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FINAL FEASIBILITY STUDY REPORT SITE 69 OPERABLE UNIT 14 (OU14) MCBC CAMP LEJEUNE NC

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CH2M HILL

Final

Feasibility Study
Site 69, Operable Unit No. 14

Marine Corps Base Camp Lejeune
Jacksonville, North Carolina

Prepared for

Department of the Navy

Naval Facilities Engineering Command
Mid-Atlantic

Contract No.
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Acronyms and Abbreviations

µg/L	microgram(s) per liter
3DMe	3-D Microemulsion
ARAR	applicable or relevant and appropriate requirement
Baker	Baker Environmental, Inc.
bgs	below ground surface
BHC	benzene hexachloride
CA	chemical agent
CEHNC	U.S. Army Engineering and Support Center, Huntsville
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action – Navy
COC	contaminant of concern
CVOC	chlorinated volatile organic compound
DCA	dichloroethane
DCE	dichloroethene
DDT	dichlorodiphenyltrichloroethane
DGM	digital geophysical mapping
DHC	*Dehalococcoides*
DO	dissolved oxygen
DoN	Department of the Navy
ERA	Ecological Risk Assessment
ERD	Enhanced Reductive Dechlorination
FS	Feasibility Study
ft	feet
ft/ft	feet per foot
ft/day	feet per day
ft/year	feet per year
GHG	greenhouse gas
GRA	General Response Action
HHRA	Human Health Risk Assessment
IAS	Initial Assessment Study
IC	institutional control
ISCO	in situ chemical oxidation
IROD	Interim Record of Decision
KGB	coaxial groundwater ventilation
LTM	long-term monitoring
LUC	land use control
LUCIP	Land Use Control Implementation Plan
MCB CamLej	Marine Corps Base Camp Lejeune
MCL	Maximum Contaminant Level
MEC	munitions and explosives of concern
mg/L	milligram(s) per liter
MNA	monitored natural attenuation
mV	millivolt(s)

n_e	effective porosity
NA	natural attenuation
NAIP	natural attenuation indicator parameter
NAVFAC	Naval Facilities Engineering Command
NCDENR	North Carolina Department of Environment and Natural Resources
NCGWQS	North Carolina Groundwater Quality Standards
NCP	National Contingency Plan
NCSWQS	North Carolina Surface Water Quality Standards
NOD	natural oxidant demand
NO_x	nitrogen oxides
O&M	operation and maintenance
ORP	oxidation-reduction potential
PCA	tetrachloroethane
PCB	polychlorinated biphenyl
PM	particulate matter
PPE	personal protective equipment
PRB	Permeable Reactive Barrier
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
ROI	radius of influence
SBP	SBP Technologies
SI	Supplemental Investigation
SO_x	sulfur oxides
SVE	soil-vapor extraction
SVOC	semivolatile organic compound
TAL	target analyte list
TCA	trichloroethane
TCE	trichloroethene
TOC	total organic carbon
TS	Treatability Study
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
UVB	vacuum vaporizer well
UXO	unexploded ordnance
VC	vinyl chloride
VOC	volatile organic compound
WAR	Water and Air Research, Inc.
ZOI	zone of influence
ZVI	zero valent iron

SECTION 1

Introduction

This report describes the Feasibility Study (FS) for Site 69, Operable Unit No. 14, at Marine Corps Base Camp Lejeune (MCB CamLej) in Onslow County, North Carolina. This FS report was prepared under the Naval Facilities Engineering Command (NAVFAC) – Atlantic, Comprehensive Long-Term Environmental Action – Navy (CLEAN) 1000 Contract N62470-08-D-1000, Contract Task Order 0081.

MCB CamLej presently covers approximately 236 square miles and is a training base for the U.S. Marine Corps. Site 69, the Rifle Range Chemical Dump, was first identified in the 1983 Basewide Initial Assessment Study (IAS) as a priority site for further investigation because of historical disposal activities (WAR, 1983). From 1950 to 1976, Site 69 was reportedly used for the disposal of chemical wastes, including polychlorinated biphenyls (PCBs), solvents, and pesticides. According to one account, chemical agent (CA) may have been disposed of in the form of 50 to 60 drums containing mustard or nerve agent (Scudder, 1982).

MCB CamLej was placed on the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) National Priorities List effective November 4, 1989 (54 *Federal Register* 41015, October 4, 1989). As a result, the U.S. Environmental Protection Agency (USEPA) Region IV, the North Carolina Department of Environment and Natural Resources (NCDENR), the Department of the Navy (DoN) and the Marine Corps entered into a Federal Facilities Agreement for MCB CamLej in 1991. The primary purpose of that agreement is to thoroughly investigate environmental impacts associated with past and present activities at the Base. The DoN's Installation Restoration Program is responsible for ensuring that appropriate CERCLA response and Resource Conservation and Recovery Act (RCRA) corrective action alternatives are developed and implemented as necessary to protect public health and welfare, and the environment at Navy installations.

1.1 Report Purpose

The purpose of this FS report is to describe the evaluation of the potential remedial alternatives to address the contamination identified during the Remedial Investigation (RI) and subsequent investigations, which were evaluated in the following sequence:

- Identify the remedial action objectives (RAOs)
- Identify potential treatment, resource recovery, and containment technologies that will satisfy these objectives
- Screen the technologies based on their effectiveness, implementability, and cost
- Assemble the technologies into treatment alternatives
- Analyze the alternatives against evaluation criteria

1.2 Report Organization

This FS report is organized as follows:

- Section 2 contains site characterization information, including a discussion of the site description and background, summaries of previous investigations, the nature and extent of contamination at the site, a streamlined risk evaluation, and natural attenuation (NA) evaluation.
- Section 3 identifies applicable or relevant and appropriate requirements (ARARs) and RAOs and discusses the initial screening of potential technologies.
- Section 4 describes the identified technologies and their development into potential alternatives.

- Section 5 discusses the evaluation of the remedial action alternatives based on effectiveness, implementability, and cost and the comparison of the alternatives based on statutory requirements, considerations, and satisfying the RAOs.
- Section 6 lists the references for the documents cited in this report.

SECTION 2

Site Characterization

This section contains site characterization information, including a discussion of site description and background, summaries of previous investigations, nature and extent of contamination, a streamlined risk evaluation, and NA evaluation.

2.1 MCB CamLej Setting

MCB CamLej is located in Onslow County, North Carolina. The Base covers approximately 236 square miles and is bisected by the New River, which flows into the Atlantic Ocean in a southeasterly direction. The Base is bordered by the Atlantic Ocean to the east, US Route 17 to the west, and State Route 24 to the north. The city of Jacksonville, North Carolina, borders the Base to the north. **Figure 2-1** shows the location of MCB CamLej.

2.2 Site Description and Physical Setting

Detailed background information for Site 69 is contained in the *Supplemental Investigation, Site 69, Operable Unit No. 14 – Rifle Range Chemical Dump, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina* (SI) (CH2M HILL, 2011). A summary of this information is provided in the following sections.

2.2.1 Site Description

Site 69, the Rifle Range Chemical Dump, is located within Operable Unit No. 14, west of the New River in the Stone Bay area of MCB CamLej, as shown in **Figure 2-2**. The site is also within the boundary of Munitions Response Program Site Unexploded Ordnance (UXO)-02. Site UXO-02 was identified in the *Final Range Identification and Preliminary Range Assessment, Marine Corps Base Camp Lejeune, Onslow, North Carolina.* (USACE, 2001) as an "Unnamed Explosive Contaminated Range." A Preliminary Assessment/Site Investigation has been conducted at Site UXO-02 under a separate CLEAN contract task order (CH2M HILL, 2009).

Site 69 encompasses approximately 14 acres, covered with vegetation and heavily wooded, primarily with pine, dogwood, and oak. The area is overgrown to the point that the boundary of the former dump is not easily discernable. In the 1990s, a 6-foot-high chain link fence was erected around the site to prevent access. Within the fence, evidence of trench disposal activities is present in the form of shallow, elongated surface depressions, and slumping associated with settlement. The surface and outer perimeter of Site 69 is unpaved, although there is a dirt road leading to the site and around the perimeter fence. The site is secluded; however, training exercises are conducted throughout the surrounding area.

2.2.2 Topography and Surface Water Hydrology

Site 69 consists of wooded land that occupies the crest of a low-lying, west-east trending ridge that gently slopes toward the east and the New River. Ground surface elevations range from 20 to 38 feet (ft) above mean sea level, and drainage features to the northeast and southeast of Site 69 convey surface water to the New River. Three surface water bodies lie within a quarter-mile of the site: the New River to the east, an unnamed tributary of the New River to the north, and Everett Creek to the south. Also, the wooded areas east of the site boundary are bisected by numerous small streams and drainage features.

2.2.3 Site Geology

Figure 2-3 illustrates the locations of the two geologic cross-sections (A-A' and B-B') shown in **Figures 2-4** and **2-5.** These interpretations are based on previous investigations conducted by Baker Environmental, Inc. (Baker) and supplemented with CH2M HILL field data collected in 2010 and 2011.

The geology in the vicinity of Site 69 consists of three distinct formations (Undifferentiated Sediments, the Belgrade Formation, and the River Bend Formation), which correspond to the surficial aquifer, Castle Hayne semi-confining unit, and Castle Hayne aquifer, respectively. The uppermost Undifferentiated Sediments consist of mostly fine-grained sand, with lesser amounts of silt and clay, present at depths of 6 to 18 ft below ground surface

(bgs). These sands are light or pale brown in color, loose, and poorly graded. The Belgrade Formation, the semi-confining unit of the Castle Hayne aquifer, lies directly under the Undifferentiated Sediments. The thickness of the Belgrade semi-confining unit in the area of Site 69 ranges from 12 ft near the New River to 30 ft in the central portion of the site.

The upper portion of the River Bend Formation underlies the Belgrade Formation. Within the vicinity of Site 69, the River Bend Formation is composed of sands, silt, shell, and fossil fragments. Sands tend to be cemented within the formation. The amount of shell fragments within the formation decreases with depth, where a greenish-gray to olive very fine sand to silt becomes present. The lower River Bend Formation was not observed during the SI field effort and limited information is available for this depth.

2.2.4 Site Hydrogeology

Hydrogeologic characteristics of the surficial (water table) and Castle Hayne aquifers underlying Site 69 were evaluated by reviewing available information from a network of shallow, intermediate, and deep monitoring wells. The surficial aquifer is composed of Undifferentiated Sediments and is underlain by the Castle Hayne confining unit or Belgrade Formation, as described in Section 2.2.3. The Castle Hayne semi-confining unit is underlain by the Castle Hayne aquifer (River Bend Formation). Surficial aquifer wells were screened from 2 to 32 ft bgs; the upper Castle Hayne aquifer wells were screened from 33 to 73 ft bgs; the middle Castle Hayne aquifer wells were screened from 48 to 115 ft bgs; and the lower Castle Hayne aquifer wells were screened from 220 to 230 ft bgs. The total depth of the Castle Hayne aquifer is unknown at Site 69 because data on geologic conditions deeper than 230 ft bgs are unavailable, and a confining or differentiating unit at the bottom of the Castle Hayne aquifer has not been encountered at Site 69. Clay is present in the IR69-GW15BCH boring at a depth of approximately 110 to 120 ft below mean sea level. This may indicate a clay lens or existing confining unit. However, there is insufficient lithological evidence at that depth to confirm the lateral extent of the clay-based soils encountered in other monitoring wells drilled to similar depths at the site.

Static water level measurements collected in March 2010 from surficial and Castle Hayne aquifer monitoring wells were presented in the SI report (CH2M HILL, 2011). Groundwater in the surficial aquifer flows radially outward from the center of Site 69, and groundwater in the upper and middle Castle Hayne aquifers generally flows to the northeast, as indicated on the potentiometric surface maps presented as **Figures 2-6** through **2-8**.

Vertical hydraulic gradients were calculated between the surficial and Castle Hayne aquifers using March 2010 water level data measured between adjacent wells screened in the respective aquifers. Generally, the vertical hydraulic gradients are downward, ranging from 0.008 to 0.817 foot per foot (ft/ft) between all monitoring well pairs except IR69-GW02DW/IR69-GW02DD, which has a slight upward potential of 0.0278 ft/ft.

Previous investigations conducted by Baker indicated the geometric mean for hydraulic conductivity in the surficial aquifer was 0.32 foot per day (ft/day) (1.12×10^{-4} centimeters per second), and the linear seepage velocity for the surficial aquifer was 0.06 ft/day, or approximately 22 feet per year (ft/year). The geometric mean for hydraulic conductivity in the upper Castle Hayne aquifer was 1.3 ft/day (4.58×10^{-4} centimeters per second), and the linear seepage velocity had a geometric mean of 0.03 ft/day (approximately 11 ft/year), using an effective porosity (n_e) value of 0.33 for fine sands.

2.3 Site History

Site 69 was first identified in the Basewide IAS as a priority site for further investigation because of historical disposal activities at the site (WAR, 1983).

From 1950 to 1976, Site 69 was reportedly used to dispose of chemical wastes that included PCBs, solvents, and pesticides. Based on available documentation, Site 69 may also have a history of CA disposal. Discarded M9 CA detector kits were observed during a 1982 site visit (WAR, 1983). Formal documentation of disposal methods, particularly related to CA, is unavailable. However, a letter dated October 6, 1982 (Scudder, 1982) refers to an interview with a former heavy equipment operator indicating that drums of possibly nerve or mustard agent were buried in trenches at Site 69. The disposal incident occurred in 1953 or 1954, when approximately 50 to 60 drums of suspected agent were reportedly delivered to the site on rubber-padded trucks and disposed of in two

trenches, each approximately 20 ft deep. The unmarked drums were light-blue or blue-green in color and were stacked in the trenches so the top layer of the drums was approximately 5 or 6 ft bgs (Scudder, 1982). A second documented disposal incident occurred in 1970 when 5-gallon cans and 55-gallon drums of dichlorodiphenyltrichloroethane (DDT), trichloroethene (TCE), and calcium hypochlorite were placed together in a common pit. As soil was being placed over the containers, an explosion occurred, resulting in a brush fire and ejection of drums as far as 120 ft from the pit (WAR, 1983).

The source area at Site 69 appears to be this waste disposal area. The primary contaminants in the groundwater at Site 69 are chlorinated volatile organic compounds (CVOCs). The continued presence of buried waste at the site suggests that soil within the waste disposal area is contaminated as well.

2.4 Summary of Investigations and Assessments

Soil and groundwater contamination resulting from chemical disposal at the site has been identified during past environmental investigations at Site 69. Following this summary in **Table 2-1**, the nature of the environmental investigations conducted at Site 69 is described in more detail.

TABLE 2-1
Summary of Previous Investigations
Operable Unit No. 14 (Site 69) Feasibility Study
Marine Corps Base Camp Lejeune, North Carolina

Investigation	Year	Actions
Rifle Range Wastewater Treatment Plant and Chemical Dump Sampling (DoN, 1981, 1982)	1981-1982	Representative samples were collected from surrounding water supply wells, existing monitoring wells, and surface water. Analytical results indicated CVOCs and trihalomethanes were present in groundwater.
Initial Assessment Study (WAR, 1983)	1983	Identified the Rifle Range Chemical Dump (Site 69) as a priority site for further investigation because of historical disposal activities at the site.
Confirmation Study (Environmental Science & Engineering, 1992)	1984-1991	Surficial groundwater, surface water, sediment, and shellfish samples were collected. Analytical results indicated that volatile organic compounds (VOCs) including TCE, trans-1,2-dichloroethene (DCE), and vinyl chloride (VC) were present in groundwater in the southern portion of the site and in the surface water.
RI (Baker, 1997)	1992-1996	Conducted a geophysical investigation near suspected disposal trenches and monitoring well cluster IR69-GW02 confirming their location. Collected surface soil, subsurface soil, surface water, sediment and groundwater (surficial, upper Castle Hayne, middle Castle Hayne, and lower Castle Hayne aquifers) samples. Analytical results indicated VOCs were present above North Carolina Groundwater Quality Standards (NCGWQS) in the surficial, upper, and middle Castle Hayne aquifers in the southern portion of the site, with the highest concentrations in the vicinity of monitoring well IR69-GW15.
Treatability Study (TS) (Baker/SBP, 1998)	1996-1997	Installed vacuum vaporizer well (UVB) and coaxial groundwater ventilation (KGB) treatment systems to evaluate these technologies as potential remedial alternatives. The UVB system was successful in reducing concentrations in the treatment well but not widespread, and the KGB system failed to operate and perform consistently.
FS (Baker, 1998)	1997	Analyzed remedial alternatives, including no action, institutional controls (ICs) for soil; and no action, ICs and NA, groundwater extraction and physical treatment, dual-phase vacuum extraction, and in-situ air stripping for groundwater. Soil and waste removal was determined not to be a viable option because of cost, safety, and logistical issues associated with the potential CA buried in the disposal trenches.
	1990s	Installed a 6-ft-high chain link fence around the site to prevent unauthorized access.
Interim Record of Decision (IROD) (Baker, 2000)	2000	Selected interim remedy for soil was institutional land use controls (LUCs). Selected interim remedy for groundwater was institutional aquifer use controls and monitored natural attenuation (MNA). Remedy included 5 years of quarterly sampling for 24 monitoring wells screened in all aquifer zones, followed by 25 years of semi-annual sampling of 12 monitoring wells to be selected based on quarterly sampling results.

TABLE 2-1
Summary of Previous Investigations
Operable Unit No. 14 (Site 69) Feasibility Study
Marine Corps Base Camp Lejeune, North Carolina

Investigation	Year	Actions
Long-term Monitoring (LTM) (Engineering and Environment, Inc., 2005)	1998-2005	Collected groundwater samples from monitoring wells in the surficial, upper Castle Hayne, and middle Castle Hayne aquifers. Analytical results indicated that vertical migration of VOCs into the upper Castle Hayne aquifer was occurring. In 2005, the LTM Program was optimized and the LTM optimization report (AGVIQ/CH2M HILL, 2005) recommended removal of Site 69 from the program because an SI was planned.
SI (CH2M HILL, 2011)	2010-2011	Collected surface soil, subsurface soil, surface water, sediment, and groundwater samples to complete the delineation of site contamination to support a final Record of Decision (ROD) for the site. The current and historical investigative activities have consistently avoided characterization of the actual waste disposal areas because of the potential presence of CA. As a result, empirical data are not available for the soil or waste material present in this area. Monitoring and screening for CA was provided by Edgewood Chemical Biological Center. Analytical results from soil samples collected outside the waste disposal area indicated concentrations of pesticides and metals in surface soil and metals in subsurface soil exceeding risk screening criteria; metals in surface water exceeding North Carolina Surface Water Quality Standards (NCSWQS); VOCs, semivolatile organic compounds (SVOCs), pesticides, and metals in sediment exceeding risk screening criteria; and VOCs, pesticides, PCBs, and metals in groundwater exceeding NCGWQS. Concentrations of cis-1,2-DCE in the upper Castle Hayne indicated the presence of a continuous source area and potential dense non-aqueous phase liquid.

A more-detailed summary of the historical reports can be found in the SI report (CH2M HILL, 2011).

2.5 Previous Treatability Study, Feasibility Study, and Interim Record of Decision

2.5.1 Treatability Study (Baker/SBP, 1998)

In February 1996, a TS was initiated to evaluate in situ groundwater treatment technologies. The two-phase TS evaluated the technical and economic feasibility of using in-well aeration technology. Figures showing the TS area and well locations are provided in **Appendix A-4** of the SI report (CH2M HILL, 2011).

The TS focused on the waste disposal area near well cluster IR69-GW15. During the TS, two in situ treatment systems were installed: a UVB system in the surficial aquifer and upper Castle Hayne aquifer zone and a KGB system in the surficial aquifer.

The UVB system consisted of a double-screened well (screened in the surficial and upper Castle Hayne aquifers) that mobilized and treated contaminants by creating a circulation cell that transported dissolved and residual mobile-phase hydrocarbons to a central well casing where they were treated, primarily through air-stripping. Vertical groundwater circulation was achieved by creating a pressure differential between the two screens, using a mechanical or air lift pump; groundwater entered through the top screen, travelled through the treatment zone, and exited through the bottom screen.

The KGB system consisted of a single-screened well in the surficial aquifer and a soil-vapor extraction (SVE) well screened in the lower vadose zone. A vacuum was applied to the SVE well while air was simultaneously pumped into the submerged well screen, which allowed the air to be circulated, treating the groundwater through air-stripping. Soil vapor recovered from the SVE well was treated by activated carbon.

The objectives of the Phase I study (March 1996 to October 1996) were to evaluate the potential for creation of a groundwater or air circulation cell that could mobilize and transport contaminants to the UVB and KGB systems for treatment; experimentally (via dye test) estimate the zone of influence (ZOI) of each circulation cell; and evaluate whether contaminants were being removed by monitoring for target VOCs in the off-gases and in groundwater (Baker/SBP, 1998). The objectives of the Phase II study (August 1997 to December 1997) were to

evaluate the contaminant removal efficiency of the UVB system by relocating the system to well IR69-GW15UW; assess the effective ZOI of the UVB system in the new location; estimate required operating time for the UVB system to achieve cleanup goals for the upper Castle Hayne aquifer; and continue operation of the KGB system in its original position.

During the initial 6 months of the Phase I study, operation of the UVB well resulted in an average target VOC reduction of 16 percent in the circulation cell. During the same time, the KGB well removed at least 22 pounds of VOCs by SVE and stripping. On average, the concentration of target VOCs was reduced by 15 percent in groundwater monitoring wells within the estimated ZOI of the KGB system.

The Phase II TS was initiated in June 1997. The KGB system experienced problems with the well screen becoming plugged with formation materials, and in October 1997, the KGB system was shut down. The Phase II UVB system was modified by moving the UVB system to IR69-GW15UW (Figure 7-3 in **Appendix A-4** of the SI report [CH2M HILL, 2011]), and operated until December 1997. The TS concluded that in-well aeration was ineffective for remediating VOC contamination at Site 69, primarily because of the low hydraulic conductivity soils in the source area.

2.5.2 Feasibility Study (Baker, 1998)

In 1998, Baker completed an FS report to present a detailed analysis of remedial alternatives based on the RI and TS results.

The FS report presented two soil remedial alternatives:

1. No action
2. ICs

Five groundwater remedial alternatives were presented, including:

1. No action
2. ICs and NA
3. Groundwater extraction and physical treatment with ICs and monitoring
4. Dual-phase vacuum extraction and physical treatment, ICs, and monitoring
5. In situ air stripping with ICs and monitoring

2.5.3 Interim Record of Decision (Baker, 2000)

In June 2000, an IROD was issued to address the human health and ecological risks posed by VOCs in groundwater and safety risks from the potential presence of buried CA. The IROD incorporated a site-specific Land Use Control Implementation Plan (LUCIP) for Site 69 in accordance with the Memorandum of Agreement dated May 24, 1999, known as the LUC Assurance Plan. An IROD, rather than a final ROD, was executed because of the reported presence of CA at the site. Based on discussions with the Design Center for Ordnance and Explosives Team of the U.S. Army Corps of Engineers (USACE), the unearthing of CA would require indefinite storage somewhere at MCB CamLej pending final disposition. At the time of the IROD, disposal alternatives for such materials were not readily available.

LUCs and MNA were selected as the remedial actions, which are required to remain in effect until the remedial goals have been achieved or the IROD is superseded by a final ROD. The remedial actions included: implementing a groundwater monitoring program targeting the VOCs of concern; conducting groundwater monitoring of metals and CA degradation products in select wells; and implementing land use and aquifer use controls (surficial and Castle Hayne aquifers). The objectives of the LUCs were to:

- Protect uncontaminated groundwater for future beneficial use
- Remediate contaminated groundwater for future beneficial use
- Prevent future potential exposure to subsurface soil, including landfill material
- Prevent migration of potential contaminants to shallow groundwater

LUCs were implemented in 2001 and updated in 2002 (Baker, 2002). The LUCs were recorded with Onslow County as a notice of contamination and in the Base geographic information system and Master Planning (**Figure 2-2**).

2.6 Nature and Extent of Contamination

The nature and extent of groundwater contamination present at Site 69 as identified by the recent SI (CH2M HILL, 2011) is discussed below. Nature and extent of contamination within soil, surface water, and sediment at Site 69 is also summarized. The current and historical investigative activities have consistently avoided characterization of the actual waste disposal areas due to the potential presence of CA. LUCs have been implemented at the site to prevent current and future exposure to contaminated media and waste. As a result, empirical data are not available for the soil or waste material present in this area. A detailed description of nature and extent of contamination within all media at Site 69 is presented in the SI report (CH2M HILL, 2011).

2.6.1 Soil

Surface and subsurface soils at Site 69 were investigated during the RI in 1994 through 1995. The soil sample locations are shown in Figure 2-8 of the RI report (Baker, 1997) presented in **Appendix A** of this report. Figures 4-1 through 4-6 from the RI report are also provided in **Appendix A** and present the positive detections of VOCs, pesticides, PCBs, and chemical surety material identified in the surface and subsurface soil samples collected during the RI. Acetophenone and hydroxyacetophenone, which are degradation compounds of the ingredient used in tear gas, were detected at low concentrations in two surface soil samples. No other chemical surety degradation compounds were detected, and no chemical surety agents were detected by the U.S. Army Technical Escort Unit during sample screening.

In February 2010, a geophysical investigation was conducted to identify subsurface geophysical anomalies indicative of disposal trenches and buried wastes within the fenced area. In addition to locating potential areas of waste disposal, the digital geophysical mapping (DGM) results were used to minimize the risk of field sampling personnel coming into direct contact with buried wastes. Geophysical data were collected along a series of linear transects, and software was used for processing, graphical display, anomaly selections, and quality assurance/quality control. The results of the geophysical investigation indicated the presence of three distinct areas of geophysical anomalies. The largest area was located in the south-central portion of Site 69, which has yielded the greatest historical detections of chlorinated solvents in groundwater. Several smaller anomalies, likely indicative of smaller burial areas, were identified, but no significant anomalies were identified outside of the fenced area of Site 69. As a result, it appears that the fence was installed in the proper location to encompass the area containing buried waste material.

Soil samples were also collected outside of the waste disposal area in 2010. Pesticides (alpha-benzene hexachloride [BHC], beta-BHC, delta-BHC, gamma-BHC, and heptachlor epoxide) and metals (arsenic, chromium, iron, and manganese) were detected in surface soils at concentrations exceeding applicable screening values. The highest concentrations of pesticides were detected in samples from the northern portion of Site 69. With the exception of iron, all metals were within one order of magnitude of background concentrations. The soil sample locations are shown in Figure 3-1 of the SI report (CH2M HILL, 2011), and presented in **Appendix A**. Figure 5-1 from the SI report is also provided in **Appendix A** and shows the soil exceedances identified during the 2010 investigation.

2.6.2 Surface Water and Sediment

Surface water and sediment at Site 69 were investigated during the Confirmation Study, RI, and SI. The surface water and sediment investigated as part of Site 69 consist of the drainage areas northeast, east, and southeast of the site. Current (2010) analytical data for surface water indicates that lead, selenium, silver, thallium, and zinc are present in surface water at concentrations that exceed applicable screening values.

The sediment results from the Confirmation Study and RI were compared to industrial and residential regional and North Carolina soil screening levels. Samples were analyzed for VOCs, SVOCs, pesticides, PCBs, CA, and metals. SVOCs, pesticides, PCBs, and CA were not detected at concentrations above screening levels in samples collected from the “onsite” (within the fence) portion of Site 69. Numerous organics and metals were detected in

the "offsite" (outside the fence) sediment samples at concentrations above screening criteria. Sediment samples were also collected from Site 69 as part of the SI field activities and analyzed for VOCs, SVOCs, target analyte list (TAL) metals, pesticides, PCBs, and total organic carbon (TOC). One VOC (VC), one SVOC (benzo(a)pyrene), pesticides (beta-BHC, delta-BHC, gamma-BHC, heptachlor epoxide, and monocrotophos), and metals (aluminum, antimony, chromium, and manganese) were detected in sediment at concentrations exceeding applicable screening values. The contaminant concentrations were generally within one order of magnitude of the most conservative screening value or background concentration.

2.6.3 Groundwater

CH2M HILL conducted comprehensive groundwater sampling in February and March 2010 and collected additional groundwater samples in March 2011 to complete horizontal and vertical delineation of the VOC plumes. The nature and extent of current groundwater conditions are discussed below. A more-detailed description of nature and extent of contamination is presented in the SI report (CH2M HILL, 2011).

The groundwater monitoring wells have been grouped as follows: the surficial aquifer (wells screened from 10 to 25 ft bgs), upper Castle Hayne aquifer (wells screened from 33 to 73 ft bgs), middle Castle Hayne aquifer (wells screened from 75 to 130 ft bgs), and lower Castle Hayne aquifer (wells screened from 220 to 230 ft bgs).

Groundwater in the surficial and upper Castle Hayne aquifers at Site 69 is primarily affected by two groups of CVOCs:

- Chlorinated ethanes (1,1,2,2- tetrachloroethane [PCA], 1,1,2- trichloroethane [TCA], and 1,2- dichloroethane [DCA])
- Chlorinated ethenes (TCE, cis- and trans-1,2-DCE, and VC)

Groundwater isoconcentration maps for the chlorinated ethanes and ethenes listed above are provided in **Figures 2-9** through **2-17**.

Concentrations of metals that exceeded twice the mean Base background concentrations and NCGWQS were detected in all aquifer zones. Chromium was within one order of magnitude of the NCGWQS, and manganese was within one order or magnitude of background concentrations. The iron concentration was five times higher than background concentrations in the sample collected from monitoring well IR69-GW15.

2.6.3.1. Surficial Aquifer

Exceedances in the surficial aquifer were limited to the groundwater samples collected from the three monitoring wells closest to the buried waste disposal areas in the south-central portion of Site 69 (IR69-GW02, IR69-GW03, and IR69-GW15) and IR69-GW04. In general, these values are relatively low, with the highest cis-1,2-DCE concentration of 180 micrograms per liter (µg/L) in IR69-GW03 and a VC concentration of 20 µg/L in IR69-GW02.

2.6.3.2. Upper Castle Hayne Aquifer

The predominant CVOCs in the upper Castle Hayne aquifer zone are chlorinated ethenes, primarily consisting of cis-1,2-DCE and VC. As in the surficial aquifer, the highest concentrations were detected in samples from the south-central portion of Site 69 (IR69-GW15IW, IR69-GW19UW, and IR69-GW19IW), with concentrations decreasing in downgradient wells to the northeast and east. IR69-GW15IW had the highest cis-1,2-DCE and VC concentrations, of 51,000 µg/L and 5,500 µg/L, respectively. The concentrations of CVOCs reported in the sample from IR69-GW15IW were at least two to three orders of magnitude higher than all other samples at the site. Based on geophysical investigation results and historical site use, these wells are located in or near the waste disposal area.

2.6.3.3. Middle Castle Hayne Aquifer

VC was the only CVOC detected in the middle Castle Hayne aquifer zone at concentrations exceeding the NCGWQS of 0.03 µg/L. VC was limited to samples collected from two monitoring wells, with a maximum concentration of 1.4 µg/L in the sample collected from monitoring well IR69-GW11DW.

Pesticides were detected in samples from IR69-GW02, IR69-GW03, IR69-GW04, and IR69-GW15 in the surficial aquifer, and in samples from IR69-GW15IW, IR69-GW04DW, and IR69-GW15DW in the upper and middle Castle Hayne aquifers. Pesticide detections in samples IR69-GW02, IR69-GW04, and IR69-GW04DW did not exceed the NCGWQS. Exceedances in the other samples were within one to two orders of magnitude of the NCGWQS. Pesticides in groundwater, assuming exposure at the groundwater–surface-water interface, were identified as posing a risk to lower trophic level receptors in the Ecological Risk Assessment (ERA).

2.7 Risk Assessments

2.7.1 Human Health Risk Assessment

A Human Health Risk Assessment (HHRA) was completed as part of the SI report (CH2M HILL, 2011) to evaluate the projected impact of contaminants of concern (COCs) on human health and/or the environment now and in the future. The exposure scenarios evaluated included exposure to surface soil, surface water, and sediment for current receptors; and exposure to surface soil, groundwater, surface water, and sediment for future receptors. Human health risks are assumed to be present as result of contaminated soils and waste materials present in the disposal trenches/ burial pits at Site 69; however, LUCs currently prevent any current or future exposure to this area. As a result, these areas were not included in the HHRA. Based on the results of this HHRA, it was concluded:

- Current site use and site-related impacts do not pose an unacceptable risk to human health.
- The future use scenario in the HHRA indicated that there would be an unacceptable risk from exposure to groundwater including CVOCs, pesticides, Aroclor-1260, and chromium in the upper Castle Hayne aquifer and CVOCs, iron, and manganese in the surficial aquifer.
- Risks associated with future receptor contact with surface water, sediment, and surface and subsurface soils were below USEPA target levels.

The residential and industrial land use scenarios evaluated are very conservative because the waste is in place, potential CA is present, and LUCs are in place to prevent soil intrusive activities. Exposure to waste and soil that could result in unacceptable risks is being controlled. Additionally, groundwater at Site 69 is not a current potable source and will not be used for potable purposes in the future because LUCs are in place to prevent groundwater intrusive activities and prohibit non-industrial and aquifer use of groundwater.

2.7.2 Ecological Risk Assessment

An ERA was completed and documented as part of the SI report (CH2M HILL, 2011) to evaluate whether past site operations have adversely affected terrestrial and aquatic communities on or adjacent to Site 69. Ecological risks are assumed to be present as result of contaminated soils and waste material in the disposal trenches/burial pits at Site 69.

The results of the ERA indicated that pesticides in soil and sediment were identified as posing a potential risk to lower trophic level receptors, but not to upper trophic level receptors. Pesticides in groundwater, assuming exposure at the groundwater–surface-water interface, were identified as posing a risk to lower trophic level receptors. Although upper trophic level receptors were not identified at risk from pesticides, the data set for sediments was limited.

Additional evaluation of the potential ecological risk associated with pesticides in soil, sediment, and groundwater for the portions of UXO-02 located outside of the Site 69 fence was conducted as part of the 2011 UXO-02 Expanded Site Investigation(CH2M HILL, 2012). This evaluation concluded that pesticides in soil and sediment are unlikely to pose unacceptable risks to ecological receptors.

2.8 Natural Attenuation Evaluation

NA is a combination of physical (dilution, volatilization, and adsorption), biological (aerobic and anaerobic biodegradation), and chemical processes (abiotic transformation) that naturally reduce the toxicity, mobility, volume, mass, or concentration of constituents. The detailed hydraulic properties of each aquifer zone are discussed in Section 2.2.4. Generally, surficial groundwater at Site 69 flows radially outward from the center of

Site 69 toward drainage features to the northeast, southeast, and east to the New River. The upper and middle Castle Hayne groundwater flows generally to the northeast towards the New River.

Biodegradation is likely the most important destructive attenuation mechanism at Site 69. In general, biodegradation occurs when sufficient amounts of electron acceptors, electron donors, and nutrients are available in groundwater. Microorganisms preferentially use electron acceptors, which provide the most energy. Dissolved oxygen (DO) is consumed first as the prime electron acceptor; nitrate is the next-preferred electron acceptor, followed by manganese, ferric iron, sulfate, and carbon dioxide. As each electron acceptor is used and depleted, the oxidation-reduction potential (ORP) of the groundwater system is driven downward.

Biodegradation of chlorinated VOCs typically occurs via reductive dechlorination, in which microorganisms use the contaminant as an electron acceptor through an electron transfer process. Reductive dechlorination occurs in a series of reactions in which the parent compound (TCE or 1,1,2,2-PCA) is reduced to daughter compounds, with each reaction forming a daughter compound with sequentially fewer chlorine atoms. The reaction optimally proceeds within sulfate reducing and methanogenic conditions; however, reductive dechlorination of TCE may also occur under denitrifying and iron-reducing conditions (USEPA, 1998). The reduced daughter products of TCE (especially VC) can also be aerobically oxidized to carbon dioxide, and 1,1,2-TCA can be degraded to VC via dichloroelimination. Chlorinated VOCs may also be transformed under abiotic mechanisms. For example, 1,1,2,2-PCA can be abiotically transformed to TCE.

2.8.1 Indicator Parameters

Natural attenuation indicator parameters (NAIPs) provide qualitative evidence of favorable conditions for biodegradation and semi-quantitative evidence of biodegradation. Among these parameters used to assess favorable subsurface conditions are a loss of other electron acceptors (DO, nitrate, and sulfate), the production of metabolic byproducts (nitrite, ferrous iron, sulfide, and methane), an increase in alkalinity, sufficient organic carbon source(s), a neutral pH, and a reduced groundwater environment (USEPA, 1998). A decrease in parent compound concentrations and/or mass, the detection of daughter products (DCE, VC, ethane, and ethene), and an increase in chloride would provide semi-quantitative evidence that reductive dechlorination is occurring.

During the March 2010 groundwater sampling event, field measurements and groundwater samples were collected to evaluate the geochemical characteristics of the surficial aquifer and the upper and middle Castle Hayne aquifers. Field measurements collected during the purging of the wells included temperature, pH, DO, ORP, ferrous iron, nitrate, and nitrite. Additionally, groundwater samples were collected and submitted for laboratory analysis of geochemical parameters including alkalinity, chloride, sulfate, sulfide, TOC, total iron, methane, ethane, and ethane. Microbial analysis was also conducted on samples from upper and middle Castle Hayne monitoring wells to assess the presence of dehalogenating bacteria (*Dehalococcoides* [DHC], *Desulfuromonas sp., Dehalobacter sp*., and *Desulfitobacterium sp.*) within and outside of the contaminant plume. The analytical results of the microbial analysis are presented in **Appendix A**.

In order to assess NA properties at Site 69 and the suitability of MNA as a remedial option, and due to potential variations in geochemistry across the site, the monitoring wells at the site were divided into “plume area wells,” samples that contained VOC concentrations exceeding the NCGWQS, and “non-plume area wells,” consistent with *Performance Monitoring of MNA Remedies for VOCs in Ground Water* (USEPA, 2004). This way the spatial distribution of NAIPs, with respect to degradation processes, could be evaluated.

This NA evaluation was also conducted in accordance with the *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water* (USEPA, 1998). The protocol uses a simplified scoring system that assigns a positive value to each NAIP result that is favorable or a negative value to unfavorable results. All points are added together to arrive at a total score. The scores for each well are averaged by plume location and aquifer to provide a general indication of evidence for biodegradation. A score of 0 to 5 indicates inadequate evidence for anaerobic degradation; 6 to 14 indicates limited evidence for anaerobic degradation; 15 to 20 indicates adequate evidence for anaerobic degradation; and greater than 20 indicates strong evidence for anaerobic degradation (USEPA, 1998). Because this scoring process is based on conditions favorable for reductive

dechlorination, it does not incorporate the benefit of zones of more oxidizing conditions for DCE and VC degradation.

Summaries of NAIPs from each well sampled during the March 2010 groundwater monitoring event and total scores are presented in **Table 2-2** and **Figures 2-18** and **2-20**. A more-detailed discussion of NA processes in each aquifer is provided below.

2.8.1.1. Surficial Aquifer

The geochemistry of groundwater upgradient of the plume, within the plume, and downgradient of the plume can provide evidence of favorable conditions for biodegradation. Therefore, NAIPs in the surficial aquifer were evaluated based on their location in reference to the contaminant plumes. IR69-GW02, IR69-GW03, IR69-GW04, and IR69-GW15 are located within the contaminant plumes. The remaining 11 surficial aquifer wells are sidegradient and/or downgradient. A summary of NAIPs measured in the surficial aquifer is provided in **Table 2-3** below:

TABLE 2-3
Surficial Aquifer NAIP Summary
Operable Unit No. 14 (Site 69) Feasibility Study
Marine Corps Base Camp Lejeune, North Carolina

Parameter	Favorable Criteria for NA	Plume Area		Non-Plume Area	
		Measured Range	Frequency Meeting Criteria	Measured Range	Frequency Meeting Criteria
Temperature (°C)	> 20 °C	10.89 - 13.48	0/4	9.75 - 16.42	0/11
DO (mg/L)	<0.5	0.24 - 0.68	3/4	0.14 - 4.61	1/11
pH (SU)	5 - 9	4.58 - 5.33	1/4	4.21 - 5.26	2/11
ORP (mV)	<50	-26.1 to 168.0	2/4	22.0 – 354.1	1/11
Fe(II) (mg/L)	>1	1.0 - 4.4	4/4	0.0 - 2.1	3/11
Sulfide (mg/L)	>1	ND	0/4	ND - 0.8 J	0/11
Nitrite (mg/L)	presence	ND - 0.198	3/4	ND - 0.099	2/11
Methane (µg/L)	>500	17 B - 150 BD	0/4**	0.3 JB - 16 B	0/11**
Chloride (mg/L)	> 2X background (16.8 mg/L)***	23 D - 48 D	4/4	ND - 20.8 D	1/11
Alkalinity (mg/L)	> 2X background (20 mg/L)****	ND - 32.1	2/4	ND - 20.8	2/11
Sulfate (mg/L)	<20	4.7 D - 150 D	3/4	5.5 - 22	10/11
Nitrate (mg/L)	<1	ND	4/4	ND	11/11
TOC (mg/L)	> 20	2.2 - 12	0/4	0.54 J - 4.5	0/11
Ethene (µg/L)	>10	ND - 0.6 J	1/4	ND	0/11
Ethane (µg/L)	>10	ND	0/4	ND	0/11

*Source: USEPA, 1998
** methane was detected in all samples at concentrations below blank concentrations
*** Background concentration calculated from upgradient well IR69-MW14
**** Assumed twice the reporting limit as the background concentration at upgradient well was 0 mg/L
B - Analyte not detected above the level reported in blanks
J - Analyte present, value may or may not be accurate or precise
D - Compound identified in an analysis at a secondary dilution factor
ND - Not Detected
SU - standard units
°C - degrees Celsius
mV - millivolts
mg/L - milligrams per liter

The average score within the plume area was 15.25, indicating adequate evidence for anaerobic degradation. The average score outside of the plume area was 4, indicating inadequate evidence for anaerobic degradation. As

shown on **Figure 2-18**, the wells with the highest scores are located within the plume area and adjacent to and/or downgradient from the waste disposal area.

Indicator parameters suggest that conditions in the CVOC plume area of the surficial aquifer are limited to somewhat favorable for reductive dechlorination. The surficial aquifer is naturally more aerobic and oxidizing than the other aquifers at the site. However, within the plume area, groundwater is more reduced and DO is typically below 0.5 mg/L. Although the presence of low levels of nitrite provides evidence of denitrification, the lack of nitrate indicates that this is not a significant process in groundwater. On the contrary, the presence of ferrous iron provides strong evidence of iron reduction, particularly in plume area wells, which had the highest concentrations. Limited methanogenesis is also occurring. Because sulfate concentrations within the plume were similar to those outside of the plume and there is very limited sulfide, no conclusion can be made in regards to sulfate reduction. Sulfate was present at one monitoring well (IR69-GW15) located within the plume at a concentration (150 mg/L) that might compete with reductive dechlorination. However, because this elevated concentration was only present at one monitoring well it may not have a significant impact. Elevated alkalinity levels at IR69-GW03 and IR69-GW15 are suggestive of biological activity. Nevertheless, alkalinity values in the surficial aquifer are generally very low compared to the other aquifer zones, which suggest a limited buffering capacity. This explains the low pH values observed in groundwater and indicates that pH values may decrease further if the reductive dechlorination process adds acidity to the groundwater system.

Although indicator parameters were limited, the presence of daughter products (1,2-DCA, cis-1,2-DCE, VC, and low-level detections of ethene) are evidence that reductive dechlorination is occurring. Historical data trends from samples collected from monitoring well IR69-GW02 show an overall decrease in TCE and DCE and an increase in VC (**Figure 2-19**), which is strongly supportive of reductive dechlorination. VC may be on a decreasing trend in this well currently. The limited presence of ethene is evidence that full reductive dechlorination can occur. Due to the somewhat aerobic nature of this aquifer, the lack of additional ethene or ethane detections is likely the result of oxidation of VC to carbon dioxide and other innocuous products. DCE and VC oxidation can occur even under relatively low DO conditions concurrent with anaerobic processes. Chloride levels within the plume area were more than double the background levels, which is also suggestive of biodegradation. Although there is evidence of reductive dechlorination, the lack of a strong carbon source (as indicated by low TOC concentrations) and low pH values may limit the rates of CVOC degradation.

2.8.1.2. Upper Castle Hayne Aquifer

Similar to the surficial aquifer, NAIPs in the upper Castle Hayne aquifer were evaluated based on their location in reference to the contaminant plumes. IR69-GW14IW is the upgradient well. Monitoring wells IR69-GW02DW, IR69-GW04IW, IR69-MW11IW, IR69-GW15IW, IR69-GW19UW, and IR69-GW19IW are located within the plumes, while the nine remaining wells are sidegradient and/or downgradient of the plume. A summary of NAIPs measured in the upper Castle Hayne aquifer is provided in **Table 2-4** below:

TABLE 2-4
Upper Castle Hayne Aquifer NAIP Summary
Operable Unit No. 14 (Site 69) Feasibility Study
Marine Corps Base Camp Lejeune, North Carolina

		Plume Area		Non-Plume Area	
Parameter	Favorable Criteria for NA	Measured Range	Frequency Meeting Criteria	Measured Range	Frequency Meeting Criteria
Temperature (°C)	> 20 °C	17.07 - 17.90	0/6	16.33 - 17.98	0/9
DO (mg/L)	<0.5	0.14 - 1.08	5/6	0.08 - 0.94	7/9
pH (SU)	5 - 9	6.75 - 7.97	6/6	7.35 - 8.34	9/9
ORP (mV)	<50	-189.4 to -137.3	6/6	-191.0 to -93.4	9/9
Fe(II) (mg/L)	>1	ND - 4.2	3/6	ND – 2.5	4/9
Sulfide (mg/L)	>1	ND	0/6	ND - 0.6 J	0/9
Nitrite (mg/L)	presence	ND - 0.165	2/6	ND - 0.099	4/9
Methane (µg/L)	>500	3 B - 74 BD	0/6**	0.6 B - 49 B	0/9**

TABLE 2-4
Upper Castle Hayne Aquifer NAIP Summary
Operable Unit No. 14 (Site 69) Feasibility Study
Marine Corps Base Camp Lejeune, North Carolina

Parameter	Favorable Criteria for NA	Plume Area		Non-Plume Area	
		Measured Range	Frequency Meeting Criteria	Measured Range	Frequency Meeting Criteria
Chloride (mg/L)	> 2X background (21.2 mg/L)***	6.2 - 170 D	3/6	4.7 - 18.1 D	0/9
Alkalinity (mg/L)	> 2X background (202 mg/L)***	61.4 - 203	1/6	101 - 219	1/9
Sulfate (mg/L)	<20	ND - 37	5/6	ND - 370 D	4/9
Nitrate (mg/L)	<1	ND	6/6	ND - 8.8	7/9
TOC (mg/L)	> 20	ND - 4.3	0/6	0.45 J - 3.1	0/9
Ethene (µg/L)	>10	ND - 63	1/6	ND - 0.2 J	0/9
Ethane (µg/L)	>10	ND - 5	0/6	ND - 0.2 J	0/9

*Source: USEPA, 1998
** methane was detected in all samples at concentrations below blank concentrations
*** Background concentrations were calculated from upgradient well IR69-MW14IW

The average score within the plume area was 16, indicating adequate evidence for anaerobic degradation. The average score outside of the plume area was 10, indicating limited evidence for anaerobic degradation. As shown on **Figure 2-20**, the wells with the highest scores are located within the plume area or just downgradient from the plume.

Indicator parameters suggest that conditions in the CVOC plume area of the upper Castle Hayne aquifer are favorable for reductive dechlorination. This aquifer appears to be naturally under anaerobic and somewhat reduced conditions, with DO typically below 0.5 mg/L and ORP below -100 mV. DO and ORP levels within the plumes are comparable to those measured outside of the plume extents. Similar to the surficial aquifer, denitrification does not appear to be a significant process. Other geochemical data indicate that iron reduction, sulfate reduction, and methanogenesis are proceeding, with the strongest evidence at IR69-GW15IW. Even though sulfide was not detected in the plume area wells, it likely precipitated with dissolved iron, and the depletion of sulfate is strong evidence for reduction. At the downgradient plume well, IR69-GW04IW, geochemical data only suggested some methanogenesis. However, this was the only well with alkalinity concentrations twice the background value, indicating that some biological activity is occurring. Within the upper Castle Hayne aquifer, pH levels are at favorable levels for microbial activity.

With the exception of IR69-GW19IW, CVOC daughter products were detected in all monitoring wells located within the plume and constitute the majority of the CVOC molar mass. Historical data trends of CVOC concentrations in samples collected from IR69-GW15IW show a decrease in TCE and an increase in daughter products (**Figure 2-19**). However, the concentrations of cis-1,2-DCE (greater than 10,000 µg/L), coupled with the relatively low historical TCE concentration (in the 100- to 1,000-µg/L range), suggest that cis-1,2-DCE may be a source compound rather than a degradation product. Ethene was detected or estimated in most of the plume wells, with a maximum concentration of 63 µg/L in source well IR69-GW15IW, providing evidence of full reductive dechlorination. Ethane was also estimated in several plume area wells. Chloride was reported at twice the background level at IR69-GW02DW, IR69-GW04IW, and IR69-GW15IW, with the highest concentration reported at IR69-GW15IW, further indicating that dechlorination is occurring in the source area. However, TOC concentrations were measured below 5 mg/L, suggesting the lack of a strong carbon source.

Microbial analysis was performed on samples collected from plume wells IR69-GW11IW and IR69-GW15IW and non-plume well IR69-GW27IW. DHC were detected at a high level (3.01E+05 gene copies per milliliter) at IR69-GW15IW only, while almost undetectable at all other wells. *Desulfitobacterium spp.* is the most prevailing species detected at this site, with concentrations in the order of 10^4 to 10^6 gene copies per milliliter in all wells sampled.

Dehalobacter spp. was not present at significant concentrations at any of the wells. Populations of *Desulfuromonas spp.* were slightly higher in IR69-GW15IW than in the two other samples, and populations of *Dehalobacter spp.* and *Desulfitobacterium spp.* were comparable between all samples. All four genera of microorganisms can carry reductive dechlorination of chloroethenes, although DHC is the only genus that can mediate complete reductive dechlorination to ethene. Therefore, reductive dechlorination at IR69-GW15IW may be more favorable than in the other wells due to the presence of DHC.

2.8.1.3. Middle Castle Hayne Aquifer

In the middle Castle Hayne aquifer, NAIPs were evaluated based on their location in reference to the contaminant plumes. IR69-GW14DW is the upgradient well. Monitoring wells IR69-GW04DW and IR69-MW11DW had exceedances of VC. No other CVOCs exceeded applicable standards in this aquifer; however, CVOCs were detected in samples collected from IR69-MW26DW and it is retained as a plume well. The eight remaining monitoring wells are sidegradient and/or downgradient of the isolated VC plumes. A summary of NAIPs measured in the middle Castle Hayne aquifer is provided in **Table 2-5** below:

TABLE 2-5
Middle Castle Hayne Aquifer NAIP Summary
Operable Unit No. 14 (Site 69) Feasibility Study
Marine Corps Base Camp Lejeune, North Carolina

		Plume Area		Non-Plume Area	
Parameter	Favorable Criteria for NA	Measured Range	Frequency Meeting Criteria	Measured Range	Frequency Meeting Criteria
Temperature (°C)	> 20 °C	17.94 - 18.72	0/3	16.43 - 20.81	1/8
DO (mg/L)	<0.5	2.24 - 10.31	0/3	0.12 - 0.73	5/7**
pH (SU)	5 - 9	7.59 - 8.37	3/3	7.24 - 8.32	8/8
ORP (mV)	<50	-185.3 to 60.3	2/3	-215.4 to -72.9	8/8
Fe(II) (mg/L)	>1	ND - 0.6	0/3	ND - 2.4	4/7**
Sulfide (mg/L)	>1	ND - 0.4 J	0/3	ND	0/8
Nitrite (mg/L)	presence	ND - 0.066	1/3	ND - 0.099	3/6**
Methane (µg/L)	>500	0.7 JB - 2 B	0/3***	1 B - 34 B	0/6***
Chloride (mg/L)	> 2X background (29.8 mg/L)****	11 D - 12	0/3	6.1 D - 41	2/8
Alkalinity (mg/L)	> 2X background (374 mg/L)****	172 - 217	0/3	151 - 249	0/8
Sulfate (mg/L)	<20	17 - 170 D	1/3	ND - 59	4/8
Nitrate (mg/L)	<1	ND	3/3	ND	7/7**
TOC (mg/L)	> 20	0.56 J - 2.5	0/3	0.84 J - 18	0/8
Ethene (µg/L)	>10	ND - 0.2 J	0/3	ND – 0.2 J	0/8
Ethane (µg/L)	>10	ND - 0.3 J	0/3	ND - 0.4 J	0/8

*Source: USEPA, 1998
**Parameter not analyzed for at all locations
*** methane was detected in all samples at concentrations below blank concentrations
**** Background concentrations were calculated from upgradient well IR69-MW14DW

The average score inside and outside of the plume area were 6 and 9, respectively, indicating limited evidence of reductive dechlorination in both areas. As previously stated, these scores do not reflect degradation via aerobic oxidation, co-metabolism, or abiotic degradation. Future monitoring of contaminant trends may be a better indicator of NA effectiveness.

Favorable indicator parameters for reductive dechlorination are limited in the middle Castle Hayne aquifer. Positive indicators include DO and ORP, which suggest that this aquifer is generally anaerobic and under predominantly reducing conditions. Although isolated zones of DO greater than 1 mg/L are observed, including at contaminated well IR69-GW04DW, this may be attributed to field equipment error. pH levels are favorable for

microbial activity. Geochemical data provide evidence of low levels of methanogenesis; however, other oxidation-reduction reactions appear to be limited. Sulfate was present at one well (IR69-GW04DW) at a concentration (170 mg/L) that might compete with reductive dechlorination. Alkalinity values are consistent across the aquifer, providing no indication of zones of increased biological activity.

VC is the only CVOC detected in the middle Castle Hayne aquifer above its NCGWQS, indicating that reductive dechlorination and/or migration of VC from the upper Castle Hayne aquifer is occurring. Because favorable indicator parameters for reductive dechlorination are limited, migration is the more likely source of VC in the middle Castle Hayne aquifer. Ethene and ethane were estimated at low levels outside of the VOC plumes, providing some evidence of degradation. However, chloride levels were consistent across the aquifer and provided no additional support for reductive dechlorination. Low TOC concentrations (typically below 3 mg/L) may limit the rates of reductive dechlorination.

Microbial analyses were performed on samples collected from non-plume wells IR69-GW15DW and IR69-MW27DW. Reductive dechlorination at these wells may be less favorable in comparison to IR69-GW15IW due to a minimal presence of DHC. *Desulfitobacterium spp.* is the most prevailing species detected at this site, with concentrations in the order of 10^4 to 10^6 gene copies per milliliter in all wells sampled. *Dehalobacter spp.* was not present at significant concentrations at any of the wells. However, *Desulfuromonas spp.* was detected at a moderate concentration (7.29E+03 gene copies per milliliter) at IR69-GW15DW, indicating good potential for reductive dechlorination at this location. Nevertheless, VC in the middle Castle Hayne aquifer zone may also be degrading via aerobic oxidation. This would support the limited extent of VC observed in the aquifer. As noted previously, isolated zones of more aerobic groundwater were measured in the aquifer, which may be facilitating oxidation, a faster reaction than reductive dechlorination. Carbon dioxide, which is an oxidative daughter product, was not analyzed.

2.8.1.4. Summary

Analysis of CVOCs and NAIPs indicated that NA is currently occurring in the surficial, upper and middle Castle Hayne aquifers. The concentration and distribution of geochemical parameters (including, but not limited to, a simplified scoring system), VOC degradation products, and VOC concentration trends suggests that subsurface conditions are limited to somewhat favorable for reductive dechlorination in the surficial aquifer and the upper Castle Hayne aquifer, and limited in the middle Castle Hayne aquifer.

The more-favorable indicators were observed within the higher concentration areas of the groundwater plumes. Microbial analysis conducted in the upper Castle Hayne and middle Castle Hayne aquifers provided evidence that the appropriate microorganisms were present in groundwater and that their population sizes were elevated within the groundwater plumes. Factors that may limit the rates of reductive dechlorination are low native organic carbon available for an electron donor and low pH values in the surficial aquifer, and isolated zones of high sulfate concentrations, which may result in competitive exclusion of dechlorinating bacteria. Nevertheless, oxidation of DCE and/or VC may be occurring in the surficial and middle Castle Hayne aquifers in more aerobic zones and would support the limited extent of the CVOC plumes in these aquifers.

2.9 Groundwater Modeling

Predictive modeling supported by empirical data was conducted as part of the SI report (CH2M HILL, 2011) to estimate the time for concentrations of COCs in groundwater to achieve NCGWQS via NA and the potential for COCs to migrate as far as the New River. Groundwater fate and transport modeling was performed for Site 69 using BIOCHLOR Version 2.2 (Aziz, et al., 2002). BIOCHLOR is a screening-level model that uses the three-dimensional analytical model by Domenico (1987) and is meant to be used only as a decision-making tool. Therefore, results of the model evaluation should be used only as guidance and not a definitive estimate of future concentrations when evaluating remedial technologies.

The flow path modeled was within the upper Castle Hayne aquifer, parallel to the estimated groundwater flow path from the source area to a potential point of discharge at the New River. The New River is approximately 1,300 ft downgradient of the presumed source area in the vicinity of monitoring well IR69-GW15IW.

A release date of 1951 and groundwater data collected from March 2010 field activities were used to calibrate the BIOCHLOR model. A two-zone model was used due to the presence of a constant source, resulting in high concentrations within the source area. A continuous source model was selected as concentrations of cis-1,2-DCE continue to increase over time in IR69-GW15IW and the presence of DNAPL is likely based on the 2010 groundwater data.

The calibrated model was used to predict constituent concentrations and the maximum plume extent for each constituent at dates of 2020 (10 years from present), 2030 (20 years from present), 2050 (40 years from present), 2070 (60 years from present), and 2110 (100 years from present). The results are summarized in **Table 2-6** and the model runs are presented in **Appendix F** of the SI report (CH2M HILL, 2011).

According to the continuous source model, the concentrations of TCE, cis-1,2-DCE, and VC will not attenuate below their respective NCGWQS (3 µg/L, 70 µg/L, and 0.03 µg/L, respectively) in the source area. The model predicts that each plume (defined as groundwater concentrations exceeding NCGWQS) will remain relatively stable over the 100-year predicted period. VC concentrations were predicted to exceed NCGWQS (0.03 µg/L) throughout the aquifer in all future models (2020 to 2110). However, VC concentrations are predicted to remain below the NCSWQS (2.4 µg/L) at the discharge point to the New River. Concentrations of TCE and cis-1,2-DCE are not predicted to exceed NCSWQS (30 µg/L for TCE; no criterion was available for cis-1,2-DCE).

TABLE 2-2

Summary of Natural Attenuation Indicator Parameters

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Well ID	Sample Date	Temperature (°C)	DO (mg/L)	pH (SU)	ORP (mV)	Ferrous Iron (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Alkalinity (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Sulfide (mg/L)	TOC (mg/L)	Methane (µg/L)	Ethane (µg/L)	Ethene (µg/L)	EPA Score
Surficial Aquifer Wells																	
IR69-GW01	03/08/10	13.93	0.99	4.66	172.6	0.6	0	0.099	10 U	1 U	22	1 U	3.6	2 B	2 U	2 U	0
IR69-GW02	03/02/10	12.17	0.68	4.96	-26.1	1	0	0.066	10 U	33.9 D	11.5 D	1 U	3.4	36 B	2 U	0.1 J	13
IR69-GW03	03/07/10	13.48	0.24	4.58	168.0	4.2	0	0.099	32.1	43	9.9	1 U	2.2	30 BD	2 U	2 U	16
IR69-GW04	03/14/10	13.09	0.26	4.99	98.7	2.2	0	0	10 U	23 D	4.7 D	1 U	5	150 BD	2 U	2 U	15
IR69-GW05	3/8-3/9/10	14.45	1.63	4.57	285.0	0.2	0	0	10 U	7.4	6.9	1 U	0.89 J	0.3 JB	2 U	2 U	2
IR69-GW06	03/09/10	16.42	1.53	4.83	278.4	0.2	0	0	10 U	10	8	1 U	0.7 J	0.3 JB	2 U	2 U	2
IR69-GW07	03/09/10	15.36	0.14	5.11	150.0	0	0	0	9.82 J	13	6.1	1 U	0.63 J	7 B	2 U	2 U	8
IR69-GW08	03/08/10	12.81	2.70	4.86	256.2	0	0	0	10 U	7	5.5	1 U	0.54 J	0.3 JB	2 U	2 U	2
IR69-GW09	03/01/10	15.39	3.29	5.26	260.9	0	0	0	10 U	20.8 D	10 D	1 U	2.4	0.7 JB	2 U	2 U	8
IR69-GW10	03/08/10	14.40	4.61	4.76	168.7	1.8	0	0	20.8	8.1	6.6	1 U	0.63 J	5 B	2 U	2 U	6
IR69-GW11	03/01/10	13.80	0.94	4.21	354.1	0.25	0	0	10 U	13.4 D	13.4 D	1 U	1.3	0.3 JB	2 U	2 U	2
IR69-GW12	02/27/10	11.61	0.63	4.95	22.0	2.1	0	0	10 U	14.3 D	8.45 D	0.8 J	4.5	16 B	2 U	2 U	8
IR69-GW13	03/01/10	11.09	0.50	4.69	65.9	1.4	0	0	10 U	7.02 D	6.18 D	1 U	4.3	9 BD	2 U	2 U	8
IR69-GW14	02/28/10	9.75	1.93	4.95	248.1	0.2	0	0.099	10 U	8.4 D	7.63 D	1 U	2.3	0.3 JB	2 U	2 U	2
IR69-GW15	03/07/10	10.89	0.28	5.33	13.5	4.4	0	0.198	15.2	48 D	150 D	1 U	12	17 B	2 U	0.6 J	17
Upper Castle Hayne Aquifer Wells																	
IR69-GW02DW	03/02/10	17.07	0.14	7.49	-189.4	1.75	0	0.0825	96.3	92.4 D	5 U	1 U	4.3	22 B	0.03 J	0.7 J	19
IR69-GW03DW	03/07/10	17.30	0.33	7.66	-172.9	0.4	0	0	143	12	1 U	1 U	0.45 J	49 B	2 U	2 U	9
IR69-MW04IW	03/15/10	17.90	1.08	7.40	-158.2	0	0	0	203	26	37	1 U	3.4	3 B	0.1 J	0.4 J	12
IR69-MW05IW	03/14/10	17.98	0.13	7.99	-126.0	0	0	0	135	4.7	34	1 U	0.83 J	20 BD	2 U	2 U	7
IR69-MW09IW	03/06/10	16.81	0.27	7.80	-190.6	1.5	8.8	0.066	144	13	54	1 U	1.8	1 B	2 U	2 U	12
IR69-MW11IW	03/13/10	17.72	0.25	7.29	-159.5	3	0	0	179	18 D	10 D	1 U	1.8	13 B	2 U	0.3 J	17
IR69-GW12DW	02/27/10	16.33	0.18	7.56	-161.9	2.3	0	0	164	10.7 D	11.5 D	0.6 J	0.56 J	0.9 JB	2 U	2 U	14
IR69-GW13IW	03/01/10	17.21	0.47	7.52	-191.0	2.5	4.4	0.033	152	18.1 D	30.5 D	1 U	1.2	21 BD	2 U	0.03 J	12
IR69-MW14IW	02/28/10	16.96	0.94	7.49	-178.1	1.75	0	0.099	101	10.6 D	23.2 D	1 U	0.49 J	1 B	2 U	2 U	7
IR69-GW15IW	03/06/10	17.22	0.20	7.25	-175.9	4.2	0	0.165	84.7	170 D	1 U	1 U	2	74 BD	5	63	21
IR69-GW19IW	03/16/10	17.37	0.25	7.97	-164.0	0	0	0	140	6.2	1 U	1 U	0.54 J	18 B	2 U	2 U	11
IR69-GW19UW	03/16/10	17.29	0.46	6.75	-137.3	0	0	0	61.4	15	1 U	1 U	1 U	28 B	2 U	2 U	14
IR69-MW26IW	03/16/10	17.61	0.08	8.23	-135.5	0	0	0.033	143	13	8.3	1 U	1.2	40 B	2 U	0.2 J	13
IR69-MW27IW	03/06/10	17.55	0.68	7.35	-93.4	0.5	0	0	219	13	20	1 U	2.2	0.6 B	2 U	2 U	6
IR69-MW28IW	03/18/10	17.58	0.32	8.34	-160.2	0	0	0	144	12	370 D	0.4 J	3.1	2 B	0.2 J	0.1 J	7
Middle Castle Hayne Aquifer Wells																	
IR69-GW02DD	03/06/10	17.97	0.20	7.43	-139.1	1	0	0.03	249	41	1 U	1 U	2.8	32 BD	0.06 J	2 U	14
IR69-MW04DW	03/14/10	18.20	10.31	8.37	60.3	0.2	0	0.066	172	11	170 D	0.4 J	0.56 J	0.7 JB	2 U	2 U	3
IR69-MW05DW	03/14/10	18.10	0.17	7.69	-215.4	0	0	0	177	6.1 D	23 D	1 U	0.84 J	3 B	0.3 J	0.1 J	9
IR69-MW09DW	03/06/10	17.13	0.12	7.64	-214.9	1.6	0	NA	200	15	4.6	1 U	18	6 B	2 U	2 U	12
IR69-MW11DW	03/13/10	17.94	2.70	7.59	-185.3	0.6	0	0	217	11 D	91 D	1 U	1.2	2 B	0.3 J	0.2 J	8
IR69-MW13DW	03/18/10	20.81	0.57	8.32	-186.7	0	0	0	198	11	50	1 U	2.6	2 B	0.4 J	0.2 J	4
IR69-MW14DW	02/28/10	16.43	0.73	7.29	-139.2	2.4	0	0.066	187	14.9 D	5.93 D	1 U	0.6 J	16 B	2 U	2 U	9
IR69-GW15DW	03/15/10	17.64	NA	7.37	-72.9	0	0	0	244	34	1.7	1 U	2.4	34 B	2 U	2 U	7
IR69-MW26DW	03/16/10	18.72	2.24	7.99	-17.4	0	0	0	193	12	17	1 U	2.5	1 B	2 U	2 U	7
IR69-MW27DW	03/06/10	17.38	0.43	7.69	-179.4	1.2	0	0.099	151	19	26	1 U	1.1	3 B	2 U	2 U	10
IR69-MW28DW	03/18/10	18.49	0.20	7.42	-142.9	NA	NA	NA	202	13	59	1 U	1.8	1 B	2 U	2 U	5
Lower Castle Hayne Wells																	
IR69-MW02BCH	03/08/10	18.06	0.57	8.10	11.0	0	0	0.099	204	1 U	3.6	1 U	3.1	60 BD	2 U	2 U	5
IR69-MW03BCH	03/09/10	17.65	0.52	7.52	-81.8	NA	NA	NA	257	46	3.2	1 U	3.2	49 BD	2 U	2 U	3
IR69-MW15BCH	03/14/10	17.55	0.58	7.71	-59.5	0	0	0	273	46	1.7	1 U	3.2	250 BD	2 U	2 U	5

Notes:

EPA scores were calculated using the USEPA Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater (USEPA, 1998)

°C - Degrees Celsius
µg/L - Micrograms per liter
mg/L - Milligrams per liter
mV - Millivolts
DO - Dissolved oxygen
ORP - Oxidation reduction potential
SU - Standard units
TOC - Total organic carbon

B - Analyte not detected above the level reported in blanks
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
D - Compound identified in an analysis at a secondary dilution factor
NA - Not analyzed
Shading indicates plume wells

EPA Score:
0 to 5 - Inadequate evidence for anaerobic biodegradation of chlorinated organic
6 to 14 - Limited evidence for anaerobic biodegradation of chlorinated organics
15 to 20 - Adequate evidence for anaerobic biodegradation of chlorinated organic
> 20 - Strong evidence for anaerobic biodegradation of chlorinated organics

TABLE 2-6

Summary of BIOCHLOR Predictions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

TCE (Initial Source Concentration 100 µg/L)

Date	Maximum Concentration (µg/L)	Distance from Source of Maximum Concentration (ft)	Maximum Plume Extent (ft)	Concentration at New River (µg/L)
2020	100	Source	700	Below SW Standard
2030	100	Source	700	Below SW Standard
2050	100	Source	700	Below SW Standard
2070	100	Source	700	Below SW Standard
2110	100	Source	700	Below SW Standard

cis-1,2-DCE (Initial Source Concentration 50,000 µg/L)

Date	Maximum Concentration (µg/L)	Distance from Source of Maximum Concentration (ft)	Maximum Plume Extent (ft)	Concentration at New River (µg/L)
2020	50,000	Source	850	Below SW Standard
2030	50,000	Source	850	Below SW Standard
2050	50,000	Source	850	Below SW Standard
2070	50,000	Source	855	Below SW Standard
2110	50,000	Source	855	Below SW Standard

VC (Initial Source Concentration 4,000 µg/L)

Date	Maximum Concentration (µg/L)	Distance from Source of Maximum Concentration (ft)	Maximum Plume Extent (ft)	Concentration at New River (µg/L)
2020	2,450	30	>1300	Below SW Standard
2030	2,450	30	>1300	Below SW Standard
2050	2,450	30	>1300	Below SW Standard
2070	2,450	30	>1300	Below SW Standard
2110	2,450	30	>1300	Below SW Standard

Notes:
TCE = Trichloroethene, cis-1,2-DCE = cis-1,2-dichloroethene, VC = vinyl chloride
"GW Standard" refers to the North Carolina 2L Groundwater Standard (TCE = 3 µg/L, cis-1,2-DCE = 70 µg/L, VC = 0.03 µg/L)
"SW Standard" refers to the North Carolia Surface Water Standard (TCE = 30 µg/L,VC = 2.4 µg/L)

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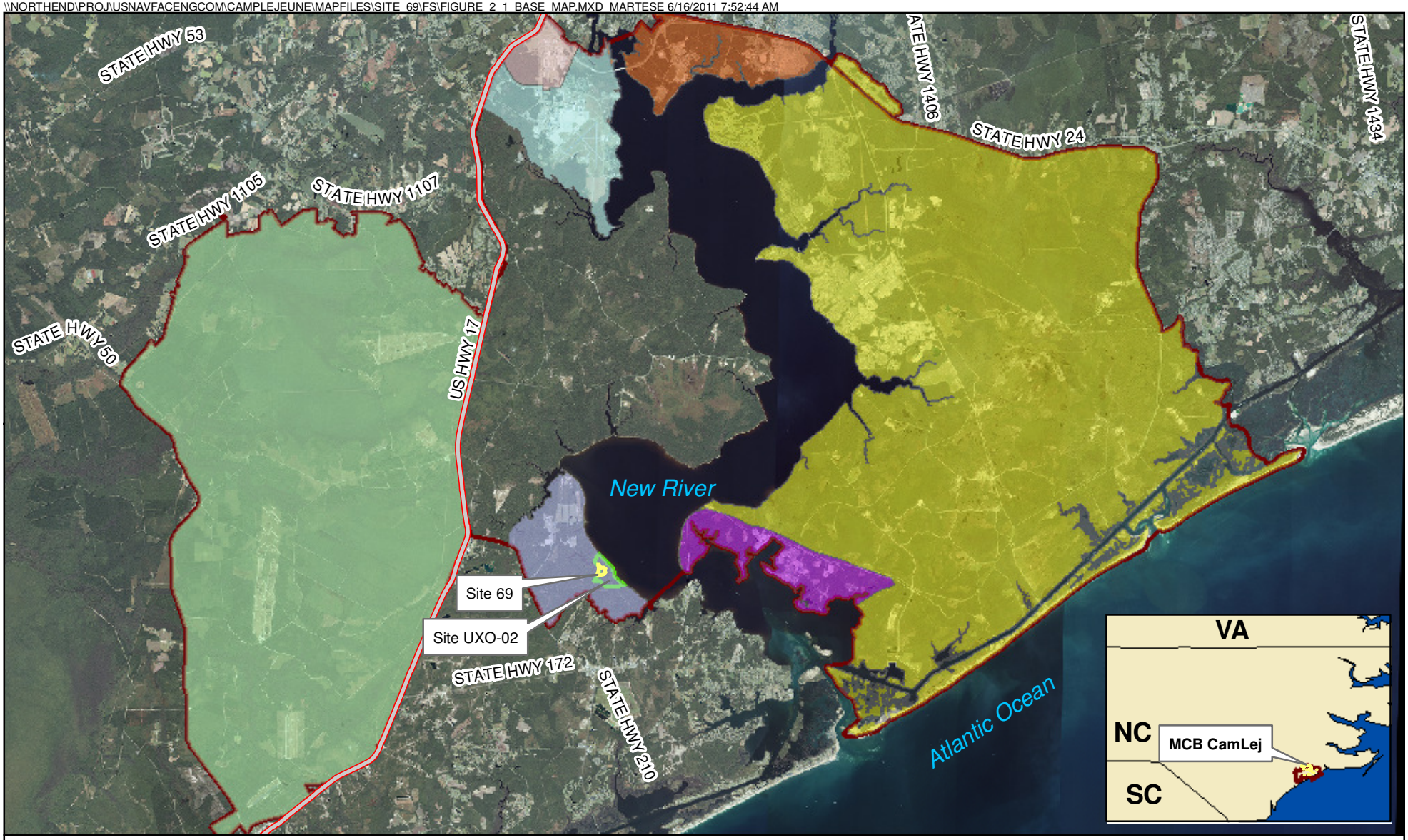

Legend

- Highways
- Installation Boundary
- Camp Geiger
- Greater Sandy Run
- Marine Corps Air Station New River
- Stone Bay
- Montford Point/Tarawa Terrace
- Courthouse Bay
- Main Side
- Site 69 Boundary
- Site UXO-02 Boundary

N

0 7,500 15,000 30,000 Feet

1 inch = 15,000 feet

Figure 2-1
Base Map
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

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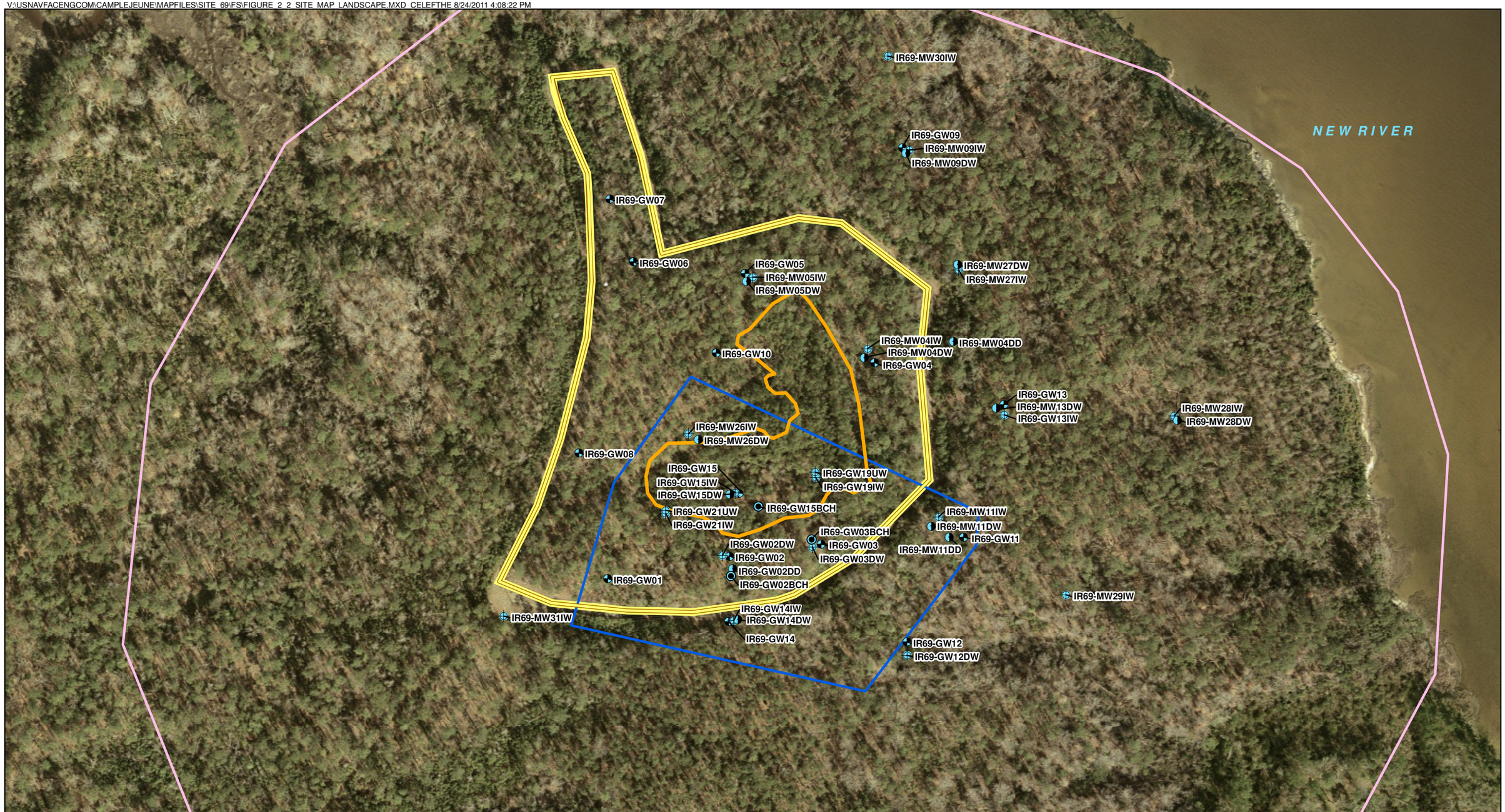

Legend

- Surficial Aquifer Well
- Upper Castle Hayne Aquifer Well
- Middle Castle Hayne Aquifer Well
- Lower Castle Hayne Aquifer Well
- Waste Disposal Area
- Site 69 Boundary

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary
- Intrusive Activities Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)

N

0 100 200 400 Feet

1 inch = 200 feet

Figure 2-2
Site Map
Site 69 Feasibility Study
MCB CamLej
North Carolina

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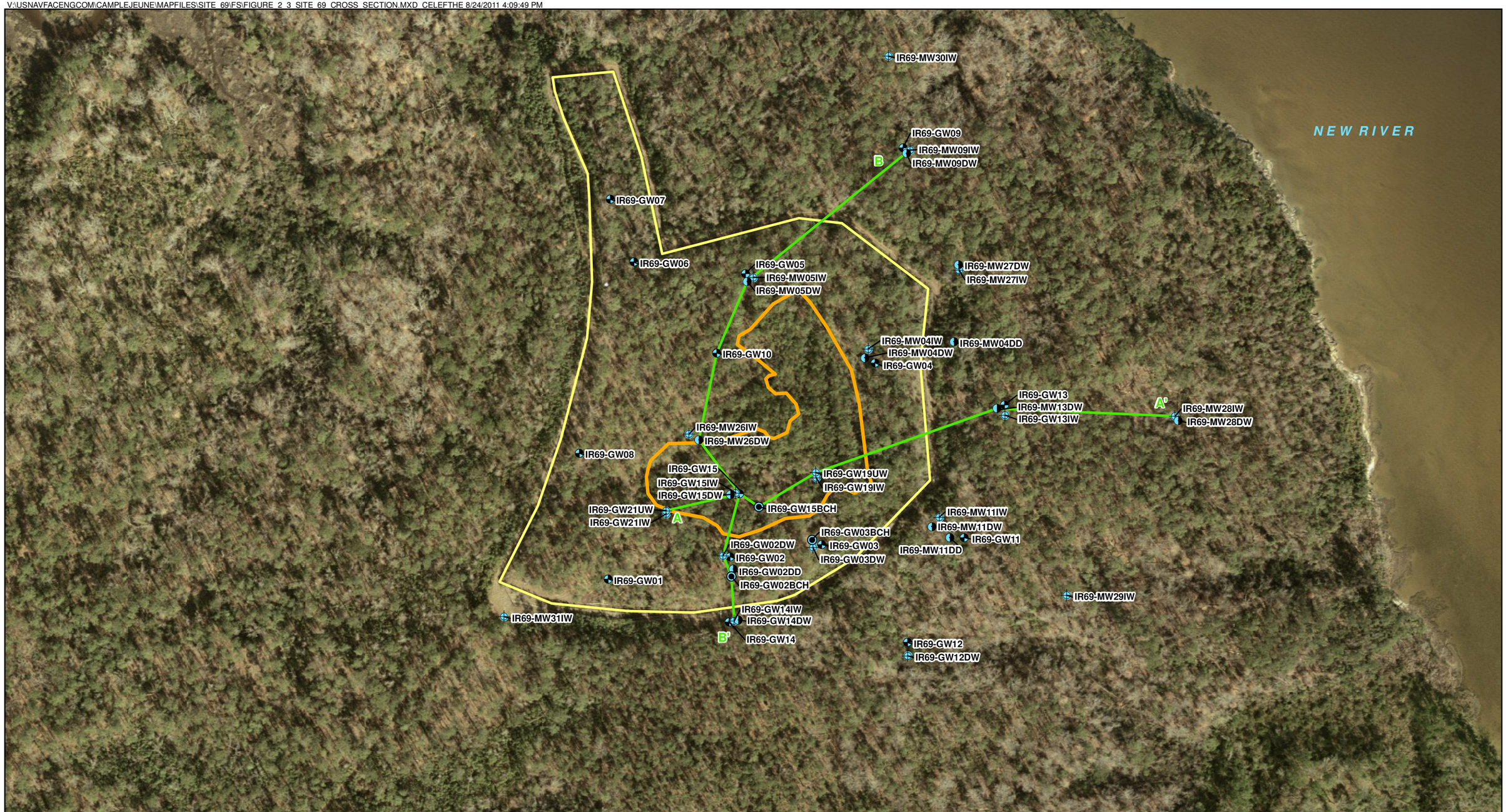


Legend

- Surficial Aquifer Well
- Upper Castle Hayne Aquifer Well
- Middle Castle Hayne Aquifer Well
- Lower Castle Hayne Aquifer Well
- Cross Section
- Waste Disposal Area
- Site 69 Boundary

Notes:
Monitoring Wells IR69-MW29IW, -MW30IW, -MW31IW, -MW04DD, and -MW11DD were installed in February 2011 and have not yet been surveyed.

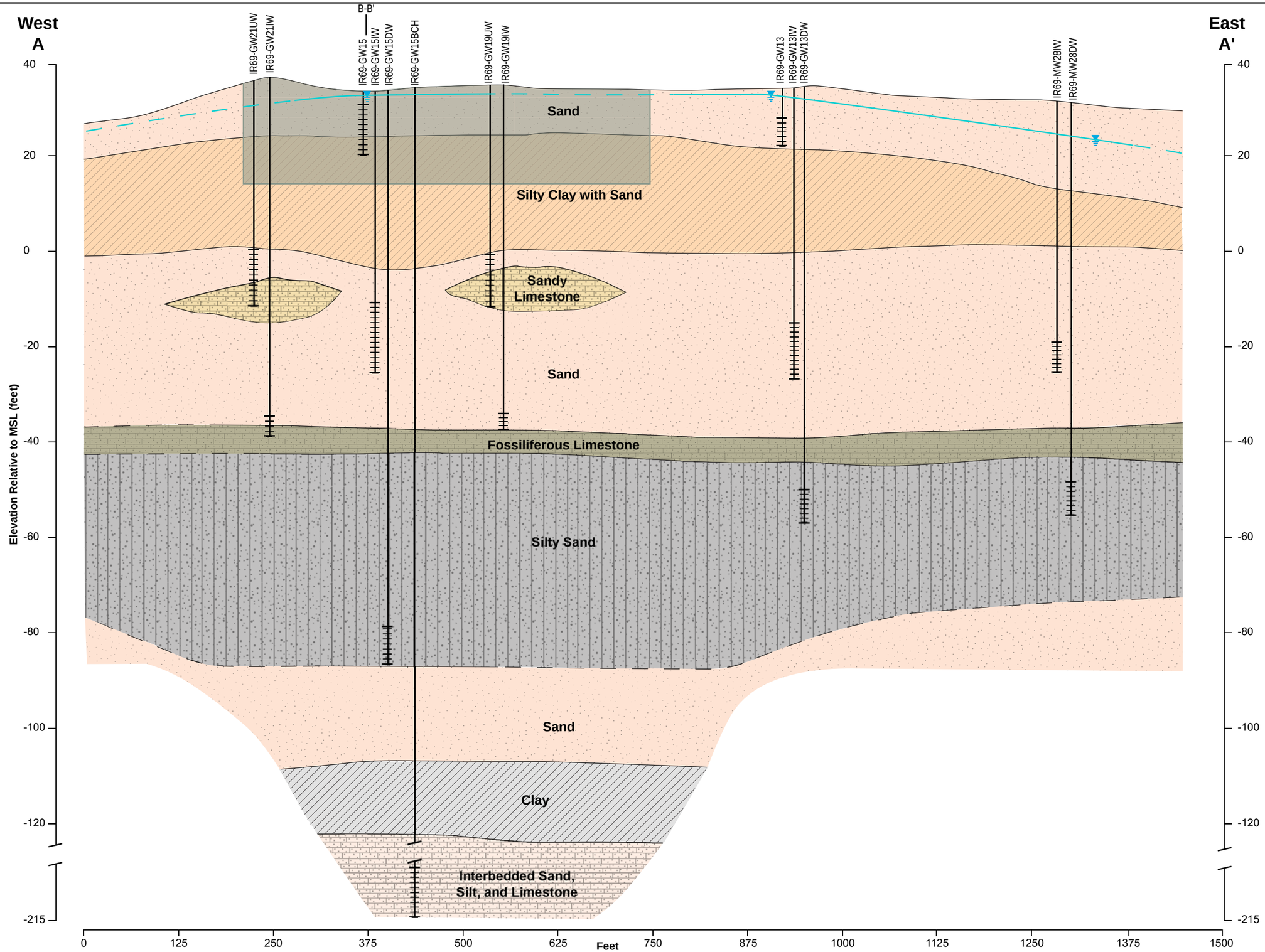
N

0 100 200 400 Feet

1 inch = 200 feet

Figure 2-3
Hydrogeological Cross Section Layout
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL.



Horizontal : 1" = 125'
Vertical: 1" = 20'
V.E. = 6.25x

LEGEND

- Sand
- Silty clay with sand
- Silty Sand
- Fossiliferous Limestone and Cemented Sand
- Sandy Limestone
- Interbedded Sand, Silt, and Limestone
- Clay
- Waste Disposal Area
- Screened Interval
- Geologic Contact (dashed where inferred)
- Water Table (dashed where inferred)

NOTE

1) The depth and thickness of the subsurface strata indicated on this section (profile) were generalized from and interpolated between test locations. Information on actual subsurface conditions apply only to the specific locations indicated. Subsurface conditions and water levels at other locations may differ from conditions occurring at the indicated locations.
2) All water levels were measured during in March 2010.

Figure 2-4
Hydrogeological Cross Section A-A'
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

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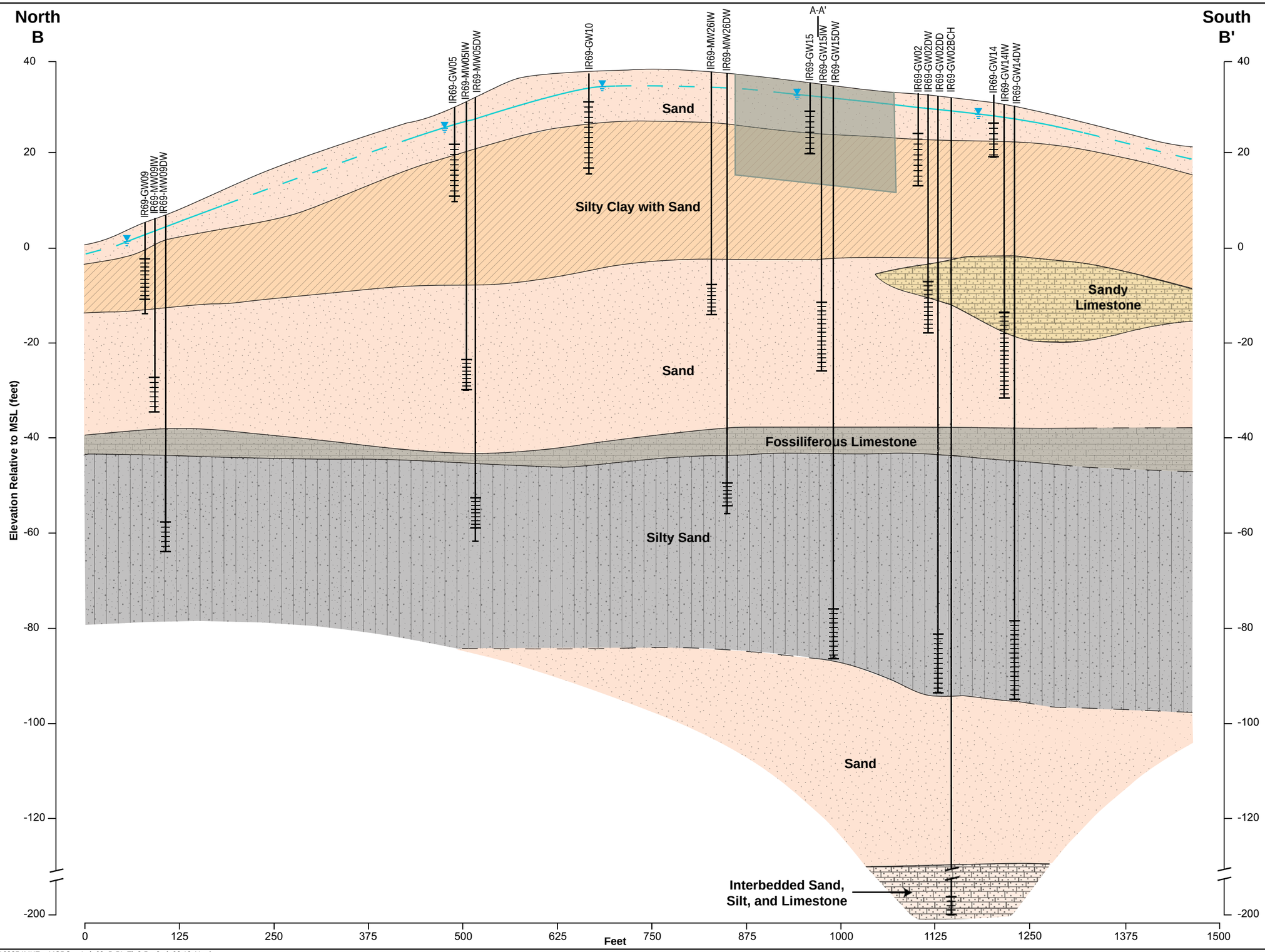

Horizontal : 1" = 125'
Vertical: 1" = 20'
V.E. = 6.25x

LEGEND

- Sand
- Silty clay with sand
- Silty Sand
- Fossiliferous Limestone and Cemented Sand
- Sandy Limestone
- Interbedded Sand, Silt, and Limestone
- Clay
- Waste Disposal Area
- Screened Interval
- Geologic Contact (dashed where inferred)
- Water Table (dashed where inferred)

NOTE

1) The depth and thickness of the subsurface strata indicated on this section (profile) were generalized from and interpolated between test locations. Information on actual subsurface conditions apply only to the specific locations indicated. Subsurface conditions and water levels at other locations may differ from conditions occurring at the indicated locations.
2) All water levels were measured during in March 2010.

Figure 2-5
Hydrogeological Cross Section B-B'
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

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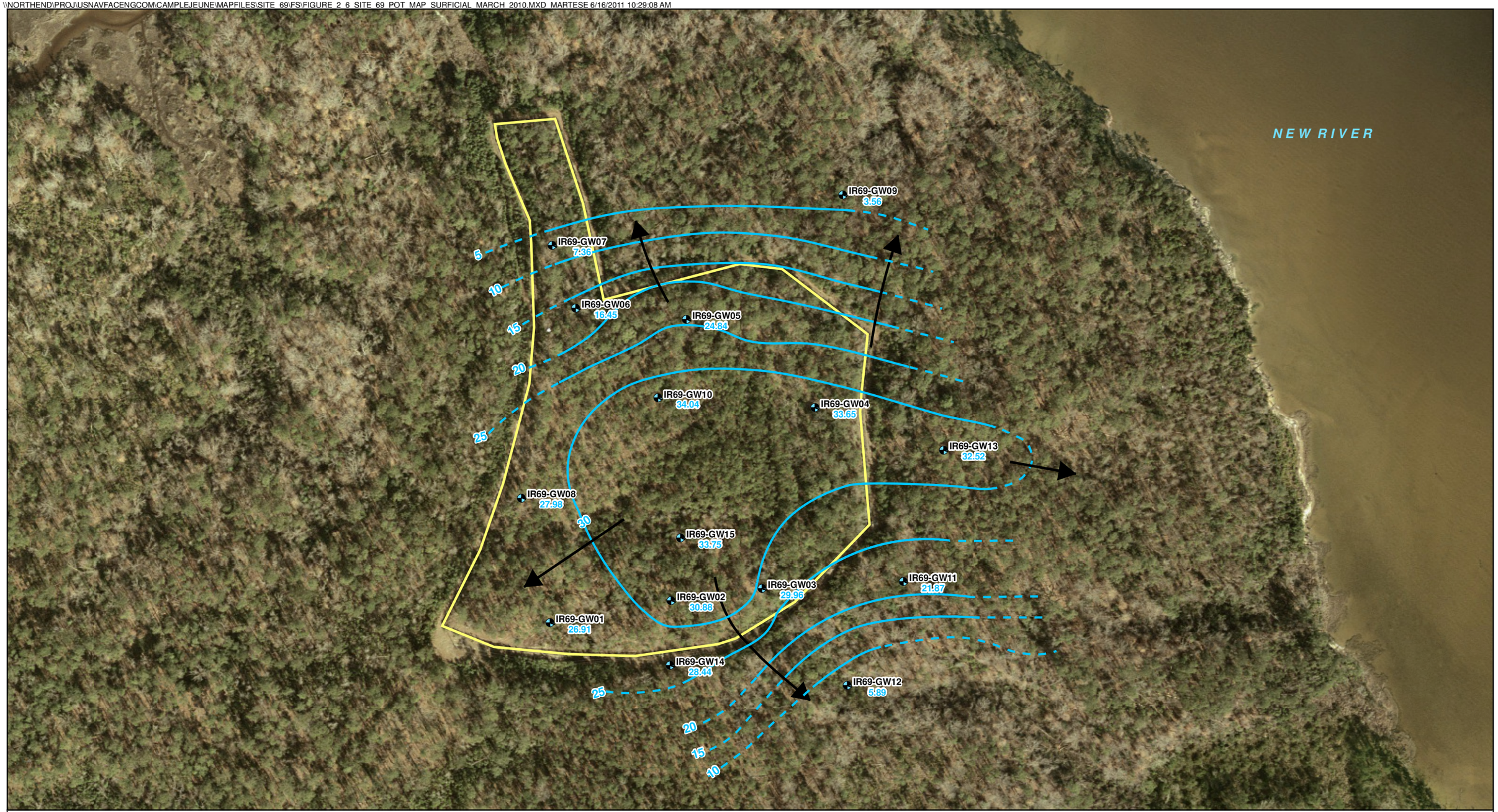


Legend

- Surficial Aquifer Well
- Groundwater Flow Direction (dashed where inferred)
- Potentiometric Contour (5 foot interval, dashed where inferred)
- Site 69 Boundary
- 30.88 Water level elevation

Notes:

- Water level elevations are reported in feet above mean sea level
- Potentiometric surface contours have been interpolated between monitoring well locations. Actual conditions may differ from those shown on this figure.
- Water levels were measured on March 19, 2010.

N

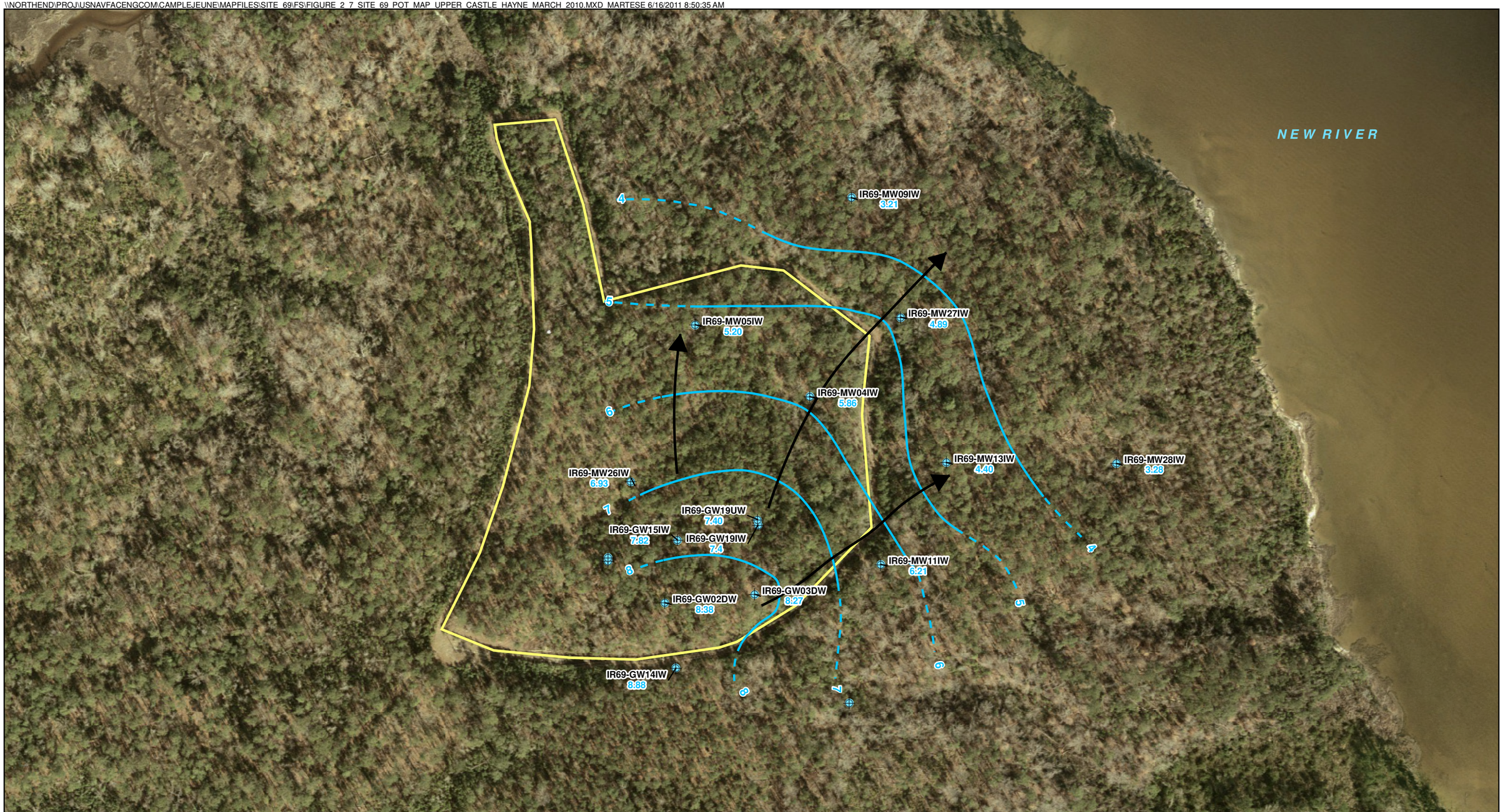
0 100 200 400 Feet

1 inch = 200 feet

Figure 2-6
Potentiometric Surface Map - Surficial Aquifer - March 2010
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

\\NORTHEND\PROJ\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\SITE_69\FS\FIGURE_2_7_SITE_69_POT_MAP_UPPER_CASTLE_HAYNE_MARCH_2010.MXD MARTESE 6/16/2011 8:50:35 AM



Legend

- Upper Castle Hayne Aquifer Well
- Groundwater Flow Direction
- Potentiometric Contour (1 foot interval, dashed where inferred)
- Site 69 Boundary
- 8.38 Water level elevation

Notes:

- Water level elevations are reported in feet above mean sea level
- Potentiometric surface contours have been interpolated between monitoring well locations. Actual conditions may differ from those shown on this figure.
- Water levels were measured on March 19, 2010.

N

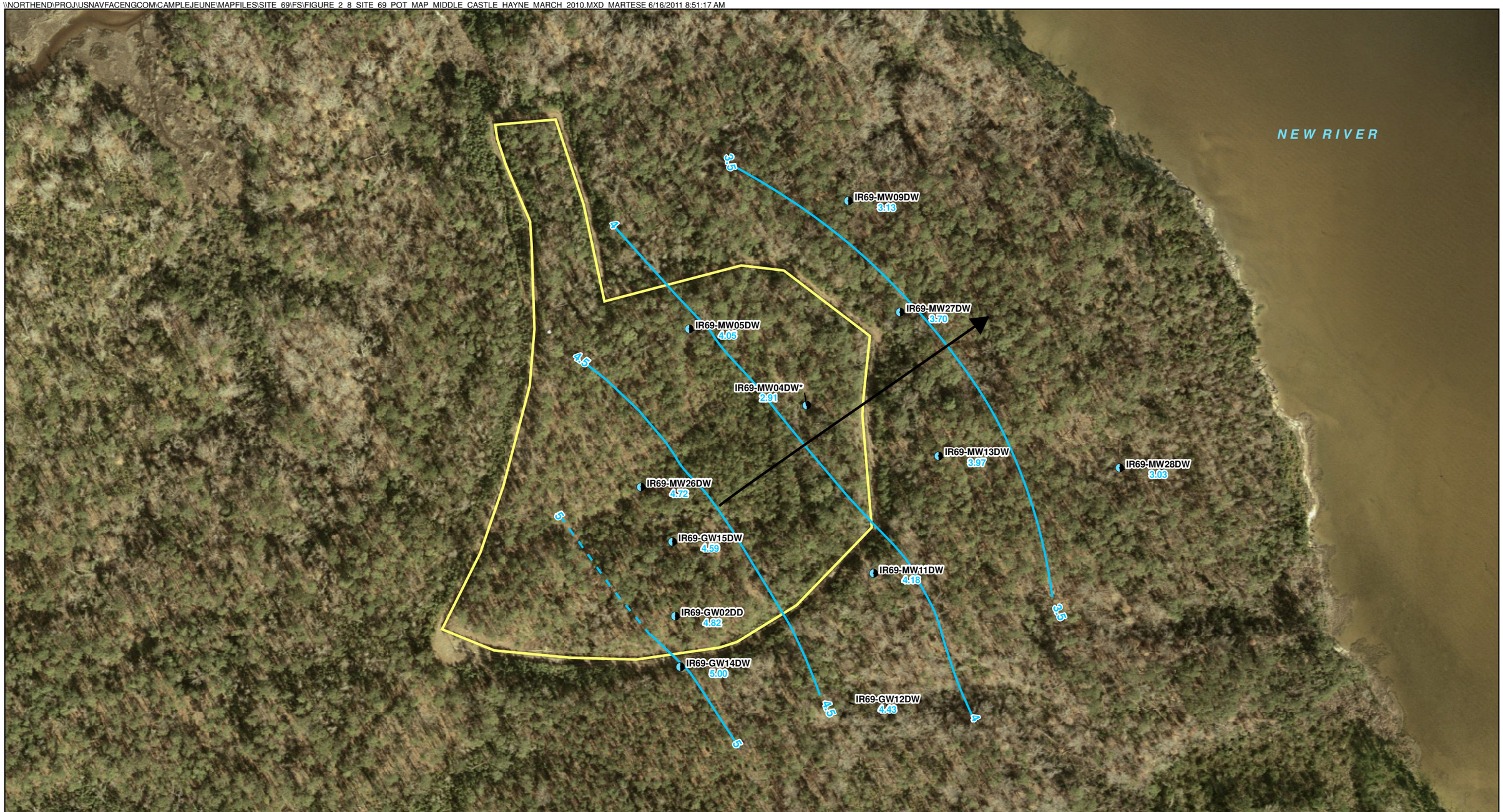
0 100 200 400 Feet

1 inch = 200 feet

Figure 2-7
Potentiometric Surface Map - Upper Castle Hayne Aquifer - March 2010
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

\\NORTHEND\PROJ\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\SITE_69\FS\FIGURE_2_8_SITE_69_POT_MAP_MIDDLE_CASTLE_HAYNE_MARCH_2010.MXD MARTESE 6/16/2011 8:51:17 AM



Legend

- Middle Castle Hayne Aquifer Well
- Groundwater Flow Direction
- Potentiometric Contour (0.5 foot interval, dashed where inferred)
- Site 69 Boundary
- 4.82 Water level elevation

Notes:

- Water level elevations are reported in feet above mean sea level
- Potentiometric surface contours have been interpolated between monitoring well locations. Actual conditions may differ from those shown on this figure.
- Water levels were measured on March 19, 2010.

* Groundwater elevation not used

N

0 100 200 400 Feet

1 inch = 200 feet

Figure 2-8
Potentiometric Surface Map - Middle Castle Hayne Aquifer - March 2010
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

V:\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\SITE_69\FS\FIGURE_2_9_CHLORINATED_ETHANE_RESULTS_SURFICIAL_AQUIFERMXD.MXD CELEFTHE 8/23/2011 11:39:40 AM

Location	1,1,2,2-PCA	1,1,2-TCA	1,2-DCA
NCGWQS	0.2	5	0.4
IR69-GW02	9.8	7.8	1.7
IR69-GW03	0.18 J	0.5 J	0.72 J
IR69-GW04	0.17 J	0.5 U	0.48 J
IR69-GW15	2.9	1.3	13

Legend
- Surficial Aquifer Well Locations
- Waste Disposal Area
- Site 69 Boundary

1,1,2-TCA Concentration
- > 5 µg/L

1,1,2,2-PCA Concentration
- > 0.2 µg/L

1,2-DCA Concentration
- > 0.4 µg/L

Notes:
- All concentrations are reported in micrograms per liter (µg/L)
- Contours have been interpolated between well locations. Actual conditions may differ from those shown on this figure.
- Only detected concentrations shown on table

NCGWQS - North Carolina Groundwater Quality Standard
J - analyte detected, value may or may not be accurate or precise
U - analyte not detected
1,1,2-TCA - 1,1,2-Trichlorethene
1,1,2,2-PCA - 1,1,2,2-Tetrachloroethane
1,2-DCA - 1,2-Dichloroethane
- All wells were sampled in March 2010

N

0 100 200 400 Feet

1 inch = 200 feet

Figure 2-9
Chlorinated Ethane Distribution, Surficial Aquifer
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

V:\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\SITE_69\FS\FIGURE_2_10_TCE_RESULTS_SURFICIAL.MXD CELEFTHE 8/23/2011 11:40:44 AM

Location	TCE (µg/L)
NCGWQS	3
IR69-GW02	2.3
IR69-GW03	3.5
IR69-GW04	0.38 J
IR69-GW09	0.3 J
IR69-GW12	0.29 J
IR69-GW15	0.38 J

Legend
- Surficial Aquifer Well Locations
- Waste Disposal Area
- Site 69 Boundary

TCE Concentration
- > 3.0 µg/L

Notes:
- All concentrations are reported in micrograms per liter (µg/L)
- Contours have been interpolated between well locations. Actual conditions may differ from those shown on this figure.
- Only detected concentrations shown on table

NCGWQS - North Carolina Groundwater Quality Standard
J - analyte detected, value may or may not be accurate or precise
TCE - Trichloroethene
- All wells were sampled in March 2010

N

0 100 200 400 Feet

1 inch = 200 feet

Figure 2-10
TCE Distribution, Surficial Aquifer
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

V:\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\SITE_69\FS\FIGURE_2_11_CIS12_DCE_RESULTS_SURFICIAL.MXD CELEFTHE 8/18/2011 2:50:45 PM

Location	cis-1,2-DCE (µg/L)
NCGWQS	70
IR69-GW02	110 J
IR69-GW03	180
IR69-GW04	3.1
IR69-GW09	6.5
IR69-GW12	0.8
IR69-GW15	2.1

Legend
- Surficial Aquifer Well Locations
- Waste Disposal Area
- Site 69 Boundary

cis-1,2-DCE Concentration
- > 70 µg/L

Notes:
- All concentrations are reported in micrograms per liter (µg/L)
- Contours have been interpolated between well locations. Actual conditions may differ from those shown on this figure.
- Only detected concentrations shown on table

NCGWQS - North Carolina Groundwater Quality Standard
J - analyte detected, value may or may not be accurate or precise
cis-1,2-DCE - cis-1,2-Dichloroethene
- All wells were sampled in March 2010

N

0 100 200 400 Feet

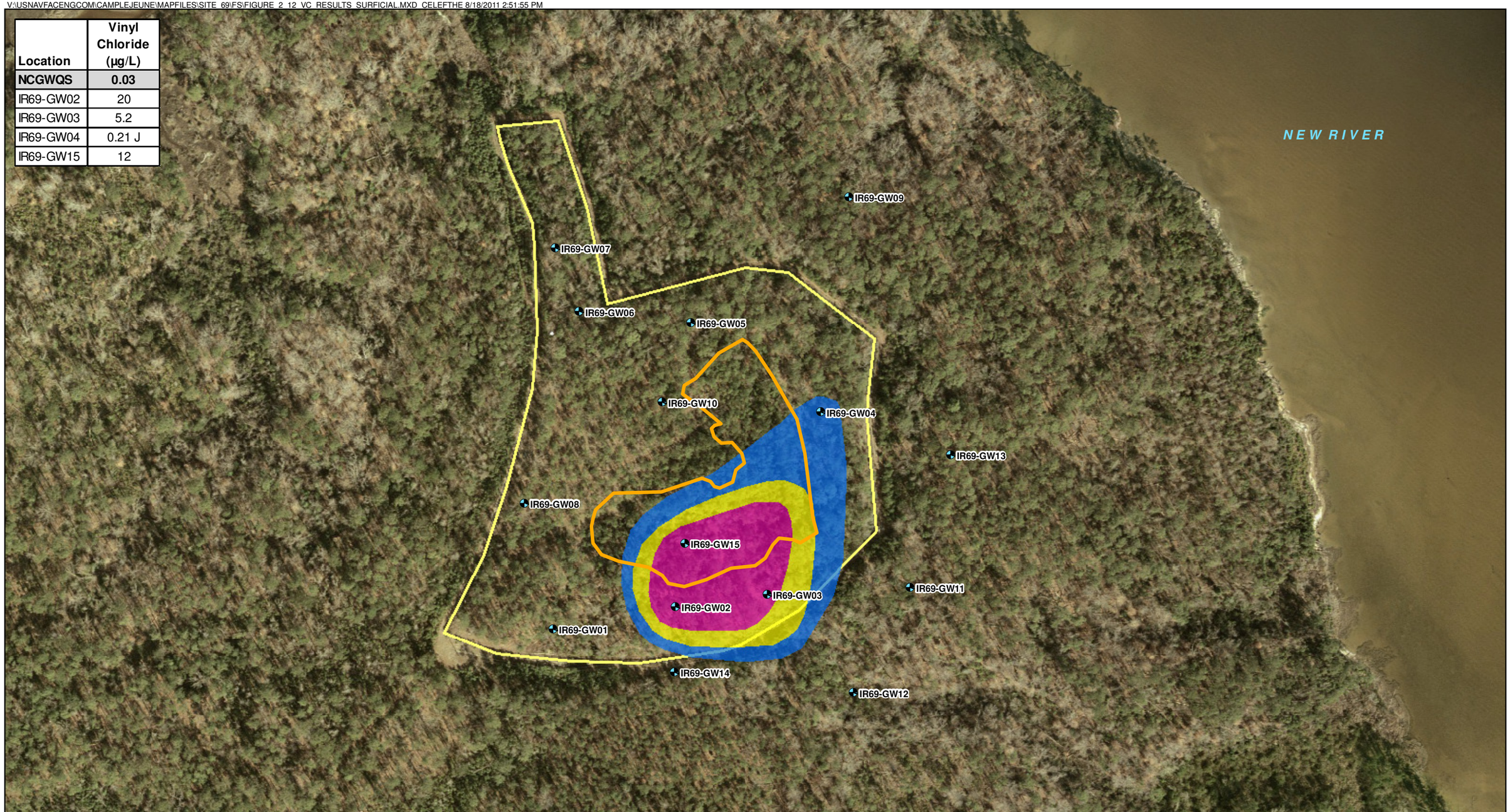
1 inch = 200 feet

Figure 2-11
cis-1,2-DCE Distribution, Surficial Aquifer
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

V:\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\SITE_69\FS\FIGURE_2_12_VC_RESULTS_SURFICIAL.MXD CELEFTHE 8/18/2011 2:51:55 PM

Location	Vinyl Chloride (µg/L)
NCGWQS	0.03
IR69-GW02	20
IR69-GW03	5.2
IR69-GW04	0.21 J
IR69-GW15	12



Legend
- Surficial Aquifer Well Locations
- Waste Disposal Area
- Site 69 Boundary

VC Concentration
- > 0.03 µg/L
- > 0.3 µg/L
- > 3.0 µg/L

Notes:
- All concentrations are reported in micrograms per liter (µg/L)
- Contours have been interpolated between well locations. Actual conditions may differ from those shown on this figure.
- Only detected concentrations shown on table

NCGWQS - North Carolina Groundwater Quality Standard
J - analyte detected, value may or may not be accurate or precise
VC - Vinyl Chloride
- All wells were sampled in March 2010

N

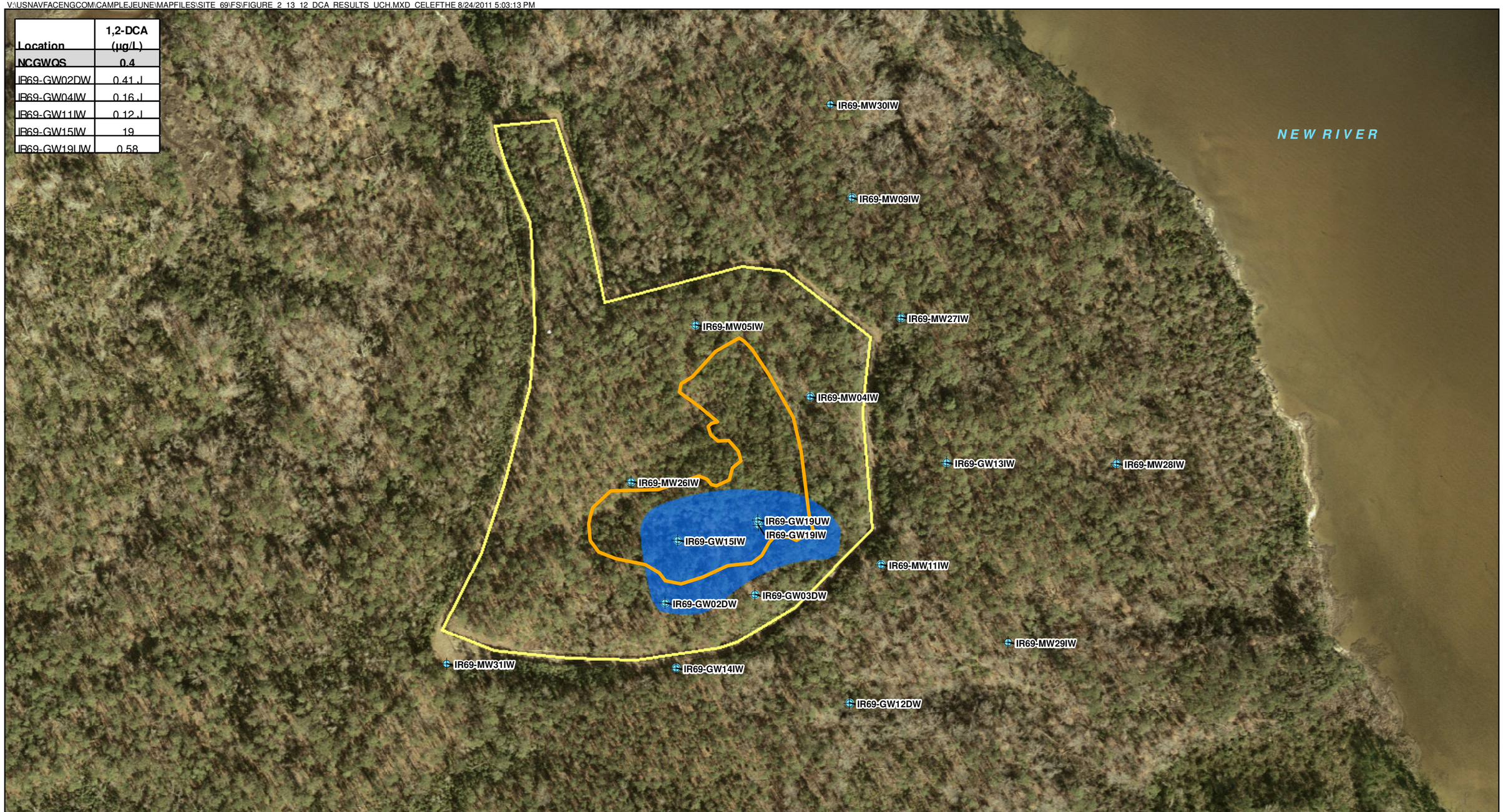
0 100 200 400 Feet

1 inch = 200 feet

Figure 2-12
Vinyl Chloride Distribution, Surficial Aquifer
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

V:\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\SITE_69\FS\FIGURE_2_13_12_DCA_RESULTS_UCH.MXD CELEFTHE 8/24/2011 5:03:13 PM



Location	1,2-DCA (µg/L)
NCGWQS	0.4
IR69-GW02DW	0.41 J
IR69-GW04IW	0.16 J
IR69-GW11IW	0.12 J
IR69-GW15IW	19
IR69-GW19UW	0.58

Legend

- Upper Castle Hayne Aquifer Well Location
- Waste Disposal Area

1,2-DCA Concentration

- > 0.4 µg/L
- Site 69 Boundary

Notes:
- All concentrations are reported in micrograms per liter (µg/L)
- Contours have been interpolated between well locations. Actual conditions may differ from those shown on this figure.
- Only detected concentrations shown on table

NCGWQS - North Carolina Groundwater Quality Standard
J - analyte detected, value may or may not be accurate or precise
1,2-DCA - 1,2-Dichloroethane
- All wells were sampled in March 2010 with the exception of IR69-MW29IW, -MW30IW, and -MW31IW which were sampled in March 2011

N

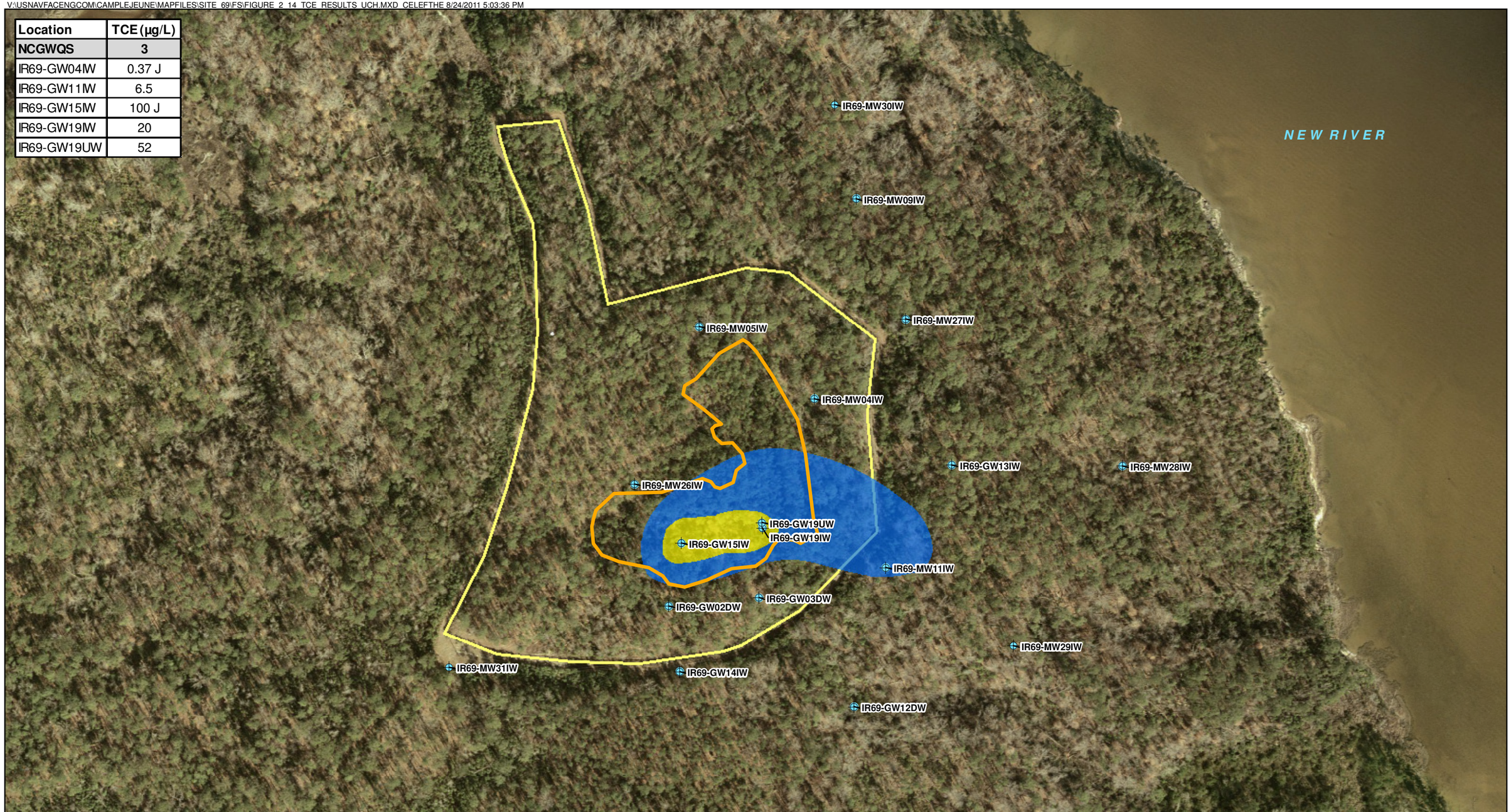
0 100 200 400 Feet

1 inch = 200 feet

Figure 2-13
1,2-DCA Distribution, Upper Castle Hayne Aquifer
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

V:\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\SITE_69\FS\FIGURE_2_14_TCE_RESULTS_UCH.MXD CELEFTHE 8/24/2011 5:03:36 PM



Location	TCE (µg/L)
NCGWQS	3
IR69-GW04IW	0.37 J
IR69-GW11IW	6.5
IR69-GW15IW	100 J
IR69-GW19IW	20
IR69-GW19UW	52

Legend

- Upper Castle Hayne Aquifer Well Location
- Waste Disposal Area
- Site 69 Boundary

TCE Concentration

- > 3.0 µg/L
- > 30.0 µg/L

Notes:
- All concentrations are reported in micrograms per liter (µg/L)
- Contours have been interpolated between well locations. Actual conditions may differ from those shown on this figure.
- Only detected concentrations shown on table

NCGWQS - North Carolina Groundwater Quality Standard
J - analyte detected, value may or may not be accurate or precise
TCE - Trichloroethene
- All wells were sampled in March 2010 with the exception of IR69-MW29IW, -MW30IW, and -MW31IW which were sampled in March 2011

N

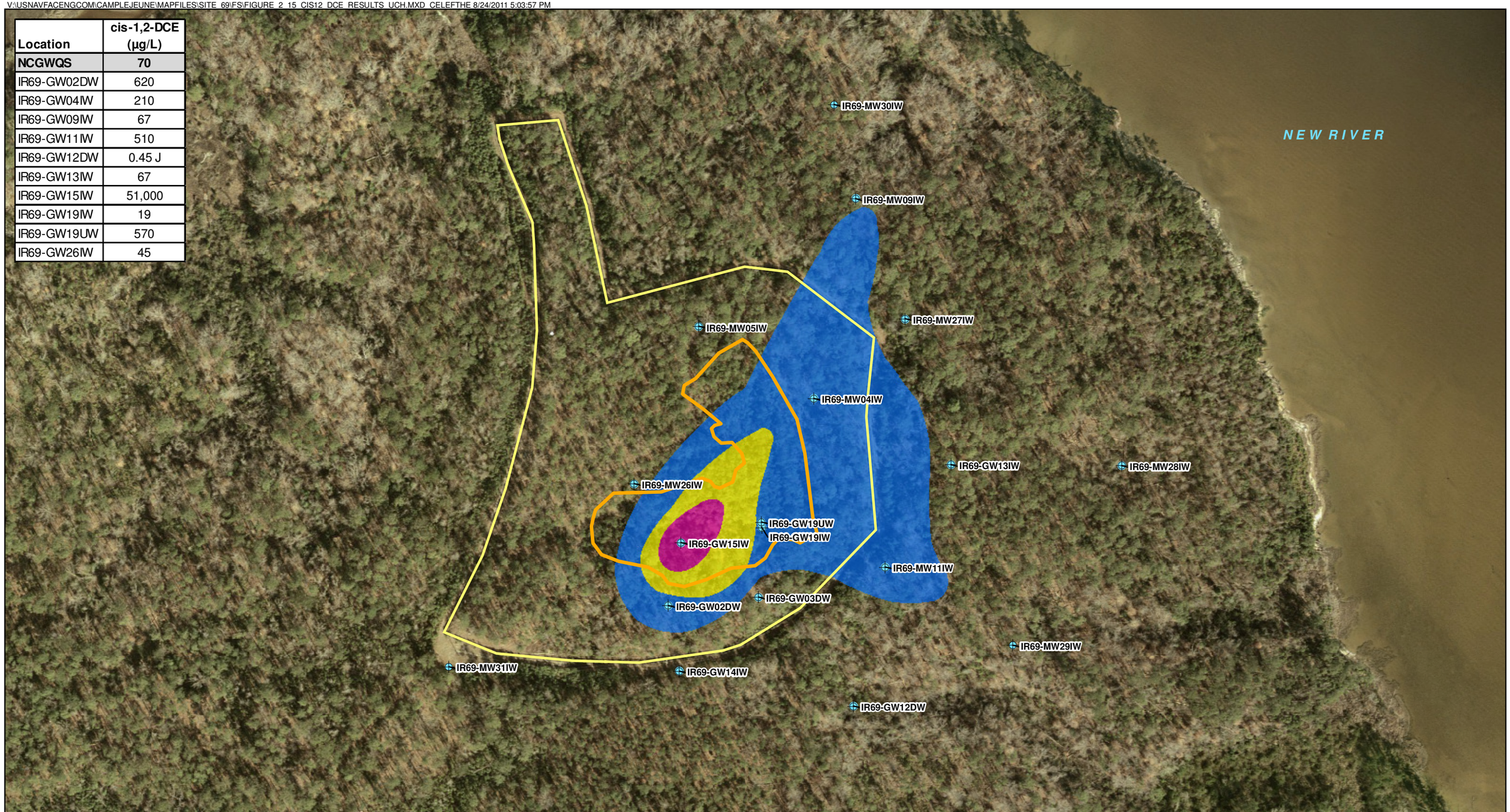
0 100 200 400 Feet

1 inch = 200 feet

Figure 2-14
TCE Distribution, Upper Castle Hayne Aquifer
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

V:\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\SITE_69\FS\FIGURE_2_15_CIS12_DCE_RESULTS_UCH.MXD CELEFTHE 8/24/2011 5:03:57 PM



Location	cis-1,2-DCE (µg/L)
NCGWQS	70
IR69-GW02DW	620
IR69-GW04IW	210
IR69-GW09IW	67
IR69-GW11IW	510
IR69-GW12DW	0.45 J
IR69-GW13IW	67
IR69-GW15IW	51,000
IR69-GW19IW	19
IR69-GW19UW	570
IR69-GW26IW	45

Legend

- Upper Castle Hayne Aquifer Well Location
- Waste Disposal Area
- Site 69 Boundary

cis-1,2-DCE Concentration

- > 70 µg/L
- > 700 µg/L
- > 7,000 µg/L

Notes:
- All concentrations are reported in micrograms per liter (µg/L)
- Contours have been interpolated between well locations. Actual conditions may differ from those shown on this figure.
- Only detected concentrations shown on table

NCGWQS - North Carolina Groundwater Quality Standard
J - analyte detected, value may or may not be accurate or precise
cis-1,2-DCE - cis-1,2-Dichloroethene
- All wells were sampled in March 2010 with the exception of IR69-MW29IW, -MW30IW, and -MW31IW which were sampled in March 2011

N

0 100 200 400 Feet

1 inch = 200 feet

Figure 2-15
cis-1,2-DCE Distribution, Upper Castle Hayne Aquifer
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

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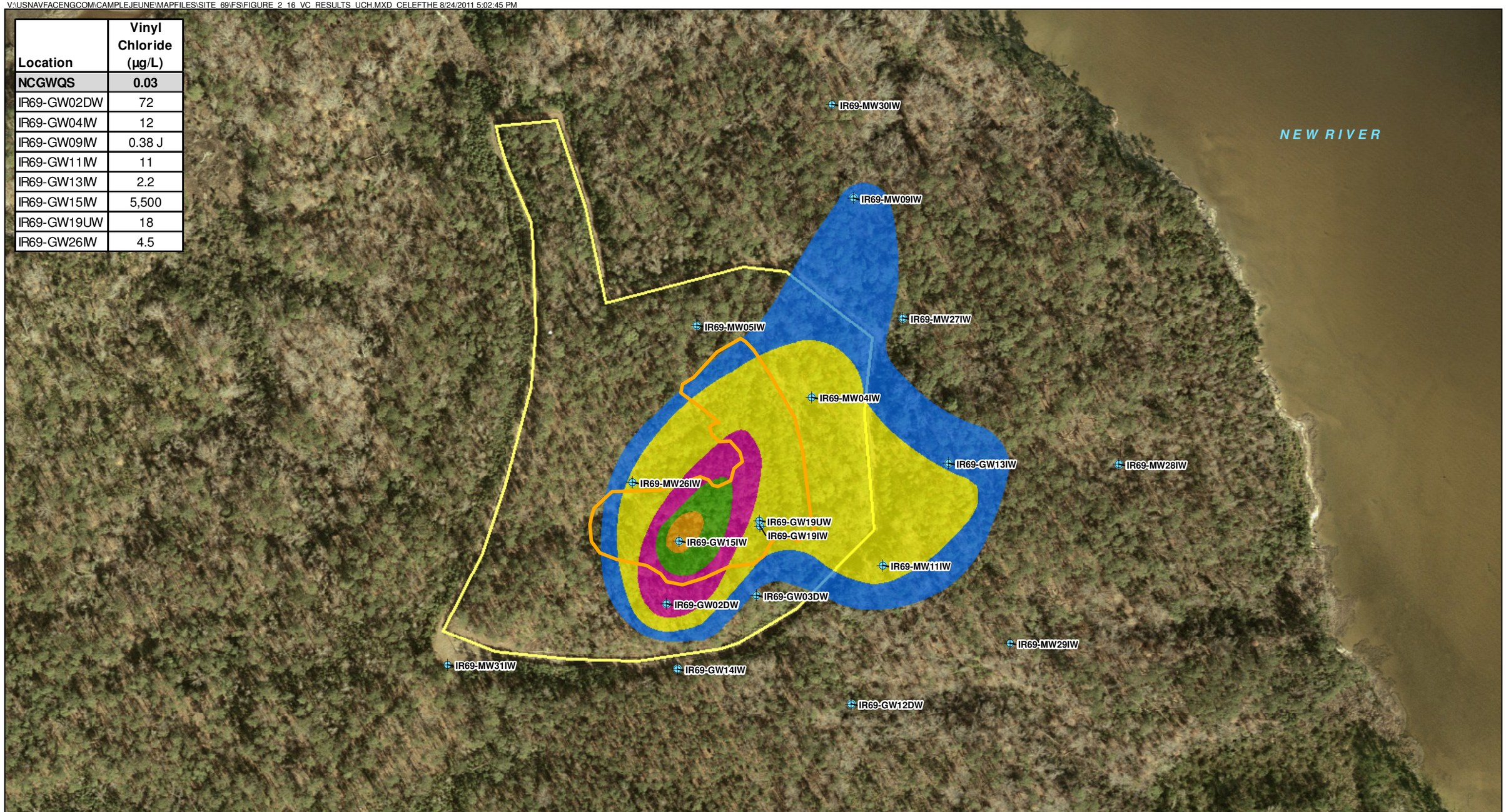


Location	Vinyl Chloride (µg/L)
NCGWQS	**0.03**
IR69-GW02DW	72
IR69-GW04IW	12
IR69-GW09IW	0.38 J
IR69-GW11IW	11
IR69-GW13IW	2.2
IR69-GW15IW	5,500
IR69-GW19UW	18
IR69-GW26IW	4.5

Legend
- Upper Castle Hayne Aquifer Well Location
- Waste Disposal Area
- Site 69 Boundary

VC Concentration
- > 0.03 µg/L
- > 3.0 µg/L
- > 30.0 µg/L
- > 300.0 µg/L
- > 3,000.0 µg/L

Notes:
- All concentrations are reported in micrograms per liter (µg/L)
- Contours have been interpolated between well locations. Actual conditions may differ from those shown on this figure.
- Only detected concentrations shown on table

NCGWQS - North Carolina Groundwater Quality Standard
J - analyte detected, value may or may not be accurate or precise
VC - Vinyl Chloride
- All wells were sampled in March 2010 with the exception of IR69-MW29IW, -MW30IW, and -MW31IW which were sampled in March 2011

N

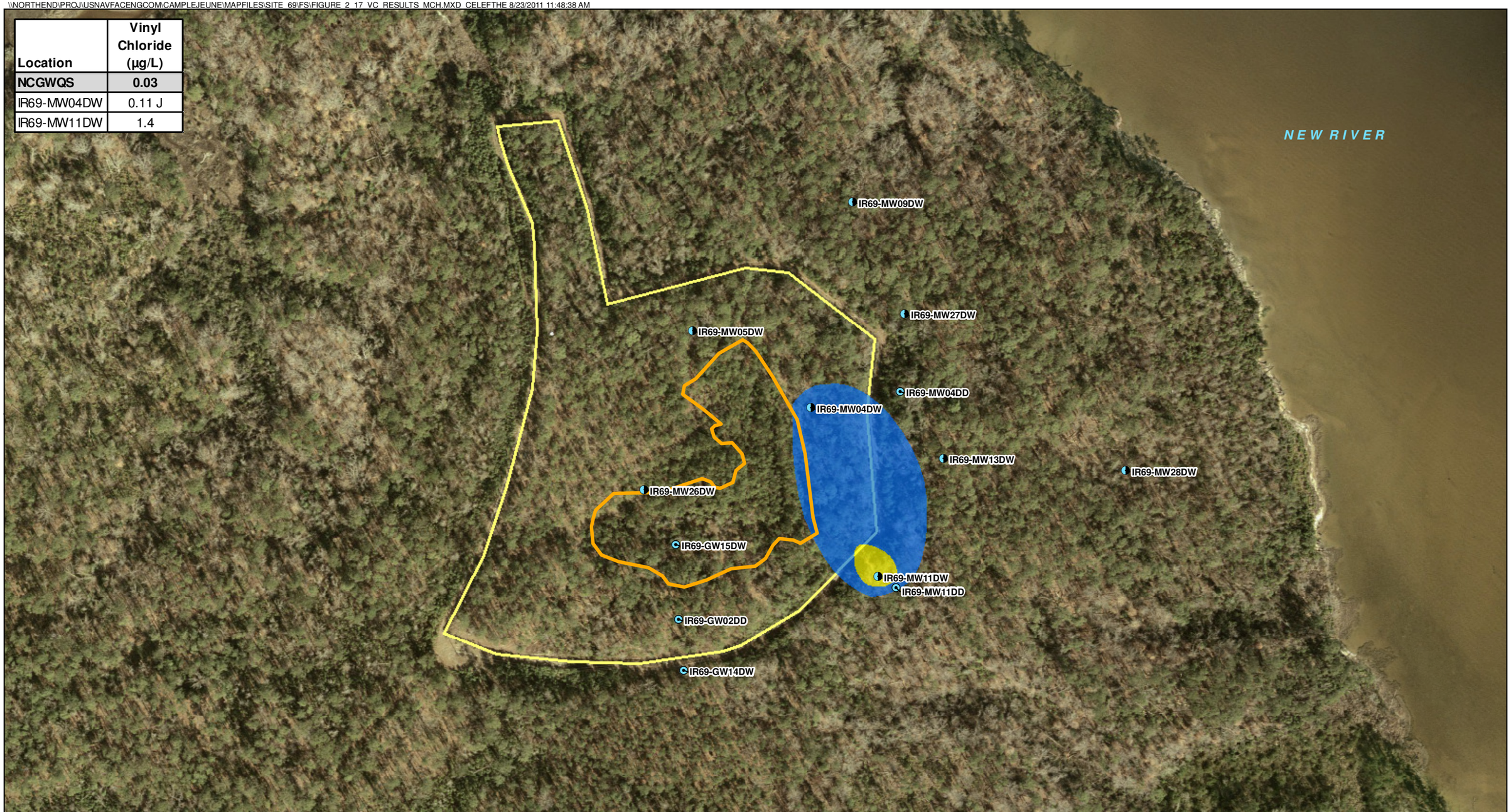
0 100 200 400 Feet

1 inch = 200 feet

Figure 2-16
Vinyl Chloride Distribution, Upper Castle Hayne Aquifer
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

\\NORTHEND\PROJ\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\SITE_69\FS\FIGURE_2_17_VC_RESULTS_MCH.MXD CELEFTHE 8/23/2011 11:48:38 AM



Location	Vinyl Chloride (µg/L)
NCGWQS	0.03
IR69-MW04DW	0.11 J
IR69-MW11DW	1.4

Legend

- Middle Castle Hayne Aquifer Well (<100 ft. bgs)
- Middle Castle Hayne Aquifer Well (>100 ft. bgs)
- Waste Disposal Area
- Site 69 Boundary

VC Concentration

- > 0.03 µg/L
- > 0.3 µg/L

Notes:
- All concentrations are reported in micrograms per liter (µg/L)
- Contours have been interpolated between well locations. Actual conditions may differ from those shown on this figure.
- Only detected concentrations shown on table

NCGWQS - North Carolina Groundwater Quality Standard
J - analyte detected, value may or may not be accurate or precise
VC - Vinyl Chloride
- All wells were sampled in March 2010 with the exception of IR69-MW04DD and -MW11DD which were sampled in March 2011
- Ft. bgs - Feet below ground surface

N

0 100 200 400 Feet

1 inch = 200 feet

Figure 2-17
Vinyl Chloride Distribution, Middle Castle Hayne Aquifer
Site 69 Feasibility Study
MCB CamLej
North Carolina

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Legend

EPA Score

- 0 to 5 Inadequate evidence for anaerobic biodegradation of chlorinated organics
- 6 to 14 Limited evidence for anaerobic biodegradation of chlorinated organics
- 15 to 20 Adequate evidence for anaerobic biodegradation of chlorinated organics
- Site 69 Boundary
- Waste Disposal Area
- Surficial aquifer cis-1,2-DCE exceeding NCGWQS

Note:
EPA scores were calculated using the USEPA Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water (USEPA, 1998)

N

0 100 200 400 Feet

1 inch = 200 feet

Figure 2-18
Natural Attenuation Indicator Parameter Conditions in the Surficial Aquifer
Site 69 Feasibility Study
MCB CamLej
North Carolina

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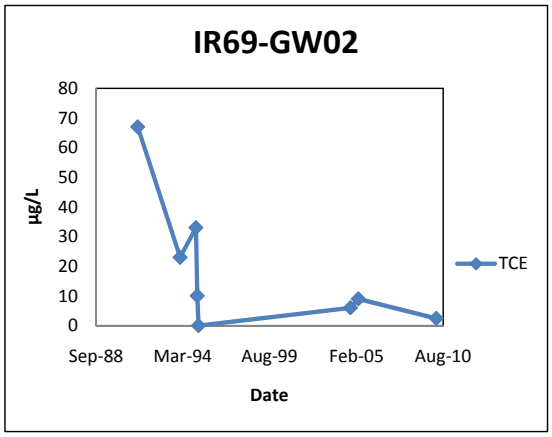

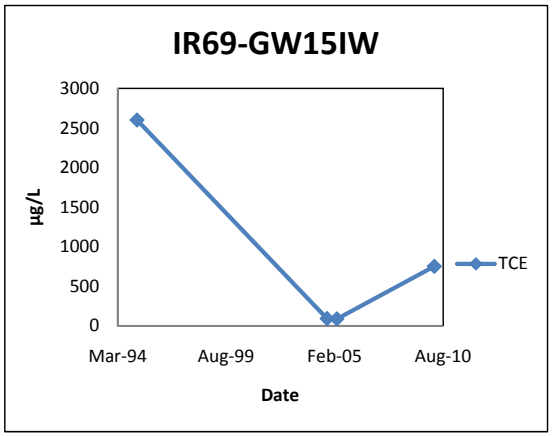

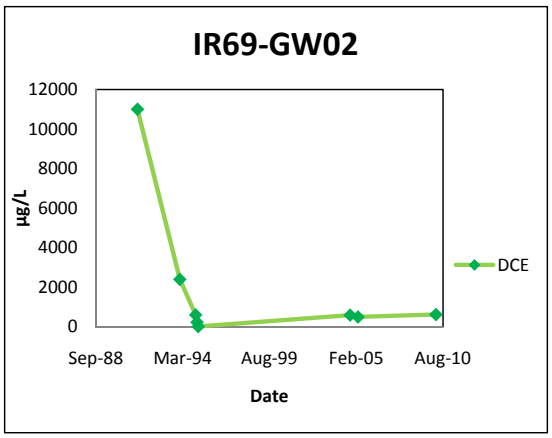

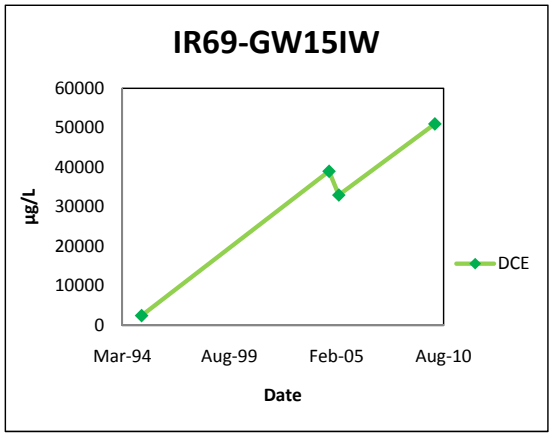

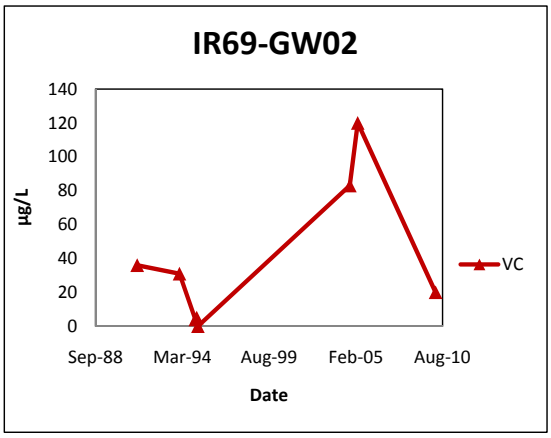

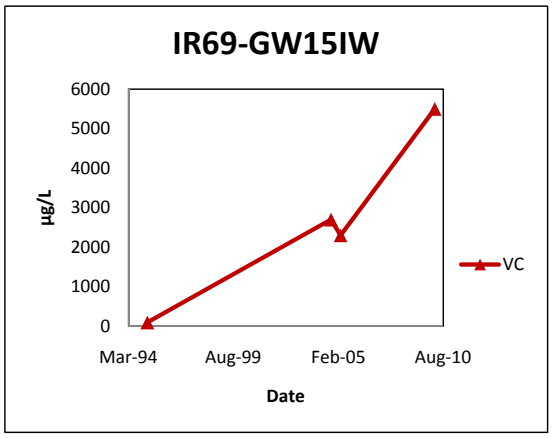

Figure 2-19
Historical Groundwater Analytical Data Trends – IR69-GW02, IR69-GW15IW
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL

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Legend

EPA Score

- 0 to 5 Inadequate evidence for anaerobic biodegradation of chlorinated organics
- 6 to 14 Limited evidence for anaerobic biodegradation of chlorinated organics
- 15 to 20 Adequate evidence for anaerobic biodegradation of chlorinated organics
- > 20 Strong evidence for anaerobic biodegradation of chlorinated organics
- Site 69 Boundary
- Waste Disposal Area
- Upper Castle Hayne aquifer cis-1,2-DCE exceeding NCGWQS

Note:
EPA scores were calculated using the USEPA Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water (USEPA, 1998)

N

0 100 200 400 Feet

1 inch = 200 feet

Figure 2-20
Natural Attenuation Indicator Parameter Conditions in the Upper Castle Hayne Aquifer
Site 69 Feasibility Study
MCB CamLej
North Carolina

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SECTION 3

Identification and Screening of Technologies

This section describes the initial steps to develop remedial alternatives for preventing further degradation of the surrounding environment, preventing exposure to buried waste and affected media, and the remediation of groundwater at Site 69, including the presentation of ARARs, development of RAOs, identification of the remediation target area, identification of General Response Actions (GRAs), and initial identification and screening of potential technologies.

3.1 Applicable or Relevant and Appropriate Regulations

Certain regulatory requirements and standards are also referred to as ARARs. There are three types of ARARs: chemical-specific, action-specific, and location-specific, which are described in further detail below. CERCLA Section 121(d), specifies in part that remedial actions for cleanup of hazardous substances must comply with requirements and standards under federal or more-stringent state environmental laws and regulations that are applicable or relevant and appropriate (i.e., ARARs) to the hazardous substances or particular circumstances at a site or obtain a waiver [see also 40 Code of Federal Regulations 300.430(f)(1)(ii)(B)]. ARARs include only federal and state environmental or facility siting laws/regulations and do not include occupational safety or worker protection requirements. In addition, in accordance with 40 Code of Federal Regulations 300.405(g)(3), other advisories, criteria, or guidance may be considered in developing remedies (so-called To-Be-Considered guidance category). Under CERCLA 121(e)(1), permits are not required for response actions conducted entirely onsite. In addition, response actions must comply with the 'substantive', as opposed to 'administrative', requirements of any of the identified ARARs.

3.1.1 Chemical-specific ARARs

Chemical-specific ARARs provide health- or risk-based concentration limits or discharge limitations in various environmental media (surface water, groundwater, soil) for specific hazardous substances, pollutants, or contaminants and are listed in **Table 3-1**. Remediation levels for most of the COCs in groundwater will be based on relevant and appropriate drinking water standards, including NCGWQS or federal Maximum Contaminant Levels (MCLs).

3.1.2 Action-specific ARARs

Action-specific ARARs are usually technology-based or activity-based requirements that define acceptable treatment and disposal procedures for hazardous substances. The action-specific ARARs for the soil and groundwater at Site 69 are summarized in **Table 3-2**.

3.1.3 Location-specific ARARs

Location-specific ARARs restrict remedial activities and media concentrations based on characteristics of surrounding environments. Location-specific ARARs may include restrictions on remedial actions within wetlands or floodplains, near locations of archeological and natural resources, near historical landmarks, near locations of known endangered species, or on protected waterways. An evaluation of location-specific ARARs for Site 69 is summarized in **Table 3-3**.

3.2 Remedial Action Objectives

RAOs consist of medium-specific goals for protecting human health and the environment. The RAOs for soil at Site 69 are based upon the presence of buried waste at the site, the potential for the presence of future residential receptors, and infiltration leading to migration of contaminants from buried waste into groundwater. The RAOs for groundwater at Site 69 are based on the potential for the presence of future residential receptors, the potential use of groundwater at the site for potable purposes in the future, and contaminated groundwater migrating into surface water.

The RAOs for Site 69 are:

1. Restore groundwater quality to meet NCDENR and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water [Class GA or Class GSA] under 15A North Carolina Administrative Code (NCAC) 02L.0201.
2. Minimize exposure to potential CA and chemical waste to the maximum extent practicable.
3. Reduce infiltration and leaching of contaminants from waste into groundwater to the maximum extent practicable.
4. Prevent exposure to soil, buried waste, and groundwater until concentrations meet levels that allow for unlimited use and unrestricted exposure.
5. Minimize potential degradation of the New River by COC affected groundwater.

3.3 Target Location Contaminants of Interest

The objective of the FS is to analyze remediation technologies that will meet the RAOs. Groundwater COCs identified in the risk assessments and agreed upon by the MCB CamLej Partnering Team are: 1,2-DCA, 1,2,4-trichlorobenzene, 4,4-DDT, aroclor-1260, chromium, cis-1,2-DCE, dieldrin, endrin, gamma-chlordane, heptachlor epoxide, methoxychlor, TCE, trans-1,2-DCE, and VC.

The results of the latest groundwater sampling event identified an 18,000-square-foot (100 ft by 180 ft) target area surrounding monitoring well cluster IR69-GW15IW, which encompasses the highest concentration of the cis-1,2-DCE plume (51,000 µg/L). The target interval for remediation is approximately 40 to 70 ft bgs (upper Castle Hayne aquifer). Groundwater samples collected from these monitoring wells have the highest cis-1,2-DCE concentrations at Site 69.

Subsurface soil impacts are assumed at Site 69 because of the presence of buried waste; however, limited data are available because of the risks associated with the potential presence of CA. The waste disposal area covers approximately 4 acres and was defined from DGM results during the SI.

3.4 General Response Actions

GRAs describe general remedial activities that may satisfy RAOs, either independently or in combination. GRAs to be considered for satisfying RAOs for the remediation of Site 69 are no action, ICs, monitoring, containment, removal, treatment, and disposal. **Table 3-4** summarizes how each GRA would achieve RAOs.

3.5 Identification and Screening of Technology Types and Process Options

Table 3-5 identifies potentially applicable technologies and process options for addressing the affected groundwater, the downgradient migration of the plume towards the New River, and exposure of receptors to affected media and waste at Site 69. Certain technologies and/or process options are not appropriate at Site 69, because of economics, impracticality, health and safety concerns, site conditions, or COC characteristics, and were excluded from further consideration.

TABLE 3-1

Chemical-Specific ARARs

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Federal and North Carolina Chemical-Specific ARARs

Media	Requirement	Prerequisite	Citation
Classification of contaminated groundwater	Groundwaters in the state naturally containing 250 mg/L or less of chloride are *classified as GA (Existing or potential source of drinking water supply for humans)* under 15A NCAC 02L .0201(1)	Groundwaters located within the boundaries or under the extraterritorial jurisdiction of the State of North Carolina **- Applicable to groundwater alternatives 1, 2, 3, 4, and 5**	15A NCAC 02L .0302(1)
	Groundwaters in the state naturally containing greater than 250 mg/L of chloride are *classified as GSA* under 15A NCAC 02L .0201(2)		15A NCAC 02L .0302(2)
Restoration of contaminated groundwater	Shall not exceed the groundwater quality standards[1] for contaminants specified in Paragraphs (g) or (h) for the site related contaminants of concern. - 1,2-DCA (0.4 µg/L), 1,2,4-trichlorobenzene (70 µg/L), 4,4-DDT (0.1 µg/L), aroclor-1260 (0.5 µg/L), chromium (10 µg/L), cis-1,2-DCE (70 µg/L), dieldrin (0.002 µg/L), endrin (2 µg/L), gamma chlordane (0.1 µg/L), heptachlor epoxide (0.004 µg/L), methoxychlor (40 µg/L),TCE (3 µg/L), trans-1,2-DCE (100 µg/L), VC (0.03 µg/L)	Class GA or GSA groundwaters with contaminant(s) concentrations exceeding standards listed in 15A NCAC 02L .0202 **- Applicable to groundwater alternatives 1, 2, 3, 4, and 5**	15A NCAC 02L .0202(a) and (b)
	Shall not exceed the Safe Drinking Water Act National Revised Primary Drinking Water Regulations: maximum contaminant levels (MCLs) for organic contaminants specified in 40 CFR 141.61(a).	Groundwaters classified as GA or GSA which are an existing or potential source of drinking water **- Relevant and Appropriate to groundwater alternatives 1, 2, 3, 4, and 5**	40 CFR 141.61(a) 15A NCAC 18C .1517
Protection of adjacent surface water body	Toxic substances: shall not exceed the numerical quality standards (maximum permissible levels) to protect human health from carcinogens through consumption of fish (and shellfish) - 1,2-DCA (37 µg/L), 1,2,4-trichlorobenzene (27 µg/L), 4,4-DDT (0.0002 µg/L), aroclor-1260 (0.000064 µg/L), chromium (20 µg/L), dieldrin (0.00005 µg/L), endrin (0.002 µg/L), gamma chlordane (0.0008 µg/L), heptachlor epoxide (0.000039 µg/L), methoxychlor (0.03 µg/L), TCE (30 µg/L), trans-1,2-DCE (10,000 µg/L), VC (2.4 µg/L)	Tidal Salt Waters classified as Class SC with chemical concentrations exceeding 15A NCAC 02B Standards **- Relevant and Appropriate to groundwater alternatives 1, 2, 3, 4, and 5**	15A NCAC 02B .0208(a)(2)(b)

Notes:

[1] Groundwater quality standards established on the basis of a National secondary drinking water standards are not utilized as remediation goals since these are based on taste, odor and other considerations unrelated to human health.

TABLE 3-2

Potential Action-Specific ARARs

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Federal Action-Specific ARARs

Action	Requirement	Prerequisite	Citation
General Construction Standards — All Land-disturbing Activities (i.e., excavation, clearing, grading, etc.)			
Managing storm water runoff from land-disturbing activities	Shall take all reasonable measures to protect all public and private property from damage caused by such activities.	Land-disturbing activity (as defined in N.C.G.S. Ch. 113A-53) of more than 1 acre of land **- Applicable to soil alternatives 3 and 4 and groundwater alternatives 3, 4, and 5**	15A NCAC 4B.0105
	Erosion and sedimentation control plan must address the following basic control objectives: (1) Identify areas subject to severe erosion, and off-site areas especially vulnerable to damage from erosion and sedimentation. (2) Limit the size of the area exposed at any one time. (3) Limit exposure to the shortest feasible time. (4) Control surface water run-off originating upgrade of exposed areas . (5) Plan and conduct land-disturbing activity so as to prevent off-site sedimentation damage. (6) Include measures to control velocity of storm water runoff to the point of discharge.		15A NCAC 4B.0106
	Erosion and sedimentation control measures, structures, and devices shall be planned, designed, and constructed to provide protection from the run-off of 10 year storm.	Land-disturbing activity (as defined in N.C.G.S. Ch. 113A-53) of more than 1 acre of land **- Applicable to soil alternatives 3 and 4 and groundwater alternatives 3, 4, and 5**	15A NCAC 4B.0108
	Shall conduct activity so that the post-construction velocity of the ten year storm run-off in the receiving watercourse to the discharge point does not exceed the parameters provided in this Rule.		15A NCAC 4B.0109
	Shall install and maintain all temporary and permanent erosion and sedimentation control measures.		15A NCAC 4B.0113
	Erosion and sedimentation control measures, structures, and devices with High Quality Water (HQW) zones shall be planned, designed and constructed to provide protection from the runoff of the 25 year storm.	Land-disturbing activity (as defined in N.C.G.S. Ch. 113A-52) of more than 1 acre of land in High Quality Water (HQW) zones **— Applicable to soil alternatives 3 and 4 and groundwater alternatives 3, 4, and 5**	15A NCAC 4B.0124(b)
	Provisions for ground cover sufficient to restrain erosion must be provided for any portion of the land-disturbing activity with 15 working days or 60 calendar days following completion of the construction or development, which period is shorter.		15A NCAC 4B.0124(e)
	Implement good construction management techniques, best management practices for sediment and erosion controls, and storm water management measures in accordance with 15A NCAC 02H .1008 to ensure storm water discharges are in compliance.	Development activity (otherwise requiring a stormwater permit) within one mile of and draining to waters classified as High Quality Waters (HQW) **— Relevant and Appropriate to soil alternatives 3 and 4 and groundwater alternatives 3, 4, and 5**	15A NCAC 02H .1006, NC General Permit CNCG 0100000

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Potential Action-Specific ARARs

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Federal Action-Specific ARARs

Action	Requirement	Prerequisite	Citation
Monitoring Well Installation, Operation, and Abandonment			
Construction of groundwater monitoring well(s)	No well shall be located, constructed, operated, or repaired in any manner that may adversely impact the quality of groundwater.	Installation of wells (including temporary) other than for water supply - **Applicable to groundwater alternatives 2, 3, 4, and 5**	15A NCAC 02C .0108(a)
	Shall be located, designed, constructed, operated and abandoned with materials and by methods which are compatible with the chemical and physical properties of the contaminants involved, specific site conditions, and specific subsurface conditions.		15A NCAC 02C .0108(c)
	Must comply with general requirements for construction of a well as provided in 15A NCAC 02C .0108(c)(1) through (12)		15A NCAC 02C .0108(c)
	Shall be constructed in such a manner as to preclude the vertical migration of contaminants with and along borehole channel.		15A NCAC 02C .0108(f)
Implementation of groundwater monitoring system	Shall be constructed in a manner that will not result in contamination of adjacent groundwaters of a higher quality.	Installation of monitoring system to evaluate effects of any actions taken to restore groundwater quality, as well as the efficacy of treatment - **Applicable to groundwater alternatives 2, 3, 4, and 5**	15A NCAC 02L .0110 (b)
Maintenance of groundwater monitoring well(s)	Every well shall be maintained by the owner in a condition whereby it will conserve and protect groundwater resources, and whereby it will not be a source or channel of contamination or pollution to the water supply or any aquifer.	Installation of wells (including temporary wells) other than for water supply - **Applicable to groundwater alternatives 2, 3, 4, and 5**	15A NCAC 02C .0112(a)
	Broken, punctured, or otherwise defective or unserviceable casing, screens, fixtures, seals, or any part of the well head shall be repaired or replaced, or the well shall be abandoned pursuant to 15A NCAC 02C .0113		15A NCAC 02C .0112(d)
	All materials used in the maintenance, replacement, or repair of any well shall meet the requirements for new installation.		15A NCAC 02C .0112(c)
Abandonment of groundwater monitoring well(s)	Shall be abandoned in accordance with the requirements of 15A NCAC 02C .0113(b)(1) and (2)	Permanent abandonment of wells (including temporary wells) other than for water supply - **Applicable to soil alternatives 3 and 4**	15A NCAC 02C .0113(b)
Underground Injection Well Installation, Operation, and Abandonment			
Construction of injection well(s) for *in-situ* treatment of groundwater	Construction, use or operation may be allowed provided the injected material does not contain any waste or any substance of a composition and concentration such that, if it were discharged to the land or waters of the state, would create a threat to human health or would otherwise render those waters unsuitable for their intended usage.	Installation of Class 5 underground injection well (Type I – In-situ Groundwater Remediation Well and Type P - Air Injection Well) - **Applicable to groundwater alternatives 3, 4, and 5**	15A NCAC 02C .0209(e)(3)
Location of injection well(s) for *in-situ* treatment of groundwater	Shall not be located in an area generally subject to flooding. Areas which are generally subject to flooding include those with concave slope, alluvial or colluvial soils, gullies, depressions, and drainage ways.	Installation of Class 5 underground injection well (Type I – In-situ Groundwater Remediation Well and Type P - Air Injection Well) - **Applicable to groundwater alternatives 3, 4, and 5**	15A NCAC 02C .0213(a)(1)
	Shall not be located at a point where the injectant would degrade the existing quality of the groundwater in the water-bearing unit into which the injectant is being released.	Installation of Class 5 underground injection well (Type I – In-situ Groundwater Remediation Well) where the concentration of any component of the injectant *exceeds* the groundwater quality standards specified in 15A NCAC 2L .0202 - **Applicable to groundwater alternatives 3, 4, and 5**	15A NCAC 02C .0213(a)(2)(A)(i)

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Potential Action-Specific ARARs

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Federal Action-Specific ARARs

Action	Requirement	Prerequisite	Citation
Underground Injection Well Installation, Operation, and Abandonment (cont.)			
	Shall not be located at a point where the injectant would result in a contravention of any of the aforementioned groundwater quality standards in the water-bearing unit into which the injectant is being released.	Installation of Class 5 underground injection well (Type I – In-situ Groundwater Remediation Well) where the concentration of any component of the injectant *is less than* the groundwater quality standards specified in 15A NCAC 2L .0202 **- Applicable to groundwater alternatives 3, 4, and 5**	15A NCAC 02C .0213(a)(2)(B)
Construction of injection well(s) for *in-situ* treatment of groundwater	Shall follow the procedures, methods, specified materials, and requirements specified in the subparagraphs (A) through (G) of this Rule for Drilling, Casing, Screens and Testing.	Installation of Class 5 underground injection well (Type I – In-situ Groundwater Remediation Well and Type P - Air Injection Well) **- Applicable to groundwater alternatives 3, 4, and 5**	15A NCAC 02C .0213(c)(1) through (4)
	Shall follow the procedures, methods, specified materials, and requirements specified in the paragraphs (1) through (8) of this Rule for Grouting and Sand-and-Gravel Packing.		15A NCAC 02C .0213(d)
Operating an injection well(s) for *in-situ* treatment of groundwater	Pressure at the well head shall be limited to a maximum which will ensure the pressure in the injection zone does not initiate new fractures or propagate existing fractures in the injection zone, initiate fractures in the confining zone, or cause the migration of injected or formation fluids outside the injection zone or area.		15A NCAC 02C .0213(e)
Abandonment of injection well(s) for *in-situ* treatment of groundwater	Shall be abandoned in accordance with the requirements of subparagraphs (1) and (2) of 15A NCAC 02C .0214(a).	Installation of Class 5 underground injection well (Type I – In-situ Groundwater Remediation Well *or* Type P Air Injection Well), including exploratory or test wells **- Applicable to groundwater alternatives 3, 4, and 5**	15A NCAC 02C .0214(a)
Control of Diffuse VOC Emissions from Groundwater Treatment			
Emissions of VOCs from groundwater treatment (e.g., sparging system)	Shall not emit any of the toxic air pollutants listed in the table of the Rule in such quantities that may cause or contribute beyond the premises (adjacent property boundary) to any significant ambient air concentration that may adversely affect human health.	Emissions of toxic air pollutants (e.g., VOCs) from facility into the ambient air **- Applicable to groundwater alternatives 4 and 5**	15A NCAC 02D .1104
	Shall install and operate reasonable available control technology to limit emissions of VOCs.	Air emissions of VOCs from facilities where there is no other applicable emissions control rule **- Relevant and Appropriate to groundwater alternatives 4 and 5**	15A NCAC 02D .0951(c)
	One of the applicable test methods in Appendix M in 40 CFR part 51 or Appendix A in 40 CFR Part 60 shall be used to determine compliance with VOC emission standards.	VOC emission source not covered by 15A NCAC 02D.2613(b) through (e) **- Relevant and Appropriate to groundwater alternatives 4 and 5**	15A NCAC 02D .2613(g)
	Control emissions by meeting limitations and work practice standards reflecting application of the maximum achievable control technology.	Air emissions of organic Hazardous Air Pollutants (e.g.,VOCs) from site remediation **- Relevant and Appropriate to groundwater alternatives 4 and 5**	40 CFR 63 Subpart G, NESHAPS for Site Remediation
	Periodic inspection of equipment and monitoring are required for the life of the remediation.		

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Potential Action-Specific ARARs

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Federal Action-Specific ARARs

Action	Requirement	Prerequisite	Citation
Waste Characterization and Storage — Primary Wastes (i.e., excavated contaminated soils)			
Characterization of solid waste (e.g., well soil cuttings)	Must determine if solid waste is hazardous waste or if waste is excluded under 40 CFR 261.4(b); and	Generation of solid waste as defined in 40 CFR 261.2 and which is not excluded under 40 CFR 261.4(a) **- Applicable to soil alternatives 3 and 4 and groundwater alternatives 2, 3, 4, and 5**	40 CFR 262.11(a)
	Must determine if waste is listed under 40 CFR Part 261; or		40 CFR 262.11(b)
	Must characterize waste by using prescribed testing methods or applying generator knowledge based on information regarding material or processes used.		40 CFR 262.11(c)
	Must refer to Parts 261, 262, 264, 265, 266, 268, and 273 of Chapter 40 for possible exclusions or restrictions pertaining to management of the specific waste.	Generation of solid waste which is determined to be hazardous **- Applicable to soil alternatives 3 and 4**	40 CFR 262.11(d)
Storage of solid waste	All solid waste shall be stored in such a manner as to prevent the creation of a nuisance, insanitary conditions, or a potential public health hazard.	Generation of solid waste which is determined *not* to be hazardous **- Relevant and Appropriate to soil alternatives 3 and 4**	15A NCAC 13B .0104(f)
	Containers for the storage of solid waste shall be maintained in such a manner as to prevent the creation of a nuisance or insanitary conditions. Containers that are broken or that otherwise fail to meet this Rule shall be replaced with acceptable containers.		15A NCAC 13B .0104(e)
Characterization of hazardous waste	Must obtain a detailed chemical and physical analysis on a representative sample of the waste(s), which at a minimum contains all the information that must be known to treat, store, or dispose of the waste in accordance with pertinent sections of 40 CFR 264 and 268.	Generation of RCRA-hazardous waste for storage, treatment or disposal **- Applicable to soil alternatives 3 and 4 and groundwater alternatives 2, 3, 4, and 5**	40 CFR 264.13(a)(1)
	Must determine the underlying hazardous constituents [as defined in 40 CFR 268.2(i)] in the waste.	Generation of RCRA characteristic hazardous waste (and is not D001 non-wastewaters treated by CMBST, RORGS, or POLYM of Section 268.42 Table 1) for storage, treatment or disposal **- Applicable to soil alternatives 3 and 4 and groundwater alternatives 2, 3, 4, and 5**	40 CFR 268.9(a)
	Must determine if the waste is restricted from land disposal under 40 CFR 268 *et seq.* by testing in accordance with prescribed methods or use of generator knowledge of waste.		40 CFR 268.7(a)(1)
	Must determine each EPA Hazardous Waste Number (Waste Code) to determine the applicable treatment standards under 40 CFR 268.40 *et. seq* .		40 CFR 268.9(a)

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Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Federal Action-Specific ARARs

Action	Requirement	Prerequisite	Citation
Waste Characterization and Storage — Primary Wastes (i.e., excavated contaminated soils) cont.			
Temporary storage of hazardous waste in containers	A generator may accumulate hazardous waste at the facility provided that: · waste is placed in containers that comply with 40 CFR 265.171-173; and	Accumulation of RCRA hazardous waste on site as defined in 40 CFR 260.10 - **Applicable to soil alternatives 3 and 4 and groundwater alternatives 2, 3, 4, and 5**	40 CFR 262.34(a) 40 CFR 262.34(a)(1)(i)
	· the date upon which accumulation begins is clearly marked and visible for inspection on each container		40 CFR 262.34(a)(2)
	· container is marked with the words "hazardous waste"; or		40 CFR 264.34(a)(3)
	· container may be marked with other words that identify the contents.	Accumulation of 55 gal. or less of RCRA hazardous waste at or near any point of generation - **Applicable to soil alternatives 3 and 4 and groundwater alternatives 2, 3, 4, and 5**	40 CFR 262.34(c)(1)
	Area must have a containment system designed and operated in accordance with 40 CFR 264.175(b) Area must be sloped or otherwise designed and operated to drain liquid resulting from precipitation, or Containers must be elevated or otherwise protected from contact with accumulated liquid.	Storage of RCRA hazardous waste in containers with *free liquids* - **Applicable to groundwater alternatives 2, 3, 4, and 5** Storage of RCRA-hazardous waste in containers that do not contain free liquids (other than F020, F021, F022, F023,F026 and F027) – **Applicable to soil alternative 4 and groundwater alternatives 2, 3, 4, and 5**	40 CFR 264.175(a) 15A NCAC 13A .0109 40 CFR 264.175(c)(1) and (2) 15A NCAC 13A .0109
Closure of RCRA container storage unit	At closure, all hazardous waste and hazardous waste residues must be removed from the containment system. Remaining containers, liners, bases, and soils containing or contaminated with hazardous waste and hazardous waste residues must be decontaminated or removed. [Comment: At closure, as throughout the operating period, unless the owner or operator can demonstrate in accordance with40 CFR 261.3(d) of this chapter that the solid waste removed from the containment system is not a hazardous waste, the owner or operator becomes a generator of hazardous waste and must manage it in accordance with all applicable requirements of parts 262 through 266 of this chapter].	Storage of RCRA hazardous waste in containers in a unit with a containment system – **Applicable to soil alternative 4 and groundwater alternatives 2, 3, 4, and 5**	40 CFR 264.178 15A NCAC 13A .0109
Temporary on-site storage of remediation waste in staging pile (e.g., excavated soils)	Must be located within the contiguous property under the control of the owner/operator where the wastes are to be managed in the staging pile originated. For purposes of this section, storage includes mixing, sizing, blending or other similar physical operations so long as intended to prepare the wastes for subsequent management or treatment.	Accumulation of solid *non-flowing hazardous remediation waste* (or remediation waste otherwise subject to land disposal restrictions) as defined in 40 CFR 260.10 - **Applicable to soil alternative 4**	40 CFR 264.554(a)(1)
Performance criteria for staging pile	Staging pile must: • facilitate a reliable, effective and protective remedy; • must be designed to prevent or minimize releases of hazardous wastes and constituents into the environment, and minimize or adequately control cross-media transfer as necessary to protect human health and the environment (e.g. use of liners, covers, run-off/run-on controls).	Storage of remediation waste in a staging pile– **Applicable to soil alternative 4**	40 CFR 264.554(d)(1)(i) and (ii) 15A NCAC 13A .0109
Operation of a staging pile	Must not operate for more than 2 years, except when an operating term extension under 40 CFR 264.554(i) is granted. *Note* : Must measure the 2-year limit (or other operating term specified) from first time remediation waste placed in staging pile	Storage of remediation waste in a staging pile– **Applicable to soil alternative 4**	40 CFR 264.554(d)(1)(iii) 15A NCAC 13A .0109
	Must not use staging pile longer than the length of time designated by EPA in appropriate decision document.		40 CFR 264.554(h) 15A NCAC 13A .0109

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Marine Corps Base Camp Lejeune, North Carolina

Federal Action-Specific ARARs

Action	Requirement	Prerequisite	Citation
Waste Characterization and Storage — Primary Wastes (i.e., excavated contaminated soils) cont.			
Design crieria for staging pile	In setting standards and design criteria must consider the following factors: • Length of time pile will be in operation; • Volumes of waste you intend to store in the pile; • Physical and chemical characteristics of the wastes to be stored in the unit; • Potential for releases from the unit; • Hydrogeological and other relevant environmental conditions at the facility that may influence the migration of any potential releases; and • Potential for human and environmental exposure to potential releases from the unit.	Storage of remediation waste in a staging pile – **Applicable to soil alternative 4**	40 CFR 264.554(d)(2)(i) – (vi) 15A NCAC 13A .0109
Closure of staging pile of remediation waste	Must be closed within 180 days after the operating term by removing or decontaminating all remediation waste, contaminated containment system components, and structures and equipment contaminated with waste and leachate.	Storage of remediation waste in staging pile in *previously contaminated area* – **Applicable to soil alternative 4**	40 CFR 264.554(j)(1) 15A NCAC 13A .0109
	Must decontaminate contaminated sub-soils in a manner that EPA determines will protect human and the environment.		40 CFR 264.554(j)(2) 15A NCAC 13A .0109
Disposal of solid waste	Shall ensure that waste is disposed of at a site or facility which is permitted to receive the waste.	Generation of solid waste intended for off-site disposal – **Relevant and Appropriate to soil alternatives 3 and 4 and groundwater alternatives 2, 3, 4, and 5**	15A NCAC 13B .0106(b)
Disposal of RCRA hazardous waste in a land-based unit	May be land disposed if it meets the requirements in the table "Treatment Standards for Hazardous Waste" at 40 CFR 268.40 before land disposal.	Land disposal, as defined in 40 CFR 268.2, of restricted RCRA waste - **Applicable to soil alternatives 3 and 4 and groundwater alternatives 2, 3, 4, and 5**	40 CFR 268.40(a) 15A NCAC 13A .0112
	All underlying hazardous constituents [as defined in 40 CFR 268.2(i)] must meet the Universal Treatment Standards (UTS), found in 40 CFR 268.48 Table UTS prior to land disposal	Land disposal of restricted RCRA characteristic wastes (D001-D043) that are not managed in a wastewater treatment system that is regulated under the CWA, that is CWA equivalent, or that is injected into a Class I nonhazardous injection well – **Applicable to soil alternatives 3 and 4 and groundwater alternatives 2, 3, 4, and 5**	40 CFR 268.40(e) 15A NCAC 13A .0112
	To determine whether a hazardous waste indentified in this section exceeds the applicable treatment standards of 40 CFR 268.40, the initial generator must test a sample of the waste extract or the entire waste, depending on whether the treatment standards are expressed as concentration in the waste extract or waste, or the generator may use knowledge of the waste. If the waste contains constituents (including UHCs in the characteristic wastes) in excess of the applicable UTS levels in 40 CFR 268.48, the waste is prohibited from land disposal, and all requirements of part 268 are applicable, except as otherwise specified.	Land disposal of RCRA toxicity characteristic wastes (D004-D011) that are newly identified (i.e., wastes, soil, or debris identified by the TCLP but not the Extraction Procedure) – **Applicable to soil alternatives 3 and 4 and groundwater alternatives 2, 3, 4, and 5**	40 CFR 268.34(f) 15A NCAC 13A .0112
Disposal of RCRA-hazardous waste in a land-based unit	Must be treated according to the alternative treatment standards of 40 CFR 268.49(c) or according to the UTSs specified in 40 CFR 268.48 applicable to the listed and/or characteristic waste contaminating the soil prior to land disposal	Land disposal, as defined in 40 CFR 268.2, of restricted hazardous soils – **Applicable to soil alternatives 3 and 4 and groundwater alternatives 2, 3, 4, and 5**	40 CFR 268.49(b) 15A NCAC 13A .0112

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Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Federal Action-Specific ARARs

Action	Requirement	Prerequisite	Citation
Institutional Controls for Contamination Left in Place			
Notice of Contaminated Site	Prepare and certify by professional land surveyor a survey plat which identifies contaminated areas which shall be entitled "NOTICE OF CONTAMINATED SITE". Notice shall include a legal description of the site that would be sufficient as a description in an instrument of conveyance and meet the requirements of NCGS 47-30 for maps and plans.	Contaminated site subject to current or future use restrictions included in a remedial action plan as provided in G.S. 143B-279.9(a) **- To-Be-Considered for soil alternatives 2, 3, and 4 and groundwater alternatives 2, 3, 4, and 5**	NCGS 143B-279.10(a)
	The Survey plat shall identify: • the location and dimensions of any disposal areas and areas of potential environmental concern with respect to permanently surveyed benchmarks; • the type location, and quantity of contamination known to exist on the site; and •any use restriction on the current or future use of the site.		NCGS 143B-279.10(a)(1)-(3)
Discharge of dredge-and-fill			
Discharge of dredge-and-fill	No discharge of dredged or fill material will be allowed unless appropriate and practicable steps are taken that minimize potential adverse impacts of the discharge on the aquatic ecosystem.	Discharges of dredged or fill material to surface waters, including wetlands. - **Applicable to soil alternatives 3 and 4**	40 CFR 230.10(d); 33 CFR 320.4(a), (b), (d), (p), (r)
Capping Waste in Place - Landfill Closure and Post-Closure			
Landfill closure performance standard	Must close the unit in a manner that: • minimizes the need for further maintenance; and • controls, minimizes, or eliminates to the extent necessary to protect human health and the environment, post –closure escape of hazardous waste, hazardous constituents, leachate, contaminated run –off, or hazardous waste decomposition products to ground or surface waters or to the atmosphere; and • complies with the relevant closure and post –closure requirements of 40 CFR 264.310.	Closure of a RCRA hazardous waste management unit – **Relevant and Appropriate to soil alternative 3**	40 CFR 264.111(a)-(c)
Landfill cover design and construction	Must cover the landfill or cell with a final cover designed and constructed to: • provide long –term minimization of migration of liquids through the closed landfill; • function with minimum maintenance; • promote drainage and minimize erosion or abrasion of the cover; • accommodate settling and subsidence so that the cover=s integrity is maintained; and • have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.	Closure of a RCRA hazardous waste management unit – **Relevant and Appropriate to soil alternative 3**	40 CFR 264.310(a)(1)–(5)

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Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Federal Action-Specific ARARs

Action	Requirement	Prerequisite	Citation
Capping Waste in Place - Landfill Closure and Post-Closure (cont.)			
Landfill cover design and construction (cont.)	This document recommends and describes a design for landfill covers that will meet the requirements of RCRA regulations. It is a multilayered system consisting, from the top down, of: • a top layer of at least 60 cm of soil, either vegetated or armored at the surface; • a granular or geosynthetic drainage layer with a hydraulic transmissivity no less than 3 x 10"5 cm /sec; and • a two–component low permeability layer comprised of (1) a flexible membrane liner installed directly on (2) a compacted soil component with an hydraulic conductivity no greater than 1 x 10~7 cm/sec. Optional layers may be added, e.g., a biotic barrier layer or a gas vent layer, depending on the need.	Construction of a RCRA hazardous waste landfill final cover – **To Be Considered**	*EPA Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments,* EPA OSWER 530 – SW –89 –047, (July 1989)
Run–on/run–off control systems for landfill cover	Run–on control system must be capable of preventing flow onto the active portion of the landfill during peak discharge from a 25–year storm event.	Construction of a RCRA hazardous waste landfill cover – **Relevant and Appropriate to soil alternative 3**	40 CFR 264.301(g)
	Run–off management system must be able to collect and control the water volume from a runoff resulting from a 24–hour, 25–year storm event.		40 CFR 264.301(h)
Protection of closed landfill	Post–closure use of property must never be allowed to disturb the integrity of the final cover, liners, or any other components of the containment system or the facility=s monitoring system unless necessary to reduce a threat to human health or the environment.	Closure of a RCRA hazardous waste landfill – **Relevant and Appropriate to soil alternative 3**	40 CFR 264.117 (c)
General post–closure care for closed landfill	Owner or operator must: • maintain the effectiveness and integrity of the final cover including making repairs to the cap as necessary to correct effects of settling, erosion, etc.; • prevent run–on and run–off from eroding or otherwise damaging final cover; and • protect and maintain surveyed benchmarks used to locate waste cells.	Closure of a RCRA hazardous waste landfill – **Relevant and Appropriate to soil alternative 3**	40 CFR 264.310(b)(1), (5) and (6)
Post–closure notices for closed landfill	Must submit to the local zoning authority a record of the type, location, and quantity of hazardous wastes disposed of within each cell of the unit.	Closure of a RCRA hazardous waste landfill –**Relevant and Appropriate to soil alternative 3**	40 CFR 264.119(a)
	Must record, in accordance with State law, a notation on the deed to the facility property – or on some other instrument which is normally examined during a title search – that will in perpetuity notify any potential purchaser of the property that: • land has been used to manage hazardous wastes; • its use is restricted under 40 CFR Part 264 Subpart G regulations; and • the survey plat and record of the type, location, and quantity of hazardous wastes disposed within each cell or other hazardous waste disposal unit of the facility required by Sections 264.116 and 264.119(a) have been filed with the local zoning authority and with the EPA Regional Administrator.	Closure of a RCRA hazardous waste landfill – **Relevant and Appropriate to soil alternative 3**	40 CFR 264.119(b)(1)(i)-(iii)

TABLE 3-3

Potential Location-Specific ARARs

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Federal and North Carolina Location-Specific ARARs

Location	Requirement	Prerequisite	Citation
Presence of wetlands	Concentrations or combination of substances, which are toxic or harmful to human, animal, or plant life may not be present in amounts, which individually or cumulatively, can cause adverse impacts on existing wetland uses. Standards provided in 15A NCAC 02B.0231(b)(1), (2), (3), (5), and (6) shall be used to ensure the maintenance or enhancement of the existing uses of wetlands identified in 15A NCAC 02B.0231(a)	Activities within, wetlands as defined by G.S. 143-212(6) – **Applicable to soil alternatives 3 and 4 and groundwater alternatives 3, 4, and 5**	15A NCAC 02B.0231(b)(4)
	Requires Federal agencies to evaluate action to minimize the destruction, loss or degradation of wetlands and to preserve and enhance beneficial values of wetlands.	Actions that involve potential impacts to or take place within wetlands - **To Be Considered for soil alternatives 3 and 4 and groundwater alternatives 3, 4, and 5**	Executive Order 11990 - *Protection of Wetlands* Section 1.(a)
Location econmpassing aquatic ecosystem as defined in 40 CFR 230.(c)	No discharge of dredged or fill material into an aquatic ecosystem is permitted if there is a practicable alternative that would have less adverse impact.	Action that involves the discharge of dredged or fill material into waters of the United States including jurisdictional wetlands - **Relevant and Appropriate for soil alternatives 3 and 4 and groundwater alternatives 3, 4, and 5**	40 CFR 230.10(a)
	No discharge of dredged of fill material shall be permitted unless appropriate and practicable steps in accordance with 40 CFR 230.70 *et seq.* have been taken that will minimize potential adverse impacts of the discharge on the aquatic ecosystem.		40 CFR 30.10(d)
	Must comply with the substantive requirements of the NWP 38 General Conditions, as appropriate, any regional or case-specific conditions recommended by the Corps District Engineer, after consultation. *Note* : Despite that consultation may be considered an administrative requirement, it should be performed to ensure activities are in compliance with substantive provisions of the permit.	On-site CERCLA action conducted by Federal agency that involves the discharge of dredged or fill material into water s of the United States including jurisdicitonal wetlands - **Relevant and Appropriate for soil alternatives 3 and 4 and groundwater alternatives 3, 4, and 5**	Nation Wide Permit (38) Cleanup of Hazardous and Toxic Waste 33 CFR 323.3(b)
Presence of floodplain designated as such on a map	Shall consider alternatives to avoid, to the extent possible, adverse effects on and incompatible development in the floodplain.	Federal actions that involve potential impacts on, or take place within, floodplains—**To Be Considered for soil alternatives 3 and 4 and groundwater alternatives 3, 4, and 5**	Executive Order 11988 – *Floodplain Management* Section 2(a)(2)
Presence of federally endangered or threatened species, as designated in 50 CFR 17.11 and 17.12 -**or**- critical habitat of such species listed in 50 CFR 17.95	Actions that jeopardize the existence of a listed species or results in the destruction or adverse modification of critical habitat must be avoided or reasonable and prudent mitigation measures taken.	Action that is likely to jeopardize fish, wildlife, or plant species or destroy or adversely modify critical habitat—**Applicable to soil alternatives 1, 2, 3 and 4**	16 USC 1531 *et seq* ., Sect. 7(a)(2)
	Except as provided in the rule, no person may take the specified reptiles.	Action that is likely to jeopardize or adversely modify critical habitat for American alligator, green turtle, and/or loggerhead turtle — **Applicable to soil alternatives 1, 2, 3 and 4**	50 CFR 17.42(a) and (b)
Migratory bird area	Protects almost all species of native birds in the United States from unregulated taking.	Presence of migratory birds **— Applicable to soil alternatives 1, 2, 3 and 4**	*Migratory Bird Treaty Act* , 16 USC 703
Coastal zone or area that will affect the coastal zone	Federal activities must be consistent with, to the area that will affect maximum extent practicable, State coastal zone management programs. Federal agencies must supply the State with a consistency determination.	Wetland, flood plain, estuary, beach, dune, barrier island, coral reef, and fish and wildlife and their habitat, within the coastal zone **— Applicable to soil alternatives 3 and 4 and groundwater alternatives 3, 4, and 5**	15 CFR 930.33(a)(1), (a)(2), (b); .35(a), (b); .36(a)

TABLE 3-4

General Response Actions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

General Response Action	Remedial Goals Met
No Action	None. Serves as a baseline to compare other response actions.
Institutional Controls	Prevents human exposure to soil and groundwater by preventing site access, placing restrictions on aquifer use and activities that may result in exposure.
Monitoring	Relies on natural attenuation to reduce contaminant concentrations without performing any other measures.
Containment	Minimizes or prevents the migration of contaminants in soil and groundwater to receptors.
Removal	Removes contaminants from the unsaturated zone by removal of the source, and from the saturated zone by physical extraction of groundwater and/or removal of impacted saturated soil.
Treatment	Reduces the mobility, toxicity, or volume of contaminated soil or groundwater.
Disposal	Minimizes the likelihood of exposure to contaminants by removing soil or extracting contaminants from groundwater and placing them in a controlled environment.

TABLE 3-5

Initial Screening of Remedial Technologies and Process Options

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

General Response Actions	Remedial Technology Types	Process Options	Descriptions	Comments	Retain for Further Evaluation
No Action	None	None	No further actions to address contaminated groundwater.	Baseline for CERCLA process.	Yes
Institutional Controls	Access and Use Restrictions	Land Use Controls	Land Use Controls issued for property within potentially contaminated areas to restrict property use and well installation.	Prevents human exposure. Will be a component of any remedial alternative.	Yes
		Fences	Security fences installed around potentially contaminated areas to limit access.	Locked, 6-foot high fence currently in place around perimeter of Site 69 and waste disposal area. Not applicable to groundwater contamination.	Yes
	Alternative Drinking Water Source	Cisterns or Tanks	Drinking water is dispensed to users from a central point.	Not applicable, no drinking water wells affected	No
		Bottled Water	Drinking water is obtained from a commercial vendor.	Not applicable, no drinking water wells affected	No
		Deeper or Upgradient Wells	Wells are installed deep or upgradient if these areas are isolated from contamination.	Not applicable, no drinking water wells affected	No
		Relocation of Intake	Intake is relocated to an uncontaminated area.	Not applicable, no drinking water intake affected	No
		Municipal Water Supply	Additional water sources are established.	Not applicable, no drinking water supply affected	No
Monitoring	Monitoring	Monitoring	Long-term monitoring is implemented to record site conditions, contamination and groundwater levels.	Potential approach for use with natural attenuation. Will be a component of any active groundwater remedial alternative.	Yes

TABLE 3-5

Initial Screening of Remedial Technologies and Process Options

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

General Response Actions	Remedial Technology Types	Process Options	Descriptions	Comments	Retain for Further Evaluation
Containment	Capping	Native Soil	Uncontaminated native soil placed over contaminated areas.	Not as effective as other caps at reducing infiltration.	No
		Clay Cap	Compacted clay placed over contaminated area. Clay should be covered by at least a foot of silty sand or sandy soil to maintain the integrity of the clay cap.	Will minimize migration of groundwater due to reduced infiltration.	Yes
		Synthetic Membranes	Synthetic membrane placed over prepared soil or geotextile surface that is over a contaminated area. The membrane is seamed by a variety of methods. The membrane must be compatible with the wastes present.	Will not come into direct contact with site contaminants.	Yes
		Asphalt or Concrete Cap	Paving grade asphalt or concrete placed over prepared contaminated area. Fill settlement must be evaluated in considering a concrete cap design.	Preparation may disturb waste disposal area potentially increasing leakage of waste materials and requiring additional health and safety precautions. Potential settling may compromise the integrity of the cap.	No
		Multilayered Cap	Cap may be composed of natural soils, soil admixtures, clay, synthetic membranes, spray-on asphalts, asphalt concrete, or Portland cement concrete and placed over contaminated areas. If properly designed, will meet RCRA requirements.	RCRA Subtitle C design applies criteria for hazardous waste disposal facilities and is most appropriate for addressing previous site use as a waste disposal area.	Yes
		Chemical Sealant or Stabilizers	Water-dispersible emulsions and/or resins placed over contaminated areas to form a crust that reduces water and wind or dust erosion. Most are nontoxic to plants and animals.	Not as effective as other caps at reducing infiltration.	No
	Vertical Barriers	Soil-Bentonite Slurry Wall	Trench downgradient of contaminated area excavated and filled with a bentonite slurry. Trench backfilled with a soil-bentonite mix.	Will contain but not treat groundwater plume. Technically impracticable to install wall deep and wide enough to contain groundwater plume.	No
		Cement-Bentonite Slurry Wall	Trench downgradient of contaminated area. Excavation filled with a cement bentonite slurry. Cement sets and forms the wall.	Will contain but not treat groundwater plume. Technically impracticable to install wall deep and wide enough to contain groundwater plume.	No
		Permeable Reactive Barrier (PRB)	Trench downgradient of contaminated area filled with permeable materials, such as zero valent iron (ZVI) or mulch/compost with a sand/gravel "binder" material. Groundwater is treated as it moves through the barrier by natural gradient.	Will treat migrating groundwater contaminated with chlorinated solvents. Services available to install wall deep and wide enough to treat plume.	Yes
		Grout Curtains	Grout is pressure-injected along contamination boundaries in a regular overlapping pattern of drilled holes.	Will contain but not treat groundwater plume. Technically impracticable to install wall deep and wide enough to contain groundwater plume.	No
		Sheet Piling/"Funnel and Gate"	Steel sheet piling driven at downgradient periphery of the plume, with "gate" containing groundwater purge wells or permeable barrier.	Technically impracticable to install sheet pile to necessary depth to contain groundwater plume.	No

TABLE 3-5

Initial Screening of Remedial Technologies and Process Options

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

General Response Actions	Remedial Technology Types	Process Options	Descriptions	Comments	Retain for Further Evaluation
Containment (cont.)	Horizontal Barriers	Block Displacement	Controlled injection of slurry in notched injection holes produces a horizontal barrier beneath contamination. Experimental process option.	Vertical migration of groundwater contamination into deeper aquifers not likely.	No
		Grout Injection	Grout pressure injected at depth through closely spaced drilled holes.	Vertical migration of groundwater contamination into deeper aquifers not likely.	No
		Liners	Liners placed to restrict vertical flow can be constructed of the same materials considered for cap construction.	Vertical migration of groundwater contamination into deeper aquifers not likely.	No
Removal	Removal or Extraction	Pump/Treat (vertical wells or horizontal wells)	Conventional groundwater extraction involves pumping in vertical wells. Other extraction devices include vacuum enhanced recovery, jet-pumping systems, etc. Extracted groundwater may be discharged to a sanitary sewer, or treated as required and then discharged, or treated and re-injected.	Ineffective for treatment of dissolved plumes within lower permeability materials. Requires operation of long term groundwater pump and treatment system and is not cost effective.	No
		Vacuum Enhanced Recovery	Application of strong vacuum to recovery wells can be used to enhance the capture zone and yield of groundwater recovery wells.	Considered prohibitively expensive. Effectiveness limited by vertical air "short circuiting".	No
		Horizontal Wells	Directionally drilled horizontal wells to increase groundwater capture.	Higher cost to install, but can be installed beneath above grade structures and directly into plume area. Geologic conditions and plume orientation are conducive to using horizontal well extraction, but health and safety issues related to potential chemical agent.	No
		Excavation	Groundwater dewatering and excavation of impacted soils.	Expensive but is the only alternative available for removal of the source including impacted soil and buried waste. Presents additional health and safety risks due to the potential presence of chemical agent.	Yes
		One-pass Trenching	Groundwater collection technique to increase production rate from low permeability areas.	Not effective for groundwater extraction/removal.	No
		Drains	Underground gravel-filled trenches generally equipped with tile or perforated pipe are installed to collect contaminated groundwater and leachate.	Cost prohibitive due to the depth of the treatment area.	No

TABLE 3-5

Initial Screening of Remedial Technologies and Process Options

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

General Response Actions	Remedial Technology Types	Process Options	Descriptions	Comments	Retain for Further Evaluation
Treatment	Enhanced Aerobic Bioremediation	Aerobic Cometabolic Bioremediation	Injection of substrate containing inducers and electron acceptors (oxygen) to enhance aerobic biodegradation. Inducers serve as carbon sources that activate aerobic enzyme systems known to degrade chlorinated VOCs (fortuitous cometabolism).	Aerobic conditions, not present in the plume area, are most effective for VC degradation via direct metabolism, cometabolic degradation and possibly direct oxidation.	No
		Anaerobic Bioremediation with Bioaugmentation (Enhanced Bioremediation)	Subsurface delivery of electron donors within the target zone to stimulate anaerobic biodegradation of chlorinated compounds by reductive dechlorination.	Applicable for cis-1,2,DCE and VC groundwater treatment. Microbial analyses of groundwater samples collected from Site 69 indicate bioaugmentation may be required to mediate reductive dechlorination.	Yes
		In-Situ Chemical Oxidation/ Reduction	Injection of oxidizing agents (Fenton's reagent, permanganate, persulfate, ozone) or reducing agents (zero-valent iron) to promote abiotic in-situ oxidation/reduction of chlorinated organic compounds.	Applicable for VOCs, ISCO is an efficient and fast acting treatment. Additional health and safety risks associated with application of an oxidant to the buried waste may create a reactive environment due to historical events. However, substrates would be injected below the waste disposal area and into the groundwater plume beneath.	Yes
		Phytoremediation	Use of plants and their associated rhizospheric microorganisms to remove, degrade, or contain chemical contaminants in groundwater.	The site is currently vegetated. Depth to water is too deep for phytoremediation to be effective.	No
	In-situ Physical, Chemical Treatment	Pneumatic and Hydraulic Fracturing	Creation of apertures in the soil to enhance bulk permeability, using pressurized gas or liquid slurry.	Localized hydraulic fracturing using a geoprobe and high pressure pumps can produce erratic results. Additional health and safety risks are associated with disturbance of buried waste material, where addition of oxygen to the subsurface may create a reactive environment or potential increase in leakage of waste materials.	No
		Air Sparging	Air is injected into saturated matrices to remove contaminants through volatilization and/or bioremediation.	Air sparging is used to promote volatilization of target VOCs is potentially feasible. Effectiveness decreases in low permeability or heterogeneous materials because of low air channel density and/or "bypassing" of dense soils (Belgrade Formation present at the site). Additional health and safety risks are associated with disturbance of buried waste material, where addition of oxygen to the subsurface may create a reactive environment or potential increase in leakage of waste materials. Further there is risk of dispersing contaminated particles, including chemical agent, into the atmosphere.	No
		Electrical Resistive Heating	Involves installation of electrodes in hexagonal or three point arrays and application of high voltage electrical power to cause boiling of volatile compounds in groundwater. Volatilized compounds are removed by SVE, treated, and discharged under permit.	Cost prohibitive and technically challenging due to depth and extent of contamination. SVE difficult due to shallow depth to groundwater. Heating of buried drums present additional health and safety risks and well as a potential increase in leakage of contained waste materials.	No

TABLE 3-5

Initial Screening of Remedial Technologies and Process Options

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

General Response Actions	Remedial Technology Types	Process Options	Descriptions	Comments	Retain for Further Evaluation
Treatment (cont.)	In-situ Physical, Chemical Treatment (cont.)	Surfactant, Cosolvent Flushing "SEAR"	Delivery of a solution that enhances contaminant transport and recovery through low permeability, heterogeneous soils. Surfactants may also be used as a "stand alone" technology to remove target VOCs by physical displacement, solubilization, desorption, with subsequent recovery of both the solution and target contaminants. However, surfactant flooding within low permeability, heterogeneous soils is unproven.	Generally not recommended for application in low permeability, heterogeneous soils, where dense materials are bypassed by the injected solution.	No
		Hot Water or Steam Flushing, Stripping	Steam is forced into an aquifer through injection wells to vaporize volatile and semivolatile contaminants. Vaporized components rise to the unsaturated zone, where they are removed by vacuum extraction and treated.	Cost prohibitive due to depth and extent of contamination. SVE difficult due to shallow depth to groundwater. Heating of buried drums present additional health and safety risks and well as a potential increase in leakage of waste materials.	No
	Ex-situ Physical, Chemical Treatment	Chemical Reduction	Reducing agents (zero-valent iron) are used to destroy organic contaminants in an ex-situ reactor.	Not technically practicable or cost effective. Requires pump and treat for groundwater capture and recovery. Pump and treat is not effective in heterogeneous, low permeability materials.	No
		Chemical Oxidation	Oxidizing agents (sodium persulfate, potassium permanganate) are used to destroy organic contaminants in an ex-situ reactor.	Not technically practicable or cost effective. Requires pump and treat for groundwater capture and recovery. Pump and treat is not effective in heterogeneous, low permeability materials.	No
		Air Stripping	Volatile organics are partitioned from groundwater by increasing the surface area of the contaminated water exposed to air. Aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration. Emissions from the air stripping system need to be monitored and may need to be treated to conform with federal (Clean Air Act) and local air emission monitoring requirements.	Requires pump and treat for groundwater capture and recovery. Pump and treat is not effective in heterogeneous, low permeability materials.	No
		Filtration	Solid particles are isolated by running a fluid stream through a porous medium. The driving force is either gravity or a pressure differential across the filtration medium.	Not applicable for site contaminants.	No
		Ion Exchange	Ions from the aqueous phase are removed by exchange with innocuous ions on the exchange medium.	Not applicable for site contaminants.	No
		Liquid-Phase Carbon Adsorption	Groundwater is pumped through a series of canisters or columns containing activated carbon to which dissolved organic contaminants adsorb. Periodic replacement or regeneration of saturated carbon is required. Wastes produced from the saturated carbon need to be properly managed.	Requires pump and treat for groundwater capture and recovery. Pump and treat is not effective in heterogeneous, low permeability materials.	No

TABLE 3-5

Initial Screening of Remedial Technologies and Process Options

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

General Response Actions	Remedial Technology Types	Process Options	Descriptions	Comments	Retain for Further Evaluation
Treatment (cont.)	Ex-situ Physical, Chemical Treatment (cont.)	Precipitation	Dissolved contaminants are transformed into an insoluble solid, facilitating the contaminants' subsequent removal from the liquid phase by sedimentation or filtration. Usually includes pH adjustment, addition of a chemical precipitant, and flocculation.	Not applicable for site contaminants.	No
		Incineration	Recovered free product heated to very high temperatures to combust organic contaminants in the presence of oxygen.	Cost prohibitive.	No
	Land Application	Land Application	Liquid wastes that are primarily organic are incorporated into the upper soil horizon so they can be degraded, transformed, or immobilized.	Not applicable for dissolved groundwater contaminants.	No
Disposal	Wastewater Discharge	POTW	Wastewater is discharged to Base wastewater treatment plant. Must comply with Base effluent standards.	Requires pump and treat for groundwater capture and recovery.	No
		Surface Waters	Wastewater is discharged to surface receiving streams. Must comply with NPDES permit standards and sampling requirements.	Requires pump and treat for groundwater capture and recovery.	No
		Reinjection	Treated/amended groundwater is reinjected into on-site wells. Federal and state regulations are very restrictive.	Requires pump and treat for groundwater capture and recovery.	No
		Deep Well Injection	Wastewater is injected into Class I wells. Federal and state regulations are very restrictive.	Requires pump and treat for groundwater capture and recovery.	No
		Evaporation Ponds	Surface impoundments are used to contain treated or untreated wastewater or groundwater until it evaporates.	Not practicable.	No

SECTION 4

Development and Screening of Alternatives

This section discusses the development of the technologies identified for further analysis into remedial alternatives. The development rationale is discussed, and a description and evaluation of the alternatives are provided. The following alternatives were developed to address Site 69 COCs in both soil and groundwater:

Soil Alternatives
1. No Action
2. LUCs
3. Capping with LUCs
4. Removal

Groundwater Alternatives
1. No Action
2. MNA with LUCs
3. Permeable Reactive Barrier (PRB) with MNA and LUCs
4. Enhanced Reductive Dechlorination (ERD) with Bioaugmentation, MNA, and LUCs
5. In situ chemical oxidation (ISCO) with MNA and LUCs

Section 121(b) of CERCLA identifies the following statutory preferences when developing and evaluating remedial alternatives:

- Remedial actions involving treatment that permanently and significantly reduce the toxicity, mobility, and volume of the COCs are preferred.
- Offsite transport and disposal of COCs without treatment is considered the least favorable remedial action when practical treatment technologies are available.
- Remedial actions that use permanent solutions, alternative treatment technologies, or resource recovery technologies are to be assessed.

In 1993, USEPA established source containment as the presumptive remedy for municipal landfills regulated under CERCLA. USEPA guidance developed in 1996 indicated that military landfills regulated under CERCLA should also consider the source containment presumptive remedy approach, when appropriate (USEPA, 1996). However, the decision framework within the 1996 guidance suggests that a presumptive remedy may not be appropriate because of the presence or potential for low and high hazard military specific wastes (decontamination kits, chemical warfare agents).

Both source containment and source removal remedial approaches have been developed as part of the FS to meet the identified RAOs. Soil and groundwater remedial alternatives that meet both of these remedial approaches are discussed below.

4.1 Development of Soil Alternatives

Based on initial screening of technologies, in accordance with RAOs specified in Section 3.2, the remedial alternatives discussed below were selected for further evaluation and analysis and are summarized in **Table 3-5**.

Information concerning soil contamination and buried waste materials is limited. Intrusive investigation activities were restricted because of the potential for CA to be present at the site.

Because of the contaminant concentrations present and potential presence of CA at Site 69, LUCs preventing the unauthorized use or exposure to contaminated soil will be considered as part of Alternatives 2 and 3. In addition, LUCs will be reviewed with the U.S. Army Engineering and Support Center, Huntsville (CEHNC) so that sufficient controls are selected for each alternative due to the potential presence of CA. The DoN and MCB CamLej will

implement the following measures as part of the LUCs: 1) file a Notice of Hazardous Substance or Waste Disposal; 2) incorporate the LUCs into the Base Master Plan.

4.2 Screening of Soil Alternatives

4.2.1 Soil Alternative 1 - No Action

The No Action Alternative is required under CERCLA to be evaluated as a baseline for other alternatives. The No Action Alternative does not include any LUCs, monitoring, or active remedial activities to minimize risk to public health or environment. Further, this alternative does nothing to reduce or monitor the contaminants present in soil. The lack of active cleanup or controls could potentially expose future receptors to contaminants at the site.

4.2.2 Soil Alternative 2 LUCs

LUCs involve the implementation of LUCs such as control boundaries to prevent site access and intrusive activities, and the installation of fencing around the site. LUCs would be updated for areas that have COC concentrations exceeding regulatory standards.

The IROD (Baker, 2000) incorporated a site-specific LUCIP for Site 69. LUCs were included as part of the selected remedial actions, which are required to remain in effect until the remedial goals have been achieved or the IROD is superseded by a final ROD. Objectives of the LUCs are:

- Prevent future potential exposure to contaminated subsurface soil (including landfill materials)

A Non-Industrial Use Control Boundary and Soil Intrusive Activities Control Boundary were established at the fenced boundary of Site 69 (**Figure 2-2**). LUCs were implemented in 2001 and updated in 2002 (Baker, 2002).

LUCs reduce the risk of exposure by limiting site access with the 6-ft fence and signs. This alternative does not include any active remedial activities to expedite reduction of contaminant concentrations. LUCs would not effectively limit ecological exposure to soils containing COCs, or prevent offsite migration of soil containing COCs by erosion, or prevent precipitation infiltration through the disposal area.

Assumptions considered in developing the cost estimate for this alternative included site notification, surveying, sign and fence maintenance, and site inspection.

4.2.3 Soil Alternative 3 – Capping and LUCs

This alternative leaves buried waste and contaminated soil in place, but installs a low-permeable cap over the waste disposal area. The objective of capping is to contain and immobilize contaminants and provide a barrier for potential receptors. Caps can be constructed from a variety of materials and may be a single-layer or multi-layer design.

A multilayer RCRA Subtitle C cap would be used to contain in situ waste and can be applied to contain site contaminants. The RCRA cap is composed of five elements: a vegetative and protective layer, drainage layer, synthetic barrier, geological material barrier, and gas vent layer. This design promotes minimal infiltration, low maintenance requirements, efficient drainage, resistance to damage, and low permeability (Battelle, 2011).

The purpose of the cap and LUCs is to: 1) protect receptors from potential contact with buried waste and affected soils, and 2) reduce infiltration, which will reduce the mobility of subsurface contamination.

The construction of a RCRA cap would be over the southern and eastern burial trenches, as indicated on **Figure 4-1**. A multi-layered RCRA cap was selected because of the nature of wastes being covered and the projected future site use at Site 69. A RCRA cap with 4 percent grading will be installed along the southern burial trench (500 ft by 250 ft) and remaining portion of the eastern burial trench (250 ft by 300 ft), to cover a total area of approximately 190,000 ft^2. Site preparation would include vegetation clearing, monitoring well abandonment and placing clean fill over the area to provide a level grade for the landfill cap. The total fill volume is estimated to be 23,664 cubic yards. The duration of field work associated with vegetation clearance and construction of the cap is expected to be 104 days. With long-term operation and maintenance (O&M) to protect the integrity of the cap from biological invasion or settling, a RCRA cap has an effective lifespan of more than 30 years. The long-term

performance of the cap is an important factor at Site 69 because the source is still buried in place. LUCs would be updated for areas that have COC concentrations exceeding regulatory standards and would be reviewed with CEHNC so that sufficient controls are selected and maintained to manage the potential presence of CA at the site.

Other assumptions used in developing the cost estimate for this alternative include the following:

- Vegetation clearance to 6 inches above ground surface, as required, due to munitions response considerations.
- Leveling of the site including spreading existing soil stockpiles and importing clean fill.
- Abandonment of wells within the capping area, as shown on **Figure 4-1,** and any additional existing wells associated with previous site studies. Figures depicting the location of wells used for the previous UVB and KGB treatment systems can be found in the final Phase I and II treatability report (Baker/SBP, 1998).
- Cap inspections and mowing/maintenance would be conducted semi-annually for 30 years.

4.2.4 Soil Alternative 4 - Removal

This alternative removes buried waste and affected soil from the waste disposal area, and disposes of the materials offsite at an approved waste disposal facility. The objective of the Removal Alternative would be to excavate the source of contaminants and remove the potential risk to receptors. The potential presence of CA and munitions and explosives of concern (MEC) will require implementation of additional health and safety precautions during soil removal and backfilling.

In the *Estimated Costs for Remedial/Response Action at Sites 41, 69, and 74 on Camp Lejeune Marine Corps Base, Camp Lejeune, North Carolina* (**Appendix B**), CEHNC provided a cost estimate for removal of the landfill material, assumed to contain mixed hazardous waste, potential CA, and ordnance, at Site 69. The CEHNC estimate was based on general assumptions, including the proposed removal of the top 10 ft of material across the entirety of the site (14 acres). However, based on the SI DGM, the waste disposal area has been estimated at approximately 4 acres and the depth of the waste disposal area could be up to 20 ft (Scudder, 1982) (**Figure 4-1**). Hazardous waste would be disposed of in a RCRA landfill, while ordnance and any CA would be disposed of separately. It is assumed that CEHNC would conduct the action based on the potential presence of CA at the site. This soil alternative would remove the source of contamination at the site.

4.3 Development of Groundwater Alternatives

Based on initial screening of technologies, in accordance with RAOs specified in Section 3.2, the following remedial alternatives were selected for further evaluation and analysis and are summarized in **Table 3-5**.

Because of the concentrations of COCs present at Site 69, LUCs prohibiting the installation of water supply wells and preventing the unauthorized use or exposure to contaminated groundwater will be considered as part of Alternatives 2, 3, 4, and 5. In addition, LUCs will be reviewed with CEHNC so that sufficient controls are selected for each alternative as a result of the potential presence of CA. The DoN and MCB CamLej will implement the following measures as part of the LUCs: 1) file a Notice of Hazardous Substance or Waste Disposal; 2) incorporate the LUCs into the Base Master Plan. MNA will also be considered as a component of Alternatives 3, 4, and 5.

4.4 Screening of Groundwater Alternatives

4.4.1 Groundwater Alternative 1 - No Action

The No Action alternative is required under CERCLA to be evaluated as a baseline for comparing other alternatives. The No Action alternative does not include any ICs, groundwater monitoring, or active remedial activities to minimize risk to public health or environment. Further, this alternative does nothing to reduce or monitor the contaminant plume in groundwater.

The No Action Alternative allows NA to reduce the contaminant plume in groundwater, but the lack of active cleanup or controls could potentially expose future receptors to contaminants in groundwater.

4.4.2 Groundwater Alternative 2 – MNA with LUCs

MNA includes groundwater monitoring to track changes in COC concentrations and NAIPs. LUCs would be employed for areas that have groundwater concentrations higher than the NCGWQS.

The IROD incorporated a site-specific LUCIP for Site 69. LUCs were included as part of the selected remedial actions, which are required to remain in effect until the remedial goals have been achieved or the IROD is superseded by a final ROD.

An Aquifer Use Control Boundary was established, encompassing Site 69 and much of Site UXO-02. In addition, a Non-Industrial Use Control Boundary and Groundwater Intrusive Activities Control Boundary were established at the fenced boundary of Site 69 (**Figure 2-2**). LUCs were implemented in 2001 and updated in 2002 (Baker, 2002).

Natural degradation is expected to proceed at Site 69, and favorable conditions exist at the location of the highest concentrations. In addition, the nature of the contamination is such that the highest concentrations appear to be very localized to monitoring well IR69-GW15 cluster with limited distribution.

MNA and LUCs will be considered part of all groundwater alternatives except the No Action alternative.

Evaluation of historical MNA trends at Site 69 is limited because of minimal data collection for portions of the site. Natural degradation is expected to continue at Site 69, although the process may take considerable time to reach regulatory cleanup goals. Based on the BIOCHLOR continuous source model, VOC concentrations are not expected to attenuate below their respective NCGWQS in the source area. The continuous source model for BIOCHLOR is conservative. The model predicts that each plume will remain relatively stable over a 100-year predicted period. Currently, 60 years from the release date of 1951, the VC plume is more than 430 ft from the New River at the closest point. VC concentrations were predicted to exceed NCGWQS (0.03 µg/L) throughout the aquifer in all future models (2020 to 2110). However, VC concentrations are predicted to remain below the NCSWQS (2.4 µg/L) at the discharge point to the New River. Furthermore, NAIPs in the upper Castle Hayne aquifer exhibit very favorable conditions for reductive dechlorination, and elevated populations of dehalogenating bacteria are present.

Other assumptions used in developing the cost estimate for this alternative are:

- Use of current monitoring well network to evaluate groundwater quality and monitor NA (**Figure 2-2**).
- Monitoring will include collecting samples from 22 monitoring wells annually for 30 years. Proposed analyses include VOCs annually and PCBs, pesticides, TAL metals, and CA every 5 years. Field parameters (such as water level, pH, specific conductance, temperature, ORP, DO, and ferrous iron) would be measured during sample collection.
- Annual monitoring reports would be submitted to document site conditions.
- Remediation progress would be reviewed by USEPA and NCDENR at 5-year intervals for 30 years.

4.4.3 Groundwater Alternative 3 - PRB with MNA and LUCs

PRBs are installed perpendicular to the flow path of a contaminated groundwater plume, producing treatment zones that allow the passage of water while treating contaminants. By using a reactive medium within the barrier, contaminant treatment can occur through physical, chemical, or biological processes. The basic objective of any treatment material is to either destroy or immobilize the contaminant or condition the groundwater system to promote the destruction or immobilization of the contaminant (Interstate Technology & Regulatory Council, 2005). Although zero valent iron (ZVI) PRBs are more expensive than common mediums such as compost or mulch, the expected performance life exceeds 30 years, compared to roughly 5 years for a PRB using mulch as a reactive medium. In addition, periodic stimulant injections are not needed.

The purpose of the groundwater PRB is to treat affected groundwater flowing between the waste disposal area and downgradient portion of the site towards the New River. Based on the hydraulic conductivity, gradient, and assumed porosity, groundwater flow through the PRB would be approximately 5.2 ft/year. The long- term performance of the ZVI PRB is an important factor at Site 69 because the source is still in place. LUCs would be

reviewed with CEHNC so that sufficient controls are selected and maintained to manage the potential presence of CA at the site.

The use of a PRB at Site 69 would involve the installation of an 800–ft-long wall composed of ZVI surrounding the eastern boundary of the site and three additional monitoring wells to monitor ZVI performance in the vicinity of the PRB (**Figure 4-2**). The PRB evaluated for Site 69 is not a traditional PRB due to the depth of the contaminants. Normal trenching activities cannot be performed to the necessary depths in the site geology. The barrier would be installed to a depth of 75 ft using vertical hydraulic fracturing methods. This iron treatment wall is a trenchless design in which iron filings are injected into a series of closely spaced boreholes (on the order of 15-foot spacing) drilled along the location of the wall using vertical hydrofracturing technology. The installation is less invasive, requiring no excavation and minimal site disturbance. In addition, it is safe with low exposure risk to personnel (GeoSierra Environmental, Inc., 2011).

Other assumptions used in developing the cost estimate for the PRB with MNA and LUCs alternative are:

- Installation of three new monitoring wells to a depth of 80 ft to monitor the PRB effectiveness.
- Semi-annual performance monitoring will be conducted from five target interval wells for 3 years to analyze for VOCs. The initial groundwater monitoring event will include analysis for pesticides, PCBs, TAL metals, and CA.
- Annual monitoring will consist of collecting samples from 22 monitoring wells for 30 years. Proposed analytes include VOCs annually and PCBs, pesticides, TAL metals, and CA every 5 years. Field parameters [such as water level, pH, specific conductance, temperature, ORP, DO, and ferric iron] will be measured during sample collection.
- Annual monitoring reports would be submitted to document site conditions.
- Remediation progress would be reviewed by USEPA and NCDENR at 5-year intervals for 30 years.

4.4.4 Groundwater Alternative 4 - ERD with Bioaugmentation, MNA and LUCs

Biodegradation of chlorinated solvents is well-documented to occur under anaerobic conditions through a process known as reductive dechlorination. Reductive dechlorination is a process in which indigenous microorganisms (e.g., fungi, bacteria, and other microbes) degrade chlorinated organic contaminants found in the subsurface. Bioaugmentation refers to the introduction of a bacterial culture capable of fully reducing chlorinated solvents to ethene. During reductive dechlorination, also known as dehalorespiration, a carbon atom in the chlorinated solvent accepts an electron from an electron donor (reduction), causing the release of a chlorine atom (dechlorination). The more chlorine atoms a compound has, the more oxidized its carbon is, and therefore, the more susceptible it is to reductive dechlorination. This process results in sequential dechlorination of a contaminant. The general, reductive dechlorination process results in the formation of degradation ("daughter") products, in the following order:

$$TCE \rightarrow cis\text{-}1,2\text{-}DCE \rightarrow VC \rightarrow ethene$$

The reductive dechlorination process begins with the released compound (i.e., TCE or DCE). The transformation rates for each step vary but tend to become slower with progress along the breakdown sequence, often resulting in accumulation of cis-1,2-DCE and VC. Further breakdown from cis-1,2-DCE and VC to ethene varies and is based on site-specific conditions.

For anaerobic biodegradation to be successful, adequate quantities of electron donors must come into contact with the active microbial consortia and target contaminants. Not all natural groundwater systems have the essential microorganisms needed to achieve complete reductive dechlorination of TCE to ethene. In these cases, bioaugmentation may be required. Bioaugmentation with DHC-containing cultures has been a widely demonstrated remedy to enhance ERD and achieve complete reductive dechlorination of chloroethenes. Presence and abundance of appropriate functional genes (*bvcA* and *vcrA*) is an important indicator that the "correct" species is present to ensure a complete reductive dechlorination process. Microbial analysis of samples collected from Site 69 demonstrates concentrations of dehalogenating bacteria are often exceeding or comparable to other

sites at MCB CamLej. Analyses of functional genes will provide further insights into the potential of the indigenous microbial consortium in reductive dechlorination of chloroethenes.

ERD involves increasing the activity of this naturally occurring process by providing an electron donor/food source. The introduced substrate (donor) serves two purposes: 1) depleting competing electron acceptors and creating strongly reducing conditions and 2) providing an electron donor source for reductive dechlorination. The effectiveness of ERD depends on successful injection of this food source into the subsurface, the presence of dechlorinating microbes at the site, and favorable hydrogeologic conditions.

Commonly used electron donors include emulsified vegetable oil, molasses, sodium lactate, corn syrup, and many others. The addition of a substrate or other enhancements for ERD may be achieved through either direct injection into new conventional wells or new horizontal wells.

Because native bacteria require an acclimation period to adjust to a change in conditions, it may require 3 to 6 months before the effectiveness of the substrate injections can be assessed adequately. During this period, semi-annual groundwater monitoring would be performed to assess treatment performance and NA of groundwater COCs. Several injections of substrate may be required to maintain or achieve the desired reducing conditions.

MNA would be implemented for the downgradient, lower concentration portion of the plume, and LUCs would be reviewed with CEHNC so that sufficient controls are selected and maintained to manage the potential presence of CA at the site.

For purposes of the FS, Alternative 4 employs ERD with a suitable substrate in combination with bioaugmentation to treat the 100-ft by 180-ft target area. The suggested substrate and culture for cost estimating purposes are 3-D Microemulsion (3DMe) and KB-1, respectively. However, the final ERD substrate and bacterial culture selection would be made during the final remedial design phase by conducting bench-scale studies. For the purpose of the FS, application of ERD substrate and bioaugmentation culture solutions to the target area were evaluated through two delivery methods: vertical injection and extraction wells on either side of the waste disposal area, or horizontal injection wells installed at varying depths beneath the buried waste. Delivery of the substrate and bacterial culture across the target area is critical to successfully remediating CVOC concentrations.

All injections will be completed by personnel wearing upgraded Level D personal protective equipment (PPE), including Tyvek suits, nitrile gloves, and face shields.

4.4.4.1. Alternative 4a—Vertical Injection/Extraction Wells

For the vertical injection/extraction well delivery alternative, groundwater would first be extracted from wells installed along the downgradient southern and eastern boundaries of the target area, just outside the waste disposal area. The extraction would then be dosed, with the ERD substrate and bioaugmentation culture to be injected into wells installed along the northern and western boundaries of the target area. This process would continue, using an onsite injection and extraction system to pull the treatment mixture through the target area until desirable substrate concentrations are adequately distributed. For cost estimating purposes, a total of 10 injection wells and 10 extraction wells completed with a screened interval of 45 to 65 ft bgs are assumed for this alternative (**Figure 4-3)**.

Two injection events of 3DMe spaced 1 year apart are assumed. Bioaugmentation using KB-1 is only proposed during the first injection event. The estimated time to complete the injection/extraction well installation is approximately 12 working days, and each injection event is expected to take approximately 6 weeks, depending on conditions encountered in the field. However, due to the spacing of the well system, there is a high amount of uncertainty over the ability to recirculate substrate in this time-frame.

4.4.4.2. Alternative 4b—Horizontal Injection Wells

For the horizontal well delivery alternative, the ERD substrate, bioaugmentation culture, and chase water would be injected in double-ended horizontal wells installed beneath the waste disposal area. For cost estimating purposes, eight horizontal wells screened for 180 ft through the target area would be installed: three at 45 ft bgs,

two at 55 ft bgs, and three at 65 ft bgs, as shown in Figure 4-4. Wells would be spaced 50 ft laterally based on an assumed horizontal 25-ft radius of influence (ROI) with vertical ROI of 5 ft.

Three 3DMe injection events are assumed annually for 3 years. Bioaugmentation using KB-1 is proposed during the first and third injection events. The estimated time to complete horizontal well installation is 48 days, and each injection event is expected to take approximately 7 working days, depending on conditions encountered in the field.

Other assumptions used to develop the cost estimates for both vertical injection/extraction well and horizontal well alternatives are:

- The total 3DMe substrate mass required for the site was estimated to be 41,600 pounds per event. A 10:1 3DMe to water ratio is required, which translates into an injection volume of approximately 42,400 gallons across the treatment area per injection event. The volume of KB-1 required is 27 liters per bioaugmentation event. For horizontal injection, the recommended chase volume is three times the injection volume, or approximately 38,000 gallons of chase water per event in total for the entire target area. The vertical injection/extraction well delivery method does not need chase water for distribution.
- Semi-annual sampling of five target interval wells will be collected for the first 3 years and analyzed for VOCs, TOC, and volatile fatty acids. The initial groundwater monitoring event will include analysis for CA.
- Annual monitoring will include collecting samples from 22 monitoring wells for 30 years. Proposed analyses include VOCs annually and PCBs, pesticides, TAL metals, and CA every 5 years. Field parameters (such as water level, pH, specific conductance, temperature, ORP, DO, and ferric iron) will be measured during sample collection.
- Annual monitoring reports will be submitted to document the site status.
- The remedy will be reviewed by USEPA and NCDENR at 5-year intervals for 30 years. Groundwater concentrations will be reviewed for reduction to levels such that concentrations can further be reduced to NCGWQS by NA within a reasonable period of time.

4.4.5 Groundwater Alternative 5 – ISCO with MNA and LUCs

ISCO consists of injecting chemical oxidants into the subsurface so that contaminants are completely oxidized into innocuous compounds. A number of chemicals can successfully degrade chlorinated solvents via chemical oxidation. Sodium permanganate is suggested as the oxidant because it is highly stable and readily miscible in water at all concentrations and temperature ranges practical for ISCO (Environmental Security Technology Certification Program, 2008). The potential dissolution of metals as a result of sodium permanganate injection is an added benefit of the ISCO alternative. Key factors influencing the effectiveness of ISCO are contact between the contaminant and the oxidant, and natural oxidant demand (NOD). Permanganate is recommended because it is relatively easy to handle in the field and has a greater persistence in the environment. Multiple injections may be needed to achieve complete removal of VOCs.

Although the oxidizing potential of the permanganate anion is less than other substrates such as persulfate and ozone, it is still efficient and fast-acting. The chemistry of permanganate is simple, predictable, and selective, and its high stability enables long contact times and transport distances in the subsurface when no excessive natural oxidant sinks are present. The reactive transport of permanganate is well investigated, and depends heavily on NOD and manganese oxide deposition (Environmental Security Technology Certification Program, 2008).

In the absence of site-specific NOD data (recommended before undertaking full- scale implementation), NOD was estimated to be 5 grams per kilogram, based on soil characterization. For a 180-ft horizontal injection interval throughout the target area, the target dosage is approximately 304,000 pounds of permanganate per injection event. To reduce the original reagent concentration from 40 percent to a 5 percent concentration, approximately 252,000 gallons of water would be required per injection event.

Precautionary measures should be exercised on application of oxidants. A disposal incident is reported to have occurred in 1970, providing evidence of potential explosive conditions with the use of oxidants. An explosion

occurred when calcium hypochlorite, a strong oxidizer, was placed in the burial pit with other wastes potentially including DDT and TCE and covered with soil (WAR, 1983). Use of horizontal wells installed 25 ft below the waste disposal area will direct the permanganate beneath the buried waste and any potential reaction. ISCO is expected to be an effective remedy for VOCs at the site; however, this alternative would not provide additional remedial benefits such as dissolution of metals.

For the purposes of the FS, two injections through horizontal wells, 2 years apart for the 100-ft by 180-ft target area, were evaluated as the delivery method, as shown in **Figure 4-4**. Eight double-ended horizontal wells screened for 180 ft through the target area (three at 45 ft bgs, two at 55 ft bgs, and three at 65 ft bgs) will be installed beneath the waste. A horizontal ROI of 25 ft and vertical ROI of 5 ft are estimated for injection through horizontal wells. Horizontal well injections are particularly well-suited for Site 69 because of the need to inject over a large area and limited access to the plume.

The estimated time to complete an injection event is approximately 40 working days, depending on conditions encountered in the field.

Other assumptions used to develop the cost estimates for the ISCO horizontal well injection alternative are:

- Semi-annual sampling of five target interval wells will be collected for the first 3 years and analyzed for VOCs. The initial groundwater monitoring event will include analysis for CA.
- Annual monitoring will include collecting samples from 22 monitoring wells for 30 years. Proposed analyses include VOCs annually and PCBs, pesticides, TAL metals, and CA every 5 years. Field parameters (water level, pH, specific conductance, temperature, ORP, DO, and ferric iron) will be measured during sample collection.
- Annual monitoring reports will be submitted to document the site status.
- Remediation progress will be reviewed by USEPA and NCDENR at 5-year intervals for 30 years.

All injections would be completed by personnel wearing upgraded Level D PPE, including Tyvek suits, nitrile gloves, and face shields.

MNA would be implemented for the downgradient, lower concentration portion of the plume, and LUCs would be reviewed with CEHNC to assure sufficient controls are selected and maintained to manage the potential presence of CA at the site.

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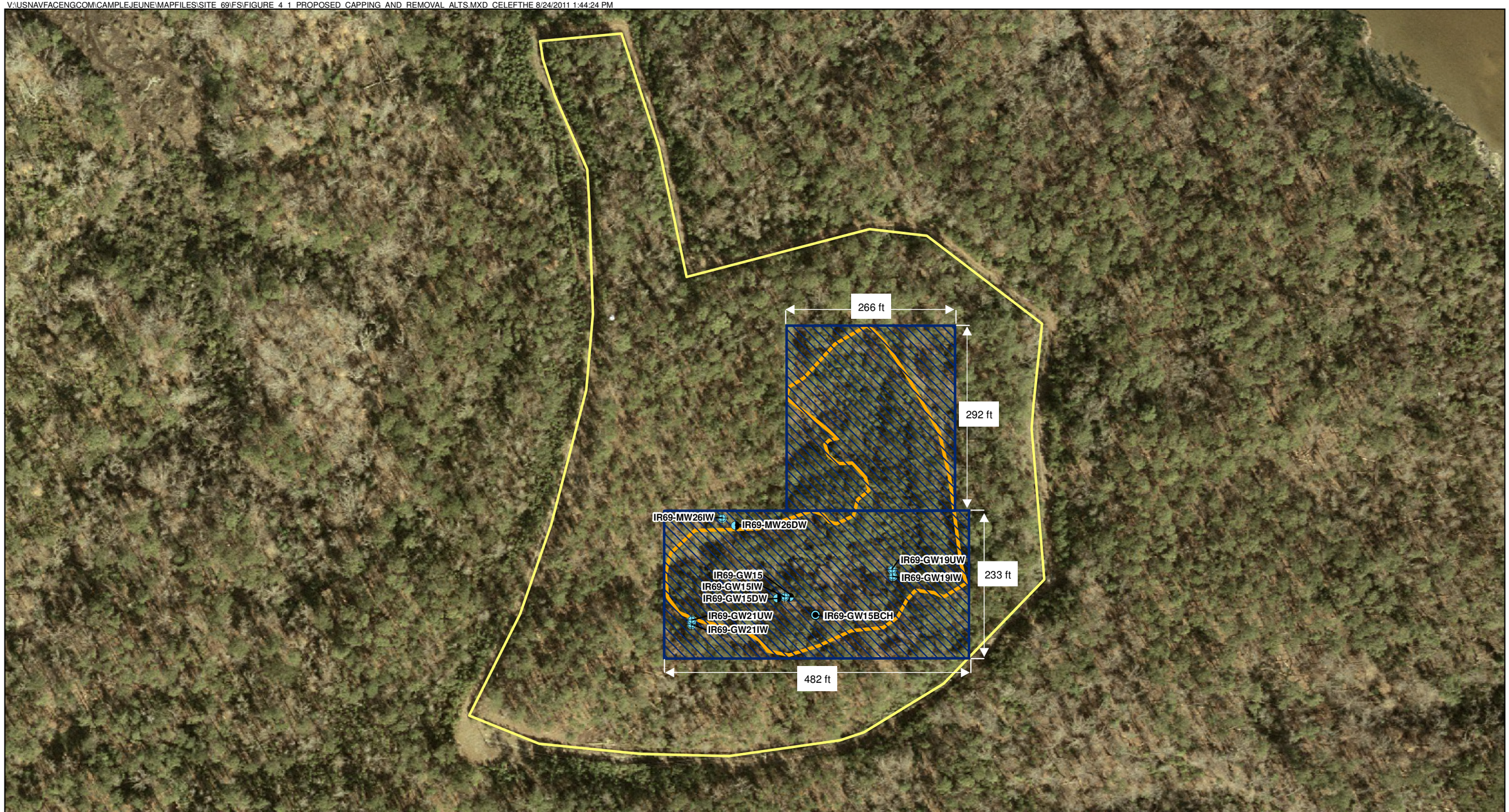

Legend

- Lower Castle Hayne Aquifer Well
- Middle Castle Hayne Aquifer Well
- Surficial Aquifer Well
- Upper Castle Hayne Aquifer Well
- Capping/Removal Area
- Waste Disposal Area
- Site 69 Boundary

Notes:
- Soil Capping - approximately 190,000 ft^2
- Soil Excavation to a depth of 20 ft bgs – approximately 141,000 yds^3

N

0 75 150 300 Feet

1 inch = 150 feet

Figure 4-1
Proposed Capping or Removal Area
Site 69 Feasibility Study
MCB CamLej
North Carolina

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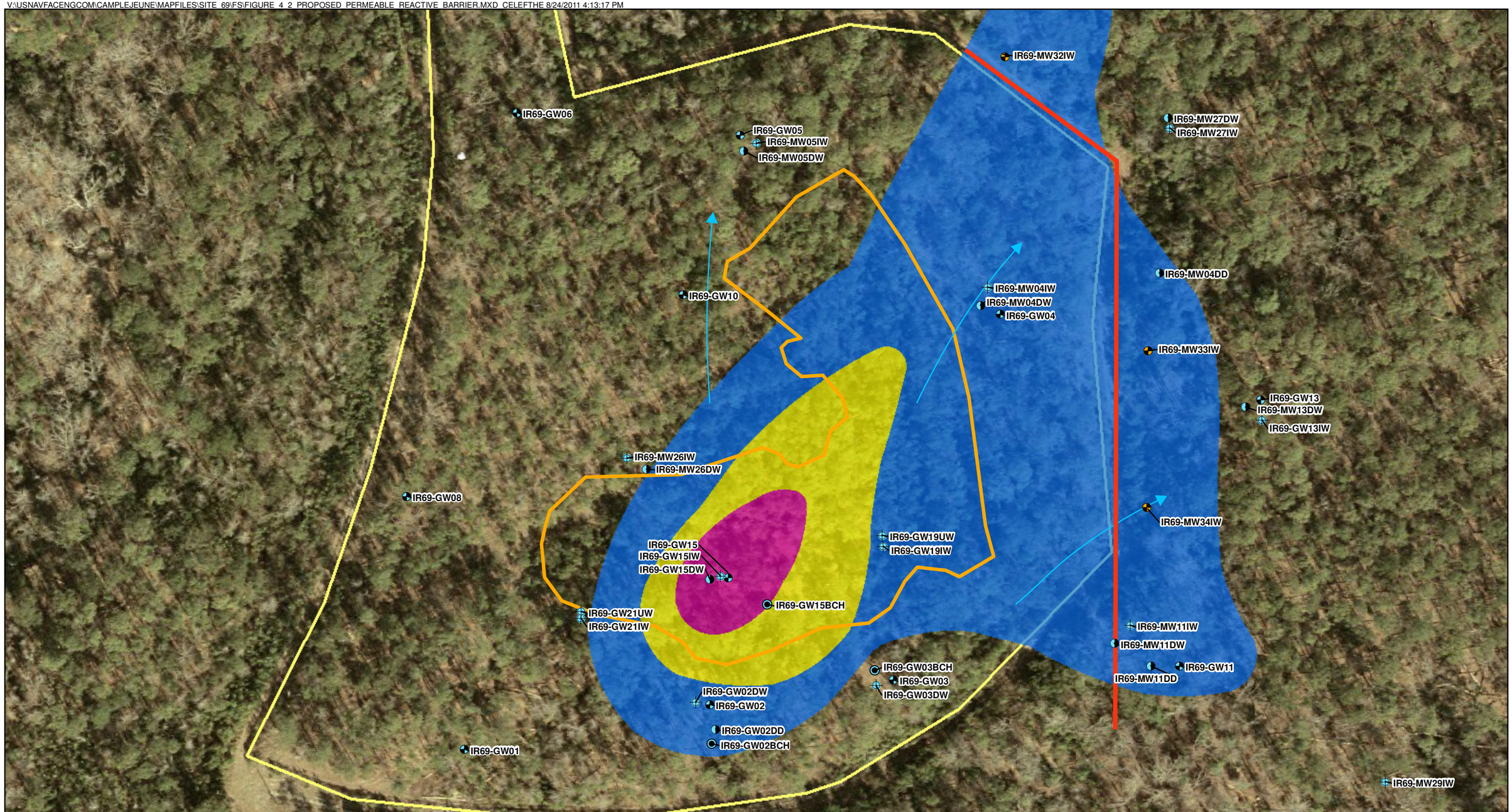

Legend

- Proposed Monitoring Wells
- Surficial Aquifer Well
- Upper Castle Hayne Aquifer Well
- Middle Castle Hayne Aquifer Well
- Lower Castle Hayne Aquifer Well
- Proposed PRB
- Groundwater Flow Direction in Upper Castle Hayne Aquifer
- Waste Disposal Area
- Site 69 Boundary

cis-1,2-DCE Concentration

- > 70 µg/L
- > 700 µg/L
- > 7,000 µg/L

Notes:
PRB to a depth of 70-75 ft bgs – approximately 800 ft long
PRB installed outside fenced area to control offsite migration of Upper Castle Hayne aquifer contaminant plume

N

0 50 100 200 Feet

1 inch = 100 feet

Figure 4-2
Proposed Permeable Reactive Barrier
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL.

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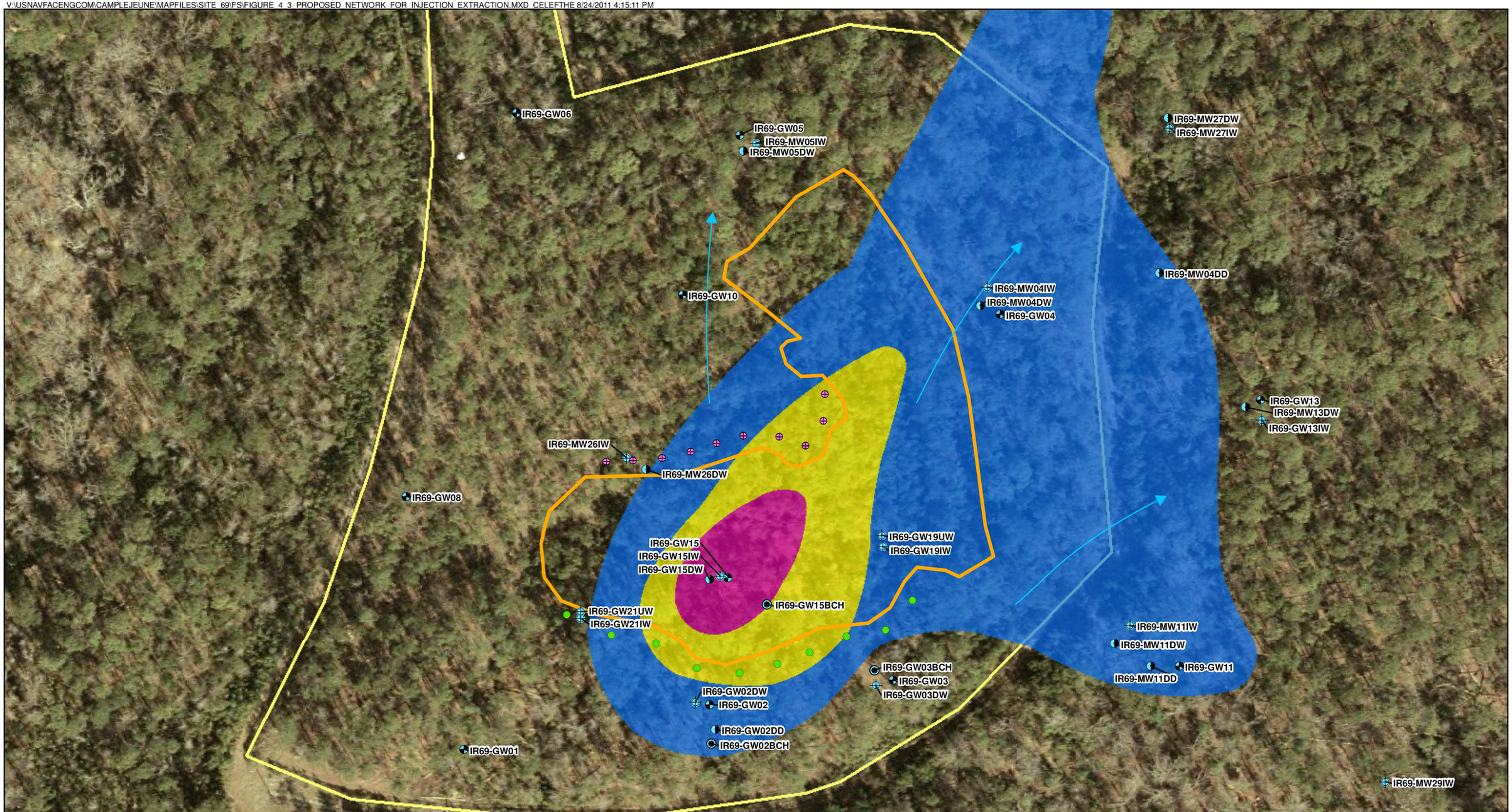

Legend

- Proposed Injection Wells
- Proposed Extraction Wells
- Surficial Aquifer Well
- Upper Castle Hayne Aquifer Well
- Middle Castle Hayne Aquifer Well
- Lower Castle Hayne Aquifer Well
- Groundwater Flow Direction in Upper Castle Hayne Aquifer
- Waste Disposal Area
- Site 69 Boundary

cis-1,2-DCE Concentration

- > 70 µg/L
- > 700 µg/L
- > 7,000 µg/L

Note:
Each Injection/Extraction location will be screened 20 ft from 45 ft to 65 ft bgs.
10 proposed injection wells
10 proposed extraction wells

N

0 50 100 200 Feet

1 inch = 100 feet

Figure 4-3
Proposed Network for Injection/Extraction
Site 69 Feasibility Study
MCB CamLej
North Carolina

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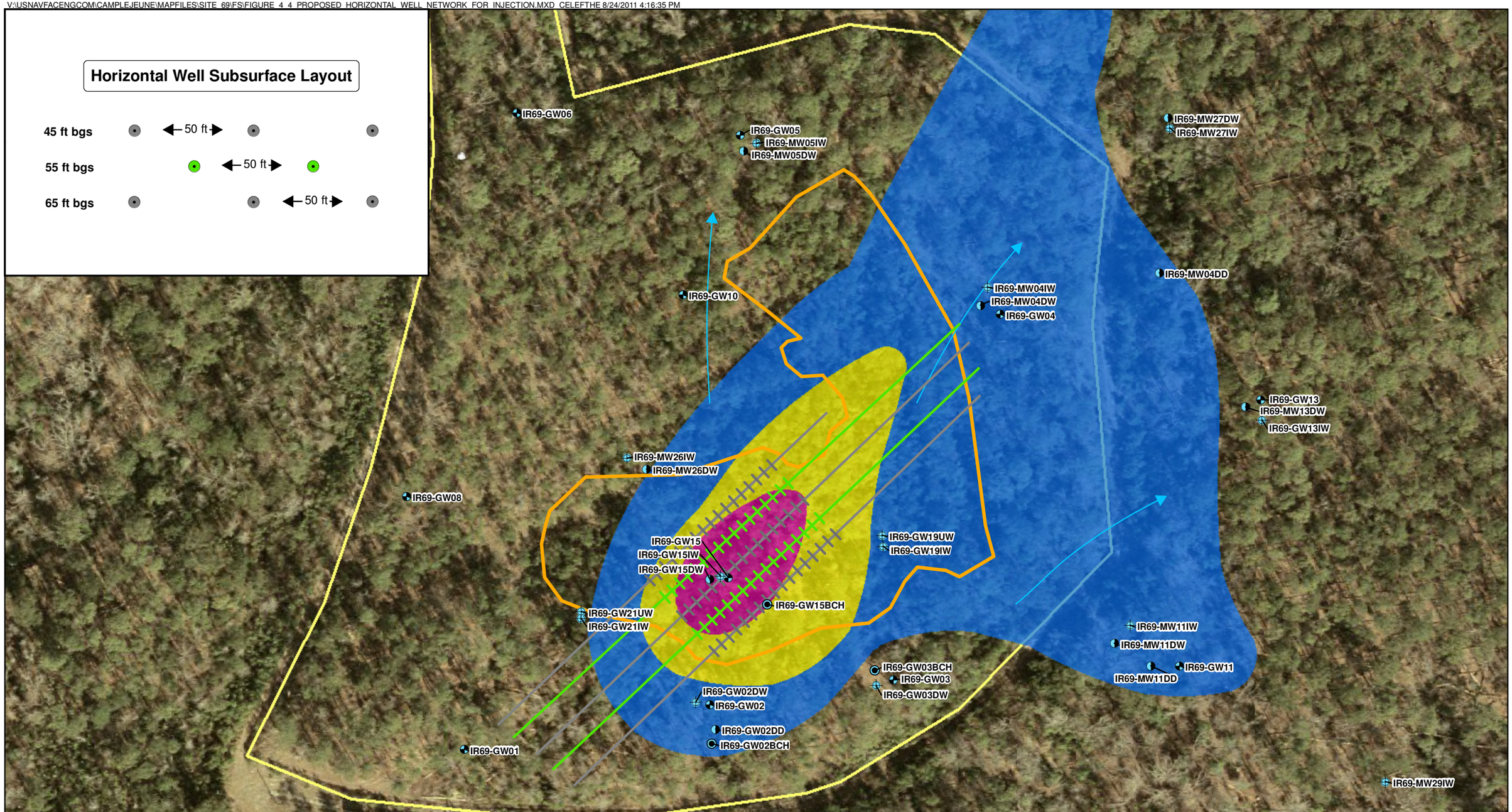

Legend

- Surficial Aquifer Well
- Upper Castle Hayne Aquifer Well
- Middle Castle Hayne Aquifer Well
- Lower Castle Hayne Aquifer Well

Proposed Horizontal Wells

- 45 ft bgs and 65 ft bgs Well Screen
- 55 ft bgs Well Screen

Proposed Horizontal Wells

- 45 ft bgs and 65 ft bgs non screen
- 55 ft bgs non screen

- Groundwater Flow Direction in Upper Castle Hayne Aquifer
- Waste Disposal Area
- Site 69 Boundary

cis-1,2-DCE Concentration

- > 70 µg/L
- > 700 µg/L
- > 7,000 µg/L

Notes:
Contours have been interpolated between well locations. Actual conditions may differ from those shown on this figure.

N

0 50 100 200 Feet

1 inch = 100 feet

Figure 4-4
Proposed Horizontal Well Network for Injection
Site 69 Feasibility Study
MCB CamLej
North Carolina

CH2MHILL.

SECTION 5

Detailed Analysis of Alternatives

The specific statutory requirements for remedial actions that must be addressed in the ROD and supported by the FS consist of each alternative's ability to:

- Protect human health and the environment
- Comply with ARARs or define criteria for invoking a waiver
- Be cost-effective
- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element or explain why this is not attainable

In addition, CERCLA 121(b)(1)(A) emphasizes evaluating long-term effectiveness and related considerations for each of the alternative remedial actions. These statutory considerations are:

- Long-term uncertainties associated with land disposal
- Goals, objectives, and requirements of the Solid Waste Disposal Act
- Persistence, toxicity, and mobility of hazardous substances and their constituents, and their propensity to bioaccumulate
- Short- and long-term potential for adverse health effects from human exposure
- Long-term maintenance costs
- Potential for future remedial action costs if the alternative were to fail
- Potential threat to human health and the environment associated with excavation, transportation, and re-disposal, or containment

The National Contingency Plan (NCP) provides nine evaluation criteria to address these statutory requirements and additional technical and policy considerations that are important for a CERCLA remedial action. The nine criteria serve as the basis for conducting the detailed analyses during the FS process and for subsequently selecting an appropriate remedial action. In this section, the remedial alternatives described in Section 4 are discussed individually against these nine evaluation criteria and then comparatively to identify key tradeoffs.

Sustainability is not one of the nine evaluation criteria. However, in support of Navy and USEPA guidance, it should be considered during remedial selection a. The Navy, in cooperation with CEHNC and Battelle, has developed a tool to incorporate sustainability metrics into the selection of remedial alternatives. SiteWise™ is a stand-alone tool that assesses the environmental footprint of remedial actions in terms of a consistent set of sustainability metrics: greenhouse gas (GHG) emissions, energy use, criteria air emissions (including nitrogen oxides [NO_x], sulfur oxides [SO_x] and particulate matter [PM_{10}]), water consumption, and worker safety. SiteWise™ provides a comparative assessment of different remedial alternatives based on the significant life-cycle impacts of each alternative, including: material production (polyvinyl chloride, 3DMe, sodium permanganate, etc.); transportation of equipment, personnel, and materials to the site; equipment use during implementation; electricity use to run equipment or pumps during the operations phase of a remedy; and residual handling (Battelle, 2010). A matrix showing how the sustainability metrics relate to the NCP criteria is provided as **Table 5-1**.

SiteWise™ results can be used to compare the different alternatives, but because many of the assumptions are based on industry standards instead of site-specific or particular remedy equipment and materials information,

they should not be viewed as the actual impacts of each remedy. Rather, they should be viewed as relative comparisons. The full results of the SiteWise™ model are provided in **Appendix C.**

5.1 Evaluation Criteria

The nine evaluation criteria provided in the NCP are described in the following subsections.

5.1.1 Protection of Human Health and the Environment

The assessment against this criterion evaluates how each alternative, as a whole, achieves and maintains protection of human health and describes how site risks are eliminated, reduced, or controlled through treatment, engineering, or ICs. This assessment also allows for consideration of whether the alternative poses unacceptable short-term or cross-media impacts.

5.1.2 Compliance with ARARs

This evaluation criterion is used to assess whether each alternative will meet all of its federal, state, and local ARARs, as described in Section 3.1. The analysis should summarize which requirements are applicable or relevant and appropriate for each alternative, and describe how the alternative meets these requirements. If a waiver is required because an ARAR is not met, the basis for justification should be discussed.

5.1.3 Long-term Effectiveness and Permanence

Long-term effectiveness and permanence are measured in terms of the risk remaining at the site after response objectives have been met. Alternatives providing the highest degree of long-term effectiveness and permanence are those that leave little or no waste at the site, do not require long-term maintenance and monitoring, and minimize the need for ICs. The evaluation of this criterion includes consideration of the following factors:

- The magnitude of residual risk to human and environmental receptors posed by any untreated waste or treatment residues remaining at the conclusion of remedial activities
- The type, degree, and adequacy of long-term controls required to manage untreated waste or treatment residues at the conclusion of remedial activities
- The long-term reliability of engineering and/or institutional actions to provide continued protection from residuals
- The potential need to replace technical components of the alternative and the potential exposure pathway and risks posed should the remedial action need replacement

5.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This evaluation criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of hazardous substances. This evaluation focuses on the following factors for each remedial alternative:

- The treatment process(es) the alternative will employ, and the materials it will treat
- The amount of hazardous substances that will be destroyed or treated, including how the principal risk(s) will be addressed
- The degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction
- The degree to which the treatment will be irreversible
- The type and quantity of residuals that will remain following treatment
- Whether the alternative would satisfy the statutory preference for treatment as a principal element

5.1.5 Short-term Effectiveness

This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until remedial response objectives are met. The following factors should be addressed for each alternative:

- Short-term risks that may affect human health in the community during construction and implementation of an alternative
- Potential adverse impacts to workers that may result during construction and implementation, including an evaluation of the effectiveness and reliability of any protective measures that would be taken
- Potential adverse environmental impacts that may result from the construction and implementation of an alternative, including an evaluation of the reliability of available mitigation measures in preventing or reducing the potential impacts
- Estimate of the time required to achieve remedial response objectives

5.1.6 Implementability

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. The following factors are considered during analysis of this criterion:

- Technical Feasibility
  - Ability to construct and operate
  - Reliability of a technology
  - Ease of undertaking additional remedial action, if needed
  - Ability to monitor effectiveness
- Administrative Feasibility
  - Ability to obtain approvals and coordinate with other agencies
- Availability of services and materials
  - Availability of adequate offsite treatment, storage capacity, and disposal services
  - Availability of necessary equipment, specialists, and provisions
  - Availability of services and materials, including the potential for obtaining competitive bids
  - Availability of prospective technologies

5.1.7 Cost

Preliminary cost estimates were developed for each remedial alternative. These cost estimates are used to compare the alternatives, not to bid the work. These estimates were developed using available information, so they have an expected accuracy of -30 percent to +50 percent for the scope of action described for each alternative. The estimates are divided into capital costs and O&M costs (which also include LTM costs) and are based on information provided by vendors, regulators, and experience on similar projects. The present worth of the capital cost and O&M is included. Details of these cost estimates are provided included in **Appendix D**. Significant uncertainties that may affect cost are discussed for each alternative.

5.1.8 State Acceptance

This assessment relates to the technical and administrative issues and concerns the state may have regarding each of the alternatives. NCDENR will review and comment on this FS report.

5.1.9 Community Acceptance

This assessment relates to the issues and concerns the public may have regarding each of the alternatives. As with state acceptance, community concerns will be used to evaluate each remedy discusses in this FS report. Consistent with the National Contingency Plan, public comments will be solicited on the selected alternative presented in the Proposed Remedial Action Plan. Any comments will be addressed in the ROD, and will be considered in selection of the remedy.

5.2 Individual Analysis of Soil Alternatives

The following detailed analyses compare each of the four soil alternatives to the nine NCP criteria. The analyses are discussed in the following subsections and are summarized in **Tables 5-2** and **5-3.**

5.2.1 Soil Alternative 1 – No Action

Protection of Human Health and the Environment. The No Action alternative is not considered to be protective of human health or the environment. As discussed in Section 2.7, risks are assumed to be present as result of affected soils and buried waste material at Site 69. This alternative does not provide treatment, engineering, or ICs that would mitigate exposure risks to receptors and does not allow for consideration of short-term or cross-media impacts such as infiltration of contaminants into groundwater.

Compliance with ARARs. This alternative does not include any remedial actions such as land disturbing or waste handling, so it would meet action-specific ARARs. This alternative would not likely meet location-specific ARARs because COCs left in place may affect sensitive ecosystems. There are no chemical-specific ARARs for soils.

Long-term Effectiveness and Permanence. This alternative does not meet the long-term effectiveness criterion because the site risks would remain indefinitely. Because LUCs would not be put in place, there would be no mechanism to limit exposure of potential future residents and ecological receptors to affected soil and buried waste.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative would provide no reduction in toxicity, mobility, or volume. Natural biodegradation would likely occur, but at unmonitored rates and at unknown locations. Therefore, it must be assumed that no contaminants would be treated or destroyed under this alternative.

Short-term Effectiveness. There would be no remedial construction and no immediate environmental, worker, or community impacts associated with this remedy in the short-term.

Implementability and Costs. There would be no implementability concerns or costs associated with this remedy.

State and Community Acceptance. No action is not likely to be considered acceptable by the State or community.

5.2.2 Soil Alternative 2 –LUCs

Protection of Human Health and the Environment. The soil LUC alternative is considered protective of human health and the environment because it will prevent exposure to affected soil and buried waste. However, relying on LUCs alone will not prevent infiltration of precipitation through the disposal area and will not prevent any ecological exposure.

Compliance with ARARs. This alternative would not likely meet location-specific ARARs because COCs left in place may affect sensitive ecosystems. There are no chemical-specific ARARs for soils.

Long-term Effectiveness and Permanence. This alternative would meet the criteria for long-term effectiveness and permanence by preventing exposure to COCs. However the issue of infiltration and potential ecological exposure still remain.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative provides no reduction in toxicity, mobility, or volume.

Short-term Effectiveness. The short-term effectiveness of this alternative is considered acceptable because there are no construction activities that would put workers, the community, or the environment at risk. This alternative can be implemented quickly and, based on the sustainability analysis, this alternative would have minimal environmental impacts.

Implementability. This alternative is easily implementable with available services.

Costs. The total present worth cost for this alternative is $46,000, with total capital costs of $13,500 and present worth cost for O&M is $32,500.

State and Community Acceptance. This alternative is likely to be accepted by the State and community.

5.2.3 Soil Alternative 3 – Capping with LUCs

Protection of Human Health and the Environment. The soil capping alternative is considered to be protective of human health and the environment because infiltration would be significantly reduced and the potential for ecological exposure would be greatly reduced. LUCs would remain in place, preventing exposure to affected soil and buried waste, mitigating potential risks from exposure to affected media.

Compliance with ARARs. This alternative would comply with location-, and action-specific ARARs. Location- and action-specific ARARs regarding land-disturbing activities during cap construction will be complied with during each activity of this alternative. There are no chemical-specific ARARs for soils.

Long-term Effectiveness and Permanence. This alternative is expected to meet the long-term effectiveness and permanence criterion. Cap inspections and mowing/maintenance would be conducted semi-annually for 30 years.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative would reduce mobility of the COCs by significantly minimizing infiltration and transfer of contaminants from the waste disposal area into groundwater and any potential runoff. Installation will promote reduced mobility; however, no treatment would be employed to reduce toxicity or volume with this soil alternative alone.

Short-term Effectiveness. The short-term effectiveness of capping is primarily contingent on engineering controls to protect the environment, workers, and the community during implementation. Implementation would require approximately 4 months of field work. Heavy equipment would be required during the initial implementation for leveling and handling fill materials. Based on the sustainability analysis, most of the overall environmental impacts for this alternative would result from material production (high-density polyethylene liner and drainage net), equipment use, and residual handling, which would include the transportation of fill and consumables. Health and safety precautions would be required due to the possibility of MEC and CA exposure at the site.

Implementability. This alternative is technically feasible and implementable with available services and materials.

Costs. The present-worth cost of capping and LUCs is estimated to be $5,513,000. Capital costs are estimated to be $4,992,000, and present-worth cost of O&M are estimated to be $521,000.

State and Community Acceptance. This alternative is likely to be accepted by the State and community.

5.2.4 Soil Alternative 4 – Removal

Protection of Human Health and the Environment. The soil removal alternative would be considered protective of human health and the environment because the source, buried waste and affected soil, would be removed from the site entirely.

Compliance with ARARs. This alternative would comply with location-, and action-specific ARARs. Location- and action-specific ARARs regarding land-disturbing activities during removal will be complied with during this alternative. Further action regarding this alternative would be coordinated with CEHNC as a separate action due to the potential presence of CA at the site. Implementation of the removal action would be dependent on identifying a permitted disposal facility that accepts CA impacted soil. There are no chemical-specific ARARs for soils.

Long-term Effectiveness and Permanence. This alternative is expected to meet the long-term effectiveness and permanence criterion. Implementation of a removal action is a permanent remedy through removing the waste material.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative would provide complete removal of buried debris in the waste disposal area, including construction debris, hazardous waste, special waste, potential ordnance and CA. Reduction of toxicity, mobility, or volume would be achieved through removal of the source.

Short-term Effectiveness. In general, this alternative is not effective in the short term because of the risks to workers and the community from the excavation and offsite disposal of potential CA and other hazardous constituents. The short-term effectiveness of this alternative is primarily contingent on engineering controls to protect the environment, workers, and the community during removal activities. While these intrusive activities are conducted directly within the waste disposal area, the risk to site workers coming into contact with the waste materials, potentially including CA, would be at its highest. However, engineering and safety controls, including field monitoring for CA, would be in place during removal to protect site workers and the environment. In addition, health and safety precautions would be required because of the possibility of MEC at the site. The results of the sustainability assessment indicated that overall environmental impacts are associated primarily with residual handling and fill transportation. Field implementation is expected to take approximately 180 days, depending on conditions encountered in the field.

Implementability. This alternative is technically feasible, but incredibly challenging. The Navy currently does not have the capability to address intrusive activities in an area potentially containing CA. Further action is not included in the scope of this study and will be coordinated with CEHNC if this alternative is selected. There are limited disposal options if CA is encountered as there are currently no permitted CA disposal facilities.

Costs. Based on the removal cost analysis provided by CEHNC (**Appendix B**), the capital and present-worth cost is estimated to be $24,502,000. There are no operating and long-term costs associated with this alternative.

State and Community Acceptance. Due to the nature of the work and contaminants and transportation of the waste material offsite, this alternative may have some difficulty gaining state and community acceptance.

5.3 Individual Analysis of Groundwater Alternatives

The following detailed analysis compares each of the five groundwater alternatives to the nine NCP criteria. The analyses are discussed in the following subsections and are summarized in **Tables 5-4** and **5-5.**

5.3.1 Groundwater Alternative 1—No Action

Protection of Human Health and the Environment. The No Action alternative is not considered to be protective of human health or the environment. As discussed in Section 2.7, the future use scenario findings of the HHRA indicated there would be an unacceptable risk from exposure to groundwater from the surficial aquifer and upper Castle Hayne aquifer. This alternative does not provide treatment, engineering, or LUCs that would mitigate exposure risks to receptors and does not allow for consideration of short-term or cross-media impacts such as groundwater discharging to the New River.

Compliance with ARARs. This alternative does not include any remedial actions such as land disturbance, well installation, injections, or waste handling, so it would meet action-specific ARARs. This alternative would not meet location-specific ARARs because no groundwater monitoring would be completed to monitor the migration of COCs in surficial aquifer. Without monitoring the impact of the discharge of surficial aquifer to sensitive ecosystems cannot be evaluated. This alternative does not meet chemical-specific ARARs for groundwater because the concentrations exceed applicable NCGWQS or MCLs.

Long-term Effectiveness and Permanence. This alternative does not meet the long-term effectiveness criterion because the site risks would remain indefinitely. Further, because ICs would not be put in place, there would be no mechanism for limiting exposure of potential future residents and ecological receptors to contaminated groundwater. It would likely require more than 50 years for the COC concentrations to meet NCGWQS/MCL levels.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative would provide no reduction in toxicity, mobility, or volume. Natural biodegradation would likely occur, but at unmonitored rates and at unknown locations. Therefore, it must be assumed that no contaminants would be treated or destroyed under this alternative.

Short-term Effectiveness. There would be no remedial construction and no immediate environmental, worker, or community impacts associated with this remedy in the short term.

Implementability and Costs. There would be no implementability concerns or costs associated with this remedy.

State and Community Acceptance. No Action is not likely to be considered acceptable by the State or community.

5.3.2 Groundwater Alternative 2 – MNA with LUCs

Protection of Human Health and the Environment. The groundwater MNA alternative is considered protective of human health and the environment because it includes LUCs to prevent exposure to groundwater and monitoring to assess the plume stability, potential cross-media contamination, and NA of COCs. NA is progressing at the site.

Compliance with ARARs. This alternative will comply with chemical-, location-, and action-specific ARARs. Achieving chemical-specific ARARs may take an extended amount of time. Location-specific ARARs regarding a wetland or endangered species are not expected to be affected. There will be no construction to affect a wetland or endangered species habitat and groundwater containing COCs is not expected to discharge to a wetland or water body based on groundwater modeling. LTM will be conducted to evaluate compliance with the location-specific ARARs. Action-specific ARARs regarding waste handling will be complied with during each activity of this alternative.

Long-term Effectiveness and Permanence. This alternative would eventually meet the long-term effectiveness and permanence criterion. However, because of the relatively high contaminant concentrations, groundwater concentrations are expected to remain above NCGWQS in the source area for an extended period of time. LUCs would restrict usage of groundwater until NCGWQS are achieved. This alternative would be assessed every 5 years for protectiveness.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative employs natural processes (biodegradation, adsorption, etc.) as a treatment, so reduction of toxicity, mobility, or volume of the plume would be a prolonged process. Evidence suggests NA is currently occurring at Site 69 in the surficial, upper Castle Hayne, and middle Castle Hayne aquifers.

Short-term Effectiveness. This alternative does not include any initial construction activities that would put the environment, workers, or the community at risk. However, based on the sustainability analysis, transportation of personnel to and from the site for annual monitoring account for the environmental impacts and worker risk associated with this alternative. This alternative could be implemented quickly.

Implementability. This alternative is technically feasible and easily implementable with available services and materials. The existing well network is sufficient for MNA.

Costs. The total 30-year present-worth cost for this alternative is estimated to be $957,000. Capital costs associated with this alternative include LUC implementation activities, and annual costs are driven by LTM costs. The capital cost for this alternative is estimated to be $22,000 and the present-worth LTM cost is estimated to be $935,000.

State and Community Acceptance. This alternative is likely to be accepted by the State and community.

5.3.3 Groundwater Alternative 3 - PRB with MNA and LUCs

Protection of Human Health and the Environment. A groundwater PRB with MNA and LUCs alternative is considered protective of human health and the environment through promotion of VOC degradation within groundwater and reducing plume migration towards the New River. Groundwater contamination would be reduced through active treatment with the groundwater flow through the PRB. LUCs would remain in place until RAOs have been met, mitigating potential human health risks from exposure to affected media.

Compliance with ARARs. This alternative will comply with chemical-, location-, and action-specific ARARs. Chemical-specific ARARs will be achieved through reduction of COCs via treatment by the PRB and NA processes. Compliance with location-specific ARARs regarding construction within or potentially affecting a wetland or endangered species habitat will be achieved through substantive compliance with the regulations and implementation of an erosion control plan. Groundwater containing COCs is not expected to discharge to a wetland or water body based on groundwater modeling. LTM will be conducted to evaluate compliance with the

location-specific ARARs. Action-specific ARARs regarding land-disturbing activities during PRB construction and waste handling will be complied with during each activity of this alternative.

Long-term Effectiveness and Permanence. This alternative is considered to meet long-term effectiveness and permanence if LUCs are in place and groundwater is monitored to ensure that the plume is attenuating and not migrating. The PRB requires little to no active maintenance, and a review of the alternative would be conducted at least every 5 years.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative would reduce toxicity, mobility, and volume of the contaminant plume by treating groundwater flowing through the PRB. Introduction of ZVI promotes abiotic degradation of chlorinated compounds.

Short-term Effectiveness. The short-term effectiveness of the PRB is primarily contingent on engineering controls to protect the environment, workers, and the community during implementation. The duration of field work associated with the installation this deep ZVI barrier is expected to be approximately 100 days. Heavy equipment would be required during the initial implementation and handling the ZVI injections. Based on the sustainability analysis, most of the overall environmental impacts for this alternative result from equipment use and consumables (ZVI) during the construction of the PRB.

Implementability. This alternative is technically feasible and implementable with available services and materials. The number of companies specializing in deep and trenchless PRB installation is limited, but an appropriate vendor is located within the region. The overall depth of the PRB is achievable with vertical hydrofracturing technology.

Costs. The present-worth cost of the PRB with MNA and LUCs is estimated to be $6,204,000. Capital costs are estimated to be $5,100,000 and the present-worth cost of monitoring is $1,104,000.

State and Community Acceptance. This alternative is likely to be accepted by the State and community.

5.3.4 Groundwater Alternatives 4a and 4b—ERD with Bioaugmentation, MNA, and LUCs

Protection of Human Health and the Environment. The groundwater ERD with bioaugmentation, MNA, and LUCs alternatives are considered protective of human health and the environment because groundwater contamination would be reduced within the target area by promoting biological degradation of COCs. LUCs would remain in place until RAOs have been met, mitigating potential human health risks from exposure to affected media.

Compliance with ARARs. These alternatives would comply with chemical-specific ARARs by reducing the concentrations of COCs through active bioremediation. There will be no construction to affect a wetland or endangered species habitat and groundwater containing COCs is not expected to discharge to a wetland or water body based on groundwater modeling. LTM will be conducted to evaluate compliance with the location-specific ARARs. Action-specific ARARs regarding land-disturbing activities during well construction and waste handling will be complied with during each activity of this alternative.

Long-term Effectiveness and Permanence. These alternatives are expected to meet the long-term effectiveness and permanence criterion. However, with injection technologies, there is a possibility of rebound. Rebound occurs when contaminants are treated in readily accessed flow paths but residual contaminants are left behind either sorbed to the soil or trapped in less transmissive zones. After active treatment is complete, the residual contaminants re-enter the aquifer through diffusion and dissolution. Additional substrate injection may be required based on performance monitoring results. The permanent risk reduction depends on the time required for biodegradation of VOCs. A review of the alternative would be conducted at least every 5 years for 30 years. In addition, LUCs would be reviewed with CEHNC so that sufficient controls are selected due to the potential presence of CA at the site and maintained until remedial goals are achieved.

Reduction of Toxicity, Mobility, or Volume through Treatment. These alternatives are expected to reduce toxicity, mobility, or volume of the COCs in groundwater through stimulation of biological degradation of

contaminants. With biological degradation, there is a possibility that degradation might stall and daughter products such as DCE and VC may accumulate. Monitoring of biological populations and bioaugmentation (addition of suitable microbial populations into the system) are included to prevent stalling of the degradation process.

Short-term Effectiveness. The short-term effectiveness of these alternatives are primarily contingent on engineering controls to protect the environment, workers, and the community during well installation and ERD substrate injection activities. This alternative poses few to no risks to site workers if they come into contact with the ERD substrate or biological culture during injections. However, during injection and extraction (Alternative 4a), there is a potential for workers to come into contact with site groundwater, so engineering and safety controls would be in place to protect site workers and the environment. The results of the sustainability assessment indicated the overall environmental impacts are primarily associated with equipment use during remedial construction, including well installation; during remedial operation, including consumables (ERD substrate) and equipment use; and during LTM by transportation of personnel and residual handling. Installation of wells for the vertical injection/extraction, Alternative 4a, is expected to take approximately 12 days, with two injection events taking approximately 6 weeks per event. Installation of wells for the horizontal wells, Alternative 4b, is expected to take approximately 48 days, with three injection events taking approximately 7 days per event. The vertical injection/extraction well and horizontal well alternatives, spaced wells and injection events, to maximize distribution of the substrate throughout the target area while avoiding intrusive activities within the waste disposal area.

Implementability. This alternative is technically challenging, but is implementable with available services and materials. One of the primary factors in any injection technology is distribution within the contaminated media. Potential issues that may affect distribution of the ERD substrate include biofouling of the well screens over time, as well as effectively capturing the treated groundwater mass for extraction because of the distance between wells in the vertical injection and extraction wells (Alternative 4a) approach. The vertical injection/extraction wells, Alternative 4a, poses the additional challenge of managing water ex-situ.

Costs. For the vertical injection and extraction well approach (Alternative 4a), the present-worth cost is estimated to be $2,630,000, with a capital cost of $1,526,000 and a present-worth monitoring cost of $1,104,000.

For the horizontal well approach (Alternative 4b), the present-worth cost is estimated to be $4,839,000, with a capital cost of $3,735,000 and a present-worth monitoring cost of $1,104,000.

State and Community Acceptance. This alternative is expected to be acceptable to the State and community.

5.3.5 Groundwater Alternative 5—ISCO with MNA and LUCs

Protection of Human Health and the Environment. The groundwater ISCO with MNA and LUCs alternative is considered protective of human health and the environment because groundwater contamination would be oxidized to innocuous compounds, thereby reducing plume migration towards the New River. LUCs would remain in place until RAOs have been met, mitigating potential human health risks from exposure to affected media.

Compliance with ARARs. This alternative would comply with chemical-specific ARARs by reducing the concentrations of COCs through chemical oxidation. There will be no construction to affect a wetland or endangered species habitat and groundwater containing COCs is not expected to discharge to a wetland or water body based on groundwater modeling. LTM will be conducted to evaluate compliance with the location-specific ARARs. Action-specific ARARs regarding land-disturbing activities during well construction and waste handling will be complied with during each activity of this alternative.

Long-term Effectiveness and Permanence. This alternative is expected to meet the long-term effectiveness and permanence criterion. However, with injection technologies, there is a possibility of rebound, as discussed in Section 5.3.4. Re-injection of the oxidant may be required based on performance monitoring results. The permanent risk reduction timeline is considered immediate upon contact with contaminants in groundwater and depends on NA processes outside of the treatment area. A review of the alternative would be conducted at least every 5 years for 30 years.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative is expected to permanently reduce the toxicity, mobility, and volume of COCs within groundwater through permanent oxidation of chemicals into innocuous compounds.

Short-term Effectiveness. The short-term effectiveness of this alternative is contingent on engineering controls to protect the environment, workers, and the community during implementation. Sodium permanganate is a strong oxidizer and poses risks to site workers during injection. However, assuming appropriate PPE is worn at all times by workers, sodium permanganate can be safely handled and injected by workers in the field, and potential reaction with the buried waste is reduced by injecting at depths below the disposal trenches. Engineering controls would be required to protect the environment from spills. Additional risks to worker safety include operating drill rigs to install the injection wells and exposure to COCs from residuals handling. The results of the sustainability assessment indicate that the overall environmental impacts are primarily associated with consumables (ISCO injectant) during remedial operation, and equipment use during remedial construction and operation. Installation of horizontal wells is expected to take approximately 48 days, with two injection events taking approximately 40 days per event.

Implementability. This alternative is technically challenging but implementable with available services and materials. One of the primary factors in any injection technology is distribution within the contaminated media. The horizontal well placement and injection event spacing were chosen to maximize distribution of the substrate throughout the target area.

Costs. For the horizontal well injection approach, the present-worth cost is estimated to be $7,613,000 with a capital cost of $6,509,000 and a present-worth monitoring cost of $1,104,000. The annual O&M cost is primarily for groundwater monitoring and reporting. It should be noted that more injections may be required due to rebound.

State and Community Acceptance. This alternative is expected to be acceptable to the State and community.

5.4 Comparative Analysis of Alternatives

In the following subsections, all of the alternatives are compared using the nine NCP criteria and the SiteWise™ sustainability model. The comparative analyses presented below are summarized in **Tables 5-1** and **5-3** for soil and groundwater, respectively.

5.4.1 Overall Protection of Human Health and the Environment

5.4.1.1. Soil

Soil Alternatives 3 and 4 are suitable for addressing buried waste and affected soil for the reduction of risk to human and ecological risk receptors, and provide an active approach to meet the RAOs. Alternative 3 is the most protective of human health and the environment as it controls the exposure to the buried waste and minimizes leaching of contaminants to groundwater.

5.4.1.2. Groundwater

All of the groundwater alternatives screened, with the exception of Alternative 1 (No Action), can achieve the RAOs specified in Section 3.2.

Groundwater Alternatives 2 through 5 are suitable for treatment of groundwater contaminated with chlorinated solvents and for the reduction of risk to human and ecological risk receptors. Groundwater Alternatives 3, 4, and 5 provide active treatment to meet the RAOs. Alternative 3 is likely the best option as it is protective of human health and the environment, easily implementable and less expensive than Alternative 5. Alternative 4a is the least expensive active treatment option, however, it provides potential issues with short-term and long-term ineffectiveness due to groundwater extraction capabilities. No alternative will permanently reduce the risks as long as the contaminant source area remains intact.

5.4.2 Compliance with ARARs

5.4.2.1. Soil

All soil alternatives, except No Action and Alternative 2, are expected to meet ARARs.

5.4.2.2. Groundwater

All groundwater alternatives, except the No Action alternative, are expected to meet ARARs. Groundwater Alternatives 2 through 5 are suitable for treatment of groundwater contaminated with chlorinated solvents and for reducing the risk to human and ecological risk receptors. Groundwater Alternatives 3, 4, and 5 provide active treatment to meet RAOs.

5.4.3 Long-term Effectiveness and Permanence

5.4.3.1. Soil

Alternatives 3 and 4 are expected to be effective at reducing impacts of COCs in the long term. Alternative 4 will provide the most immediate solution for long-term effectiveness. Alternatives 2 and 3 are considered to meet permanence goals by maintaining LUCs over time when paired with a groundwater alternative. Alternative 4 would be a permanent remedy by effectively removing the source. No long term GHG or criteria pollutant emissions are expected with any of the alternatives.

5.4.3.2. Groundwater

Alternatives 2 through 5 are expected to be effective in the long term, although “rebound” is a potential issue with any injection scenario. Active treatment is intended to treat the area of the plume with the highest concentrations of COCs and allow NA to reduce groundwater contaminant concentrations preventing migration towards the New River. Alternative 2 would take the longest time to achieve RAOs without active treatment. Alternative 3 would take the longest of the active treatment alternatives because it relies on the plume to flow through the PRB, but is protective to downgradient receptors. Alternative 4 relies on biological degradation rather than chemical or physical processes to remove contaminant mass, taking longer than Alternative 5, which would likely remove COCs the fastest. Distribution and rebound may hinder the effectiveness of ERD and ISCO. The majority of the long term GHG or criteria pollutant emissions are related to LTM which is included in each of the alternatives, with the exception of Alternative 1, No Action.

5.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

5.4.4.1. Soil

Treatment is not involved with Alternative 2, so there would be no reduction in the toxicity, mobility, or volume of COCs. Alternative 3 would reduce mobility through minimized infiltration; however, no treatment is involved to reduce toxicity or volume. Reduction of toxicity, mobility, or volume would be achieved with Alternative 4.

5.4.4.2. Groundwater

Alternative 5 will quickly reduce the toxicity and volume of the plume, while under Alternative 4 toxicity, mobility, and volume will be reduced at a relatively slower rate. Toxicity, mobility, and volume will be reduced outside of the source area with Alternative 3 as the plume migrates. Alternative 2 provides reduction in toxicity, mobility, or volume. Under Alternative 1, natural biodegradation will occur at unmonitored rates and at unknown locations; therefore, it must be assumed that no contaminants are treated or destroyed.

5.4.5 Short-term Effectiveness

5.4.5.1. Soil

Short-term effectiveness in terms of risks to workers, the community, and the environment are minimized for Alternative 2, LUCs. Alternatives 3, Capping, and 4, Removal, pose an elevated risk to workers through the use of heavy equipment and significant soil movement, and Alternative 4 would also pose potential risk of exposure to CA and MEC. These risks would be minimized through the use of safety controls, appropriate PPE, and air monitoring. The duration of short-term exposure risk associated with implementing Alternative 3, Capping, is expected to be approximately 5 months. Alternative 4 would present the greatest short-term risk to workers and the community near the disposal transportation route and the environment due to the nature of materials

potentially disposed of at the site; however, it also would exhibit the shortest remediation timeline while effectively addressing the source. The duration of short-term exposure risk associated with implementing Alternative 4, Removal, is expected to be approximately 6 months.

The generation of GHGs and criteria pollutants are the highest for the Alternative 4, Removal, followed by Alternative 3, Capping, and are mostly a result of the amount of construction activities required to implement each of the alternatives. Similarly, Alternative 4, Removal, has the highest energy and water usage followed by Alternative 3, Capping, also related to the amount of construction activities. Alternative 2, LUCs, had the lowest overall relative environmental impacts for the viable soil alternatives. A summary of the relative rankings for the sustainability metrics related to the short term effectiveness criteria is provided in **Table 5-6** below.

TABLE 5-6
Soil Alternative Relative Rankings
Operable Unit No. 14 (Site 69) Feasibility Study
Marine Corps Base Camp Lejeune, North Carolina

Alternative	GHG	Energy Use	Water Use	NO_x	SO_x	PM_{10}	Accident Risk Fatality	Accident Risk Injury	Overall Rank
Alternative 1 No Action	0	0	0	0	0	0	0	0	0
Alternative 2 LUCs	1	1	1	1	1	1	1	1	1
Alternative 3 Capping and LUCs	2	2	2	2	2	2	2	2	2
Alternative 4 Removal	3	3	3	3	3	3	3	3	3

5.4.5.2. Groundwater

Short-term effectiveness in terms of risks to workers, the community, and the environment is minimized for groundwater alternatives 2 through 5 (MNA, PRB, ERD, and ISCO; respectively) through the use of appropriate PPE and air monitoring. The duration of short-term exposure risk associated with implementing alternatives 3 through 5 ranges from approximately 100 days for alternative 3, PRB, to 3 years for alternative 4 , ERD. Alternative 5 has a higher short-term risk because of the use of oxidants. Alternatives 4 and 5 are most likely to achieve RAOs in the shortest period of time because of enhanced distribution of relatively fast acting reagents, particularly chemical oxidation. Subsurface distribution is key to the effectiveness and treatment time-frame of alternatives 4 and 5 (microbes, ERD substrate or oxidant). The time frame associated with complete dechlorination via bioremediation can be many years. Alternative 2 likely would exhibit the least short-term effectiveness because the remediation timeline would be dictated by the rate of natural biodegradation, and Alternative 3 would be limited because it relies on groundwater to flow through the PRB as it migrates towards the New River.

Alternative 3 had the highest GHG emissions, energy use, criteria pollutant emissions, and the highest accident risk for injury and fatality. Alternative 5, ISCO, had the highest relative water use, driven by water requirements during injections. The ERD alternatives, 4a and 4b, had similar overall environmental impacts which were slightly lower than Alternative 5, ISCO. Alternative 2, MNA, had the lowest overall relative impacts for the viable groundwater alternatives. A summary of the relative rankings for the sustainability metrics related to the short term effectiveness criteria is provided in **Table 5-7** below.

TABLE 5-7
Groundwater Alternative Relative Rankings
Operable Unit No. 14 (Site 69) Feasibility Study
Marine Corps Base Camp Lejeune, North Carolina

Alternative	GHG	Energy Use	Water Use	NO_x	SO_x	PM_{10}	Accident Risk Fatality	Accident Risk Injury	Overall Rank
Alternative 1 No Action	0	0	0	0	0	0	0	0	0
Alternative 2 MNA	1	1	1	1	1	1	1	1	1
Alternative 3 PRB with MNA and LUCs	5	5	2	5	5	5	5	5	5
Alternative 4a ERD with Bioaugmentation MNA and LUCs Vertical Injection/Extraction Wells	2	2	3	2	2	2	2	2	2
Alternative 4b ERD with Bioaugmentation MNA and LUCs Horizontal Wells	3	3	4	3	3	3	3	3	3
Alternative 5 ISCO	4	4	5	4	4	4	4	4	4

5.4.6 Implementability

5.4.6.1. Soil

Each alternative is implementable, with materials and services readily available. The potential presence of CA at the site requires extra health and safety precautions as well, making Alternative 4 the most difficult to implement. Additionally, there are no permitted disposal facilities that will accept CA impacted soil. Further action regarding Alternative 4 would require substantial interagency coordination with CEHNC.

5.4.6.2. Groundwater

Each alternative is implementable, with materials and services readily available. However, subsurface injections rely heavily on the ability to distribute reagents uniformly at acceptable quantities. In Alternative 4, injection through vertical injection and extraction wells (Alternative 4a) would be more difficult to implement than injection through horizontal wells (Alternative 4b). Further, implementation of a trenchless PRB would be easier than injections through horizontal wells. ISCO (Alternative 5) would require extra health and safety precautions for the handling of the oxidant. Alternatives 4 and 5 would involve installation of 20 injection/extraction wells or 5,600 linear ft of horizontal wells.

5.4.7 Cost

Tables 5-3 and **5-5** summarize the direct and indirect capital costs, as well as long-term O&M costs (as applicable) for the alternatives. The detailed cost estimates are provided in **Appendix D**.

5.4.7.1. Soil

The estimated present-worth cost of soil Alternative 2 is $46,000. The estimated present-worth cost of Alternative 3 is $5,513,000, which is approximately 20 percent of the cost of Alternative 4, estimated at $24,502,000.

5.4.7.2. Groundwater

The estimated present-worth cost of groundwater Alternative 2 is $957,000. The estimated present-worth cost of Alternative 3 is $6,204,000, which is more than two times the cost of Alternative 4a ($2,630,000) and approximately 20 percent more than Alternative 4b ($4,839,000). Alternative 5 ($7,613,000) is the most expensive of the groundwater alternatives.

5.4.8 State Acceptance

5.4.8.1. Soil

State acceptance is likely for all soil alternatives, except for No Action and Alternative 2.

5.4.8.2. Groundwater

State acceptance is likely for all groundwater alternatives, except for the No Action Alternative.

5.4.9 Community Acceptance

5.4.9.1. Soil

Community acceptance is likely for all soil alternatives, except for the No Action Alternative and possibly the Removal Action Alternative.

5.4.9.2. Groundwater

Community acceptance is likely for all groundwater alternatives, except for the No Action Alternative.

TABLE 5-1

NCP Criteria and Sustainability Metrics

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

NCP Critieria	Subcriteria	Sustainability Metrics					
		Energey Consumption	GHG Emissions	Criteria Pollutants Emission	Resource Consumption	Worker Impact	Community Impacts
Protection of Human Health and the Environment	Protection of Human Health and Environment						
Compliance with ARARs	Compliance with ARARs						
	Compliance with Chemical-Specific ARARs						
	Compliance with Action-Specific ARARs						
	Compliance with Location-Specific ARARs						
	Compliance with other criteria, advisories, and guidance						
	Long-Term Effectiveness and Permanence						
Long-Term Effectiveness and Permanence	Magnitude of Residual Risk		E	E			
	Adequacy and reliability of controls						
Reduction in Toxicity, Mobility, and Volume	Treatment Process used and materials treated						
	Amount of Hazardous materials destroyed or treated						
	Degree of Expected Reductions in Toxicity, Mobility, and Volume						
	Degree of which treatment is irreversible						
	Type and Quantity of Residual Remaining After Remedial Action						
Short-Term Effectiveness	Protection of Community During Remedial Action						A
	Protection of Workers During Remedial Action					B	
	Environmental Impacts	F	E	D	C		
	Time until RAOs are achieved						
Implementability	Ability to construct and operate the Technology						
	Reliability of the Technology						
	Ease of undertaking additional remedial actions, if necessary						
	Ability to Monitor Effectiveness of Remedy						
	Ability to obtain approvals from other agencies						
	Coordination with other agencies						
	Availability of offsite treatment, storage, and disposal services and capacity						
	Availability of necessary equipment and specialists						
	Availability of Prospective Technologies						
Cost	Capital Costs						
	Operating and Maintenance Costs						
	Present Worth Costs						

Legend:
A - Compliments NCP criteria but also addresses risks to community in terms of potential for injury or fatality associated with traffic
B - Compliments NCP criteria but also addresses potential for injury or fatality associated with total hours worked
C - Use of non-renewable energy (coal for power requirements [fuel])
D - Impacts associated with release of VOCs to the atmosphere
E - Some emissions persist only in the short term; others last for decades and may persist after RAOs have been achieved
F - Environmental impacts associated with energy extraction from earth resources

TABLE 5-2

Summary of Soil Remedial Alternatives Evaluated Against the Nine Criteria

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Land Use Controls	Alternative 3 Capping with LUCs	Alternative 4 Removal
Overall Protection of Human Health and the Environment	Will not meet RAOs. Human health risks associated with potential receptors and the potential future use of land for industrial or residential uses.	Will meet RAOs for human receptors by preventing exposure to impacted soil and buried waste. Will not meet RAOs for ecological receptors.	Will meet RAOs by reducing groundwater recharge through infiltration and preventing exposure to impacted soil and buried waste.	Will meet RAOs by removing impacted soil and buried waste from the waste disposal area.
Compliance with ARARs	Does not comply with location-specific ARARs.	Does not comply with location-specific ARARs.	Complies with ARARs.	Complies with ARARs.
Long-term Effectiveness and Permanence	Will not reduce risk; therefore, is not effective in the long term. Additionally, no mechanism is in place to limit exposure of potential receptors to impacted soil or disposed waste at the site.	Permanent risk reduction is possible by maintaining land use controls over time; however, is not effective at reducing impacts of COCs.	Permanent risk reduction is possible by maintaining land use controls over time, and would reduce migration of COCs through reduced infiltration.	A permanent remedy is possible by removing the waste material.
Reduction of Toxicity, Mobility or Volume Through Treatment	No treatment is involved, so it does not meet this criterion.	No treatment is involved, so it does not meet this criterion.	Reduces mobility through reduced infiltration. No treatment is involved to reduce toxicity or volume.	Reduces toxicity, mobility, or volume through removal of the waste disposal area.
Short-term Effectiveness	No short-term impacts because nothing is implemented.	Will minimize or prevent exposure to affected media by limiting site activities.	Requires engineering controls during construction to protect the environment, and safety controls to protect workers.	Removal would provide the fastest contaminant reduction in the waste disposal area. Worker and community safety is an issue due to the nature of materials potentially disposed of at the site.
Implementability	No construction or operation.	No construction. Services are available to update and maintain control documentation.	Services and materials are available; and the technology is easily implementable. Health and safety precautions would be required due to the possibility of MEC at the Site.	Services and materials are available. Intrusive activity into the waste disposal area provides additional challenges during implementation. Health and safety precautions would be required due to the potential presence of MEC and chemical agent at the site.
Cost	$0	$46,000	$5,513,000	$24,502,000
State Acceptance	This alternative is not likely to be accepted by the state.	This alternative is likely to be accepted by the state environmental regulators.	This alternative is likely to be accepted by the state environmental regulators.	This alternative is likely to be accepted by the state environmental regulators.
Community Acceptance	This alternative is not likely to be accepted by the community.	This alternative is likely to be accepted by the community.	This alternative is likely to be accepted by the community.	Due to the nature of the work and contaminants, this alternative may have some difficulty gaining community acceptance.

TABLE 5-3

Summary of Cost Analysis - Soil

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North

General Response Action	Soil Alternative 2 LUCs			Soil Alternative 3 Capping - RCRA Subtitle C[a]			Soil Alternative 4 Removal		
	-30%	Estimate	+50%	-30%	Estimate	+50%	-30%	Estimate	+50%
Total Capital Costs	**$9,450**	**$13,500**	**$20,250**	**$3,494,243**	**$4,991,775**	**$7,487,663**	**$17,151,059**	**$24,501,512**	**$36,752,269**
Subsequent Years' Costs	$22,804	**$32,578**	$48,867	$364,871	$521,244	$781,867	$0	$0	$0
Total Present Worth Costs	**$32,254**	**$46,078**	**$69,117**	**$3,859,114**	**$5,513,019**	**$8,269,529**	**$17,151,059**	**$24,501,512**	**$36,752,269**

[a] Includes 4.5% discount rate

TABLE 5-4

Summary of Groundwater Remedial Alternatives Evaluated Against the Nine Criteria

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Monitored Natural Attenuation with LUCs	Alternative 3 Permeable Reactive Barrier with MNA and LUCs	Alternative 4 Enhanced Reductive Dechlorination[ab] with Bioaugmentation, MNA, and LUCs	Alternative 5 In Situ Chemical Oxidation[b] with MNA and LUCs
Overall Protection of Human Health and the Environment	Will not meet RAOs. Human health risks associated with potential receptors and the potential future use of groundwater as a potable source.	Will eventually meet RAOs. Prolonged period of time required to meet RAOs due to reliance on natural processes.	Will meet RAOs by promoting degradation of VOCs and reducing plume migration towards the New River.	Will meet RAOs by promoting reductive dechlorination within the target area and reduce plume migration towards the New River.	Will meet RAOs via oxidation of VOCs within the target area and reduce plume migration towards the New River.
Compliance with ARARs	Does not comply with chemical-specific or location-specific ARARs.	Complies with ARARs.	Complies with ARARs.	Complies with ARARs.	Complies with ARARs.
Long-term Effectiveness and Permanence	Will not reduce risk; therefore, is not effective in the long term. Additionally, no mechanism is in place to monitor (1) attenuation of VOCs and (2) potential migration of plume into deeper aquifers and the New River.	Expected to be an effective remedy for treatment of groundwater if land use controls are in place and groundwater is monitored to ensure that the plume is not migrating. Permanent risk reduction is not possible since the waste disposal area will remain intact and due to this continuous source, monitoring would need to be conducted for an indefinite amount of time.	Expected to be an effective treatment of migrating groundwater contaminated with chlorinated solvents if land use controls are in place and groundwater is monitored to ensure that the plume is attenuating and not migrating. Permanent risk reduction is not possible since the waste disposal area will remain intact, requiring continued monitoring.	Expected to be an effective remedy for treatment of chlorinated solvent impacted groundwater if land use controls are in place and groundwater is monitored to ensure the plume is attenuating and not migrating. Permanent risk reduction is not possible since the waste disposal area will remain intact, requiring continued monitoring.	Expected to be an effective remedy for treatment of groundwater contaminated with VOCs if land use controls are in place and the groundwater is monitored to ensure the plume is attenuating and not migrating. Permanent risk reduction is not possible since the waste disposal area will remain intact, requiring continued monitoring.
Reduction of Toxicity, Mobility or Volume Through Treatment	No treatment is involved, so it does not meet this criterion.	Reduces toxicity, mobility, and volume over a prolonged period of time by naturally degrading contaminants.	Reduces toxicity, mobility, or volume through degradation of migrating VOCs through abiotic dehalogenation.	Reduces toxicity, mobility, or volume through promotion of biologically mediated reductive dechlorination.	Reduces toxicity, mobility, or volume through chemical oxidation of dissolved phase VOCs to carbon dioxide, water and chloride.
Short-term Effectiveness	No short-term impacts because nothing is implemented.	Monitoring and land use controls would be required during the duration of remediation.	Requires engineering controls during construction to protect environment, and safety controls to protect workers. Monitoring would be required during the duration of remediation.	Requires engineering controls during injection to protect environment, and safety controls to protect workers. Monitoring would be required during the duration of remediation.	Chemical oxidation is a relatively fast process with high contaminant reduction expected in the treatment area over short duration. Monitoring would be required during the duration of remediation. Safety controls required due to the use of oxidants and corrosive materials to protect worker safety. Potential issue of introduced oxidants causing explosive conditions with potential buried waste.
Implementability	No construction or operation.	Services and materials are available; and the technology is easily implementable.	Services and materials are available; the technology required is easily implementable but requires specialized equipment available through a limited number of companies.	This alternative is technically challenging, but easily implementable with available services and materials. Substrate distribution issues are possible with any injection technology. Distance between the injection and extraction wells provides an additional challenge with the vertical well alternative[a].	This alternative is technically challenging, but easily implementable with available services and materials. Substrate distribution issues are possible with any injection technology. Health and safety precautions would be required handling the oxidant.
Cost	$0	$957,000	$6,204,000	$2,630,000[a] $4,839,000[b]	$7,613,000[b]
State Acceptance	This alternative is not likely to be accepted by the state.	This alternative is likely to be accepted by the state environmental regulators.	This alternative is likely to be accepted by the state environmental regulators.	This alternative is likely to be accepted by the state environmental regulators.	This alternative is likely to be accepted by the state environmental regulators.
Community Acceptance	This alternative is not likely to be accepted by the community.	This alternative is likely to be accepted by the community.	This alternative is likely to be accepted by the community.	This alternative is likely to be accepted by the community.	This alternative is likely to be accepted by the community.

Notes:

No groundwater alternative will achieve permanence with the source still in place.

[a] Vertical well alternative

[b] Horizontal well alternative

TABLE 5-5

Summary of Cost Analysis - Groundwater

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North

General Response Action	Groundwater Alternative 2 MNA[a]			Groundwater Alternative 3 Permeable Reactive Barrier[a]			Groundwater Alternative 4a Enhanced Reductive Dechlorinization with Bioaugmentation - Vertical Injection/Extraction Wells[a]			Groundwater Alternative 4b Enhanced Reductive Dechlorinization with Bioaugmentation - Horizontal Injection Wells[a]			Groundwater Alternative 5 In Situ Chemical Oxidation[a]		
	-30%	Estimate	+50%	-30%	Estimate	+50%	-30%	Estimate	+50%	-30%	Estimate	+50%	-30%	Estimate	+50%
Total Capital Costs	**$15,435**	**$22,050**	**$33,075**	**$3,570,116**	**$5,100,165**	**$7,650,248**	**$1,068,133**	**$1,525,905**	**$2,288,857**	**$2,614,757**	**$3,735,367**	**$5,603,050**	**$4,556,302**	**$6,509,003**	**$9,763,504**
Subsequent Years' Costs	$654,282	$934,689	$1,402,033	$772,974	$1,104,248	$1,656,372	$772,974	$1,104,248	$1,656,372	$772,974	$1,104,248	$1,656,372	$772,974	$1,104,248	$1,656,372
Total Present Worth Costs[b]	**$669,717**	**$956,739**	**$1,435,108**	**$4,343,089**	**$6,204,413**	**$9,306,619**	**$1,841,107**	**$2,630,153**	**$3,945,229**	**$3,387,730**	**$4,839,615**	**$7,259,422**	**$5,329,276**	**$7,613,251**	**$11,419,876**

[a] Includes 30 years GW monitoring

[b] Includes 4.5% discount rate

SECTION 6

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Appendix A
Historical Results Reference

microbialinsights

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Fax:

Identifier: 043HC **Date Rec:** 03/19/2010 **Report Date:** 03/26/2010

Client Project #: **Client Project Name:** CTO-081

Purchase Order #:

Analysis Requested: mRNA

Reviewed By:

Anita Biernacki

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MICROBIAL INSIGHTS, INC.

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Tel. (865) 573-8188 Fax. (865) 573-8133

mRNA

Client: **CH2M HILL**
Project: CTO-081

MI Project Number: **043HC**
Date Received: 03/19/2010

Sample Information

Client Sample ID:		**IR69-GW15IW-10A**	**IR69-GW27IW-10A**	**IR69-GW27DW-10A**	**IR69-GW11IW-10A**	**IR69-GW15DW-10A**
Sample Date:		03/18/2010	03/18/2010	03/18/2010	03/18/2010	03/18/2010
Units:		gene copies/mL	gene copies/mL	gene copies/mL	gene copies/mL	gene copies/mL
Analyst:		CT	CT	CT	CT	CT
Dechlorinating Bacteria						
Dehalococcoides spp.	DHC	**3.01E+05**	**3.20E+00**	**1.01E+01**	**7.00E-01**	**3.00E-01 (J)**
Desulfuromonas spp.	DSM	**2.94E+01**	<1.00E+00	**2.57E+01**	**1.00E+00 (J)**	**7.29E+03**
Dehalobacter spp.	DHB	**3.40E+01**	**4.40E+00**	**6.90E+00**	**6.50E+00**	**1.69E+01**
Desulfitobacterium spp.	DSB	**7.01E+05**	**4.44E+06**	**7.80E+04**	**3.21E+05**	**2.73E+05**
Functional Genes						
Toluene Dioxygenase	TOD	<1.00E+00	<1.00E+00	<1.00E+00	<1.00E+00	<1.00E+00
Phylogenetic Group						
Methane Oxidizing Bacteria	MOB	<1.00E+00	<1.00E+00	<1.00E+00	<1.00E+00	<1.00E+00

Legend:
NA = Not Analyzed NS = Not Sampled J = Estimated gene copies below PQL but above LQL I = Inhibited
< = Result not detected

microbialinsights

2340 Stock Creek Blvd.
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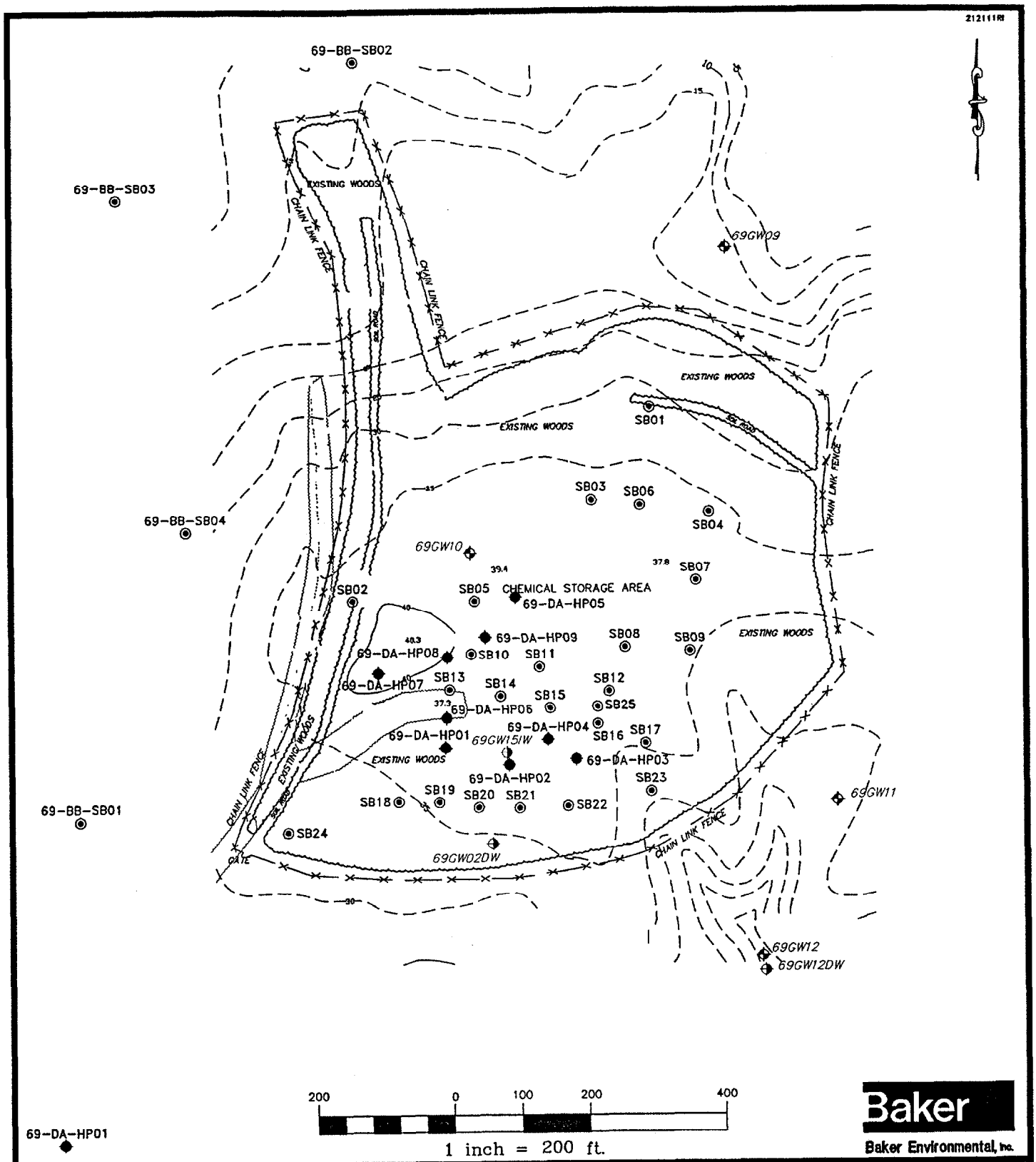
Phone: (865) 573-8188
Fax: (865) 573-8133
Email: info@microbe.com

Identifier: 043HC **Date Rec:** 03/19/2010 **Report Date:** 03/26/2010

Client Project #: **Client Project Name:** CTO-081

Purchase Order #:

Comments:

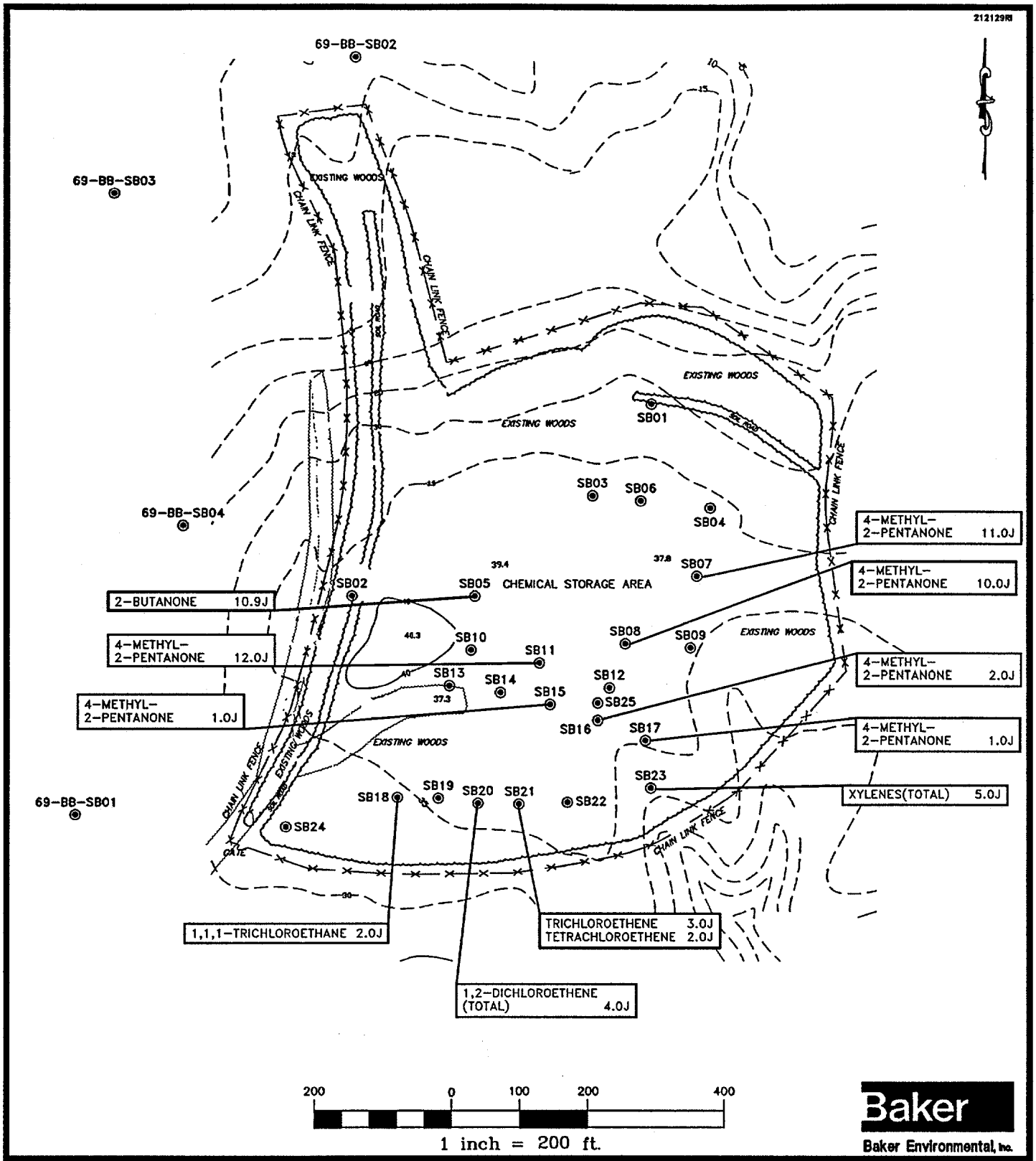


LEGEND

- 69GW9 — SHALLOW MONITORING WELL LOCATION
- 69GW02DW — DEEP MONITORING WELL LOCATION
- SB01 — SURFACE SOIL SAMPLING LOCATION
- 69-DA-HP01 — HYDROPUNCH LOCATION
- FENCE
- VEGETATION
- TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 2-8
SURFACE AND SUBSURFACE SOIL SAMPLING LOCATIONS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

SB01 SURFACE SOIL SAMPLING LOCATION

FENCE

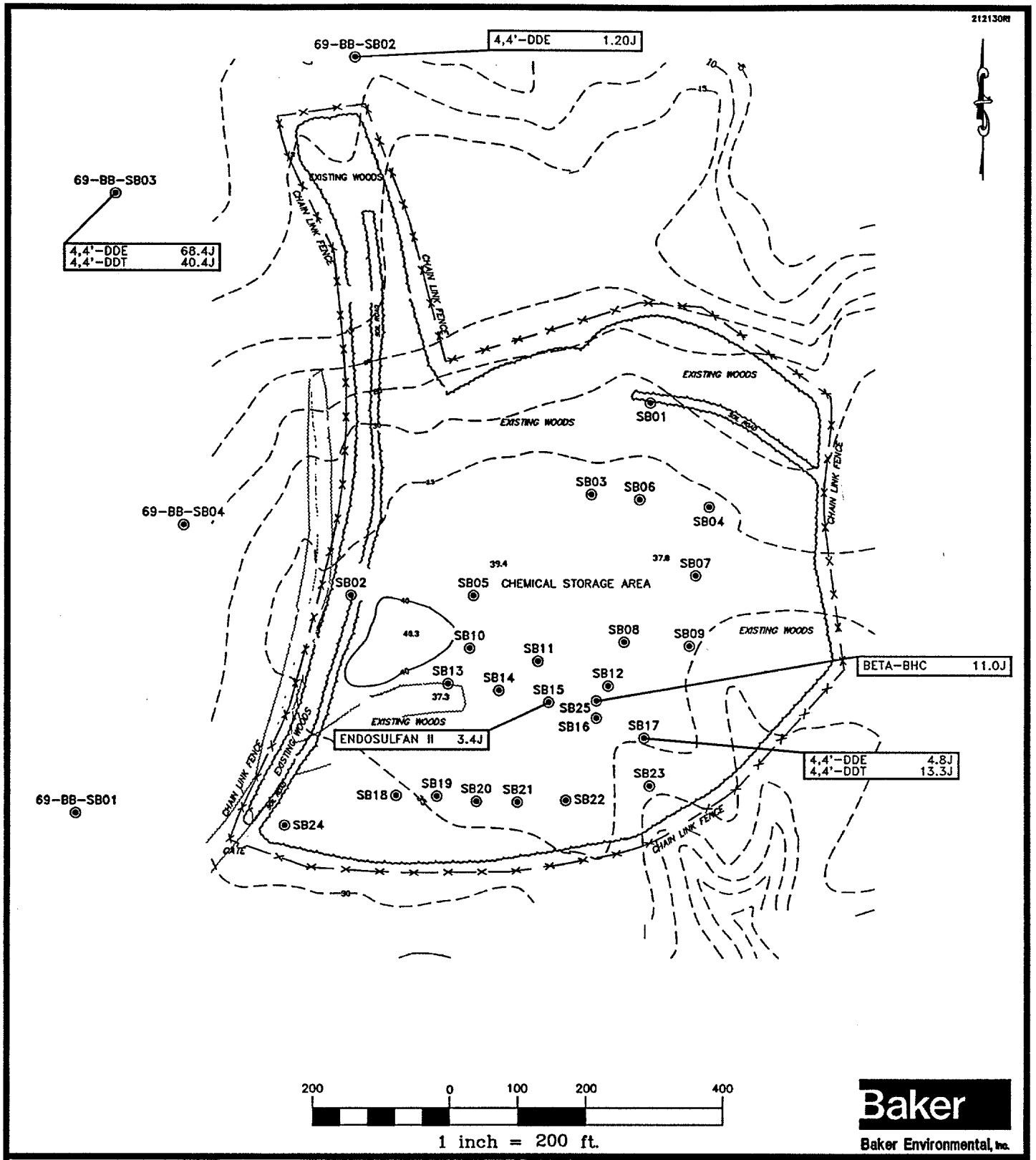
VEGETATION

TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-1
POSITIVE DETECTIONS OF VOCs IN SURFACE SOILS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

SB01 — SURFACE SOIL SAMPLING LOCATION

FENCE

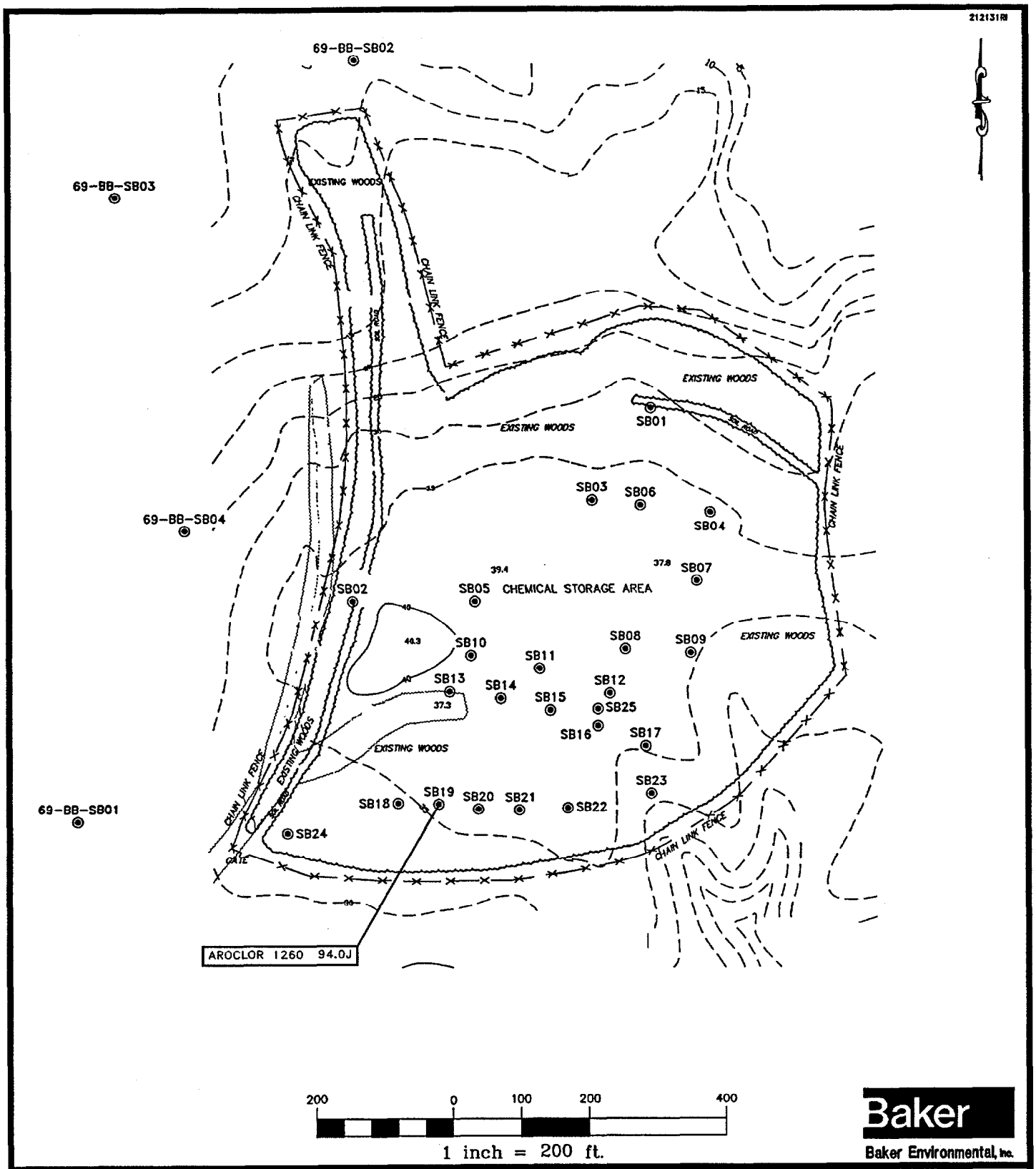
VEGETATION

TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-2
POSITIVE DETECTIONS OF PESTICIDES IN SURFACE SOILS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

SB01 — SURFACE SOIL SAMPLING LOCATION

FENCE

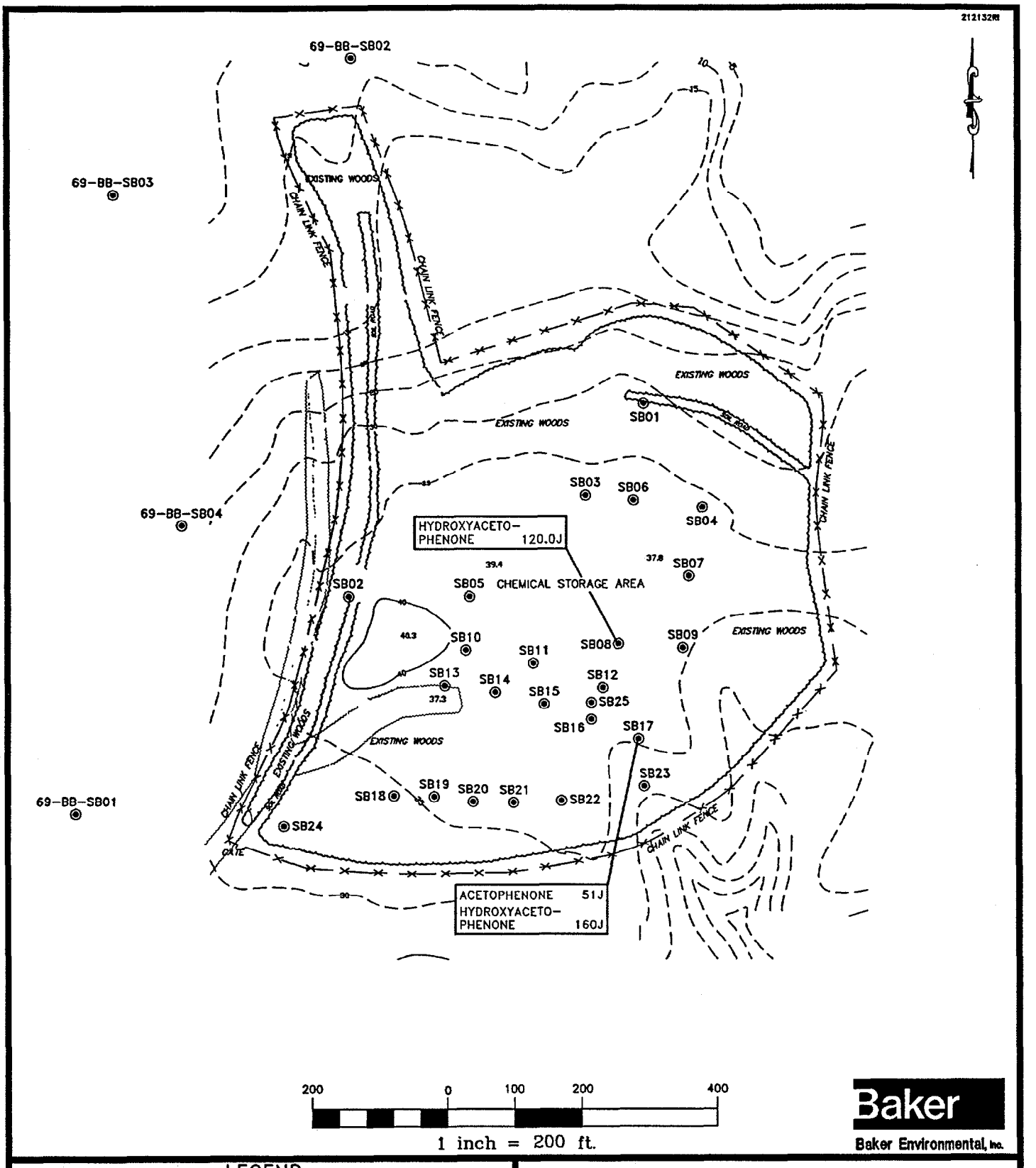
VEGETATION

TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-3
POSITIVE DETECTION OF PCBs
IN SURFACE SOILS
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

SB01 SURFACE SOIL SAMPLING LOCATION

FENCE

VEGETATION

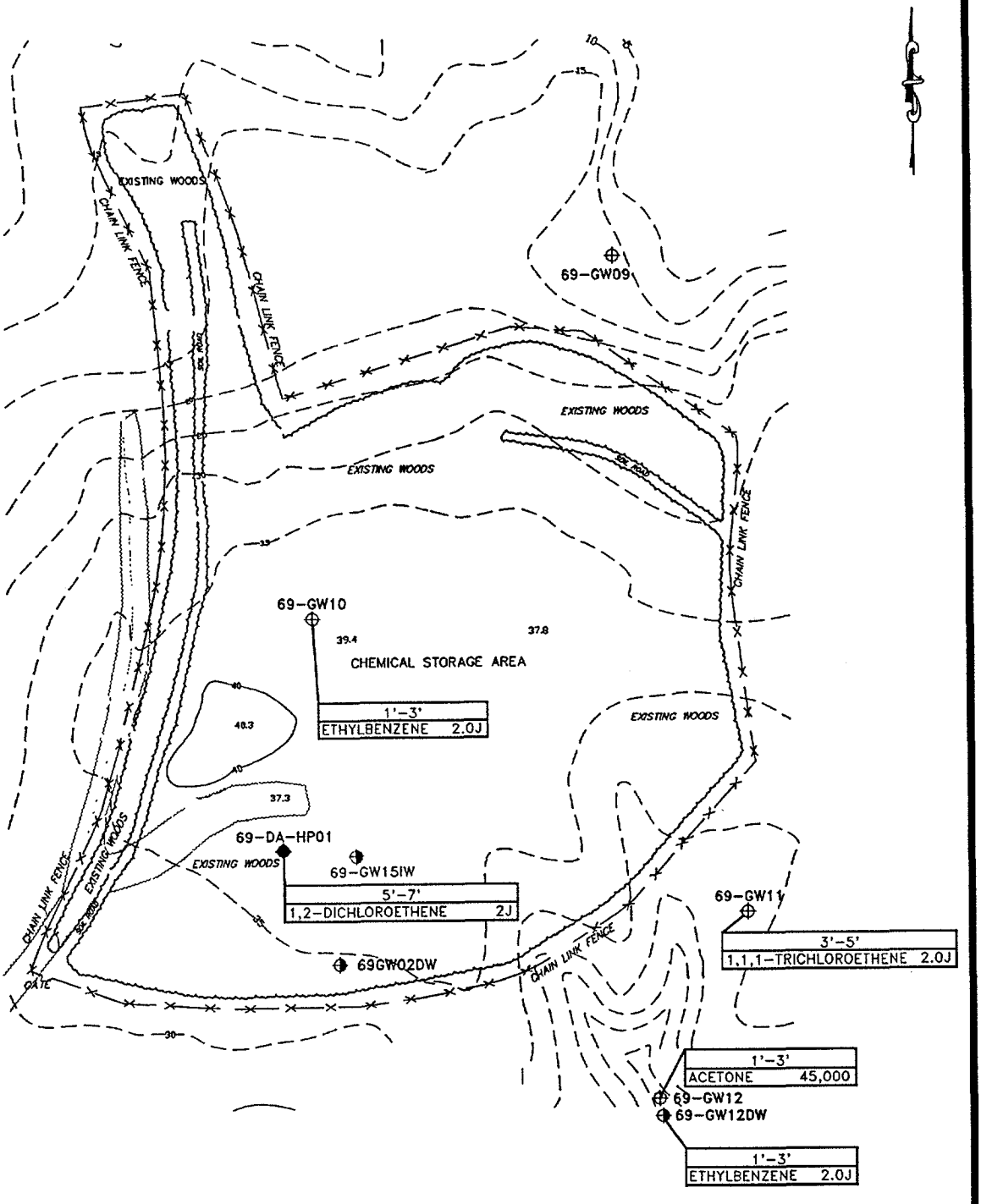
TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-4
POSITIVE DETECTIONS OF CHEMICAL SURETY MATERIAL IN SURFACE SOILS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212133RI



Baker

Baker Environmental, Inc.

LEGEND

69-GW09 EXISTING SHALLOW WELLS (BAKER)

69-GW02DW EXISTING DEEP WELLS (BAKER)

69-DA-HP01 HYDROPUNCH LOCATION

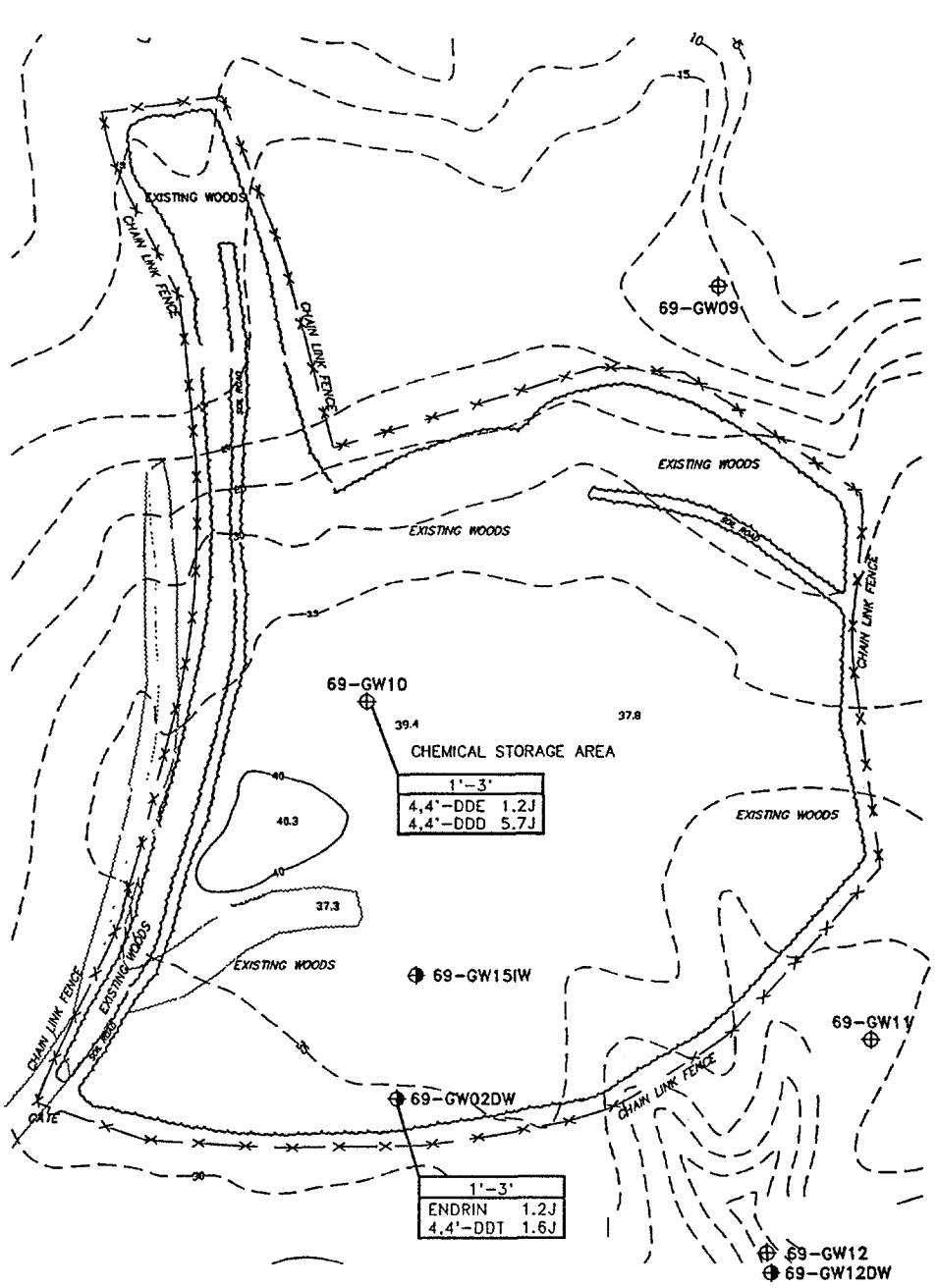
TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-5
POSITIVE DETECTIONS OF VOCs
IN SUBSURFACE SOILS
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212134R1



200 0 100 200 400

1 inch = 200 ft.

Baker

Baker Environmental, Inc.

LEGEND

69-GW09 EXISTING SHALLOW WELLS

69-GW02DW EXISTING DEEP WELLS

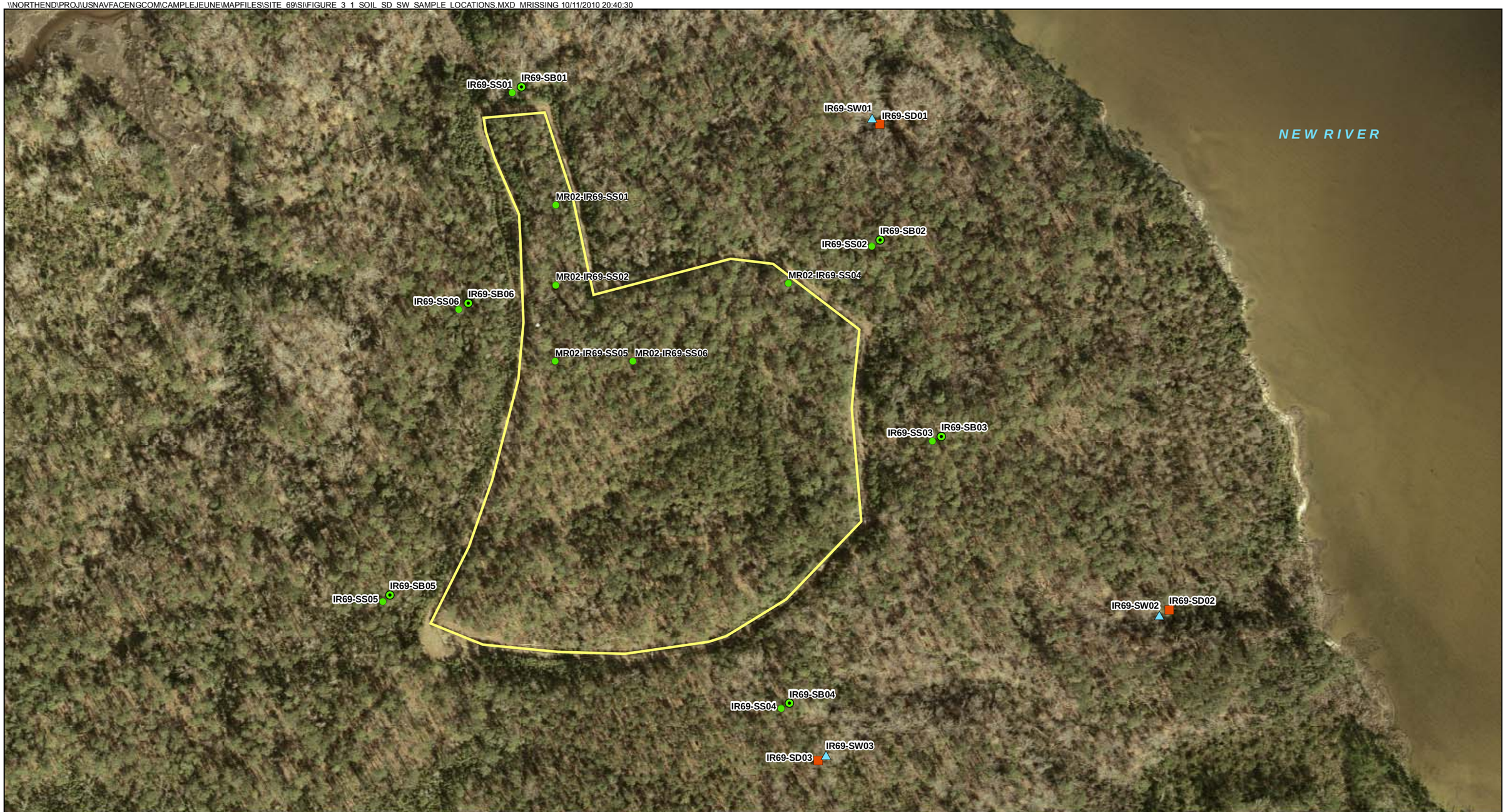
TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-6
POSITIVE DETECTION OF PESTICIDES IN SUBSURFACE SOILS
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

\\NORTHEND\PROJ\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\SITE_69\SI\FIGURE_3_1_SOIL_SD_SW_SAMPLE_LOCATIONS.MXD MRISSING 10/11/2010 20:40:30



Legend

Sampling Locations

- Surface Soil
- Subsurface Soil
- Surface Water
- Sediment
- Site 69

N

0 100 200 400 Feet

1 inch = 200 feet

Figure 3-1
Surface Water, Sediment, and Soil Sample Locations
Supplemental Investigation
Site 69, Operable Unit No. 14
MCB CamLej
North Carolina

CH2MHILL

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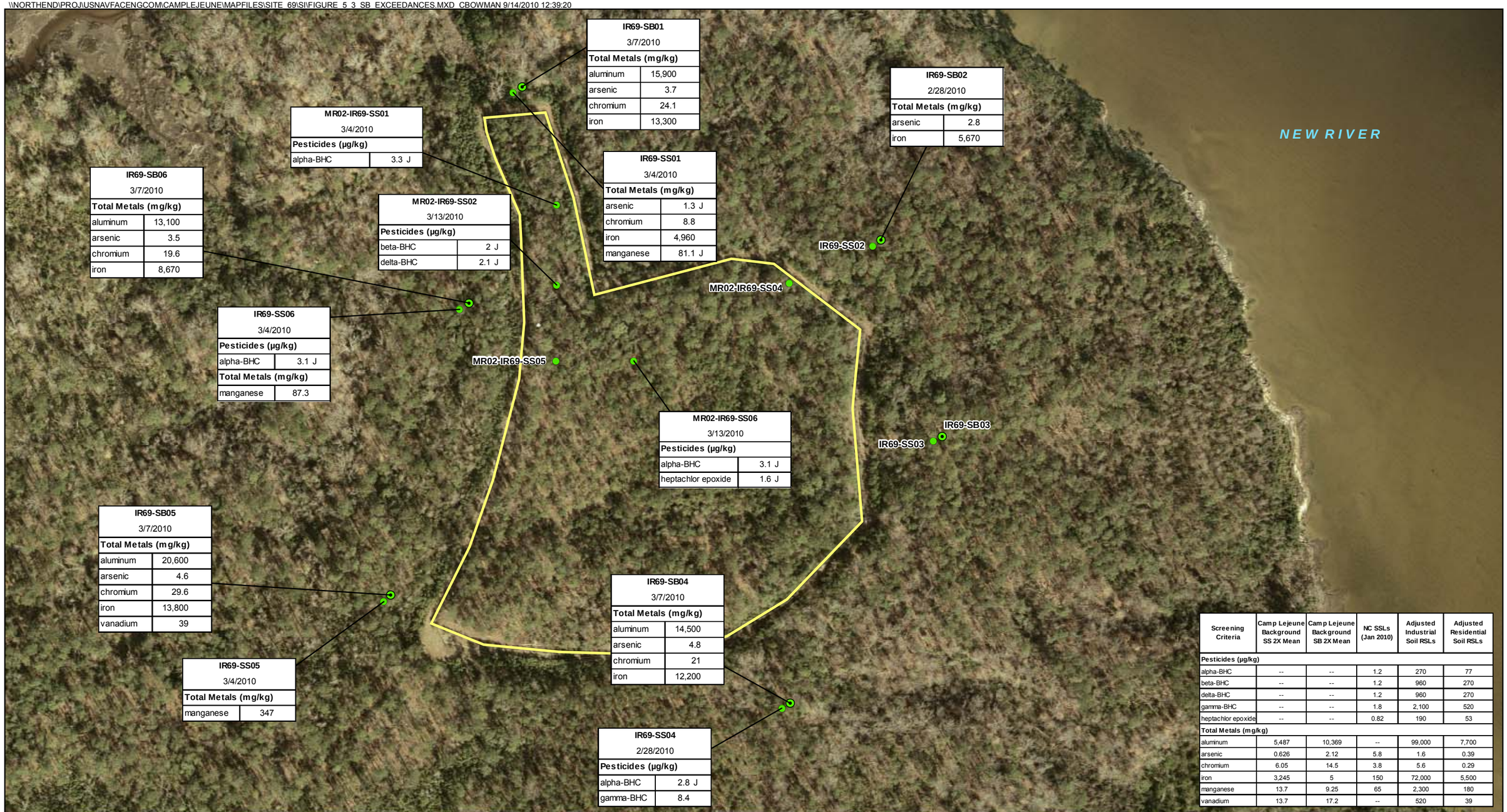
\\NORTHEND\PROJ\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\SITE_69\SI\FIGURE_5_3_SB_EXCEEDANCES.MXD CBOWMAN 9/14/2010 12:39:20



Screening Criteria	Camp Lejeune Background SS 2X Mean	Camp Lejeune Background SB 2X Mean	NC SSLs (Jan 2010)	Adjusted Industrial Soil RSLs	Adjusted Residential Soil RSLs
Pesticides (µg/kg)					
alpha-BHC	--	--	1.2	270	77
beta-BHC	--	--	1.2	960	270
delta-BHC	--	--	1.2	960	270
gamma-BHC	--	--	1.8	2,100	520
heptachlor epoxide	--	--	0.82	190	53
Total Metals (mg/kg)					
aluminum	5,487	10,369	--	99,000	7,700
arsenic	0.626	2.12	5.8	1.6	0.39
chromium	6.05	14.5	3.8	5.6	0.29
iron	3,245	5	150	72,000	5,500
manganese	13.7	9.25	65	2,300	180
vanadium	13.7	17.2	--	520	39

Legend
- Surface Soil Sampling Locations
- Subsurface Soil Sampling Locations
- Site 69

Notes:
J- Analyte present, value may or may not be accurate or precise
mg/kg - milligrams per kilogram
µg/kg -micrograms per kilogram
NC SSLs - NC Department of Environment and Natural Resources'
Federal Remediation Branch Soil Screening Levels
RSLs - USEPA Regional Screening Levels

N

0 100 200 400 Feet

1 inch = 200 feet

Figure 5-1
Soil Exceedances - March 2010
Supplemental Investigation
Site 69, Operable Unit No. 14
MCB CamLej
North Carolina

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Appendix B
CEHNC Removal Cost Analysis

US Army Engineering and Support Center, Huntsville
Site 69, MCB Camp Lejeune (EXCAVATION)
CONTRACT W912DY-04-D-0000

Task	Task Name	Total Task Cost
1	Work Plan / Plans and Specifications	$122,241
2	14 acre Soil Removal & Fill	$27,801,393.18
2a	Brush Removal	$33,588.96
2b	Blast Berm Construction	$2,986,612.66
2c	Excavation of 14 acres 10FT. Depth	$23,407,060.59
2d	Backfill 14 acres / Seeding	$1,374,130.97
	FOR OFFICIAL USE ONLY	
	TOTAL	$27,923,634.64

US Army Engineering and Support Center, Huntsville
Site 69, MCB Camp Lejeune (EXCAVATION)
CONTRACT W912DY-04-D-0000
TASK NO.: Summary
TASK TITLE:

ITEM NUMBER	CATEGORY	EMPLOYEE TYPE	BURDENED LABOR RATES FIXED PRICE	TIME & MATLS	HOURS	TOTAL BILLINGS
$0.00	MECHANIC		$32.27	$35.53	0.0	$0.00
$0.00	MECHANIC (CEA)		$21.29	$24.75	0.0	$0.00
$0.00	CERTIFIED INDUST HYGIENIST		$105.98	$116.79	80.0	$8,478.72
$0.00	SENIOR SCIENTIST		$104.84	$115.99	40.0	$4,193.42
$0.00	STAFF SCIENTIST		$68.69	$75.33	2,983.3	$204,917.47
$0.00	FIELD OFFICE (ADMIN)		$35.72	$38.69	4,893.3	$174,794.41
$0.00	DRAFTER I		$42.07	$46.36	0.0	$0.00
$0.00	EMERGENCY MEDICAL TECH		$25.88	$28.04	0.0	$0.00
$0.00	COMPUTER PROGRAMMER		$73.12	$81.11	0.0	$0.00
$0.00	LABORER		$20.42	$22.11	14,116.7	$288,229.53
$0.00	LABORER (CEA)		$8.37	$9.03	0.0	$0.00
$0.00	HEAVY EQUIPMENT OPERATOR		$30.87	$33.93	0.0	$0.00
$0.00	GEOLOGIST		$70.36	$77.67	0.0	$0.00
$0.00	GEOPHYSICAL INSTRU OPER		$52.82	$57.55	0.0	$0.00
$0.00	PROJECT MANAGER		$98.34	$108.15	570.3	$56,082.36
$0.00	GIS MANAGER		$83.05	$92.11	40.0	$3,322.00
$0.00	ENGINEERING TECH I		$39.24	$43.36	8,470.0	$332,373.42
$0.00	ENGINEERING TECH II		$51.43	$56.87	0.0	$0.00
$0.00	INDUSTRIAL HYGIENIST		$75.53	$82.98	2,823.3	$213,256.77
$0.00	LAB TECHNICIAN		$38.10	$42.02	0.0	$0.00
$0.00	SECURITY GUARD		$25.74	$28.32	0.0	$0.00
$0.00	SENIOR UXO SUPERVISOR		$68.95	$76.99	4,973.3	$342,935.70
$0.00	SUXO (4% hazard pay)		$71.56	$79.91	0.0	$0.00
$0.00	SUXO (8% hazard pay)		$74.16	$82.84	0.0	$0.00
$0.00	SURVEYOR		$37.94	$41.42	0.0	$0.00
$0.00	TRUCK DRIVER		$28.03	$30.92	0.0	$0.00
$0.00	UXO TECHNICIAN I		$39.32	$42.67	0.0	$0.00
$0.00	UXO TECHNICIAN I (4% Haz Pay)		$40.77	$44.27	0.0	$0.00
$0.00	UXO TECHNICIAN I (8% Haz Pay)		$42.24	$45.87	0.0	$0.00
$0.00	UXO TECHNICIAN II		$47.06	$51.08	8,516.0	$400,750.96
$0.00	UXO TECHNICIAN II (4% Haz Pay)		$48.82	$53.01	56.0	$2,733.92
$0.00	UXO TECHNICIAN II (8% Haz Pay)		$50.58	$54.94	8,470.0	$428,453.60
$0.00	UXO TECHNICIAN III		$56.20	$61.41	3,971.7	$223,195.97
$0.00	UXO TECHNICIAN III (4% Haz Pay)		$58.30	$63.74	0.0	$0.00
$0.00	UXO TECHNICIAN III (8% Haz Pay)		$60.42	$66.06	1,411.7	$85,287.47
$0.00	GEOPHYSICIST-PROJECT		$99.49	$109.85	0.0	$0.00
$0.00	PROGRAM MANAGER		$131.14	$144.86	40.0	$5,245.78
$0.00	WORD PROCESSOR		$34.66	$37.73	120.0	$4,159.42
$0.00	UXO QUALITY CONTROL SPEC		$62.56	$67.84	0.0	$0.00
$0.00	UXO QC (4 % hazard pay)		$63.76	$69.13	0.0	$0.00
$0.00	UXO QC (8 % hazard pay)		$66.14	$71.71	0.0	$0.00
$0.00	UXO SAFETY OFFICER		$62.51	$67.80	4,973.3	$310,881.11
$0.00	UXO SSHO (4 % hazard pay)		$63.70	$69.09	0.0	$0.00
$0.00	UXO SSHO (8 % hazard pay)		$66.06	$71.66	0.0	$0.00
$0.00	UXO SWEEP PERSONNEL		$38.45	$41.74	0.0	$0.00
$0.00	SENIOR ENGINEER		$96.35	$106.31	64.0	$6,166.58
$0.00	STAFF ENGINEER		$74.07	$82.65	2,983.3	$220,967.69
$0.00	JUNIOR ENGINEER		$56.00	$61.90	2,943.3	$164,838.54
$0.00	SITE GEOPHYSICIST		$72.75	$80.69	0.0	$0.00
$0.00	SITE PROJECT MANAGER		$80.91	$87.78	4,973.3	$402,378.13
$0.00	CONTRACT SPECIALIST		$73.97	$81.80	48.0	$3,550.69
$0.00	BUSINESS MANAGER		$88.60	$97.88	0.0	$0.00
$0.00	EQUIPMENT SPECIALIST		$55.12	$59.97	120.0	$6,614.81
$0.00	QUALITY MANAGER		$86.45	$95.54	0.0	$0.00
$0.00	IT/COMMUNICATIONS MANAGER		$90.63	$98.64	0.0	$0.00
$0.00	IT/COMMUNICATIONS SPECIALIST		$64.38	$71.15	0.0	$0.00
$0.00	ADMIN MANAGER		$63.87	$69.39	60.0	$3,832.47
$0.00	ADMIN SPECIALIST		$41.79	$45.33	80.0	$3,343.13
$0.00	RESOURCE MANAGER		$77.19	$85.34	40.0	$3,087.63
$0.00	FINANCE SPECIALIST		$62.21	$67.67	40.0	$2,488.43
TOTAL SERVICES					77,901.0	$3,906,560.12
SUBTOTAL TRAVEL & LIVING						$1,036,834.00
SUBTOTAL EQUIPMENT						$8,095,378.31
SUBTOTAL MATERIALS & SUPPLIES						$14,964.00
SUBTOTAL OTHER DIRECT COSTS						$43,377.71
TOTAL PRIME CONTRACTOR COSTS						$13,097,114.15
SUBTOTAL SUBCONTRACTOR						$13,955,765.08
TOTAL COST						$27,052,879.23
FEE						
	FEE ON PRIME SERVICES, TRAVEL & LIVING, MATERIALS & SUPPLIES @			8.00%		$312,524.81
	FEE ON SUBCONTRACTORS @			4.00%		$558,230.60
SUBTOTAL FEE						$870,755.41
TOTAL TASK						$27,923,634.64

US Army Engineering and Support Center, Huntsville
Site 69, MCB Camp Lejeune (EXCAVATION)
CONTRACT W912DY-04-D-0000
TASK NO.: 1 TYPE: FIXED PRICE
TASK TITLE: Work Plan / Plans and Specifications

ITEM NUMBER	CATEGORY	EMPLOYEE TYPE	BURDENED LABOR RATES FIXED PRICE	TIME & MATLS	HOURS	TOTAL BILLINGS
0006	0 MECHANIC	0	$32.27	$35.53	0.0	$0.00
0006	0 CERTIFIED INDUST HYGIENIST	0	$105.98	$116.79	80.0	$8,478.72
0006	0 SENIOR SCIENTIST	0	$104.84	$115.99	40.0	$4,193.42
0006	0 STAFF SCIENTIST	0	$68.69	$75.33	160.0	$10,989.97
0006	0 FIELD OFFICE (ADMIN)	0	$35.72	$38.69	0.0	$0.00
0006	0 DRAFTER I	0	$42.07	$46.36	0.0	$0.00
0006	0 EMERGENCY MEDICAL TECH	0	$25.88	$28.04	0.0	$0.00
0006	0 COMPUTER PROGRAMMER	0	$73.12	$81.11	0.0	$0.00
0006	0 LABORER	0	$20.42	$22.11	0.0	$0.00
0006	0 LABORER (CEA)	0	$8.37	$9.03	0.0	$0.00
0006	0 HEAVY EQUIPMENT OPERATOR	0	$30.87	$33.93	0.0	$0.00
0006	0 GEOLOGIST	0	$70.36	$77.67	0.0	$0.00
0006	0 GEOPHYSICAL INSTRU OPER	0	$52.82	$57.55	0.0	$0.00
0006	0 PROJECT MANAGER	0	$98.34	$108.15	80.0	$7,867.26
0006	0 GIS MANAGER	0	$83.05	$92.11	40.0	$3,322.00
0006	0 ENGINEERING TECH I	0	$39.24	$43.36	0.0	$0.00
0006	0 ENGINEERING TECH II	0	$51.43	$56.87	0.0	$0.00
0006	0 INDUSTRIAL HYGIENIST	0	$75.53	$82.98	0.0	$0.00
0006	0 LAB TECHNICIAN	0	$38.10	$42.02	0.0	$0.00
0006	0 SECURITY GUARD	0	$25.74	$28.32	0.0	$0.00
0006	0 SENIOR UXO SUPERVISOR	0	$68.95	$76.99	80.0	$5,516.39
0006	0 SUXO (4% hazard pay)	0	$71.56	$79.91	0.0	$0.00
0006	0 SUXO (8% hazard pay)	0	$74.16	$82.84	0.0	$0.00
0006	0 SURVEYOR	0	$37.94	$41.42	0.0	$0.00
0006	0 TRUCK DRIVER	0	$28.03	$30.92	0.0	$0.00
0006	0 UXO TECHNICIAN I	0	$39.32	$42.67	0.0	$0.00
0006	0 UXO TECHNICIAN I (4% Haz Pay)	0	$40.77	$44.27	0.0	$0.00
0006	0 UXO TECHNICIAN I (8% Haz Pay)	0	$42.24	$45.87	0.0	$0.00
0006	0 UXO TECHNICIAN II	0	$47.06	$51.08	0.0	$0.00
0006	0 UXO TECHNICIAN II (4% Haz Pay)	0	$48.82	$53.01	0.0	$0.00
0006	0 UXO TECHNICIAN II (8% Haz Pay)	0	$50.58	$54.94	0.0	$0.00
0006	0 UXO TECHNICIAN III	0	$56.20	$61.41	0.0	$0.00
0006	0 UXO TECHNICIAN III (4% Haz Pay)	0	$58.30	$63.74	0.0	$0.00
0006	0 UXO TECHNICIAN III (8% Haz Pay)	0	$60.42	$66.06	0.0	$0.00
0006	0 GEOPHYSICIST-PROJECT	0	$99.49	$109.85	0.0	$0.00
0006	0 PROGRAM MANAGER	0	$131.14	$144.86	40.0	$5,245.78
0006	0 WORD PROCESSOR	0	$34.66	$37.73	120.0	$4,159.42
0006	0 UXO QUALITY CONTROL SPEC	0	$62.56	$67.84	0.0	$0.00
0006	0 UXO QC (4 % hazard pay)	0	$63.76	$69.13	0.0	$0.00
0006	0 UXO QC (8 % hazard pay)	0	$66.14	$71.71	0.0	$0.00
0006	0 UXO SAFETY OFFICER	0	$62.51	$67.80	80.0	$5,000.76
0006	0 UXO SSHO (4 % hazard pay)	0	$63.70	$69.09	0.0	$0.00
0006	0 UXO SSHO (8 % hazard pay)	0	$66.06	$71.66	0.0	$0.00
0006	0 UXO SWEEP PERSONNEL	0	$38.45	$41.74	0.0	$0.00
0006	0 SENIOR ENGINEER	0	$96.35	$106.31	64.0	$6,166.58
0006	0 STAFF ENGINEER	0	$74.07	$82.65	160.0	$11,850.76
0006	0 JUNIOR ENGINEER	0	$56.00	$61.90	120.0	$6,720.47
0006	0 SITE GEOPHYSICIST	0	$72.75	$80.69	0.0	$0.00
0006	0 SITE PROJECT MANAGER	0	$80.91	$87.78	80.0	$6,472.57
0006	0 CONTRACT SPECIALIST		$73.97	$81.80	0.0	$0.00
	TOTAL SERVICES				1404.0	$100,940.71
	SUBTOTAL TRAVEL & LIVING					$0.00
	SUBTOTAL EQUIPMENT					$8,950.50
	SUBTOTAL MATERIALS & SUPPLIES					$0.00
	SUBTOTAL OTHER DIRECT COSTS					$4,275.00
	TOTAL PRIME CONTRACTOR COSTS					$114,166.21
	SUBTOTAL SUBCONTRACTOR					$0.00
	TOTAL COST					$114,166.21
	FEE					
	FEE ON PRIME SERVICES, TRAVEL & LIVING, MATERIALS & SUPPLIES @			8.00%		$8,075.26
	FEE ON SUBCONTRACTORS @			4.00%		$0.00
	SUBTOTAL FEE					$8,075.26
TOTAL TASK						$122,241.46

US Army Engineering and Support Center, Huntsville
Site 69, MCB Camp Lejeune (EXCAVATION)
CONTRACT W912DY-04-D-0000
TASK NO.: 1
TASK TITLE: Work Plan / Plans and Specifications

TYPE: FIXED PRICE

TYPE
8
T&M 0005
FFP 0006

ITEM NUMBER	CATEGORY	EMPLOYEE TYPE	BURDENED LABOR RATES FIXED PRICE	TIME & MATLS	HOURS	TOTAL BILLINGS
0006	0 MECHANIC	0	$32.27	$35.53		$0.00
0006	0 CERTIFIED INDUST HYGIENIST	0	$105.98	$116.79	80	$8,478.72
0006	0 SENIOR SCIENTIST	0	$104.84	$115.99	40	$4,193.42
0006	0 STAFF SCIENTIST	0	$68.69	$75.33	160	$10,989.97
0006	0 FIELD OFFICE (ADMIN)	0	$35.72	$38.69		$0.00
0006	0 DRAFTER I	0	$42.07	$46.36		$0.00
0006	0 EMERGENCY MEDICAL TECH	0	$25.88	$28.04		$0.00
0006	0 COMPUTER PROGRAMMER	0	$73.12	$81.11		$0.00
0006	0 LABORER	0	$20.42	$22.11		$0.00
0006	0 HEAVY EQUIPMENT OPERATOR	0	$30.87	$33.93		$0.00
0006	0 GEOLOGIST	0	$70.36	$77.67		$0.00
0006	0 GEOPHYSICAL INSTRU OPER	0	$52.82	$57.55		$0.00
0006	0 PROJECT MANAGER	0	$98.34	$108.15	80	$7,867.26
0006	0 GIS MANAGER	0	$83.05	$92.11	40	$3,322.00
0006	0 ENGINEERING TECH I	0	$39.24	$43.36		$0.00
0006	0 ENGINEERING TECH II	0	$51.43	$56.87		$0.00
0006	0 INDUSTRIAL HYGIENIST	0	$75.53	$82.98		$0.00
0006	0 LAB TECHNICIAN	0	$38.10	$42.02		$0.00
0006	0 SECURITY GUARD	0	$25.74	$28.32		$0.00
0006	0 SENIOR UXO SUPERVISOR	0	$68.95	$76.99	80	$5,516.39
0006	0 SUXO (4% hazard pay)	0	$71.56	$79.91		$0.00
0006	0 SUXO (8% hazard pay)	0	$74.16	$82.84		$0.00
0006	0 SURVEYOR	0	$37.94	$41.42		$0.00
0006	0 TRUCK DRIVER	0	$28.03	$30.92		$0.00
0006	0 UXO TECHNICIAN I	0	$39.32	$42.67		$0.00
0006	0 UXO TECHNICIAN I (4% Haz Pay)	0	$40.77	$44.27		$0.00
0006	0 UXO TECHNICIAN I (8% Haz Pay)	0	$42.24	$45.87		$0.00
0006	0 UXO TECHNICIAN II	0	$47.06	$51.08		$0.00
0006	0 UXO TECHNICIAN II (4% Haz Pay)	0	$48.82	$53.01		$0.00
0006	0 UXO TECHNICIAN II (8% Haz Pay)	0	$50.58	$54.94		$0.00
0006	0 UXO TECHNICIAN III	0	$56.20	$61.41		$0.00
0006	0 UXO TECHNICIAN III (4% Haz Pay)	0	$58.30	$63.74		$0.00
0006	0 UXO TECHNICIAN III (8% Haz Pay)	0	$60.42	$66.06		$0.00
0006	0 GEOPHYSICIST-PROJECT	0	$99.49	$109.85		$0.00
0006	0 PROGRAM MANAGER	0	$131.14	$144.86	40	$5,245.78
0006	0 WORD PROCESSOR	0	$34.66	$37.73	120	$4,159.42
0006	0 UXO QUALITY CONTROL SPEC	0	$62.56	$67.84		$0.00
0006	0 UXO QC (4 % hazard pay)	0	$63.76	$69.13		$0.00
0006	0 UXO QC (8 % hazard pay)	0	$66.14	$71.71		$0.00
0006	0 UXO SAFETY OFFICER	0	$62.51	$67.80	80	$5,000.76
0006	0 UXO SSHO (4 % hazard pay)	0	$63.70	$69.09		$0.00
0006	0 UXO SSHO (8 % hazard pay)	0	$66.06	$71.66		$0.00
0006	0 UXO SWEEP PERSONNEL	0	$38.45	$41.74		$0.00
0006	0 SENIOR ENGINEER	0	$96.35	$106.31	64	$6,166.58
0006	0 STAFF ENGINEER	0	$74.07	$82.65	160	$11,850.76
0006	0 JUNIOR ENGINEER	0	$56.00	$61.90	120	$6,720.47
0006	0 SITE GEOPHYSICIST	0	$72.75	$80.69		$0.00
0006	0 SITE PROJECT MANAGER	0	$80.91	$87.78	80	$6,472.57
0006	0 CONTRACT SPECIALIST	0	$73.97	$81.80		$0.00
0006	0 BUSINESS MANAGER	0	$88.60	$97.88		$0.00
0006	0 EQUIPMENT SPECIALIST	0	$55.12	$59.97	40	$2,204.94
0006	0 QUALITY MANAGER	0	$86.45	$95.54		$0.00
0006	0 IT/COMMUNICATIONS MANAGER	0	$90.63	$98.64		$0.00
0006	0 IT/COMMUNICATIONS SPECIALIST	0	$64.38	$71.15		$0.00
0006	0 ADMIN MANAGER	0	$63.87	$69.39	60	$3,832.47
0006	0 ADMIN SPECIALIST	0	$41.79	$45.33	80	$3,343.13
0006	0 RESOURCE MANAGER	0	$77.19	$85.34	40	$3,087.63
0006	0 FINANCE SPECIALIST		$62.21	$67.67	40	$2,488.43
	TOTAL SERVICES				1,404.0	$100,940.71

2 Site Visits

TRAVEL & LIVING				
AIR FARE	$650.00	/RND TRIP	TRIPS	$0.00
M&IE	$39.00	/DAY	DAYS	$0.00
LODGING	$40.00	/NIGHT	NIGHTS	$0.00
HOME TRAVEL	$1,000.00	/RND TRIP	TRIPS	$0.00
AIRFARES (Huntsville)	$800.00	/RND TRIP	TRIPS	$0.00
PER DIEM (Huntsville) incl local taxes	$102.00	/DAY	DAYS	$0.00
CAR RENTAL	$125.00	/DAY	DAYS	$0.00
SUV RENTAL	$500.00	/WEEK	WEEKS	$0.00
LONG TERM M&IE (55%)	$21.45	/DAY	DAYS	$0.00
LONG TERM LODGING (55%)	$22.00	/NIGHT	NIGHTS	$0.00
MISCELLANOUS TRAVEL COST	$50.00	/WEEK	WEEKS	$0.00
SUBTOTAL TRAVEL & LIVING				$0.00

$0.00

EQUIPMENT					
COMPUTER USAGE	$8.50	/HOUR	1053	HOURS	$8,950.50
GIS WORKSTATION	$27.00	/HOURS		HOURS	$0.00
CAD TIME	$10.50	/HOURS		HOURS	$0.00
WHITE'S HANDHELD LOCATOR	$105.00	/MONTH		MONTHS	$0.00
UXO FIELD DATA COLLECTORS-PALMTOPS	$105.00	/MONTH		MONTHS	$0.00
HANDHELD DATA COLLECTION DEVICES-ALLEGROS	$310.00	/MONTH		MONTHS	$0.00
EM61 MK2 RENTAL WITH PDGPS	$1,600.00	/MONTH		MONTHS	$0.00
VALLON VMX-2	$895.00	/MONTH		MONTHS	$0.00
MAGNA TRAC MAGNETOMETER	$95.00	/MONTH		MONTHS	$0.00
PORTABLE TOILETS	$85.00	/MONTH		MONTHS	$0.00
CHAIN SAWS	$300.00	/EA		EACH	$0.00
WEED EATERS	$225.00	/EA		EACH	$0.00
MAGNETOMETER BASE STATION	$300.00	/MONTH		MONTHS	$0.00
CESIUM 858 MAGNETOMETER	$60.00	/DAY		DAYS	$0.00
GRADIOMETER	$90.00	/DAY		DAYS	$0.00
GPS BASE STATION	$2,660.00	/MONTH		MONTHS	$0.00
OVERNIGHT SERVICES AND HANDLING	$175.00	/WEEK		WEEKS	$0.00
RADIO CONTROLLED FIRING DEVICE	$225.00	/MONTH		MONTHS	$0.00
SCHONSTEDT MAGNETIC LOCATORS	$120.00	/MONTH		MONTHS	$0.00
GPS PERSONAL NAVIGATORS	$80.00	/MONTH		MONTHS	$0.00
EM61 SHIPPING COST	$1,000.00	/TRIP		TRIPS	$0.00
SCHOENSTEDTS MOB/DEMOB	$55.00	/TRIP		TRIPS	$0.00
ROLLOFF (20 C.Y.)(8 tons)	$500.00	/WEEK		WEEKS	$0.00
TRACK HOE/DOZER	$3,500.00	/MONTH		MONTHS	$0.00
FUEL TRUCK	$1,500.00	/MONTH		MONTHS	$0.00
ROAD MAINTENANCE	$100,000.00	/LS		LS	$0.00
EXPLOSIVES/MAGAZINES	$10,000.00	/LS		LS	$0.00
DEMOLITION	$3,000.00	/LS		LS	$0.00
LEICA DGPS STATIONS	$2,660.00	/MONTH		MONTHS	$0.00
USRADS	$7,035.00	/MONTH		MONTHS	$0.00
DIGITAL CAMERA RENTAL	$85.00	/MONTH		MONTHS	$0.00
ALL TERRAIN VEHICLES	$1,025.00	/MONTH		MONTHS	$0.00
RADIO RENTAL	$30.00	/MONTH		MONTHS	$0.00
TRAILER MOB. / DEMOB.	$1,500.00	/TRAILER		TRAILERS	$0.00
TRAILER RENTAL/OFFICE RENTAL	$1,000.00	/MONTH		MONTHS	$0.00
VEHICLE RENTAL - 4WD TRUCK including gas	$750.00	/WEEK		WEEKS	$0.00
VEHICLE RENTAL - MINI VAN FOR CREW	$1,400.00	/MONTH		MONTHS	$0.00
VEHICLE RENTAL - CAR	$250.00	/WEEK		WEEKS	$0.00
SUBTOTAL EQUIPMENT					$8,950.50
SUPPLIES & MATERIALS					
FIELD H&S SUPPLIES	$1,000.00	/LS		LS	$0.00
VIDEO TAPES	$1.00	/TAPE		TAPES	$0.00
FIELD BOOKS	$12.00	/BOOK		BOOKS	$0.00
FIRST AID KIT	$50.00	/KIT		KITS	$0.00
MISCELLANEOUS SUPPLIES	$25.00	/EA		EA	$0.00
SUBTOTAL MATERIALS & SUPPLIES					$0.00
OTHER DIRECT COSTS					
TELEPHONE / FAX	$100.00	/MONTH	0.5	MONTHS	$50.00
SHIPPING / POSTAGE	$12.50	/EA	10	EACH	$125.00
CELLULAR PHONE	$100.00	/MONTH		MONTHS	$0.00
COLOR REPRODUCTION	$1.00	/COPY	2000	COPIES	$2,000.00
FedEX Large Packages	$67.00	/EA		EA	$0.00
COLOR COPIES/MAPS	$1.00	/EA	800	EA	$800.00
WORK STATION PLOTTER	$4.20	/HR		HRS	$0.00
WEB HOST FEE	$30.00	/MONTH		MONTHS	$0.00
REPORT COVER/BINDERS	$7.50	/COPY	20	COPIES	$150.00
REPRODUCTION	$0.07	/COPY	10000	COPIES	$700.00
UPS FREIGHT	$25.00	/EA		EA	$0.00
PLOTTER SUPPLIES	$1,500.00	/LS		LS	$0.00
CD DATA	$2.00	/EA	200	EACH	$400.00
SCANNING OF DOCUMENTS	$0.50	/PAGE		PAGES	$0.00
MISCELLANOUS OFFICE SUPPLIES	$25.00	/WEEK	2	WEEKS	$50.00
SUBTOTAL OTHER DIRECT COSTS					$4,275.00
TOTAL PRIME CONTRACTOR COSTS					$114,166.21
SUBCONTRACTOR					
SUBCONTRACTOR -	$1.00	/LS		LS	$0.00
SUBCONTRACTOR -	1				$0.00
SUBCONTRACTOR -	1				$0.00
SUBTOTAL SUBCONTRACTOR					$0.00
TOTAL COST					$114,166.21
FEE					
FEE ON PRIME SERVICES, TRAVEL & LIVING, MATERIALS & SUPPLIES @			8.00%	$	8,075.26
FEE ON SUBCONTRACTORS @			4.00%	$	-
SUBTOTAL FEE				$	8,075.26
TOTAL TASK					$122,241.46

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US Army Engineering and Support Center, Huntsville
Site 69, MCB Camp Lejeune (EXCAVATION)
CONTRACT **W912DY-04-D-0000**
TASK NO.: 2 **TYPE: FIXED PRICE**
TASK TITLE: **14 acre Soil Removal & Fill**

ITEM NUMBER	CATEGORY	EMPLOYEE TYPE	BURDENED LABOR RATES FIXED PRICE	TIME & MATLS	HOURS	TOTAL BILLINGS
0006	0 MECHANIC	0	$32.27	$35.53	0.0	$0.00
0006	0 CERTIFIED INDUST HYGIENIST	0	$105.98	$116.79	0.0	$0.00
0006	0 SENIOR SCIENTIST	0	$104.84	$115.99	0.0	$0.00
0006	0 STAFF SCIENTIST	0	$68.69	$75.33	2823.3	$193,927.50
0006	0 FIELD OFFICE (ADMIN)	0	$35.72	$38.69	4893.3	$174,794.41
0006	0 DRAFTER I	0	$42.07	$46.36	0.0	$0.00
0006	0 EMERGENCY MEDICAL TECH	0	$25.88	$28.04	0.0	$0.00
0006	0 COMPUTER PROGRAMMER	0	$73.12	$81.11	0.0	$0.00
0006	0 LABORER	0	$20.42	$22.11	14116.7	$288,229.53
0006	0 HEAVY EQUIPMENT OPERATOR	0	$30.87	$33.93	0.0	$0.00
0006	0 GEOLOGIST	0	$70.36	$77.67	0.0	$0.00
0006	0 GEOPHYSICAL INSTRU OPER	0	$52.82	$57.55	0.0	$0.00
0006	0 PROJECT MANAGER	0	$98.34	$108.15	490.3	$48,215.09
0006	0 GIS MANAGER	0	$83.05	$92.11	0.0	$0.00
0006	0 ENGINEERING TECH I	0	$39.24	$43.36	8470.0	$332,373.42
0006	0 ENGINEERING TECH II	0	$51.43	$56.87	0.0	$0.00
0006	0 INDUSTRIAL HYGIENIST	0	$75.53	$82.98	2823.3	$213,256.77
0006	0 LAB TECHNICIAN	0	$38.10	$42.02	0.0	$0.00
0006	0 SECURITY GUARD	0	$25.74	$28.32	0.0	$0.00
0006	0 SENIOR UXO SUPERVISOR	0	$68.95	$76.99	4893.3	$337,419.31
0006	0 SUXO (4% hazard pay)	0	$71.56	$79.91	0.0	$0.00
0006	0 SUXO (8% hazard pay)	0	$74.16	$82.84	0.0	$0.00
0006	0 SURVEYOR	0	$37.94	$41.42	0.0	$0.00
0006	0 TRUCK DRIVER	0	$28.03	$30.92	0.0	$0.00
0006	0 UXO TECHNICIAN I	0	$39.32	$42.67	0.0	$0.00
0006	0 UXO TECHNICIAN I (4% Haz Pay)	0	$40.77	$44.27	0.0	$0.00
0006	0 UXO TECHNICIAN I (8% Haz Pay)	0	$42.24	$45.87	0.0	$0.00
0006	0 UXO TECHNICIAN II	0	$47.06	$51.08	8516.0	$400,750.96
0006	0 UXO TECHNICIAN II (4% Haz Pay)	0	$48.82	$53.01	56.0	$2,733.92
0006	0 UXO TECHNICIAN II (8% Haz Pay)	0	$50.58	$54.94	8470.0	$428,453.60
0006	0 UXO TECHNICIAN III	0	$56.20	$61.41	3971.7	$223,195.97
0006	0 UXO TECHNICIAN III (4% Haz Pay)	0	$58.30	$63.74	0.0	$0.00
0006	0 UXO TECHNICIAN III (8% Haz Pay)	0	$60.42	$66.06	1411.7	$85,287.47
0006	0 GEOPHYSICIST-PROJECT	0	$99.49	$109.85	0.0	$0.00
0006	0 PROGRAM MANAGER	0	$131.14	$144.86	0.0	$0.00
0006	0 WORD PROCESSOR	0	$34.66	$37.73	0.0	$0.00
0006	0 UXO QUALITY CONTROL SPEC	0	$62.56	$67.84	0.0	$0.00
0006	0 UXO QC (4 % hazard pay)	0	$63.76	$69.13	0.0	$0.00
0006	0 UXO QC (8 % hazard pay)	0	$66.14	$71.71	0.0	$0.00
0006	0 UXO SAFETY OFFICER	0	$62.51	$67.80	4893.3	$305,880.35
0006	0 UXO SSHO (4 % hazard pay)	0	$63.70	$69.09	0.0	$0.00
0006	0 UXO SSHO (8 % hazard pay)	0	$66.06	$71.66	0.0	$0.00
0006	0 UXO SWEEP PERSONNEL	0	$38.45	$41.74	0.0	$0.00
0006	0 SENIOR ENGINEER	0	$96.35	$106.31	0.0	$0.00
0006	0 STAFF ENGINEER	0	$74.07	$82.65	2823.3	$209,116.92
0006	0 JUNIOR ENGINEER	0	$56.00	$61.90	2823.3	$158,118.06
0006	0 SITE GEOPHYSICIST	0	$72.75	$80.69	0.0	$0.00
0006	0 SITE PROJECT MANAGER	0	$80.91	$87.78	4893.3	$395,905.57
0006	0 CONTRACT SPECIALIST	0	$73.97	$81.80	48.0	$3,550.69
0006	0 BUSINESS MANAGER	0	$88.60	$97.88	0.0	$0.00
0006	0 EQUIPMENT SPECIALIST	0	$55.12	$59.97	80.0	$4,409.87
0006	0 QUALITY MANAGER	0	$86.45	$95.54	0.0	$0.00
0006	0 IT/COMMUNICATIONS MANAGER	0	$90.63	$98.64	0.0	$0.00
0006	0 IT/COMMUNICATIONS SPECIALIST	0	$64.38	$71.15	0.0	$0.00
0006	0 ADMIN MANAGER	0	$63.87	$69.39	0.0	$0.00
0006	0 ADMIN SPECIALIST	0	$41.79	$45.33	0.0	$0.00
0006	0 RESOURCE MANAGER	0	$77.19	$85.34	0.0	$0.00
0006	0 FINANCE SPECIALIST	0	$62.21	$67.67	0.0	$0.00
	TOTAL SERVICES				76497.0	$3,805,619.41
	SUBTOTAL TRAVEL & LIVING					$1,036,834.00
	SUBTOTAL EQUIPMENT					$8,086,427.81
	SUBTOTAL MATERIALS & SUPPLIES					$14,964.00
	SUBTOTAL OTHER DIRECT COSTS					$39,102.71
	TOTAL PRIME CONTRACTOR COSTS					$12,982,947.94
	SUBTOTAL SUBCONTRACTOR					$13,955,765.08
	TOTAL COST					$26,938,713.02
	FEE					
	FEE ON PRIME SERVICES			8.00%		$304,449.55
	FEE ON SUBCONTRACTORS @			4.00%		$558,230.60
	SUBTOTAL FEE					$862,680.16
TOTAL TASK						$27,801,393.18

US Army Engineering and Support Center, Huntsville
Site 69, MCB Camp Lejeune (EXCAVATION)
CONTRACT W912DY-04-D-0000
TASK NO.: 2a
TASK TITLE: Brush Removal

TYPE: FIXED PRICE

TYPE 8
T&M 0005
FFP 0006

14 acres

ITEM NUMBER		CATEGORY	EMPLOYEE TYPE	BURDENED LABOR RATES FIXED PRICE	TIME & MATLS	HOURS	TOTAL BILLINGS	
0006	0	MECHANIC	0	$32.27	$35.53		$0.00	1 Tech II each brush team (anom avoidance)
0006	0	CERTIFIED INDUST HYGIENIST	0	$105.98	$116.79		$0.00	
0006	0	SENIOR SCIENTIST	0	$104.84	$115.99		$0.00	
0006	0	STAFF SCIENTIST	0	$68.69	$75.33		$0.00	
0006	0	FIELD OFFICE (ADMIN)	0	$35.72	$38.69		$0.00	
0006	0	DRAFTER I	0	$42.07	$46.36		$0.00	
0006	0	EMERGENCY MEDICAL TECH	0	$25.88	$28.04		$0.00	
0006	0	COMPUTER PROGRAMMER	0	$73.12	$81.11		$0.00	
0006	0	LABORER	0	$20.42	$22.11		$0.00	
0006	0	HEAVY EQUIPMENT OPERATOR	0	$30.87	$33.93		$0.00	
0006	0	GEOLOGIST	0	$70.36	$77.67		$0.00	
0006	0	GEOPHYSICAL INSTRU OPER	0	$52.82	$57.55		$0.00	
0006	0	PROJECT MANAGER	0	$98.34	$108.15		$0.00	
0006	0	GIS MANAGER	0	$83.05	$92.11		$0.00	
0006	0	ENGINEERING TECH I	0	$39.24	$43.36		$0.00	
0006	0	ENGINEERING TECH II	0	$51.43	$56.87		$0.00	
0006	0	INDUSTRIAL HYGIENIST	0	$75.53	$82.98		$0.00	
0006	0	LAB TECHNICIAN	0	$38.10	$42.02		$0.00	
0006	0	SECURITY GUARD	0	$25.74	$28.32		$0.00	
0006	0	SENIOR UXO SUPERVISOR	0	$68.95	$76.99		$0.00	
0006	0	SUXO (4% hazard pay)	0	$71.56	$79.91		$0.00	
0006	0	SUXO (8% hazard pay)	0	$74.16	$82.84		$0.00	
0006	0	SURVEYOR	0	$37.94	$41.42		$0.00	
0006	0	TRUCK DRIVER	0	$28.03	$30.92		$0.00	
0006	0	UXO TECHNICIAN I	0	$39.32	$42.87		$0.00	
0006	0	UXO TECHNICIAN I (4% Haz Pay)	0	$40.77	$44.27		$0.00	
0006	0	UXO TECHNICIAN I (8% Haz Pay)	0	$42.24	$45.87		$0.00	
0006	0	UXO TECHNICIAN II	0	$47.06	$51.08	46	$2,164.69	includes mob/demob
0006	0	UXO TECHNICIAN II (4% Haz Pay)	0	$48.82	$53.01	56	$2,733.92	
0006	0	UXO TECHNICIAN II (8% Haz Pay)	0	$50.58	$54.94		$0.00	
0006	0	UXO TECHNICIAN III	0	$56.20	$61.41		$0.00	
0006	0	UXO TECHNICIAN III (4% Haz Pay)	0	$58.30	$63.74		$0.00	
0006	0	UXO TECHNICIAN III (8% Haz Pay)	0	$60.42	$66.06		$0.00	
0006	0	GEOPHYSICIST-PROJECT	0	$99.49	$109.85		$0.00	
0006	0	PROGRAM MANAGER	0	$131.14	$144.86		$0.00	
0006	0	WORD PROCESSOR	0	$34.66	$37.73		$0.00	
0006	0	UXO QUALITY CONTROL SPEC	0	$62.56	$67.84		$0.00	
0006	0	UXO QC (4 % hazard pay)	0	$63.76	$69.13		$0.00	
0006	0	UXO QC (8 % hazard pay)	0	$66.14	$71.71		$0.00	
0006	0	UXO SAFETY OFFICER	0	$62.51	$67.80		$0.00	
0006	0	UXO SSHO (4 % hazard pay)	0	$63.70	$69.09		$0.00	
0006	0	UXO SSHO (8 % hazard pay)	0	$66.06	$71.66		$0.00	
0006	0	UXO SWEEP PERSONNEL	0	$38.45	$41.74		$0.00	
0006	0	SENIOR ENGINEER	0	$98.35	$106.31		$0.00	
0006	0	STAFF ENGINEER	0	$74.07	$82.65		$0.00	
0006	0	JUNIOR ENGINEER	0	$56.00	$61.90		$0.00	
0006	0	SITE GEOPHYSICIST	0	$72.75	$80.69		$0.00	
0006	0	SITE PROJECT MANAGER	0	$80.91	$87.78		$0.00	
0006	0	CONTRACT SPECIALIST	0	$73.97	$81.80		$0.00	
0006	0	BUSINESS MANAGER	0	$88.60	$97.88		$0.00	
0006	0	EQUIPMENT SPECIALIST	0	$55.12	$59.97		$0.00	
0006	0	QUALITY MANAGER	0	$86.45	$95.54		$0.00	
0006	0	IT/COMMUNICATIONS MANAGER	0	$90.63	$98.64		$0.00	
0006	0	IT/COMMUNICATIONS SPECIALIST	0	$64.38	$71.15		$0.00	
0006	0	ADMIN MANAGER	0	$63.87	$69.39		$0.00	
0006	0	ADMIN SPECIALIST	0	$41.79	$45.33		$0.00	
0006	0	RESOURCE MANAGER	0	$77.19	$85.34		$0.00	
0006	0	FINANCE SPECIALIST	0	$62.21	$67.67		$0.00	
		TOTAL SERVICES				102.0	$4,898.62	

TRAVEL & LIVING				
AIR FARE	$650.000	/RND TRIP	2 TRIPS	$1,300.00
M&IE	$39.000	/DAY	14 DAYS	$546.00
LODGING	$40.000	/NIGHT	12 NIGHTS	$480.00
HOME TRAVEL	$1,000.000	/RND TRIP	TRIPS	$0.00
AIRFARES (Huntsville)	$800.000	/RND TRIP	TRIPS	$0.00
PER DIEM (Huntsville) incl local taxes	$102.000	/DAY	DAYS	$0.00
CAR RENTAL	$125.000	/DAY	DAYS	$0.00
SUV RENTAL	$500.000	/WEEK	WEEKS	$0.00
LONG TERM M&IE (55%)	$21.450	/DAY	DAYS	$0.00
LONG TERM LODGING (55%)	$22.000	/NIGHT	NIGHTS	$0.00
MISCELLANOUS TRAVEL COST	$50.000	/WEEK	WEEKS	$0.00
SUBTOTAL TRAVEL & LIVING				$2,326.00

EQUIPMENT					
COMPUTER USAGE	$8.50	/HOUR		HOURS	$0.00
GIS WORKSTATION	$27.00	/HOURS		HOURS	$0.00
CAD TIME	$10.50	/HOURS		HOURS	$0.00
WHITE'S HANDHELD LOCATOR	$105.00	/MONTH		MONTHS	$0.00
UXO FIELD DATA COLLECTORS-PALMTOPS	$105.00	/MONTH		MONTHS	$0.00
HANDHELD DATA COLLECTION DEVICES-AI	$310.00	/MONTH		MONTHS	$0.00
EM61 MK2 RENTAL WITH PDGPS	$1,600.00	/MONTH		MONTHS	$0.00
VALLON VMX-2	$895.00	/MONTH		MONTHS	$0.00
MAGNA TRAC MAGNETOMETER	$95.00	/MONTH		MONTHS	$0.00
PORTABLE TOILETS	$85.00	/MONTH	0.5	MONTHS	$42.50
CHAIN SAWS	$300.00	/EA		EACH	$0.00
WEED EATERS	$225.00	/EA		EACH	$0.00
MAGNETOMETER BASE STATION	$300.00	/MONTH		MONTHS	$0.00
CESIUM 858 MAGNETOMETER	$60.00	/DAY		DAYS	$0.00
GRADIOMETER	$90.00	/DAY		DAYS	$0.00
GPS BASE STATION	$2,660.00	/MONTH		MONTHS	$0.00
OVERNIGHT SERVICES AND HANDLING	$175.00	/WEEK		WEEKS	$0.00
RADIO CONTROLLED FIRING DEVICE	$225.00	/MONTH		MONTHS	$0.00
SCHONSTEDT MAGNETIC LOCATORS	$120.00	/MONTH	1.0	MONTHS	$120.00
GPS PERSONAL NAVIGATORS	$80.00	/MONTH	1.0	MONTHS	$80.00
EM61 SHIPPING COST	$1,000.00	/TRIP		TRIPS	$0.00
SCHOENSTEDTS MOB/DEMOB	$55.00	/TRIP	1.0	TRIPS	$55.00
ROLLOFF (20 C.Y.)(8 tons)	$500.00	/WEEK		WEEKS	$0.00
TRACK HOE/DOZER	$3,500.00	/MONTH		MONTHS	$0.00
FUEL TRUCK	$1,500.00	/MONTH		MONTHS	$0.00
ROAD MAINTENANCE	$100,000.00	/LS		LS	$0.00
EXPLOSIVES/MAGAZINES	$10,000.00	/LS		LS	$0.00
DEMOLITION	$3,000.00	/LS		LS	$0.00
LEICA DGPS STATIONS	$2,660.00	/MONTH		MONTHS	$0.00
USRADS	$7,035.00	/MONTH		MONTHS	$0.00
DIGITAL CAMERA RENTAL	$85.00	/MONTH	1.0	MONTHS	$85.00
ALL TERRAIN VEHICLES	$1,025.00	/MONTH		MONTHS	$0.00
RADIO RENTAL	$30.00	/MONTH	1.0	MONTHS	$30.00
TRAILER MOB. / DEMOB.	$1,500.00	/TRAILER		TRAILERS	$0.00
TRAILER RENTAL/OFFICE RENTAL	$1,000.00	/MONTH		MONTHS	$0.00
VEHICLE RENTAL - 4WD TRUCK including ga	$750.00	/WEEK	4.0	WEEKS	$3,000.00
VEHICLE RENTAL - MINI VAN FOR CREW	$1,400.00	/MONTH		MONTHS	$0.00
VEHICLE RENTAL - CAR	$250.00	/WEEK		WEEKS	$0.00
SUBTOTAL EQUIPMENT					$3,412.50
SUPPLIES & MATERIALS					
FIELD H&S SUPPLIES	$1,000.00	/LS	0.3	LS	$250.00
VIDEO TAPES	$1.00	/TAPE		TAPES	$0.00
FIELD BOOKS	$12.00	/BOOK	2.0	BOOKS	$24.00
FIRST AID KIT	$50.00	/KIT	2.0	KITS	$100.00
MISCELLANEOUS SUPPLIES	$25.00	/EA		EA	$0.00
SUBTOTAL MATERIALS & SUPPLIES					$374.00
OTHER DIRECT COSTS					
TELEPHONE / FAX	$100.00	/MONTH		MONTHS	$0.00
SHIPPING / POSTAGE	$12.50	/EA		EACH	$0.00
CELLULAR PHONE	$100.00	/MONTH	1.0	MONTHS	$100.00
COLOR REPRODUCTION	$1.00	/COPY		COPIES	$0.00
FedEX Large Packages	$87.00	/EA		EA	$0.00
COLOR COPIES/MAPS	$1.00	/EA		EA	$0.00
WORK STATION PLOTTER	$4.20	/HR		HRS	$0.00
WEB HOST FEE	$30.00	/MONTH		MONTHS	$0.00
REPORT COVER/BINDERS	$7.50	/COPY		COPIES	$0.00
REPRODUCTION	$0.07	/COPY		COPIES	$0.00
UPS FREIGHT	$25.00	/EA		EA	$0.00
PLOTTER SUPPLIES	$1,500.00	/LS		LS	$0.00
CD DATA	$2.00	/EA		EACH	$0.00
SCANNING OF DOCUMENTS	$0.50	/PAGE		PAGES	$0.00
MISCELLANOUS OFFICE SUPPLIES	$25.00	/WEEK		WEEKS	$0.00
SUBTOTAL OTHER DIRECT COSTS					$100.00
TOTAL PRIME CONTRACTOR COSTS					$11,111.12
SUBCONTRACTOR					
SUBCONTRACTOR -	$21,236.49	/LS	1.0	LS	$21,236.49
SUBCONTRACTOR -					$0.00
SUBCONTRACTOR -					$0.00
SUBTOTAL SUBCONTRACTOR					$21,236.49
TOTAL COST					$32,347.61
FEE					
FEE ON PRIME SERVICES			8.00%		$391.89
FEE ON SUBCONTRACTORS @			4.00%		$849.46
SUBTOTAL FEE					$1,241.35
TOTAL TASK					$33,588.96

Brush Removal

Equipment Co $1,500.00 per day

Light Brush - Clear 8 Acre per day

Heavy Brush - Clear 2 Acre per day

Brush Team(s 2

Event	Personnel		Hourly rate	Hours	Equipment/ren	Total
Brush Clearing (Local)	Supervisor (HEC	2	$30.87	35	$ 10,500.00	$ 12,661.08
	Laborer (6)	12	$20.42	35		$ 8,575.41
						$ 21,236.49

Acreage	# Acres/day	Total Days	Mob/demob	AL HRS FOR (tal # calendar days	
14	2	4		35	7
				Total Weeks	Total Months
				1	0.3

US Army Engineering and Support Center, Huntsville
Site 69, MCB Camp Lejeune (EXCAVATION)
CONTRACT W912DY-04-D-0000
TASK NO.: 2b
TASK TITLE: Blast Berm Construction

TYPE: FIXED PRICE

ITEM NUMBER		CATEGORY	EMPLOYEE TYPE	BURDENED LABOR RATES FIXED PRICE	TIME & MATLS	HOURS	TOTAL BILLINGS
0006	0	MECHANIC	0	$32.27	$35.53		$0.00
0006	0	CERTIFIED INDUST HYGIENIST	0	$105.98	$116.79		$0.00
0006	0	SENIOR SCIENTIST	0	$104.84	$115.99		$0.00
0006	0	STAFF SCIENTIST	0	$68.69	$75.33		$0.00
0006	0	FIELD OFFICE (ADMIN)	0	$35.72	$38.69	1280	$45,722.75
0006	0	DRAFTER I	0	$42.07	$46.38		$0.00
0006	0	EMERGENCY MEDICAL TECH	0	$25.88	$28.04		$0.00
0006	0	COMPUTER PROGRAMMER	0	$73.12	$81.11		$0.00
0006	0	LABORER	0	$20.42	$22.11		$0.00
0006	0	HEAVY EQUIPMENT OPERATOR	0	$30.87	$33.93		$0.00
0006	0	GEOLOGIST	0	$70.36	$77.67		$0.00
0006	0	GEOPHYSICAL INSTRU OPER	0	$52.82	$57.55		$0.00
0006	0	PROJECT MANAGER	0	$98.34	$108.15	128	$12,587.62
0006	0	GIS MANAGER	0	$83.05	$92.11		$0.00
0006	0	ENGINEERING TECH I	0	$39.24	$43.38		$0.00
0006	0	ENGINEERING TECH II	0	$51.43	$56.87		$0.00
0006	0	INDUSTRIAL HYGIENIST	0	$75.53	$82.98		$0.00
0006	0	LAB TECHNICIAN	0	$38.10	$42.02		$0.00
0006	0	SECURITY GUARD	0	$25.74	$28.32		$0.00
0006	0	SENIOR UXO SUPERVISOR	0	$88.95	$78.99	1280	$88,262.20
0006	0	SUXO (4% hazard pay)	0	$71.56	$79.91		$0.00
0006	0	SUXO (8% hazard pay)	0	$74.16	$82.84		$0.00
0006	0	SURVEYOR	0	$37.94	$41.42		$0.00
0006	0	TRUCK DRIVER	0	$28.03	$30.92		$0.00
0006	0	UXO TECHNICIAN I	0	$39.32	$42.67		$0.00
0006	0	UXO TECHNICIAN I (4% Haz Pay)	0	$40.77	$44.27		$0.00
0006	0	UXO TECHNICIAN I (8% Haz Pay)	0	$42.24	$45.87		$0.00
0006	0	UXO TECHNICIAN II	0	$47.06	$51.08		$0.00
0006	0	UXO TECHNICIAN II (4% Haz Pay)	0	$48.82	$53.01		$0.00
0006	0	UXO TECHNICIAN II (8% Haz Pay)	0	$50.58	$54.94		$0.00
0006	0	UXO TECHNICIAN III	0	$56.20	$61.41	2560	$143,864.38
0006	0	UXO TECHNICIAN III (4% Haz Pay)	0	$58.30	$63.74		$0.00
0006	0	UXO TECHNICIAN III (8% Haz Pay)	0	$60.42	$66.06		$0.00
0006	0	GEOPHYSICIST-PROJECT	0	$99.49	$109.85		$0.00
0006	0	PROGRAM MANAGER	0	$131.14	$144.86		$0.00
0006	0	WORD PROCESSOR	0	$34.66	$37.73		$0.00
0006	0	UXO QUALITY CONTROL SPEC	0	$62.56	$67.84		$0.00
0006	0	UXO QC (4 % hazard pay)	0	$63.76	$69.13		$0.00
0006	0	UXO QC (8 % hazard pay)	0	$66.14	$71.71		$0.00
0006	0	UXO SAFETY OFFICER	0	$62.51	$67.80	1280	$80,012.23
0006	0	UXO SSHO (4 % hazard pay)	0	$63.70	$69.09		$0.00
0006	0	UXO SSHO (8 % hazard pay)	0	$66.06	$71.66		$0.00
0006	0	UXO SWEEP PERSONNEL	0	$38.45	$41.74		$0.00
0006	0	SENIOR ENGINEER	0	$96.35	$106.31		$0.00
0006	0	STAFF ENGINEER	0	$74.07	$82.65		$0.00
0006	0	JUNIOR ENGINEER	0	$56.00	$61.90		$0.00
0006	0	SITE GEOPHYSICIST	0	$72.75	$80.69		$0.00
0006	0	SITE PROJECT MANAGER	0	$80.91	$87.78	1280	$103,561.04
0006	0	CONTRACT SPECIALIST	0	$73.97	$81.80	24	$1,775.34
0006	0	BUSINESS MANAGER	0	$88.60	$97.88		$0.00
0006	0	EQUIPMENT SPECIALIST	0	$55.12	$59.97	40	$2,204.94
0006	0	QUALITY MANAGER	0	$86.45	$95.54		$0.00
0006	0	IT/COMMUNICATIONS MANAGER	0	$90.63	$98.64		$0.00
0006	0	IT/COMMUNICATIONS SPECIALIST	0	$64.38	$71.15		$0.00
0006	0	ADMIN MANAGER	0	$63.87	$69.39		$0.00
0006	0	ADMIN SPECIALIST	0	$41.79	$45.33		$0.00
0006	0	RESOURCE MANAGER	0	$77.19	$85.34		$0.00
0006	0	FINANCE SPECIALIST	0	$62.21	$67.67		$0.00
		TOTAL SERVICES				7,808.0	$477,990.50

TRAVEL & LIVING			
AIR FARE	$650.000	/RND TRIP	TRIPS $0.00
M&IE	$39.000	/DAY	1120 DAYS $43,680.00
LODGING	$40.000	/NIGHT	1115 NIGHTS $44,600.00
HOME TRAVEL	$1,000.000	/RND TRIP	TRIPS $0.00
AIRFARES (Huntsville)	$800.000	/RND TRIP	TRIPS $0.00
PER DIEM (Huntsville) incl local taxes	$102.000	/DAY	DAYS $0.00
CAR RENTAL	$125.000	/DAY	DAYS $0.00
SUV RENTAL	$500.000	/WEEK	WEEKS $0.00
LONG TERM M&IE (55%)	$21.450	/DAY	DAYS $0.00
LONG TERM LODGING (55%)	$22.000	/NIGHT	NIGHTS $0.00
MISCELLANOUS TRAVEL COST	$50.000	/WEEK	WEEKS $0.00
SUBTOTAL TRAVEL & LIVING			$88,280.00

TYPE 8

T&M	0005
FFP	0006

14 acres/cost
225,000 C.Y.
$456 mob/demob equipment (loader, spreader)
$2.77 loading (per C.Y. includes equipment, labor)
$5.25 hauling (per C.Y. includes equipment, labor)
$1.73 spreading (per C.Y. includes equipment, labor)
* borrow pit on base
Totals
$3,648.00 mob/demob equipment (loader, spreader) 4 each
$623,250.00 loading (per C.Y. includes equipment, labor)
$1,181,250.00 hauling (per C.Y. includes equipment, labor)
$389,250.00 spreading (per C.Y. includes equipment, labor)
$2,197,398.00 Total
All costs taken from PCCost Book

Time for 1 Truck, Loader, Spreader
30 acres/time (per C.Y. includes equipment, labor)

C.Y.	Time/Hours	
45	1	loading
44	1	* hauling
72	1	spreading

Total Time/Hours

5000	loading
5114	* hauling
3125	spreading

Total Time/10 hour days

500	loading
512	* hauling
313	spreading

4 trucks hauling
128 work days
1280 work hours
224 per diem days
32.0 weeks
8.0 months

EQUIPMENT					
COMPUTER USAGE	$8.50	/HOUR	3904.0	HOURS	$33,184.00
GIS WORKSTATION	$27.00	/HOURS		HOURS	$0.00
CAD TIME	$10.50	/HOURS		HOURS	$0.00
WHITE'S HANDHELD LOCATOR	$105.00	/MONTH		MONTHS	$0.00
UXO FIELD DATA COLLECTORS-PALMTOPS	$105.00	/MONTH		MONTHS	$0.00
HANDHELD DATA COLLECTION DEVICES-A	$310.00	/MONTH		MONTHS	$0.00
EM61 MK2 RENTAL WITH PDGPS	$1,600.00	/MONTH		MONTHS	$0.00
VALLON VMX-2	$895.00	/MONTH		MONTHS	$0.00
MAGNA TRAC MAGNETOMETER	$95.00	/MONTH		MONTHS	$0.00
PORTABLE TOILETS	$85.00	/MONTH	24.0	MONTHS	$2,040.00
CHAIN SAWS	$300.00	/EA		EACH	$0.00
WEED EATERS	$225.00	/EA		EACH	$0.00
MAGNETOMETER BASE STATION	$300.00	/MONTH		MONTHS	$0.00
CESIUM 858 MAGNETOMETER	$60.00	/DAY		DAYS	$0.00
GRADIOMETER	$90.00	/DAY		DAYS	$0.00
GPS BASE STATION	$2,660.00	/MONTH		MONTHS	$0.00
OVERNIGHT SERVICES AND HANDLING	$175.00	/WEEK		WEEKS	$0.00
RADIO CONTROLLED FIRING DEVICE	$225.00	/MONTH		MONTHS	$0.00
SCHONSTEDT MAGNETIC LOCATORS	$120.00	/MONTH		MONTHS	$0.00
GPS PERSONAL NAVIGATORS	$80.00	/MONTH		MONTHS	$0.00
EM61 SHIPPING COST	$1,000.00	/TRIP		TRIPS	$0.00
SCHOENSTEDTS MOB/DEMOB	$55.00	/TRIP		TRIPS	$0.00
ROLLOFF (20 C.Y.)(8 tons)	$500.00	/WEEK		WEEKS	$0.00
TRACK HOE/DOZER	$3,500.00	/MONTH		MONTHS	$0.00
FUEL TRUCK	$1,500.00	/MONTH		MONTHS	$0.00
ROAD MAINTENANCE	$100,000.00	/LS		LS	$0.00
EXPLOSIVES/MAGAZINES	$10,000.00	/LS		LS	$0.00
DEMOLITION	$3,000.00	/LS		LS	$0.00
LEICA DGPS STATIONS	$2,860.00	/MONTH		MONTHS	$0.00
USRADS	$7,035.00	/MONTH		MONTHS	$0.00
DIGITAL CAMERA RENTAL	$85.00	/MONTH		MONTHS	$0.00
ALL TERRAIN VEHICLES	$1,025.00	/MONTH		MONTHS	$0.00
RADIO RENTAL	$30.00	/MONTH	32.0	MONTHS	$960.00
TRAILER MOB. / DEMOB.	$1,500.00	/TRAILER		TRAILERS	$0.00
TRAILER RENTAL/OFFICE RENTAL	$1,000.00	/MONTH	8.0	MONTHS	$8,000.00
VEHICLE RENTAL - 4WD TRUCK including ga	$750.00	/WEEK	64.0	WEEKS	$48,000.00
VEHICLE RENTAL - MINI VAN FOR CREW	$1,400.00	/MONTH		MONTHS	$0.00
VEHICLE RENTAL - CAR	$250.00	/WEEK		WEEKS	$0.00
SUBTOTAL EQUIPMENT					$92,184.00
SUPPLIES & MATERIALS					
FIELD H&S SUPPLIES	$1,000.00	/LS	1.0	LS	$1,000.00
VIDEO TAPES	$1.00	/TAPE		TAPES	$0.00
FIELD BOOKS	$12.00	/BOOK		BOOKS	$0.00
FIRST AID KIT	$50.00	/KIT	4.0	KITS	$200.00
MISCELLANEOUS SUPPLIES	$25.00	/EA		EA	$0.00
SUBTOTAL MATERIALS & SUPPLIES					$1,200.00
OTHER DIRECT COSTS					
TELEPHONE / FAX	$100.00	/MONTH		MONTHS	$0.00
SHIPPING / POSTAGE	$12.50	/EA	4.0	EACH	$50.00
CELLULAR PHONE	$100.00	/MONTH	32.0	MONTHS	$3,200.00
COLOR REPRODUCTION	$1.00	/COPY		COPIES	$0.00
FedEX Large Packages	$67.00	/EA		EA	$0.00
COLOR COPIES/MAPS	$1.00	/EA		EA	$0.00
WORK STATION PLOTTER	$4.20	/HR		HRS	$0.00
WEB HOST FEE	$30.00	/MONTH		MONTHS	$0.00
REPORT COVER/BINDERS	$7.50	/COPY		COPIES	$0.00
REPRODUCTION	$0.07	/COPY	2500.0	COPIES	$175.00
UPS FREIGHT	$25.00	/EA		EA	$0.00
PLOTTER SUPPLIES	$1,500.00	/LS		LS	$0.00
CD DATA	$2.00	/EA		EACH	$0.00
SCANNING OF DOCUMENTS	$0.50	/PAGE		PAGES	$0.00
MISCELLANOUS OFFICE SUPPLIES	$25.00	/WEEK		WEEKS	$0.00
SUBTOTAL OTHER DIRECT COSTS					$3,425.00
TOTAL PRIME CONTRACTOR COSTS					$663,079.50
SUBCONTRACTOR					
SUBCONTRACTOR - Dirt work	$2,197,398.00	/LS	1.0	LS	$2,197,398.00
SUBCONTRACTOR -					$0.00
SUBCONTRACTOR -					$0.00
SUBTOTAL SUBCONTRACTOR					$2,197,398.00
TOTAL COST					$2,860,477.50
FEE					
FEE ON PRIME SERVICES			8.00%		$38,239.24
FEE ON SUBCONTRACTORS @			4.00%		$87,895.92
SUBTOTAL FEE					$126,135.16
TOTAL TASK					$2,986,612.66

US Army Engineering and Support Center, Huntsville
Site 69, MCB Camp Lejeune (EXCAVATION)
CONTRACT W912DY-04-D-0000
TASK NO.: 2c
TASK TITLE: Excavation of 14 acres 10FT. Depth

TYPE: FIXED PRICE

ITEM NUMBER		CATEGORY	EMPLOYEE TYPE	BURDENED LABOR RATES FIXED PRICE	TIME & MATLS	HOURS	TOTAL BILLINGS
0006	0	MECHANIC	0	$32.27	$35.53		$0.00
0006	0	CERTIFIED INDUST HYGIENIST	0	$105.98	$116.79		$0.00
0006	0	SENIOR SCIENTIST	0	$104.84	$115.99		$0.00
0006	0	STAFF SCIENTIST	0	$68.69	$75.33	2823	$193,927.50
0006	0	FIELD OFFICE (ADMIN)	0	$35.72	$38.69	2823	$100,852.15
0006	0	DRAFTER I	0	$42.07	$46.36		$0.00
0006	0	EMERGENCY MEDICAL TECH	0	$25.88	$28.04		$0.00
0006	0	COMPUTER PROGRAMMER	0	$73.12	$81.11		$0.00
0006	0	LABORER	0	$20.42	$22.11	14117	$288,229.53
0006	0	HEAVY EQUIPMENT OPERATOR	0	$30.87	$33.93		$0.00
0006	0	GEOLOGIST	0	$70.36	$77.67		$0.00
0006	0	GEOPHYSICAL INSTRU OPER	0	$52.82	$57.55		$0.00
0006	0	PROJECT MANAGER	0	$98.34	$108.15	283	$27,816.40
0006	0	GIS MANAGER	0	$83.05	$92.11		$0.00
0006	0	ENGINEERING TECH I	0	$39.24	$43.36	8470	$332,373.42
0006	0	ENGINEERING TECH II	0	$51.43	$56.87		$0.00
0006	0	INDUSTRIAL HYGIENIST	0	$75.53	$82.98	2823	$213,256.77
0006	0	LAB TECHNICIAN	0	$38.10	$42.02		$0.00
0006	0	SECURITY GUARD	0	$25.74	$28.32		$0.00
0006	0	SENIOR UXO SUPERVISOR	0	$68.95	$76.99	2823	$194,682.79
0006	0	SUXO (4% hazard pay)	0	$71.56	$79.91		$0.00
0006	0	SUXO (8% hazard pay)	0	$74.16	$82.84		$0.00
0006	0	SURVEYOR	0	$37.94	$41.42		$0.00
0006	0	TRUCK DRIVER	0	$28.03	$30.92		$0.00
0006	0	UXO TECHNICIAN I	0	$39.32	$42.67		$0.00
0006	0	UXO TECHNICIAN I (4% Haz Pay)	0	$40.77	$44.27		$0.00
0006	0	UXO TECHNICIAN I (8% Haz Pay)	0	$42.24	$45.87		$0.00
0006	0	UXO TECHNICIAN II	0	$47.06	$51.08	8470	$398,586.27
0006	0	UXO TECHNICIAN II (4% Haz Pay)	0	$48.82	$53.01		$0.00
0006	0	UXO TECHNICIAN II (8% Haz Pay)	0	$50.58	$54.94	8470	$428,453.60
0006	0	UXO TECHNICIAN III	0	$56.20	$61.41	1412	$79,331.58
0006	0	UXO TECHNICIAN III (4% Haz Pay)	0	$58.30	$63.74		$0.00
0006	0	UXO TECHNICIAN III (8% Haz Pay)	0	$60.42	$66.06	1412	$85,287.47
0006	0	GEOPHYSICIST-PROJECT	0	$99.49	$109.85		$0.00
0006	0	PROGRAM MANAGER	0	$131.14	$144.86		$0.00
0006	0	WORD PROCESSOR	0	$34.66	$37.73		$0.00
0006	0	UXO QUALITY CONTROL SPEC	0	$62.56	$67.84		$0.00
0006	0	UXO QC (4 % hazard pay)	0	$63.76	$69.13		$0.00
0006	0	UXO QC (8 % hazard pay)	0	$66.14	$71.71		$0.00
0006	0	UXO SAFETY OFFICER	0	$62.51	$67.80	2823	$176,485.57
0006	0	UXO SSHO (4 % hazard pay)	0	$63.70	$69.09		$0.00
0006	0	UXO SSHO (8 % hazard pay)	0	$66.06	$71.66		$0.00
0006	0	UXO SWEEP PERSONNEL	0	$38.45	$41.74		$0.00
0006	0	SENIOR ENGINEER	0	$96.35	$106.31		$0.00
0006	0	STAFF ENGINEER	0	$74.07	$82.65	2823	$209,116.92
0006	0	JUNIOR ENGINEER	0	$56.00	$61.90	2823	$158,118.06
0006	0	SITE GEOPHYSICIST	0	$72.75	$80.69		$0.00
0006	0	SITE PROJECT MANAGER	0	$80.91	$87.78	2823	$228,427.95
0006	0	CONTRACT SPECIALIST	0	$73.97	$81.80		$0.00
0006	0	BUSINESS MANAGER	0	$88.60	$97.88		$0.00
0006	0	EQUIPMENT SPECIALIST	0	$55.12	$59.97		$0.00
0006	0	QUALITY MANAGER	0	$86.45	$95.54		$0.00
0006	0	IT/COMMUNICATIONS MANAGER	0	$90.63	$98.64		$0.00
0006	0	IT/COMMUNICATIONS SPECIALIST	0	$64.38	$71.15		$0.00
0006	0	ADMIN MANAGER	0	$63.87	$69.39		$0.00
0006	0	ADMIN SPECIALIST	0	$41.79	$45.33		$0.00
0006	0	RESOURCE MANAGER	0	$77.19	$85.34		$0.00
0006	0	FINANCE SPECIALIST	0	$62.21	$67.67		$0.00
TOTAL SERVICES						65,219.6	$3,114,945.98

TRAVEL & LIVING					
AIR FARE	$650.000	/RND TRIP	23	TRIPS	$14,950.00
M&IE	$39.000	/DAY	11385	DAYS	$444,015.00
LODGING	$40.000	/NIGHT	11362	NIGHTS	$454,480.00
HOME TRAVEL	$1,000.000	/RND TRIP		TRIPS	$0.00
AIRFARES (Huntsville)	$800.000	/RND TRIP		TRIPS	$0.00
PER DIEM (Huntsville) incl local taxes	$102.000	/DAY		DAYS	$0.00
CAR RENTAL	$125.000	/DAY		DAYS	$0.00
SUV RENTAL	$500.000	/WEEK		WEEKS	$0.00
LONG TERM M&IE (55%)	$21.450	/DAY		DAYS	$0.00
LONG TERM LODGING (55%)	$22.000	/NIGHT		NIGHTS	$0.00
MISCELLANOUS TRAVEL COST	$50.000	/WEEK		WEEKS	$0.00
SUBTOTAL TRAVEL & LIVING					$913,445.00

TYPE

8

T&M	0005
FFP	0006

14	acres	
225,867	C.Y.	
40	C.Y. rolloffs per day	
800	C.Y. per day	
282	work days	
4	loaders	
$2.77	per C.Y.	
$625,651.59		
$200,000	protective plating	
$825,651.59	Total Cost	

Site Personnel

		UXO Team	Total Site Personnel
1	Tech III		23
6	Tech II		
		Sampling Team	
1	Staff Scientist		
2	laborers		
		Site Management	
1	Site PM		
1	SUXOS		
1	Staff Engineer		
1	Safety Officer		
1	Field Office (Admin)		
		Personnel Decon Station	
1	Jr. Engineer		
3	laborers		
		Packaging Crew	
1	Industrial Hygienist		
3	E. Tech I		
282	in field, all teams		
282	work days		
2823	work hours		
495	per diem days		
70.7	weeks		
17.7	months		
1.5	years		

Sampling

1 sample for every 4 rolloffs	
40 rolloffs /day = 10 samples per work day	
10	samples per work day
283	work days
2830	samples
$1,300	per sample
$3,679,000	Total Cost for Sampling

Confirmation Samples

Walls - 1 per 1000 ft. = 4000 L.F.= 30 samples	
Bottom - 14 acres = 610 samples	
Total Samples - 700 which includes QA/QC	
700	samples
$1,300	per sample
$910,000	Total Cost for Confirmation Samples

Ordnance Disposal (on site)

200	rounds
$50	per round
$10,000	Total Cost for Ordnance Disposal

CAIS Disposal

20	complete kits
$5,000	per kit
$100,000	Total Cost for CAIS Disposal

EQUIPMENT						
COMPUTER USAGE	$8.50	/HOUR		HOURS	$0.00	Landfill Cost
GIS WORKSTATION	$27.00	/HOURS		HOURS	$0.00	225,867 C.Y.
CAD TIME	$10.50	/HOURS		HOURS	$0.00	$40.00 per C.Y.
WHITE'S HANDHELD LOCATOR	$105.00	/MONTH		MONTHS	$0.00	$9,034,680.00
UXO FIELD DATA COLLECTORS-PALMTOPS	$105.00	/MONTH		MONTHS	$0.00	
HANDHELD DATA COLLECTION DEVICES-A	$310.00	/MONTH		MONTHS	$0.00	Transportation Cost
EM61 MK2 RENTAL WITH PDGPS	$1,600.00	/MONTH		MONTHS	$0.00	20 miles
VALLON VMX-2	$895.00	/MONTH		MONTHS	$0.00	(225,867 C.Y./20 C.Y.) x $3.75 x 20mi tri $847,001.00
MAGNA TRAC MAGNETOMETER	$95.00	/MONTH		MONTHS	$0.00	
PORTABLE TOILETS	$85.00	/MONTH	88.4	MONTHS	$7,513.39	Landfill and Transportation Cost taken from:
CHAIN SAWS	$300.00	/EA		EACH	$0.00	Report on Treatment, Storage, & Disposal Facilities for HTRW
WEED EATERS	$225.00	/EA		EACH	$0.00	Put out by the Environmental and Munitions Center of Expertise
MAGNETOMETER BASE STATION	$300.00	/MONTH		MONTHS	$0.00	Omaha Dis.
CESIUM 858 MAGNETOMETER	$60.00	/DAY		DAYS	$0.00	
GRADIOMETER	$90.00	/DAY		DAYS	$0.00	
GPS BASE STATION	$2,660.00	/MONTH		MONTHS	$0.00	
OVERNIGHT SERVICES AND HANDLING	$175.00	/WEEK		WEEKS	$0.00	
RADIO CONTROLLED FIRING DEVICE	$225.00	/MONTH		MONTHS	$0.00	
SCHONSTEDT MAGNETIC LOCATORS	$400.00	/EA	4.0	EACH	$1,600.00	
GPS PERSONAL NAVIGATORS	$80.00	/MONTH		MONTHS	$0.00	
EM61 SHIPPING COST	$1,000.00	/TRIP		TRIPS	$0.00	
SCHOENSTEDTS MOB/DEMOB	$55.00	/TRIP		TRIPS	$0.00	
ROLLOFF (20 C.Y.)(8 tons)	$500.00	/WEEK		WEEKS	$0.00	
ECBC AIR MONITORING/SUPPORT	$45,000.00	/WEEK	70.7	WEEKS	$3,182,142.86	
SAMPLING	$3,679,000.00	/LS	1	LS	$3,679,000.00	
CONFIRMATION SAMPLING	$910,000.00	/LS	1	LS	$910,000.00	
ORDNANCE DISPOSAL	$10,000.00	/LS	1	LS	$10,000.00	
CAIS DISPOSAL	$100,000.00	/LS	1	LS	$100,000.00	
LEICA DGPS STATIONS	$2,660.00	/MONTH		MONTHS	$0.00	
USRADS	$7,035.00	/MONTH		MONTHS	$0.00	
DIGITAL CAMERA RENTAL	$85.00	/MONTH		MONTHS	$0.00	
ALL TERRAIN VEHICLES	$1,025.00	/MONTH		MONTHS	$0.00	
RADIO RENTAL	$50.00	/EA	23.0	EACH	$1,150.00	
TRAILER MOB. / DEMOB.	$1,500.00	/TRAILER		TRAILERS	$0.00	
TRAILER RENTAL/OFFICE RENTAL	$1,000.00	/MONTH	17.7	MONTHS	$17,678.57	
VEHICLE RENTAL - 4WD TRUCK including ga	$375.00	/WEEK	106.1	WEEKS	$39,776.79	
VEHICLE RENTAL - MINI VAN FOR CREW	$1,400.00	/MONTH		MONTHS	$0.00	
VEHICLE RENTAL - CAR	$250.00	/WEEK		WEEKS	$0.00	
SUBTOTAL EQUIPMENT					$7,948,861.61	
SUPPLIES & MATERIALS						
FIELD H&S SUPPLIES	$1,000.00	/LS	10.0	LS	$10,000.00	
VIDEO TAPES	$1.00	/TAPE		TAPES	$0.00	
FIELD BOOKS	$12.00	/BOOK	20.0	BOOKS	$240.00	
FIRST AID KIT	$50.00	/KIT	20.0	KITS	$1,000.00	
MISCELLANEOUS SUPPLIES	$25.00	/EA		EA	$0.00	
SUBTOTAL MATERIALS & SUPPLIES					$11,240.00	
OTHER DIRECT COSTS						
TELEPHONE / FAX	$100.00	/MONTH		MONTHS	$0.00	
SHIPPING / POSTAGE	$12.50	/EA	36.0	EACH	$450.00	
CELLULAR PHONE	$100.00	/MONTH	176.8	MONTHS	$17,678.57	
COLOR REPRODUCTION	$1.00	/COPY		COPIES	$0.00	
FedEX Large Packages	$67.00	/EA	200.0	EA	$13,400.00	
COLOR COPIES/MAPS	$1.00	/EA	100.0	EA	$100.00	
WORK STATION PLOTTER	$4.20	/HR		HRS	$0.00	
WEB HOST FEE	$30.00	/MONTH		MONTHS	$0.00	
REPORT COVER/BINDERS	$7.50	/COPY		COPIES	$0.00	
REPRODUCTION	$0.07	/COPY	5000.0	COPIES	$350.00	
UPS FREIGHT	$25.00	/EA		EA	$0.00	
PLOTTER SUPPLIES	$1,500.00	/LS		LS	$0.00	
CD DATA	$2.00	/EA		EACH	$0.00	
SCANNING OF DOCUMENTS	$0.50	/PAGE		PAGES	$0.00	
MISCELLANOUS OFFICE SUPPLIES	$25.00	/WEEK	70.7	WEEKS	$1,767.86	
SUBTOTAL OTHER DIRECT COSTS					$33,746.43	
TOTAL PRIME CONTRACTOR COSTS					$12,022,239.02	
SUBCONTRACTOR						
SUBCONTRACTOR - Excavation	$825,651.59	/LS	1.0	LS	$825,651.59	
SUBCONTRACTOR - Landfill	$9,034,680.00		1.0		$9,034,680.00	
SUBCONTRACTOR - Transportation	$847,001.00		1.0		$847,001.00	
SUBTOTAL SUBCONTRACTOR					$10,707,332.59	
TOTAL COST					$22,729,571.61	
FEE						
FEE ON PRIME SERVICES			8.00%		$249,195.68	
FEE ON SUBCONTRACTORS @			4.00%		$428,293.30	
SUBTOTAL FEE					$677,488.98	
TOTAL TASK					$23,407,060.59	

US Army Engineering and Support Center, Huntsville
Site 69, MCB Camp Lejeune (EXCAVATION)
CONTRACT W912DY-04-D-0000
TASK NO.: 2d
TASK TITLE: Backfill 14 acres / Seeding

TYPE: FIXED PRICE

TYPE
8
T&M 0005
FFP 0006

ITEM NUMBER		CATEGORY	EMPLOYEE TYPE	BURDENED LABOR RATES FIXED PRICE	TIME & MATLS	HOURS	TOTAL BILLINGS
0006	0	MECHANIC	0	$32.27	$35.53		$0.00
0006	0	CERTIFIED INDUST HYGIENIST	0	$105.98	$116.79		$0.00
0006	0	SENIOR SCIENTIST	0	$104.84	$115.99		$0.00
0006	0	STAFF SCIENTIST	0	$68.69	$75.33		$0.00
0006	0	FIELD OFFICE (ADMIN)	0	$35.72	$38.69	790	$28,219.51
0006	0	DRAFTER I	0	$42.07	$46.36		$0.00
0006	0	EMERGENCY MEDICAL TECH	0	$25.88	$28.04		$0.00
0006	0	COMPUTER PROGRAMMER	0	$73.12	$81.11		$0.00
0006	0	LABORER	0	$20.42	$22.11		$0.00
0006	0	HEAVY EQUIPMENT OPERATOR	0	$30.87	$33.93		$0.00
0006	0	GEOLOGIST	0	$70.38	$77.67		$0.00
0006	0	GEOPHYSICAL INSTRU OPER	0	$52.82	$57.55		$0.00
0006	0	PROJECT MANAGER	0	$98.34	$108.15	79	$7,811.07
0006	0	GIS MANAGER	0	$83.05	$92.11		$0.00
0006	0	ENGINEERING TECH I	0	$39.24	$43.36		$0.00
0006	0	ENGINEERING TECH II	0	$51.43	$56.87		$0.00
0006	0	INDUSTRIAL HYGIENIST	0	$75.53	$82.98		$0.00
0006	0	LAB TECHNICIAN	0	$38.10	$42.02		$0.00
0006	0	SECURITY GUARD	0	$25.74	$28.32		$0.00
0006	0	SENIOR UXO SUPERVISOR	0	$68.95	$76.99	790	$54,474.32
0006	0	SUXO (4% hazard pay)	0	$71.56	$79.91		$0.00
0006	0	SUXO (8% hazard pay)	0	$74.16	$82.84		$0.00
0006	0	SURVEYOR	0	$37.94	$41.42		$0.00
0006	0	TRUCK DRIVER	0	$28.03	$30.92		$0.00
0006	0	UXO TECHNICIAN I	0	$39.32	$42.67		$0.00
0006	0	UXO TECHNICIAN I (4% Haz Pay)	0	$40.77	$44.27		$0.00
0006	0	UXO TECHNICIAN I (8% Haz Pay)	0	$42.24	$45.87		$0.00
0006	0	UXO TECHNICIAN II	0	$47.06	$51.08		$0.00
0006	0	UXO TECHNICIAN II (4% Haz Pay)	0	$48.82	$53.01		$0.00
0006	0	UXO TECHNICIAN II (8% Haz Pay)	0	$50.58	$54.94		$0.00
0006	0	UXO TECHNICIAN III	0	$56.20	$61.41		$0.00
0006	0	UXO TECHNICIAN III (4% Haz Pay)	0	$58.30	$63.74		$0.00
0006	0	UXO TECHNICIAN III (8% Haz Pay)	0	$60.42	$66.06		$0.00
0006	0	GEOPHYSICIST-PROJECT	0	$99.49	$109.85		$0.00
0006	0	PROGRAM MANAGER	0	$131.14	$144.86		$0.00
0006	0	WORD PROCESSOR	0	$34.66	$37.73		$0.00
0006	0	UXO QUALITY CONTROL SPEC	0	$62.56	$67.84		$0.00
0006	0	UXO QC (4 % hazard pay)	0	$63.78	$69.13		$0.00
0006	0	UXO QC (8 % hazard pay)	0	$66.14	$71.71		$0.00
0006	0	UXO SAFETY OFFICER	0	$62.51	$67.80	790	$49,382.55
0006	0	UXO SSHO (4 % hazard pay)	0	$63.70	$69.09		$0.00
0006	0	UXO SSHO (8 % hazard pay)	0	$66.06	$71.66		$0.00
0006	0	UXO SWEEP PERSONNEL	0	$38.45	$41.74		$0.00
0006	0	SENIOR ENGINEER	0	$96.35	$106.31		$0.00
0006	0	STAFF ENGINEER	0	$74.07	$82.65		$0.00
0006	0	JUNIOR ENGINEER	0	$56.00	$61.90		$0.00
0006	0	SITE GEOPHYSICIST	0	$72.75	$80.69		$0.00
0006	0	SITE PROJECT MANAGER	0	$80.91	$87.78	790	$63,916.58
0006	0	CONTRACT SPECIALIST	0	$73.97	$81.80	24	$1,775.34
0006	0	BUSINESS MANAGER	0	$88.60	$97.88		$0.00
0006	0	EQUIPMENT SPECIALIST	0	$55.12	$59.97	40	$2,204.94
0006	0	QUALITY MANAGER	0	$86.45	$95.54		$0.00
0006	0	IT/COMMUNICATIONS MANAGER	0	$90.63	$98.64		$0.00
0006	0	IT/COMMUNICATIONS SPECIALIST	0	$64.38	$71.15		$0.00
0006	0	ADMIN MANAGER	0	$63.87	$69.39		$0.00
0006	0	ADMIN SPECIALIST	0	$41.79	$45.33		$0.00
0006	0	RESOURCE MANAGER	0	$77.19	$85.34		$0.00
0006	0	FINANCE SPECIALIST	0	$62.21	$67.87		$0.00
TOTAL SERVICES						3,239.4	$207,784.31

TRAVEL & LIVING				
AIR FARE	$650.000	/RND TRIP	TRIPS	$0.00
M&IE	$39.000	/DAY	417 DAYS	$16,263.00
LODGING	$40.000	/NIGHT	413 NIGHTS	$16,520.00
HOME TRAVEL	$1,000.000	/RND TRIP	TRIPS	$0.00
AIRFARES (Huntsville)	$800.000	/RND TRIP	TRIPS	$0.00
PER DIEM (Huntsville) incl local taxes	$102.000	/DAY	DAYS	$0.00
CAR RENTAL	$125.000	/DAY	DAYS	$0.00
SUV RENTAL	$500.000	/WEEK	WEEKS	$0.00
LONG TERM M&IE (55%)	$21.450	/DAY	DAYS	$0.00
LONG TERM LODGING (55%)	$22.000	/NIGHT	NIGHTS	$0.00
MISCELLANOUS TRAVEL COST	$50.000	/WEEK	WEEKS	$0.00
SUBTOTAL TRAVEL & LIVING				$32,783.00

14	acres backfill	
225000	C.Y.	
$456	mob/demob equipment (dozer, spreader)	
$2.77	loading (per C.Y. includes equipment, labor)	
$1.73	spreading (per C.Y. includes equipment, labor)	
	Totals	
$3,648.00	mob/demob equipment (loader, spreader) 4 each	
$623,250.00	dozer (per C.Y. includes equipment, labor)	
$389,250.00	spreading (per C.Y. includes equipment, labor)	
$1,016,148.00	Total	
	All costs taken from PCCost Book	
Time for 1 Dozer, Spreader		
30 acres/time	(per C.Y. includes equipment, labor)	
C.Y.	Time/Hours	
100	1	dozer
72	1	spreading
	Total Time/Hours	
	2250	loading
	3125	spreading
4	dozer / spreader	
	Total Time/10 hour days	
	225	loading
	313	spreading
79	work days	
790	work hours	
139	per diem days	
19.9	weeks	
5.0	months	
Seeding		
$975	mechanical seeding, 215 lb./acre	
	(includes equip. labor, seed)	
$13,650	Total	
	MSMeans Book	

EQUIPMENT					
COMPUTER USAGE	$8.50	/HOUR	647.9	HOURS	$5,507.03
GIS WORKSTATION	$27.00	/HOURS		HOURS	$0.00
CAD TIME	$10.50	/HOURS		HOURS	$0.00
WHITE'S HANDHELD LOCATOR	$105.00	/MONTH		MONTHS	$0.00
UXO FIELD DATA COLLECTORS-PALMTOPS	$105.00	/MONTH		MONTHS	$0.00
HANDHELD DATA COLLECTION DEVICES-A	$310.00	/MONTH		MONTHS	$0.00
EM61 MK2 RENTAL WITH PDGPS	$1,600.00	/MONTH		MONTHS	$0.00
VALLON VMX-2	$895.00	/MONTH		MONTHS	$0.00
MAGNA TRAC MAGNETOMETER	$95.00	/MONTH		MONTHS	$0.00
PORTABLE TOILETS	$85.00	/MONTH	14.9	MONTHS	$1,265.89
CHAIN SAWS	$300.00	/EA		EACH	$0.00
WEED EATERS	$225.00	/EA		EACH	$0.00
MAGNETOMETER BASE STATION	$300.00	/MONTH		MONTHS	$0.00
CESIUM 858 MAGNETOMETER	$60.00	/DAY		DAYS	$0.00
GRADIOMETER	$90.00	/DAY		DAYS	$0.00
GPS BASE STATION	$2,660.00	/MONTH		MONTHS	$0.00
OVERNIGHT SERVICES AND HANDLING	$175.00	/WEEK		WEEKS	$0.00
RADIO CONTROLLED FIRING DEVICE	$225.00	/MONTH		MONTHS	$0.00
SCHONSTEDT MAGNETIC LOCATORS	$120.00	/MONTH		MONTHS	$0.00
GPS PERSONAL NAVIGATORS	$80.00	/MONTH		MONTHS	$0.00
EM61 SHIPPING COST	$1,000.00	/TRIP		TRIPS	$0.00
SCHOENSTEDTS MOB/DEMOB	$55.00	/TRIP		TRIPS	$0.00
ROLLOFF (20 C.Y.)(8 tons)	$500.00	/WEEK		WEEKS	$0.00
TRACK HOE/DOZER	$3,500.00	/MONTH		MONTHS	$0.00
FUEL TRUCK	$1,500.00	/MONTH		MONTHS	$0.00
ROAD MAINTENANCE	$100,000.00	/LS		LS	$0.00
EXPLOSIVES/MAGAZINES	$10,000.00	/LS		LS	$0.00
DEMOLITION	$3,000.00	/LS		LS	$0.00
LEICA DGPS STATIONS	$2,660.00	/MONTH		MONTHS	$0.00
USRADS	$7,035.00	/MONTH		MONTHS	$0.00
DIGITAL CAMERA RENTAL	$85.00	/MONTH		MONTHS	$0.00
ALL TERRAIN VEHICLES	$1,025.00	/MONTH		MONTHS	$0.00
RADIO RENTAL	$30.00	/MONTH	14.9	MONTHS	$446.79
TRAILER MOB. / DEMOB.	$1,500.00	/TRAILER		TRAILERS	$0.00
TRAILER RENTAL/OFFICE RENTAL	$1,000.00	/MONTH	5.0	MONTHS	$4,964.29
VEHICLE RENTAL - 4WD TRUCK including ga	$750.00	/WEEK	39.7	WEEKS	$29,785.71
VEHICLE RENTAL - MINI VAN FOR CREW	$1,400.00	/MONTH		MONTHS	$0.00
VEHICLE RENTAL - CAR	$250.00	/WEEK		WEEKS	$0.00
SUBTOTAL EQUIPMENT					$41,969.71
SUPPLIES & MATERIALS					
FIELD H&S SUPPLIES	$1,000.00	/LS	2.0	LS	$2,000.00
VIDEO TAPES	$1.00	/TAPE		TAPES	$0.00
FIELD BOOKS	$12.00	/BOOK		BOOKS	$0.00
FIRST AID KIT	$50.00	/KIT	3.0	KITS	$150.00
MISCELLANEOUS SUPPLIES	$25.00	/EA		EA	$0.00
SUBTOTAL MATERIALS & SUPPLIES					$2,150.00
OTHER DIRECT COSTS					
TELEPHONE / FAX	$100.00	/MONTH		MONTHS	$0.00
SHIPPING / POSTAGE	$12.50	/EA	8.0	EACH	$100.00
CELLULAR PHONE	$100.00	/MONTH	14.9	MONTHS	$1,489.29
COLOR REPRODUCTION	$1.00	/COPY		COPIES	$0.00
FedEX Large Packages	$67.00	/EA		EA	$0.00
COLOR COPIES/MAPS	$1.00	/EA		EA	$0.00
WORK STATION PLOTTER	$4.20	/HR		HRS	$0.00
WEB HOST FEE	$30.00	/MONTH		MONTHS	$0.00
REPORT COVER/BINDERS	$7.50	/COPY		COPIES	$0.00
REPRODUCTION	$0.07	/COPY	600.0	COPIES	$42.00
UPS FREIGHT	$25.00	/EA		EA	$0.00
PLOTTER SUPPLIES	$1,500.00	/LS		LS	$0.00
CD DATA	$2.00	/EA		EACH	$0.00
SCANNING OF DOCUMENTS	$0.50	/PAGE		PAGES	$0.00
MISCELLANOUS OFFICE SUPPLIES	$25.00	/WEEK	8.0	WEEKS	$200.00
SUBTOTAL OTHER DIRECT COSTS					$1,831.29
TOTAL PRIME CONTRACTOR COSTS					$286,518.30
SUBCONTRACTOR					
SUBCONTRACTOR - Backfill	$1,016,148.00	/LS	1.0	LS	$1,016,148.00
SUBCONTRACTOR - Seeding	$13,650.00		1.0		$13,650.00
SUBCONTRACTOR -					$0.00
SUBTOTAL SUBCONTRACTOR					$1,029,798.00
TOTAL COST					$1,316,316.30
FEE					
FEE ON PRIME SERVICES			8.00%		$16,622.74
FEE ON SUBCONTRACTORS @			4.00%		$41,191.92
SUBTOTAL FEE					$57,814.66
TOTAL TASK					$1,374,130.97

DEPARTMENT OF THE ARMY
HUNTSVILLE CENTER, CORPS OF ENGINEERS
P.O. BOX 1600
HUNTSVILLE, ALABAMA 35807-4301

REPLY TO
ATTENTION OF:

CEHNC-OE-CW

MEMORANDUM FOR Environmental Management Division, EQB, (Robert Lowder) Building 12, Marine Corps Base, PSC Box 20004, Camp Lejeune, NC 28542

SUBJECT: Estimated Costs for Remedial/Response Action at Sites 41, 69, and 74 on Camp Lejeune Marine Corps Base, Camp Lejeune, North Carolina

1. The U. S. Army Engineering and Support Center, Huntsville was tasked on 18 September, 2007 by Camp Lejeune Environmental Management Division to complete cost estimates for final remedies at site 41, 69, and 74. In an effort to complete this task Ms. Betina Johnson and Mr. Bruce Whisenant visited Camp Lejeune on 7 and 8 November, 2007 to review the administrative record for the subject sites as well as discuss possible scenarios with Mr. Robert Lowder, Environmental Project Manager.

2. Upon return from the site visit, Mr. Bruce Whisenant and Mr. David Horvath reviewed and summarized records for subject sites and prepared cost estimates for 2 options at each site: engineered cap, and removal of all material. The estimates are attached as well as the site summaries used to prepare these estimates.

3. The estimated total costs for actions at each site are summarized as:

a. Site 41, Camp Geiger Dump near Former Trailer Park, $3,295,000.00 (cap), $63,624,000.00 (removal)

b. Site 69, Rifle Range Chemical Dump, $1,696,000.00 (cap), $30,716,000.00 (removal)

c. Site 74, Mess Hall Grease Pit Disposal Area, $2,758,000.00 (cap), $50,763,000.00 (removal)

4. For further clarification, and/or comments please contact Ms. Betina Johnson by telephone at (256) 895-1238 or by e-mail at Betina.V.Johnson@us.army.mil. Thank you for the opportunity to assist in this effort.

Charles L. Twing
Chief, Chemical Warfare Design Center
For Ordnance and Explosives Directorate

Camp Lejeune, North Carolina
Landfill Cost Alternative Analysis

Executive Summary:

The U.S. Army Engineering and Support Center, Huntsville (CEHNC) was tasked by Camp Lejeune to evaluate and provide a rough order cost estimates for the removal and capping alternatives for three landfills located on the installation. Site 41 (Camp Geiger Dump near the Former Trailer Park), Site 74 (Mess Hall Grease Pit Disposal Area), and Site 69 (Rifle Range Chemical Dump) were reviewed and a cost basis was prepared. All three landfills were assumed to contain mixed hazardous and toxic waste (HTW), ordnance, and Chemical Agent Identification Sets (CAIS). Unexploded Ordnance and chemical warfare material (CWM) are a safety hazard and constitutes a hazard to the installation personnel, public (if accessible) and to the environment. The disposal of the hazardous waste shall be conducted by a facility which operates as a Treatment, Storage, and Disposal Facility (TSDF) under Resource Conservation and Recovery Act (RCRA) regulations. The following Rough Order of Magnitude Costs were formulated based upon very conservative assumptions. In order to reduce the cost numerous methods could and should be implemented prior to a removal action. Those would include historical photographical analysis, geophysical survey, intrusive test pits, and sampling and analysis in order to reduce the volume of material to be disposed and thus reduce the removal cost estimate. The following Table contains the Summary of the Rough Order of Magnitude Estimates for the Capping and Removal alternatives for each site and a total for all three sites. The detailed cost estimates are provided in the appendices.

Site Location	Description	Summary Cost Estimate of Capping Landfill	Summary Cost Estimate for Removal of Landfill Contents
Site 41	Camp Geiger Dump near the Former Trailer Park	$3, 079,000 + 7 % (CEHNC Oversight) = $3,295,000	$57,840,000 + 10% (Contingency & oversight) = $63,624,000
Site 74	Mess Hall Grease Pit Disposal Area	$2,578,000 + 7 % (CEHNC Oversight) = $2,758,000	$46,148,000 + 10% (Contingency & oversight) = $50,763,000
Site 69	Rifle Range Chemical Dump	$1,585,000 + 7 % (CEHNC Oversight) = $1,696,000	$27,924,000 + 10% (Contingency & oversight) = $30,716,000
Total Cost		$7,749,000	$145,103,000

1.0 Site 41 – Camp Geiger Dump Near Former Trailer Park Site Description and Alternative Analysis

1.1 Site 41- Camp Geiger Dump Near Former Trailer Park

1.1.1 Site Location and Setting.

Site 41, Camp Geiger Dump Near Former Trailer Park, is located in the Camp Geiger area of MCB Camp Lejeune. The site is situated east of U.S. Highway 17, south of the former Camp Geiger trailer park, west of an unnamed tributary, and north of Tank Creek. The unnamed tributary and Tank Creek flow into Southwest Creek east of the site. Southwest Creek discharges into the New River approximately 3 miles downstream of this confluence. The area is heavily wooded and vegetated. The physical boundary of the former disposal area is barely discernible. Dirt roads are present along the boundary and through the center of the site. Some portions of these roads are overgrown and impassible due to standing water. The area of the former dump is estimated to be approximately 30 acres (Water & Air Research, 1983). Aerial photographs of the site confirm this estimation. The areas along the eastern and southern boundaries are classified as wooded wetlands. These areas are down slope of the former disposal area. Throughout the former disposal area are piles of construction debris, mainly metal and concrete. Drums of various sizes (i.e., 5 gallons up to 55 gallons) were noted during the site reconnaissance throughout the disposal area at "random" locations (e.g., one drum or canister was observed at various areas throughout the site). Most of the drums were rusted and unidentifiable. However, one empty canister was labeled "Dry Cleaning Solvent." There were no areas where more than one or two drums were noted on the ground surface.

1.1.2 Topography and Surface Drainage

The former dump is situated at a local topographic high area with an elevation of approximately 20 feet mea sea level. With the exception of the northwest portion of the study area, which is relatively flat, the area surrounding the former dump is comprised of moderate to steep hillsides which slope toward the unnamed tributary to the north and east, and to Tank Creek to the south and southwest. Soils identified by the Soil Conservation Service survey (USDA, 1984) identified excavated soils at Site 41. The occurrence of excavated soils at Site 41 would tend to confirm past disposal activities. Excavated soils are typically poorly drained and lack vertical layering. Surface waters are subject to standing water during the wet seasons of the year. Standing water was observed along old roadways throughout the site.

1.1.3 Site History

Site 41 was used as an open burn dump from 1946 to 1970. The dump received construction debris and several types of wastes including: petroleum, oil, and lubricants (POL); solvents; batteries; and ordnance including thousands of mortar shells, one case of grenades, and one 105mm Howitzer shell. In addition, it is reported that in the mid-1960s, at least two waste disposal incidents occurred involving the disposal of drummed wastes from trucks. At such times, a fire truck was present. These wastes were described as being similar to the types of wastes disposed of at Site 69 (Rifle Range Chemical Dump). More definitive information is not available to properly identify these wastes. However, it is known that drums of chemical training agents, which may contain small quantities of blister agents, were disposed of at Site 69. In addition, an incident occurred at Site 69 involving the explosion of containers containing HTH.

1.1.4 Site Geology and Hydrogeology

Previous investigations conducted at Site 41 involved the installation of monitoring wells and the collection of static water levels. The site is underlain primarily by silty sand, with discontinuous layers of shelly sand, silty-clay sand, silt, and clay. The surface of the shallow groundwater lies within the silty sand at depths ranging from 2.56 to 10.75 feet below ground surface. Groundwater flow was reported to be southeast toward Tank Creek and the unnamed tributary. Based on the topography of the area, shallow groundwater may flow radially from the site.

1.1.5 Land Use and Demographics

The area encompassing Site 41 is occasionally used for military training exercises. The site is not fenced; therefore, access is not restricted from within the base or U.S. Highway 17. The closest military complex is Camp Geiger, located approximately two miles northeast of the site. Future land use of the area is reserved for military training. Hunting is permitted in the area via permission from the base command. The area downslope of the site is a wooded wetland. There may be sensitive ecological receptors in this area.

1.1.6 Previous Investigations and Findings

1.1.6.1 Groundwater Investigations

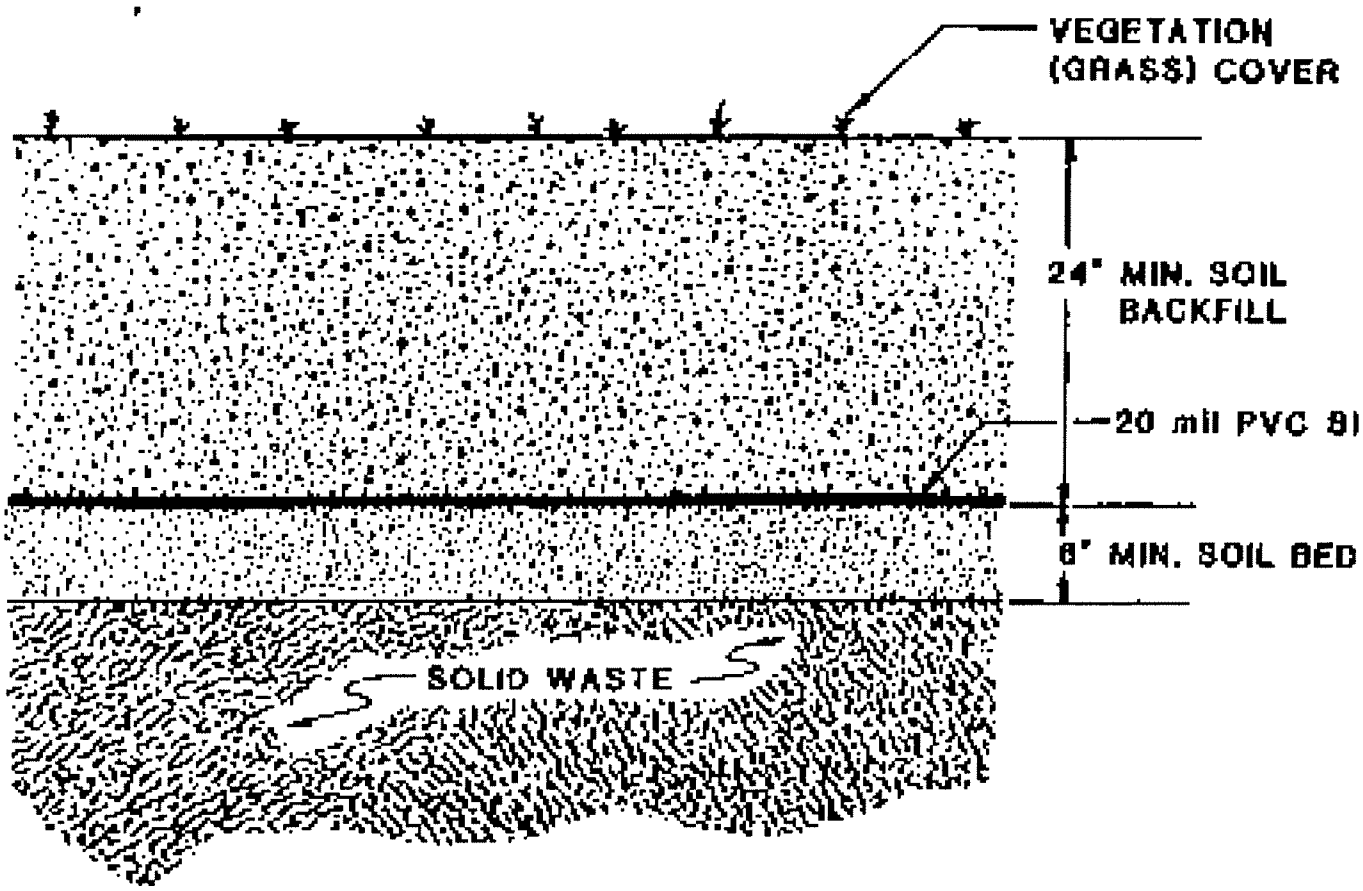
Monitoring wells were sampled and detected levels of chromium, Lead, Dichlorodifluoromethane, vinyl chloride , benzene , and RDX (cyclotrimethylenetrinitramine), a compound associated with explosives, was detected in a well.

1.1.6.2 Surface Water/Sediment Investigation

Four surface water and sediment samples were collected in 1987; two from Tank Creek and two from the unnamed tributary (see Figure 2-16). The surface water samples were analyzed for the same parameters as groundwater. Sediment samples were analyzed for the following compounds: Oil and grease,phenols, Aldrin, the pesticide deltaBHC or hexachlorocyclohexane (BHC,D), total chromium, hexavalent chromium, lead, samples from Tank Creek revealed the explosive constituent trinitrotochene (2,4,6-TNT). Overall, surface water and sediments may be impacted by the former disposal activities at Site 41.

1.2 Site 41 Landfill Cap Estimate Basis

The installation desires to review a rough order of magnitude cost basis for the risk reduction of access to this landfill by community at a proposed housing development in close vicinity to this former landfill. The overall project would be to provide Ordnance and Explosive personnel in support of construction activities to include the placement of fill material on the landfill, placement of a geo-textile fabric cover and complete fence of the perimeter of the former landfill compound. The cost basis closure design developed for the site includes a low permeability 'top cap', well vegetated side slopes, and an integrated drainage system to capture and remove surface runoff, reducing percolation and subsequent leachate generation. The site closure design includes the placement of PVC sheet, soil bedding and cover material, a passive landfill gas venting system, drainage improvements, and seeding, mulching and sodding of the completed landfill. A typical cross section through the final cover is shown in Figure 1:



FINAL COVER DESIGN

FIGURE 1

1.3 Site 41 Removal Action

The installation desires to review a rough order of magnitude cost basis for the complete risk reduction (i.e. removal of this landfill) to alleviate future installation and community concerns. The overall project would be to provide complete removal of waste disposed of in the landfill to include construction debris, hazardous waste, special waste, ordnance, and Chemical Agent Identification Sets (CAIS). Ordnance and Explosive personnel shall be in support of construction activities to oversee ordnance and CAIS operations and the disposition of these items. Although source removal shall be undertaken by this removal action project and will alleviate future aquifer degradation, the existing aquifer contamination as a result of former past activities may remain an issue

post removal. This estimate does not address aquifer contamination or post landfill removal aquifer monitoring. Some of the key assumptions shall be identified in the following Table 1:

Key Assumptions for Site 41 Removal	Quantity / Duration
Heavy clearing and grubbing (30 acres)	30 acres
Blast berm construction (this blast berm will be used for fill material at excavation completion) Assume 4 sides of landfill for blast mitigation (20 feet tall x 200 feet wide (slope 1/5 feet)=75 yds per foot of berm Berm will be in place prior to intrusive operations (clean fill)	5390 LF x 75 yds=404,250 CY of clean material
10 feet deep x 30 acres for material to be placed in 20 yard roll off contaminated with pesticides residue therefore, disposed at hazardous waste landfill =484,000 yds/ 20 yds roll off= 24200 trucks	484, 400 CY hazardous waste landfill
PPE-Modified Level D operations with approximately one week Level B operations	605 days
24200 Trucks / 40 per day= 605 days or 800 CY per day	605 work days / 10 hrs day=6050 hrs for excavation
Excavation heavy equipment with protective plating (blast protection)	4 each x $50K=$200K
Site restoration /sodding	30 acres
Crew Makeup	
UXO crew 6 member for duration	605 work days
sampling crew (3 members)	605 work days
Assume field construction crew (7 total) 4 equipment operators, one safety and one supervisor, one resident engineer	
One PM, engineering, and office support for project (work plan,	$ 250K
Personnel Decon Station and operators, 4 total	605 work days
Edgewood Chemical and Biological Center air monitoring and support ($45K per week) x 121 weeks	$5,445,000
Packaging Crew (Level C and B) 4 person for excavation duration	605 days
Disposal and Analytical	
Hazardous waste disposition into RCRA landfill (pesticide contaminated)	484, 400 CY hazardous waste landfill

Assume 200 drums to be overpacked and disposed (pesticides and solvents)	200 overpacked dums as Hazardous waste
Assume 1 sample per every 4 roll off (40/4= 10 x 605=6050)samples plus 200 unknowns=6250 x $1000/sample=	$6,250,000
Confirmation samples (bottom and side wall) one per 1000 square feet Walls (5390 lftx 10 feet=54 samples) plus bottom (30 acres=1307 samples) say 1400 samples to include QA/QC	$1,400,000
Dispose on site 5000 ordnance rounds at $150 per round	$750,000
CAIS disposal (assume 20 complete kits) X $5,0000 disposal each	$100,000

2.0 Site 74 - Mess Hall Grease Pit Disposal Area Site Description and Alternative Analysis

2.1 Site Location and Setting

Site 74 the Mess Hall Grease Pit Disposal Area is located in a stand of woods approximately l/2 mile east of Holcomb Boulevard in the northeast portion of MCB Camp Lejeune. There are two areas of concern at Site 74: the Grease Pit Disposal Area and the Former Pest Control Area. The Mess Hall Grease Pit Disposal Area north of the gravel road, and west of the dirt-access road is approximately three acres in size. The grease pit reportedly measures 135 feet long, 30 feet wide and 12 feet deep. The Pest Control Area is located approximately 20 to 50 yards south of the grease pit and 75 yards east of Supply Well 654. The total size of the Pest Control Area has been estimated at 100 feet by 100 feet. The area which surrounds the former pest control area may also be associated with disposal operations based on historical aerial photographs. Both areas are overgrown with vegetation and trees, and is predominantly flat. There are some signs of previous disposal activities. One former trench is somewhat discernible; drum fragments were observed penetrating the surface just west of a dirt access road. The former location of the grease pit (at the intersection of the dirt road and gravel road) is also discernible, but not apparent. The former grease pit area sits somewhat lower than the dirt access road. During some of the previous site visits, the area was covered with water, indicating a poor drainage area. The former pesticide control area is heavily vegetated. The former pest control building is no longer present. The foundation is barely discernible. The surrounding area mentioned previously is also heavily vegetated.

2.2 Topography and Surface Drainage

The land is primarily flat. A low area is present at the location of the former grease pit, west of the dirt access road. This low area is occasionally ponded during periods of heavy precipitation. There are no noticeable drainage pathways other than this low-lying portion of the site.

2.3 Site History

Information reviewed indicated that three separate activities occurred at Site 74: the disposal of grease/food into a large pit; burials of 55-gallon drums near the grease pit, possibly containing PCB transformer oil and pesticides; and the disposal of pesticide-soaked bags of sawdust in wetland areas for mosquito control. At least one attempt to burn the grease using a more flammable substance failed. In 1954, Hurricane Hazel passed through the area and washed/floated the grease from the pit. The use of the pit was discontinued. The disposal of about 20 drums of PCB containing transformer oil reported occurred about 1963. The pest control activities reportedly occurred during the period

1950-1958. Pesticide drum burials were reported to occur in the early 1950s. One or more truckloads of pesticides in 55-gallon drums were disposed of at this site. It is also important to note that some drums may have been left over from a burial/disposal incident at the Rifle Range Chemical Dump (Site 69). Since drums containing chemical agents are reportedly buried at Site 69, it is possible that drums containing chemical agents are also buried at Site 74. There is no documentation with respect to the drums contents that were originally planned for disposal at Site 69 but were disposed of at Site 74. Historical photographs indicate that in the mid 195Os, the former pest control area was used as either a disposal area, or a staging area for fill. Multi-toned mounded materials are depicted in the 1956 aerial photograph. It is unknown whether this material is simply piles of soil, or waste. Since that time, no significant activity in this area has been documented via aerial photographs. Several trenches near the former grease pit, primarily north of the grease pit, are depicted in aerial photographs. These trenches may be associated with the disposal of pesticide, PCB, or chemical agent wastes in drums.

2.4 Site Geology and Hydrogeology

Site 74 is underlain primarily by sand and silty sand. The shallow groundwater lies within the silty sand. The depth to the groundwater was measured to be between 2.01 to 12.2 feet bgs. Shallow groundwater flows east at an approximate gradient of 0.014 ft/ft.

2.5 Land Use and Demographics

The area around Site 74 is occasionally used for military training. The closest military complex is associated with a water treatment plant and administrative building located about one-half mile west of the site. Midway Park, a large housing development, is located about one mile northwest of the site. Future land use of the area is reserved for military training. The upper reaches of Wallace Creek, located approximately two miles southeast of the site, is designated as a natural area. There are no sensitive ecological populations reported to habitat the site area.

2.6 Previous Investigations and Findings

Previous investigations at Site 74 focused on soil and groundwater. There is no on-site surface water. Henderson Pond, the nearest surface water body, is located approximately 0.4 miles southeast of the site.

2.6.1 Soil Investigation

Soil borings were taken in the Pest Control Area with the samples were analyzed for organochlorine pesticides. Analytical findings indicate that DDD, DDE, and DDT were present in the soil.

2.6.2 Groundwater Sampling

Monitoring wells (Figure 2-11) were installed as part of past investigations The groundwater samples collected during the 1984 investigation were analyzed for the following target compounds: organochlorine pesticides, chlorinated herbicides, and PCBs. Only two contaminants, DDE and DDT, were detected in monitoring well. The groundwater samples collected during the 1986/1987 investigation were analyzed for the following compounds: organochlorine pesticides, chlorinated herbicides, PCBs, tetrachlorodioxin, and volatile organics. Aldrin was reported, at a concentration of 0.029 pg/L, in the groundwater sample collected from monitoring well

2.6.3 Pre-Investigation Sampling and Findings

Organic contamination was not detected in the groundwater samples collected at this site. Total metals detected at this site were aluminum, barium, iron, magnesium, potassium, and sodium. Applicable standards have been established for only barium and iron. The iron concentration detected in both wells exceeded the North Carolina Water Quality Standards.

2.6.4 Geophvsical Investigation

A geophysical investigation was conducted at Site 74 in July 1992. The purpose of the geophysical investigation was to delineate potential disposal areas and assist in the scoping of the RI/FS. This survey indicated a probability of subsurface disposal only near the west end of Line 4 + 60N.

2.7 Site 74 Landfill Cap Estimate Basis

The installation desires to review a rough order of magnitude cost basis for the risk reduction of access to this landfill by installation personnel in close vicinity to this former landfill. The overall project would be to provide Ordnance and Explosive personnel in support of construction activities to include the placement of fill material on the landfill, placement of a geo-textile fabric cover and complete fence of the perimeter of the former landfill compound. The cost basis closure design developed for the site includes a low permeability 'top cap', well vegetated side slopes, and an integrated drainage system to capture and remove surface runoff, reducing percolation and subsequent leachate generation. The site closure design includes the placement of PVC sheet, soil bedding and cover material, a passive landfill gas venting system, drainage improvements, and seeding, mulching and sodding of the completed landfill. A typical cross section through the final cover is shown in Figure 1:

2.8 Site 74 Removal Action

The installation desires to review a rough order of magnitude cost basis for the complete risk reduction (i.e. removal of this landfill) to alleviate future installation and community concerns. The overall project would be to provide complete removal of waste disposed of in the landfill to include construction debris, hazardous waste, special waste, ordnance, and Chemical Agent Identification Sets (CAIS). Ordnance and Explosive personnel shall be in support of construction activities to oversee ordnance and CAIS operations and the disposition of these items. Although source removal shall be undertaken by this removal action project and will alleviate future aquifer degradation, the existing aquifer contamination as a result of former past activities may remain an issue post removal. This estimate does not address aquifer contamination or post landfill removal aquifer monitoring. Some of the key assumptions shall be identified in the following Table:

Key Assumptions for Site 74 Removal	Quantity / Duration
Heavy clearing and grubbing (24.2 acres)	24.2 acres
Blast berm construction (this blast berm will be used for fill material at excavation completion) Assume 4 sides of landfill for blast mitigation (20 feet tall x 200 feet wide (slope 1/5 feet)=75 yds per foot of berm Berm will be in place prior to intrusive operations (clean fill)	4000 LF x 75 yds=300,000 CY of clean material
10 feet deep x 24.2 acres for material to be placed in 20 yard roll off contaminated with pesticides residue therefore, disposed at hazardous waste landfill =390,428 yds/ 20 yds roll off= 19521 trucks	390,428 CY hazardous waste landfill
Relocate gravel road (temporary around site's perimeter)	2000 ft
19521 Trucks / 40 per day= 488 days or 800 CY per day	488 work days / 10 hrs day=4880 hrs for excavation
PPE-Modified Level D operations with approximately one week Level B operations	488 days
Excavation heavy equipment with protective plating (blast protection)	4 each x $50K=$200K
Site restoration /sodding	24.2 acres
Crew Makeup	
UXO crew 6 member for duration	488 work days

sampling crew (3 members)	488 work days
Assume field construction crew (7 total) 4 equipment operators, one safety and one supervisor, one resident engineer	
One PM, engineering, and office support for project (work plan,	$ 250K
Personnel Decon Station and operators, 4 total	488 work days
Edgewood Chemical and Biological Center air monitoring and support ($45K per week) x 98 weeks	$4,410,000
Packaging Crew (Level C and B) 4 person for excavation duration	488 days
Disposal and Analytical	
Hazardous waste disposition into RCRA landfill (pesticide contaminated)	390,428 CY hazardous waste landfill
Assume 200 drums to be overpacked and disposed (pesticides and solvents)	200 overpacked dums as Hazardous waste
Assume 1 sample per every 4 roll off (40/4= 10 x 488=4880)samples plus 200 unknowns=5080 x $1000/sample=	$5,080,000
Confirmation samples (bottom and side wall) one per 1000 square feet Walls (4000 lftx 10 feet=40 samples) plus bottom (24.2 acres=1054 samples) say 1200 samples to include QA/QC	$1,200,000
Dispose on site 200 ordnance rounds at $150 per round	$30,000
CAIS disposal (assume 20 complete kits) X $5,0000 disposal each	$100,000

3.0 Site 69 - Rifle Range Chemical Dump Site Description and Alternative Analysis

3.1 Site Location and Setting

Site 69, the Rifle Range Chemical Dump, is located west of the New River estuary in the area of MCB Camp Lejeune known as the Rifle Range. The site is a former disposal ground (i.e., landfill), and is approximately 6 acres in size. The site is heavily wooded with several species of trees, including pine, dogwood and oak. The understory comprises sparse grasses and shrubs. Access is restricted by a chain-link fence with a locked entrance gate. The site is located approximately three miles east-southeast of the intersection of Route 17 and Route 210. The site is situated where a light-duty, unnamed roadway splits to form a "Y." This road shall be referred to in this Work Plan as the "access road." The New River is located about one-quarter mile east of the site. Everett Creek is located about one-half mile south of the site. An unnamed tributary to the New River is situated about one-quarter mile north of the site. A light duty road borders the site to the west. Both the Everett Creek and the unnamed tributary drain into the New River. During a site reconnaissance on September 5, 1991, five areas of suspected disposal activities were observed. A brief description of these areas is presented below. Two areas of stained soils were identified in the south-central portion of the site. Both areas were similar in appearance--dark brown seeping soils. The first area, Stained Soil Area No. 1, was approximately 15 feet by 15 feet in area; the second stained area, Stained Soil Area No. 2, was smaller, approximately 7 feet in diameter. High readings on a metal detector were obtained at both of the stained areas. The areas immediately surrounding the two stained locations were covered with undisturbed vegetation and small trees. No particular odors were identified during the site visit. Immediately north of Stained Soil Area what appeared to be a former disposal area approximately 1 to 2 feet wide by 20 feet long. Many glass vials, white powder material, and containers for chemical agent test sets were scattered along the ground surface in this area. Adjacent to this area, a long trench was observed approximately 75 feet long and 4 to 6 feet wide. The trench surface was covered with vegetation. Numerous mounds of soil were located alongside the trench. Readings from the metal detector were elevated at these mounds. The approximate location of this trench corresponds to a trench identified in the USEPA Environmental Photographic Interpretation Center (EPIC) study. In the north-central portion of the site, an evidently disturbed area was found with a rectangular-shaped covering approximately 0.25 acre. The ground cover and trees in this area presently consist of an immediate growth of lawn vegetation and saplings; the vegetation immediately around the area is more dense, and the trees are more mature.

3.2 Topography and Surface Drainage

Site 69 is situated at a topographic high for the immediate surrounding area. Most of the site within the fence is flat; however, the topography surrounding the site slopes gently in all directions. During the September 1991 site reconnaissance, portions of the site area exhibited standing water, which could indicate poor drainage. Surface water runoff from the northern portion of the site may drain toward the unnamed tributary located to the north; however, the surrounding area is heavily wooded and consists of a dense understory that could inhibit off-site drainage at great distances. Surface runoff from the southeastern portion of the site apparently drains to unnamed ditches that drain into the New River. Surface runoff from the southwestern portion of the site drains into the Everett Creek basin, which could potentially drain into Everett Creek and the New River. However, as previously mentioned, the surrounding areas are heavily wooded and consist of a thick understory, which could inhibit overland surface runoff at great distances.

3.3 Site History

Site 69 was used as a chemical waste dump between 1950 and 1976. The waste materials were reportedly disposed in pits or trenches, 6 to 20 feet deep. Various wastes have been reportedly disposed of at the site, including: polychlorinated biphenyls (PCBs), fire retardants, pentachlorophenol, dichlorodiphenyltrichloroethylene (DDT), trichloroethene (TCE), malathion, diazinon, lindane, calcium hypochlorite, gas cylinders, high-test hypochlorite (HTH), drums of "gas" [possibly training agent containing chloroacetophenone (CN)], chemical agent test kits for chemical warfare, and fired and unfired blank rifle cartridges. It is also reported that drums containing chemical agents (e.g., mustard gas, blister agents, etc.) were buried at Site 69. Two areas were identified by a civilian employee in October 1982. The employee stated that in 1953, he operated equipment used to bury 55-gallon drums. The employee stated that extensive protective clothing was required, including a gas mask, hood, jacket, and gauntlets. The employee stated that the drums were protected by rubber matting on the bed of the truck, as well as rubber-padded equipment. The original pit was abandoned after burying approximately 15 drums. The remaining 35 to 40 drums were buried approximately 40 yards away in a single pit. Although it was intended to create a pit 20 feet deep, the sides of the pit caved in repeatedly. In both pits, the drums are reported to be positioned side by side and stacked several rows deep. The top layer of drums is reported to be approximately 5 feet below ground surface. Based on conversations with personnel from The U.S. Army Environmental Center (USAEC) formerly the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) and the U.S. Army Technical Escort Unit (TEU), there is a high probability that chemical agent training kits, as opposed to chemical warfare devices, are buried at the site.

PCBs were reportedly sealed in cement septic tanks prior to disposal at the site. The presence of the fired and unfired rifle cartridges indicate that troop-training exercises have occurred in this area. In 1970, an explosion reportedly occurred at Site 69 during a disposal operation. Containers of DDT, TCE and calcium hypochlorite had been placed in a pit at the site. While the containers were being covered with earth, an explosion and fire occurred. The site is inactive at present. Access is restricted by a chain-link fence. No known training activities are presently conducted within the fenced-in area.

3.4 Site Geology and Hydrogeology

Previous investigative activities at Site 69 involved the drilling of shallow soil borings, and the construction of eight monitoring wells in these borings. The site is reportedly underlain by silty sand and sandy clay with discontinuous layers of clayey sand, sand, sandy silt, and clayey silt The water table was encountered in silty sand and clayey sand at depths ranging from approximately 5 to 22 feet below ground surface (bgs), and in silty sand, clayey sand, and sandy clay at depths ranging from approximately 7 to 27 feet bgs Groundwater flow may be impacted by watershed boundaries. Shallow groundwater flow is reported to be across the site toward the north and northwest. However, a review of the topography of the site as well as the hydrology of the area indicate that groundwater flow under the eastern portion of the former dump is east-southeast in the southeast section, and east-northeast in the northeast section.

3.5 Land Use and Demographics

The area around Site 69 is used for military training. A fence has been constructed around the site to prevent access. The closest military complex, the Rifle Range, is located approximately one mile northwest of the site. Future land use of the area is reserved for military training only. Hunting is not permitted in the area. Sensitive environmental areas would include the unnamed tributary to the north of the site and Everett Creek to the south. Both of these water bodies are in a coastal wetland. There are no sensitive human receptors within one mile of the site area. An elementary school is located approximately two miles west of the site.

3.6 Previous Investigations and Findings

This section summarizes the results of previous environmental investigations.

3.6.1 Soil

No soil samples have been collected at Site 69, Rifle Range Chemical Dump.

3.6.2 Groundwater

Groundwater monitoring wells were installed and sampled at Site 69. The samples were analyzed for PCBs, pentachlorophenol, residual chlorine,

organochlorine pesticides, mercury and volatile organic compounds (VOCs). PCBs, pentachlorophenol, and chlorine were not detected in the samples. Mercury was detected, but at levels significantly lower than the North Carolina Groundwater. Samples from monitoring wells located along the southern and eastern portion of the site contained VOCs such as benzene, 1,2-dichloroethane, trans-1,2-dichloroethene, trichloroethene, toluene, and vinyl chloride. A second round of groundwater samples was collected from the eight monitoring wells. The samples were analyzed for the same compounds plus tetrachlorodioxin, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), and ethylene dibromide. The results from this sampling were similar to those of the 1984 sampling; various VOCs were detected. Monitoring wells were sampled in January 1991and analyzed for full target compound list (TCL) organics. Pesticides and semivolatiles were not detected in the samples. As with the other rounds of sampling, various VOCs were detected: carbon disulfide, 1,2 - dichloroethelyene (1,2-DCE) , TCE , vinyl chloride , and chlorobenzene . Detected inorganics included aluminum, antimony , arsenic, barium , beryllium, calcium, chromium, cobalt, copper, cyanide , iron , lead , magnesium, manganese, nickel, potassium , silver, sodium, thallium, vanadium, and zinc. Groundwater flow direction in this portion of the site is believed to be southeast, based on the topography of this area and the drainage pattern.

3.6.3 Sediment

Sediment samples were collected from two unnamed tributaries that drain from Site 69 into the New River estuary. The two tributaries are located east-southeast of the site. The samples were analyzed for organochlorine pesticides, PCBs, pentachlorophenol, VOCs, mercury, residual chlorine, tetrachlorodioxin, MEK, MIBK, and ethylene dibromide . The only compounds detected in these samples included dichlorodiphenyldichloroethane (DDD),dichlorodiphenyldichloroethylene (DDE) , and pentachlorophenol. In January 1991, three sediment samples were collected at the same locations where surface water samples were collected. The samples were analyzed for full TCL organics. No VOCs, pesticides, or semivolatiles were detected in the samples. Inorganics detected in the samples included aluminum, antimony, barium, beryllium, cadmium, calcium, chromium, copper, iron , lead, magnesium, manganese, potassium, silver, vanadium, and zinc . Sediment samples were collected along the New River, Everett Creek, and an unnamed tributary to the river, as part of an Ecological Risk Assessment for Site 69.

2.6.4 Geophysical Investigation

Geophysical surveys were conducted at Site 69. At Site 69, lateral changes in conductivity were observed across two broad areas located in the south and north portions of the site. In the central portion of the site and partially coincident with the increased conductivities, buried metallic and ferrous metallic objects were detected. The greater lateral extent of increased conductivity relative to that

of the buried metal locations, may indicate the previous widespread burial of non-metallic materials and/or the limits of a conductive contaminant plume. The areas identified with geophysics appear to be coincident with burial trenches identified on 1956, 1958, and 1964 aerial photographs by EPIC.

2.7 Site 69 Landfill Cap Estimate Basis

The installation desires to review a rough order of magnitude cost basis for the risk reduction of access to this landfill by installation personnel (troop training) in close vicinity to this former landfill. The overall project would be to provide Ordnance and Explosive personnel in support of construction activities to include the placement of fill material on the landfill, placement of a geo-textile fabric cover and complete fence of the perimeter of the former landfill compound. The cost basis closure design developed for the site includes a low permeability 'top cap', well vegetated side slopes, and an integrated drainage system to capture and remove surface runoff, reducing percolation and subsequent leachate generation. The site closure design includes the placement of PVC sheet, soil bedding and cover material, a passive landfill gas venting system, drainage improvements, and seeding, mulching and sodding of the completed landfill. A typical cross section through the final cover is shown in Figure 1:

2.8 Site 69 Removal Action

The installation desires to review a rough order of magnitude cost basis for the complete risk reduction (i.e. removal of this landfill) to alleviate future installation and community concerns. The overall project would be to provide complete removal of waste disposed of in the landfill to include construction debris, hazardous waste, special waste, ordnance, and Chemical Agent Identification Sets (CAIS). Ordnance and Explosive personnel shall be in support of construction activities to oversee ordnance and CAIS operations and the disposition of these items. Although source removal shall be undertaken by this removal action project and will alleviate future aquifer degradation, the existing aquifer contamination as a result of former past activities may remain an issue post removal. This estimate does not address aquifer contamination or post landfill removal aquifer monitoring. Some of the key assumptions shall be identified in the following Table:

Key Assumptions for Site 69 Removal	Quantity / Duration
Heavy clearing and grubbing (14 acres)	14 acres
Blast berm construction (this blast berm will be used for fill material at excavation completion) Assume 4 sides of landfill for blast mitigation (20 feet tall x 200 feet wide (slope 1/5 feet)=75 yds per foot of berm Berm will be in place prior to intrusive operations (clean fill)	3000 LF x 75 yds=225,000 CY of clean material
10 feet deep (assume average depth) x 14 acres for	225,867 CY

material to be placed in 20 yard roll off contaminated with pesticides residue therefore, disposed at hazardous waste landfill =225867 yds/ 20 yds roll off= 11293 trucks	hazardous waste landfill
Upgrade gravel road (temporary to access site's)	2000 ft
11293 Trucks / 40 per day= 282 days or 800 CY per day	282 work days / 10 hrs day=2820 hrs for excavation
PPE-Modified Level D operations with approximately one week Level B operations	282 days
Excavation heavy equipment with protective plating (blast protection)	4 each x $50K=$200K
Site restoration /sodding	14 acres
Crew Makeup	
UXO crew 6 member for duration	282 work days
sampling crew (3 members)	282 work days
Assume field construction crew (7 total) 4 equipment operators, one safety and one supervisor, one resident engineer	
One PM, engineering, and office support for project (work plan,	$ 200K
Personnel Decon Station and operators, 4 total	282 work days
Edgewood Chemical and Biological Center air monitoring and support ($45K per week) x 57 weeks	$2,565,000
Packaging Crew (Level C and B) 4 person for excavation duration	282 days
Disposal and Analytical	
Hazardous waste disposition into RCRA landfill (pesticide contaminated)	225,867 CY hazardous waste landfill
Assume 200 drums to be overpacked and disposed (pesticides and solvents)	200 overpacked dums as Hazardous waste
Assume 1 sample per every 4 roll off (40/4= 10 x 282=2820)samples plus 200 unknowns=3020 x $1000/sample=	$3,020,000
Confirmation samples (bottom and side wall) one per 1000 square feet Walls (3000 lftx 10 feet=30 samples) plus bottom (14 acres=610 samples) say 700 samples to include QA/QC	$700,000
Dispose on site 200 ordnance rounds at $150 per round	$30,000
CAIS disposal (assume 20 complete kits) X $5,0000 disposal each	$100,000

Appendix C
SiteWise™ Results

APPENDIX C

Sustainability Analysis for Site 69

Introduction

This appendix presents the approach taken and results obtained from a sustainability analysis that CH2M HILL performed for Site 69 located on Marine Corps Base Camp Lejeune (MCB CamLej) in Onslow County, North Carolina. Site 69 was historically referred to as the Rifle Range Chemical Dump.

Alternatives are presented to address Site 69 COCs in both soil and groundwater. Four alternatives are provided for the treatment of soil and five alternatives are provided for the treatment of groundwater at Site 69. A detailed summary of the remedial alternatives is provided in Section 4 of the Site 69 Feasibility Study (FS).

A sustainability analysis was performed by CH2M HILL using SiteWise™ Version 1.0 (Battelle, 2010) for the following remedial alternatives:

Soil Alternatives

1. No Action
2. Institutional Controls with Land Use Controls (LUCs)
3. Capping with LUCs
4. Removal

Groundwater Alternatives

1. No Action
2. Monitored Natural Attenuation (MNA) with LUCs
3. Permeable Reactive Barrier (PRB) with MNA and LUCs
4. Enhanced Reductive Dechlorination (ERD) with Bioaugmentation, MNA, and LUCs
5. 4a. Vertical Well Injection-Extraction Delivery Method
6. 4b. Horizontal Well Injection Delivery Method
7. In Situ Chemical Oxidation (ISCO) with MNA and LUCs

Method and Assumptions

The SiteWise™ tool consists of a series of Excel-based spreadsheets used to conduct a baseline assessment of sustainability metrics. The assessment is carried out using a spreadsheet-based building block approach, where every remedial alternative is first broken down into modules that mirror the phases of remedial action work, specifically: remedial investigation (RI), remedial action construction (RAC), remedial action operation (RAO), and long-term monitoring (LTM).

SiteWise™ uses various emission factors from governmental or non-governmental research sources to determine the environmental impact of each activity. The quantitative metrics calculated by the tool include:

1. GHGs reported as carbon dioxide equivalents (CO_2e), consisting of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O);
2. Energy usage (expressed as British Thermal Units [BTU]);
3. Water usage (gallons of water);
4. Air emissions of criteria pollutants consisting of nitrogen (NO_x), sulfur oxides (SO_x), and particulate matter (PM_{10}); and
5. Accident risk (risk of injury and risk of fatality).

Each metric is kept separate during the sustainability analysis because they are measured in disparate units. For the purpose of this discussion the term footprint will be used to describe the impacts in each metric. To estimate

the sustainability footprint for each remedial alternative, only those elements of the RI, RAC, RAO, and LTM possessing important sustainability elements were included in the assessment. The footprints of each remedial phase are combined into overall footprints for each remedial action.

A lower environmental footprint indicates lower deleterious impacts to environmental and social metrics, which collectively make up the SiteWise™ sustainability metrics. Conversely, a higher environmental footprint indicates higher deleterious impacts associated with the SiteWise™ metrics. The major conclusions of this sustainability analysis are incorporated into the short-term effectiveness criteria evaluation of the FS report.

The following assumptions are used for the SiteWise™ tool evaluation:

Soil Alternatives

- Remedial Investigation: No actions for any alternative.
- Remedial Construction: cap materials, transportation of personnel, materials, equipment, material use, water consumption, equipment use, and residual handling.
  - Alternative 3 involves the construction of a RCRA Subtitle C cap covering an area of 220,176 ft^2 and comprised of a geosynthetic (HDPE) liner, geomembrane, HDPE composite drainage net, and 23,664 cubic yards (cy) of fill material. Site preparation includes vegetation clearance and the abandonment of two 20-ft wells, three 50-ft wells, two 80-ft wells, one 120-ft well, and one 250-ft well. Also included is water used for dust suppression.
  - Alternative 4 involves the removal of 140,741 cy of buried waste and impacted soils. Site preparation includes vegetation clearance and the abandonment of two 20-ft wells, three 50-ft wells, two 80-ft wells, one 120ft well, and one 250-ft well. Also included is water used for dust suppression.
- Remedial Operation: Material use, transportation of personnel, transportation of equipment, residual handling, and water consumption.
  - Alternative 2 involves surveying, LUCs, and oversight.
  - Alternative 3 involves semi-annual inspection and maintenance for 30 years. Includes local personnel transportation and mowing.
- Long Term Monitoring (LTM): No actions for any alternative.

Groundwater Alternatives

- Remedial Investigation: No actions for any alternative.
- Remedial Construction: well materials, transportation of personnel, transportation of equipment, treatment chemicals and material use, water consumption, equipment use, and residual handling.
  - Alternative 3 involves the construction of an 800 ft long, 15 to 75 ft deep, and 1 inch wide zero valent iron (ZVI) PRB. Includes all site preparation, construction, and material disposal.
  - Alternative 4a involves installation of 10 vertical injection and 10 vertical extraction wells, screened from 45 to 65 feet below ground surface (bgs) on opposite sides of the waste disposal area. Includes all site preparation, installation, and material disposal.
  - Alternative 4b involves installation of 8 horizontal wells with 180 ft screens below the target area: three at 45 ft bgs, two at 55 ft bgs, and three at 65 ft bgs. Includes site preparation, installation, and material disposal.
  - Alternative 5 involves installation of 8 horizontal wells with 180 ft screens below the target area: three at 45 ft bgs, two at 55 ft bgs, and three at 65 ft bgs. Includes site preparation, installation, and material disposal.

- Remedial Operation: Treatment chemical and material use, transportation of personnel, transportation of equipment, and water consumption.
  - Alternative 3 includes semi-annual performance monitoring of five wells for three years.
  - Alternative 4a involves injection of 41,600 lbs of 3DMe75 (75% substrate concentration) into the injection/extraction well network for two annual events. Each event is expected to take 6 weeks to fully distribute substrate into the aquifer. Injection of 27 liters of a bioaugmentation culture will be included in the first injection event. This alternative includes injection events and pump operation, weekly operations and maintenance are not included in SiteWise because it is assumed to be a local commute. This alternative also includes semi-annual sampling of five wells for three years.
  - Alternative 4b involves injection of 41,600 lbs of 3DMe75 into the horizontal well network for three annual events. Injection of 27 liters of a bioaugmentation culture will be included in the first and third injection events. This alternative includes injection events and oversight. This alternative also includes semi-annual sampling of five wells for three years.
  - Alternative 5 involves injection of 280,000 gallons of 5% sodium permanganate solution (122,000 lbs sodium permanganate) into the horizontal well network per event for two events one year apart and includes injection events and oversight. This alternative also includes semi-annual sampling of five wells for three years.
- LTM: LTM will be included in Alternatives 2 though 5.
  - All alternatives include annual sampling of 22 groundwater monitoring wells for 30 years.

General Assumptions

The specific assumptions made for the individual remedies are presented in **Tables C-1** through **C-8**. The equipment property assumptions are presented in **Table C-9**. The following overall assumptions are used for the SiteWise™ tool evaluation:

- Since Site 69 is relatively far from the MCB CamLej field trailer, a temporary trailer will be provided during field work that takes longer than 1 month to complete.
- Field events that take longer than 1 month will also include 1 round trip home for all site workers.
- Edgewood Chemical Biological Center (ECBC) will provide support for potential chemical agent onsite during sampling requiring Low Flow methods and any intrusive or long-term site work. The ECBC mobile lab is required for any intrusive work where materials will be taken offsite to laboratories or landfill.
- Unexploded ordnance (UXO) support will be required for any site visits.
- Distance to IDW landfill: Assume waste is non-hazardous and landfill is located 200 miles away from MCB CamLej. A specific landfill has not been chosen for the project.
- All oversight workers and LTM samplers will be traveling from Raleigh, NC which is 220 miles roundtrip to MCB CamLej
- The complete environmental footprint for production of equipment used, or production of the vehicles used for transportation, is not considered in this analysis.
- For materials being shipped onsite, the transportation of these materials was captured using the EQUIPMENT TRANSPORTATION or RESIDUAL HANDLING sections.
- The distances per trip for materials shipped onsite and IDW shipped offsite were included at full weight going for half of the total distance and empty for the other half, assuming a round trip total mileage.
- The following density conversions were used:
  - Soil : 1.5 tons/cy

- Sand : 1.5 tons / cy
- ZVI: 2.43 tons/cy
- 3DMe: 8.35 lbs/gallon
- Sodium Permanganate: 11.43 lbs/gallon

- The following average distances traveled were used unless specific distances were known:
  - Oversight/Monitoring Support – 220 miles roundtrip
  - UXO Support – 1,000 miles roundtrip
  - ECBC Support – 850 miles roundtrip
  - Vegetation Clearing/Maintenance – 40 miles roundtrip
  - Utility Location – 300 miles roundtrip
  - Surveying – 40 miles roundtrip
  - General Heavy Equipment – 40 miles roundtrip
  - Capping Crew and Equipment – 1,000 miles roundtrip
  - Excavation Crew and Equipment – 1,400 miles roundtrip
  - Monitoring and Injection Well Drillers/Rig – 1,400 miles roundtrip
  - PRB Installation Crew and Equipment – 1,000 miles roundtrip
  - Horizontal Directional Drilling Drillers/Rig – 1,000 miles roundtrip
  - Injection Support – 1,400 miles roundtrip

Results and Conclusions

A comparative analysis for the soil and groundwater alternatives is provided below. Each alternative, with the exception of No Action, was ranked against each other in each impact category. The rank order was based on lowest impact, for example, a rank of 1 in GHG emissions means that the alternative had the lowest GHG emissions out of all alternatives. The relative ranking of each alternative for each impact was then averaged and rounded to the nearest whole number to calculate the overall rank for the alternative. It is important to note that the average ranking assumes each metric is weighted equally.

The No Action alternative was not included in the final ranking because it is not considered a viable alternative and is only used in the Feasibility Study to provide a baseline comparison. It is given a rank of zero and is not included in the discussion below.

It should be noted that while this analysis compares the environmental footprints of each of the alternatives, the alternatives provide different end-uses. Therefore, a comparison of the results of the alternatives needs to be made in the context of the benefits (e.g., ARAR compliance, contaminant reduction, cost effectiveness, and etc.) of each of the alternatives.

Soil

A comparative analysis for the soil remedial alternatives is summarized in **Figure C-1**. **Table C-10** presents a comparison of the quantitative environmental footprint metrics evaluated for each of the soil remedial alternatives. **Tables C-11** through **C-13** present the detailed quantitative environmental footprint metrics of each main activity (excluding Alternative 1: No Action) for the soil remedial alternatives. **Figures C-2** through **C-4** graphically present these results. The environmental footprint for each alternative is discussed below.

- Alternative 1— No Action

Alternative 1 has no sustainability impacts because no action occurs.

- Alternative 2— Institutional Controls with LUCs

Minimal environmental impacts are associated with this alternative because no active remediation occurs. All impacts are associated with transportation of personnel to the site. LUCs had the lowest impact in all categories and ranked 1st of the viable remedial alternatives. Results are provided in **Table C-11** and **Figure C-2**.

- Alternative 3— Capping with LUCs

The majority of the environmental impacts for this alternative are from material production (HDPE liner and drainage net), equipment use, and residual handling which included transportation of fill and consumables to the Site since no IDW was assumed to be generated during the installation of the cap. These activities account for over 80% of the GHG emissions and total energy used. Residual handling and equipment use are the primary drivers of NO_X, SO_X, and PM_{10} impacts, while personnel transportation and residual handling are the primary drivers of accident risk. Water consumption is driven by the use of water for dust suppression. Capping with LUCs had the second highest impact in all categories and ranked 2nd of the viable remedial alternatives. Results are provided in **Table C-12** and **Figure C-3**.

- Alternative 4— Removal

The majority of the environmental impacts for this alternative are from residual handling and fill transportation. This accounts for approximately 80% of the GHG emissions and total energy used. Residual handling and equipment use are the primary drivers of NO_X, SO_X, and PM_{10} impacts, and residual handling is the primary driver of accident risk due to the high number of trips to and from the landfill. Water consumption is driven by the use of water for dust suppression. The Removal Alternative had the highest impact in all categories and ranked 3rd of the viable remedial alternatives. Results are provided in **Table C-13** and **Figure C-4**.

Groundwater Alternatives

A comparative analysis for the groundwater remedial alternatives is summarized in **Figure C-5**. **Table C-14** presents a comparison of the quantitative environmental footprint metrics evaluated for each of the groundwater remedial alternatives. **Tables C-15** through **C-18** present the detailed quantitative environmental footprint metrics of each main activity (excluding Alternative 1: No Action) for the groundwater remedial alternatives. **Figures C-6** through **C-10** graphically present these results. The environmental footprint for each alternative is discussed below.

- Alternative 1— No Action

Alternative 1 has no sustainability impacts because no action occurs.

- Alternative 2— Monitored Natural Attenuation with LUCs

Residual handling and the transportation of personnel during long term monitoring account for the environmental impacts associated with this alternative. MNA is ranked 1st of the viable alternatives evaluated. Results are provided in **Table C-15** and **Figure C-6**.

- Alternative 3—Permeable Reactive Barrier with MNA and LUCs

The environmental impact of Alternative 3 is primarily associated with equipment use and consumables (ZVI) during the construction of the PRB. Equipment use and consumables account for over 90% of GHG emissions and total energy used. The PRB footprints for NO_X, SO_X, and PM_{10} emissions are highest among the groundwater alternatives and they are primarily driven by equipment use during installation of the PRB. The potential accident risk for this alternative is the highest of the groundwater alternatives, and is primarily due to personnel transportation to the Site for construction and long term monitoring. The ZVI PRB Alternative had the highest footprint in all categories except water impacts and ranks 5th (last) of the viable groundwater alternatives evaluated. Results are provided in **Table C-16** and **Figure C-7**.

- Alternative 4a— Enhanced Reductive Dechlorination with Bioaugmentation, MNA and LUCs (Vertical Wells)

The GHG emissions and total energy used footprints for Alternative 4a were comparable between each remedial phase. RAC impacts were primarily due to equipment use during well installation, RAO impacts were driven by consumables (ERD substrate) and equipment use, and the LTM impacts are driven by transportation of personnel and residual handling. Water use is driven by the RAO phase for mixing with ERD substrate and powering the injection-extraction pumps. $NO_{X,}$ and PM_{10} emissions are primarily driven by equipment use during the RAC phase. SO_x emissions were primarily driven by equipment use during the RAO phase (injection-extraction pumps). The

potential accident risk for this alternative is driven by personnel transportation for construction, operations, and long term monitoring. Water consumption is driven by the use of water for well installation and injections. The potential accident risk for this alternative is the lowest. This alternative was ranked 2nd out of the viable groundwater alternatives. Results are provided in **Table C-17** and **Figure C-8**.

- Alternative 4b— Enhanced Reductive Dechlorination with Bioaugmentation, MNA and LUCs (Horizontal Wells)

The GHG footprint for Alternative 4b is primarily driven by equipment use during the RAC phase (installation of injection wells), and consumables (ERD substrate) during the RAO phase. Similarly, total energy used is driven by equipment use during RAC, consumables during RAO, and also transportation of personnel during LTM. Water impacts are driven by substrate dilution and chase water requirements during the RAO phase. NO_X, SO_X, and PM_{10} emissions are primarily driven by equipment use during construction. The potential accident risk for this alternative is driven by personnel transportation for construction, operations, and long term monitoring. The environmental impact and emissions of Alternative 4b is almost twice that of Alternative 4a in all impact categories. This alternative was ranked 3rd out of the viable groundwater alternatives. Results are provided in **Table C-17** and **Figure C-9**.

- Alternative 5— In Situ Chemical Oxidation with MNA and LUCs

The GHG and total energy impacts of Alternative 5 are primarily associated with consumables (ISCO injectant) used during the RAO phase and equipment use during RAC and RAO. Water consumption is primarily driven by water requirements during injections. NO_X, SO_X, and PM_{10} emissions are primarily driven by equipment use during RAC and RAO. Accident risk is attributed primarily to personnel transportation. This alternative was ranked 4th out of the viable groundwater alternatives. Results are provided in **Table C-18** and **Figure C-10**.

Uncertainty Assessment

The characterization factors used to calculate global warming potential in SiteWise™ V1.0 appear to be dated. The Integovernmental Panel on Climate Change (IPCC) has updated these characterization factors within the last several years. The IPCC changes are not significant and their use in the model is not expected to significantly alter the results.

The SiteWise™ tool does not include an option for the 3DMe to be used in the ERD injections or guar powder to be used in the ZVI injections. It was assumed that the 3DMe and dry guar impacts could be considered equivalent to vegetable oil.

The SiteWise™ tool does not include an option for the injection of sodium permanganate. It was assumed another ISCO injectant (hydrogen peroxide) was the closest to the sodium permanganate in composition and therefore used in this analysis.

Recommendations

The estimates from the SiteWise tool were used to estimate the environmental footprint of the alternatives. Once the alternative is selected, it is recommended the footprint of the selected alternative be further evaluated in the design phase of the projects to explore opportunities to optimize the environmental footprint of the project and integrate sustainable remediation best practices in the design, construction, and operation of the alternative.

TABLE C-1

Soil Alternative 2 (Institutional Controls with LUCs) Assumptions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Sitewise Tab	Assumptions
Remedial Investigation	No Actions
Remedial Action Construction	No Actions
Remedial Action Operations	**Survey, Land Use Controls, and Oversight**
Transportation	
Personnel Transportation - Road	Oversight - 1 driver, 220 miles R/T from Raleigh, NC (1 trip)
	UXO support - 1 driver, 1,000 miles R/T from Gainsville, FL (1 trip)
	Surveying - 2 people, 40 miles R/T from Cedar Point, NC (1 trip)
Longterm Monitoring	No Actions

Notes:

R/T = round trip

UXO - Unexploded Ordnance

TABLE C-2

Soil Alternative 3 (Capping with LUCs) Assumptions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

GENERAL ASSUMPTIONS/CONVERSIONS

Waste Disposal Area = 190,000 sq ft

Estimated volume of fill material = 23, 664 cy

Soil weight = 1.5 tons/cy

SITEWISE TAB	Assumptions
Remedial Investigation	No Actions
Remedial Action Construction	**Installation of RCRA Subtitle C Landfill Cap**
Material Production	
Construction Materials	HDPE Liner (190,000 sq ft, assume 100 mil) HDPE Drainage Net (190,000 sq ft assume 75% open area = 47,500 sq ft of material, 5 mm thick)
Well Decommissioning	(9) 2" Schedule 40 PVC wells - assume (2) 20 ft, (3) 50 ft, (2) 80 ft, (1) 120 ft, and (1) 250 ft
Transportation	Note: Material transportation and additional equipment that did not fit in the space allowed by the model in this category is accounted for under Residuals Handling
Personnel Transportation - Road	Overall Assumption - Long-term construction activities will include one roundtrip home per month. 1 month has 20 working days. Capping is expected to take 92 working days with 12 days of site preparation and completion activities (5.3 months, assume 6 trips), site preparation activities are expected to take 8 days. Oversight - 1 person, 220 miles R/T from Raleigh, NC, 8 trips - 6 monthly trips plus extra front-end and back-end trip Utility locating - 1 driver, 220 miles R/T from Raleigh, NC (1 trip) UXO support - 1 driver, 1000 R/T from Gainsville, FL (6 trips) Drilling, heavy duty support truck, diesel - 1 driver, 1400 miles R/T from Huntsville, AL (1 trip) ECBC support, humvee - 3 people, 850 miles R/T from Aberdeen, MD (6 trips) Capping, light duty support truck - 2 people, 1000 miles R/T from Atlanta, GA (6 trips) Surveying - 2 people, 40 miles R/T from Cedar Point, NC (1 trip) Vegetation Clearing - 2 people, 40 miles R/T from Jacksonville, NC (1 trip)
Equipment Transportation - Road	Loaders (2) - assume 7.5 tons, 40 miles R/T from Jacksonville, NC (2 trips- 80 miles total) Vegetation clearance equipment: Fecon FTX 440 machine - assume 22 tons, 40 miles R/T from Jacksonville, NC Medium excavator - assume 22 tons, 40 miles R/T from Jacksonville, NC Compactor - assume 40 tons, 40 miles R/T from Jacksonville, NC (1 trip) Field trailer/generator for duration of project (Assume trailer and generator weigh 6.5 tons and are transported from Wilmington 100 miles round trip) Dozer - assume 32 tons, 40 miles R/T from Jacksonville, NC (1 trip) Driller trailer with Grouter IV for well abandonment - assume 2 tons, 1400 miles R/T from Huntsville, AL

TABLE C-2

Soil Alternative 3 (Capping with LUCs) Assumptions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

GENERAL ASSUMPTIONS/CONVERSIONS

Waste Disposal Area = 190,000 sq ft
Estimated volume of fill material = 23, 664 cy
Soil weight = 1.5 tons/cy

Equipment use	Place and cap 23,664 cubic yards of fill material, assume each piece of equipment moves all fill
Earthwork	Dozer for vegetation and protective layer, grading
	Medium excavator for spreading soils/common fill layer
	Front end loader for loading/unloading soil stockpiles
	Backhoe loader for moving or spreading stockpiled soils
Blower, compressor, mixer, and other	Grouter IV for mixing concrete batches for well abandonment (assume 2 x 8-hr days 2.5 hp mixer)
Generators	1 Generator (for field trailer)- running 10 hrs/day for duration of project (100 kw generator = 134 hp - assume 100 to 175 hp diesel generator, 104 days = 1040 hrs)
Capping Equipment	Roller/compactor over 190,000 square ft, 92 workdays
Residual Handling (includes capping materials and additional equipment transportation)	Fill materials - sand/topsoil from Base borrow pit 23,664 cy x 1.5 tons/cy = 35,496 tons shipped 40 miles R/T (one full/ empty load)
	Assume 24 tons/truck = 1,480 full truck loads from Base Borrow pit (20 miles one way)
	Geomembrane - 220,176 sq ft of liner/8,333 sq ft per panel = 26.4 panels x 2,500 lbs/panel x ton/2000 lbs = 33 tons
	Assume 33 tons of geomembrane shipped 500 miles one way
	Composite drainage net - 220,176 sq ft of liner, assume mass per weight of liner is 3.5 oz/sq yd x 1 sq ft/0.111 sq yd x 1 oz/3.125E-5 short tons = 2.7 tons
	Assume 2.7 tons of liner shipped 500 miles one way
	Geosynthetic liner - 220,176 sq ft of liner, assume mass per weight of liner is 6.0 oz/sq yd x 1 sq ft/0.111 sq yd x 1 oz/3.125E-5 short tons = 4.6 tons
	Assume 4.6 tons of liner shipped 500 miles one way
	Empty loads: 3 trips for liner, membrane, drainage net (500 mi), 1,480 trips 20 miles for fill materials
Other Known Onsite Activities	Water use - dust suppression during capping activities
	Assume water sprayed at site entrance @ 2 gpm x 15 min/hr x 4 hr/day x 92 days = 11,040 gallons
Remedial Action Operations	Semi-annual cap inspection and mowing oversight for 30 years
Transportation	
Personnel Transportation - Road	Inspection/oversight - 1 person, 220 miles R/T from Raleigh, NC (60 trips)
	Landscaper, cap mowing - 40 miles R/T from Jacksonville, NC (60 trips)
Equipment Transportation - Road	Mowing equipment - 1 person, 40 miles R/T from Jacksonville, NC (60 trips= 2,400 mi total)
	Assume 1 ton of mowing equipment
Longterm Monitoring	No Actions

Notes:

cy = cubic yard
R/T = round trip
sq ft = square feet
sq yd = square yard
PVC = polyvinyl chloride
hp = horsepower

TABLE C-3

Soil Alternative 4 (Removal) Assumptions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

GENERAL ASSUMPTIONS/CONVERSIONS

Waste Disposal Area = 190,000 ft^2

Estimated depth of disposal area = 20 ft

Estimated Volume of excavated/fill material = 3,800,000 ft^3 = 140,741 cy

Estimated weight of excavated/fill material = 140,741 cy * 1.5 tons/cy = 211,112 tons

SITEWISE TAB	Assumptions
Remedial Investigation	No Actions
Remedial Action Construction	**Excavation/backfill of waste disposal area**
Material Production	
Well Decommissioning	(9) 2" Schedule 40 PVC wells - assume (2) 20 ft, (3) 50 ft, (2) 80 ft, (1) 120 ft, and (1) 250 ft
Transportation	Overall Assumption - Long-term construction activities will include one roundtrip home per month. 1 month has 20 working days. All site activities are expected to take 184 working days (9.2 months, assume 10 trips).
Personnel Transportation - Road	Oversight - 1 driver, 220 miles R/T from Raleigh, NC (10 trips) Utility locating - 1 driver, 220 miles R/T from Raleigh, NC (1 trip) UXO support - 1 driver, 1000 R/T from Gainsville, FL (10 trips) ECBC support, Humvee - 850 miles R/T from Aberdeen, MD (10 trips), 3 people Excavation, light duty support truck - 2 people, 1400 miles R/T from Huntsville, AL (10 trips) Surveying - 2 people, 40 miles R/T from Cedar Point, NC (1 trip) Vegetation clearing - 2 people, 40 miles R/T from Jacksonville, NC (1 trip) Drilling, heavy duty support truck, diesel - 1 driver, 1400 miles R/T from Huntsville, AL (1 trip)
Equipment Transportation - Road	4 front end loaders - assume 6 tons each, 40 miles R/T from Jacksonville, NC (4 trips = 160 miles total) 4 dozers - assume 32 tons each, 160 miles total (same as loaders) Driller trailer with Grouter IV for well abandonment - assume 2 tons, 1400 miles R/T from Huntsville, AL (1 trip) Vegetation clearance equipment: Fecon FTX 440 machine - assume 22 tons, 40 miles R/T from Jacksonville, NC Field trailer/generator for duration of project (Assume trailer and generator weigh 6.5 tons and are transported from Wilmington 100 miles round trip) ECBC Mobile Laboratory and Generator (assume 6.5 tons total transported from Aberdeen, 850 mi roundtrip)
Equipment use	Excavate and backfill 140,741 cy of soil
Earthwork	Assume that Loaders and excavators move the total amount of soil twice (once during excavation and once during backfilling) = 281,482 cy of soil
Blower, compressor, mixer, and other	Grouter IV for mixing concrete batches for well abandonment (assume 2 x 8-hr days 2.5 hp mixer)
Generators	2 Generators (for field trailer and ECBC Mobile Lab)- running 10 hrs/day for duration of project (100 kw generator = 134 hp - assume 100 to 175 hp diesel generator, 184 days = 1840 hrs)
Residual Handling (and material transportation)	Fill materials - sand from Base borrow pit shipped 20 miles 1 way Assume 24 tons/truck = 8796 full truck loads from Base Borrow pit/8796 empty truck loads Excavated soil - assume same volume as fill material, non-hazardous soil - disposed of at landfill 200 miles away (assume 24 tons/truck = 8796 trips one way)
Other Known Onsite Activities	Water use - dust suppression during removal activities Assume water sprayed at site entrance @ 2 gpm x 15 min/hr x 4 hr/day x 180 days = 21,600 gallons
Remedial Action Operations	No Actions
Longterm Monitoring	No Actions

Notes:

cy = cubic yards
gpm = gallons per minute
ECBC = Edgewood Chemical Biological Center
ft = feet or foot
hp = horsepower
hrs = hours
min = minutes
PVC = polyvinyl chloride
R/T= round trip
UXO = Unexploded ordnance

TABLE C-4

Groundwater Alternative 2 (MNA with LUCs) Assumptions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Sitewise Tab	Assumptions
Remedial Investigation	No Actions
Remedial Action Construction	No Actions
Remedial Action Operations	**Survey, Land Use Controls, and Oversight**
Transportation	
Personnel Transportation - Road	Oversight - 1 driver, 220 miles R/T from Raleigh, NC (1 trip)
	UXO support - 1 driver, 1,000 miles R/T from Gainsville, FL (1 trip)
	Surveying - 2 people, 40 miles R/T from Cedar Point, NC (1 trip)
Longterm Monitoring	**Annual sampling of 22 wells for 30 years VOCs (PDB), and every 5 years for PCBs, Pesticides, Metals, Chemical Agent (low flow), set PDBs first trip**
Transportation	
Personnel Transportation - Road	Field staff - 2 people, 220 miles R/T from Raleigh, NC (30 trips)
	UXO support - 1 driver, 1,000 miles R/T from Gainsville, FL (30 trips)
	ECBC support (every 5 years)- 3 people, 1 humvee, 850 miles R/T from Aberdeen, MD (6 trips)
	IDW - 1 driver, 220 miles R/T from Raleigh, NC (30 trips)
Residual Handling	
Residual Disposal/Recycling	1 gallon of IDW per well during VOC sampling only x 22 wells = 22 gallons (24 trips) - 0.1 ton
	8 gallons of IDW per well generated during low-flow sampling x 22 wells = 176 gallons (6 trips) - 1 ton
	IDW is transported 200 miles to landfill (one way), 30 empty trips

Notes:

ECBC = Edgewood Chemical Biological Center

IDW = investigation derived waste

R/T = round trip

UXO = unexploded ordnance

PVC = polyvinyl chloride

VOC = volatile organic compounds

TABLE C-5

Groundwater Alternative 3 (PRB with MNA and LUCs) Assumptions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

GENERAL ASSUMPTIONS/CONVERSIONS

PRB Trenchless dimensions = 800' x 75' x 1"

Assume 360 tons of 100% iron shavings

SITEWISE TAB	Assumptions
Remedial Investigation	No Actions
Remedial Action Construction	**Construction of Trenchless PRB through ZVI vertical hydrofracturing, assume LUCs are installed during Construction activities**
Material Production	
Well Materials	53 injection wells, 75 ft deep, Specialized metal fracturing wells assume 4" diameter steel casing
Treatment Chemicals and Materials	360 tons of 100% iron shavings 53 injection points (13,585 lbs ZVI per injection) 7,200 lbs guar needed for slurry, proxy vegetable oil, divided evenly between injection point (136 lb per injection point)
Transportation	Overall Assumption - Long-term construction activities will include one roundtrip home per month. 1 month has 20 working days. RAC activities are expected to take 100 working days (estimated by vendor) (5 months, assume 5 trips).
Personnel Transportation - Road	Oversight - 1 driver, 220 miles R/T from Raleigh, NC (7 trips) includes 2 additional trips pre and post construction
	Utility Locating - 1 driver, 220 miles R/T from Raleigh, NC (1 trip)
	Drilling, heavy duty support truck - 3 people, 1,000 miles R/T from Atlanta, GA (5 trips) Surveying - 2 people, 40 miles R/T from Cedar Point, NC (1 trip)
	Vegetation Clearing - 2 people, 40 miles R/T from Jacksonville, NC (1 trip) UXO support - 1 driver, 1,000 miles R/T from Gainsville, FL (5 trips) ECBC support, humvee - 3 people, 850 miles R/T from Aberdeen, MD (5 trips) PRB Crew, light duty support trucks- 2 vehicles, 2 people per truck, 1,000 miles R/T from Atlanta, GA (5 trips each= 10 trips total)
Equipment Transportation - Road	Rotary Drill Rig - 32 tons + DPT drill rig - 8 tons = 40 tons total, 1,000 miles R/T from Atlanta, GA
	Vegetation clearing - Transport Fecon FTX 440 machine - 22 tons, 40 miles R/T from Jacksonville, NC 2 heavy duty drilling support trucks with trailer - 20 tons equipment each, 1,000 miles R/T from ATL: stainless steel mix tanks, concrete hoppers, skid mounted centrifugal pump, lull, Moffett forklifts, and tooling. 2 trips, 20 tons each, 1,000 miles
	Field trailer/generator for duration of project (Assume trailer and generator weigh 6.5 tons and are transported from Wilmington 100 miles R/T) ECBC Mobile Laboratory and Generator (assume 6.5 tons total transported from Aberdeen, 850 mi R/T)
Equipment use	
Drilling	Mud Rotary drilling - 53, 6" diameter injection points @ 15 ft spacing to depth of 75 ft, 2 hours to install each point (106 hrs)
	DPT drilling - 26, active resistivity strings @ 30 ft spacing to depth of 75 ft, 4 hours to install each point (104 hrs)
Generators	Generator for ZVI PRB injection system - diesel powered, 330 hp, in operation 10 hrs/day for 100 days = 1000 hrs
	2 Generators (for field trailer and ECBC Mobile Lab)- running 10 hrs/day for duration of project (100 kw generator = 134 hp - assume 100 to 175 hp diesel generator, 100 days = 1000 hrs each)
Residual Handling	
Residual Disposal/Recycling (includes ZVI and Guar shipment)	Water/slurry - Assume 200 gallons x 53 injection points = 10,600 gallons (development and driller mud slurry) 212 drums + 10 decon IDW drums 222 drums x 0.25 tons per drum = 56 tons Assume 2 loads of 28 tons to Landfill (200 miles one way)
	Iron/ hydroxypropyl guar (HPG) transportation - materials shipped 1,000 miles R/T from Atlanta, GA, 360 tons (720,000 lbs), from vendor 10 lb ZVI per gallon of guar slurry, need 72,000 gal of guar slurry, assume 0.1 lb guar per gallon of water, 7,200 lb guar powder needed (3.6 tons). Assume 10 trips at 36.4 tons each, 500 miles one way. 10 empty trips, 500 miles
	Soil IDW = 1.25 x borehole (6" nominal borehole) x 53 injection points, 75 ft deep/27 ft/cy x 1.5 tons/cy = 54 tons, assume 2 trips at 27 tons, 200 miles to landfill, 2 empty trips
Other Known Onsite Activities	72,000 gallons of water required to mix with iron and HPG, 200 gallons per well (10,600 total) for installation, 500 gallons of water consumption for decontamination = 83,100 gallons

TABLE C-5

Groundwater Alternative 3 (PRB with MNA and LUCs) Assumptions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

GENERAL ASSUMPTIONS/CONVERSIONS

PRB Trenchless dimensions = 800' x 75' x 1"

Assume 360 tons of 100% iron shavings

Remedial Action Operations	Annual sampling of 5 wells for 3 yrs for VOC analysis - 3 sampling events (PDB), IDW negligible
Transportation	
Personnel Transportation - Road	Field staff - 2 people, 220 miles R/T from Raleigh, NC (3 trips)
	UXO support - 1 driver, 1,000 miles R/T from Gainesville, FL (3 trips)
Longterm Monitoring	**Annual sampling of 22 wells for 30 years VOCs (PDB), and every 5 years for PCBs, Pesticides, Metals, Chemical Agent (low flow), set PDBs first trip**
Transportation	
Personnel Transportation - Road	Field staff - 2 people, 220 miles R/T from Raleigh, NC (30 trips) UXO support - 1 driver, 1,000 miles R/T from Gainsville, FL (30 trips)
	ECBC support (every 5 years)- 3 people, 1 humvee, 850 miles R/T from Aberdeen, MD (6 trips) IDW - 1 driver, 220 miles R/T from Raleigh, NC (30 trips)
Residual Handling	
Residual Disposal/Recycling	1 gallon of IDW per well during VOC sampling only x 22 wells = 22 gallons (24 trips) - 0.1 ton 8 gallons of IDW per well generated during low-flow sampling x 22 wells = 176 gallons (6 trips) - 1 ton, IDW is taken 200 miles to landfill (one way), 30 empty trips

Notes:

ECBC = Edgewood Chemical Biological Center

hp = horsepower

IDW = investigation derived waste

PDB = passive diffusion bag

PRB = permeable reactive barrier

R/T = round trip

UXO = unexploded ordnance

VOC = volatile organic compounds

ZVI = zero valent iron

TABLE C-6

Groundwater Alternative 4a (ERD with Bioaugmentation, MNA, and LUCs - Vertical Wells) Assumptions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

GENERAL ASSUMPTIONS/CONVERSIONS

Regenesis 3-D Microemulsion (3DMe)-75

soil weight = 1.5 tons/cy

SITEWISE TAB	Assumptions
Remedial Investigation	No Actions
Remedial Action Construction	**Install 10 injection and 10 extraction wells and injection system (12 day duration)**
Material Production	
Well Materials	20 x 4" Schedule 40 PVC installed to depth of 65 ft
Transportation	
Personnel Transportation - Road	Oversight - 1 driver, 220 miles R/T from Raleigh (1 trip)
	Utility locating - 1 driver, 220 miles R/T from Raleigh, NC (1 trip)
	Drilling support truck, heavy duty - 2 people, 1400 miles R/T from Huntsville, AL (1 trip)
	ECBC support - 3 people, humvee, 850 miles R/T from Aberdeen, MD (1 trip)
	Surveying - 2 people, 40 miles R/T from Cedar Point, NC (1 trip)
	UXO support - 1 driver, 1,000 miles R/T from Gainsville, FL (1 trip)
	Vegetation Clearing - 2 people, 40 miles R/T from Jacksonville, NC (1 trip)
	Drilling support, heavy duty truck - drill rig, equipment, tooling, well construction materials (sand, grout, bentonite) - 20 tons, 1,400 miles R/T from Huntsville, AL
	ECBC Mobile Lab and generator (6.5 tons, 850 miles R/T)
	Piping/well materials - 1,300 ft x 4" Sched 40 PVC piping = approx 3,500 lbs; estimated 22,440 lbs of sand/bentonite/grout for well installation; 4,150 lbs of empty drums
	Total of 15 tons shipped 100 miles R/T from Wilmington, NC, one full (15 tons total, 50 miles one way) 1 empty load
	Trailer, manifold, injection equipment to be installed semi-permanently during operations- 15 tons from Charlotte 250 miles, one way (1 empty trip)
	Vegetation Clearing - Transport Fecon FTX 440 machine - 22 tons, 40 miles R/T from Jacksonville, NC (1 trip)
Equipment use	
Drilling	Sonic drilling (Geoprobe 8140DT or similar), 20 wells to 65 ft, 5 hrs to install each injection/extraction well using sonic rig (12 days total installation)
Generators	100 kw generator to run ECBC mobile laboratory, 10 hrs/day for 12 days = 230 hrs, 100-175 hp
Residual Handling	
Residue Disposal/Recycling	Soil IDW - borehole volume plus 20% for soil residuals
	22.6 cy x 1.5 tons/cy = 34 tons, 200 miles to landfill
	Water IDW - Purge 3 well volumes per well and 10 gallons decon per well = 550 gallons
	550 gallons x 8.35lbs/gal/2000 lb/ton = 2.3 tons, 200 miles to landfill
	Empty trips - 2 x 200 miles
Other Known Onsite Activities	Water use - 4,000 gals for well installation
Remedial Action Operations	**System will be run continuously for 6 weeks for 2 batches of ERD substrate, Annual sampling of 5 wells for 3 yrs for VOC, TOC, and VFA analysis - 3 sampling events**
Material Production	
Treatment Chemicals and Materials	3DMe75 substrate with bioaugmentation culture - 41,600 pounds 75% substrate (31,200 lbs, proxy Vegetable oil in SiteWise) and 27 liters culture per injection event (bioaugmentation culture - 1st event only, assume negligible impact) (3,120 lbs per injection point, 2 events, 10 injection points)
Transportation	*Note Weekly O&M trips required during operations, assume performed by local operators, negligible impact
Personnel Transportation - Road	Field staff - 2 people, 220 miles R/T from Raleigh, NC (5 trips), 2 cars
	UXO support - 1 driver, 1,000 miles R/T from Gainesville, FL (5 trips)
	ECBC support - 3 people, humvee, 850 miles R/T from Aberdeen, MD (3 trips)
	IDW - 1 driver, 220 miles R/T from Raleigh, NC (3 trips)
Equipment Transportation - Road	3DMe75 - Shipped 300 miles one way from Greenville, SC - 41,600lbs (21 tons) x 2 events. (600 miles Full, 600 miles Empty total)
Equipment use	
pumps	10 x 1.5 hp pumps, operating continuously per injection event (2 events, 6 week duration= 1008 hrs per pump per event)
Residual Handling	
Residue Disposal/Recycling	Water - assume 1 drum of water generated per sampling event = 0.25 tons, transport to landfill 200 miles away (3 full, 3 empty trips 200 miles)
Other Known Onsite Activities	Water use - 38,000 gallons per injection for ERD injections (76,000 gallons)
Longterm Monitoring	**Annual sampling of 22 wells for 30 years VOCs (PDB), and every 5 years for PCBs, Pesticides, Metals, CA (low flow), set PDBs first trip**
Transportation	
Personnel Transportation - Road	Field staff - 2 people, 220 miles R/T from Raleigh, NC (30 trips)
	UXO support - 1 driver, 1,000 miles R/T from Gainsville, FL (30 trips)
	ECBC support (every 5 years)- 3 people, 1 humvee, 850 miles R/T from Aberdeen, MD (6 trips)
	IDW - 1 driver, 220 miles R/T from Raleigh, NC (30 trips)
Residual Handling	
Residual Disposal/Recycling	1 gallon of IDW per well during VOC sampling only x 22 wells = 22 gallons (24 trips) - 0.1 ton
	8 gallons of IDW per well generated during low-flow sampling x 22 wells = 176 gallons (6 trips) - 1 ton
	IDW is taken 200 miles to landfill (one way), 30 empty trips

Notes:

ECBC = Edgewood Chemical Biological Center

IDW = investigation derived waste

hp = horsepower

PDB = passive diffusion bag

PRB = permeable reactive barrier

PVC = polyvinyl chloride

R/T = round trip

UXO = unexploded ordnance

VOC = volatile organic compounds

TABLE C-7

Groundwater Alternative 4b (ERD with Bioaugmentation, MNA, and LUCs - Horizontal Wells) Assumptions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

GENERAL ASSUMPTIONS/CONVERSIONS
Regenesis 3-D Microemulsion (3DMe)-75
soil weight = 1.5 tons/cy

SITEWISE TAB	Assumptions
Remedial Investigation	No Actions
Remedial Action Construction	**Install 8 Horizontal wells (48 day duration)**
Material Production	
Well Materials	8, 4" HDPE horizontal direction drilled wells - 3 wells at 45 ft bgs (600 ft each), 2 wells at 55 ft bgs (700 ft) and 3 wells at 65 ft bgs (800 ft), assume schedule 40 PVC
Transportation	2 month duration, assume one trip home per month
Personnel Transportation - Road	Oversight - 1 driver, 220 miles R/T from Raleigh (2 trip) Utility locating - 1 driver, 220 miles R/T from Raleigh, NC (1 trip) Drilling support truck, heavy duty diesel - 3 people, 1000 miles R/T from Julian, PA (2 trips) Surveying - 2 people, 40 miles R/T from Cedar Point, NC (1 trip) Vegetation Clearing - 2 people, 40 miles R/T from Jacksonville, NC (1 trip) UXO support - 1 driver, 1,000 miles R/T from Gainsville, FL (2 trip) ECBC support - 3 people, humvee, 850 miles R/T from Aberdeen, MD (2 trips) HDD Rig - 40 tons transported 1000 miles R/T from Julian, PA Drilling materials, heavy duty truck- 20 tons of equipment, tooling, well construction materials (sand, grout, bentonite) from Julian, PA, 1000 miles Vegetation Clearing - Transport Fecon FTX 440 machine - 22 tons, 40 miles R/T from Jacksonville, NC (1 trip) Field trailer/generator for duration of project (Assume trailer and generator weigh 6.5 tons and are transported from Wilmington 100 miles round trip) ECBC Mobile Laboratory and Generator (assume 6.5 tons total transported from Aberdeen, 850 mi roundtrip)
Equipment use	
Drilling	HDD Drilling (assume HSA in SiteWise) assume each well takes approximately 6 x 8 hr days to install (48 hrs each).
Generators	2 Generators (for field trailer and ECBC Mobile Lab)- running 10 hrs/day for duration of project (100 kw generator = 134 hp - assume 100 to 175 hp diesel generator, 48 days = 480 hrs each)
Residual Handling	
Residue Disposal/Recycling (includes equipment shipment)	Soil IDW - borehole volume plus 20% for soil residuals (8" diameter borehole, 5600 ft of borehole = 72 cy * 20% = 86.5 cy), 86.5 cu yd x 1.5 tons/cy = 130 tons, 6 trips - 22 tons/trip - 200 miles to landfill Water IDW - 3 well volumes purged per horizontal well = 10,920 gallons, 10,920 gallons x 8.3 lbs/gal x ton/2000 lbs = 45 tons, 2 trips - 23 tons/trip - 200 miles to landfill Empty IDW trips - 8 trips 200 miles Piping/well materials - 5600 ft x 4" HDPE piping = 15,848 lbs shipped 50 miles one way from Wilmington, NC, full (8 tons), 1 empty trip
Other Known Onsite Activities	Water Use 10,000 gallons for well installation
Remedial Action Operations	**Three Injection Events 7 days each, Annual sampling of 5 wells for 3 yrs for VOC, TOC, and VFA analysis**
Material Production	
Treatment Chemicals and Materials	3DMe75 substrate with bioaugmentation culture - 41,600 pounds 75% substrate (31,200 lbs "dry weight), proxy vegetable oil in SiteWise) and 27 liters culture per injection event (bioaugmentation culture - 1st and 3rd events only, assume negligible impact) (3,900 lbs per injection point, 8 injection points, 3 events)
Transportation	
Personnel Transportation - Road	Field staff - 2 people, 220 miles R/T from Raleigh, NC each in their own vehicles for monitoring, single vehicle for injection oversight assume injection oversight occurs during monitoring trips (6 trips) UXO support - 1 driver, 1,000 miles R/T from Gainesville, FL (3 trips) ECBC support - 3 people, humvee, 850 miles R/T from Aberdeen, MD (3 trips) IDW - 1 driver, 220 miles R/T from Raleigh, NC (3 trips) Injection support crew - 2 people, 1,400 mile R/T from Huntsville, AL (3 trips)
Equipment Transportation - Road	3DMe75 - Shipped 300 miles one way from Greenville, SC - 41,600lbs (21 tons) x 3 events. assume tanks and mixing equipment weigh 4 tons and are Injection equipment, DSI Grouter 4 - 1400 miles roundtrip, 1,200 lbs + heavy duty trailer 12-15,000 lbs (8 tons) for 3 events,
Equipment use	
Pump Operation	2 Grouter IV Pumps used for injection purposes, 10 hrs/day x 21 days = 210 hrs, 2.5 hp
Residual Handling	
Residue Disposal/Recycling	Water - assume 1 drum of water generated per sampling event = 0.25 tons, transport to landfill 200 miles away (3 full, 3 empty trips 200 miles)
Other Known Onsite Activities	Water Use 38,000 gallons per injection (114,000 gallons total)
Longterm Monitoring	**Annual sampling of 22 wells for 30 years VOCs (PDB), and every 5 years for PCBs, Pesticides, Metals, CA (low flow), set PDBs first trip**
Transportation	
Personnel Transportation - Road	Field staff - 2 people, 220 miles R/T from Raleigh, NC (30 trips) UXO support - 1 driver, 1,000 miles R/T from Gainsville, FL (30 trips) ECBC support (every 5 years)- 3 people, 1 humvee, 850 miles R/T from Aberdeen, MD (6 trips) IDW - 1 driver, 220 miles R/T from Raleigh, NC (30 trips)
Residual Handling	
Residual Disposal/Recycling	1 gallon of IDW per well during VOC sampling only x 22 wells = 22 gallons (24 trips) - 0.1 ton 8 gallons of IDW per well generated during low-flow sampling x 22 wells = 176 gallons (6 trips) - 1 ton IDW is taken 200 miles to landfill (one way), 30 empty trips

Notes:
ECBC = Edgewood Chemical Biological Center
IDW = investigation derived waste
hp = horsepower
PDB = passive diffusion bag
PRB = permeable reactive barrier
PVC = polyvinyl chloride
R/T = round trip
UXO = unexploded ordnance
VOC = volatile organic compounds
ZVI = zero valent iron

TABLE C-8

Groundwater Alternative 5 (ISCO with MNA and LUCs - Horizontal Wells) Assumptions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

GENERAL ASSUMPTIONS/CONVERSIONS

Sodium Permanganate

soil weight = 1.5 tons/cy

SITEWISE TAB	Assumptions
Remedial Investigation	No Actions
Remedial Action Construction	**Install 8 Horizontal wells (48 day duration)**
Material Production	
Well Materials	8, 4" HDPE horizontal direction drilled wells - 3 wells at 45 ft bgs (600 ft each), 2 wells at 55 ft bgs (700 ft) and 3 wells at 65 ft bgs (800 ft), assume schedule 40 PVC
Transportation	2 month duration, assume one trip home per month
Personnel Transportation - Road	Oversight - 1 driver, 220 miles R/T from Raleigh (2 trip) Utility locating - 1 driver, 220 miles R/T from Raleigh, NC (1 trip) Drilling support truck, heavy duty diesel - 3 people, 1000 miles R/T from Julian, PA (2 trips) Vegetation Clearing - 2 people, 40 miles R/T from Jacksonville, NC (1 trip) Surveying - 2 people, 40 miles R/T from Cedar Point, NC (1 trip) UXO support - 1 driver, 1,000 miles R/T from Gainsville, FL (2 trip) ECBC support - 3 people, humvee, 850 miles R/T from Aberdeen, MD (2 trips) HDD Rig - 40 tons transported 1000 miles R/T from Julian, PA Drilling supplies, heavy duty truck- 20 tons of equipment, tooling, well construction materials (sand, grout, bentonite) from Julian, PA Vegetation Clearing - Transport Fecon FTX 440 machine - 22 tons, 40 miles R/T from Jacksonville, NC (1 trip) Field trailer/generator for duration of project (Assume trailer and generator weigh 6.5 tons and are transported from Wilmington 100 miles round trip) Assume field trailer stays onsite for 3 years ECBC Mobile Laboratory and Generator (assume 6.5 tons total transported from Aberdeen, 850 mi roundtrip)
Equipment use	
Drilling	HDD Drilling (assume HSA in SiteWise) assume each well takes approximately 6 x 8 hr days to install (48 hrs each), lengths above in well materials.
Generators	2 Generators (for field trailer and ECBC Mobile Lab)- running 10 hrs/day for duration of project (100 kw generator = 134 hp - assume 100 to 175 hp diesel generator, 48 days = 480 hrs each)
Residual Handling	
Residue Disposal/Recycling (includes equipment shipment)	Soil IDW - borehole volume plus 20% for soil residuals (8" diameter borehole, 5600 ft of borehole = 72 cy * 20% = 86.5 cy) 86.5 cu yd x 1.5 tons/cy = 130 tons 6 trips - 22 tons/trip - 200 miles to landfill Water IDW - 3 well volumes purged per horizontal well = 10,920 gallons 10,920 gallons x 8.3 lbs/gal x ton/2000 lbs = 45 tons 2 trips - 23 tons/trip - 200 miles to landfill Empty IDW trips - 8 trips 200 miles Piping/well materials - 5600 ft x 4" HDPE piping = 15,848 lbs shipped 50 miles one way from Wilmington, NC, full (8 tons), 1 empty trip
Other Known Onsite Activities	Water Use 10,000 gallons for well installation

TABLE C-8

Groundwater Alternative 5 (ISCO with MNA and LUCs - Horizontal Wells) Assumptions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

GENERAL ASSUMPTIONS/CONVERSIONS

Sodium Permanganate

soil weight = 1.5 tons/cy

Remedial Action Operations	**2 Injection Events 40 days each, Annual sampling of 5 wells for 3 yrs for VOCs**
Material Production	
Treatment Chemicals and Materials	Inject total of 122,000 lbs of 100% sodium permanganate (15,250 lbs/well) per injection, proxy hydrogen peroxide in SiteWise, 8 injection points, 2 events
Transportation	
Personnel Transportation - Road	Field staff - 2 people, 220 miles R/T from Raleigh, NC each in their own vehicles for monitoring, single vehicle for injection oversight (6 monitoring trips, 2 injection trips= 8 trips)
	UXO support - 1 driver, 1,000 miles R/T from Gainesville, FL (5 trips) ECBC support - 3 people, humvee, 850 miles R/T from Aberdeen, MD (2 trips) IDW - 1 driver, 220 miles R/T from Raleigh, NC (3 trips) Injection support crew - 2 people, 1,400 mile R/T from Huntsville, AL (2 trips)
Equipment Transportation - Road	Sodium permanganate (40% solution = 304,420 lb, 152 tons per injection event) shipped from LaSalle IL (1050 miles one way). Assume 40 tons per load, 4 full trips, 4 empty trips per injection event Injection equipment, DSI Grouter 4 - 1400 miles one way, 1,200 lbs + heavy duty trailer 12-15,000 lbs (8 tons) for 2 events (full both ways)
Equipment use	
Pumps	2 Grouter IV Pumps used for injections, 10 hrs/day x 80 days = 800 hrs per pump 2.5 hp
Generators	For field trailer 100kw (100 - 175 hp diesel generator) running 10 hrs/day x 80 days = 800 hrs
Residual Handling	
Residue Disposal/Recycling	Water - assume 1 drum of water generated per sampling event = 0.25 tons, transport to landfill 200 miles away (3 full, 3 empty trips 200 miles)
Other Known Onsite Activities	Water Use 252,200 gallons for injections (to dilute 40% solution to 5% solution) per event - 504,800 gallons total
Longterm Monitoring	**Annual sampling of 22 wells for 30 years VOCs (PDB), and every 5 years for PCBs, Pesticides, Metals, CA (low flow), set PDBs first trip**
Transportation	
Personnel Transportation - Road	Field staff - 2 people, 220 miles R/T from Raleigh, NC (30 trips) UXO support - 1 driver, 1,000 miles R/T from Gainsville, FL (30 trips) IDW - 1 driver, 220 miles R/T from Raleigh, NC (30 trips)
Residual Handling	
Residual Disposal/Recycling	1 gallon of IDW per well during VOC sampling only x 22 wells = 22 gallons (24 trips) - 0.1 ton 8 gallons of IDW per well generated during low-flow sampling x 22 wells = 176 gallons (6 trips) - 1 ton IDW is taken 200 miles to landfill (one way), 30 empty trips

Notes:

ECBC = Edgewood Chemical Biological Center

IDW = investigation derived waste

hp = horsepower

PDB = passive diffusion bag

PRB = permeable reactive barrier

PVC = polyvinyl chloride

R/T = round trip

UXO = unexploded ordnance

VOC = volatile organic compounds

ZVI = zero valent iron

TABLE C-9

Equipment Use Assumptions

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Task	Equipment Type	Weight (lbs)	Weight (tons)
Drilling	DPT Rig	16,000	8
Drilling	Hollow Stem Auger	64,000	32
Drilling	HDD Drill Rig	80,000	40
Drilling	Heavy Duty Support	80,000	40
Excavating	Backhoe	26,000	13
Excavating	Compactor	80,000	40
Excavating	Medium Excavator	44,000	22
Excavating	Dozer	64,000	32
Excavating	Backhoe Loader	15,000	7.5
Excavating	Front End Loader	12,000	6
Site Support	ECBC Mobile Lab	10,000	5
Site Support	Field Trailer	10,000	5
Site Support	100kw Diesel Generator	3,000	1.5

TABLE C-10

Sustainability Analysis Metrics Quantified for Each Soil Alternative

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Remedial Alternatives	GHG Emissions	Total energy Used	Water Consumption	NO_x emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
	metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Alternative 1 - No Action	0	0	0	0	0	0	0	0
Alternative 2 - LUCs	6.11E-01	6.63E+00	0.00E+00	4.89E-04	1.58E-04	1.06E-04	1.11E-05	7.93E-04
Alternative 3 - Capping	3.62E+02	1.03E+04	1.11E+04	7.83E-01	1.74E-01	7.91E-02	7.47E-04	1.07E-01
Alternative 4 - Removal	5.04E+03	9.21E+04	2.16E+04	8.40E+00	1.75E+00	9.86E-01	1.53E-02	3.13E+00

Relative Ranking

Remedial Alternatives	GHG Emissions	Total energy Used	Water Consumption	NO_x emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury	Overall Rank
	metric ton	MMBTU	gallons	metric ton	metric ton	metric ton			
Alternative 1 - No Action	0	0	0	0	0	0	0	0	0
Alternative 2 - LUCs	1	1	1	1	1	1	1	1	1
Alternative 3 - Capping	2	2	2	2	2	2	2	2	2
Alternative 4 - Removal	3	3	3	3	3	3	3	3	3

Notes:
LUCs - land use controls

MMBTU - million Britsh Thermal Unit
NOx - Nitrogen Oxides
SOx - Sulfur Oxides
PM10 - Particulate Matter
GHG - Greeenhouse Gases
Overall Rank is the calculated average of the relative ranks rounded to the nearest whole number.

TABLE C-11

Soil Alternative 2 (LUCs) Sustainability Analysis

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Phase	Activities	GHG Emissions	Total Energy Used	Water Impacts	NO_x Emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Remedial Action Construction	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.61	6.6E+00	NA	4.9E-04	1.6E-04	1.1E-04	1.1E-05	7.9E-04
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	0.61	6.63E+00	0.00E+00	4.89E-04	1.58E-04	1.06E-04	1.11E-05	7.93E-04
Total		**6.1E-01**	**6.6E+00**	**0.0E+00**	**4.9E-04**	**1.6E-04**	**1.1E-04**	**1.1E-05**	**7.9E-04**

Notes:
MMBTU - million Britsh Thermal Unit
NOx - Nitrogen Oxides
SOx - Sulfur Oxides
PM10 - Particulate Matter
NA - Not Applicable

TABLE C-12

Soil Alternative 3 (Capping with LUCs) Sustainability Analysis

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Phase	Activities	GHG Emissions	Total Energy Used	Water Impacts	NO_x Emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Remedial Action Construction	Consumables	174.08	6.6E+03	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	10.61	2.1E+02	NA	1.1E-02	2.7E-03	1.7E-03	3.1E-04	2.2E-02
	Transportation-Equipment	2.27	3.3E+01	NA	2.6E-03	4.9E-04	3.4E-04	4.2E-06	8.7E-04
	Equipment Use and Misc	85.67	2.0E+03	1.1E+04	6.7E-01	1.5E-01	6.3E-02	5.7E-05	2.4E-02
	Residual Handling	73.87	1.3E+03	NA	8.4E-02	1.6E-02	1.1E-02	2.3E-04	4.9E-02
	Sub-Total	346.50	1.01E+04	1.11E+04	7.66E-01	1.70E-01	7.66E-02	6.09E-04	9.66E-02
Remedial Action Operations	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	11.79	1.3E+02	NA	1.3E-02	3.0E-03	1.9E-03	1.3E-04	9.5E-03
	Transportation-Equipment	3.44	3.8E+01	NA	3.7E-03	8.9E-04	5.6E-04	5.8E-06	1.2E-03
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	15.23	1.67E+02	0.00E+00	1.64E-02	3.93E-03	2.46E-03	1.38E-04	1.07E-02
Total		**3.6E+02**	**1.0E+04**	**1.1E+04**	**7.8E-01**	**1.7E-01**	**7.9E-02**	**7.5E-04**	**1.1E-01**

MMBTU - million Britsh Thermal Unit
NOx - Nitrogen Oxides
SOx - Sulfur Oxides
PM10 - Particulate Matter
NA - Not Applicable
GHG - Greeenhouse Gases

TABLE C-13

Soil Alternative 4 (Removal) Sustainability Analysis

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Phase	Activities	GHG Emissions	Total Energy Used	Water Impacts	NO_x Emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Remedial Action Construction	Consumables	0.56	2.9E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	18.89	3.6E+02	NA	1.9E-02	4.8E-03	3.1E-03	5.7E-04	4.1E-02
	Transportation-Equipment	3.56	5.2E+01	NA	4.0E-03	7.8E-04	5.4E-04	6.5E-06	1.4E-03
	Equipment Use and Misc	419.27	7.9E+03	2.2E+04	3.2E+00	7.4E-01	2.9E-01	1.0E-04	4.4E-02
	Residual Handling	4,596.20	8.4E+04	NA	5.2E+00	1.0E+00	7.0E-01	1.5E-02	3.0E+00
	Sub-Total	5,038.48	9.21E+04	2.16E+04	8.40E+00	1.75E+00	9.86E-01	1.53E-02	3.13E+00
Total		**5.0E+03**	**9.2E+04**	**2.2E+04**	**8.4E+00**	**1.7E+00**	**9.9E-01**	**1.5E-02**	**3.1E+00**

Notes:
MMBTU - million Britsh Thermal Unit
NOx - Nitrogen Oxides
SOx - Sulfur Oxides
PM10 - Particulate Matter
NA - Not Applicable

TABLE C-14

Sustainability Analysis Metrics Quantified for Each Groundwater Alternative

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Remedial Alternatives	GHG Emissions	Total energy Used	Water Consumption	NOx emissions	SOx Emissions	PM10 Emissions	Accident Risk Fatality	Accident Risk Injury
	metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Alternative 1 - No Action	0	0	0	0	0	0	0	0
Alternative 2 - MNA	4.57E+01	6.41E+02	0.00E+00	4.90E-02	1.12E-02	7.29E-03	6.10E-04	4.99E-02
Alternative 3 - ZVI PRB	8.10E+02	1.05E+04	8.31E+04	2.24E+00	4.66E-01	2.04E-01	1.17E-03	1.02E-01
Alternative 4a - ERD - Vertical Wells	9.35E+01	1.67E+03	9.15E+04	1.97E-01	9.77E-02	2.01E-02	8.13E-04	6.91E-02
Alternative 4b - ERD - Horizontal Wells	2.14E+02	4.45E+03	1.26E+05	6.37E-01	1.33E-01	6.14E-02	9.53E-04	8.76E-02
Alternative 5 - ISCO	3.78E+02	6.54E+03	5.16E+05	1.01E+00	2.01E-01	9.79E-02	9.72E-04	9.49E-02

Relative Ranking

Remedial Alternatives	GHG Emissions	Total energy Used	Water Consumption	NO_x emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury	Overall Rank
	metric ton	MMBTU	gallons	metric ton	metric ton	metric ton			
Alternative 1 - No Action	0	0	0	0	0	0	0	0	0
Alternative 2 - MNA	1	1	1	1	1	1	1	1	1
Alternative 3 - ZVI PRB	5	5	2	5	5	5	5	5	5
Alternative 4a - ERD - Vertical Wells	2	2	3	2	2	2	2	2	2
Alternative 4b - ERD - Horizontal Wells	3	3	4	3	3	3	3	3	3
Alternative 5 - ISCO	4	4	5	4	4	4	4	4	4

Notes:
MNA - monitored natural attenuation
PRB - permeable reactive barrier
ERD - enhanced reductive dechlorination
ISCO - in situ chemical oxidation
MMBTU - million Britsh Thermal Unit
NOx - Nitrogen Oxides
SOx - Sulfur Oxides
PM10 - Particulate Matter
GHG - Greeenhouse Gases
Overall Rank is the calculated average of the relative ranks rounded to the nearest whole number.

TABLE C-15

Groundwater Alternative 2 - MNA Sustainability Analysis

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Phase	Activities	GHG Emissions	Total Energy Used	Water Impacts	NO_x Emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Longterm Monitoring	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.67	7.3E+00	NA	5.9E-04	1.7E-04	1.1E-04	1.1E-05	7.9E-04
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	0.67	7.32E+00	0.00E+00	5.85E-04	1.74E-04	1.15E-04	1.11E-05	7.93E-04
Total		**6.7E-01**	**7.3E+00**	**0.0E+00**	**5.9E-04**	**1.7E-04**	**1.1E-04**	**1.1E-05**	**7.9E-04**

Notes:
MNA - monitored natural attenuation
MMBTU - million Britsh Thermal Unit
NOx - Nitrogen Oxides
SOx - Sulfur Oxides
PM10 - Particulate Matter
GHG - Greeenhouse Gases

TABLE C-16

Groundwater Alternative 3 - ZVI PRB Sustainability Analysis

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Phase	Activities	GHG Emissions	Total Energy Used	Water Impacts	NO_x Emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Remedial Action Construction	Consumables	462.21	3.5E+03	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	17.27	2.8E+02	NA	1.8E-02	4.2E-03	2.8E-03	4.6E-04	3.3E-02
	Transportation-Equipment	7.24	1.1E+02	NA	8.2E-03	1.6E-03	1.1E-03	9.6E-06	2.0E-03
	Equipment Use and Misc	262.14	5.7E+03	8.3E+04	2.2E+00	4.5E-01	1.9E-01	1.3E-05	5.5E-03
	Residual Handling	13.78	3.0E+02	NA	1.6E-02	3.0E-03	2.1E-03	4.4E-05	9.1E-03
	Sub-Total	761.55	9.84E+03	8.31E+04	2.19E+00	4.55E-01	1.97E-01	5.31E-04	4.99E-02
Remedial Action Operations	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	1.93	2.1E+01	NA	1.7E-03	5.0E-04	3.3E-04	3.7E-05	2.6E-03
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	1.93	2.10E+01	0.00E+00	1.66E-03	4.98E-04	3.30E-04	3.67E-05	2.64E-03
Longterm Monitoring	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	30.80	4.3E+02	NA	3.2E-02	7.9E-03	5.0E-03	5.5E-04	4.0E-02
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	14.25	2.1E+02	NA	1.6E-02	3.1E-03	2.2E-03	4.5E-05	9.4E-03
	Sub-Total	45.06	6.34E+02	0.00E+00	4.84E-02	1.11E-02	7.17E-03	5.99E-04	4.91E-02
Total		**8.1E+02**	**1.0E+04**	**8.3E+04**	**2.2E+00**	**4.7E-01**	**2.0E-01**	**1.2E-03**	**1.0E-01**

Notes:
PRB - permeable reactive barrier
MMBTU - million Britsh Thermal Unit
NOx - Nitrogen Oxides
SOx - Sulfur Oxides
PM10 - Particulate Matter
NA - Not Applicable
GHG - Greeenhouse Gases

TABLE C-17

Groundwater Alternative 4a - ERD (Vertical Injection-Extraction Wells) Sustainability Analysis

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Phase	Activities	GHG Emissions	Total Energy Used	Water Impacts	NO_x Emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Remedial Action Construction	Consumables	3.68	7.6E+01	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	2.53	4.9E+01	NA	2.7E-03	5.9E-04	4.0E-04	5.9E-05	4.2E-03
	Transportation-Equipment	4.27	6.3E+01	NA	4.9E-03	9.3E-04	6.5E-04	6.9E-06	1.4E-03
	Equipment Use and Misc	16.89	3.3E+02	4.0E+03	1.3E-01	2.5E-02	1.2E-02	6.1E-06	2.6E-03
	Residual Handling	0.95	1.7E+01	NA	1.1E-03	2.1E-04	1.4E-04	3.0E-06	6.3E-04
	Sub-Total	28.33	5.30E+02	4.00E+03	1.38E-01	2.68E-02	1.28E-02	7.51E-05	8.91E-03
Remedial Action Operations	Consumables	9.34	2.3E+02	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	4.36	9.2E+01	NA	3.9E-03	1.1E-03	7.4E-04	1.3E-04	9.5E-03
	Transportation-Equipment	1.71	2.5E+01	NA	1.9E-03	3.7E-04	2.6E-04	2.9E-06	6.0E-04
	Equipment Use and Misc	11.68	2.3E+02	8.8E+04	1.6E-02	6.0E-02	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	1.43	2.1E+01	NA	1.6E-03	3.1E-04	2.2E-04	4.5E-06	9.4E-04
	Sub-Total	28.51	5.99E+02	8.75E+04	2.39E-02	6.20E-02	1.21E-03	1.39E-04	1.10E-02
Longterm Monitoring	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	22.41	3.3E+02	NA	1.9E-02	5.8E-03	3.8E-03	5.5E-04	4.0E-02
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	14.25	2.1E+02	NA	1.6E-02	3.1E-03	2.2E-03	4.5E-05	9.4E-03
	Sub-Total	36.66	5.41E+02	0.00E+00	3.53E-02	8.89E-03	6.00E-03	5.99E-04	4.91E-02
Total		**9.4E+01**	**1.7E+03**	**9.2E+04**	**2.0E-01**	**9.8E-02**	**2.0E-02**	**8.1E-04**	**6.9E-02**

Notes:
ERD - enhanced reductive dechlorination
MMBTU - million Britsh Thermal Unit
NOx - Nitrogen Oxides
SOx - Sulfur Oxides
PM10 - Particulate Matter
NA - Not Applicable
GHG - Greeenhouse Gases

TABLE C-18

Groundwater Alternative 4b - ERD (Horizontal Wells) Sustainability Analysis

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Phase	Activities	GHG Emissions	Total Energy Used	Water Impacts	NO_x Emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Remedial Action Construction	Consumables	15.87	3.3E+02	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	6.30	7.8E+01	NA	6.6E-03	1.5E-03	1.0E-03	1.2E-04	8.5E-03
	Transportation-Equipment	5.60	8.2E+01	NA	6.4E-03	1.2E-03	8.5E-04	7.2E-06	1.5E-03
	Equipment Use and Misc	77.39	1.5E+03	1.1E+04	5.7E-01	1.2E-01	5.1E-02	2.3E-05	1.0E-02
	Residual Handling	3.92	7.0E+01	NA	4.5E-03	8.5E-04	5.9E-04	1.2E-05	2.6E-03
	Sub-Total	109.08	2.02E+03	1.13E+04	5.91E-01	1.20E-01	5.35E-02	1.61E-04	2.26E-02
Remedial Action Operations	Consumables	57.10	9.3E+02	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	5.91	1.1E+02	NA	5.9E-03	1.5E-03	9.8E-04	1.8E-04	1.3E-02
	Transportation-Equipment	5.60	8.2E+01	NA	6.4E-03	1.2E-03	8.5E-04	1.0E-05	2.1E-03
	Equipment Use and Misc	0.44	8.1E+00	1.1E+05	8.8E-04	4.3E-04	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	1.43	2.1E+01	NA	1.6E-03	3.1E-04	2.2E-04	4.5E-06	9.4E-04
	Sub-Total	70.47	1.15E+03	1.14E+05	1.47E-02	3.49E-03	2.04E-03	1.93E-04	1.59E-02
Longterm Monitoring	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	17.42	1.1E+03	NA	1.4E-02	4.5E-03	3.0E-03	5.5E-04	4.0E-02
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	17.01	1.9E+02	NA	1.8E-02	4.4E-03	2.7E-03	4.5E-05	9.4E-03
	Sub-Total	34.43	1.28E+03	0.00E+00	3.20E-02	8.89E-03	5.78E-03	5.99E-04	4.91E-02
Total		**2.1E+02**	**4.4E+03**	**1.3E+05**	**6.4E-01**	**1.3E-01**	**6.1E-02**	**9.5E-04**	**8.8E-02**

Notes:
ERD - enhanced reductive dechlorination
MMBTU - million Britsh Thermal Unit
NOx - Nitrogen Oxides
SOx - Sulfur Oxides
PM10 - Particulate Matter
NA - Not Applicable
GHG - Greeenhouse Gases

TABLE C-19

Groundwater Alternative 5 - ISCO Sustainability Analysis

Operable Unit No. 14 (Site 69)

Feasibility Study

Marine Corps Base Camp Lejeune, North Carolina

Phase	Activities	GHG Emissions	Total Energy Used	Water Impacts	NO_x Emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Remedial Action Construction	Consumables	15.87	3.3E+02	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	3.89	8.1E+01	NA	4.0E-03	9.1E-04	6.2E-04	1.2E-04	8.5E-03
	Transportation-Equipment	5.60	8.2E+01	NA	6.4E-03	1.2E-03	8.5E-04	7.2E-06	1.5E-03
	Equipment Use and Misc	76.03	1.4E+03	1.0E+04	5.7E-01	1.1E-01	5.1E-02	2.3E-05	1.0E-02
	Residual Handling	3.92	7.0E+01	NA	4.5E-03	8.5E-04	5.9E-04	1.2E-05	2.6E-03
	Sub-Total	105.32	2.00E+03	1.00E+04	5.86E-01	1.13E-01	5.31E-02	1.61E-04	2.26E-02
Remedial Action Operations	Consumables	148.85	2.4E+03	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	6.14	9.6E+01	NA	5.8E-03	1.6E-03	1.0E-03	1.5E-04	1.1E-02
	Transportation-Equipment	39.75	5.8E+02	NA	4.5E-02	8.7E-03	6.0E-03	5.4E-05	1.1E-02
	Equipment Use and Misc	40.29	8.9E+02	5.1E+05	3.3E-01	6.9E-02	3.1E-02	0.0E+00	0.0E+00
	Residual Handling	1.43	2.1E+01	NA	1.6E-03	3.1E-04	2.2E-04	4.5E-06	9.4E-04
	Sub-Total	236.45	4.00E+03	5.06E+05	3.86E-01	7.95E-02	3.87E-02	2.12E-04	2.32E-02
Longterm Monitoring	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	22.41	3.3E+02	NA	1.9E-02	5.8E-03	3.8E-03	5.5E-04	4.0E-02
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	14.25	2.1E+02	NA	1.6E-02	3.1E-03	2.2E-03	4.5E-05	9.4E-03
	Sub-Total	36.66	5.41E+02	0.00E+00	3.53E-02	8.89E-03	6.00E-03	5.99E-04	4.91E-02
Total		**3.8E+02**	**6.5E+03**	**5.2E+05**	**1.0E+00**	**2.0E-01**	**9.8E-02**	**9.7E-04**	**9.5E-02**

Notes:
ISCO - in situ chemical oxidation
MMBTU - million Britsh Thermal Unit
NOx - Nitrogen Oxides
SOx - Sulfur Oxides
PM10 - Particulate Matter
NA - Not Applicable
GHG - Greeenhouse Gases

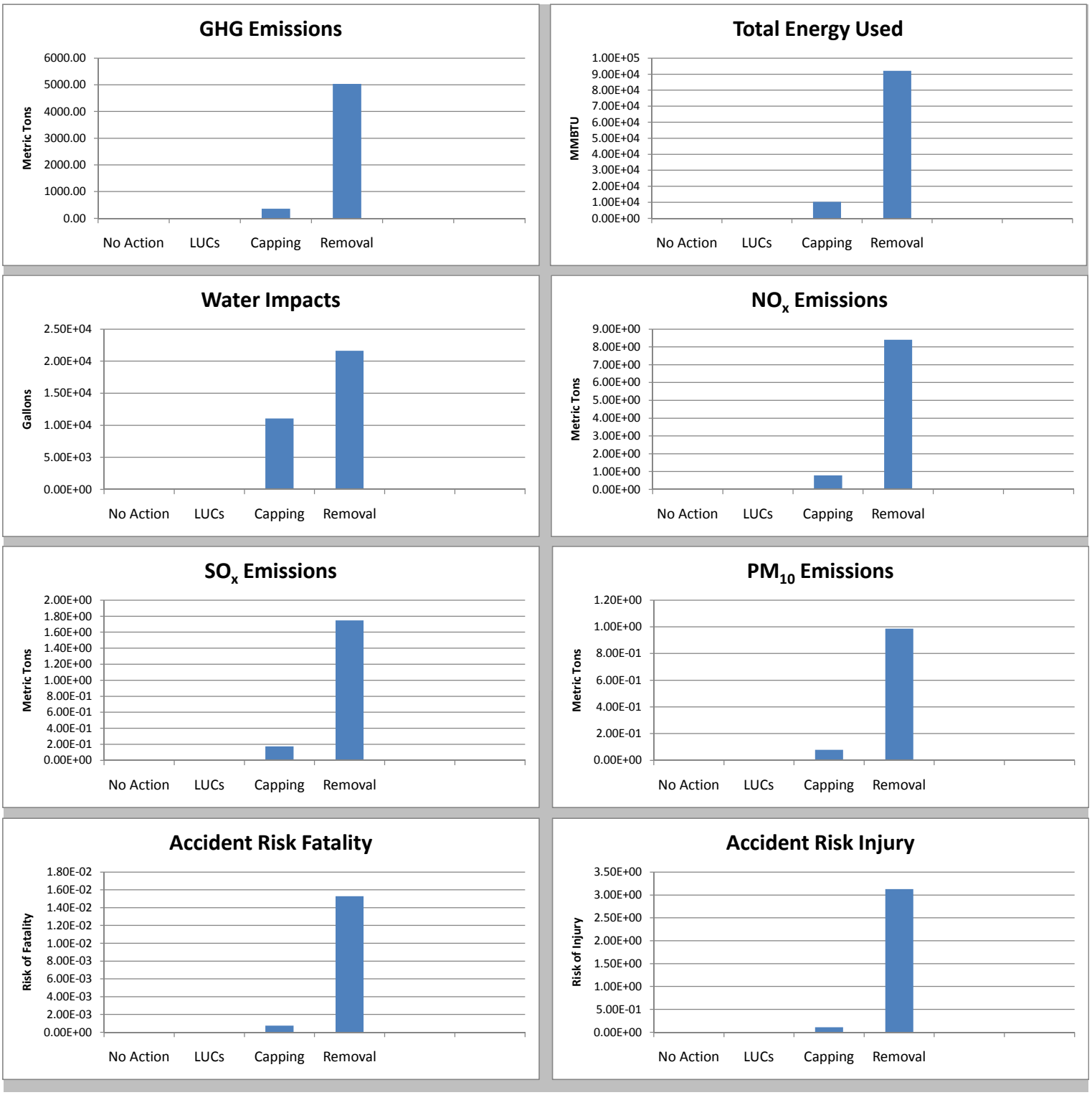


Figure C-1
Sustainability Analysis Summary - Soil
Site 69 Feasibility Study
MCB CamLej
North Carolina

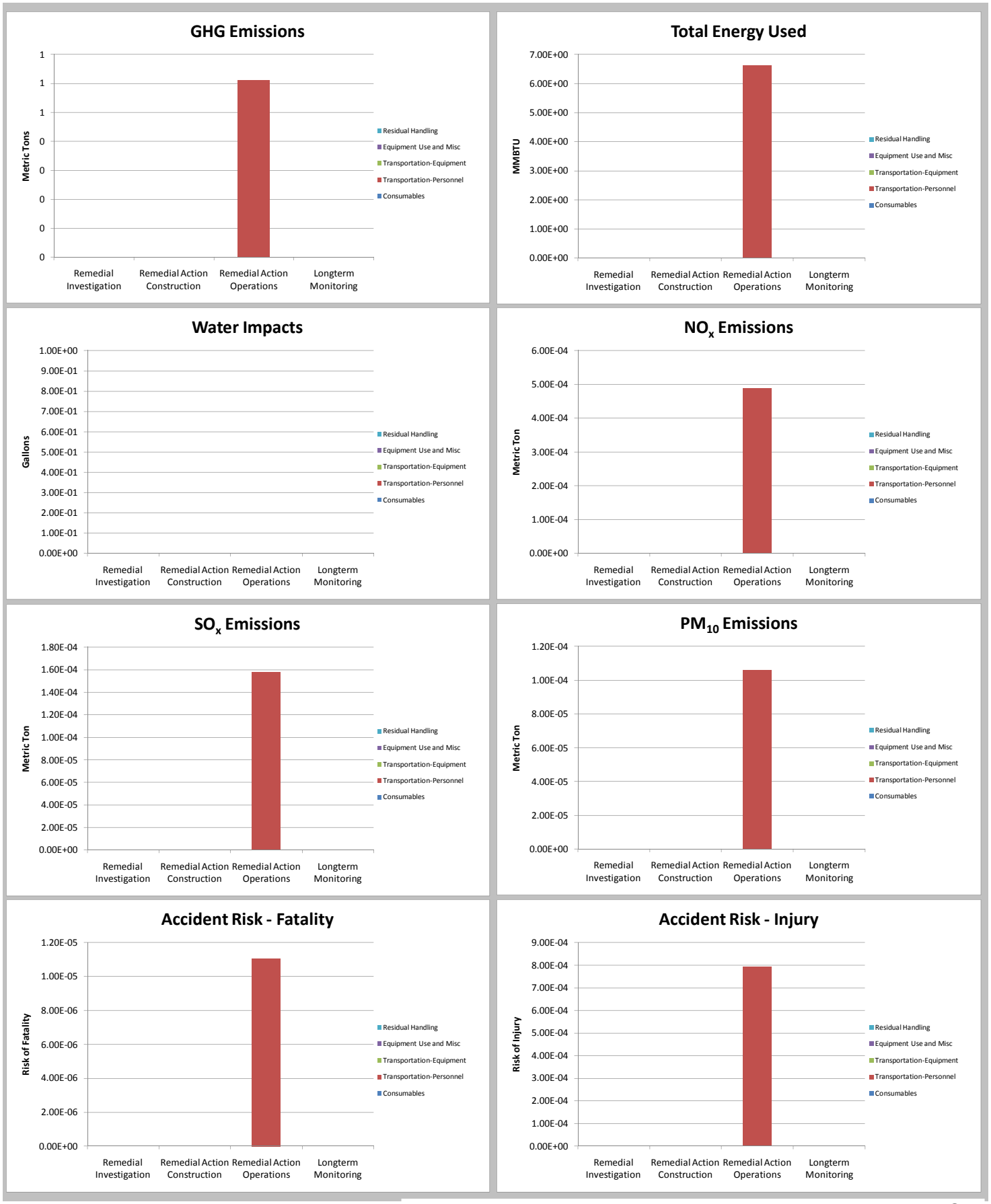


Figure C-2
Sustainability Analysis - Soil Alternative 2 - LUCs
Site 69 Feasibility Study
MCB CamLej
North Carolina

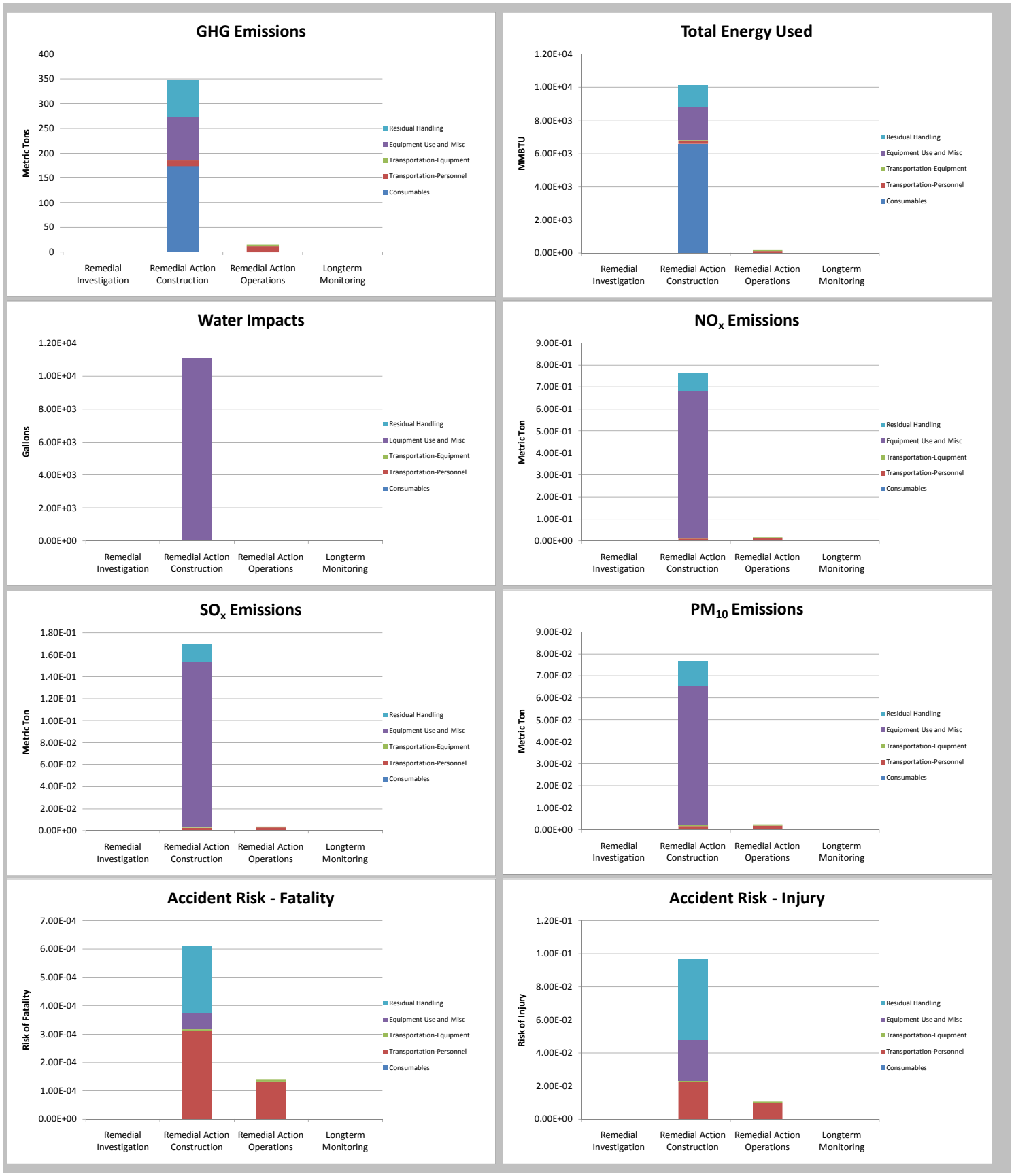


Figure C-3
Sustainability Analysis - Soil Alternative 3 - Capping
Site 69 Feasibility Study
MCB CamLej
North Carolina

Figure C-4
Sustainability Analysis - Soil Alternative 4 - Removal
Site 69 Feasibility Study
MCB CamLej
North Carolina

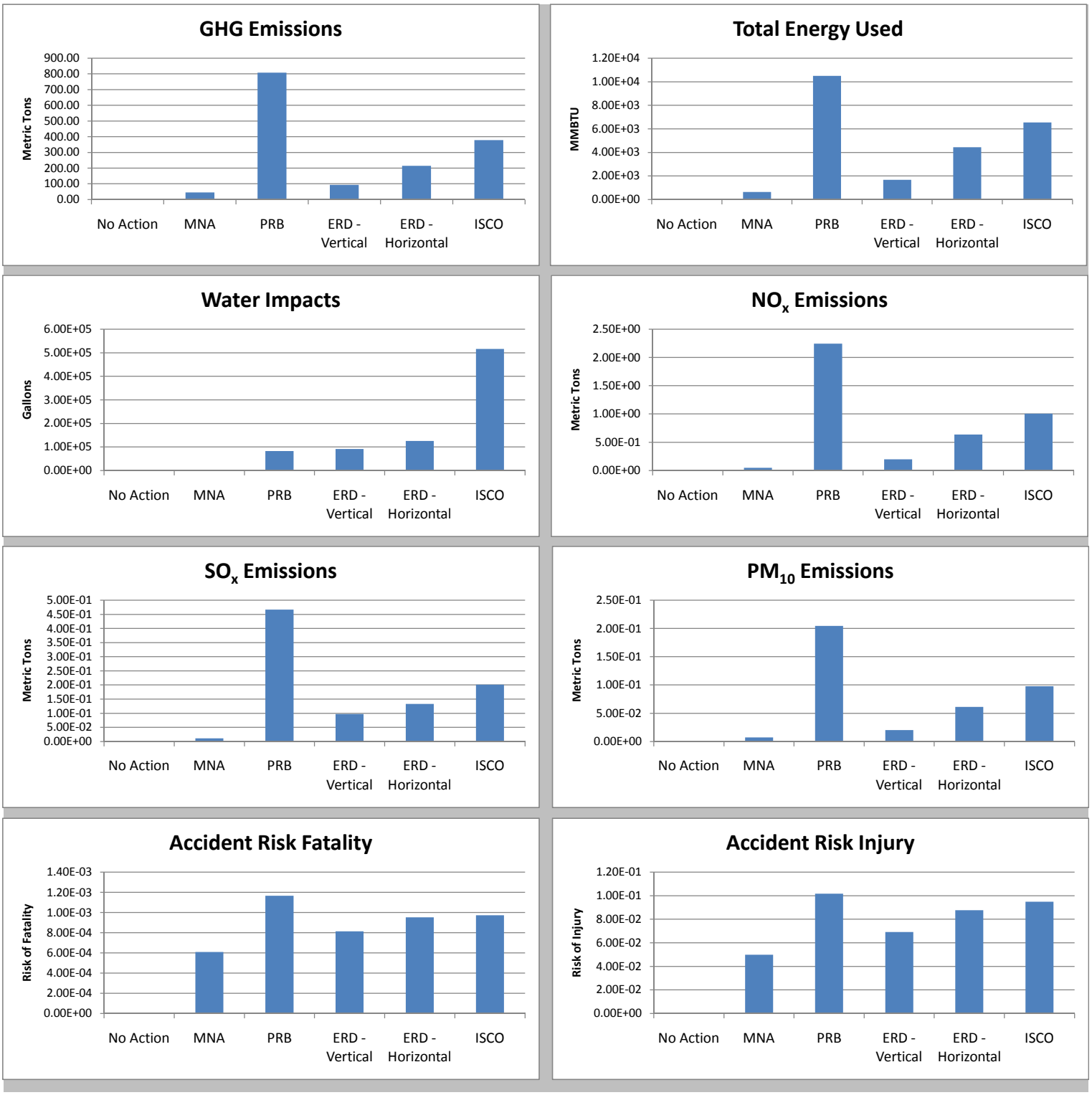


Figure C-5
Sustainability Analysis Summary - Groundwater
Site 69 Feasibility Study
MCB CamLej
North Carolina

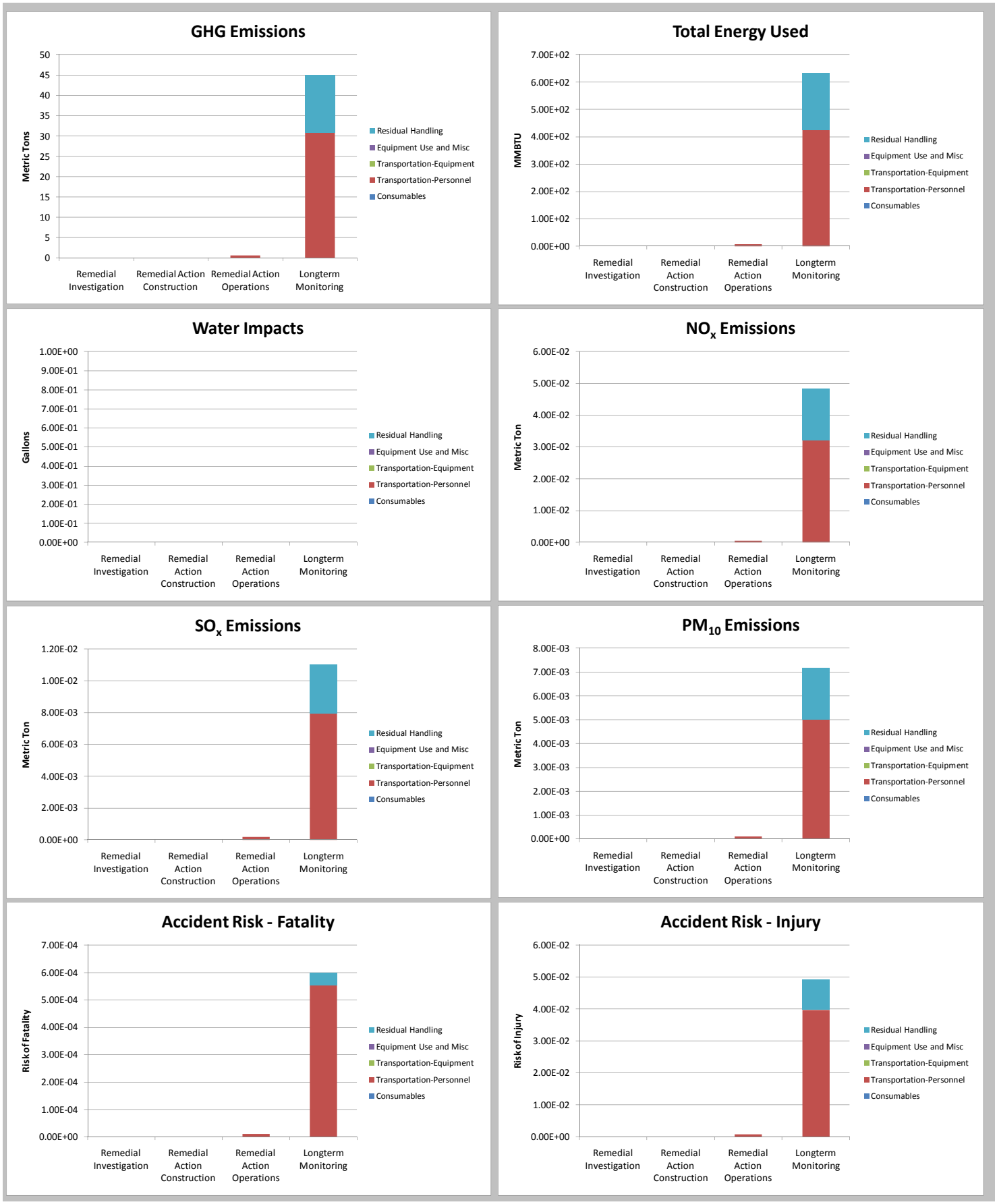


Figure C-6
Sustainability Analysis - Groundwater Alternative 2 - Monitored Natural Attenuation
Site 69 Feasibility Study
MCB CamLej
North Carolina

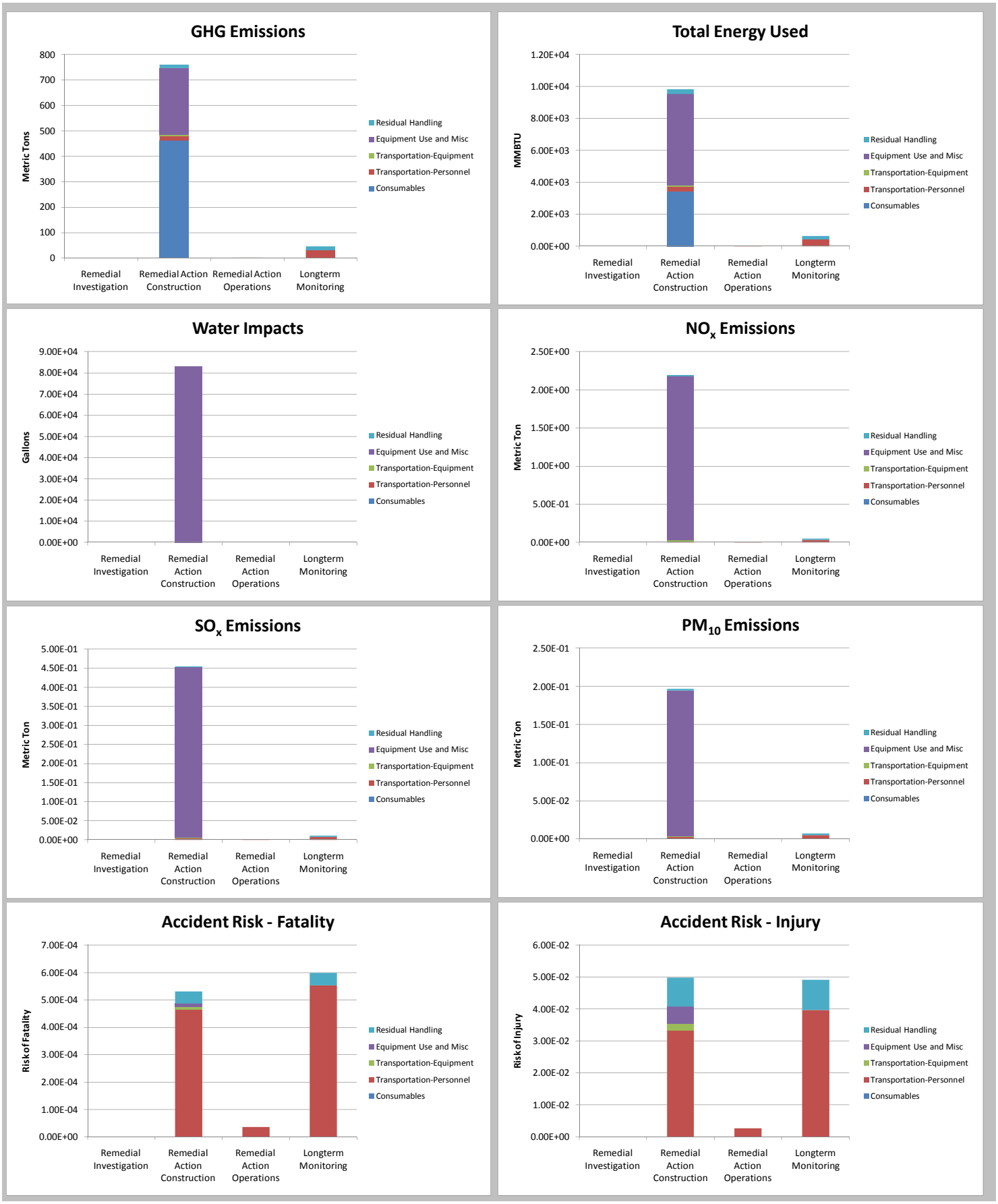


Figure C-7
Sustainability Analysis - Groundwater Alternative 3 - ZVI PRB
Site 69 Feasibility Study
MCB CamLej
North Carolina

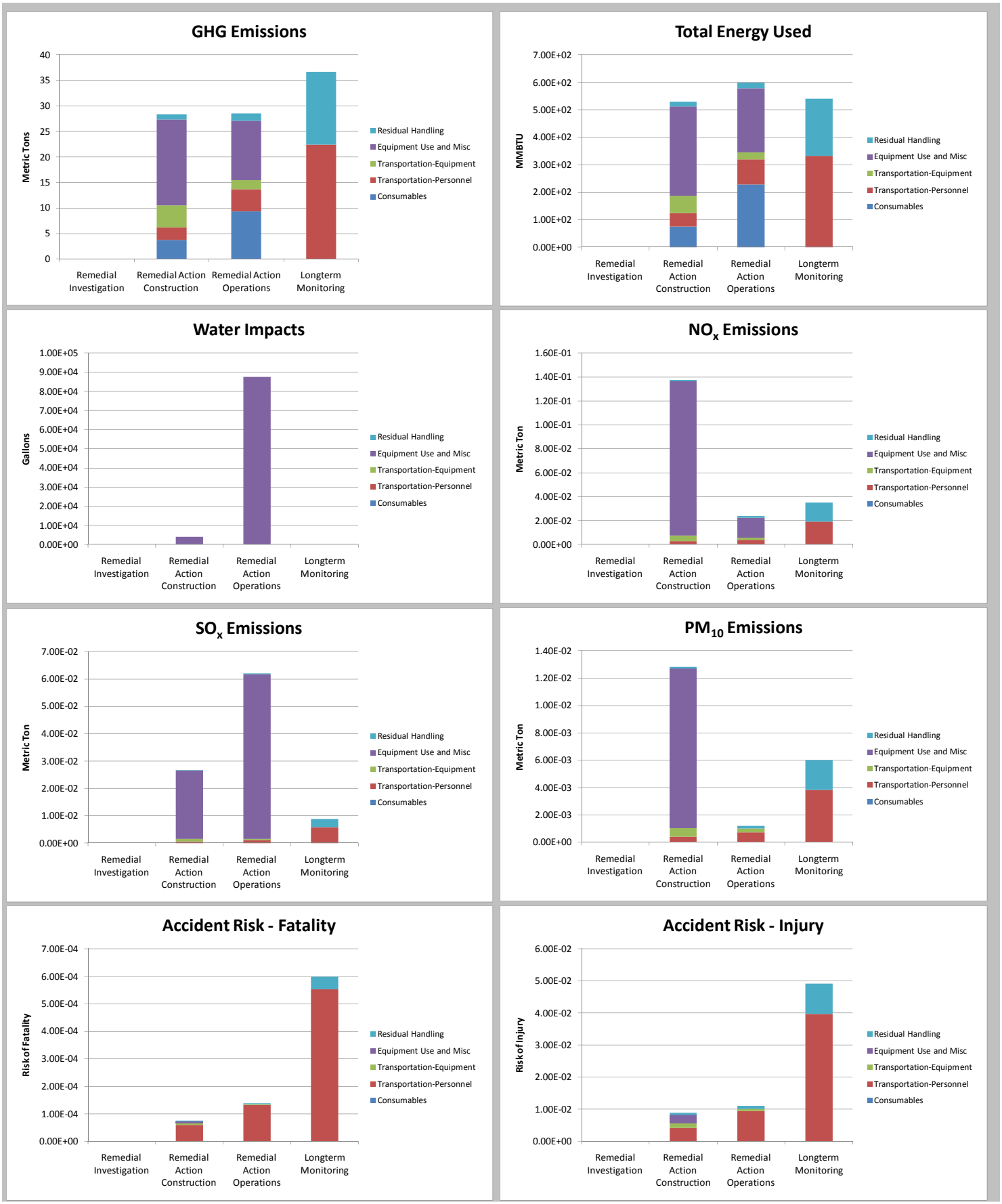


Figure C-8
Sustainability Analysis - Groundwater Alternative 4a - ERD Vertical Injection Extraction Wells
Site 69 Feasibility Study
MCB CamLej
North Carolina

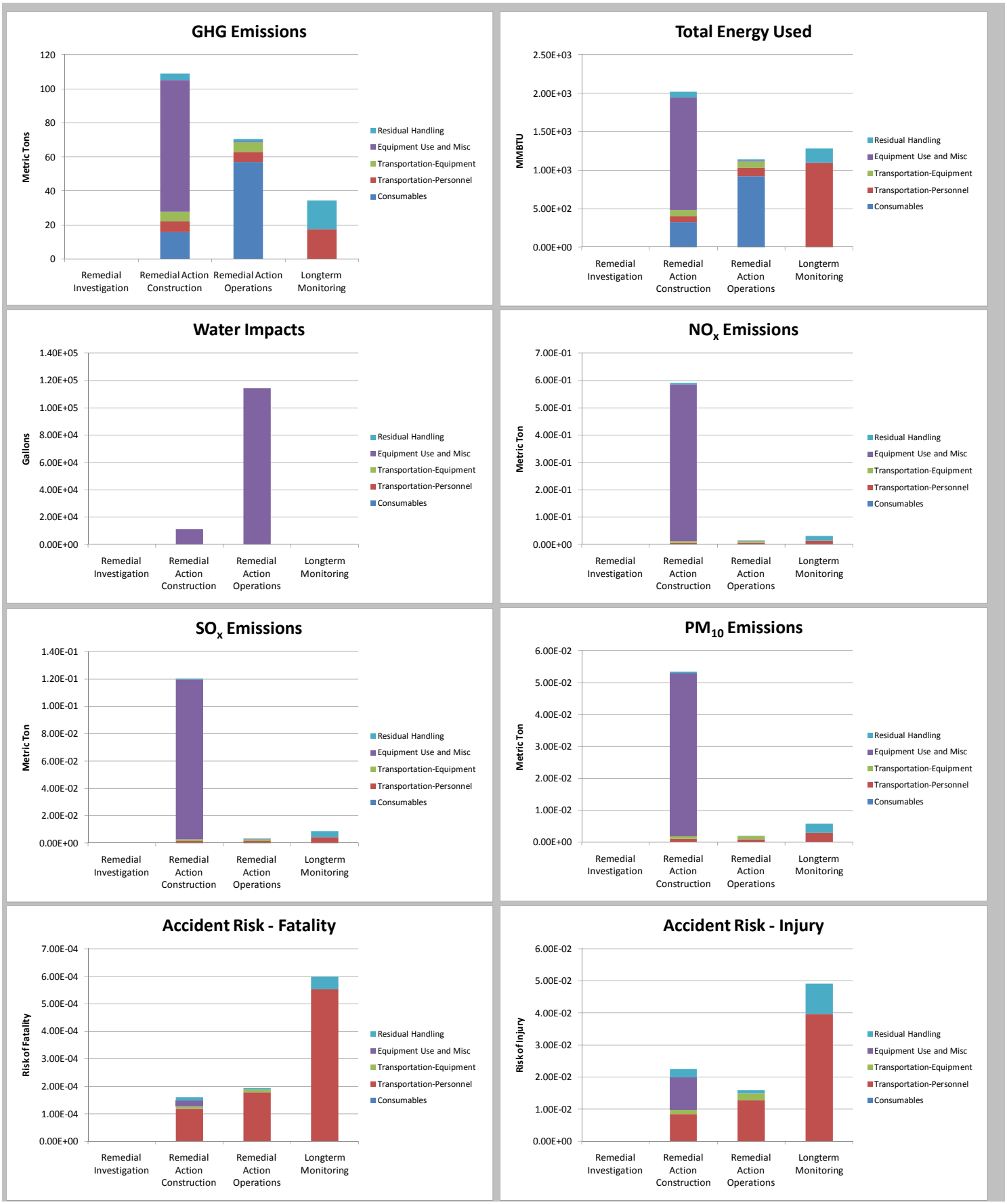


Figure C-9
Sustainability Analysis - Groundwater Alternative 4b - ERD Horizontal Wells
Site 69 Feasibility Study
MCB CamLej
North Carolina

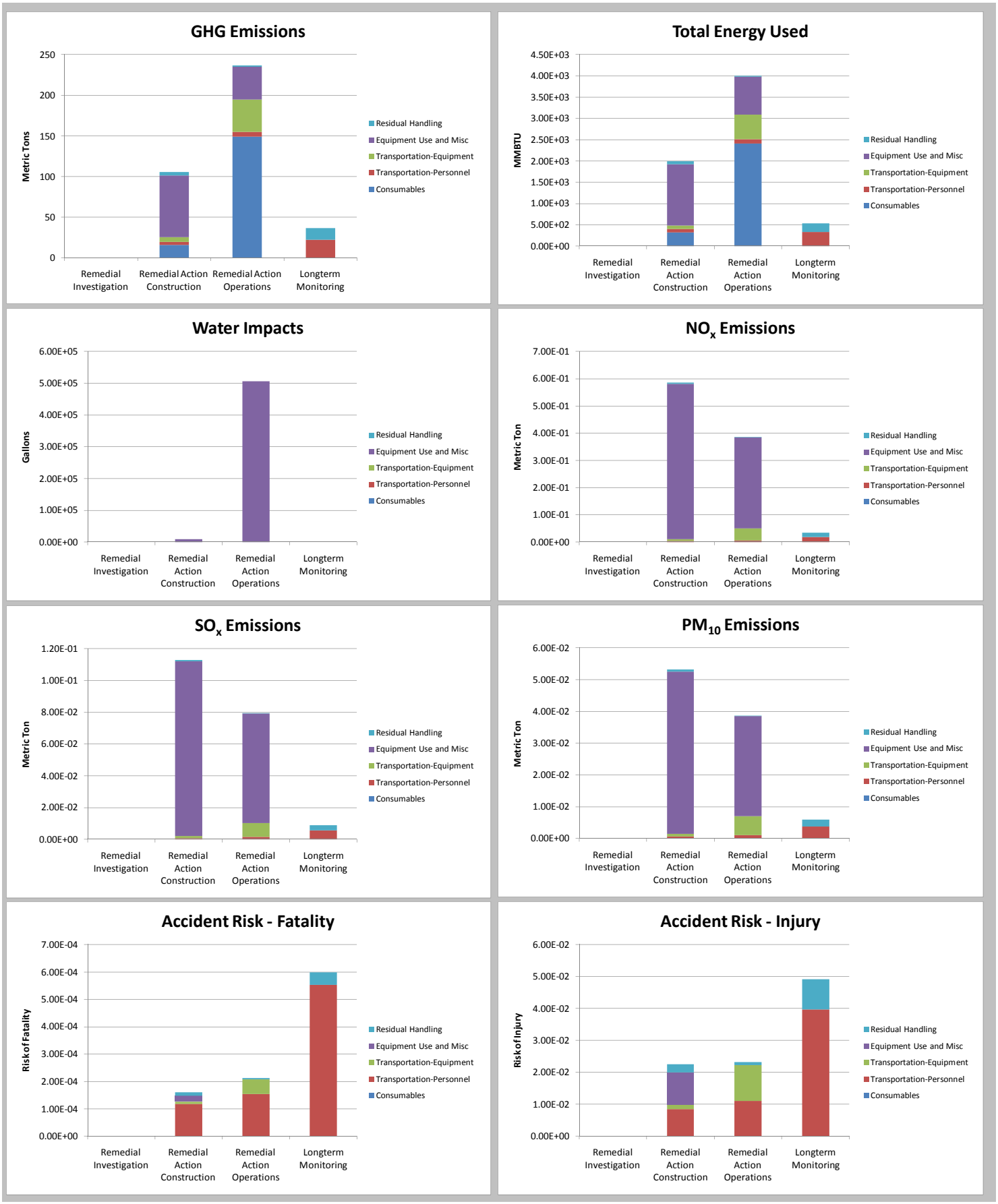


Figure C-10
Sustainability Analysis - Groundwater Alternative 5 - ISCO
Site 69 Feasibility Study
MCB CamLej
North Carolina

Appendix D
Detailed Cost Estimates

TABLE 5-2

Summary of Cost Analysis - Soil

Operable Unit No. 14 (Site 69)

Feasibility Study

MCB CamLej

North Carolina

General Response Action	Soil Alternative 2 LUCs			Soil Alternative 3 Capping - RCRA Subtitle C[a]			Soil Alternative 4 Removal		
	-30%	Estimate	+50%	-30%	Estimate	+50%	-30%	Estimate	+50%
Total Capital Costs	**$9,450**	**$13,500**	**$20,250**	**$3,494,243**	**$4,991,775**	**$7,487,663**	**$17,151,059**	**$24,501,512**	**$36,752,269**
Subsequent Years' Costs	$22,804	**$32,578**	$48,867	$364,871	$521,244	$781,867	$0	$0	$0
Total Present Worth Costs	**$32,254**	**$46,078**	**$69,117**	**$3,859,114**	**$5,513,019**	**$8,269,529**	**$17,151,059**	**$24,501,512**	**$36,752,269**

[a] Includes 4.5% discount rate

COST ESTIMATE for Alternative 2 Land Use Controls

SITE 69, Operable Unit No. 14, MCB Camp Lejeune

CAPITAL AND OPERATIONAL COSTS					
Item/Activity	Qty	Unit	Unit Cost	Cost	Comments
Land Use Controls					
Site notification, sign maintanence, and site survey	1	event	$10,000	$10,000	Engineer's Estimate
Capital Subtotal				$10,000	
Project Management			5%	$500	
G&A			7%	$700	
Profit			8%	$800	
Contingency			15%	$1,500	
TOTAL CAPITAL COST				**$13,500**	
Operations & Maintenance and Periodic Activities					
Description	Qty	Unit	Unit Cost	Cost	Comments
Semi-annual inspection	2	year	$1,000	$2,000	Engineer's Estimate
Yearly O&M and Periodic Maintenance				$2,000	
PRESENT WORTH ANALYSIS					
Number of Years of Operation =	30	years			
Effective Interest Rate =	4.5%				
			Present Worth		
Capital Cost =	$13,500		$13,500		
O&M Costs=	$2,000		$32,578		
TOTAL PRESENT WORTH COST			**$46,078**		

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered “order-of-magnitude” estimates, with an expected accuracy of -30% to +50%

*Real discount rates taken from the Appendix C of the OMB Circular A-94 http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html

COST ESTIMATE for Alternative 3 Soil Capping

SITE 69, Operable Unit No. 14, MCB Camp Lejeune

Assumptions:
Waste disposal area 190,000 sq. ft.
Estimated Time to Complete Capping installation = 20 weeks
Estimated Volume of fill material = 23,664 cubic yards

CAPITAL AND OPERATIONAL COSTS					
Item/Activity	Qty	Unit	Unit Cost	Cost	Comments
Field Preparation					
Utility Location	1	day	$1,500	$1,500	Engineer's Estimate
Vegetation clearance	5	acres	$2,500	$12,500	Engineer's Estimate
Wetlands Delineation	1	LS	$7,500	$7,500	Engineer's Estimate
SPCC preparation	1	LS	$10,000	$10,000	Engineer's Estimate
Edgewood Chemical & Biological Center (ECBC)					
Field Monitoring	20	day	$11,000	$220,000	Cost estimate from vendor (ECBC), well abandonment, site prep
Capping Subcontractor					
site prep - 1 ft fill over area	7000	cy	$40	$280,000	Engineer's Estimate
Installation of RCRA Subtitle C Cap	5	acres	$440,000	$2,200,000	Engineer's Estimate
Field Oversight (labor & expenses)	114	day	$2,000	$228,000	Site Super, H&S + lodging/per diem
Design, Work Plans, Permits	1	LS	$50,000	$50,000	UIC permit, project work plans, gw modeling
Reporting	1	LS	$15,000	$15,000	Engineer's Estimate
UXO Support	114	day	$1,500	$171,000	Engineer's Estimate (utility locate, veg clearing, wetlands delineation, capping)
Monitoring Well Abandonment	1	LS	$15,000	$15,000	Engineer's Estimate
Land Use Controls					
Site notification, sign maintanence, and site survey	1	LS	$10,000	$10,000	Engineer's Estimate
Capital Subtotal				$3,220,500	
Project Management			5%	$161,025	
Construction Management			8%	$257,640	
G&A			11%	$354,255	
Profit			6%	$193,230	
Contingency			25%	$805,125	
TOTAL CAPITAL COST				**$4,991,775**	

Operations & Maintenance and Periodic Activities					
Description	Qty	Unit	Unit Cost	Cost	Comments
Semi-annual mowing and inspection	2	year	$5,000	$10,000	Engineer's Estimate
Repair every 5 years	1	LS	$22,000	$22,000	Engineer's Estimate
Yearly O&M and Periodic Maintenance				$32,000	

PRESENT WORTH ANALYSIS			
Number of Years of Operation =	30	years	
Effective Interest Rate =	4.5%		
			Present Worth
Capital Cost =	$4,991,775		$4,991,775
O&M Costs=	$32,000		$521,244
TOTAL PRESENT WORTH COST			**$5,513,019**

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered "order-of-magnitude" estimates, with an expected accuracy of -30% to +50%
A groundwater alternative would be selected in conjunction with this alternative.
*Real discount rates taken from the Appendix C of the OMB Circular A-94 http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html

COST ESTIMATE for Alternative 4 Soil Removal

SITE 69, Operable Unit No. 14, MCB Camp Lejeune

Assumptions:
Waste disposal area = 190,000 sq. ft.
Estimated depth of disposal area = 20 ft
Estimated time to excavate & backfill = 180 days
Estimated volume of excavated/fill material = 1,407,407 cubic yards

CAPITAL AND OPERATIONAL COSTS					
Item/Activity	Qty	Unit	Unit Cost	Cost	Comments
Field Preparation					
Utility Location	1	day	$1,500	$1,500	Engineer's Estimate
Vegetation clearance	1	LS	$16,794	$16,794	Army Corps of Engineers - estimate 50% of cost for reduced acreage to remove/backfill
Wetlands Delineation	1	LS	$7,500	$7,500	Engineer's Estimate
SPCC preparation	1	LS	$10,000	$10,000	Engineer's Estimate
Edgewood Chemical & Biological Center (ECBC)					
Field Monitoring	184	day	$11,000	$2,024,000	Cost estimate from veondor (ECBC)
Excavation Subcontractor					
Work Plan / Plans & Specifications	1	LS	$50,000	$50,000	
Blast Berm Construction	1	LS	$1,493,306	$1,493,306	Army Corps of Engineers - estimate 50% of cost for reduced acreage to remove/backfill
Excavation (4 acres to 20 ft deep)	1	LS	$11,703,530	$11,703,530	Army Corps of Engineers - estimate 50% of cost for reduced acreage to remove/backfill
Backfill/Seeding (4 acres to 20 ft deep)	1	LS	$687,065	$687,065	Army Corps of Engineers - estimate 50% of cost for reduced acreage to remove/backfill
Field Oversight (labor & expenses)	184	day	$2,000	$368,000	Site super, H&S + lodging/per diem
Reporting	1	LS	$15,000	$15,000	Engineer's Estimate
UXO Support	184	day	$1,500	$276,000	Engineer's Estimate (utility locate, veg clearing, wetlands delineation, removal)
Monitoring Well Abandonment	1	LS	$15,000	$15,000	Engineer's Estimate
Capital Subtotal				$16,667,695	
Project Management			5%	$833,385	
G&A			11%	$1,833,447	
Profit			6%	$1,000,062	
Contingency			25%	$4,166,924	
TOTAL CAPITAL COST				**$24,501,512**	

PRESENT WORTH ANALYSIS		
		Present Worth
Capital Cost =	$24,501,512	$24,501,512
TOTAL PRESENT WORTH COST		**$24,501,512**

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered "order-of-magnitude" estimates, with an expected accuracy of -30% to +50%
A groundwater alternative would be selected in conjunction with this alternative.
*Real discount rates taken from the Appendix C of the OMB Circular A-94 http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html

TABLE 5-4

Summary of Cost Analysis - Groundwater

Operable Unit No. 14 (Site 69)

Feasibility Study

MCB CamLej

North Carolina

General Response Action	Groundwater Alternative 2 MNA[a]			Groundwater Alternative 3 Permeable Reactive Barrier[a]			Groundwater Alternative 4a Enhanced Reductive Dechlorinization with Bioaugmentation - Vertical Injection/Extraction Wells[a]			Groundwater Alternative 4b Enhanced Reductive Dechlorinization with Bioaugmentation - Horizontal Injection Wells[a]			Groundwater Alternative 5 In Situ Chemical Oxidation[a]		
	-30%	Estimate	+50%	-30%	Estimate	+50%	-30%	Estimate	+50%	-30%	Estimate	+50%	-30%	Estimate	+50%
Total Capital Costs	**$15,435**	**$22,050**	**$33,075**	**$3,570,116**	**$5,100,165**	**$7,650,248**	**$1,068,133**	**$1,525,905**	**$2,288,857**	**$2,614,757**	**$3,735,367**	**$5,603,050**	**$4,556,302**	**$6,509,003**	**$9,763,504**
Subsequent Years' Costs	$654,282	$934,689	$1,402,033	$772,974	$1,104,248	$1,656,372	$772,974	$1,104,248	$1,656,372	$772,974	$1,104,248	$1,656,372	$772,974	$1,104,248	$1,656,372
Total Present Worth Costs[b]	**$669,717**	**$956,739**	**$1,435,108**	**$4,343,089**	**$6,204,413**	**$9,306,619**	**$1,841,107**	**$2,630,153**	**$3,945,229**	**$3,387,730**	**$4,839,615**	**$7,259,422**	**$5,329,276**	**$7,613,251**	**$11,419,876**

[a] Includes 30 years GW monitoring

[b] Includes 4.5% discount rate

COST ESTIMATE for Alternative 2 MONITORED NATURAL ATTENUATION

SITE 69 (Operable Unit No. 14) MCB Camp Lejeune

Assumptions:

Annual Monitoring for 30 years
Number of Wells = 22
ECBC Chemical Agent Screening with Low Flow Sampling

Low Flow Sampling every 5 years for VOCs, PCBs, Metals, Pesticides, Chemical Agent
PDB Sampling for VOCs only every other year

CAPITAL AND OPERATIONAL COSTS					
Item/Activity	Qty	Unit	Unit Cost	Cost	Comments
Land Use Controls					
Site notification, sign maintanence, and site survey	1	LS	$15,000	$15,000	Engineer's Estimate
Subtotal *Capital*				$15,000	
Project Management			5%	$750	
G&A			11%	$1,650	
Profit			6%	$900	
Contingency			25%	$3,750	
TOTAL CAPITAL COST				**$22,050**	
GROUNDWATER MONITORING					
See Groundwater Monitoring Present Worth Worksheet					
GROUNDWATER MONITORING					
PRESENT WORTH ANALYSIS					
Number of Years of Operation =	30	years			
Effective Interest Rate =	4.5%				
			Present Worth		
Capital Cost =	$22,050		$22,050		
Subsequent Years LTM Costs =			$934,689		
TOTAL PRESENT WORTH COST			**$956,739**		

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered "order-of-magnitude" estimates, with an expected accuracy of -30% to +50%

*Nominal discount rates taken from the Appendix C of the OMB Circular A-94 http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html

COST ESTIMATE for Alternative 3 Permeable Reactive Barrier

SITE 69 (Operable Unit No. 14) MCB Camp Lejeune

Treatment Assumptions:
Treatment area 800' x 75' x 1"
Estimated Time to Complete PRB installation = 80-100 days
Estimated Volume of 100% zero valent iron (ZVI) = 4980 cubic feet
Assume 360 tons of 100% iron shavings

Monitoring Assumptions:
Annual Monitoring of 22 wells for 30 years
Semi-Annual PRB Monitoring of 5 wells for 3 years

TREATMENT CAPITAL AND OPERATIONAL COSTS					
Item/Activity	Qty	Unit	Unit Cost	Cost	Comments
Field Preparation					
Utility Location	1	LS	$6,000	$6,000	Engineer's Estimate
Vegetation clearance	1	LS	$5,000	$5,000	Engineer's Estimate
Wetlands Delineation	1	LS	$7,500	$7,500	Engineer's Estimate
SPCC preparation	1	LS	$10,000	$10,000	Engineer's Estimate
Edgewood Chemical & Biological Center (ECBC)					
Field Monitoring	100	day	$11,000	$1,100,000	Cost estimate from vendor (ECBC)
PRB Subcontractor					
Installation of PRB consisting of ZVI	1	LS	$1,893,500	$1,893,500	Cost estimate from vendor (GeoSierra Environmental 80 to 100 work days) includes 3 monitoring wells
Field Oversight (labor & expenses)	105	day	$2,000	$210,000	Engineer's Estimate (SITE SUPER)
Design, Work Plans, Permits	1	LS	$50,000	$50,000	project work plans
Reporting	1	LS	$15,000	$15,000	Engineer's Estimate
UXO Support	105	day	$1,500	$157,500	Engineer's Estimate
Land Use Controls					
Site notification, sign maintanence, and site inspection	1	LS	$15,000	$15,000	Engineer's Estimate
Subtotal				$3,469,500	
Project Management			5%	$173,475	
G&A			11%	$381,645	
Profit			6%	$208,170	
Contingency			25%	$867,375	
TOTAL CAPITAL COST				**$5,100,165**	

SEMI-ANNUAL PRB GROUNDWATER MONITORING. YEARS 1-3					
Description	Qty	Unit	Unit Cost	Cost	Comments
Groundwater sampling					
Labor, Travel, Per Diem	2	event	$5,000	$10,000	
Equipment	2	event	$1,000	$2,000	
UXO Support	2	event	$3,000	$6,000	2 days/event (1 day install + 1 day sampling oversight)
Sample Analysis	16	sample	$85	$1,360	VOCs (5 wells x 2 events)
Chemical agent analysis/transportation	5	sample	$1,500	$7,500	Engineer's Estimate (ECBC) - 5 wells initial event
T&D Purge Water	1	55 gal	$100	$100	non-haz waste; Avg purge vol of 8 gals/well during low flow, 1 gal/well PDBs
Subtotal *Groundwater Sampling*				$26,960	
Reporting					
Reporting Labor (1 annual)	1	rpt	$15,000	$15,000	
Subtotal *Reporting*				$15,000	
Subtotal				$41,960	
Project Management			5%	$2,098	
G&A			11%	$4,616	
Profit			6%	$2,518	
Contingency			25%	$10,490	
SEMI-ANNUAL GROUNDWATER MONITORING. YEARS 1-3				**$61,681**	

COST ESTIMATE for Alternative 3 Permeable Reactive Barrier

SITE 69 (Operable Unit No. 14) MCB Camp Lejeune

Treatment Assumptions:
Treatment area 800' x 75' x 1"
Estimated Time to Complete PRB installation = 80-100 days
Estimated Volume of 100% zero valent iron (ZVI) = 4980 cubic feet
Assume 360 tons of 100% iron shavings

Monitoring Assumptions:
Annual Monitoring of 22 wells for 30 years
Semi-Annual PRB Monitoring of 5 wells for 3 years

ANNUAL GROUNDWATER MONITORING			
See Groundwater Monitoring Present Worth Worksheet			
ANNUAL GROUNDWATER MONITORING			
PRESENT WORTH ANALYSIS			
Number of Years of Semi-Annual PRB Monitoring =	3	years	
Number of Years of Annual Monitoring =	30	years	
Effective Interest Rate =	4.5%		
			Present Worth
Capital Cost =	$5,100,165		$5,100,165
Semi-Annual PRB Groundwater Monitoring. Years 1-3 =	$61,681		$169,559
Annual Groundwater Monitoring =			$934,689
TOTAL PRESENT WORTH COST			**$6,204,413**

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered "order-of-magnitude" estimates, with an expected accuracy of -30% to +50%

*Real discount rates taken from the Appendix C of the OMB Circular A-94 http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html

COST ESTIMATE for Alternative 4a Enhanced Reductive Dechlorination - Vertical Injection/Extraction Wells

SITE 69 (Operable Unit No. 14) MCB Camp Lejeune

Treatment Assumptions:

Treatment area 100' x 180'
Install (10) injection and (10) extraction wells
Estimated Time to Complete 1 injection event = 10 days
Assume installation of 1 well/5 hrs

Assume 41,600 pounds 3-D Microemulsion
Assume 27 liters of KB-1 bioaugmentation culture
Assume second injection required without bioaugmentation
2 Injection evenst 2 years apart

Monitoring Assumptions:

Semi-annual Monitoring of 5 wells for 3 years
Annual Monitoring of 22 wells for 30 years

CAPITAL COSTS					
Item/Activity	Qty	Unit	Unit Cost	Cost	Comments
Site Preparation					
Utility Location	1	LS	$2,250	$2,250	Engineer's Estimate
Vegetation clearance	1	LS	$5,000	$5,000	Engineer's Estimate
UXO Support	4	day	$1,500	$6,000	Engineer's Estimate
Field Oversight and Expenses (Field Prep)	4	day	$1,500	$6,000	Engineer's Estimate
Injection/extraction well installation					
Drilling/Well Installation	20	well	$7,500	$150,000	Engineer's Estimate
Field Oversight and Expenses	12	day	$1,500	$18,000	Engineer's Estimate (1 x 65 ft wells/day)
UXO Support	12	day	$1,500	$18,000	Engineer's Estimate
Edgewood Chemical & Biological Center (ECBC)					
Field Monitoring	12	day	$11,000	$132,000	Cost estimate from vendor (ECBC)
Land Use Control (LUC) survey	1	LS	$15,000	$15,000	Engineer's Estimate
Installation of recirculation system	1	LS	$250,000	$250,000	Engineer's Estimate
Subtotal *Well/System Installation*				$602,250	
Subcontractor - First Injection Event					
System startup and injection of Bioaugmentation culture	5	day	$4,000	$20,000	Engineer's Estimate
ERD substrate	1	LS	$123,552	$123,552	Cost estimate from vendor (Regenesis 3-D Microemulsion 75)
KB-1 Bioaugmentation culture	1	LS	$5,200	$5,200	Cost estimate from vendor (SiREM) material + shipping
Field Oversight and Expenses	5	day	$2,000	$10,000	Engineer's Estimate
Operation and Maintenance	6	day	$4,000	$24,000	1 day per week of system operation includes UXO support'
Design, Work Plans, Permits	1	LS	$50,000	$50,000	UIC permit, project work plans, gw modeling
Reporting	1	LS	$15,000	$15,000	Engineer's Estimate
Subtotal *First Injection Event*				$247,752	
Subcontractor - Second Injection Event					
ERD substrate	1	LS	$123,552	$123,552	Cost estimate from vendor (Regenesis 3-D Microemulsion 75)
Field Oversight and Expenses	5	day	$2,000	$10,000	Engineer's Estimate
Operation and Maintenance	6	day	$4,000	$24,000	1 day per week of system operation includes UXO support'
Design, Work Plans	1	LS	$10,000	$10,000	Instructions, Workplan updates
Reporting	1	LS	$15,000	$15,000	Engineer's Estimate,
Subtotal *Second Injection Event (Includes 3% yearly inflation adjustment)*				$188,029	
Subtotal				$1,038,031	
Project Management			5%	$51,902	
G&A			11%	$114,183	
Profit			6%	$62,282	
Contingency			25%	$259,508	
TOTAL CAPITAL COST				**$1,525,905**	

COST ESTIMATE for Alternative 4a Enhanced Reductive Dechlorination - Vertical Injection/Extraction Wells

SITE 69 (Operable Unit No. 14) MCB Camp Lejeune

SEMI-ANNUAL GROUNDWATER MONITORING. YEARS 1-3					
Description	Qty	Unit	Unit Cost	Cost	Comments
Groundwater sampling					
Labor, Travel, Per Diem	2	event	$5,000	$10,000	
Equipment	2	event	$1,000	$2,000	
UXO Support	2	event	$3,000	$6,000	2 days/event (1 day install + 1 day sampling oversight)
Sample Analysis	16	sample	$85	$1,360	VOCs (5 wells x 2 events)
Chemical agent analysis/transportation	5	sample	$1,500	$7,500	Engineer's Estimate (ECBC) - 5 wells initial event
T&D Purge Water	1	55 gal	$100	$100	non-haz waste; Avg purge vol of 8 gals/well during low flow, 1 gal/well PDBs
Subtotal *Groundwater Sampling*				$26,960	
Reporting					
Reporting Labor (1 annual)	1	rpt	$15,000	$15,000	
Subtotal *Reporting*				$15,000	
Subtotal				$41,960	
Project Management			5%	$2,098	
G&A			11%	$4,616	
Profit			6%	$2,518	
Contingency			25%	$10,490	
SEMI-ANNUAL GROUNDWATER MONITORING. YEARS 1-3				**$61,681**	
ANNUAL GROUNDWATER MONITORING					
See Groundwater Monitoring Present Worth Worksheet					
ANNUAL GROUNDWATER MONITORING					
PRESENT WORTH ANALYSIS					
Number of Years of Quarterly Monitoring =	3	years			
Number of Years of Annual Monitoring =	30	years			
Effective Interest Rate =	4.5%				
			Present Worth		
Capital Cost =	$1,525,905		$1,525,905		
Semi-Annual Groundwater Monitoring. Years 1-3 =	$61,681		$169,559		
Annual Groundwater Monitoring =			$934,689		
TOTAL PRESENT WORTH COST			**$2,630,153**		

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered "order-of-magnitude" estimates, with an expected accuracy of -30% to +50%

*Real discount rates taken from the Appendix C of the OMB Circular A-94 http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html

COST ESTIMATE for Alternative 4b ERD - Horizontal Injection

SITE 69 (Operable Unit No. 14) MCB Camp Lejeune

Treatment Assumptions:

Treatment area 100' x 180'
Install (8) horizontal injection wells
Estimated Time to Complete 1 injection event = 7 days
1 ERD injection event annually for 3 years

Assume 41,600 pounds - 3D Microemulsion 75
Assume 27 liters of KB-1 bioaugmentation culture during 1st and 3rd injections
Assume second injection required without bioaugmentation

Monitoring Assumptions:

Annual Monitoring of 22 wells for 30 years
Semi-annual Monitoring of 5 wells for years 1-3 (3 Years)

CAPITAL COSTS					
Item/Activity	Qty	Unit	Unit Cost	Cost	Comments
Design, Work Plans	1	LS	$20,000	$20,000	Instructions, Workplan updates
Utility Location	1	LS	$6,000	$6,000	Engineer's Estimate
Vegetation Clearance	1	LS	$5,000	$5,000	Engineer's Estimate
UXO Support	5	daily	$1,500	$7,500	Engineer's Estimate
Subtotal *Site Preparation*				$38,500	
Monitoring Well Installation Subcontractor					
Labor & Expenses	48	day	$1,000	$48,000	Engineer's Estimate
Well Installation	4200	LF	$215	$903,000	Cost estimate from vendor (DTD)
Backhoe rental	5	week	$8,000	$40,000	Engineer's estimate
ECBC Field Monitoring	48	day	$11,000	$528,000	Cost estimate from vendor (ECBC)
Field Oversight (labor & expenses)	48	day	$2,000	$96,000	Engineer's Estimate
Land Use Controls Survey	1	LS	$15,000	$15,000	Engineer's Estimate
Waste Disposal Subcontractor					
Soil IDW	1	LS	$7,500	$7,500	Engineer's Estimate
Liquid IDW	1	LS	$24,000	$24,000	Engineer's Estimate
Subtotal *Monitoring Well Installation*				$1,661,500	
Subcontractor for First Injection Event					
Injection of ERD substrate and Bioaugmentation culture	1	LS	$42,275	$42,275	Cost estimate from vendor (Tri-State/Major Drilling)
ERD substrate	1	LS	$123,552	$123,552	Cost estimate from vendor (Regenesis 3-D Microemulsion 75)
Bioaugmentation culture	1	LS	$5,200	$5,200	Cost estimate from vendor (SiREM) material + shipping
Tanks, anaerobic water preparation, material handling	1	LS	$10,000	$10,000	Engineer's Estimate
ECBC Field Monitoring	7	day	$11,000	$77,000	Cost estimate from vendor (ECBC)
Field Oversight (labor & expenses)	7	day	$2,000	$14,000	Engineer's Estimate
Subtotal *First Injection Event*				$272,027	
Subcontractor for Second Injection Event					
Injection of ERD substrate	1	LS	$42,275	$42,275	Cost estimate from vendor (Tri-State/Major Drilling)
ERD substrate	1	LS	$123,552	$123,552	Cost estimate from vendor (Regenesis 3-D Microemulsion 75)
ECBC Field Monitoring	7	day	$11,000	$77,000	Cost estimate from vendor (ECBC)
Field Oversight (labor & expenses)	7	day	$2,000	$14,000	Engineer's Estimate
Subtotal *Second Injection Event (includes 3% yearly inflation adjustment)*				$264,532	
Subcontractor for Third Injection Event					
Injection of ERD substrate and Bioaugmentation culture	1	LS	$42,275	$42,275	Cost estimate from vendor (Tri-State/Major Drilling)
ERD substrate	1	LS	$123,552	$123,552	Cost estimate from vendor (Regenesis 3-D Microemulsion 75)
Bioaugmentation culture	1	LS	$5,200	$5,200	Cost estimate from vendor (SiREM) material + shipping
Tanks, anaerobic water preparation, material handling	1	LS	$10,000	$10,000	Engineer's Estimate
ECBC Field Monitoring	7	day	$11,000	$77,000	Cost estimate from vendor (ECBC)
Field Oversight (labor & expenses)	7	day	$2,000	$14,000	Engineer's Estimate
Reporting	1	LS	$15,000	$15,000	Engineer's Estimate
Subtotal *Third Injection Event (includes 3% yearly inflation adjustment)*				$304,507	

COST ESTIMATE for Alternative 4b ERD - Horizontal Injection

SITE 69 (Operable Unit No. 14) MCB Camp Lejeune

Subtotal				$2,541,066	
Project Management			5%	$127,053	
G&A			11%	$279,517	
Profit			6%	$152,464	
Contingency			25%	$635,266	
TOTAL CAPITAL COST				**$3,735,367**	
SEMI-ANNUAL GROUNDWATER MONITORING. YEARS 1-3					
Description	Qty	Unit	Unit Cost	Cost	Comments
Groundwater sampling					
Labor, Travel, Per Diem	2	event	$5,000	$10,000	
Equipment	2	event	$1,000	$2,000	
UXO Support	2	event	$3,000	$6,000	2 days/event (1 day install + 1 day sampling oversight)
Sample Analysis	16	sample	$85	$1,360	VOCs (5 wells x 2 events)
Chemical agent analysis/transportation	5	sample	$1,500	$7,500	Engineer's Estimate (ECBC) - 5 wells initial event
T&D Purge Water	1	55 gal	$100	$100	non-haz waste; Avg purge vol of 8 gals/well during low flow, 1 gal/well PDBs
Subtotal *Groundwater Sampling*				$26,960	
Reporting					
Reporting Labor (1 annual)	1	rpt	$15,000	$15,000	
Subtotal *Reporting*				$15,000	
Subtotal				$41,960	
Project Management			5%	$2,098	
G&A			11%	$4,616	
Profit			6%	$2,518	
Contingency			25%	$10,490	
SEMI-ANNUAL GROUNDWATER MONITORING. YEARS 1-3				**$61,681**	
ANNUAL GROUNDWATER MONITORING. YEARS 1-30					
See Groundwater Monitoring Present Worth Worksheet					
ANNUAL GROUNDWATER MONITORING. YEARS 4-30					
PRESENT WORTH ANALYSIS					
Number of Years of Semi-Annual Monitoring =	3	years			
Number of Years of Annual Monitoring =	30	years			
Effective Interest Rate =	4.5%				
			Present Worth		
Capital Cost =	$3,735,367		$3,735,367		
Semi-Annual Groundwater Monitoring. Years 1-3 =	$61,681		$169,559		
Annual Groundwater Monitoring =			$934,689		
TOTAL PRESENT WORTH COST			**$4,839,615**		

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered "order-of-magnitude" estimates, with an expected accuracy of -30% to +50%

*Real discount rates taken from the Appendix C of the OMB Circular A-94 http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html

COST ESTIMATE for Alternative 5a ISCO - Horizontal Injection

SITE 69 (Operable Unit No. 14) MCB Camp Lejeune

Treatment Assumptions:
Treatment area 100' x 180' x 35'
Install (8) horizontal injection wells = 48 days
Estimated Time to Complete 1 injection event = 40 days
2 Injection events, 2 yrs apart
Assume 304,000 lbs permanganate and 279,000 gallons of 5% solution per injection event
Assume 5% permanganate for injection volume

Monitoring Assumptions:
Annual Monitoring of 22 wells for 30 years
Semi-annual Monitoring of 22 wells for years 1-3 (3 Years)

TREATMENT CAPITAL AND OPERATIONAL COSTS					
Item/Activity	Qty	Unit	Unit Cost	Cost	Comments
Design, Work Plans	1	LS	$20,000	$20,000	Instructions, Workplan updates
Utility Location	1	LS	$6,000	$6,000	Engineer's Estimate
Vegetation Clearance	1	LS	$5,000	$5,000	Engineer's Estimate
UXO Support	5	daily	$1,500	$7,500	Engineer's Estimate
Subtotal *Site Preparation*				$38,500	
Monitoring Well Installation Subcontractor					
Labor & Expenses	48	day	$1,000	$48,000	Engineer's Estimate
Well Installation	4200	LF	$215	$903,000	Cost estimate from vendor (DTD)
Backhoe rental	5	week	$8,000	$40,000	Engineer's estimate
ECBC Field Monitoring	48	day	$11,000	$528,000	Cost estimate from vendor (ECBC)
Field Oversight (labor & expenses)	48	day	$2,000	$96,000	Engineer's Estimate
Land Use Controls Survey	1	LS	$15,000	$15,000	Engineer's Estimate
Waste Disposal Subcontractor					
Soil IDW	1	LS	$7,500	$7,500	Engineer's Estimate
Liquid IDW	1	LS	$24,000	$24,000	Engineer's Estimate
Subtotal *Monitoring Well Installation*				$1,661,500	
Subcontractor for First Injection Event					
Injection of sodium permanganate (KMnO4)	40	day	$1,810	$72,400	Cost estimate from vendor (Tri-State/Major Drilling)
Sodium Permanganate	304,000	LS	$2.38	$723,520	Cost and volume estimate from vendor (Carus Chemical)
ECBC Field Monitoring	40	day	$11,000	$440,000	Cost estimate from vendor (ECBC)
Field Oversight (labor & expenses)	40	day	$2,000	$80,000	Engineer's Estimate
Subtotal *First Injection Event*				$1,315,920	
Subcontractor for Second Injection Event					
Injection of sodium permanganate (KMnO4)	40	day	$1,810	$72,400	Cost estimate from vendor (Tri-State/Major Drilling)
Sodium Permanganate	304,000	LS	$2.38	$723,520	Cost and volume estimate from vendor (Carus Chemical)
ECBC Field Monitoring	40	day	$11,000	$440,000	Cost estimate from vendor (ECBC)
Field Oversight (labor & expenses)	40	day	$2,000	$80,000	Engineer's Estimate
Reporting	1	LS	$15,000	$15,000	Engineer's Estimate
Subtotal *Second Injection Event (includes 3% yearly inflation adjustment)*				$1,411,973	
Subtotal				$4,427,893	
Project Management			5%	$221,395	
G&A			11%	$487,068	
Profit			6%	$265,674	
Contingency			25%	$1,106,973	
TOTAL CAPITAL COST				**$6,509,003**	

COST ESTIMATE for Alternative 5a ISCO - Horizontal Injection

SITE 69 (Operable Unit No. 14) MCB Camp Lejeune

SEMI-ANNUAL GROUNDWATER MONITORING. YEARS 1-3					
Description	Qty	Unit	Unit Cost	Cost	Comments
Groundwater sampling					
Labor, Travel, Per Diem	2	event	$5,000	$10,000	
Equipment	2	event	$1,000	$2,000	
UXO Support	2	event	$3,000	$6,000	2 days/event (1 day install + 1 day sampling oversight)
Sample Analysis	16	sample	$85	$1,360	VOCs (5 wells x 2 events)
Chemical agent analysis/transportation	5	sample	$1,500	$7,500	Engineer's Estimate (ECBC) - 5 wells initial event
T&D Purge Water	1	55 gal	$100	$100	non-haz waste; Avg purge vol of 8 gals/well during low flow, 1 gal/well PDBs
Subtotal *Groundwater Sampling*				$26,960	
Reporting					
Reporting Labor (1 annual)	1	rpt	$15,000	$15,000	
Subtotal *Reporting*				$15,000	
Subtotal				$41,960	
Project Management			5%	$2,098	
G&A			11%	$4,616	
Profit			6%	$2,518	
Contingency			25%	$10,490	
SEMI-ANNUAL GROUNDWATER MONITORING. YEARS 1-3				**$61,681**	

ANNUAL GROUNDWATER MONITORING

See Groundwater Monitoring Present Worth Worksheet

ANNUAL GROUNDWATER MONITORING

PRESENT WORTH ANALYSIS			
Number of Years of Semi-Annual Monitoring =	3	years	
Number of Years of Annual Monitoring =	30	years	
Effective Interest Rate =	4.5%		
			Present Worth
Capital Cost =	$6,509,003		$6,509,003
Semi-Annual Groundwater Monitoring. Years 1-3 =	$61,681		$169,559
Annual Groundwater Monitoring =			$934,689
TOTAL PRESENT WORTH COST			**$7,613,251**

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered "order-of-magnitude" estimates, with an expected accuracy of -30% to +50%

*Real discount rates taken from the Appendix C of the OMB Circular A-94 http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html

Groundwater Monitoring Present Worth Worksheet

SITE 69 (Operable Unit No. 14) MCB Camp Lejeune

Assumptions:

Annual Monitoring of 22 wells for 30 years
Passive Diffusion Bag sampling (annually for VOCs) + Low Flow sampling (every 5 yrs for PCBs, Pesticides, and Metals)
VOCs analysis (annually) and PCBs, Pesticides, Metals analysis (every 5 yrs)
Chemical Agent analysis includes onsite ECBC air monitoring, sample transportation, and CA analysis
Non-haz waste; Average purge vol of 8 gals/well low flow + 1 gal/well PDB sampling
Includes UXO Support

Year	Analytes	Annual Analytical Cost	Labor and Supplies	Reporting	PM, G&A, Profit, and Contingency (35%)	Total	Present Worth
1	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	$934,688.56
2	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
3	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
4	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
5	VOCs, PCB, PEST, metals, CA	$20,000	$50,000	$15,000	$29,750	$114,750	
6	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
7	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
8	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
9	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
10	VOCs, PCB, PEST, metals, CA	$20,000	$50,000	$15,000	$29,750	$114,750	
11	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
12	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
13	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
14	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
15	VOCs, PCB, PEST, metals, CA	$20,000	$50,000	$15,000	$29,750	$114,750	
16	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
17	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
18	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
19	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
20	VOCs, PCB, PEST, metals, CA	$20,000	$50,000	$15,000	$29,750	$114,750	
21	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
22	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
23	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
24	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
25	VOCs, PCB, PEST, metals, CA	$20,000	$50,000	$15,000	$29,750	$114,750	
26	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
27	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
28	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
29	VOCs	$3,000	$15,000	$15,000	$11,550	$44,550	
30	VOCs, PCB, PEST, metals, CA	$20,000	$50,000	$15,000	$29,750	$114,750	

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*Nominal discount rates taken from the Appendix C of the OMB Circular A-94 http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html

COST ESTIMATE for Alternative 4 Soil Removal

SITE 69, Operable Unit No. 14, MCB Camp Lejeune

Assumptions:
Waste disposal area = 190,000 sq. ft.
Estimated depth of disposal area = 20 ft
Estimated time to excavate & backfill = 180 days
Estimated volume of excavated/fill material = 1,407,407 cubic yards

CAPITAL AND OPERATIONAL COSTS					
Item/Activity	Qty	Unit	Unit Cost	Cost	Comments
Field Preparation					
Utility Location	1	day	$1,500	$1,500	Engineer's Estimate
Vegetation clearance	1	LS	$16,794	$16,794	Army Corps of Engineers - estimate 50% of cost for reduced acreage to remove/backfill
Wetlands Delineation	1	LS	$7,500	$7,500	Engineer's Estimate
SPCC preparation	1	LS	$10,000	$10,000	Engineer's Estimate
Edgewood Chemical & Biological Center (ECBC)					
Field Monitoring	184	day	$11,000	$2,024,000	Cost estimate from veondor (ECBC)
Excavation Subcontractor					
Work Plan / Plans & Specifications	1	LS	$50,000	$50,000	
Blast Berm Construction	1	LS	$1,493,306	$1,493,306	Army Corps of Engineers - estimate 50% of cost for reduced acreage to remove/backfill
Excavation (4 acres to 20 ft deep)	1	LS	$11,703,530	$11,703,530	Army Corps of Engineers - estimate 50% of cost for reduced acreage to remove/backfill
Backfill/Seeding (4 acres to 20 ft deep)	1	LS	$687,065	$687,065	Army Corps of Engineers - estimate 50% of cost for reduced acreage to remove/backfill
Field Oversight (labor & expenses)	184	day	$2,000	$368,000	Site super, H&S + lodging/per diem
Reporting	1	LS	$15,000	$15,000	Engineer's Estimate
UXO Support	184	day	$1,500	$276,000	Engineer's Estimate (utility locate, veg clearing, wetlands delineation, removal)
Monitoring Well Abandonment	1	LS	$15,000	$15,000	Engineer's Estimate
Capital Subtotal				$16,667,695	
Project Management			5%	$833,385	
G&A			11%	$1,833,447	
Profit			6%	$1,000,062	
Contingency			25%	$4,166,924	
TOTAL CAPITAL COST				**$24,501,512**	

PRESENT WORTH ANALYSIS		
		Present Worth
Capital Cost =	$24,501,512	$24,501,512
TOTAL PRESENT WORTH COST		**$24,501,512**

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered "order-of-magnitude" estimates, with an expected accuracy of -30% to +50%
A groundwater alternative would be selected in conjunction with this alternative.
*Real discount rates taken from the Appendix C of the OMB Circular A-94 http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html