.00086	0.0086	NA	NA	NA
4-Methylphenol	NA	NA	NA	0.0076	0.076	0.76
Nitrobenzene	NA	NA	NA	0.00077	0.0077	0.077
Bis(2-chloroethyl)ether	0.00016	0.0016	0.016	NA	NA	NA
Heptachlor epoxide	0.000019	0.00019	0.0019	-	-	-
Arsenic	0.00010	0.0010	0.01	0.00047	0.0047	0.047
Cadmium	NA	NA	NA	0.00074	0.0074	0.074
Iron	NA	NA	NA	0.46	4.6	46
Manganese	NA	NA	NA	0.0078	0.078	0.78

- Cancer risk is less than 1E-6 or Hazard Index is less than 0.1
NA Not applicable. No cancer slope factor or Reference Dose for this chemical.

TABLE 6-16

REMEDIAL GOAL OPTIONS - SOIL (mg/kg)
30-YEAR RESIDENT
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Cancer Risk			Hazard Index		
	1E-6	1E-5	1E-4	0.1	1	10
Antimony	NA	NA	NA	2.5	25	250
Arsenic	0.35	3.5	35	2.1	21	210
Beryllium	0.038	0.38	3.8	11	110	1,100
Chromium VI	NA	NA	NA	12	120	1,200
Iron	NA	NA	NA	1,900	19,000	190,000
Thallium	NA	NA	NA	0.45	4.5	45

NA Not applicable. No cancer slope factor or Reference Dose for this chemical.

TABLE 6-17

REMEDIAL GOAL OPTIONS - GROUNDWATER (mg/L)
30-YEAR RESIDENT
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Cancer Risk			Hazard Index		
	1E-6	1E-5	1E-4	0.1	1	10
1,1-Dichloroethene	0.000097	0.00097	0.0097	-	-	-
1,4-Dichlorobenzene	0.0025	0.025	0.25	0.61	6.1	61
Benzene	0.0016	0.016	0.16	0.0036	0.036	0.36
Chlorobenzene	NA	NA	NA	0.018	0.18	1.8
Vinyl chloride	0.000032	0.00032	0.0032	NA	NA	NA
4-Methylphenol	NA	NA	NA	0.0053	0.053	0.53
Nitrobenzene	NA	NA	NA	0.00054	0.0054	0.054
Bis(2-chloroethyl)ether	0.000059	0.00059	0.0059	NA	NA	NA
Heptachlor epoxide	0.0000069	0.000069	0.00069	0.000014	0.00014	0.0014
Arsenic	0.000038	0.00038	0.0038	0.00033	0.0033	0.033
Cadmium	NA	NA	NA	0.00052	0.0052	0.052
Iron	NA	NA	NA	0.33	3.3	33
Manganese	NA	NA	NA	0.0054	0.054	0.54

- Cancer risk below 1E-6 or Hazard Index below 0.1

NA Not applicable. No cancer slope factor or Reference Dose for this chemical.

TABLE 6-18

REMEDIAL GOAL OPTIONS - SOIL (mg/kg)
FULL TIME EMPLOYEE
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Analyte	Cancer Risk			Hazard Index		
	1E-6	1E-5	1E-4	0.1	1	10
Antimony	NA	NA	NA	-	-	-
Arsenic	1.2	12	120	-	-	-
Beryllium	0.18	1.8	18	930	9,300	93,000
Chromium VI	NA	NA	NA	140	1,400	14,000
Iron	NA	NA	NA	46,600	466,000	4,660,000
Thallium	NA	NA	NA	-	-	-

NA Not applicable. No cancer slope factor or Reference Dose for this chemical.

7.0 ECOLOGICAL ASSESSMENT

This section contains background information on ecological resources at Operable Unit 2 (OU2), the results of a wetlands delineation, and an ecological risk assessment. Published reports, USEPA and regional guidance, and information gathered during a field activity in April 1995 were used in the preparation of this section.

7.1 WETLAND DELINEATION

Wetlands and other areas under jurisdiction of Section 404 of the federal Clean Water Act (CWA; 33 USC 1251 et seq.) were delineated at OU2. This wetland delineation is intended to support FS design efforts, including predesign activities and the preparation of plans, specifications, cost estimates, and other necessary documentation for characterization and possible remediation of OU2. The wetland delineation will assist designers in minimizing wetland impacts during the characterization and remediation process, support application for any necessary permits or approvals for unavoidable wetland impacts, and provide baseline data for use in the preparation of a wetland mitigation plan, if required.

Field data sheets and a list of plant and animal species observed on the site are presented in the Appendix K (Volume IV).

7.1.1 Site Description

OU2 is located on the eastern bank of Slocum Creek in the central portion of MCAS Cherry Point. Slocum Creek is a public trust, tidally-influenced, brackish tributary of the Neuse River, which in turn flows into Pamlico Sound. The stream is classified as "SC" by the State of North Carolina, and the salinity varies over time between 0 and 33 with an average of 10 to 20. The North Carolina Wildlife Resources Commission has designated Slocum Creek as an "Inland Primary Nursery Area." OU2 is bisected by Turkey Gut, a small channelized freshwater tributary of Slocum Creek that drains a portion of the Air Station south of the wastewater treatment plant. General site features are shown on Plate 15 (Volume V) and Figure 7-1.

The portion of the site in the wetlands, on the slopes above the wetlands, and much of the landfill is primarily forested in native vegetation. The portion associated with the sewage treatment plant is vegetated with non-native grasses and mowed periodically (Weyerhaeuser, 1994). Numerous debris piles, composed of asphalt, soil, old cars, barrels, lockers, and rusted metal, are located along the south bank of Turkey Gut adjacent

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ROOSEVELT ROAD
APPROXIMATE LOCATION OF FENCE
SITE 43 SEWAGE TREATMENT PLANT
DRUMMED RETROLEUM (ABANDONED)
STORAGE
TURKEY
SITE 46 POLISHING POND 2
SITE 46 POLISHING POND 1
WASH RACK
MWR STORAGE AREA
AUTO HOBBY SHOP
SITE 76 VEHICLE MAINTENANCE AREA (HOBBY SHOP)
SLOCUM CREEK
HABITAT TYPES
SECOND GROWTH LOBLOLLY PINE STAND (12.5 AC)
COASTAL PLAIN SMALL STREAM SWAMP (6.2 AC)
OLD FIELD (3.9 AC)
MESIC MIXED HARDWOOD FOREST (17.2 AC)
DEVELOPED AREA AND GRASSED LAWN (25.9 AC)
WETLAND DATA POINTS
REVISIONS
Brown & Root Environmental
ATLANTIC DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORFOLK, VIRGINIA
CHERRY POINT, NORTH CAROLINA
OU2
WETLANDS DELINEATION AND HABITAT DESCRIPTIONS
AS SHOWN
XX-XX-XXXX
XXXXXX-XX-X-XXXX
FIGURE 7-1

to the landfill. This portion of the landfill is characterized by old field vegetation dominated by grasses and scattered young trees.

7.1.2 Background Information

Available background information sources on OU2 include two aerial photographs dated January 22, 1994 (Weyerhaeuser, 1994) and December 26, 1993 (COE, 1993); a preliminary survey of the area (HNUS, 1994); an inventory of rare species, natural communities, and critical areas of Cherry Point (LeBlond et al., 1994); the fish and wildlife management plan for Cherry Point (Rogers, 1990); a fisheries inventory in Slocum Creek (Fleming and Hightower, 1995); and a soil survey (SCS, 1989). Information from these sources is summarized in the following sections.

7.1.2.1 Aerial Photographs

A black and white aerial photograph dated January 22, 1994 (Weyerhaeuser, 1994) and a color photograph dated December 26, 1993 (COE, 1993) provided a good representation of the forested and non-forested areas of OU2. The hardwood-dominated wetlands adjacent to Slocum Creek and Turkey Gut appear as a textured light gray in the photographs, contrasting with the dark textured gray (black and white photo) or dark green (color photo) corresponding to pine-dominated uplands. Bottomland hardwoods predominate the poorly drained soils, and pines can be found on the drier portions of OU2. Therefore, the boundary between photographic signatures corresponding to hardwood-dominated wetlands and pine-dominated uplands provided a general idea of where wetlands might be expected.

7.1.2.2 Preliminary Survey

A preliminary survey of OU2 with proposed waste sampling data points was included in the RI Work Plan (Halliburton NUS, June 1994a). This survey contains accurate locations of roads, buildings, contour lines, and approximate locations of the landfill, data points, and shoreline. The contour lines provided a quick orientation to OU2 and identified lower elevation portions of OU2 likely to contain wetlands.

7.1.2.3 Inventory of the Rare Species, Natural Communities, and Critical Areas

An inventory of the rare species, natural communities, and critical areas of MCAS Cherry Point was published in 1994 and contains information and habitat descriptions useful in a wetlands delineation (LeBlond et al., 1994). This document provides locations and descriptions of the rare species and habitat types located on MCAS Cherry Point during an extensive survey by the North Carolina Natural Heritage

Program. Particularly useful during the wetlands delineation were the descriptions of the wetland and upland habitat types including the Mesic Mixed Hardwood Forest and the Coastal Plain Small Stream Swamp (LeBlond et al., 1994).

7.1.2.4 Fish and Wildlife Management Plan

The fish and wildlife management plan contains excellent information on animal species found on the Air Station and a history of their management, but it was of little use in this wetlands delineation (Rogers, 1990).

7.1.2.5 Fisheries Inventory

A fisheries inventory of Slocum Creek contained good information on those species found in Slocum Creek, but it was of little use in this wetlands delineation (Fleming and Hightower, 1995).

7.1.2.6 Soil Survey

OU2 contains three dominant soil types. The developed portion of the site is mapped in the soil survey as "Norfolk-loamy fine sand (2 to 6 percent slopes)." The Norfolk soil is well drained and is on low ridges and side slopes near drainage ways on uplands. This soil type commonly supports urban development. The "Suffolk loamy sand (10 to 30 percent slopes)" soil type is well drained and located on the side slopes adjacent to Slocum Creek. This soil type is not hydric; however, it does contain small wet inclusions at the base of the slope adjacent to the creek. The third dominant soil type is the developed landfill. On OU2, the Suffolk loamy sand contains the most extensive wetlands.

7.1.3 Field Methodology

This section contains information on general wetland delineation procedures, the field protocol used to delineate wetlands, and a description of how the wetlands were marked for surveying.

7.1.3.1 Wetland Delineation Background

The wetland delineation of OU2 utilized the three-parameter approach based on vegetation, soils, and hydrology developed in the Corps of Engineers (COE) Wetlands Delineation Manual (Environmental Laboratory, 1987). With the exception of certain "problem area" situations and other specific exceptions identified in the COE Manual, any area delineated as a wetland had to display positive evidence of the following three characteristics:

- Hydrophytic vegetation
- Hydric soils
- Wetland hydrology

Hydrophytic Vegetation

Hydrophytic Vegetation is defined in the guidance as the sum total of macrophytic plant life growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content. Most common plant species in the United States have been assigned an indicator status based on empirical observations of their relative occurrence in wetlands and uplands. These include

- OBL - Obligate Wetland: Plant species that occur almost always (estimated probability greater than 99 percent) in wetlands under natural conditions; however, they may occur rarely (estimated probability less than 1 percent) in non-wetlands.

- FACW - Facultative Wetland: Plant species that occur usually (estimated probability 67 to 99 percent) in wetlands, but also occur (estimated probability 1 to 33 percent) in non-wetlands.

- FAC - Facultative: Plant species with a similar likelihood (estimated probability 33 to 67 percent) of occurring in both wetlands and non-wetlands.

- FACU - Facultative Upland: Plant species that occur sometimes (estimated probability 1 to 33 percent) in wetlands, but occur more often (estimated probability 67 to 99 percent) in non-wetlands.

- UPL - Upland: Plant species that occur rarely (estimated probability less than 1 percent) in wetlands, but occur almost always (estimated probability greater than 99 percent) in non-wetlands under natural conditions.

For some plant species, the indicator status was modified by adding "+" or "-". A "+" means that the plant species is slightly more likely to occur in wetlands than suggested by its indicator status alone. A "-" means that the plant species is slightly less likely to occur in wetlands than suggested by its indicator status alone.

To document that an area supports hydrophytic vegetation, more than 50 percent of the dominant plant species in each vegetational stratum must have an indicator status of OBL, FACW, or FAC (excluding FAC-). Although the COE Manual suggests the use of 4 strata (Trees, Saplings and Shrubs, Herbs, and Woody

Vines), the supplemental guidance issued by the U.S. Army Corps of Engineers also allows the use of a 5-stratum approach, as follows:

- Canopy - Trees greater than 5 inches diameter at breast height (DBH).
- Saplings - Woody plants less than 5 inches in DBH but over 20 feet in height.
- Shrubs - Woody plants greater than 3.0 feet in height and less than 20 feet in height.
- Herbs - Plants less than 3.0 feet in height.
- Woody Vines - Woody vines climbing on trees.

Vegetation in wetlands may display one or more morphological adaptations that assist in survival under saturated soil conditions. The COE Manual lists several such morphological adaptations, including buttressed (swollen) tree trunks, unusually shallow root systems, adventitious roots, and others. The hydrophytic vegetation parameter may be met if two or more dominant species display one or more of these adaptations, even if the vegetation is composed primarily of FACU or UPL species.

Hydric Soil

Hydric Soil is defined in the COE Manual as soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation. The Soil Conservation Service has developed a list of soil series (soils having similar profile characteristics) in Craven County, North Carolina that meet the definition of hydric soil (SCS, June 1991). If soil profile data collected in a specific area can be matched to a recognized soil series, then its status as hydric can be determined by checking the list.

Otherwise, a determination can be made based on the presence of one or more field indicators of hydric soil listed in the COE Manual. The most readily observable indicator is soil color. Soil colors are expressed in terms of hue, value, and chroma using a Munsell Soil Color Chart. Typically, soil colors with a chroma of 1 (regardless of hue and value) are indicative of hydric soils. Soils with a chroma of 2 that are also mottled (spotted) are generally hydric as well. Other readily observable indicators of hydric soils include a predominantly organic soil profile (histosols or mineral soils with histic epipedons), sulfidic material (rotten egg smell), or iron and manganese concretions (black or dark brown specks).

Wetland Hydrology

Wetland Hydrology is defined in the COE Manual as the sum total of wetness characteristics in areas that are inundated or have saturated soils for a sufficient duration to support hydrophytic vegetation. Areas

generally must be inundated or saturated for at least 5 percent of the growing season (in some cases 12.5 percent) during typical rainfall years for wetland hydrology as defined in the COE Manual to be present. The presence of wetland hydrology is usually determined through direct or indirect evidence of seasonal saturation or inundation. The COE Manual lists several other indicators of wetland hydrology that indirectly suggest that an area has wetland hydrology even though it may be dry at the time of observation. These include the presence of the following:

- Watermarks - lines on trees or other upright structures that represent the maximum static water level reached during an inundation event.
- Drift lines - accumulations of debris along a contour that represents the height of an inundation event
- Sediment deposits - thin layers of mud or fine debris coating vegetation or the soil surface
- Drainage patterns - deposited debris or scoured leaf litter indicative of water flow patterns

Other indicators of wetland hydrology are commonly recognized by wetland scientists even though they are not recognized in the COE Manual. These include blackened leaf litter on the soil surface and the presence of oxidized rhizospheres (thin rust colored soil zone surrounding living plant roots). Although the presence of these indicators cannot be used as the sole basis for the determination of wetland hydrology, their presence can be noted as supplementary supporting information.

Field indicators of wetland hydrology, especially observation of inundation or saturation, must be viewed in the context of recent rainfall occurrences and seasonal water table fluctuations. For example, the presence of saturation during a seasonally wet time period or immediately following heavy rainfall cannot be used to conclude that wetland hydrology is present, and the absence of saturation during a seasonally dry period or following a drought cannot be used to conclude that wetland hydrology is absent. It may be necessary to revisit the site at a later time to determine whether the wetland hydrology parameter is met.

7.1.3.2 Wetland Delineation Field Protocol

Preliminary reconnaissance of OU2 revealed that repetitious data collection in every plant community following rigorously defined transects, as outlined in Part IV, Section D, Subsection 2 of the COE Manual for sites over 5 acres in size, was not necessary to accurately determine the location of wetland boundaries.

Instead, representative locations were selected on the upland and wetland sides of the suspected wetland boundary to confirm its accuracy with respect to delineation criteria in the COE Manual.

Observations at each selected representative location were completed using a data form developed by the COE for the 1987 COE Manual (Environmental Laboratory, 1987). First, dominant plant species were recorded for lands surrounding each location (generally a 30-foot radius circle, but not crossing the wetland boundary) together with their Indicator Status for Region 2 (which includes North Carolina) according to Reed (September 1988). Other plant species that were not dominant were also recorded. Second, a hole was dug with a soil auger, and the soil profile was noted to a depth of approximately 30 inches (or auger refusal due to compacted soils). Third, any hydrologic indicators present in the area were noted (e.g., drainage patterns, water stained leaves, oxidized root channels in the upper 12 inches of soil, depth to surface water, depth to saturation, shallow rooted trees).

7.1.3.3 Wetland Boundary Staking, Survey, and Mapping

One wetland boundary was staked to separate upland from wetland areas on OU2. Seventy-nine points were marked by pink flagging tied to trees or shrubs along the wetland boundary at roughly 50-foot intervals (closer as necessary to show turns in the boundary). Each flag was labeled "WET D" to identify the wetland followed by a sequential number. For example, the flag labeled "WET D-3" is the third sequential flag on the boundary of the "D" wetland.

Each representative location selected for recording vegetation, soils, and hydrology data was associated with a numbered flag. A wetland data point was taken on the wetland side of the boundary and an upland data point was taken on the upland side of the boundary. Appendix K.1 (Volume IV) contains separate field data sheets completed for each data point location.

The coordinates of each flag were surveyed by a professional land surveyor and transferred to a topographic base drawing.

7.1.4 Habitat Descriptions

Five principal plant communities can be distinguished on OU2. The landfill supports Old Field vegetation and Second Growth Loblolly Pine stands. The native soils adjacent to Turkey Gut generally support Mesic Mixed Hardwood Forest on the slopes and Coastal Plain Small Stream Swamp in the wetlands. The developed portion of the site is characterized by buildings, roads, graveled parking lots, and mowed grass lawns.

Most wetland areas adjacent to Slocum Creek showed indications of shallow inundation and flooding. A distinct drift line was observed at the base of the slope and near the wetland boundary. April is a relatively wet month in coastal North Carolina, and areas saturated to the surface for at least 5 percent of the growing season would be expected to be saturated within at least 12 inches of the surface in April. The delineated wetland boundary generally follows the base of a sharp topographic rise of approximately five feet, separating saturated soils from generally well-drained soils. Distinct changes in vegetation and soil are also noticeable along this topographic rise.

Five plant communities and two aquatic systems are differentiated on the basis of vegetation and location, and each is described below.

7.1.4.1 Coastal Plain Small Stream Swamp (6.0 Acres)

The wetlands adjacent to Slocum Creek and Turkey Gut were characterized as a Coastal Plain Small Stream Swamp (LeBlond et al., 1994). These are the only wetlands that have been identified at OU2. Although Turkey Gut was channelized in the past, the adjacent areas still exhibit wetland hydrology, soils, and vegetation. Most of these areas were observed to be saturated at the surface. Six inches of black organic muck over gleyed sand characterized these soils. Dominant canopy species are red maple, alder, sweet bay, and black willow with some bald cypress, tulip poplar, and loblolly pine. A shrub layer of sweet bay and alder is present. The herbaceous layer is sparse and dominated by lizard's tail, jewel-weed, netted chain fern, and Virginia creeper.

Much of the swamp along Turkey Gut has been altered by beaver activity. An old dam was located near wetland data point D-60, while an active dam was constructed at D-34. The trees in these areas have been flooded and killed, allowing sunlight to penetrate to the forest floor. These ponds have an open water area surrounded by a dense growth of grasses, sedges, and lizard's tail.

This wetland is characterized by saturated soils between the uplands and Turkey Gut. The hydrology of this wetland is due to upland runoff trapped in level areas and depressions between Turkey Gut and the uplands.

This wetland type forms a corridor of high quality wildlife habitat bordering Slocum Creek as it crosses urban surroundings. The forest contains large, mature timber with dead snags and hollow trees being common. The soils serve to intercept and filter urban runoff prior to its entering Slocum Creek. Species observed in this habitat are recorded in Appendix K.2 (Volume IV), while Rogers (1990) contains information on the management of game species and threatened and endangered species at the Air Station. While LeBlond

et al. (1994) located no unique species or habitats in the area of OU2, the occurrence of the American alligator in the portion of Slocum Creek bordering OU2 was documented.

7.1.4.2 Old Field (39.8 Acres)

This upland vegetation type is found on the compacted soils of the landfill and supports a grassy cover of fescue, broomsedge, groundsel-tree, goldenrod, cat briar, scattered loblolly pine, black willow, and red cedar. The landfill is characterized by piles of asphalt rubble, old cars, lockers, barrels, rusted metal, and broken glass along the wetland border adjacent to Turkey Gut.

While this vegetation type provides some wildlife habitat and contributes to the vegetated corridor along Slocum Creek, the relative habitat value of this site does not approach that of the areas previously described and, following remediation, could provide an opportunity for upland wildlife habitat restoration. Species noted in this habitat are listed in Appendix K.2 (Volume IV).

7.1.4.3 Second Growth Loblolly Pine Stand (10.5 Acres)

A portion of the landfill is dominated by a nearly pure stand of loblolly pine up to 12 inches DBH. While the area provides some wildlife habitat, the young age of the stand, lack of structural diversity, and lack of a shrub or herbaceous layer limits the value of this area for wildlife.

7.1.4.4 Mesic Mixed Hardwood Forest (17.2 Acres)

The Suffolk loamy sand soils of the slope between the level upland areas and the wetlands contained no saturation at 30 inches. The dominant canopy species are loblolly pine, southern red oak, pignut hickory, American holly, sweetgum, and sweet bay with a subcanopy of dogwood, sweet bay, pignut hickory, and oaks with an herbaceous layer of muscadine grape vines. The largest trees are loblolly pine, and some exceed 20 inches DBH.

This upland vegetation type provides high quality wildlife habitat and contributes significantly to the wildlife and scenic value of the forested corridor along Slocum Creek. The forest contains mast producing trees that provide acorns and hickory nuts for gray squirrels, whitetail deer, woodpeckers, and various other species. The trees are old enough to provide nesting sites in decaying snags and hollows for cavity nesting species such as tufted titmice, great-crested flycatchers, woodpeckers, screech owls, and raccoons. Appendix K.2 (Volume IV) contains a list of the species identified in this habitat.

7.1.4.5 Developed Areas and Mowed Grass Lawn (25.0 Acres)

The remainder of the site is a developed upland area containing the sewage treatment facilities and polishing ponds. The portion of the developed area not covered by buildings, ponds, or graveled areas is characterized by lawn grasses maintained by regular mowing and is of minimal value to wildlife. Eastern bluebirds, killdeer, and common crows were observed foraging in this habitat. Additional information on species observed in these areas is provided in Appendix K.2 (Appendix IV).

7.1.4.6 Slocum Creek

Slocum Creek is a public trust, tidally-influenced, brackish tributary of the Neuse River, which in turn flows into Pamlico Sound. The stream is classified as "SC" and is approximately 800 feet wide at the confluence of Turkey Gut. Salinity in this portion of the stream varies between 0 and 33 but averages 10 to 20. The stream is bordered by Coastal Plain Small Stream Swamp in the low areas and Mesic Mixed Hardwood Forest on the low bluffs. Bald cypress border most of the shoreline. The stream is a N.C. Wildlife Resources Commission designated Inland Primary Nursery Area and provides habitat for the following fish species: Atlantic menhaden, spot, striped mullet, pumpkinseed, gizzard shad, longnose gar, redear sunfish, bluegill, black crappie, largemouth bass, and golden shiner (Fleming and Hightower, 1995; Appendix K.3, Volume IV).

7.1.4.7 Turkey Gut

OU2 is bisected by Turkey Gut, a small channelized freshwater tributary to Slocum Creek that drains a portion of MCAS Cherry Point south of the sewage treatment plant. This stream is classified as "C" and is approximately 10 feet wide and varies in depth from 2 inches to 2 feet. The stream was clear on the April 12 and 13, 1995 site visit. The downstream portion of Turkey Gut adjacent to Slocum Creek has channelized vertical banks of 1 to 2 feet in height. Upstream of point D-31 the main stream is not channelized, and the banks are less than 1 foot in height. Cars, barrels, lockers, concrete, and rusted metal have been pushed into the wetland between points D-56 and D-60. The odor of petrochemical products was present in a borehole in the wetlands, at a depth of 10 inches at point D-61. Fish, frogs, and aquatic insects were observed in the stream.

7.2 THREATENED AND ENDANGERED SPECIES

Appendix K.4 (Volume IV) contains a copy of the Air Station's Fish and Wildlife Management Plan. An intensive threatened and endangered species survey of MCAS Cherry Point was conducted by the North

Carolina Natural Heritage Program (LeBlond et al., 1994; Appendix K.5, Volume IV). The only threatened or endangered species located during the survey near OU2 was the American alligator, which was observed in Slocum Creek.

7.3 ECOLOGICAL RISK ASSESSMENT

7.3.1 Introduction and Preliminary Problem Formation

The MCAS Cherry Point is part of a military installation located in southeastern Craven County, North Carolina. OU2 is one of several sites on this facility requiring investigation in accordance with CERCLA. As a result, B&R Environmental performed an RI at this site. The primary objective of an RI is to characterize the nature and extent of contamination and to assess the potential risks to human health and the environment. This Ecological Risk Assessment (ERA) was prepared to characterize the current impacts of site contamination on aquatic and terrestrial plants and wildlife and habitats that support these organisms. The results of the ERA, as well as the human health risk assessment conducted under the RI, will serve as the basis for determining whether remediation is required at this site.

This effort represents a "baseline assessment," conducted to evaluate potential risks to ecological receptors under existing site contamination conditions, assuming that no remediation is to be conducted (i.e., the "no action" alternative). The baseline ERA only considers impacts associated with past disposal practices or releases of chemical contaminants at the site; permitted or regulated chemical releases occurring as a result of current operations are not addressed.

This ERA consists of two major steps. This section represents the introduction. The remaining portions of this chapter summarize the process used to determine whether contaminants measured in samples of various environmental media (e.g., surface soil, water, sediment) represent a potential risk to ecological receptors. The remaining sections of this ERA describe the following elements, each of which are discussed in greater detail in the remainder of this chapter:

- Preliminary Problem Formulation - the first phase of an ERA which discusses the goals, breadth, and focus of the ERA and includes a characterization of the exposure setting, identifies the assessment and measurement endpoints that will be evaluated, and develops a conceptual model that describes how contaminants associated with OU2 may come into contact with ecological receptors inhabiting this area.

- Preliminary Exposure and Risk Characterization - this portion of the ERA identifies the magnitude of the contaminant concentrations to which ecological receptors may be exposed and assess the potential risk associated with these contaminants.

The ERA was conducted in accordance with available guidance documents (USEPA, March 1989a, March 1989b, December 1991a, February 1992d, and September 1994a). Recent risk assessment guidance, including the USEPA "Eco Update" bulletins (USEPA, 1991b, 1991c, 1992a, 1992b, and 1992c), recent publications (e.g., Suter, 1993; Calabrese and Baldwin, 1993), and the results of discussions with representatives from Region IV USEPA, also served as sources of information used in the preparation of this ERA.

7.3.1.1 Site Description (OU2)

The MCAS Cherry Point is part of a military installation located in southeastern Craven County, North Carolina. The Air Station is located on an 11,485-acre tract of land bounded on the north by the Neuse River, on the east by Handcock Creek, and on the south by North Carolina Highway 101. The irregular western boundary line lies approximately 3/4-mile west of Slocum Creek. The entire Air Station is located on a peninsula, with Core and Bogue Sounds to the south.

OU2 is located in the western central portion of MCAS Cherry Point near Slocum Creek. OU2 is bisected by Turkey Gut, a small, freshwater channelized tributary of Slocum Creek that drains a portion of MCAS Cherry Point. Turkey Gut is classified as "C" by the state. Fish and aquatic insects have been observed in this stream.

Slocum Creek is a public trust, tidally-influenced, brackish tributary of the Neuse River, which in turn flows into Pamlico Sound. The stream is classified as "SC" by the state. The stream provides habitat for the following fish species: Atlantic menhaden, spot, striped mullet, pumpkinseed, gizzard shad, longnose gar, redear sunfish, bluegill, black crappie, largemouth bass, and golden shiner (Fleming and Hightower, 1995; Appendix K.3, Volume IV). Section 7.1 provides a detailed description of both Slocum Creek and Turkey Gut.

7.3.1.1.1 Surrounding Habitat

Five principal plant communities can be distinguished on OU2. The landfill supports Old Field vegetation and Second Growth Loblolly Pine stands. The native soils adjacent to Turkey Gut generally support Mesic Mixed Hardwood Forest on the slopes and Coastal Plain Small Stream Swamp in the wetlands. The

developed portion of the site is characterized by buildings, roads, graveled parking lots, and mowed grass lawns.

A detailed description of the habitats at OU2 is provided in Section 3.0 of the RI Report and in Section 7.1 of this document. Wildlife identified at OU2 is listed in Appendix K.2 (Volume IV).

7.3.1.1.2 Physical Features/Topography

The climate of OU2 is best described as being warm and humid with an average annual temperature of 46°F (winter). Winters are typically short and mild, whereas summers are usually long and hot. The average rainfall is approximately 54.5 inches (SCS, 1989).

OU2 contains three dominant soil types. The developed portion of the site is mapped in the soil survey as "Norfolk-loamy fine sand (2 to 6 percent slopes)." The Norfolk soil is well drained and is on low ridges and side slopes near drainage ways on uplands. This soil type commonly supports urban development. The "Suffolk loamy sand (10 to 30 percent slopes)" soil type is well drained and located on the side slopes adjacent to Slocum Creek. This soil type is not hydric; however, it does contain small wet inclusions at the base of the slope adjacent to the creek. The third dominant soil type is the developed landfill. On OU2, the Suffolk loamy sand contains the most extensive wetlands.

7.3.1.1.3 Sensitive Habitats

A wetland delineation was conducted in April 1995 by B&R Environmental. This delineation identified approximately 6.0 acres of wetlands adjacent to Turkey Gut and Slocum Creek. These wetlands support a Coastal Plain Small Stream Swamp. The wetland habitat on OU2 is described in detail in Section 7.1.4.1

7.3.1.1.4 Threatened and Endangered Species

An intensive threatened and endangered species survey of MCAS Cherry Point was conducted in 1994 by the North Carolina Natural Heritage Program (Appendix K.5), Volume IV. The only threatened or endangered species located near OU2 during the survey was the American alligator which was observed in Slocum Creek.

7.3.1.2 Sampling Locations and Analyses

A summary of the nature and extent of contamination at OU2 is located in Section 4.0 along with a summary of the data. The complete analytical database is presented in Appendix H (Volume II). This ecological risk assessment is based mainly on surface water, sediment, and soil samples. Surface water and sediment samples were collected in 1994, and soil data were collected between 1991 and 1995. Leachate water samples collected in 1995 and groundwater samples collected in 1994 were also utilized in this assessment, albeit to a lesser extent than the other media.

7.3.1.2.1 Surface Water

Four locations were sampled in Turkey Gut (OU2SW3, OU2SW4, OU2SW5, and OU2SW6) during RI field activities in 1994; three locations were selected in Slocum Creek (OU2SW1, OU2SW2, and OU2SW7). Each sample collected was analyzed for the full TCL/TAL. Both filtered and unfiltered samples were collected, but the ERA is based only upon the unfiltered samples. Sample OU2SW5 was the most upstream sample collected from Turkey Gut; therefore, this sample represented background for this stream. Sample OU2SW7 served as the background location for Slocum Creek. The four Turkey Gut locations (OU2SW3 through OU2SW6) were sampled in 1996. The samples were analyzed for chloride to confirm that Turkey Gut is freshwater.

7.3.1.2.2 Leachate Water

Leachate water samples were collected from three sampling locations on OU2 in July 1995. Sample OU2LW01, the only true groundwater outcrop sample, was collected from a spring/seep near the former 10LW01 sample location. Sample OU2LW02 was collected from a pond near the former 10LW02 location. The third sample, OU2LW06, was collected at a new sampling site from a shallow, narrow ponded area approximately 100 feet long. Each sample collected was analyzed for the full TCL, TAL, and cyanide.

7.3.1.2.3 Groundwater

Groundwater samples were collected from sampling sites throughout OU2 in 1994 and 1996. Samples were collected from the surficial aquifer and were analyzed for full TCL, TAL, and cyanide. Groundwater sampling is discussed in further detail in Section 4.0.

7.3.1.2.4 Sediment

Surface water sampling stations in Turkey Gut and Slocum Creek were also used for the collection of sediment samples. Sample OU2SW5 was the sample collected furthest upstream in Turkey Gut; therefore, this sample represented background for this stream. Sample OU2SW7 served as the background location for Slocum Creek.

7.3.1.2.5 Soil

Surface soil samples used in this ERA were collected during three rounds of investigation at OU2 beginning in 1991 and sampling performed in July 1995 and April 1996. The ERA was based only on surface soil samples (i.e., those collected from depths of 2 feet or less). A total of five samples were collected at OU2 in the three initial sampling rounds, but not all were analyzed for each class of contaminants. Samples were only analyzed for metals and volatile organics. Samples taken during July 1995 were analyzed for full TCL organics, TAL metals, and cyanide. Four samples were collected in April 1996. Two were analyzed for dioxins, and two were analyzed for the full TCL organics, TAL metals, and cyanide. Soil sampling activities at OU2 are discussed in greater detail in Section 4.0, and surface soil data used for the ecological risk assessment are presented in Table 4-3.

Background soil samples were collected from several locations throughout the Air Station (Plate 3 and Figure 2-2) during the RFI, TDM, and RI activities. Background soil sampling is discussed in Section 4.0.

7.3.1.3 Assessment and Measurement Endpoints

As discussed in USEPA (September 1994a), one of the major tasks in the Problem Formulation section of an ERA is to identify assessment and measurement endpoints. An assessment endpoint is defined as "an explicit expression of actual environmental values that are to be protected." Measurement endpoints are "measurable responses to a stressor that are related to the valued characteristics chosen as the assessment endpoints (Suter, 1993; USEPA, February 1992)." For this ERA, the most appropriate assessment endpoint is the maintenance of receptor populations that inhabit or utilize OU2. Therefore, the specific objectives of this assessment are to determine whether exposure to chemical contaminants present in the soil, surface water, and sediments at OU2 is likely to result in declines in wildlife receptor populations. Declines in populations could result in a shift in community structure and possible elimination of resident species.

As indicated above, measurement endpoints are related to assessment endpoints, but these endpoints are more easily quantified or observed. In essence, measurement endpoints serve as surrogates for assessment

endpoints. While declines in populations and shifts in community structure can be quantified, studies of this nature are generally time-consuming and difficult to interpret. However, measurement endpoints indicative of reproductive success of individuals are relatively easy to measure and can be related to the assessment endpoint (e.g., decreased reproductive success of individuals results in shifts in population structure, potentially altering the community composition associated with OU2). Therefore, for this ERA, contaminant concentrations unlikely to alter the reproductive success of individuals were selected as measurement endpoints.

7.3.1.4 Conceptual Site Model

This conceptual model (Figure 7-2) is designed to identify potentially exposed receptor populations and applicable exposure pathways, based on the physical nature of the site and the potential contaminant source areas. Actual or potential exposures of ecological receptors associated with OU2 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.

7.3.1.5 Contaminant Sources and Release Mechanisms

There are three sources of contaminants at OU2: (1) a former landfill which accepted municipal garbage and waste from Air Station operations, (2) a former sludge impoundment and sludge application area, and (3) unlined ponds used as aeration basins at the sewage treatment plant. Fire training exercises were conducted in the landfill area south of Turkey Gut.

Chemicals from the identified sources may be released to the surrounding environment primarily through volatilization, wind erosion, and infiltration. Constituents in the site soil may volatilize from surficial material or become airborne via wind erosion. Fugitive dust may also be generated during ground-intrusive activities, such as construction or excavation. These chemicals are dispersed in the surrounding environment and transported off site to downwind locations, where they may re-partition to surface soil, surface water, or sediment through gravitational settling, precipitation, and deposition.

Infiltrating precipitation may cause the contamination of subsurface soil and groundwater. Contaminants disposed of in the unlined ponds, landfill, or sludge application area or burned on the unprotected ground may have solubilized and migrated downward towards water bearing units. Chemicals with a stronger tendency to adsorb to organic matter in soil are expected to migrate at a slower rate. Upon entering the

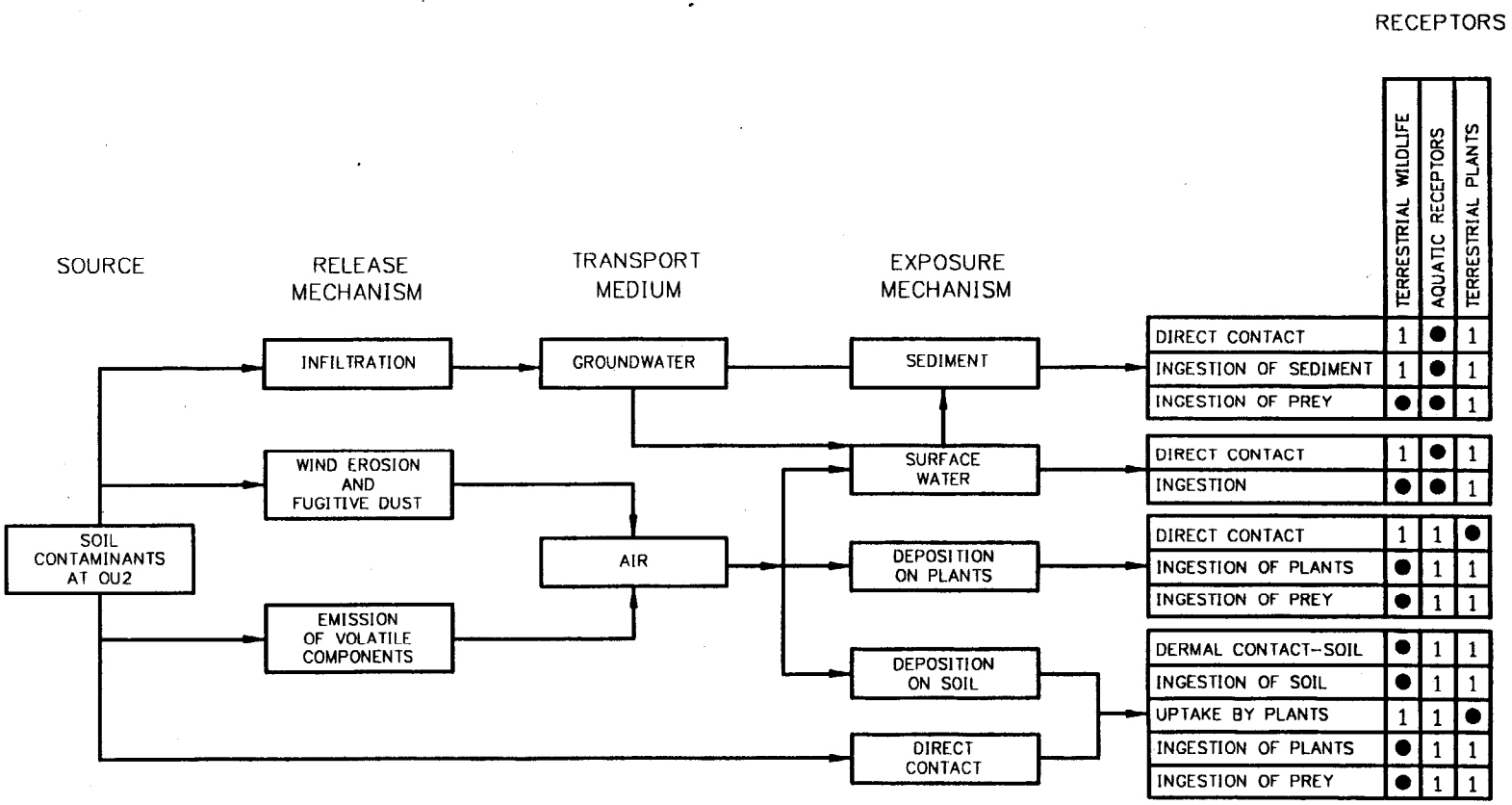

FIGURE 7-2

ECOLOGICAL CONCEPTUAL SITE MODEL
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Halliburton NUS CORPORATION

water column, a chemical is carried with the flow of groundwater to downgradient locations. Groundwater from the site eventually discharges to surface water; contaminants may be subsequently deposited in sediment or they may accumulate in the tissues of aquatic organisms.

7.3.1.6 Exposure Pathways

Based on the nature of the source areas and media-specific transport mechanisms, ecological receptors have the potential to come into direct contact with contaminants present in surface soil and to contaminants transported via groundwater into surface water and sediments (Figure 7-2). Therefore, contaminant concentrations present in these three media will be the focus of this ERA. Ecological receptors are indirectly in contact with contaminants present in groundwater; potential risks associated with these contaminants will be reflected in the evaluation of potential risks associated with surface water contaminants.

Terrestrial receptors associated with OU2 (e.g., terrestrial plants and animals) may be exposed to soil contaminants via incidental ingestion of soil, uptake of contaminants through roots, and ingestion of contaminated food items. Terrestrial receptors may also come into contact with contaminants present in Turkey Gut by using this small freshwater stream as a source of drinking water. Exposure to contaminants present in Slocum Creek via this pathway was considered unlikely due to its brackish nature (Section 7.1). Exposure to contaminants present in the soil via dermal contact may occur but is likely to represent a minor pathway because fur, feathers, and chitinous exoskeletons minimize transfer of contaminants across dermal tissue. Although volatile chemicals have been detected in soil samples collected from this site, inhalation was not considered to represent a significant exposure pathway because air concentrations were likely to be minor. In addition, few burrowing animals are found in this portion of North Carolina, limiting the possibility that these types of animals might encounter elevated concentrations of these contaminants present in subsurface soils.

Aquatic organisms inhabiting Slocum Creek and Turkey Gut may be exposed to contaminants via direct contact with surface water and sediments, ingestion of surface water and sediments, and consumption of contaminated prey. It is unlikely that aquatic receptors are present in significant numbers in leachate water/ponded areas since these areas, although numerous, are small and ephemeral.

7.3.2 Preliminary Exposure Assessment and Risk Characterization

As identified by USEPA (September 1994a), the second step in the ecological risk assessment project compares the maximum likely environmental exposure levels with contaminant concentrations that are protective of ecological receptors. Once this step is completed, the results of this study will be reviewed

to determine whether a) little or no risk is associated with OU2 or b) additional information must be generated to verify that ecological receptors are at risk.

7.3.2.1 Exposure Estimation

The major objective of the ERA is to estimate chemical concentrations to which ecological receptors inhabiting OU2 or adjoining areas impacted by OU2-related contaminants might be exposed. Exposures can be quantified as either an exposure point concentration (e.g., a medium-specific concentration of contaminant that may be encountered by an ecological receptor) or an intake dose. Exposure point concentrations were developed for aquatic organisms and terrestrial biota. Intake doses (mass of contaminant taken in by a receptor per unit body weight per unit time) were also determined for terrestrial fauna. Dose estimates were based on food consumption, incidental ingestion of soil, and ingestion of drinking water.

7.3.2.1.1 Surface Water and Sediment Exposure Point Concentrations

As discussed in Section 7.3.2, risks to aquatic receptors from surface water and sediment were determined using data from four sample locations in Turkey Gut (OU2SW3, OU2SW4, OU2SW5, and OU2SW6) and three locations in Slocum Creek (OU2SW1, OU2SW2, and OU2SW7).

Sample OU2SW5, collected from Turkey Gut upstream from OU2, represented background sediment and surface water for this stream. Exposure estimates for aquatic receptors in Turkey Gut were based on the maximum contaminant concentrations detected in sediment and surface water in samples OU2SW3, OU2SW4, and OU2SW6 (Tables 7-1 and 7-2).

Sample OU2SW7 served as the background location for sediment and surface water samples collected from Slocum Creek. Exposure estimates for aquatic receptors in Slocum Creek were based on the maximum concentration for each surface water and sediment contaminant detected in samples OU2SW1 and OU2SW2 (Tables 7-3 and 7-4).

7.3.2.1.2 Leachate Water and Groundwater Exposure Point Concentrations

Leachate samples OU2LW02 and OU2LW06 were used for drinking water exposure point concentrations for terrestrial receptors. Sample OU2LW01 was not used for this pathway since it is located adjacent to Slocum Creek. This sampling location is frequently inundated with water from Slocum Creek. Therefore, contaminants from the seep will be accounted for in Slocum Creek surface water risk characterization.

TABLE 7-1

SELECTION OF SURFACE WATER CONTAMINANTS OF CONCERN
TURKEY GUT
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Frequency of Detection	Background Concentration (µg/L)	Maximum Concentration (µg/L)	Chronic[1] Screening Value (µg/L)	Hazard Quotient	Reason for Elimination as Contaminant of Potential Concern
1,1-Dichloroethane	1/3	< DL	2.00E+00	8.10E-01	2.50E+00	
1,4-Dichlorobenzene	1/3	< DL	2.00E+00	1.12E+01	1.79E-01	Does not exceed criteria
Benzene	1/3	< DL	1.00E+00	5.30E+01	1.89E-02	Does not exceed criteria
Chlorobenzene	1/3	< DL	1.00E+01	1.95E+02	5.13E-04	Does not exceed criteria
Chloroethane	1/3	< DL	3.00E+00	NB		
Cis-1,2-Dichloroethane	1/3	< DL	1.00E+00	2.00E+03	5.00E-04	Does not exceed criteria
Vinyl Chloride	1/3	< DL	1.00E+00	8.78E+01	1.14E-02	Does not exceed criteria
Bis(2-ethylhexyl)phthalate	2/3	< DL	6.00E+00	3.22E+01	1.86E-01	Does not exceed criteria
4,4'-DDD	1/3	< DL	2.80E-02	6.40E-03	4.38E+00	
gamma-BHC (Lindane)	2/3	< DL	8.10E-03	8.00E-02	1.01E-01	Does not exceed criteria
Heptachlor Epoxide	1/3	< DL	1.90E-03	3.80E-03	5.00E-01	Does not exceed criteria
Aluminum	2/3	1.01E+03	1.02E+02	NA		Does not exceed 2X background
Arsenic	1/3	< DL	2.95E+00	1.90E+02	1.58E-02	Does not exceed criteria
Barium	3/3	9.00E+01	5.60E+01	NA		Does not exceed 2X background
Manganese	3/3	1.05E+02	4.58E+02	8.03E+01	5.70E+00	

NB = No Benchmark
NA = Not Applicable
< DL = Less than detection limit
1 = See Table 7-8

TABLE 7-2

SELECTION OF SEDIMENT CONTAMINANTS OF CONCERN
TURKEY GUT
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Frequency of Detection	Background Concentration (µg/kg)	Maximum Concentration (µg/kg)	Sediment[1] Screening Value (µg/kg)	Hazard Quotient	Reason for Elimination as Contaminant of Potential Concern
Di-n-butylphthalate	3/3	6.40E+02	5.00E+02	2.92E+03	1.71E-01	Does not exceed criteria
4,4'-DDD	2/3	4.50E-01	3.40E+00	4.83E+04	7.04E-05	Does not exceed criteria
4,4'-DDE	2/3	1.40E+00	7.85E-01	4.95E+01	1.59E-02	Does not exceed criteria
alpha-Chlordane	3/3	5.70E-01	2.50E+01	1.70E+00	1.47E+01	
Dieldrin	3/3	< DL	2.20E+01	3.30E+00	6.67E+00	
gamma-Chlordane	3/3	2.80E+00	8.80E+00	1.70E+00	5.18E+00	
Heptachlor	2/3	< DL	1.50E-01	7.70E+00	1.95E-02	Does not exceed criteria
Heptachlor Epoxide	1/3	< DL	1.60E+01	7.70E+00	2.08E+00	
Aluminum	3/3	9.03E+03	1.11E+04	NA		Does not exceed 2X background
Arsenic	3/3	< DL	3.70E+00	8.00E+03	4.63E-04	Does not exceed criteria
Barium	3/3	3.61E+01	2.68E+01	NA		Does not exceed 2X background
Chromium	3/3	5.55E+00	1.75E+01	3.30E+04	5.30E-04	Does not exceed criteria
Copper	2/3	< DL	5.50E+01	2.80E+04	1.96E-03	Does not exceed criteria
Lead	3/3	1.33E+01	2.88E+01	2.10E+04	1.37E-03	Does not exceed criteria
Manganese	3/3	6.40E+00	9.74E+01	3.00E+05	3.25E-04	Does not exceed criteria
Mercury	1/3	1.70E-01	1.00E-01	NA		Does not exceed 2X background
Vanadium	3/3	9.30E+00	3.14E+01	NB		
Zinc	3/3	6.80E+00	2.74E+01	6.80E+04	4.03E-04	Does not exceed criteria

NB = No Benchmark
NA = Not Applicable
< DL = Less than detection limit
1 See Table 7-9

TABLE 7-3

SELECTION OF SURFACE WATER CONTAMINANTS OF CONCERN
SLOCUM CREEK
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Frequency of Detection	Background Concentration (µg/L)	Maximum Concentration (µg/L)	Chronic[1] Screening Value (µg/L)	Hazard Quotient	Reason for Elimination as Contaminant of Potential Concern
Chloroform	2/2	1.00E+00	1.00E+00	8.15E+02	1.23E-03	Does not exceed criteria
Cis-1,2-dichloroethane	2/2	1.00E+00	2.00E+00	1.13E+03	1.77E-03	Does not exceed criteria
4,4'-DDD	2/2	3.40E-02	3.90E-02	2.50E-02	1.56E+00	
Barium	2/2	3.70E+01	6.00E+01	NA		Does not exceed 2X background
Manganese	2/2	3.50E+02	4.32E+02	NA		Does not exceed 2X background

NA = Not Applicable
1 = See Table 7-8

TABLE 7-4

SELECTION OF SEDIMENT CONTAMINANTS OF CONCERN
SLOCUM CREEK
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Frequency of Detection	Background Concentration (µg/kg)	Maximum Concentration (µg/kg)	Sediment[1] Screening Value (µg/kg)	Hazard Quotient	Reason for Elimination as Contaminant of Potential Concern
2-Butanone	1/2	< DL	1.30E+01	9.64E+02	1.35E-02	Does not exceed criteria
Di-n-butylphthalate	2/2	3.00E+02	8.00E+02	1.06E+03	7.55E-01	Does not exceed criteria
4,4'-DDD	1/2	< DL	2.70E+00	1.93E+01	1.40E-01	Does not exceed criteria
Aluminum	2/2	8.76E+03	1.10E+03	NA		Does not exceed 2X background
Arsenic	1/2	3.60E+00	1.80E+00	NA		Does not exceed 2X background
Barium	2/2	3.58E+01	4.60E+00	NA		Does not exceed 2X background
Chromium	1/2	5.75E+01	6.00E+00	NA		Does not exceed 2X background
Lead	1/2	3.77E+01	8.70E+00	NA		Does not exceed 2X background
Manganese	2/2	3.94E+02	1.18E+02	NA		Does not exceed 2X background
Zinc	2/2	1.13E+02	2.25E+01	NA		Does not exceed 2X background

NA = Not Applicable
< DL = Less than detection limit
1 = See Table 7-9

Groundwater contaminant concentrations were only analyzed qualitatively. Several organic compounds, mainly volatile organics, were present in groundwater samples but were not found in leachate water sample OU2-LW01. Furthermore, the concentration of several inorganics were higher in groundwater samples than this leachate water sample. This suggests that the contaminant plume may have not fully reached surface water on OU2 (Slocum Creek), or may not fully outcrop to surface water. Since receptors are not in direct contact with groundwater, and since groundwater contaminant concentrations will be diluted upon impingement to surface water, risks to aquatic receptors from groundwater cannot be fully characterized. As stated in Section 7.3.1.6, groundwater contaminants that have reached surface water, Turkey Gut or Slocum Creek, should be accounted for in surface water risk characterization. However, future impingement of the groundwater plume to surface water and migration of more compounds to Turkey Gut and Slocum Creek are possible. Results and detailed discussions of leachate water and groundwater sampling are presented in Section 4.0.

7.3.2.1.3 Soil Exposure Point Concentrations

The ecological risk assessment was based only on surface soil samples (2 feet or less) collected from OU2. Five samples were collected at OU2 during the initial three rounds of sampling, but not all were analyzed for each class of contaminants. Five samples were analyzed for inorganic contaminants, and three samples were analyzed for volatile organic contaminants. During July 1995, thirteen samples taken throughout OU2 were analyzed for TCL/TAL and cyanide. During April 1996, four samples were collected. Two of these were analyzed for TCL/TAL and cyanide, and two were analyzed for dioxins. Soil sampling activities at OU2 are discussed in greater detail in Section 4.0, and surface soil data used for the ecological risk assessment are presented in Table 4-3 and summarized in Table 7-5. Exposure concentrations used to initially screen the potential risk to ecological receptors were based on the maximum concentration for each surface soil contaminant detected in samples collected from OU2. These maximums, along with the mean soil contaminant concentrations, were also used in the models that estimated contaminant dose received by terrestrial fauna via ingestion of food and soil. All surface soil data presented in Table 4-3 were used in the ERA except for the food-chain modeling. The food chain models were run in 1995. Based on a review of the 1996 data, the results from this modeling would not change significantly. Mean soil contaminant concentrations are presented in Appendix K.7.

Background soil samples were collected from several locations throughout the Air Station during the RFI, TDM, and RI activities. Background soil sampling is discussed in Section 4.0.

TABLE 7-5

SELECTION OF SOIL CONTAMINANTS OF CONCERN
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Frequency of Detection	Average Background Concentration (μg/kg)	Maximum Concentration (μg/kg)	Screening Value[1] (μg/kg)	Hazard Quotient	Reason for Elimination
Aluminum	18/18	5.08E+06	1.30E+07	1.01E+07	1.29E+00	
Antimony	4/18	< DL	3.60E+03	1.00E+04	3.60E-01	Does not exceed criteria
Arsenic	20/20	2.94E+03	1.71E+04	3.00E+04	5.70E-01	Does not exceed criteria
Barium	20/20	1.20E+04	1.03E+05	5.00E+05	2.06E-01	Does not exceed criteria
Beryllium	1/20	4.15E+02	2.80E+02	NA		Does not exceed 2x background
Cadmium	8/20	1.35E+03	6.40E+03	5.00E+03	1.28E+01	
Chromium	20/20	8.85E+03	5.12E+04	2.50E+05	2.05E-01	Does not exceed criteria
Cobalt	13/20	2.61E+03	1.60E+03	NA		Does not exceed 2x background
Copper	19/20	2.81E+03	5.08E+04	1.00E+05	5.08E-01	Does not exceed criteria
Lead	18/20	5.41E+03	7.65E+04	2.00E+05	3.83E-01	Does not exceed criteria
Manganese	18/18	8.75E+03	2.11E+05	1.50E+06	1.41E-01	Does not exceed criteria
Mercury	10/18	1.93E+02	1.00E+03	2.50E+03	4.00E-01	Does not exceed criteria
Nickel	15/20	7.50E+03	5.40E+03	NA		Does not exceed 2x background
Selenium	6/20	5.48E+02	3.10E+03	3.00E+03	1.03E+00	
Silver	3/20	1.69E+03	3.70E+03	1.00E+04	3.70E-01	Does not exceed criteria
Thallium	3/20	4.80E-01	6.70E+03	6.30E+03	1.06E+00	
Vanadium	20/20	9.58E+03	2.42E+04	2.00E+05	1.32E-01	Does not exceed criteria
Zinc	19/20	6.49E+03	2.09E+05	2.50E+05	8.36E-01	Does not exceed criteria

TABLE 7-5 (Continued)
SELECTION OF SOIL CONTAMINANTS OF CONCERN
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Frequency of Detection	Average Background Concentration (µg/kg)	Maximum Concentration (µg/kg)	Screening Value[1] (µg/kg)	Hazard Quotient	Reason for Elimination
1,2-Dichloroethene	1/18	< DL	2.00E+01	7.00E+05	2.86E-05	Does not exceed criteria
2,4-Dinitrophenol	1/18	< DL	8.50E+02	2.00E+04	4.25E-02	Does not exceed criteria
4-Nitrophenol	1/18	< DL	8.50E+02	3.80E+02	2.24E+00	
Methylene chloride	1/18	4.00E+00	1.20E+01	8.80E+03	1.35E-03	Does not exceed criteria
Toluene	2/18	9.25E+00	4.20E+01	1.50E+03	2.80E-02	Does not exceed criteria
Xylene	6/18	1.93E+01	1.10E+01	1.60E+08	6.80E-01	Does not exceed criteria
Benzo(a)anthracene	1/15	< DL	1.60E+02	1.00E+03	1.60E-01	Does not exceed criteria
Benzo(a)pyrene	1/15	< DL	2.40E+02	1.00E+03	2.40E-01	Does not exceed criteria
Benzo(b)fluoranthene	1/15	< DL	1.70E+02	1.00E+03	1.70E-01	Does not exceed criteria
Benzo(g,h,i)perylene	1/15	< DL	2.50E+02	1.00E+03	2.50E-01	Does not exceed criteria
Benzo(k)fluoranthene	1/15	< DL	1.60E+02	1.00E+03	1.60E-01	Does not exceed criteria
Chrysene	1/15	< DL	2.20E+02	1.00E+03	2.20E-01	Does not exceed criteria
Di-n-octylphthalate	2/15	2.04E+02	1.90E+02	2.76E+03	6.88E-02	Does not exceed criteria
Fluoranthene	1/15	< DL	2.70E+02	1.00E+04	2.70E-02	Does not exceed criteria
Indeno(1,2,3-cd)pyrene	1/15	< DL	1.40E+02	1.00E+03	1.40E-01	Does not exceed criteria
Pyrene	1/15	< DL	3.60E+02	5.00E+03	7.20E-02	Does not exceed criteria
4,4'-DDD	2/15	2.14E+00	4.30E+01	1.00E+02	4.30E-01	Does not exceed criteria
4,4'-DDE	6/15	6.25E-01	6.90E+01	1.00E+02	6.90E-01	Does not exceed criteria
4,4'-DDT	7/15	5.10E-01	3.50E+01	1.00E+02	3.50E-01	Does not exceed criteria

TABLE 7-5 (Continued)
SELECTION OF SOIL CONTAMINANTS OF CONCERN
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Frequency of Detection	Average Background Concentration (µg/kg)	Maximum Concentration (µg/kg)	Screening Value[1] (µg/kg)	Hazard Quotient	Reason for Elimination
alpha-Chlordane	7/15	1.45E+00	2.70E+01	4.90E+02	5.50E-02	Does not exceed criteria
Aroclor-1254	2/15	< DL	3.10E+01	5.00E+02	6.20E-02	Does not exceed criteria
Aroclor-1260	1/15	< DL	6.30E+02	5.00E+02	1.26E+00	
Dieldrin	4/14	1.10E+00	2.00E+01	4.00E+01	5.00E-01	Does not exceed criteria
Endosulfan I	1/15	4.30E-01	7.60E+00	4.07E+03	1.87E-03	Does not exceed criteria
Endrin aldehyde	6/14	< DL	2.70E+01	5.60E+02	4.82E-02	Does not exceed criteria
Heptachlor	1/15	4.50E-02	2.00E+00	5.00E+01	4.00E-02	Does not exceed criteria
gamma-Chlordane	2/15	1.19E+00	2.90E+01	4.90E+02	5.92E-02	Does not exceed criteria
OCDD	2/2	NA	1.01E+00	4.00E+00	2.53E-01	Does not exceed criteria
Total HpCDF	1/2	NA	2.65E-02	4.00E-01	6.63E-2	Does not exceed criteria

NA = Not Available; Not Analyzed
< DL = Less than detection limit
[1]See Table 7-10

7.3.2.2 Dose Calculations

As discussed above, the potential impact to ecological receptors resulting from exposure to OU2 contaminants will be evaluated by calculating exposure point concentrations and by estimating the total dose that organisms inhabiting this site might receive. For OU2, receptors include aquatic biota (e.g., fish, invertebrates, plants) inhabiting Slocum Creek and Turkey Gut, terrestrial biota, plants, and invertebrates.

Representative species were selected to calculate the potential dose received by birds and mammals inhabiting OU2. Calculated doses were then compared to toxicological endpoints (e.g., laboratory derived toxicity data) in order to access potential risks to these organisms. While dose calculations can also be performed for other species (e.g., plants, reptiles, amphibians, fish, soil invertebrates), toxicological data with which to compare these calculated doses are limited. Instead, potential risks to these receptors were identified by comparing exposure point contaminant concentrations to benchmark values protective of ecological receptors (see Section 7.3.2.3).

Criteria considered in the selection of representative terrestrial species used in the dose calculation models included the relationship of the representative species to species or guilds associated with the site, consistency of potential exposure scenarios with the species or functional groups being evaluated, and the probability that these representative species might be maximally exposed to site contaminants. The eastern cottontail rabbit, red fox, and red-tailed hawk were selected as representative species for the terrestrial receptors inhabiting OU2.

Eastern cottontail rabbit (*Sylvilagus floridanus*)

The eastern cottontail rabbit, a small herbivore commonly found at MCAS Cherry Point, was selected as a representative species to represent other small herbivorous mammals associated with OU2 due to its constant contact with the ground and its importance as a prey species. The eastern cottontail rabbit prefers a mix of vegetation types (Webster et al., 1985) and would be expected to incidentally ingest soil along with herbaceous plants. This species' home range is relatively small, as little as 0.8 ha (USEPA, 1993b). As a result, it may spend most, if not all, of its lifetime on or near areas of localized contamination. In addition, the eastern cottontail is known to constitute a large portion of the carnivore prey base and is a common food source for foxes and hawks (Webster et al., 1985); both predators are known to use the site. Receptor-specific parameters used to calculate total potential dose are summarized in Table 7-6.

Species other than the cottontail rabbit were under consideration to represent this guild. The short-tailed shrew was given consideration, but it is one of only a few species of terrestrial small mammals in the area

TABLE 7-6

PARAMETERS FOR ECOLOGICAL RECEPTORS
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Receptor	Guild	Parameter	Value	Reference
Eastern cottontail rabbit (*Sylvilagus floridanus*)	Herbivore	Body Weight	1,134 grams	Chapman and Morgan (1973)
		Skin Surface	1,254 cm^2	estimated from Stahl (1967)
		Water Ingestion	110.0 grams/day	Estimated from Calder and Braun (1983)
		Food Ingestion	95.9 grams/day	estimated from Nagy (1987)
		Soil Ingestion	6.3% of diet	based on jackrabbit diet (USEPA, 1993b)
		Inhalation Rate	0.63 m^3/day	estimated from Stahl (1967)
		Home range	7.8 ha	Althoff and Storm (1989)
Red fox (*Vulpes vulpes*)	Carnivore	Body Weight	4,820 grams	Storm et al. (1976)
		Skin Surface	3,220 cm^2	estimated from Stahl (1967)
		Water Ingestion	404.9 grams/day	Estimated from Calder and Braun (1983)
		Food Ingestion	361.5 grams/day	Sargeant (1978)
		Soil ingestion	2.8% of diet	USEPA (1993b)
		Inhalation Rate	2.0 m^3/day	estimated from Stahl (1967)
		Home range	1,967 ha	USEPA (1993b)
Red-tailed hawk (*Buteo jamaicensis*)	Carnivore	Body Weight	1,154 grams	Steenhof (1983)
		Skin Surface	1,021 cm^2	estimated from Walsberg and King (1978)
		Water Ingestion	64.9 grams/day	Estimated from Calder and Braun (1983)
		Food Ingestion	115.4 grams/day	Craighead and Craighead (1956)
		Soil ingestion	2% of diet	lowest value for avian species (USEPA, 1993b)
		Inhalation Rate	0.42 m^3/day	estimated from Lasiewski and Calder (1971)
		Home range	60 - 160 ha	Fitch et al. (1946)

to occasionally burrow (in contaminated soil), and the species prefers wooded areas, which are limited at MCAS Cherry Point (Webster et al., 1985). The white-footed mouse was also considered, but it may spend large amounts of time above ground, limiting its contact with contaminated soil or forage (Webster et al., 1985). Hence, the rabbit, rather than these two species, was selected to represent primary consumers associated with OU2.

Red fox (Vulpes vulpes)

The red fox was chosen as a representative mammalian predator because it is common in eastern North Carolina and has been observed on MCAS Cherry Point (during site investigations). It is one of only a few mid-size carnivorous mammals in the region, and its ecology resembles that of similar species. Receptor-specific parameters used in dose calculations for this species are summarized in Table 7-6. Like the eastern cottontail, the red fox prefers several different vegetated habitats and edge areas (USEPA, 1993b) which can be found on MCAS Cherry Point. Eastern cottontails are known to be an important food source for the red fox, and the carnivore is considered to be quite effective in the control of small mammal populations (Webster et al., 1985). As a result, the red fox plays a vital role in the food chain.

Red-tailed Hawk (Buteo jamaicensis)

The red-tailed hawk was selected as an ecological receptor because it is a common avian predator at MCAS Cherry Point (pers. comm., Abernethy). It is known to inhabit a variety of habitats, such as old fields, wetlands, and pastures (USEPA, 1993b). These areas can be found at MCAS Cherry Point. Eastern cottontail rabbits, common at MCAS Cherry Point, are a frequent food source for the red-tailed hawk, as are other small mammals (USEPA, 1993b). Therefore, the red-tailed hawk fills a crucial niche in the local ecology, and its habits are generally indicative of similar avian predators. It is also probable that this species will exhibit a differing degree of sensitivity to contamination than will the two representative mammalian receptors selected for this ERA. Physical and physiological parameters used in calculating the total dose of contaminants potentially received by the red-tailed hawk are summarized in Table 7-6.

7.3.2.2.1 Estimating Chemical Concentrations in Vegetation to Calculate Dose

The concentration of a chemical in vegetation is a function of both aerial deposition on the plant surfaces and the root uptake of chemicals from soil. Airborne contamination was not considered to be a factor at OU2. Therefore, the maximum concentration of chemical measured in soil were used to estimate plant contaminant concentrations.

The concentration of a chemical in vegetation due to root uptake is a function of the soil concentration and a chemical-specific soil-to-plant biotransfer factor (partitioning coefficient). Methods developed by the California Air Pollution Control Officers Association (CAPCOA, 1993) were adapted to calculate uptake of contamination by plants from soil. Vegetative contaminant concentrations predicted using these models were chosen to represent potential contaminants present in the food items of OU2 herbivores (e.g., herbaceous material consumed by the eastern cottontail rabbit).

7.3.2.2.2 Estimating Chemical Concentrations in Herbivores to Calculate Dose

For the purposes of this ERA, contaminant concentrations present in herbivore tissue were based on calculations that considered all appropriate exposure pathways, including ingestion of contaminants present in vegetation. Biotransfer factors (Fa) for organics were estimated as follows (Travis and Arms, 1988):

$$\log Fa = -7.6 + \log K_{ow}$$

where:

K_{ow} = octanol-water partition coefficient.

For metals, Fa was taken from Baes et al. (1984).

It was conservatively assumed that the red fox and red-tailed hawk fed exclusively on herbivores (rabbit) from this area. These predicted tissue concentrations, therefore, served to assess potential exposure of these predators to contaminants via ingestion of prey items.

7.3.2.2.3 Calculating Dose Received from the Ingestion of Prey

Transport of contaminants through the food chain to terrestrial ecological receptors is a potential concern at this facility. It was conservatively assumed that all ingested contaminants were absorbed (absorption fraction = 1.0). The equation used to estimate contaminant intake from ingestion of contaminated food items are as follows:

$$PD_{\text{ingestion of prey}} = (PC_{prey} * F * FA * FI * AF)/(WR * CF)$$
$$PD_{\text{ingestion of vegetation}} = (PC_{vegetation} * F * FV * FI * AF)/(WR * CF)$$

where:

PD = predicted dose from ingestion of food items (prey or vegetation; mg/kg/day)

PC = predicted contaminant concentration (vegetation or prey; mg/kg)

F = food consumed (mg/day)

FA = animals as a percentage of diet

FV = vegetation as a percentage of diet

FI = fractional intake (% of home range that overlaps impacted area; assumed to equal 100%)

AF = absorption fraction (unitless)

WR = weight of receptor (kg)

CF = conversion factor (kg to mg)

7.3.2.2.4 Calculating Dose Received from the Ingestion of Soil

The estimation of intake of contaminants in soil (both intentional and incidental) was determined using the maximum measured soil concentration of a given contaminant. Intestinal absorption (AF) was also conservatively assumed to equal 100 percent. Daily intake of contaminants as a result of ingestion of soil was determined using the following equation:

$$PD_{\text{ingestion of soil}} = (PC_{soil} * FI * SA * AF * F)/(WR * CF)$$

where:

PD = predicted dose from ingestion of soil (mg/kg/day)

PC = predicted contaminant concentration in soil (mg/kg)

FI = fractional intake (% of home range that overlaps impacted area; assumed to equal 100%)

SA = percent of diet that equals soil

AF = absorption fraction (unitless)

F = food consumed (mg/kg)

WR = body weight (kg)

CF = conversion factor (kg to mg)

7.3.2.2.5 Calculating Dose Received from the Ingestion of Water

Consumption of surface water contaminated with OU2-related contaminants is only applicable to terrestrial vertebrate receptors drinking water from Turkey Gut and leachate/ponded water. Slocum Creek was considered to be too brackish to serve as a source of drinking water. All terrestrial receptors are assumed to use Turkey Gut and/or leachate/ponded water for drinking purposes. The maximum concentrations from these areas combined were used in dose estimation. The number of positive sample hits for most contaminants in water were too low to calculate mean concentrations in drinking water for the mean

exposure scenario. Surface water contaminant concentrations used for drinking waster exposure are summarized in Table 7-7. Absorption of contaminants was assumed to equal 1.0 (e.g., 100%). The equation for drinking water ingestion is as follows:

$$PD_{\text{water ingestion}} = (PC_{water} * FI * AF * WI)/(WR * CF)$$

where:

PD = predicted dose from drinking water ingestion (mg/kg/day)

PC = concentration of a contaminant in water (mg/L = mg/kg)

FI = fractional intake (% of home range that overlaps impacted area; assumed to equal 100%)

WI = water intake (L/day = mg/day)

AF = absorption fraction (unitless)

WR = weight of receptor (kg)

CF = conversion factor (kg to mg)

7.3.2.3 Risk Characterization

In this ERA, Benchmark Toxicity Values (BTVs) were selected to screen exposure point concentrations detected in soil, surface water, and sediment to determine if they qualify as contaminants of potential concern (COPCs) with regard to ecological receptors. Final contaminants of concern were identified following two methods. In addition to exposure point concentrations, the potential concentrations of contaminants taken in by receptor organisms (e.g., dose) from maximum and mean concentration exposure scenarios were compared to concentrations protective of these organisms (RfD). Methods for benchmark selection for each media and potential receptor are described below.

7.3.2.3.1 Derivation of Surface Water BTVs

Actual exposures of MCAS Cherry Point aquatic receptors to COPCs are assumed to be primarily chronic (long-term) exposures, usually at sublethal concentrations. For this ERA, benchmark values used to identify surface water COPCs were either chronic screening levels for surface water provided by USEPA Region IV or surrogate chronic benchmark values estimated from available toxicity data (Table 7-8). Benchmark values for freshwater were used to evaluate Turkey Gut; saltwater values were incorporated for Slocum Creek.

While BTVs provided by USEPA Region IV were preferentially used in this ERA, a number of contaminants were present in surface water samples collected from both Turkey Gut and Slocum Creek for which no BTVs had been provided. For 1,1-dichloroethane, a risk-based screening value provided by USEPA Region III

TABLE 7-7
MAXIMUM SURFACE WATER CONTAMINANT CONCENTRATIONS
DRINKING WATER EXPOSURE
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Maximum Concentration (μg/L)	Source of Maximum Concentration[1,2]
Aluminum	495.0	Ponded Water
Arsenic	3.6	Ponded Water
Barium	56.0	Turkey Gut
Cadmium	3.1	Ponded Water
Chromium	5.0	Ponded Water
Copper	9.3	Ponded Water
Lead	5.3	Ponded Water
Manganese	458.0	Turkey Gut
Nickel	1.2	Ponded Water
Selenium	3.6	Ponded Water
Thallium	2.9	Ponded Water
Vanadium	2.3	Ponded Water
Zinc	58.2	Ponded Water
1,1-Dichloroethane	2.0	Turkey Gut
1,4-Dichlorobenzene	2.0	Turkey Gut
Benzene	1.0	Turkey Gut
Bis(2-ethylhexyl)phthalate	6.0	Turkey Gut
Chlorobenzene	10.0	Turkey Gut
Chloroethane	3.0	Turkey Gut
Cis-1,2-dichloroethene	1.0	Turkey Gut
Vinyl Chloride	1.0	Turkey Gut
Xylene	2.0	Ponded Water
4,4'-DDD	0.028	Turkey Gut
4,4'-DDT	0.29	Ponded Water
Aldrin	0.10	Ponded Water
Dieldrin	0.26	Ponded Water

TABLE 7-7
MAXIMUM SURFACE WATER CONTAMINANT CONCENTRATIONS
DRINKING WATER EXPOSURE
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Maximum Concentration (μg/L)	Source of Maximum Concentration[1,2]
Endrin	0.10	Ponded Water
gamma-BHC (Lindane)	0.12	Ponded Water
Heptachlor	0.13	Ponded Water
Heptachlor epoxide	0.0019	Turkey Gut

[1]See Table 7-1
[2]From leachate/seep water samples OU2-LW02 and OU2-LW06

TABLE 7-8

SURFACE WATER SCREENING VALUES
SLOCUM CREEK AND TURKEY GUT
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Stream	Chronic Screening Value (μg/L)	Source
1,1-Dichloroethane	Turkey Gut	8.10E-01	USEPA Region III risk-based screening value for freshwater
1,4-Dichlorobenzene	Turkey Gut	1.12E+01	USEPA Region IV chronic screening value for freshwater
Benzene	Turkey Gut	5.30E+01	USEPA Region IV chronic screening value for freshwater
Chlorobenzene	Turkey Gut	1.95E+02	USEPA Region IV chronic screening value for freshwater
Chloroethane	Turkey Gut	NA	No benchmark available
Chloroform	Slocum Creek	8.15E+02	USEPA Region IV chronic screening value for saltwater
Cis-1,2-dichloroethene	Slocum Creek	1.13E+03	USEPA Region IV chronic screening value for saltwater
	Turkey Gut	2.00E+03	USEPA Region IV chronic screening value for freshwater
Vinyl chloride	Turkey Gut	8.78E+01	Suter and Mabrey (1994)
Bis(2-ethylhexyl)phthalate	Turkey Gut	3.22E+01	Suter and Mabrey (1994)
4,4'-DDD	Slocum Creek	2.50E-02	USEPA Region IV chronic screening value for saltwater
	Turkey Gut	6.40E-03	USEPA Region IV chronic screening value for freshwater
gamma-BHC (Lindane)	Turkey Gut	8.00E-02	USEPA Region IV chronic screening value for freshwater
Heptachlor epoxide	Turkey Gut	3.80E-03	USEPA Region IV chronic screening value for freshwater
Arsenic	Turkey Gut	1.90E+02	USEPA Region IV chronic screening value for freshwater
Manganese	Turkey Gut	8.03E+01	Suter and Mabrey (1994)

(USEPA Region III, 1994) was used. For vinyl chloride, bis(2-ethylhexyl) phthalate, and manganese, benchmark valves provided by Oak Ridge National Laboratory (Suter and Mabry, 1994) were used.

7.3.2.3.2 Derivation of Sediment BTVs

Unlike surface waters, national criteria have yet to be established for contaminants in sediments. The current lack of sediment criteria is largely a function of the difficulties associated with identifying biologically available concentrations of sediment contaminants. Adverse impacts associated with contaminated sediments are primarily related to the concentration of contaminant in interstitial (e.g., pore) water. The adsorption/desorption of contaminants from sediment particles into interstitial water is governed by complex, interrelated chemical and physical processes. Models have been developed to predict the concentration of nonpolar organic contaminants that may be dissolved into interstitial water and therefore become biologically available. However, no equivalent, widely-accepted models currently exist for predicting the partitioning of metals or polar organics between water and sediment particles. As a result of these factors, separate approaches were used to identify sediment benchmarks in this ERA.

Sediment screening values provided by USEPA Region IV served as benchmark values for a number of potential organic and inorganic sediment contaminants (Table 7-9). USEPA Region IV screening values consist of laboratory practical quantification limits, as well as effects values reported in Long and Morgan (1991), MacDonald (1993), and Long et al. (1995). Long and Morgan (1991) and Long et al. (1995) developed "apparent effects" data sets for various sediment toxicants by compiling biological effects data (e.g., reductions in benthic populations associated with the presence of a contaminant) for a specific toxicant. These data were then placed in ascending order (toxicant concentration producing no effect to toxicant concentration producing the greatest effect) and the 10th and 50th percentile of these ordered data were identified. The 10th and 50th percentiles were defined as the "Effects Range-Low" (ER-L) and the "Effects Range-Median" (ER-M), respectively, for each chemical considered. Although the apparent effects database is founded predominantly on the effects of toxic materials on marine organisms, ER-L and ER-M values have been adopted by various agencies (e.g., National Oceanic and Atmospheric Administration) as appropriate screening criteria for marine, estuarine, and freshwater sediments.

USEPA Region IV screening values have not been derived for several contaminants measured in sediment samples. For a number of nonpolar inorganic contaminants, equilibrium partitioning (EP) models were used to convert surface water benchmarks to benchmarks appropriate for sediment. This was the case for 4,4'DDD, 4,4'-DDE, heptachlor, heptachlor epoxide, di-n-butylphthalate, and 2-butanone. As noted above, EP models have been developed to predict biologically available concentrations of nonpolar organic sediment contaminants. As described in detail in USEPA (1993a), biological availability of nonpolar organic

TABLE 7-9

SEDIMENT SCREENING VALUES
SLOCUM CREEK AND TURKEY GUT
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Stream	Sediment Screening Value (μg/kg)	Source[1]
4,4'-DDD	Slocum Creek	1.93E+01	USEPA Region IV screening value for saltwater, applied to EP; log K_{ow} = 5.99
	Turkey Gut	4.83E+04	USEPA Region IV screening value for freshwater, applied to EP; log K_{ow} = 5.99
4,4'-DDE	Turkey Gut	4.95E+01	USEPA Region IV screening value for freshwater, applied to EP; log K_{ow} = 5.76
4,4'-DDT	Turkey Gut	3.30E+00	USEPA Region IV screening value for sediment
alpha-Chlordane	Turkey Gut	1.70E+00	USEPA Region IV screening value for sediment
Dieldrin	Turkey Gut	3.30E+00	USEPA Region IV screening value for sediment
gamma-Chlordane	Turkey Gut	1.70E+00	USEPA Region IV screening value for sediment
Heptachlor	Turkey Gut	7.70E+00	USEPA Region IV screening value for freshwater, applied to EP; log K_{ow} = 5.40
Heptachlor epoxide	Turkey Gut	7.70E+00	USEPA Region IV screening value for freshwater, applied to EP; log K_{ow} = 5.40
Di-n-butylphthalate	Slocum Creek	1.06E+03	USEPA Region IV screening value for saltwater, applied to EP; log K_{ow} = 4.57
	Turkey Gut	2.92E+03	USEPA Region IV screening value for freshwater, applied to EP; log K_{ow} = 4.57
2-Butanone	Slocum Creek	9.64E+02	Shell Chemie (1975) applied to EP; log K_{ow} = 0.29
Arsenic	Turkey Gut	8.00E+03	USEPA Region IV screening value for sediment
Chromium	Turkey Gut	3.30E+04	USEPA Region IV screening value for sediment
Copper	Turkey Gut	2.80E+04	USEPA Region IV screening value for sediment
Lead	Turkey Gut	2.10E+04	USEPA Region IV screening value for sediment
Manganese	Turkey Gut	3.00E+05	Baudo et al. (1990)
Zinc	Turkey Gut	6.80E+04	USEPA Region IV screening value for sediment

[1] All Log K_{ow} values from Thistle Publishing (1994)
No benchmark was available for vanadium.

chemicals in sediments is correlated not to the total sediment chemical concentration (bulk sediment concentration) but with the concentration of chemical present in the sediment pore water. It has also been observed that the bioavailability of nonpolar organic chemicals is equally correlated with the concentration of organic carbon present in a given sediment. EP modeling, therefore, revolves around the interrelationship between pore water concentrations, octanol/water (K_{ow}) and sediment organic partitioning coefficients (K_{oc}), and bulk sediment concentrations of nonpolar organics. Based on these interrelationships, the organic carbon normalized benchmark criterion can be determined for a chemical by employing its specific organic carbon partitioning coefficient. The resulting benchmark values are therefore independent of organic carbon sediment properties (USEPA, 1993a).

EP modeling was used to determine organic carbon normalized chronic benchmark values for nonpolar organics. Using the K_{ow} values listed in Table 7-9, the following regression formula was used to predict K_{oc}:

$$\log_{10}K_{oc} = 0.00028 + 0.983 \log_{10}K_{ow} \text{ (USEPA, 1993a)}$$

This K_{oc} value was used to predict chronic benchmark sediment values by utilizing chronic benchmark surface water values (USEPA, 1993a):

$$\text{sediment benchmark value}_{oc}(\mu g/g_{oc}) = K_{oc} \bullet \text{surface water benchmark value (mg/L)}$$

To account for possible differences in total organic carbon (TOC) concentrations present in sediments, the organic carbon-normalized sediment benchmark value was "converted" to dry weight-normalized sediment benchmark values using the following formula:

$$\text{sediment benchmark value } (\mu g/g) = \text{sediment benchmark value}_{oc}(\mu g/g_{oc}) \bullet (\%TOC/100)$$

Bulk sediment concentrations of nonpolar organic contaminants present at a location were then compared to sediment benchmark criteria adjusted for the percent TOC present in sediments. Since no site-specific sediment organic carbon data were available, a value of 1 percent (f_{oc} = 0.01) was chosen to represent this site.

7.3.2.3.3 Derivation of Soil BTVs

Contaminant threshold values for surface soil (Table 7-10) were obtained from a number of sources, including:

- Those established by the Quebec Ministry of the Environment for soil (Direction des Substances Dangereuses, 1988)
- Maximum allowable concentrations established by various regulatory agencies for amending farm soil with sewage sludge
- Earthworm toxicity data (Thompson, 1971)
- *Trace Elements in Soils and Plants* (Kabata-Pendias and Pendias, 1992)
- Predicted Earthworm LD50 values, using ECOSAR (USEPA, September 1994b)
- Soil contaminant threshold values developed by the Ontario Ministry of the Environment (Richardson, 1987)
- Interim Canadian Environmental Criteria (CCME, 1991)
- USEPA Region III Risk-Based Contamination Tables, First Quarter (USEPA, 1995).

While the majority of these sources have identified conservative, "safe" soil contaminant levels from a human health perspective, only a few have developed soil benchmark values that have protection of ecological receptors as a goal. When possible, the ERA preferentially selected those soil benchmark values that considered impacts to ecological receptors. However, in a number of instances, surface soil benchmarks developed to be protective of human health had to be used.

7.3.2.3.4 Derivation of Receptor-specific Reference Doses

As discussed in Section 7.3.2.2, risks to terrestrial receptors were be evaluated by estimating the total potential dose received by selected receptor organisms and comparing these dose calculations to contaminant concentrations protective of these receptors. Information on the toxicity of environmental contaminants to terrestrial wildlife is generally limited. Most information generated to date involves impacts

TABLE 7-10

SOIL SCREENING VALUES
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Screening Value (μg/kg)	Source
Aluminum	1.01E+07	Maximum Cumulative Addition (Missouri DNR, 1988)
Antimony	1.00E+04	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Arsenic	3.00E+04	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Barium	5.00E+05	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Cadmium	5.00E+03	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Chromium	2.50E+05	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Copper	1.00E+05	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Lead	2.00E+05	Kabata-Pendias and Pendias (1992)
Manganese	1.50E+06	Kabata-Pendias and Pendias (1992)
Mercury	2.50E+03	Richardson (1987)
Selenium	3.00E+03	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Silver	1.00E+04	Kabata-Pendias and Pendias (1992)
Thallium	6.30E+03	Human health residential soil screening level (USEPA Region III, 1995)
Vanadium	2.00E+05	Agricultural soil screening level (CCME, 1991)
Zinc	2.50E+05	Richardson (1987)
1,2-Dichloroethene	7.00E+05	Human health residential soil screening level (USEPA Region III, 1995)
Methylene chloride	8.89E+03	Earthworm 14-d LC50/100 from ECOSAR (USEPA, 1994b)
Toluene	1.50E+03	Richardson (1987)
Xylene	1.60E+08	Human health residential soil screening level (USEPA Region III, 1995)

TABLE 7-10 (CONTINUED)
SOIL SCREENING VALUES
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Screening Value (µg/kg)	Source
Benzo(a)anthracene	1.00E+03	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Benzo(a)pyrene	1.00E+03	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Benzo(b)fluoranthene	1.00E+03	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Benzo(g,h,i)perylene	1.00E+03	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Benzo(k)fluoranthene	1.00E+03	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Chrysene	1.00E+03	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Di-n-octylphthalate	2.76E+03	Earthworm 14-d LC50/100 from ECOSAR for Di-n-butylphthalate (USEPA, 1994b)
Fluoranthene	1.00E+04	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Indeno(1,2,3-cd)pyrene	1.00E+03	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
Pyrene	5.00E+03	Richardson (1987)
2,4-Dinitrophenol	2.00E+04	Soil benchmark for terrestrial plants (Will and Suter, 1994)
4-Nitrophenol	3.80E+02	Earthworm 14-d LC50/100 (Neuhauser et al., 1985)
4,4'-DDD	1.00E+02	Maximum allowable concentration (USSR, 1984)
4,4'-DDE	1.00E+02	Maximum allowable concentration (USSR, 1984)
4,4'-DDT	1.00E+02	Maximum allowable concentration (USSR, 1984)
alpha-Chlordane	4.90E+02	Human health residential soil screening level (USEPA Region III, 1995)
Aroclor-1254	5.00E+02	Agricultural soil screening level (CCME, 1991)
Aroclor-1260	5.00E+02	Agricultural soil screening level (CCME, 1991)
Dieldrin	4.00E+01	Human health residential soil screening level (USEPA Region III, 1995)
Endosulfan I	4.07E+03	Earthworm 14-d LC50/100 from ECOSAR for Endosulfan II (USEPA, 1994b)

TABLE 7-10 (CONTINUED)
SOIL SCREENING VALUES
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Contaminant of Potential Concern	Screening Value (µg/kg)	Source
Endrin aldehyde	5.60E+02	Thompson (1971)
Heptachlor	5.00E+01	Threshold level for contaminated soils (Direction des Substances Dangerous, 1988)
gamma-Chlordane	4.90E+02	Human health residential soil screening level (USEPA Region III, 1995)
OCDD	4.00E+00	Human health residential soil screening level (USEPA Region III, 1995) for 2,3,7,8-TCDD converted to OCDD using TEF of 0.001.
Total HpCDD	4.00E-01	Human health residential screening level (USEPA Region III, 1995) for 2,3,7,8-TCDD converted to HpCDD using TEF of 0.01.

of agricultural contaminants on non-target wildlife species; little information exists on the impact of industrial chemicals and contaminants on ecological receptors (Opresko et al., 1994). Furthermore, much of the data that are available reflect acute effects (e.g., mortality), and interpretation of the potential effects that long-term, chronic exposure to a contaminant might have on wildlife populations is difficult. Because of these and other data limitations, species-specific NOAELs (no-observed-adverse-effects levels) for chronic exposures to a given chemical must be derived from the results of toxicity tests performed on different species of wildlife or, more frequently, on laboratory animals.

When possible, NOAELs and LOAELs (lowest-observed-adverse-effects levels) for domestic and wild mammals and birds (e.g., surrogate species) were obtained from the primary literature, USEPA review documents, and secondary sources such as the Registry of Toxic Effects of Chemical Substances, the Integrated Risk Information System (IRIS), and Opresko et al. (1994). NOAELs and LOAELs represent daily contaminant dose levels normalized to the body weight of the test animals. To reduce the need to extrapolate between data and to limit the uncertainty associated with deriving NOAEL values, emphasis was placed on those studies in which reproductive and developmental endpoints were considered (e.g., toxicity test endpoints indicative of potential population-level effects).

Although toxicity test data that reflected potential long-term (chronic) impacts to test organisms were preferentially sought, these types of data were not uniformly available. In order to derive reproductive NOAEL values for each of the representative ecological receptors considered in this risk assessment, a series of "Uncertainty Factors" (UFs) were applied to the available toxicity data. UFs are designed to account for the uncertainty associated with extrapolating from toxicity data experimentally obtained from one organism in order to estimate the potential toxic impact on another receptor organism. The UFs used in this ERA were based on recommended values employed by Region III USEPA (1994), Opresko et. al (1994), and Calabrese and Baldwin (1993). The following UFs were developed to account for the uncertainty associated with the following:

- Extrapolating chronic endpoints from the results of acute toxicity tests (UF = 10)
- Deriving chronic endpoints from the results of tests conducted over subchronic exposure periods (UF = 10)
- Deriving endpoints that were reflective of chronic, reproductive effects from toxicity tests that used non-sensitive endpoints (UF = 10)
- Deriving NOAEL values from test results reported in terms of LOAEL values (UF = 10)

- Extrapolations of toxicity test data generated on test organisms to receptors with the same class (UF = 10)

- Extrapolations of toxicity test date generated on test organisms to receptors belonging to a different class (UF = 100)

Although no clear guidance has been developed to define what constitutes a subchronic exposure, both USEPA (1993a) and Opresko et al. (1994) consider exposure periods of less than 50 percent of a species' lifespan to represent a subchronic exposure period for mammalian species. This same definition of subchronic exposure was used in this ERA. As outlined in Opresko et al. (1994), information defining chronic/subchronic exposure periods for avian toxicity tests is even more limited and these tests are not well standardized. Therefore, an exposure period of 10 weeks or less was defined as a subchronic exposure period for avian species (Opresko et al., 1994).

The derivation of reference doses (RfDs) for each chemical of concern and each receptor species considered in this ERA is summarized in Tables 7-11 through 7-13. These tables list the chemicals of concern, surrogate species used in each toxicity test, the endpoint used to quantify the toxic response of the surrogate organisms, and the laboratory test result [expressed as a dose (mg/kg/day)]. No suitable toxicity data were available for several soil contaminants evaluated during the initial screening. Therefore, these compounds could not be included in foodchain modeling. The UF values applied to these test results are also listed in Table 7-11 through 7-13. Using the following formula, a "scaling factor", defined as the product of the reciprocals of all applicable UFs, was calculated:

$$\text{Scaling Factor (SF)} = (1/UF_a * 1/UF_b * 1/UF_c * .... 1/UF_x)$$

Receptor-specific RfD values were then derived by multiplying the laboratory test result by the chemical-specific scaling factor:

$$\text{Receptor-Specific RfD (mg/kg/day)} = \text{SF} * \text{Laboratory Test Result (mg/kg/day)}$$

7.3.3 Risk Characterization Results

Potential risks to ecological receptors that may inhabit OU2 were assessed by comparing exposure point concentrations and estimated doses to benchmark values protective of receptor organisms. After the initial screening steps described below were completed, the ratio of the exposure level and the benchmark value is determined. If this ratio, called the Hazard Quotient (HQ), is greater than 1.0, then the contaminant is

TABLE 7-11

DERIVATION OF REFERENCE DOSE (RfD) VALUES FOR THE EASTERN COTTONTAIL
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Test Species	Endpoint	Lab Test Result (mg/kg/day)	Acute to Chronic UF	Sub-Chronic Exposure UF	Non-Sensitive Enpoint UF	LOAEL to NOAEL UF	Species to Species UF	*Scaling Factor	**Derived NOAEL (mg/kg/day)	Source of Lab Test Result
Aluminum	Rat	Reprod.; NOAEL	5.00E+01	1	1	1	1	10	1.00E-01	5.00E+00	1
Antimony	Mouse	Longevity; LOAEL	1.25E+00	1	1	10	10	10	1.00E-03	1.25E-03	1
Arsenic	Mouse	Reprod.; LOAEL	1.26E+00	1	1	1	10	10	1.00E-02	1.26E-02	1
Barium	Rat	Growth; NOAEL	5.06E+00	1	1	10	1	10	1.00E-02	5.06E-02	1
Beryllium	Rat	Reprod.; NOAEL	6.60E-01	1	1	1	1	10	1.00E-01	6.60E-02	1
Cadmium	Mouse	Reprod.; LOAEL	2.52E+00	1	1	1	10	10	1.00E-02	2.52E-02	1
Chromium	Mouse	Reprod; LOAEL	4.60E+00	1	1	1	10	10	1.00E-02	4.60E-02	1
Cobalt	Rat	Liver damage; LOAEL	1.57E+02	1	1	10	10	10	1.00E-03	1.57E-01	2
Copper	Rat	Reprod.; NOAEL	6.60E+01	1	1	1	1	10	1.00E-01	6.60E+00	1
Lead	Rat	Kidney Damage; NOAEL	8.00E+00	1	1	1	1	10	1.00E-01	8.00E-01	1
Manganese	Rat	Reprod.; NOAEL	8.80E+01	1	1	1	1	10	1.00E-01	8.80E+00	1
Mercury	Mouse	Reprod.; NOAEL	1.32E+01	1	1	1	1	10	1.00E-01	1.32E+00	1

TABLE 7-11 (Continued)
DERIVATION OF REFERENCE DOST (RfD) VALUES FOR THE EASTERN COTTONTAIL
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Test Species	Endpoint	Lab Test Result (mg/kg/day)	Acute to Chronic UF	Sub-Chronic Exposure UF	Non-Sensitive Enpoint UF	LOAEL to NOAEL UF	Species to Species UF	*Scaling Factor	**Derived NOAEL (mg/kg/day)	Source of Lab Test Result
Nickel	Rat	Reprod.; NOAEL	4.00E+01	1	1	1	1	10	1.00E-01	4.00E+00	1
Selenium	Mouse	Reprod.; LOAEL	7.50E-01	1	1	1	10	10	1.00E-01	7.50E-02	1
Silver	Rat	Mortality; LOAEL	1.81E+02	1	10	10	10	10	1.00E-04	1.81E-02	3
Thallium	Rat	Reprod.; LOAEL	7.40E-01	1	10	1	10	10	1.00E-03	7.4E-04	1
Vanadium	Rat	Reprod.; NOAEL	1.14E+01	1	1	1	1	10	1.00E-01	1.14E+00	4
Zinc	Rat	Reprod.; NOAEL	1.60E+02	1	1	1	1	10	1.00E-01	1.60E+01	1
Benzene	Mouse	Reprod.; LOAEL	2.63E+02	1	1	1	10	10	1.00E-02	2.63E+00	
Chlorobenzene	Beagle	Mortality; NOAEL	2.73E+01	1	10	10	1	10	1.00E-03	2.73E-02	5
Chloroethane		NA									
Methylene chloride	Rat	Liver damage; NOAEL	5.85E+00	1	1	10	1	10	1.00E-02	5.85E-02	4
Vinyl chloride	Rat	Mortality; LOAEL	1.70E+00	1	1	1	10	10	1.00E-02	1.70E-02	4
1,1-Dichloroethane		NA									
1,2-Dichloroethene	Mouse	Body wt./Liver NOAEL	4.52E+02	1	10	10	1	10	1.00E-03	4.52E-01	5
1,4-Dichlorobenzene		NA									

TABLE 7-11 (Continued)
DERIVATION OF REFERENCE DOST (RfD) VALUES FOR THE EASTERN COTTONTAIL
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Test Species	Endpoint	Lab Test Result (mg/kg/day)	Acute to Chronic UF	Sub-Chronic Exposure UF	Non-Sensitive Enpoint UF	LOAEL to NOAEL UF	Species to Species UF	*Scaling Factor	**Derived NOAEL (mg/kg/day)	Source of Lab Test Result
Bis(2-ethylhexyl) phthalate	Mouse	Reprod.; NOAEL	1.83E+01	1	1	1	1	10	1.00E-01	1.83E+00	1
Di-n-butylphthalate	Mouse	Reprod.; NOAEL	5.50E+02	1	1	1	1	10	1.00E-01	5.50E+01	1
Toluene	Mouse	Reprod.; NOAEL	2.60E+02	1	1	1	1	10	1.00E-01	2.60E+01	4
2,4-Dinitrophenol		NA									
4-Nitrophenol		NA									
Xylene	Mouse	Reprod.; NOAEL	2.06E+00	1	1	1	1	10	1.00E-01	2.06E-01	1
Benzo(a)anthracene		NA									
Benzo(a)pyrene	Mouse	Reprod.; LOAEL	1.00E+01	1	1	1	10	10	1.00E-02	1.00E-01	1
Benzo(b)flouranthene		NA									
Benzo(g,h,i)perylene		NA									
Benzo(k)flouranthene		NA									
Chrysene		NA									
Fluoranthene	Mouse	Reprod.; NOAEL	1.25E+02	1	1	1	1	10	1.00E-01	1.25E+01	6
Indeno(1,2-cd)pyrene		NA									
Pyrene	Mouse	Kidney Lesions; NOAEL	7.50E+01	1	10	10	1	10	1.00E-03	7.50E-02	7
4,4'-DDD	Rat	Reprod.; NOAEL	8.00E-01	1	1	1	1	10	1.00E-01	8.00E-02	1

TABLE 7-11 (Continued)
DERIVATION OF REFERENCE DOST (RfD) VALUES FOR THE EASTERN COTTONTAIL
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Test Species	Endpoint	Lab Test Result (mg/kg/day)	Acute to Chronic UF	Sub-Chronic Exposure UF	Non-Sensitive Enpoint UF	LOAEL to NOAEL UF	Species to Species UF	*Scaling Factor	**Derived NOAEL (mg/kg/day)	Source of Lab Test Result
4,4'-DDE	Rat	Reprod.; NOAEL	8.00E-01	1	1	1	1	10	1.00E-01	8.00E-02	1
4,4'-DDT	Rat	Reprod.; NOAEL	8.00E-01	1	1	1	1	10	1.00E-01	8.00E-02	1
Aldrin	Rat	Reprod.; NOAEL	2.00E-01	1	1	1	1	10	1.00E-01	2.00E-02	4
alpha-Chlordane	Mouse	Reprod.; NOAEL	4.58E+00	1	1	1	1	10	1.00E-01	4.58E-01	4
Dieldrin	Rat	Reprod.; LOAEL	2.00E-01	1	1	1	10	10	1.00E-02	2.00E-03	4
Endosulfan I (II)	Rat	Reprod.; NOAEL	1.50E+00	1	10	1	1	10	1.00E-02	1.50E-02	1
Endrin	Mouse	Reprod.; LOAEL	9.20E-01	1	1	1	10	10	1.00E-02	9.20E-03	4
Endrin aldehyde	Mouse	LOAEL	9.20E-01	1	1	1	10	10	1.00E-02	9.20E-03	4
gamma-Chlordane	Mouse	Reprod.; NOAEL	4.58E+00	1	1	1	1	10	1.00E-01	4.58E-01	4
Heptachlor	Rat	Reprod.; NOAEL	8.00E-01	1	1	1	1	10	1.00E-01	8.00E-02	1
Heptachlor epoxide	Beagle	Body wt./Liver LOAEL	2.00E-02	1	1	1	10	10	1.00E-02	2.00E-04	5
Lindane (gamma-BHC)	Rat	Reprod.; NOAEL	8.00E+00	1	1	1	1	10	1.00E-01	8.00E-01	4
PCBs (Aroclor 1254)	Mouse	Reprod.; LOAEL	1.35E+00	1	1	1	10	10	1.00E-02	1.35E-02	4

TABLE 7-11 (Continued)
DERIVATION OF REFERENCE DOST (RfD) VALUES FOR THE EASTERN COTTONTAIL
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

NA = Not Available

1: Opresko et al. (1994)
2: ATSDR (1991)
3: ATSDR (1990)
4: Will and Suter (1994)
5: Calculated from IRIS (1995)
6: IRIS (1990)
7: USEPA (1989b)

UFa = Acute to Chronic
UFb = Subchronic Exposure
UFc = Non-sensitive Endpoint
UFd = LOAEL to NOAEL
UFe = Species to Species; 10 within class, 100 between classes

*Scaling Factor = (1/UFa*1/UFb*1/UFc*1/UFd*1/UFe)
**Derived Wildlife RfD = Lab Test Endpoint * Scaling Factor

TABLE 7-12

DERIVATION OF REFERENCE DOSE (RfD) VALUES FOR THE RED FOX
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Test Species	Endpoint	Lab Test Result (mg/kg/day)	Acute to Chronic UF	Sub-Chronic Exposure UF	Non-Sensitive Enpoint UF	LOAEL to NOAEL UF	Species to Species UF	*Scaling Factor	**Derived NOAEL (mg/kg/day)	Source of Lab Test Result
Aluminum	Rat	Reprod.; NOAEL	5.00E+01	1	1	1	1	10	1.00E-01	5.00E+00	1
Antimony	Mouse	Longevity; LOAEL	1.25E+00	1	1	10	10	10	1.00E-03	1.25E-03	1
Arsenic	Mouse	Reprod.; LOAEL	1.26E+00	1	1	1	10	10	1.00E-02	1.26E-02	1
Barium	Rat	Growth; NOAEL	5.06E+00	1	1	10	1	10	1.00E-02	5.06E-02	1
Beryllium	Rat	Reprod.; NOAEL	6.60E-01	1	1	1	1	10	1.00E-01	6.60E-02	1
Cadmium	Mouse	Reprod.; LOAEL	2.52E+00	1	1	1	10	10	1.00E-02	2.52E-02	1
Chromium	Mouse	Reprod; LOAEL	4.60E+00	1	1	1	10	10	1.00E-02	4.60E-02	1
Cobalt	Rat	Liver damage; LOAEL	1.57E+02	1	1	10	10	10	1.00E-03	1.57E-01	2
Copper	Rat	Reprod.; NOAEL	6.60E+01	1	1	1	1	10	1.00E-01	6.60E+00	1
Lead	Rat	Kidney Damage; NOAEL	8.00E+00	1	1	1	1	10	1.00E-01	8.00E-01	1
Manganese	Rat	Reprod.; NOAEL	8.80E+01	1	1	1	1	10	1.00E-01	8.80E+00	1
Mercury	Mouse	Reprod.; NOAEL	1.32E+01	1	1	1	1	10	1.00E-01	1.32E+00	1

TABLE 7-12 (Continued)
DERIVATION OF REFERENCE DOSE (RfD) VALUES FOR THE RED FOX
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Test Species	Endpoint	Lab Test Result (mg/kg/day)	Acute to Chronic UF	Sub-Chronic Exposure UF	Non-Sensitive Enpoint UF	LOAEL to NOAEL UF	Species to Species UF	*Scaling Factor	**Derived NOAEL (mg/kg/day)	Source of Lab Test Result
Nickel	Rat	Reprod.; NOAEL	4.00E+01	1	1	1	1	10	1.00E-01	4.00E+00	1
Selenium	Mouse	Reprod.; LOAEL	7.50E-01	1	1	1	10	10	1.00E-01	7.50E-02	1
Silver	Rat	Mortality; LOAEL	1.81E+02	1	10	10	10	10	1.00E-04	1.81E-02	3
Thallium	Rat	Reprod.; LOAEL	7.40E-01	1	10	1	10	10	1.00E-03	7.4E-04	1
Vanadium	Rat	Reprod.; NOAEL	1.14E+01	1	1	1	1	10	1.00E-01	1.14E+00	4
Zinc	Rat	Reprod.; NOAEL	1.60E+02	1	1	1	1	10	1.00E-01	1.60E+01	1
Benzene	Mouse	Reprod.; LOAEL	2.63E+02	1	1	1	10	10	1.00E-02	2.63E+00	4
Chlorobenzene	Beagle	Mortality; NOAEL	2.73E+01	1	10	10	1	10	1.00E-03	2.73E-02	5
Chloroethane		NA									
Methylene chloride	Rat	Liver damage; NOAEL	5.85E+00	1	1	10	1	10	1.00E-02	5.85E-02	4
Vinyl chloride	Rat	Mortality; LOAEL	1.70E+00	1	1	1	10	10	1.00E-02	1.70E-02	4
1,1-Dichloroethane		NA									
1,2-Dichloroethene	Mouse	Body wt./Liver NOAEL	4.52E+02	1	10	10	1	10	1.00E-03	4.52E-01	5
1,4-Dichlorobenzene		NA									

TABLE 7-12 (Continued)
DERIVATION OF REFERENCE DOSE (RfD) VALUES FOR THE RED FOX
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Test Species	Endpoint	Lab Test Result (mg/kg/day)	Acute to Chronic UF	Sub-Chronic Exposure UF	Non-Sensitive Enpoint UF	LOAEL to NOAEL UF	Species to Species UF	*Scaling Factor	**Derived NOAEL (mg/kg/day)	Source of Lab Test Result
Bis(2-ethylhexyl) phthalate	Mouse	Reprod.; NOAEL	1.83E+01	1	1	1	1	10	1.00E-01	1.83E+00	1
Di-n-butylphthalate	Mouse	Reprod.; NOAEL	5.50E+02	1	1	1	1	10	1.00E-01	5.50E+01	1
Toluene	Mouse	Reprod.; NOAEL	2.60E+02	1	1	1	1	10	1.00E-01	2.60E+01	4
2,4-Dinitrophenol		NA									
4-Nitrophenol		NA									
Xylene	Mouse	Reprod.; NOAEL	2.06E+00	1	1	1	1	10	1.00E-01	2.06E-01	1
Benzo(a)anthracene		NA									
Benzo(a)pyrene	Mouse	Reprod.; LOAEL	1.00E+01	1	1	1	10	10	1.00E-02	1.00E-01	1
Benzo(b)flouranthene		NA									
Benzo(g,h,i)perylene		NA									
Benzo(k)flouranthene		NA									
Chrysene		NA									
Fluoranthene	Mouse	Reprod.; NOAEL	1.25E+02	1	1	1	1	10	1.00E-01	1.25E+01	6
Indeno(1,2-cd)pyrene		NA									
Pyrene	Mouse	Kidney Lesions; NOAEL	7.50E+01	1	10	10	1	10	1.00E-03	7.50E-02	7
4,4'-DDD	Rat	Reprod.; NOAEL	8.00E-01	1	1	1	1	10	1.00E-01	8.00E-02	1

TABLE 7-12 (Continued)
DERIVATION OF REFERENCE DOSE (RfD) VALUES FOR THE RED FOX
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Test Species	Endpoint	Lab Test Result (mg/kg/day)	Acute to Chronic UF	Sub-Chronic Exposure UF	Non-Sensitive Enpoint UF	LOAEL to NOAEL UF	Species to Species UF	*Scaling Factor	**Derived NOAEL (mg/kg/day)	Source of Lab Test Result
4,4'-DDE	Rat	Reprod.; NOAEL	8.00E-01	1	1	1	1	10	1.00E-01	8.00E-02	1
4,4'-DDT	Rat	Reprod.; NOAEL	8.00E-01	1	1	1	1	10	1.00E-01	8.00E-02	1
Aldrin	Rat	Reprod.; NOAEL	2.00E-01	1	1	1	1	10	1.00E-01	2.00E-02	4
alpha-Chlordane	Mouse	Reprod.; NOAEL	4.58E+00	1	1	1	1	10	1.00E-01	4.58E-01	4
Dieldrin	Rat	Reprod.; LOAEL	2.00E-01	1	1	1	10	10	1.00E-02	2.00E-03	4
Endosulfan I (II)	Rat	Reprod.; NOAEL	1.50E+00	1	10	1	1	10	1.00E-02	1.50E-02	1
Endrin	Mouse	Reprod.; LOAEL	9.20E-01	1	1	1	10	10	1.00E-02	9.20E-03	4
Endrin aldehyde	Mouse	LOAEL	9.20E-01	1	1	1	10	10	1.00E-02	9.20E-03	4
gamma-Chlordane	Mouse	Reprod.; NOAEL	4.58E+00	1	1	1	1	10	1.00E-01	4.58E-01	4
Heptachlor	Rat	Reprod.; NOAEL	8.00E-01	1	1	1	1	10	1.00E-01	8.00E-02	1
Heptachlor epoxide	Beagle	Body wt./Liver LOAEL	2.00E-02	1	1	1	10	10	1.00E-02	2.00E-04	5
Lindane (gamma BHC)	Rat	Reprod.; NOAEL	8.00E+00	1	1	1	1	10	1.00E-01	8.00E-01	4
PCBs (Aroclor 1254)	Mouse	Reprod.; LOAEL	1.35E+00	1	1	1	10	10	1.00E-02	1.35E-02	4

TABLE 7-12 (Continued)
DERIVATION OF REFERENCE DOSE (RfD) VALUES FOR THE RED FOX
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

NA = Not Available

1: Opresko et al. (1994)
2: ATSDR (1991)
3: ATSDR (1990)
4: Will and Suter (1994)
5: Calculated from IRIS (1995)
6: IRIS (1990)
7: USEPA (1989b)

UFa = Acute to Chronic
UFb = Subchronic Exposure
UFc = Non-sensitive Endpoint
UFd = LOAEL to NOAEL
UFe = Species to Species; 10 within class, 100 between classes

*Scaling Factor = (1/UFa*1/UFb*1/UFc*1/UFd*1/UFe)
**Derived Wildlife RfD = Lab Test Endpoint * Scaling Factor

TABLE 7-13

DERIVATION OF REFERENCE DOSE (RfD) VALUES FOR THE RED-TAILED HAWK
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Test Species	Endpoint	Lab Test Result (mg/kg/day)	Acute to Chronic UF	Sub-Chronic Exposure UF	Non-Sensitive Enpoint UF	LOAEL to NOAEL UF	Species to Species UF	*Scaling Factor	**Derived NOAEL (mg/kg/day)	Source of Lab Test Result
Aluminum	Ringed Dove	Reprod.; NOAEL	1.11E+02	1	1	1	1	10	1.00E-01	1.11E+01	1
Antimony	Mouse	Longevity; LOAEL	1.25E+00	1	1	10	10	100	1.00E-04	1.25E-04	1
Arsenic	Mallard Duck	Mortality; NOAEL	5.14E+00	1	1	10	1	10	1.00E-02	5.14E-02	1
Barium	Chick	Mortality; NOAEL	2.09E+01	1	1	10	1	10	1.00E-02	2.09E-01	1
Beryllium	Rat	Reprod.; NOAEL	6.60E-01	1	1	1	1	100	1.00E-02	6.60E-03	1
Cadmium	Mallard Duck	Reprod.; NOAEL	1.45E+00	1	1	1	1	10	1.00E-01	1.45E-01	1
Chromium	Black Duck	Reprod; NOAEL	4.60E+00	1	1	1	1	10	1.00E-01	4.60E-01	1
Cobalt	Rat	Liver damage; LOAEL	1.57E+02	1	1	10	10	100	1.004-04	1.57E-02	2
Copper	Chicken	Growth; NOAEL	3.32E+01	1	1	1	1	10	1.00E-01	3.32E+00	3
Lead	Americ. Kestrel	Reprod.; NOAEL	3.85E+00	1	1	1	1	10	1.00E-01	3.85E-01	1
Manganese	Rat	Reprod.; NOAEL	8.80E+01	1	1	1	1	100	1.00E-02	8.80E-01	1
Mercury	Mallard Duck	Reprod.; LOAEL	6.40E-02	1	1	1	10	10	1.00E-02	6.40E-04	1
Nickel	Mallard Duckling	Behavior; NOAEL	7.74E+01	1	1	10	1	10	1.00E-02	7.74E-01	1

TABLE 7-13 (Continued)
DERIVATION OF REFERENCE DOST (RfD) VALUES FOR THE RED-TAILED HAWK
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Test Species	Endpoint	Lab Test Result (mg/kg/day)	Acute to Chronic UF	Sub-Chronic Exposure UF	Non-Sensitive Enpoint UF	LOAEL to NOAEL UF	Species to Species UF	*Scaling Factor	**Derived NOAEL (mg/kg/day)	Source of Lab Test Result
Selenium	Mallard Duck	Reprod.; NOAEL	4.00E-01	1	1	1	1	10	1.00E-01	4.00E-02	1
Silver	Rat	Mortality; LOAEL	1.81E+02	1	10	10	10	100	1.00E-05	1.81E-03	4
Thallium	Rat	Reprod.; LOAEL	7.40E-01	1	10	1	10	100	1.00E-04	7.40E-05	1
Vanadium	Mallard Duck	Mortality.; NOAEL	1.14E+01	1	1	10	1	10	1.00E-02	1.14E-01	5
Zinc	Mallard Duck	Mortality; LOAEL	3.00E+02	1	10	1	10	10	1.00E-03	3.00E-01	1
Benzene	Mouse	Reprod.; LOAEL	2.63E+02	1	1	1	10	100	1.00E-03	2.63E-01	5
Chlorobenzene	Beagle	Mortality; NOAEL	2.73E+01	1	10	10	1	100	1.00E-04	2.73E-03	6
Chloroethane		NA									
Methylene chloride	Rat	Liver Damage; NOAEL	5.85E+00	1	1	10	1	100	1.00e-03	5.85E-03	3
Vinyl chloride	Rat	Mortality; LOAEL	1.70E+00	1	1	1	10	100	1.00E-03	1.70E-03	5
1,1-Dichloroethane		NA									
1,2-Dichloroethene	Mouse	Body wt./Liver NOAEL	4.52E+02	1	10	10	1	100	1.00E-04	4.52E-02	1
1,4-Dichlorobenzene		NA									
Bis(2-ethylhexyl) phthalate	Ring Dove	Reprod.; NOAEL	1.11E+00	1	1	1	1	10	1.00E-01	1.11E-01	1

TABLE 7-13 (Continued)
DERIVATION OF REFERENCE DOST (RfD) VALUES FOR THE RED-TAILED HAWK
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Test Species	Endpoint	Lab Test Result (mg/kg/day)	Acute to Chronic UF	Sub-Chronic Exposure UF	Non-Sensitive Enpoint UF	LOAEL to NOAEL UF	Species to Species UF	*Scaling Factor	**Derived NOAEL (mg/kg/day)	Source of Lab Test Result
Di-n-octylphthalate	Ring Dove	Reprod.; NOAEL	1.11E+00	1	1	1	10	10	1.00E-02	1.11E-01	1
Toluene	Mouse	Reprod.; NOAEL	2.60E+02	1	1	1	1	100	1.00E-02	2.60E+00	5
Xylene	Mouse	Reprod.; NOAEL	2.06E+00	1	1	1	1	100	1.00E-02	2.06E-02	1
2,4-Dinitrophenol		NA									
4-Nitrophenol		NA									
Benzo(a)anthracene		NA									
Benzo(a)pyrene	Mouse	Reprod.; LOAEL	1.00E+01	1	1	1	10	100	1.00E-03	1.00E-02	1
Benzo(b)flouranthene		NA									
Benzo(g,h,i)perylene		NA									
Benzo(k)flouranthene		NA									
Chrysene		NA									
Fluoranthene	Mouse	Reprod.; NOAEL	1.25E+02	1	1	1	1	100	1.00E-02	1.25E+00	7
Indeno(1,2-cd)pyrene		NA									
Pyrene	Mouse	Kidney Lesions; NOAEL	7.50E+01	1	10	10	1	100	1.00E-04	7.50E-03	8
4,4'-DDD	Brown Pelican	Reprod.; LOAEL	2.80E-03	1	1	1	10	10	1.00E-02	2.80E-05	1
4,4'-DDE	Brown Pelican	Reprod.; LOAEL	2.80E-03	1	1	1	10	10	1.00E-02	2.80E-05	1

TABLE 7-13 (Continued)
DERIVATION OF REFERENCE DOST (RfD) VALUES FOR THE RED-TAILED HAWK
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

Chemical	Test Species	Endpoint	Lab Test Result (mg/kg/day)	Acute to Chronic UF	Sub-Chronic Exposure UF	Non-Sensitive Enpoint UF	LOAEL to NOAEL UF	Species to Species UF	*Scaling Factor	**Derived NOAEL (mg/kg/day)	Source of Lab Test Result
4,4'-DDT	Brown Pelican	Reprod.; LOAEL	2.80E-03	1	1	1	10	10	1.00E-02	2.80E-05	1
Aldrin	Red-winged Blackbird	Reprod.; NOAEL	2.00E-01	1	1	1	1	10	1.00E-01	2.00E-02	5
alpha-Chlordane	Red-winged Blackbird	Mortality; NOAEL	2.14E+00	1	1	10	1	10	1.00E-02	2.14E-02	5
Dieldrin	Rat	Reprod.; LOAEL	2.00E-01	1	1	1	10	100	1.00E-03	2.00E-04	5
Endosulfan I (II)	Gray Partridge	Reprod.; NOAEL	1.00E+01	1	1	1	1	10	1.00E-01	1.00E+00	5
Endrin	Mallard Duck	Reprod.; LOAEL	3.00E-01	1	1	1	1	10	1.00E-01	3.00E-02	5
Endrin aldehyde	Mouse	LOAEL	9.20E-01	1	1	1	10	100	1.00E-03	9.20E-04	5
gamma-Chlordane	Red-winged Blackbird	Mortality; NOAEL	2.14E+00	1	1	10	1	10	1.00E-02	2.14E-02	5
Heptachlor	Rat	Reprod.; NOAEL	8.00E-01	1	1	1	1	100	1.00E-02	8.00E-03	1
Heptachlor epoxide	Beagle	Body wt./Liver LOAEL	2.00E-02	1	1	1	10	100	1.00E-03	2.00E-05	6
Lindane (gamma BHC)	Mallard Duck	Reprod.; LOAEL	2.00E+01	1	1	1	1	10	1.00E-01	2.00E+00	5
PCBs (Aroclor 1242)	Screech Owl	Reprod.; NOAEL	4.10E-01	1	1	1	1	10	1.00E-01	4.10E-02	5

TABLE 7-13 (Continued)
DERIVATION OF REFERENCE DOST (RfD) VALUES FOR THE RED-TAILED HAWK
OPERABLE UNIT 2
MCAS CHERRY POINT, NORTH CAROLINA

NA = Not Available

1: Opresko et al. (1994)
2: ATSDR (1991)
3: NTP (1993)
4: ATSDR (1990)
5: Will and Suter (1994)
6: Calculated from IRIS (1995)
7: IRIS (1990)
8: USEPA (1989b)

UFa = Acute to Chronic
UFb = Subchronic Exposure
UFc = Non-sensitive Endpoint
UFd = LOAEL to NOAEL
UFe = Species to Species: 10 within class, 100 between classes

*Scaling Factor = (1/UFa*1/UFb*1/UFc*1/UFd*1/UFe)
**Derived Wildlife RfD = Lab Test Endpoint * Scaling Factor

retained as a final COPC. The results of the risk characterization are summarized in Tables 7-1 to 7-5 and are described below.

Several chemicals under preliminary consideration as COPCs at OU2 (calcium, iron, magnesium, potassium, and sodium) are essential nutrients and are usually considered to be nontoxic (Direction des Substances Dangereuses, 1988). These chemicals were, therefore, eliminated from further consideration as final COPCs from all media.

The same process was used to select COPCs for the surface water, sediment, and soil. The maximum detected concentration of a contaminant was compared to two times the average concentration of contaminant present in the background sample. This first screening step applied only to inorganic contaminants; all organic contaminants were retained for further consideration in the second step.

All inorganic contaminants present in concentrations two times greater than the average background concentration and all organic contaminants were compared to benchmark values protective of these receptor organisms. This approach is conservative and is likely to overestimate, rather than underestimate risk. The resulting risk values calculated in this manner integrate the predicted chemical concentration, receptor-specific exposure parameters, and chemical-specific toxicity. Again, leachate water samples (OU2LW02 and OU2LW06) were used only for drinking water exposure investigations (Section 7.3.2.2.5), and groundwater was only investigated qualitatively (Section 7.3.2.1.2).

Receptor-specific calculated doses or exposure point concentrations were compared to reference doses (RfDs) or to media-specific (e.g., surface water, sediment, and soil) benchmark values. The ratio of the exposure level or intake concentration to the RfD or benchmark value (HQ) is defined as follows:

$$HQ_i = Intake_i(\text{exposure point concentration}_i)/RfD_i\ (\text{benchmark value}_i)$$

where:

HQ_i = Hazard Quotient for chemical "i" (unitless)

$Intake_i$ = intake of chemical "i" (mg/kg/day) or exposure point concentration$_i$ (mg/kg)

RfD_i = reference dose of chemical "i" (mg/kg/day) or benchmark value$_i$ (mg/kg)

Potential adverse impacts were considered possible when the ratio of the contaminant intake (exposure concentration) to its respective RfD (benchmark value) exceeded unity (1.0). The HQ value should not be construed as being probabilistic but rather as a numerical indicator of the extent to which a predicted intake (exposure concentration) exceeds or is less than an RfD (benchmark value). When HQ values exceed 1.0,

it is an indication that ecological receptors are potentially at risk; additional data are necessary to confirm with greater certainty whether these receptors are actually at risk.

Receptor-specific Hazard Indices (HIs) are generated by summing the individual HQs for all the chemicals of concern. If the value of the HI exceeds unity, a risk to the receptors as a result of the combined exposure to these chemicals was also considered a possibility.

The use of HQs is probably the most common method used for risk characterization in ERAs. Advantages of this method, according to Barnthouse et al. (1986), include the following:

- The HQ method is relatively easy to implement, is generally accepted, and can be applied to any data.

- This method is useful when a large number of contaminants must be screened.

This method of risk characterization has some inherent limitations. One primary limitation is that it is a "yes/maybe" method for relating toxicity to exposure. That is, it uses single values for exposure concentrations and benchmark values and does not account for incremental or cumulative toxicity.

7.3.3.1 Surface Water COPCs

Inorganic contaminants present in concentrations that exceeded two times the background concentration were considered preliminary surface water COPCs. All organic chemicals detected in surface water samples were also considered preliminary COPCs. These contaminants were then compared to their respective benchmark values. The list of final surface water COPCs for each stream was compiled by calculating the HQ for all organic contaminants detected and for those inorganic COPCs that exceeded two times background. Contaminants with HQs greater than 1.0 were retained as final COPCs, as were contaminants for which no benchmark could be identified (see Section 7.3.4).

This screening process is summarized in Tables 7-1 and 7-3. As a result, only 4,4'-DDD (HQ = 1.56) was identified as a COPC in the surface water of Slocum Creek. This pesticide was detected in the sample collected upstream of OU2 and in samples collected above and below Turkey Gut at similar concentrations that exceeded the benchmark value. Therefore, OU2 is not the source of 4,4'-DDD in Slocum Creek.

Surface water COPCs identified in Turkey Gut were:

- 1,1-Dichloroethane (HQ = 2.50)
- 4,4'-DDD (HQ = 4.38)
- Chloroethane (no benchmark identified)
- Manganese (HQ = 4.67)

The organic compounds only were detected in a single sample (OU2SW4). Manganese was detected in all samples from Turkey Gut; however, the concentration at the farthest upstream sample also exceeded the benchmark value.

The toxicity of these COPCs is summarized in Appendix K.6 (Volume IV).

7.3.3.2 Sediment COPCs

The list of final sediment COPCs for each stream was compiled by calculating the HQ of all organic contaminants detected and for those inorganic COPCs which exceeded two times background. Contaminants with HQs greater than 1.0 were retained as final COPCs. Derivation of benchmark values is described in Section 7.3.4. Several contaminants were retained as COPCs because toxicity-based benchmark values were not available to assess these sediment contaminants. The results of this screening process are summarized in Tables 7-2 and 7-4. No contaminants were identified as sediment COPCs for Slocum Creek.

This screening process identified the following contaminants as sediment COPCs for Turkey Gut:

- alpha-Chlordane (HQ = 14.7)
- Dieldrin (HQ = 6.67)
- gamma-Chlordane (HQ = 5.18)
- Heptachlor epoxide (HQ = 2.08)
- Vanadium - no benchmark was available

The concentrations that exceeded the benchmark value were only detected in a single sample (OU2SD3).

The toxicity of these COPCs is summarized in Appendix K.6 (Volume IV).

7.3.3.3 Soil COPCs

The list of final soil COPCs for OU2 was compiled by calculating the HQs of all organic contaminants detected and for those inorganic COPCs which exceeded two times background. Contaminants with HQs greater than 1.0 were retained as final COPCs. Derivation of benchmark values is described in Section 7.3.4. The results of this screening process are summarized in Table 7-5. The following contaminants were identified as soil COPCs for OU2:

- Aluminum (HQ = 1.29)
- Cadmium (HQ = 1.28)
- Selenium (HQ = 1.03)
- Thallium (HQ = 1.06)
- 4-Nitrophenol (HQ = 2.24)
- Aroclor-1260 (HQ = 1.26)

The benchmark valves were exceeded only in single samples. The sample locations exceeding the benchmark values were scattered throughout OU2. It should be noted that benchmark value for thallium is based on a human health residential soil screening level, and the benchmark value for Aroclor-1260 is based on an agricultural soil screening.

The toxicity of these COPCs is summarized in Appendix K.6 (Volume IV).

7.3.3.4 Results of Dose Calculations

In addition to comparing exposure point concentrations to media-specific benchmark values, risks to ecological receptors were evaluated by conservatively estimating the potential dose received by representative terrestrial receptors and comparing these values to contaminant concentrations protective of these receptors (e.g., species-specific RfDs). Exposure pathways incorporated in these dose calculations included incidental ingestion of soil, ingestion of terrestrial vegetation, ingestion of contaminated prey species, and ingestion of drinking water (e.g., water from Turkey Gut or leachate/ponded water). The dose calculations are included in Appendix K.7 (Volume IV), and the resulting HQs are summarized in Tables 7-14 and 7-15. As discussed earlier, these calculations were based on a number of conservative assumptions, including the use of winter weights in all calculations, the assumption that all three receptors lived and foraged exclusively on OU2 (e.g, that their home range = OU2), that all ingested contaminants were absorbed, etc. Two dose calculation model runs were performed using the more conservative maximum soil concentrations and the mean values to obtain a risk range.

TABLE 7-14

MAJOR CONTRIBUTORS TO RISK AT OPERABLE UNIT 2
MAXIMUM SOIL CONTAMINANT CONCENTRATION SCENARIO
MCAS CHERRY POINT, NORTH CAROLINA

Receptor	Contaminants of Concern	Total HI per COC for all Pathways	% Contribution of COC to Total Receptor HI	Pathway	Total HI per Pathway	% Contribution of Pathway to Total Receptor HI
Eastern Cottontail Rabbit	Thallium	48.7	39.6	Soil	106.0	86.0
	Antimony	22.3	18.1	Water	0.2	0.2
	Aluminum	14.0	11.4	Food	17.0	13.8
	Barium	13.4	10.9			
	Arsenic	7.9	6.4			
	all others	16.7	13.5			
	Total Receptor HI	123.0				
Red Fox	Thallium	22.2	48.9	Soil	41.6	91.5
	Antimony	6.1	13.4	Water	0.2	0.5
	Aluminum	5.5	12.1	Food	3.7	8.0
	Barium	4.4	9.6			
	Arsenic	2.9	6.4			
	all others	4.4	9.6			
	Total Receptor HI	45.5				
Red-Tailed Hawk	Thallium	224.0	68.0	Soil	264.0	80.3
	Antimony	58.1	17.7	Water	1.0	0.3
	Zinc	15.7	4.8	Food	63.9	19.4
	4,4'-DDE	5.5	1.7			
	Mercury	5.4	1.7			
	all others	20.3	6.21			
	Total Receptor HI	329.0				

TABLE 7-15

MAJOR CONTRIBUTORS TO RISK AT OPERABLE UNIT 2
MEAN SOIL CONTAMINANT CONCENTRATION SCENARIO
MCAS CHERRY POINT, NORTH CAROLINA

Receptor	Contaminants of Concern	Total HI per COC for all Pathways	% Contribution of COC to Total Receptor HI	Pathway	Total HI per Pathway	% Contribution of Pathway to Total Receptor HI
Eastern Cottontail Rabbit	Thallium	26.2	46.7	Soil	48.1	85.8
	Antimony	14.2	25.4	Water	0.2	0.4
	Aluminum	5.0	8.9	Food	7.8	13.8
	Barium	3.4	6.1			
	Chromium	1.9	3.3			
	all others	5.5	9.7			
	Total Receptor HI	56.1				
Red Fox	Thallium	11.9	56.8	Soil	18.9	90.0
	Antimony	3.9	18.5	Water	0.2	1.0
	Aluminum	2.0	9.3	Food	1.9	9.1
	Barium	1.2	5.5			
	Chromium	0.7	3.3			
	all others	1.3	6.7			
	Total Receptor HI	21.0				
Red-Tailed Hawk	Thallium	120.0	68.6	Soil	145.0	82.5
	Antimony	37.1	21.2	Water	1.0	0.6
	Zinc	3.2	1.8	Food	29.7	17.0
	Silver	2.4	1.4			
	DDD	2.0	1.2			
	all others	10.3	5.8			
	Total Receptor HI	175.0				

Using maximum soil contaminant concentrations, the HI for the eastern cottontail rabbit was 123.0, indicating that this species may be at risk as a result of exposure to OU2-related contaminants. Thallium (HQ = 48.7), antimony (HQ = 22.3), and aluminum (HQ = 14.0) contributed significantly to the potential risks received by this receptor. As summarized in Table 7-14, incidental ingestion of contaminated soil contributed most significantly to this final HI value. Incidental ingestion of soil accounted for 86.0 percent of its exposure to these contaminants, the ingestion of vegetation accounted for 13.8 percent of total exposure, and the contribution from drinking water exposure was negligible.

The HI calculated for the red fox for the maximum scenario equaled 45.5 (Table 7-14). Similar to the eastern cottontail, thallium (HQ = 22.2), antimony (HQ = 6.1), and aluminum (HQ = 5.5) accounting for the majority of the total risk. Also like the rabbit, incidental ingestion of contaminated soil accounted for the majority (almost 92 percent) of total exposure. The contribution to risk from the ingestion of water was insignificant while the ingestion of contaminated prey items contributed 8.0 percent of the total dose received.

The HI for the red-tailed hawk was 329.0 under the maximum exposure scenario. For this raptor, thallium was again the primary contributor to risk, accounting for 68 percent of the total HI (Table 7-14), while antimony accounted for another 17.7 percent. Zinc, mercury, and 4,4'-DDE had slight contributions to risk as well. The incidental ingestion of soil contributed approximately 80 percent of total contaminant exposure, followed by the ingestion of food (19.4 percent); contributions to risk by the ingestion of water from Turkey Gut or ponded areas were insignificant.

Using the mean soil contaminant concentrations, the total HI for the eastern cottontail rabbit was 56.1 (Table 7-15), which is less than half the value using the maximum soil concentrations. As with the maximum concentration exposure scenario, thallium, antimony, and aluminum were the greatest contributors to risk, with HQs of 26.2, 14.2, and 5.0, respectively. Ingestion of contaminated soil accounted for 85.8 percent of total risk to this receptor. Ingestion of vegetation contributed almost 14 percent, and the contributions from drinking water were insignificant.

The red fox HI for the mean exposure scenario was 21.0, also less than half the value for the maximum exposure scenario (Table 7-15). Thallium accounted for 56.8 percent of total risk, while antimony and aluminum accounted for 18.5 percent and 9.3 percent, respectively. Similar to the maximum scenario, incidental ingestion of contaminated soil contributed almost 90 percent to total risk for the red fox, ingestion of prey accounted for 9.1 percent, and the contribution from drinking water was negligible.

The total HI for the red-tailed hawk under the mean exposure scenario was 175.0; this value is much less than the value for this raptor under the maximum exposure scenario. Thallium and antimony contributed the most to total risk, 68.6 percent and 21.2 percent respectively (Table 7-15). Zinc, silver, and 4,4'-DDD also made modest contributions to risk. Ingestion of contaminated soil accounted for almost 83 percent of the risk to the red-tailed hawk, similar to the maximum scenario, while the contribution from ingestion of prey accounted for 17 percent of the total. Drinking water exposure was insignificant.

Thallium was the greatest contributor to risk to all receptors for dose calculations under both maximum and mean soil contaminant concentration scenarios. Aluminum was also a major contributor to risk in dose calculations, mainly for the eastern cottontail rabbit and red fox. These two elements were also COPCs from the initial soil screening against benchmark values. However, thallium was present in only 3 of 18 surface soil samples. Therefore the presence of this element may be indicative of "hot spots" of contamination. Antimony was the second greatest contributor to risk for all receptors under both maximum and mean scenarios; however, antimony was present in only 3 of 16 samples. The toxicity of the final COPCs listed in Tables 7-14 and 7-15 are summarized in Appendix K.6 (Volume IV). The ecological assessment conservatively assumed that all three receptors would live their entire life at OU2 and would be exposed to the "hot spots" all the time. The receptors would not be exposed to areas of soil containing these metals all the time.

7.3.4 Uncertainties Analysis

Uncertainty is associated with all aspects of the ecological risk assessment presented in the preceding sections. This section provides a summary of these uncertainties, with a discussion of how they may affect the final risk values discussed in Section 7.3.3.

Once the risk assessment is complete, the results must be reviewed and evaluated to identify the type and magnitude of uncertainty involved. Reliance on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. For example, to account for uncertainties in the development of exposure assumptions, conservative estimates must be made to ensure that the assumptions are protective of receptors inhabiting the area of potential exposure. If a number of conservative assumptions are combined in an exposure model, the resulting calculations will propagate the uncertainties associated with those assumptions. This uncertainty is biased toward overpredicting risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

Generally, risk assessments carry two types of uncertainty - measurement and informational. Measurement uncertainty refers to the variability inherent in measured data. For example, this type of uncertainty is associated with analytical data used to characterize contaminant concentrations present in various environmental media; the risk assessment reflects the accumulated variances of the individual values used. Informational uncertainty stems from the limited availability of information needed to complete various portions of the assessment. Often this gap is significant; information regarding the effects of industrial chemicals on wildlife receptors, on the biological mechanism of action of a chemical, the impact physiological differences on exposure pathways or the behavior of a chemical in various environmental media (e.g., soil) is often absent.

Uncertainty is associated with each of the steps of the risk assessment process, including:

- Uncertainty in the selection of chemicals of concern arises from the extent to which the field samples accurately represent areas of contamination and the procedures used to include or exclude constituents as chemicals of concern

- Uncertainty associated with the exposure assessment includes the methods used and the assumptions made to determine exposure point concentrations

- Uncertainty in the toxicity assessment includes the quality of the existing data to support a determination of potential adverse impacts to ecological receptors

- Uncertainty in risk characterization includes that associated with the potential effects of exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier activities.

While these and other sources contribute to uncertainty, the manner ("direction") in which uncertainty impacts the final predictions produced by this assessment (i.e., over or under prediction) can be influenced by the assumptions made throughout the risk assessment process. As noted above, conservative assumptions were made so that the final calculated risks would result in an overestimation of potential risks attributable to conditions associated with OU2. Thus, uncertainty is associated with the degree to which the numerical values produced as a result of this process overestimate the actual risks.

7.3.4.1 Uncertainty in Selection of Chemicals of Potential Concern

The selection of final COPCs may increase the uncertainty associated with the final ecological risk values. Although a conservative, systematic, step-wise process was followed to identify chemicals to be excluded from further evaluation, it is possible that species sensitive to these compounds may inhabit the area near OU2 and be adversely impacted. The conservative approach employed throughout this ERA should serve to reduce this possibility but, in the face of data limitations regarding the impacts of industrial chemicals to most wildlife receptors, uncertainties remain.

7.3.4.2 Uncertainty in Exposure Assessment

Uncertainty in the exposure assessment arises for the methods used to calculate exposure point concentrations, the selection of benchmark values and endpoints, and the selection of exposure parameters.

7.3.4.2.1 Identification and Selection of Ecological Endpoints

Unlike human health risk assessments, the ERA must consider risks to many different species. However, calculation of risk values for each potential receptor species is not possible. For this ERA, conservative benchmark values that are protective of a wide range of ecological receptors were sought. The underlying assumptions associated with the use of these benchmarks is that contaminant concentrations in excess of these benchmarks are indicative of potential impacts to actual receptors inhabiting the area. However, species-specific physiological differences that may influence an organism's response to a contaminant or subtle behavioral differences that may increase/decrease a receptor's contact with a contaminant are seldom known. The use of benchmark values, while necessary, will introduce error into the results of an assessment.

In addition to uncertainty regarding the degree to which exceedances of benchmark values reflect risks to members of a community, uncertainty in the results of the risk assessment process arises when extrapolations are made across levels of ecological organization or from laboratory studies to field conditions. The majority of the currently available toxicological data rests on the response of individuals exposed to chemicals. Extrapolations from these simple endpoints to more complex, ecologically relevant endpoints such as impacts to populations or communities introduces uncertainty into the results of the risk assessment. The uncertainty associated with extrapolations from results based on laboratory test conditions to field situations has long been acknowledged but remains difficult to quantify.

7.3.4.2.2 Determination of Exposure Point Concentrations

The maximum detected contaminant concentration was used to indicate contaminant concentrations to which ecological receptors might be exposed. If the samples evaluated in this ERA are representative of contaminant concentrations associated with OU2, then this approach is conservative and should overestimate potential risks to ecological receptors. Maximum and mean soil contaminant concentrations were used in models that predict contaminant doses for ecological receptors. As with the initial screening, the use of maximum soil concentrations in these foodchain models will tend to overestimate risk. Therefore, mean concentrations were also used in risk calculations to obtain a range of risk numbers, although several conservative assumptions were retained. Because the extent to which the samples collected from sampling sites on OU2 actually represent contaminant concentrations present at OU2 is unknown, the determination of the exposure point concentrations contributes to the uncertainty associated with this ERA.

7.3.4.3 Uncertainty in the Toxicological Evaluation

Uncertainty associated with the toxicity assessment is associated with hazard assessment and dose-response evaluations for the chemicals of concern. The risk assessment deals with characterizing the nature and strength of the evidence of causation or the likelihood that a chemical that induces adverse effects in standard laboratory animals will also induce adverse effects in wildlife species.

Uncertainty in risk assessment arises from the nature and quality of the available toxicity data. Uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose-related; when postulated mechanisms of toxicity are similar for laboratory and wildlife species; and when the chemical of concern is structurally similar to other chemicals for which the toxicity is more completely characterized.

7.3.4.4 Uncertainty in the Risk Characterization

Uncertainty in risk characterization stems, in part, from the fact that this process does not consider antagonistic or synergistic effects. Little or no information is available to determine the potential for antagonism or synergism for the chemicals of concern. Therefore, this uncertainty cannot be discussed in terms of its impact on the risk assessment, since it may either underestimate or overestimate potential ecological risk.

There are several compounds (e.g., chloroethane, vanadium) that could not be evaluated in the ERA since no toxicity data could be identified. It is not known how this lack of information may impact the

characterization of risks associated with this site. No suitable surrogate compounds could be identified and used in this ERA for these compounds. Hence, they were retained as potential contaminants of concern. Their impact on the results of the assessment is unknown.

Since toxicity data for ecological receptors are scarce for many contaminants, extrapolations from laboratory species were necessary. Laboratory toxicity data were adjusted using uncertainty factors (UFs) to conservatively account for uncertainties inherent in data extrapolations. As a result, the calculated reference doses (RFDs) were extremely low. Therefore, the resulting HQs are, in part, a result of the lack of toxicity data, rather than actual risk.

7.3.5 Summary

The maximum exposure point concentrations and estimated dose received by receptors were compared to benchmark values that are protective of ecological receptors. Contaminants exceeding these values were regarded as ecological COPCs, and their toxicological properties were summarized. The relative potential risks that each of these COPCs might pose to ecological receptors inhabiting the area near OU2 were then evaluated in the form of Hazard Quotients.

Since only a few COPCs were identified in Turkey Gut surface waters and since their HQs were relatively low, potential risks to aquatic receptors from surface water contamination alone are expected to be minimal. In Turkey Gut sediments, only a few COPCs were identified and related HQs were generally low. The pesticide COPCs identified may be of concern due to their tendency to persist and bioaccumulate. However, these pesticides are no longer in use and were not COPCs in OU2 site soil. In addition, pesticides were also detected in background soil samples collected at the Air Station (not only at OU2).

Only one COPC (4,4'-DDD) was identified in Slocum Creek surface water. This pesticide was detected at similar concentrations in all samples collected from Slocum Creek, including the location upstream of OU2. Therefore, OU2 is not the source of this COPC. No COPCs were identified in Slocum Creek sediment. Therefore, there is no indication that the pesticides detected in Turkey Gut are migrating to Slocum Creek.

The benchmark values for the soil COPCs were exceeded only at single sample locations, suggesting a lack of widespread contamination. In addition, some of the benchmark values were based on human health or agricultural scenarios. As a result, risks to terrestrial receptors from contamination in OU2 soils appear to be insignificant.

There is no significant risk posed to ecological receptors from OU2 site contaminants in soil, Slocum Creek, or Turkey Gut. The results of the ecological assessment indicate that some contaminants are present in soil and Turkey Gut sediment in concentrations that result in HQs indicative of potential risk. However, risks implied by these exceedances are mitigated by several factors.

- Only a few COPCs were identified at OU2.
- HQs for COPCs were relatively low.
- Detections of many of the COPCs were isolated.
- Contaminants posing potential risk from exposure to Turkey Gut sediment were also detected in background soil samples collected at the Air Station (not only at OU2) and are not migrating to Slocum Creek.
- Risk numbers generated from the food chain models were based on scattered detections of chemicals. The models conservatively assumed that the receptors were be exposed to the detections their entire life. In addition, the risk values were mainly driven by uncertainty in toxicity data, rather than actual risk.

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APPENDIX A

SOIL BORING, TEST PIT, MONITORING WELL BORING, AND GEOPHYSICAL LOG SHEETS

A.1 SOIL BORING LOG SHEETS - 1983 THROUGH 1996

A.2 TEST PIT LOG SHEETS - 1992 AND 1993

A.3 MONITORING WELL LOG SHEETS - 1981 THROUGH 1996

A.4 GEOPHYSICAL LOG SHEETS - 1994

A.1 SOIL BORING LOG SHEETS - 1983 THROUGH 1996

BORING LOG

PROJECT NAME: CHERRY POINT CTO 190
PROJECT NUMBER: 4513
DRILLING COMPANY: HALDIN HUBER
WATER LEVEL DATA:

BORING NUMBER: OU2 SB9
DATE: 4-11-96
GEOLOGIST: FRED W RAMSFIR

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	FID or PID Reading (ppm)
									OU2SB-01-0001 # FOR ANALYSIS.	
S-1 1140	2	5/6			LOOSE	YEL BRN	SILTY SAND	SP	WOOD FRAGS, S-1, 2-4'	27
		8/10	1.8/2.0							
S-2 1145	4	7/6			LOOSE	YEL BRN	SILTY SAND	SP	WOOD, PLASTIC PAPER FRAGS	16
		7/7	1.0/2.0			TO GREY			4-6'	
	6									
S-3 1158		3/4			LOOSE	GREY BLK	SILT SAND	SP	PLASTIC, PAPER	50
	8	40/2	1.5/2.0			YEL BRN				
S-4 1105		7/6			LOOSE	YEL BRN	SILTY SAND	SP	PLASTIC WOOD PAPER TRASH	18
	10	2/4	.5/2.0						COLLECTED	
									~~OU02SB-01~~ OU02SB-07-0010	
							TD = 8'			
							SS TO 10'		*OU02SB09-0001	
									COLLECTED USING	
									SHOVEL + STAINLESS STEEL TROWELL	

*When rock coring enter rock brokeness.

CONVERTED TO WELL: ___ Yes ✓ No;
BORING ~~WELL~~ I.D.#: OU2 SB09
REMARKS: 8 ppm @ GZ 0.0 AT BZ ~~HTS~~ 1153
0 ppm @ GZ 1200, 0.0 @ BZ
PURPOSE, TO SAMPLE FOR SOILS SENT TO LAB. FOR ANAL.
Signature(s): [illegible]

BORING LOG

PROJECT NAME: CHERRY POINT
PROJECT NUMBER: 4513
DRILLING COMPANY: HARDIN-HUTSER
WATER LEVEL DATA:

BORING NUMBER: OU2SB10
DATE: 4-15-96
GEOLOGIST: FRED W. RAMSER

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	FID or PID Reading (ppm)
S-1 1102		4/3			LOOSE	YEL	BRN TO DKBRN SAND & SILT		COLLECTED OU02SB-10-0001*	0.0
	2	2/2	1.0/2.0				SOME ORGANICS TR WOOD FRAG> (BURNT)		FOR DIOXIN	
S-2 1108		8/11			LOOSE	YEL	BRN TO FINE TO MED SAND	SP	MOIST	0.0
	4	15/16	2.0/2.0			GREYISH BRN				
S-3 1115		7/8				YEL BRN	SILT TR WOOD CHARCOAL	SP/SM		0.0
	6	10/12	2.0/2.0		LOOSE	GREY	MED SAND TR WOOD CHARCOAL	SP/SM	SATURATE @ 6' COLLECTED OU02SB-10-0406	
							TD @ 4'			
							SP TO 6'			
							H_2O @ 6'			

*When rock coring enter rock brokeness.

CONVERTED TO WELL: ___ Yes ✓ No; WELL I.D.#: —

REMARKS: HOLE COLLASPED BACKFILLED 2' WITH CUTTINGS
PURPOSE OF THIS BORING IS TO COLLECT SOIL FOR CHEM. ANALYTICAL
*S-1 SAMPLE COLLECTED FROM 0-1' INTERVAL, BOTTOM PORTION OF 0-2' FOOT SPLIT SPOON NOT RECOVERED.

Signature(s): FWRamser

A.3 MONITORING WELL LOG SHEETS - 1981 THROUGH 1996

BORING LOG

PROJECT NAME: CHERRY POINT CTO190
PROJECT NUMBER: 4513
DRILLING COMPANY: HARDIN HUBER
WATER LEVEL DATA:

BORING NUMBER: OU2HP07 (OU2MW13)
DATE: 4-5-96
GEOLOGIST: FREDI RAMSER

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	FID or PID Reading (ppm)
						BLK YEL-BRN	TOP SOIL MED SAND		AUGERED TO TWO FEET	
	2									
S-1 1044					SOFT/LOOSE	PALE GREY	CLAYSAND	SP/SC	WET MAYBE PERCH	0.0
	4		1.8/2.0							
S-2 1100		1/60			LOOSE	PALE MOD BRN + YEL	MED SAND	SP	SATURATED	0.0
	6	10/11	1.5/2.0				BROWN		PLACE SCREEN @ 2'-12'	
	8						AUGER TO 13'			
							YEL BRN MED SAND			
	10									
	12									

*When rock coring enter rock brokeness.

CONVERTED TO WELL: ✓ Yes ___ No;
WELL I.D.#: OU2HP07 → OU2MW13
REMARKS: ATV RIG 4¼ HSA 2" SPLIT SPOONS

Signature(s): [illegible]

BORING LOG

PROJECT NAME: CHERRY POINT
PROJECT NUMBER: 4513
DRILLING COMPANY: HARDIN-HUBER
WATER LEVEL DATA:

BORING NUMBER: OU2HPØ8(OU2MW14)
DATE: 4-4-96
GEOLOGIST: FRED W RAMSER

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	FID or PID Reading (ppm)
						PK BRN TO MED BROWN	MED SAND		AUGERED TO TWO FT.	
	2									
S-1 1450		3/3			LOOSE	MOD BRN TO YEL BRN	MED SAND TR SILT	SP/SM	MOIST	0.0
	4	3/4	1.8/2.0			PALE TO				
S-2 1456		2/3			LOOSE	MODERATE YELLOWISH	MEDSAND	SP	MOIST	0.0
	6	4/5	1.8/2.0			BRN				
S-3 1506		10/3			LOOSE		MODERATE YELLOWISH BRN MED SAND	SP	MOIST	0.0
	8	4/5	1.5/2.0							
S-4 1513		2/3			LOOSE					0.0
	10	2/3	1.5/2.0						MOIST	
S-5 1520		1/2			LOOSE	MOTTLED PALE TO MOD. YEL BRN	MED SAND	SP	TRACE IRON STAINING	0.0
	12	3/5	1.7/2.0				3" SILTY FINE SAND LAYER @ 11.5'			
S-6 1529		3/6			LOOSE	MOTTLED MOD TO PALE YEL BRN	MED TO COARSE SAND	SP		0.0
	14	7/9	1.4/2.0						WET AT 13'	
S-7 1540		3/6			DENSE			SP	SATURATED	0.0
	16	9/10	1.3/2.0						MEASURED H_2O IN HOLE @ 13'	
							AUGERED TO 21'		PLACE SCREEN @ 11' TO 21'	
							TO INSTALL PVC			
							SANDS BEGIN TO RUN INTO AUGER UP TO WATER TABLE			
							WILL USE POTABLE WATER TO KEEP SAND			
							DOWN OUT OF AUGERS			
							DRILLED TO 22'			

*When rock coring enter rock brokeness.

CONVERTED TO WELL: ✓ Yes ___ No;
WELL I.D.#: OU2HPØ8 → OU2MW14
REMARKS: ATV RIG, 4 1/4 HSA, 140 lb HAMMER

Signature(s): FWRamser

BORING LOG

PROJECT NAME: CHERRY POINT CTO190
PROJECT NUMBER: 4513
DRILLING COMPANY: HARDIN-HUBER
WATER LEVEL DATA:

BORING NUMBER: OU2 HP09 (OU2 MW15)
DATE: 4-9-96
GEOLOGIST: FRED W. RAMSER

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	FID or PID Reading (ppm)
	2									
S-1 1555		4/4			LOOSE	LT OLIVE GREY	MED TO FINE SAND TR SILT	SP	MOIST	0.0
	4	5/6	1.5/2.0							
S-2 1552		5/5			MED LOOSE		MED TO FINE SAND	SP	WET @ 5.5'	0.0
	6	5/5	2.0/2.0							
S-3 1605		3/4					MED TO FINE SAND	SP	SHT.	0.0
	8	5/7	2.0/2.0			LT OLIVE GREY	SAND			
							AUGERED TO 13'			
	10									
	12									
									INSTALL WELL	
									SCREEN 3-13'	
									SAND 2-13	

*When rock coring enter rock brokeness.

CONVERTED TO WELL: ✓ Yes ___ No; WELL I.D.#: OU2MW15
REMARKS: BGI ATV RIG 7" SPLIT SPOON; 4 1/4 HSA

Signature(s): [illegible]

BORING LOG

PROJECT NAME: CHERRY POINT
PROJECT NUMBER: 4513
DRILLING COMPANY: HARDIN-HUBER
WATER LEVEL DATA:

BORING NUMBER: OU2HP09 10
DATE: 4-10-96
GEOLOGIST: FRED WRANKSER

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	FID or PID Reading (ppm)
									AUGERED TO TWO FEET	
	2									
S-1 0925		3/3			LOOSE	MED BRN	SILTY FINE SAND	SP/SC	MOIST	0.0
	4	2/3	2.0/2.0			YEL GREY			WET @ 3'	
S-2 0928		3/4			LOOSE (SUPT)		SILTY FINE SAND TR CLAY	SC	MOIST	0.0
	6	5/6	2.0/2.0				CLAYEY FINE SAND	SC		
S-3 0933		5/4			LOOSE	YEL BRN	MED SAND	SP/SC	HIT H_2O @ 6'	0.0
	8	6/8	1.8/2.0			YEL GREY	MOTTLED		CLAY 2" @ 8'	
							AUGER TO 14.5'		SCREEN 4-14	
	10					YEL BRN	MED SAND	SP	SAND 3-14.5	
						YEL GREY			BENTONITE 2-3	
	12									
	14									

*When rock coring enter rock brokeness.

CONVERTED TO WELL: ___ Yes ✓ No; WELL I.D.#: PVC PULLED, HOLE BACKFILLED
REMARKS: B61 ATV RIG, 4 1/4 HSA, SPLITSPOONS

Signature(s): [illegible]

BORING LOG

PROJECT NAME: CHERRY POINT CTO 190
PROJECT NUMBER: 4513
DRILLING COMPANY: HARDIN - HUBER
WATER LEVEL DATA:

BORING NUMBER: OU2 HP11
DATE: 4-10-96
GEOLOGIST: FRED W RAMSEY

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	FID or PID Reading (ppm)
							TOP SOIL YEL BRN - GREY SAN			
	2						↓			
S-1 1325		3/5			LOOSE	LIGHT OLIVE GREY	FINE SAND + SILT TR CLAY	SP/SC	MOIST	0.0
	4	6/7	2.0							
S-2 1328		3/4			LOOSE		FINE SAND		MOIST	0.0
	6	4/4	2.0/2.0			YEL BRN	MED SAND INTERLAYER		WET @ 5.5	
S-3 1333		4/4			LOOSE	YEL BRN	MED SAND INTERLAYERED W/ FINE SAN	SP	WET	0.0
	8	5/2	2.0/2.0			TO PALE YEL BRN		SP	AUGER TO 14'	
							AUGERED TO	SP	SCREEN 4'-14'	
	10						15'		SAND 3-15'	
							YEL BRN SAND			
	12									
	14									
							↓	↓		

*When rock coring enter rock brokeness.

CONVERTED TO WELL: ✓ Yes ___ No; WELL I.D.#: OU2 MW16

REMARKS: BGL TRUCK MT. 4 1/4 HSA, 2" SPLIT SPOONS

Signature(s): FWRamsey

BORING LOG

PROJECT NAME: CHERRY POINT CTO 160
PROJECT NUMBER: 4513
DRILLING COMPANY: HARDIN HUBER
WATER LEVEL DATA:

BORING NUMBER: OU2 HP 12
DATE: 4-10-96
GEOLOGIST: FRED W RAMSER

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	FID or PID Reading (ppm)
	2									
S-1 1620		9/6			MED LOOSE	YEL BRN	FINE TO MED SAND SOME SILT	SP/SC	MOIST	0.0
	4	9/11	1.3/2.0				↓			
S-2 1623		3/6			LOOSE	YEL BRN	MED SAND	SP	WET @ 5.4'	0.0
	6	7/8	1.2/2.0							
S-3 1630		5/4			LOOSE	MOTTLED YEL	MED SAND	SP	WET IRON STAIN	
	8	5/4	1.2/2.0			ORANGE BRN			2" CLAY LAYER	0.0
S-4 1635		2/3			LOOSE		AS ABOVE	SP		
	10	4/6	1.2/2.0							0.0
							AUGERED TO 14		SCREEN 3-13	
									SAND 2-14	
									BENTONITE 1-2	

*When rock coring enter rock brokeness.

CONVERTED TO WELL: ___ Yes ✓ No; WELL I.D.#: PVC PULLED HOLE BACKFILLED
REMARKS: B-61 TRUCK 4 1/4 HSA 2" SPLIT SPOONS

Signature(s): F W Ramser

BORING LOG

PROJECT NAME: CHERRY POINT CTO 190
PROJECT NUMBER: 4513
DRILLING COMPANY: HARDIN-HUBER
WATER LEVEL DATA: HIT H_2O ~5'

BORING NUMBER: OU2HP13
DATE: 4-9-96
GEOLOGIST: FREDW RAMSER

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	FID or PID Reading (ppm)
									AUGERED TO 2'	
	2	4/5								
S-1 ~~1350~~		4/5			MED LOOSE	YEL-BRN TO PINK	FINE TO MED SAND	SP	MOIST	0.0
1350	4	6/7	1.8/2.0			MEL GRAY MOTTLED				
S-2 1357		2/4			↓	↓	FINE TO MED SAND COARSING DOWNWARD	SP/SC	MOIST TO WET	0.0
	6	5/6	1.5/2.0		↓	↓	~2" CLAY LAYER @ 6' +4.5'			
S-3 1400		2/2							HIT H_2O @ 5.6'	
	8	1/2	1.2/2.0			MED GREY	BLUISH CLAYEY FINE SAND COARSING DOWN TO MED SAND	CL/SP		0.0
S-4 1408		2/2			LOOSE		SAME AS ABOVE		PLACE SCREEN @ 3-13'	0.0
	10	1/2	2.0/2.0				W/CLAYEY SAND ~9' (3" THICK)			
							AUGERED TO 13.5'			

*When rock coring enter rock brokeness.

CONVERTED TO WELL: ___ Yes ✓ No; WELL I.D.#: PVC PULLED, HOLE BACKFILLED

REMARKS: D-61 ATV, 150 lb HAMMER, 2" SPLIT SPOONS FOR LITHOLOGY CHART
4'/4 HSA

Signature(s): FWRamser

APPENDIX B

MONITORING WELL CONSTRUCTION SHEETS
1981 THROUGH 1996

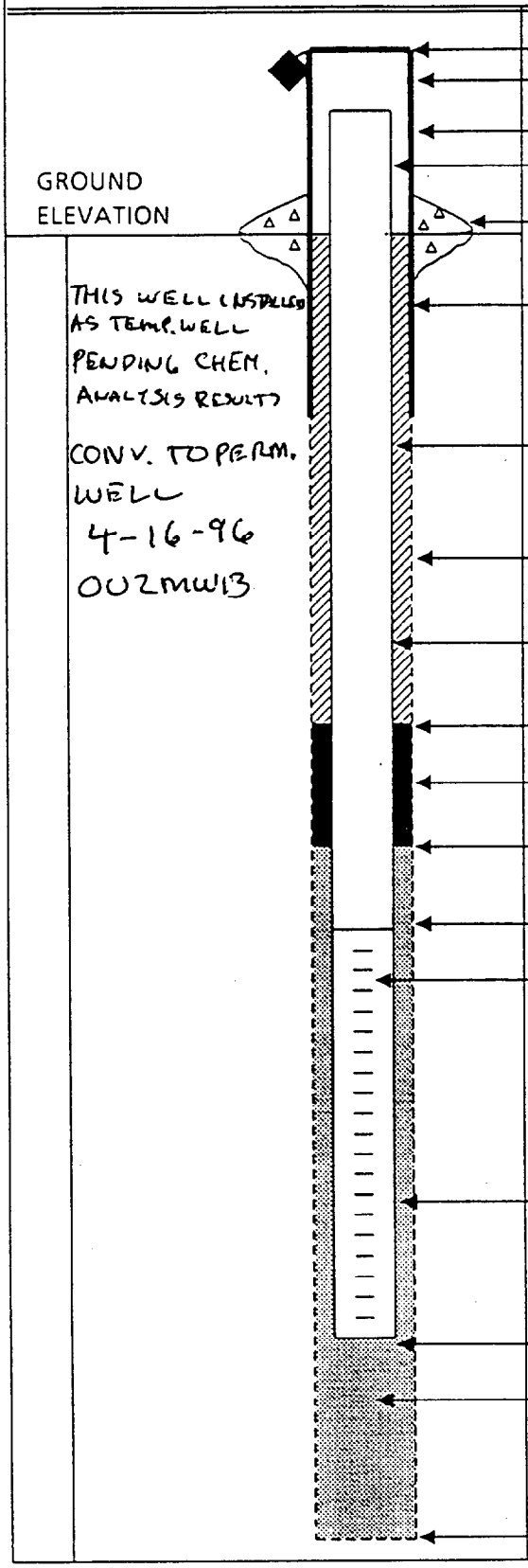
BORING NO.: HP07
OU2MW13

OVERBURDEN
MONITORING WELL SHEET

PROJECT CHERRY POINT CTO 190
PROJECT NO. 4513
ELEVATION 7.7
FIELD GEOLOGIST FREDLRAMSER

LOCATION OU2
BORING HP07
DATE 4.5.96

DRILLER DAVETAYLOR H&H
DRILLING METHOD HSA
DEVELOPMENT METHOD PUMP



ELEVATION OF TOP OF SURFACE CASING: 9.67
ELEVATION OF TOP OF RISER PIPE:
STICK - UP TOP OF SURFACE CASING: 3
STICK - UP RISER PIPE : 2'
TYPE OF SURFACE SEAL: 5'x5'x6" SQ CONCRETE PAD w/POST
I.D. OF SURFACE CASING: 6" SQ
TYPE OF SURFACE CASING: STEEL
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: SCH 40 PVC
BOREHOLE DIAMETER: 8"
TYPE OF BACKFILL: NONE
ELEVATION / DEPTH TOP OF SEAL: 7.7 / 0.0'
TYPE OF SEAL: 3/8" BENTONITE
DEPTH TOP OF SAND PACK: 1
ELEVATION / DEPTH TOP OF SCREEN: 5.7 / 2
TYPE OF SCREEN: PVC
SLOT SIZE x LENGTH: .010 x 10
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: #1 GRAVEL
ELEVATION / DEPTH BOTTOM OF SCREEN: -4.3 / 12
ELEVATION / DEPTH BOTTOM OF SAND PACK: -4.8 / 12.5
TYPE OF BACKFILL BELOW OBSERVATION WELL:
ELEVATION / DEPTH OF HOLE: -4.8 / 12.5

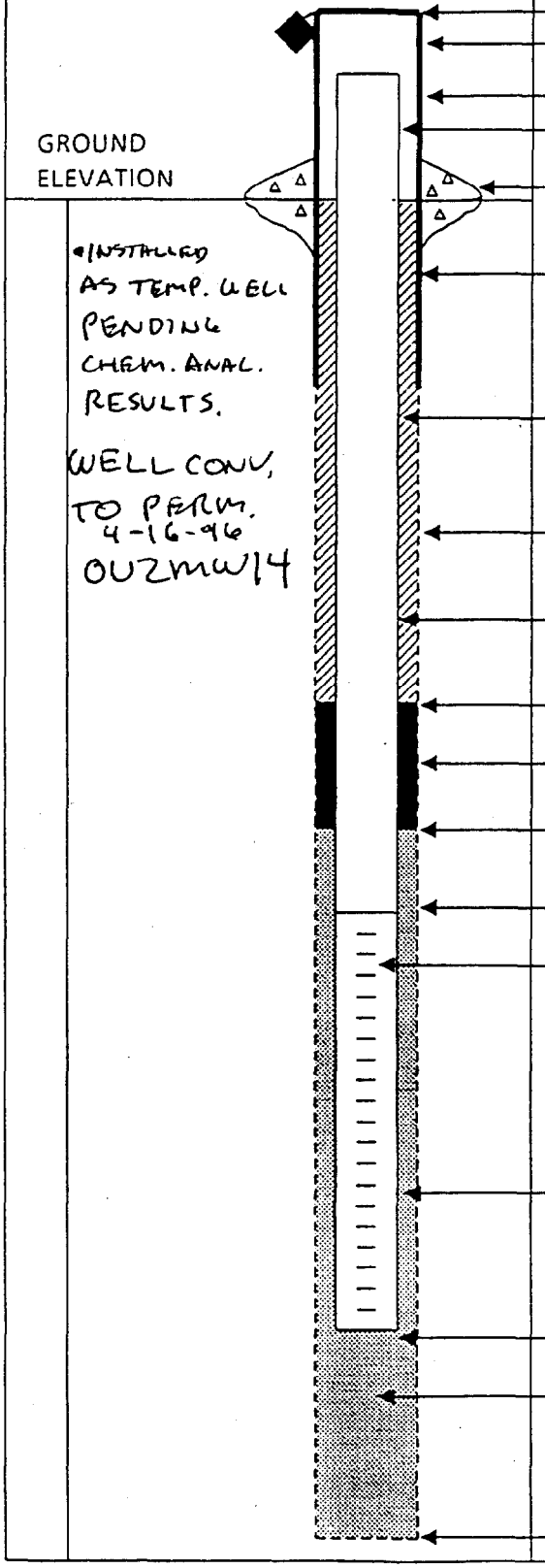
BORING NO.: HP08
OU2MW14

OVERBURDEN
MONITORING WELL SHEET

PROJECT CHERRY POINT
PROJECT NO. 4513
ELEVATION 24.4
FIELD GEOLOGIST FREDW RAMSER

LOCATION OU2
BORING HP08
DATE 4-4-96

DRILLER DAVE TAYLOR
DRILLING METHOD HSA
DEVELOPMENT METHOD PUMP



ELEVATION OF TOP OF SURFACE CASING :
ELEVATION OF TOP OF RISER PIPE: 26.63

STICK - UP TOP OF SURFACE CASING: 3
STICK - UP RISER PIPE : 2'

TYPE OF SURFACE SEAL: 5'x5'x6" SQ PAD w/POST

I.D. OF SURFACE CASING: 6" SQ
TYPE OF SURFACE CASING: STEEL

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: PVC SCH 40

BOREHOLE DIAMETER: 8"

TYPE OF BACKFILL:

ELEVATION / DEPTH TOP OF SEAL: 17.4 / 7'

TYPE OF SEAL: BENTONITE PELLETS

DEPTH TOP OF SAND PACK: 15.4 9'

ELEVATION / DEPTH TOP OF SCREEN: 13.4 / 11'

TYPE OF SCREEN: PVC

SLOT SIZE x LENGTH: .010" x 10'

I.D. OF SCREEN: 2"

TYPE OF SAND PACK: #1 GRAVEL

ELEVATION / DEPTH BOTTOM OF SCREEN: 3.4 / 21'

ELEVATION / DEPTH BOTTOM OF SAND PACK: 2.4 / 2
TYPE OF BACKFILL BELOW OBSERVATION WELL:

ELEVATION / DEPTH OF HOLE: 2.4 / 22'

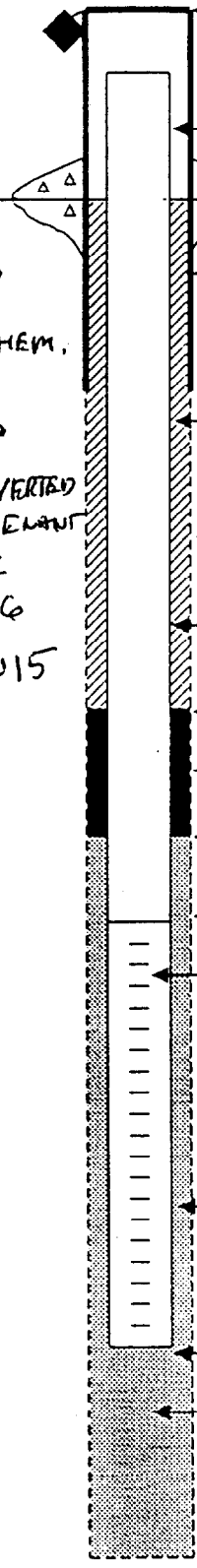
BORING NO.: HP09
OU2MW15

OVERBURDEN
MONITORING WELL SHEET

PROJECT CHERRY POINT
PROJECT NO. 4513
ELEVATION 24.2
FIELD GEOLOGIST FRED W RAMSER

LOCATION OU2
BORING HP09
DATE 4-9-96

DRILLER DAVE TAYLOR
DRILLING METHOD HSA
DEVELOPMENT METHOD PUMP



GROUND ELEVATION

THIS WELL INSTALLED AS TEMP. PENDING CHEM. ANALYSIS RESULTS.

WELL CONVERTED TO A PERMENANT STRUCTURE 4-16-96

OU2MW15

ELEVATION OF TOP OF SURFACE CASING :
ELEVATION OF TOP OF RISER PIPE: 26.36

STICK - UP TOP OF SURFACE CASING: 3
STICK - UP RISER PIPE : 2'

TYPE OF SURFACE SEAL: 5'x5'x6" SQ PAD "SACKRETE" W/POST

I.D. OF SURFACE CASING: 6" SQ
TYPE OF SURFACE CASING: STEEL

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: PVC SCH 40

BOREHOLE DIAMETER: 8"

TYPE OF BACKFILL: NONE

ELEVATION / DEPTH TOP OF SEAL: 23.2 / 1

TYPE OF SEAL: 3/8" BENTONITE PELLETS

DEPTH TOP OF SAND PACK: 2

ELEVATION / DEPTH TOP OF SCREEN: 21.2 / 3

TYPE OF SCREEN: PVC

SLOT SIZE x LENGTH: .010" x 10'

I.D. OF SCREEN: 2"

TYPE OF SAND PACK: #1 GRAVEL

ELEVATION / DEPTH BOTTOM OF SCREEN: 11.2 / 13

ELEVATION / DEPTH BOTTOM OF SAND PACK: 10.2 / 14

TYPE OF BACKFILL BELOW OBSERVATION WELL: SAND

ELEVATION / DEPTH OF HOLE: 10.2 / 14

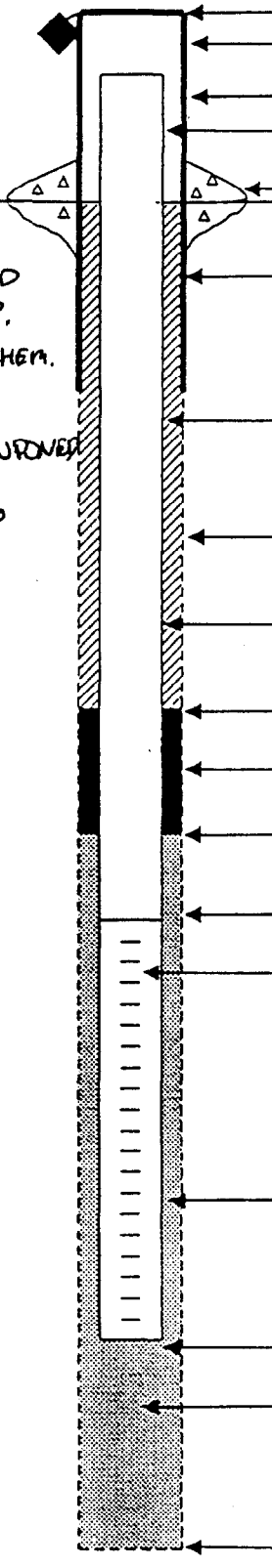
BORING NO.: HP10
OU2

OVERBURDEN
MONITORING WELL SHEET

PROJECT CHERRY POINT
PROJECT NO. 4513
ELEVATION 21.7
FIELD GEOLOGIST FRED WRAMSER

LOCATION OU 2
BORING HP10
DATE 4-10-96

DRILLER DAVE TAYLOR
DRILLING METHOD HSA
DEVELOPMENT METHOD PUMP



GROUND ELEVATION

THIS WELL INSTALLED AS TEMP. PENDING CHEM. ANALYSIS

* WELL ABANDONED 4-16-96

ELEVATION OF TOP OF SURFACE CASING :
ELEVATION OF TOP OF RISER PIPE:
STICK - UP TOP OF SURFACE CASING:
STICK - UP RISER PIPE : 2.0
TYPE OF SURFACE SEAL:
I.D. OF SURFACE CASING:
TYPE OF SURFACE CASING:
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: PVC SCH 40
BOREHOLE DIAMETER: 8"
TYPE OF BACKFILL:
ELEVATION / DEPTH TOP OF SEAL: 12
TYPE OF SEAL: 3/8" BENTONITE PELLETS
DEPTH TOP OF SAND PACK: 3
ELEVATION / DEPTH TOP OF SCREEN: 14
TYPE OF SCREEN: PVC
SLOT SIZE x LENGTH: .010" x 10'
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: #1 GRAVEL
ELEVATION / DEPTH BOTTOM OF SCREEN: 114
ELEVATION / DEPTH BOTTOM OF SAND PACK: 116
TYPE OF BACKFILL BELOW OBSERVATION WELL:
ELEVATION / DEPTH OF HOLE: 114

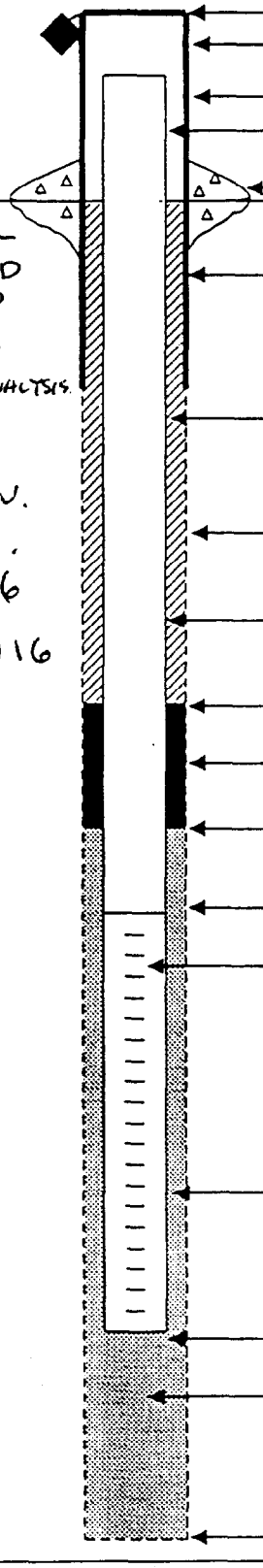
BORING NO.: HP11
OU2MW16

OVERBURDEN
MONITORING WELL SHEET

PROJECT CHERRY POINT
PROJECT NO. 4513
ELEVATION 23.6
FIELD GEOLOGIST FRED W RAMSER

LOCATION OU2
BORING HP11
DATE 4-16-96

DRILLER DAVE TAYLOR H.H.
DRILLING METHOD HSA
DEVELOPMENT METHOD PUMP



GROUND ELEVATION

THIS WELL INSTALLED AS TEMP PENDING CHEM. ANALYSIS RESULTS

WELL CONV. TO PERM. 4-16-96

OU2MW16

ELEVATION OF TOP OF SURFACE CASING:
ELEVATION OF TOP OF RISER PIPE: 25.29

STICK - UP TOP OF SURFACE CASING: 3'
STICK - UP RISER PIPE: 2'

TYPE OF SURFACE SEAL: 5'x5'x6" SQ PAD "SACKRETE" W/POST

I.D. OF SURFACE CASING: 6" SQ
TYPE OF SURFACE CASING: STEEL

RISER PIPE I.D. 2"
TYPE OF RISER PIPE: PVC SCH 40

BOREHOLE DIAMETER: 8"

TYPE OF BACKFILL: NONE

ELEVATION / DEPTH TOP OF SEAL: 21.6 / 2

TYPE OF SEAL: 3/8 BENTONITE PELLETS

DEPTH TOP OF SAND PACK: 3

ELEVATION / DEPTH TOP OF SCREEN: 19.6 / 4

TYPE OF SCREEN: PVC

SLOT SIZE x LENGTH: .010 x 10'

I.D. OF SCREEN: 2"

TYPE OF SAND PACK: #1 GRAVEL

ELEVATION / DEPTH BOTTOM OF SCREEN: 9.6 / 14

ELEVATION / DEPTH BOTTOM OF SAND PACK: 8.6 / 15

TYPE OF BACKFILL BELOW OBSERVATION WELL:

ELEVATION / DEPTH OF HOLE: 8.6 / 15

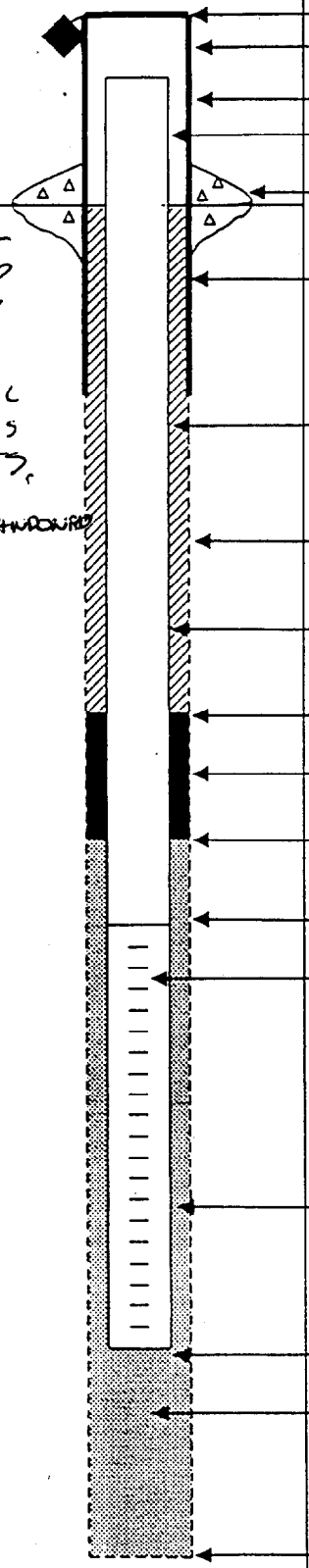
BORING NO.: HP12
OU2

OVERBURDEN
MONITORING WELL SHEET

PROJECT CHERRY POINT
PROJECT NO. 4513
ELEVATION 23.6
FIELD GEOLOGIST FRED W. RAMSER

LOCATION OU2
BORING HP12
DATE 4-10-96

DRILLER DAVE TAYLOR
DRILLING METHOD HSA
DEVELOPMENT METHOD PUMP



GROUND ELEVATION

THIS WELL INSTALLED AS TEMP PENDING CHEMICAL ANALYSIS RESULTS.

* WELL ABANDONED 4-16-96

ELEVATION OF TOP OF SURFACE CASING :
ELEVATION OF TOP OF RISER PIPE:
STICK - UP TOP OF SURFACE CASING:
STICK - UP RISER PIPE : 2'
TYPE OF SURFACE SEAL:
I.D. OF SURFACE CASING:
TYPE OF SURFACE CASING:
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: PVC SCH 40
BOREHOLE DIAMETER: 8"
TYPE OF BACKFILL:
ELEVATION / DEPTH TOP OF SEAL: 11
TYPE OF SEAL: 3/8" BENTONITE PELL
DEPTH TOP OF SAND PACK: 2
ELEVATION / DEPTH TOP OF SCREEN: 13
TYPE OF SCREEN: PVC
SLOT SIZE x LENGTH: .010 x10'
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: #1 GRAVEL
ELEVATION / DEPTH BOTTOM OF SCREEN: 113
ELEVATION / DEPTH BOTTOM OF SAND PACK: 1
TYPE OF BACKFILL BELOW OBSERVATION WELL:
ELEVATION / DEPTH OF HOLE: 114

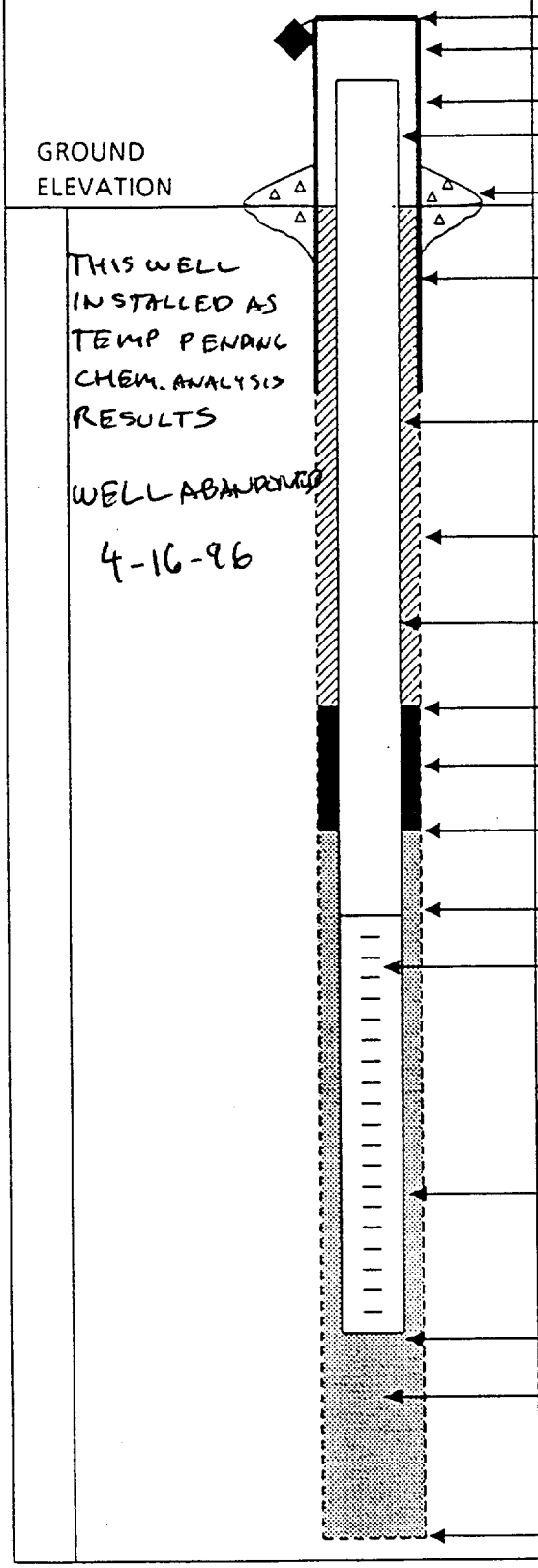
BORING NO.: HP13
OU2

OVERBURDEN
MONITORING WELL SHEET

PROJECT CHERRY POINT
PROJECT NO. 4513
ELEVATION 22.7
FIELD GEOLOGIST FRED WRAMSER

LOCATION OU2
BORING HP13
DATE 4-9-96

DRILLER DAVE TAYLOR
DRILLING METHOD HSA
DEVELOPMENT METHOD PUMP



THIS WELL INSTALLED AS TEMP PENDING CHEM. ANALYSIS RESULTS

WELL ABANDONED 4-16-96

ELEVATION OF TOP OF SURFACE CASING :
ELEVATION OF TOP OF RISER PIPE:
STICK - UP TOP OF SURFACE CASING:
STICK - UP RISER PIPE : 2'
TYPE OF SURFACE SEAL: ~~5'x5'x6" SQ PVC CONCRETE PAD W/P.PVC~~
I.D. OF SURFACE CASING:
TYPE OF SURFACE CASING:
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: PVC SCH 40
BOREHOLE DIAMETER: 8"
TYPE OF BACKFILL:
ELEVATION / DEPTH TOP OF SEAL: 11
TYPE OF SEAL: 3/8" BENTONITE PELLETS
DEPTH TOP OF SAND PACK: 2
ELEVATION / DEPTH TOP OF SCREEN: 13
TYPE OF SCREEN: PVC SCH 40
SLOT SIZE x LENGTH: .010" x 10'
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: #1 GRAVEL
ELEVATION / DEPTH BOTTOM OF SCREEN: 113
ELEVATION / DEPTH BOTTOM OF SAND PACK: 114
TYPE OF BACKFILL BELOW OBSERVATION WELL:
ELEVATION / DEPTH OF HOLE: 114