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FINAL

FEASIBILITY STUDY FOR OPERABLE UNIT NO. 14 (SITE 69)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0212

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EXECUTIVE SUMMARY

INTRODUCTION

This report presents the Feasibility Study (FS) conducted at Operable Unit (OU) Number (No.) 14, for Site 69 (Rifle Range Chemical Dump) at Marine Corps Base (MCB) Camp Lejeune, North Carolina. Baker Environmental, Inc. (Baker) has prepared this FS for Contract Task Order (CTO) 0212 under the Department of the Navy (DoN), Atlantic Division Naval Facilities Engineering Command, Comprehensive Long-Term Environmental Action Navy (CLEAN) Program. This FS is primarily based on data collected during the Remedial Investigation (RI) and Treatability Study (TS) conducted for Site 69.

Site Description and History

MCB Camp Lejeune is located within the Coastal Plain Physiographic Province in Onslow County, North Carolina, approximately 45 miles south of New Bern and 47 miles north of Wilmington. The facility covers approximately 236 square miles. The military reservation is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean. The eastern border of MCB Camp Lejeune is the Atlantic shoreline. The western and northwestern boundaries are U.S. Route 17 and State Route 24, respectively. The City of Jacksonville, North Carolina, borders MCB Camp Lejeune to the north.

Site 69 has a reported history of chemical warfare materiel (CWM) disposal. The CWM suspected at MCB Camp Lejeune are chemical agent identification sets (CAIS).

CAIS were produced in large quantities (110,000) and various configurations by the U.S. Army to train soldiers and sailors in the identification of actual chemical warfare agents and in the proper actions upon identification (U.S. Army, 1993). The sets contain vials (ampules) or bottles of agent. The agents used in these sets could contain blister agents [mustard (H) and lewisite (L)], nerve agents (GA, GB and VX), blood agents [hydrogen cyanide (AC) and cyanogen chloride (CK)], and choking agent [phosgene (CG)].

There are several different types of CAIS. Unfortunately, the types of CAIS used at MCB Camp Lejeune are unknown. In addition, there is a lack of information to properly identify the quantity or disposal methods associated with the CAIS. With respect to disposal, it is not known whether the CWM was destroyed (via burning or detonation) prior to disposal. Existing information, however, does mention that drums were used during disposal.

Site 69, the Rifle Range Chemical Dump, is located west of the New River in the area of MCB Camp Lejeune known as the Rifle Range. The site is approximately 14 acres in size and is situated in a topographically high area. The area is overgrown to the point that the boundary of the former dump is not readily noticeable. Three surface water bodies are located 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. The site area is rather secluded; however, training exercises are conducted throughout the surrounding area. Currently a fence surrounds the site to restrict access.

The site is underlain by silty sands from the ground surface to a depth of approximately 18 feet. Beneath the silty sand is a fairly continuous sandy clay, and sand and clay unit. The upper unit of

the Castle Hayne, which was encountered below the sand and clay retarding layer, consists of silty sand with shell and limestone fragments.

During the period 1950 to 1976, the area was used to dispose chemical wastes including polychlorinated biphenyls (PCBs), solvents, pesticides, calcium hypochlorite, high-test hypochlorite (HTH), and drums of "gas", which possibly contained CWM such as "mustard gas."

Remedial Investigation

The RI field investigations were initiated in January 1994 and completed in April 1996. Data collected during the RI were evaluated to assess the extent of contamination in all site media and the potential for human health and ecological risks to occur based on current and future potential exposure at the site.

Conclusions

The following conclusions were made during the RI.

1. Shallow groundwater has been impacted with volatile organic compounds by former disposal operations. The VOC contamination, which is dominated by 1,2-DCE, is present in the southern portion of the site, near monitoring wells 69-GW02 and 69-GW15. In this area, VOCs are above State and Federal drinking water standards. VOCs were also detected in offsite shallow wells, but at much lower levels. Off-site contaminant levels are below Federal and State drinking water standards. The horizontal extent of the VOC plume in the shallow aquifer has been defined, and is primarily present under the former disposal area.

2. The vertical extent of VOC contamination (i.e., primarily 1,2-DCE) in groundwater appears to be centered in the upper portion of the Castle Hayne Aquifer. VOC levels in the upper portion of the Castle Hayne appear to decrease rapidly as the plume migrates offsite to the east-southeast. Offsite VOC levels in the upper portion of the Castle Hayne are below State and Federal groundwater standards.

3. Groundwater quality in the intermediate zone of the Castle Hayne Aquifer has been slightly impacted by the VOCs. Low levels of 1,2-DCE were detected in wells GWO3DD and GW15DW at concentrations below State and Federal drinking water standards. No off-site intermediate zone wells exhibited contamination.

4. Target VOCs have not migrated to the deep zone of the Castle Hayne Aquifer.

5. Although VOCs are present in both the shallow and Castle Hayne Aquifers, the vertical and horizontal extent of contamination is limited in area. Based on existing data, the plume is estimated to cover an area of approximately three to four acres centering near well cluster GW15.

6. The source of the VOCs may be associated with buried waste near well cluster 69-GW15. This area contains a significant amount of buried metallic debris, based on the results of the geophysical surveys. It is possible that the source of VOCs are within the fill area and may

continue to impact groundwater quality; however, VOC levels in downgradient wells 69-GW02 and 69-GW03 appear to be decreasing.

7. Elevated total metals in shallow groundwater are not believed to be indicative of past disposal operations. This conclusion is based on the following: metal concentrations in soil are similar to levels typically encountered throughout MCB Camp Lejeune; there is no pattern or plume to suggest that the total metals are elevated due to a source; total metals in groundwater are similar to some of the background wells throughout the base; and dissolved metals in groundwater are not elevated.

8. Onsite ponded water in the southern portion of the site is contaminated with VOCs. The ponded water appears to be hydraulically connected to the shallow aquifer.

9. Offsite surface water bodies have not been impacted by the site.

10. Under current human health exposure scenarios, there are no adverse human health risks mainly because groundwater in this area is not utilized for potable supply, and because access to the site is restricted.

11. Under future potential human health exposure scenarios involving residential use of the area, adverse human health risks would result due to groundwater exposure. Future residential use of the area is unlikely since the site is suspected of containing buried CWM.

12. There are no significant ecological risks to aquatic or terrestrial receptors associated with Site 69. Although environmental media concentrations exceeded ARARs/TBCs, aquatic biosurveys indicate fish and benthic macroinvertebrate populations that are representative of typical estuarine and tidal freshwater systems that are not adversely impacted by contaminant sources.

13. Based on the human health and ecological risk assessments, groundwater is the only medium of concern at Site 69. Although there is no current groundwater exposure pathway that would result in adverse human health risks, VOCs are migrating into the Castle Hayne Aquifer. The Castle Hayne is utilized extensively throughout MCB Camp Lejeune and the surrounding communities as a source of water.

Areas of Concern Requiring Remediation and/or Institutional Controls

The results of the baseline human health RA and the ecological risk assessment were evaluated to determine the areas of concern (AOC) within OU No. 14 that may warrant remediation or institutional controls to protect the public health and the environment. This determination is presented below for Site 69.

Site 69 Areas of Concern

Shallow and deep groundwater and soil (including the landfill material) are media at Site 69 which could potentially pose unacceptable future human health or ecological risks. As mentioned previously, these media do not present unacceptable risks to human health or the environment, at present.

Shallow and deep groundwater have been combined as one area of concern because of their hydraulic connection to one another (the aquifers are interconnected to each other and are contaminated by the same source). Shallow groundwater within the southeast portion of the former disposal area has exhibited elevated VOCs (mainly 1,2-DCE, TCE, and vinyl chloride) and to a limited degree, total metals (mainly iron and manganese). The total metals may be elevated as a result of sampling techniques/geologic conditions and not because of former disposal activities. Although there is no current human receptor associated with groundwater, future potential exposure to groundwater could occur under a residential land use scenario, or via migration of VOCs to potable supply wells in the Castle Hayne. Although no base supply wells are in danger of being contaminated, new wells or off-base wells could potentially be contaminated over time.

The following objectives have been identified for groundwater:

- Prevent future potential exposure to contaminated groundwater.
- Protect uncontaminated groundwater for future potential beneficial use.
- Restore contaminated groundwater for future potential beneficial use.

Soil, including the landfill material, has been identified as the second AOC at Site 69. The soil/landfill material does not currently result in unacceptable human health risks, but may result in unacceptable risks under a future potential scenario involving residential land use or construction. The fact that the site is suspected to contain CWM results in a risk from a safety as well as a health standpoint.

The following remedial action objectives have been identified for soil at Site 69:

- Prevent future potential exposure to contaminated subsurface soil (including landfill materials); and
- Prevent potential migration of VOC contaminants to shallow groundwater.

DETAILED ANALYSIS OF SITE 69 REMEDIAL ALTERNATIVES

Site 69 Soil (SO) Alternatives

The soil remedial alternatives developed for Site 69 are listed below:

- Alternative 69SO-1 - No Action
- Alternative 69SO-2 - Institutional Controls

No containment alternatives were proposed due to the implementability of a cap at the site.

Alternative 69SO-1 - No Action

Description: The No Action Alternative is required by the NCP to provide a baseline comparison for other remediation alternatives. Under the No Action Alternative, no remedial action would be performed to reduce the toxicity, mobility, or volume of soil contamination or waste at Site 69.

Cost: There are no costs associated with this alternative.

Alternative 69SO-2 - Institutional Controls

Description: Under this alternative, institutional controls would be implemented to limit access and control future use of the site. These institutional controls would consist of maintenance of an existing fence and designation of the area as a restricted, or limited-use area.

Under this alternative, the existing 6-foot high chain-link fencing encompassing the site would be maintained to restrict site access. In addition, several warning signs would be posted along the fence to indicate that wastes are buried at the site and that construction activities are prohibited within the fenced area.

Under this alternative, the site would be given a land use category in the Base Master Plan that would prohibit residential use of the area of invasive construction activities.

Cost: The estimated costs of this alternative are as follows:

- Capital: $0
- Annual operation and maintenance: $900
- Net present worth (30-year): $13,800

Site 69 Groundwater (GW) Alternatives

The groundwater remedial alternatives developed for Site 69 are listed below:

- Alternative 69GW-1 - No Action
- Alternative 69GW-2 - Institutional Controls and Natural Attenuation
- Alternative 69GW-3 - Groundwater Extraction and Physical Treatment with Institutional Controls and Monitoring
- Alternative 69GW-4 - Dual-Phase Vacuum Extraction and Groundwater Extraction and Physical Treatment, Institutional Controls and Monitoring
- Alternative 69GW-5 - In Situ Air Striping with Institutional Controls and Monitoring

Alternative 69GW-1 - No Action

Description: Under this alternative, no actions would be taken to contain or treat contaminated groundwater at Site 69.

Shallow groundwater generally flows radially from the center of the site, whereas deeper groundwater in the Castle Hayne Aquifer flows in a general easterly direction towards the New River. Groundwater on site currently is not used for any purpose. Potable water throughout the Base is supplied by wells located in the mid and lower regions of the Castle Hayne Aquifer. The shallow aquifer is not used as a potable water supply on Base. However, both the shallow and upper Castle Hayne Aquifers are classified as GA waters under the North Carolina Water Quality Standards

(NCWQS), which are current or potential sources of drinking water. There are no groundwater production wells located downgradient of the site.

Cost: there are no costs associated with this alternative.

Alternative 69GW-2 - Institutional Controls and Natural Attenuation

Description: Under this alternative, a long-term groundwater monitoring program, along with land use restrictions, will be implemented as institutional controls. In addition, remedial actions associated with the in situ, naturally occurring biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization/destruction of the VOCs in groundwater are expected in the form of natural attenuation. Twenty-four monitoring wells will be included under this program. Samples collected from these wells will be analyzed for TCL VOCs. The suspected source of contamination will not be removed because of the possible presence of CWM and the current U. S. Army policy regarding the disturbance of CWM. Because the suspected source will not be removed, a State waiver may be required for the implementation of this alternative.

In an effort to provide additional evidence that natural attenuation is occurring, this alternative incorporates the option of performing an annual contaminant fate and transport model.

Cost: The estimated costs of this alternative are as follows:

- Capital: $0
- Annual operation and maintenance: $63,000 (years 1-5); $24,000 (years 6-30)
- Net present worth (30-year): $535,000

Alternative 69GW-3 - Groundwater Extraction and Physical Treatment, Institutional Controls, and Monitoring

Description: Under this alternative, a groundwater extraction, treatment, and discharge system would be constructed for the shallow and upper Castle Hayne Aquifers, and operated on site.

The groundwater extraction system would be used to extract and contain groundwater contaminated above the cleanup goals developed for the shallow and upper Castle Hayne Aquifers (i.e., NCWQS). If possible, the system would be operated until groundwater cleanup goals are achieved. However, these levels may be impossible to achieve since it has been demonstrated that groundwater contaminant levels typically reach asymptotic levels, which may exceed NCWQS. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached, which exceed NCWQS for some contaminants, then the cleanup goals would be re-evaluated at that time.

Groundwater would be pumped using a series of downgradient well pairs located near the downgradient edge of the contaminant plume and a well pair located near the plume cellar. Each well pair would consist of a shallow well (approximately 25 feet deep) and an upper Castle Hayne well (approximately 60 feet deep). All pumping wells would be connected to a common header pipe that discharges to a common treatment system.

The groundwater treatment system included under this alternative has been sized to accommodate a total flowrate of 100 gpm.

Based on available data, it appears that a pretreatment system may be needed for the removal of suspended solids and nuisance metals from groundwater, such as iron and manganese, to prevent fouling (clogging) of the air stripper. If necessary, an acid (e.g., sulfuric acid) or sequesterant (e.g., polyphosphate chemicals) addition system could be included in the system with only a modest increase in capital and operating cost, which would help keep dissolved iron and manganese in solution. With this type of system, a low-profile air stripper would be desirable because, if necessary, it could be disassembled and cleaned periodically much easier than could a packed tower.

If a more aggressive pretreatment system is needed for the removal of suspended solids and nuisance metals from groundwater, capital and operating costs would increase by more than twofold. In this case, the pretreatment could consist of equalization, flocculation/precipitation, clarification, filtration, and sludge dewatering.

The treated groundwater would be discharged to the New River, which is located approximately 1,200 feet from the site.

Under this alternative, a groundwater sampling program would be initiated for the site. The groundwater sampling program would incorporate the periodic sampling of existing groundwater monitoring wells. Initially, groundwater sampling would be conducted on a semi-annual basis (i.e., two times per year) until a stable or decreasing trend in contaminant levels is observed.

In addition to the environmental monitoring program, institutional controls would be implemented under this alternative to restrict groundwater usage in the vicinity of the site. The site would be given a groundwater use category in the Base Master Plan that would prohibit installation of potable water supply wells in the vicinity of the site (e.g., within a 1,000-foot radius).

Cost: The estimated costs of this alternative are as follows:

- Capital: $1,047,000
- Annual operation and maintenance: $67,000
- Net present worth (30-year): $2,088,000

Alternative 69GW-4 - Dual Phase Vapor Extraction with Groundwater Extraction and Physical Treatment, Institutional Controls, and Monitoring

Description: A groundwater extraction, treatment, and discharge system would be constructed for the upper Castle Hayne Aquifer and operated on site.

Groundwater would be pumped using a series of downgradient wells located near the downgradient edge of the contaminant plume and a well located near the plume center. The downgradient set of extraction wells was developed based on the pumping rate necessary to contain the plume, the number of wells needed to achieve the pumping rate, and the optimum spacing between the wells to capture the groundwater. In addition to capturing groundwater near the downgradient edge of the plume, the groundwater collection system was also designed to pump water from the immediate source area to prevent the spread of the highly contaminated groundwater. The total flowrate for the conceptual pumping well extraction system is 76 gpm.

Dual-Phase Vacuum Extraction System - Source Area and Shallow Aquifer

Under this alternative, an area approximately 100 feet by 300 feet (30,000 square feet) of contaminated soil and shallow groundwater would be remediated using a dual-phase vacuum extraction (DPVE) system, which removes contaminated soil gas and shallow groundwater for subsequent treatment.

DPVE is a method to remediate soil and groundwater using only a single extraction system. This method is well-suited for shallow aquifers with low hydraulic conductivities and for sites with high water tables (shallow vadose zones), such as Site 69.

The dual phase vacuum extraction and treatment system would consist of several major components. The extraction system would include the extraction wells (each 20 feet deep) and underground interconnecting well piping. Three extraction wells and a radius of influence of 50-feet were assumed for costing purposes. Radii of influence can range from about 20 feet to more than 100 feet. In addition, it was assumed that the DPVE system would produce 9 gpm from each extraction well, compared to 3 gpm using a conventional submersible pump. A DPVE pilot test would be required to determine the actual radius of influence (i.e., optimum well spacings) and groundwater yield for Site 69.

The DPVE treatment system would include the following major components:

- Air/water separator system
- Liquid ring vacuum pump system with associated air/water separator and heat exchanger
- A vapor-phase carbon adsorption system with associated pre-treatment heat exchanger

The groundwater treatment system included under this alternative has been sized to accommodate a total flowrate of 125 gpm. However, during a remedial design phase, additional capacity for potential future increases in groundwater flowrates could be designed into the system.

Based on available data, it appears that a pretreatment system may be needed for the removal of suspended solids and nuisance metals from groundwater, such as iron and manganese, to prevent fouling (clogging) of the air stripper. An acid (e.g., sulfuric acid) or suquesterant (e.g., polyphosphate chemicals) addition system would be included in the system with only a modest increase in capital and operating cost, which would help keep dissolved iron and manganese in solution. With this type of system, a low-profile air stripper would be desirable because, if necessary, it could be disassembled and cleaned periodically much easier than could a packed tower.

If a more aggressive pretreatment system is needed for the removal of suspended solids and nuisance metals from groundwater, capital and operating costs would increase by more than twofold. In this case, the pretreatment could consist of equalization, flocculation/precipitation, clarification, filtration, and sludge dewatering.

As with Alternative 69GW-3, a groundwater sampling program and institutional controls would be initiated for the site.

Cost: The estimated costs of this alternative are as follows:

- Capital: $1,238,000
- Annual operation and maintenance: $98,200
- Net present worth (15-year): $2,337,000
- Net present worth (30-year): $2,748,000

The estimated cost does not include the cost of performing an on-site pilot test, which would most likely range from approximately $100,000 to $200,000.

Alternative 69GW-5 - In Situ Air Stripping with Institutional Controls and Monitoring

Description: In situ air stripping is an innovative technology that was developed and patented by a German company, IEG Technologies Corporation in 1992. IEG's in situ stripping technology is called UVB (German: Unterdruck Verdampfer Brunnen), which in English is translated as vacuum vaporize well.

The in situ air stripping process consists of a specially adapted vacuum vaporizer well that contains a vacuum reactor, an aboveground blower, and an off-gas treatment system. The off-gas treatment system typically consists of activated carbon units.

The vacuum vaporizer well has two separate screen segments, one at the well bottom where groundwater enters the well and one above the vacuum reactor. The groundwater entering the well through the lower screened segment is drawn upward through the well, is stripped of volatile contaminants, and returns to the aquifer through the upper screened segment. This pumping action generates a three dimensional circulation flow of groundwater within the area surrounding the well. In some wells, an additional pump is installed to enhance the pumping effect of the air bubbles. The contaminated air is transported upward within the well by the induced vacuum and is then drawn to the off-gas treatment system.

The conceptual pumping well arrangement, includes three UVB systems to remediate groundwater in the upper Castle Hayne Aquifer. The three wells would be positioned near the plume center.

As with Alternatives 69GW-3 and 69GW-4, a groundwater sampling program and institutional controls would be initiated for the site.

Cost: The estimated costs of this alternative are as follows:

- Capital: $246,000
- Annual operation and maintenance: $39,000
- Net present worth (30-year): $853,000

1.0 INTRODUCTION

This FS has been prepared by Baker Environmental, Inc. (Baker) under the DON Atlantic Division Naval Facilities Engineering Command (LANTDIV) Comprehensive Long-Term Environmental Action Navy (CLEAN) Program for Contract Task Order 0212 (RI/FS) for Operable Unit No. 14. This FS has been conducted in accordance with the requirements delineated in the National Contingency Plan (NCP) for remedial actions [40 Code of Federal Regulations (CFR) 300.430]. These NCP regulations were promulgated under CERCLA, commonly referred to as Superfund, and amended by the Superfund Amendments and Reauthorization Act (SARA) signed into law on October 17, 1986. The USEPA's document Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988a) has been used as guidance for preparing this document.

Marine Corps Base (MCB), Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) on October 4, 1989 (54 Federal Register 41015, October 4, 1989). The United States Environmental Protection Agency (USEPA) Region IV, the North Carolina Department of Environment, Health and Natural Resources (NC DEHNR) and the United States Department of the Navy (DON) then entered into a Federal Facilities Agreement (FFA) for MCB, Camp Lejeune. The primary purpose of the FFA is to ensure that environmental impacts associated with past and present activities at the MCB, Camp Lejeune are thoroughly investigated and appropriate CERCLA Response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives are developed and implemented as necessary to protect public health and the environment (FFA, 1989).

This FS has been based on data collected during the RI and treatability study conducted at Site 69 (Operable Unit No. 14) (Baker, 1994). Site 69 is referred to as the Rifle Range Chemical Dump in most background reports and documents. Field investigations at this site began in January 1994 and continued through April 1996. Detailed findings of the field investigations and potential impacts to human health and the environment are provided in the RI Report under separate cover (Baker, 1996). A treatability study was conducted from March 26, 1996 to October 1996 (Phase I) to evaluate the effectiveness of in-situ groundwater treatment. A Phase II TS involving this same technology was conducted for a four-month period in 1997. The treatability study, scope, data evaluation, conclusions, and recommendations are presented in the Final TS Report (Baker, 1998) and summarized in Section 1.8 of this FS.

1.1 Purpose and Organization of the Report

1.1.1 Purpose of the Feasibility Study

The purpose of the FS for OU No. 14 is to identify remedial alternatives that are protective of human health and the environment, attain Federal and State requirements that are applicable or relevant and appropriate, and are cost-effective. In general, the FS process under CERCLA serves to ensure that appropriate remedial alternatives are developed and evaluated, such that relevant information concerning the remedial action options can be presented and an appropriate remedy selected. The FS involves two major phases:

- Development and screening of remedial action alternatives, and
- Detailed analysis of remedial action alternatives.

The first phase includes the following major activities:

1. Developing remedial action objectives and remediation levels
2. Developing general response actions
3. Identifying volumes or areas of affected media
4. Identifying and screening potential technologies and process options
5. Evaluating process options
6. Assembling alternatives
7. Defining alternatives
8. Screening and evaluating alternatives.

Section 121(b)(1) of CERCLA requires that an assessment of permanent solutions and alternative treatment technologies or resource recovery technologies that, in whole or in part, will result in a permanent and significant decrease in the toxicity, mobility, or volume of the hazardous substance, pollutant, or contaminant be conducted. In addition, according to CERCLA, treatment alternatives should be developed ranging from an alternative that, to the degree possible, would eliminate the need for long-term management of alternatives to alternatives which involve treatment that would reduce toxicity, mobility, or volume as their principal element. A containment option involving little or no treatment and a no-action alternative should also be developed.

The second major phase of the FS consists of: (1) evaluating the potential alternatives in detail with respect to nine evaluation criteria to address statutory requirements and preferences of CERCLA; and (2) performing a comparison analysis of the evaluated alternatives.

1.1.2 Report Organization

This FS Report is organized in six sections. The Introduction (Section 1.0) presents the purpose of the report, a brief discussion of the FS process, and pertinent site background information including a summary of the nature and extent of contamination at OU No. 14. Human health and ecological risks are also presented in Section 1.0. Section 2.0 contains the remedial action objectives and remediation levels that have been established for the site. Section 3.0 contains the identification of general response actions, and the identification and preliminary screening of the remedial action technologies and process options. Section 4.0 contains the development, detailed analysis, and comparison of remedial action alternatives for Site 69. The detailed analysis is based on a set of nine criteria including short- and long-term effectiveness, implementability, cost, state and local acceptance, compliance with applicable regulations, and overall protection of human health and the environment. The references are listed in Section 5.0.

1.2 Site Background Information

Background information pertaining to OU No. 14 is presented in this section. Section 1.2.1 provides a history of Site 69 and Section 1.2.2 describes the geographical, geologic, hydrogeologic and surficial setting of the Site 69 area. Additional background information pertaining to this operable unit can be found in the RI Report (Baker, 1996).

1.2.1 History

Operable Unit No. 14 consists of Site 69. Site 69 has a reported history of chemical warfare materiel (CWM) disposal. During the period 1950 to 1976, the area was used to dispose chemical wastes

including polychlorinated biphenyls (PCBs), solvents, pesticides, calcium hydrochlorite, high-test hypochlorite (HTH), and drums of "gas" which possibly contained CWM.

The CWM suspected at MCB Camp Lejeune are chemical agent identification sets (CAIS). [The following information about CAIS was obtained directly from documents published by the U.S. Army Chemical Materiel Destruction Agency (USACMDA).] There are various classifications associated with disposal of CWM. Based on a report published by USACMDA, Site 69 was classified as a "Classification 3 - Suspected Burial" (USACMDA, 1993). A classification 3 site is a site at which one or more of the following conditions apply:

- The normal duty activities performed on this site indicate a strong suspicion that buried CWM may still exist even though they are indicated in literature as destroyed. An example would be a burn pit where not all of the munitions may have been consumed even though the period literature indicated that they were.

- Chemical weapons were known to be disposed of on this site, but period literature indicates that the site was cleared. The period definition of cleared, and the technology for clearing such locations at that time, may lead to the conclusion that not everything was removed.

- The site is a known chemical range but the literature is unclear as to whether chemical agent was applied to the site by spraying (such that there would be no buried ordnance) or by range firing/bombing.

Based on information collected during the RI, which may not have been available at the time the USACMDA report was published, Site 69 may actually be classified as a Class 2 site (Likely Burial).

A Class 2 site is a site in which the following condition applies:

- The burial of CWM has been reported.

With respect to the criteria for a Class 2 site, a background report has indicated the burial of "gas" at Site 69 (Eakes, 1982). The report also indicated that agents may be at the site.

CAIS were produced in large quantities (110,000) and various configurations by the U.S. Army to train soldiers and sailors in the identification of actual chemical warfare agents and in the proper actions upon identification (U.S. Army, 1993). The sets contain vials (ampules) or bottles of agent. The agents used in these sets could contain blister agents [mustard (H) and lewisite (L)], nerve agents (GA, GB and VX), blood agents [hydrogen cyanide (AC) and cyanogen chloride (CK)], and choking agent [phosgene (CG)].

There are several different types of CAIS. One variety of CAIS was an instructional "sniff set" that contained agent impregnated charcoal. It was intended for use indoors to instruct military personnel in recognizing the odors of chemical agent. This type of set contained only small amounts of chemical agent. A second major variety of CAIS, designed for use outdoors, consisted of agent (pure or in solution) in sealed pyrex tubes. The gas tubes would be detonated, creating an agent cloud. Soldiers would then try to identify the agent based on its odor and other characteristics. These typically contained more agent then the instructional "sniff sets" and could produce a much greater hazard. A third major variety of CAIS were those containing bulk mustard. These CAIS were used in

decontamination training by purposely contaminating the terrain or equipment with mustard, and then teaching the soldiers how to don the correct protective clothing and decontaminate the area or equipment. These CAIS contained relatively large quantities of pure mustard.

Unfortunately, the types of CAIS used at MCB Camp Lejeune are unknown. However, drums containing calcium hypochlorite, a decontaminant, have been identified at the base. Therefore, it is possible that the third variety of CAIS mentioned above (i.e., CAIS containing pure mustard) may have been used at MCB Camp Lejeune. Based on "best professional judgements" made by personnel at the U.S. Army Chemical Materiel Destruction Agency (USACMDA), CAIS at MCB Camp Lejeune most likely did not contain nerve agents. However, a memo with a hand drawn sketch of Site 69 identified that "mustard or nerve gas" was disposed of at two locations within the site (Scudder, 1982).

In summary, there is a good likelihood that CWM are present at Site 69. However, there is a lack of information to properly identify the amount, types, or disposal methods associated with CAIS disposal. With respect to disposal, it is not known whether the CWM was destroyed (via burning or detonation) prior to disposal. Existing information, however, does mention that drums were used during disposal.

1.2.2 Site Description and Setting

Site 69, the Rifle Range Chemical Dump, is located west of the New River in the area of MCB Camp Lejeune known as the Rifle Range (see Figure 1-1). The site is approximately 14 acres in size and is situated in a topographic high area. The area is overgrown to the point that the boundary of the former dump is not readily noticeable. Three surface water bodies are located 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. The site area is secluded; however, training exercises are conducted throughout the surrounding area. Currently, a fence surrounds the site to restrict access.

Figure 1-2 provides an overview of the site and includes the general location of all monitoring wells installed in pre-RI studies and during the RI (Note: This figure does not include any wells installed after the RI).

The site is underlain by silty sands from the ground surface to a depth of approximately 18 feet. Beneath the silty sand is a fairly continuous sandy clay, and sand and clay unit, to a depth of approximately 27 feet. This unit could potentially act as a retarding layer. The upper unit of the Castle Hayne, which was encountered below the sand and clay retarding layer, consists of silty sand with shell and limestone fragments.

The upper portion of the formation is comprised of silty sand with shell and limestone fragments with an average thickness of approximately 40 feet. Below the silty sand is a sand unit with trace to little silt. This unit also exhibits a sandy clay/clayey sand layer, with an approximate thickness of 109 feet, at a depth of 145 feet. The deep borings to the bottom of the Castle Hayne encountered limestone beds in the lower portion, beneath the sand unit. These limestone beds are identified in the literature as "marked beds" for the bottom of the Castle Hayne, and were encountered in the three deep borings performed in March/April 1996 at depths of approximately 207 feet.

Beneath the limestone beds is silty sand with a 4 foot thick silty , sandy clay layer/lenses. At a depth of 245 feet, a silty sand unit was encountered which appeared to be glauconitic. Glauconitic is a descriptive terms which refers to a greenish platy materia which occurs in sediments of marine origin.

A glauconitic sand unit is identified as part of the Beaufort formation which lies below the Castle Hayne aquifer and the Beaufort confining unit.

The shallow groundwater is typically encountered within a few feet of ground surface to a depth of approximately 5 feet. Groundwater flow is radial from the site to the low lying areas to the north, south, east, and west. Groundwater flow in the upper portion of the Castle Hayne is towards the south/southeast in the southern portion of the site. There would appear to be some interconnection between the shallow water table aquifer and the Castle Hayne aquifer due to the similar groundwater elevations at some of the monitoring well locations. Groundwater flow in the deep portion of the Castle Hayne aquifer is eastward towards the New River. Recharge for the Castle Hayne aquifer would be from the west, and possibly from the surficial aquifer as the units are separated by a semiconfining layer. The gradient for the deep Castle Hayne aquifer was calculated to be 0.002 ft/ft, which is flat.

1.2.3 Pre-Remedial Investigation Studies

Previous investigations conducted under the DoN's IR Program during the late 1980s and early 1990s at Site 69 focused on shallow groundwater, surface water, and sediment. Eight shallow wells were installed (69GW01-69GW08), and only four surface water/sediment samples were collected. No soil samples were obtained prior to the RI. Shallow groundwater exhibited elevated levels of volatile organics in the southern portion of the site, primarily in Monitoring Well 69GW2 and 69GW3. The volatiles included 1,2-dichloroethene (DCE) (11,000 µg/L), trichloroethene (TCE) (67 µg/L), and vinyl chloride (36 µg/L). Surface water samples obtained from on-site standing water in low-lying areas of the site revealed the same constituents as were detected in shallow groundwater, but at much lower levels. These low-lying areas were located in the southern portion of the site near Well 69-GW02.

1.3 Remedial Investigation

The RI field investigations were initiated in January 1994 and completed in April 1996.

The remedial investigation at Site 69 was initiated by performing a geophysical survey to characterize the site with respect to buried material. Determining the potential areas of buried drums was important since these drums could potentially contain CWM. Contact with CWM was purposely avoided.

Following the geophysical survey, shallow test borings were hand augered and soil samples were obtained to characterize surface soil quality and near subsurface soil quality. A total of 29 shallow test borings was installed, in addition to several test borings to characterize background soil quality. The samples were analyzed for full Target Compound List (TCL) organics, Target Analyte List (TAL) inorganics, and CWM degradation compounds. Surface and subsurface soil samples were also collected during the drilling of monitoring well test borings and analyzed for the same constituents. In March 1995, nine subsurface soil samples were collected within the site area to define subsurface soil quality near a suspected source area. These samples were collected from just above the water table. All soil samples were screened in the field by the U.S. Army Technical Escort Unit so that soil samples containing chemical agents would not be forwarded to the laboratory, and for on-site safety reasons.

During the RI, it was necessary to conduct several different investigations in order to characterize the extent of contamination in groundwater. The initial RI groundwater investigation (January 1994)

focused on defining the extent of VOC contamination in the shallow aquifer. Four shallow wells (GW09, GW10, GW11, and GW12) were installed to a depth between 12.5 and 20.5 feet below ground surface (bgs). The well locations are shown in Figure 1-2. In addition, two wells were installed to depths of 50 feet bgs (well GW02DW) and 58 feet bgs (well GW12DW) in order to determine whether the VOCs were migrating vertically into the upper zone of the Castle Hayne aquifer. The results of the groundwater sampling of the existing wells and newly-installed wells indicated two significant findings. First, the concentrations detected in well GW02 were lower than detected during the Confirmation Study, which preceded the RI. Second, VOCs were detected in the upper zone of the Castle Hayne aquifer above the North Carolina WQS, but much lower than the concentrations detected in the shallow aquifer during previous sampling rounds.

In order to further characterize the extent of VOC contamination, additional monitoring wells were installed in the shallow aquifer and the Castle Hayne aquifer in May 1994. Well GW13 was installed east of the site at a depth of 13 feet bgs to determine offsite groundwater conditions in the shallow aquifer (see Figure 1-2). Well GW02DD was installed adjacent to well GW02 at a depth of 125 feet bgs to determine whether VOCs had migrated from the upper zone to the intermediate zone of the Castle Hayne aquifer. Wells GW03DW and GW13DW were installed east of the suspected source area in the upper zone of the aquifer in order to evaluate vertical and horizontal migration of VOCs from the suspected source area (i.e., the area near well GW02). Both of these wells were installed at a depth of 60 feet bgs.

The four newly-installed wells were sampled in June 1994. The two wells installed in the upper zone of the Castle Hayne aquifer (i.e., wells GW03DW and GW13DW) exhibited low levels of VOCs, indicating that the VOCs have migrated from the suspected source area. Well GW02DD did not exhibit any VOCs, indicating that VOCs have not migrated to the intermediate zone of the aquifer.

In December 1994, a three-well cluster (wells GW14, GW14IW, and GW14DW) was installed south of well cluster GW02 in order to better define the horizontal and vertical extent of contamination. This step was deemed necessary since shallow groundwater flow and VOC migration was believed to be south-southeast, and therefore, contamination in this area was possible. It was determined that the area to the south of the suspected source area needed to be characterized. The cluster of wells consisted of a well in the shallow aquifer (GW14), a well in the upper zone of the Castle Hayne aquifer (GW14IW), and a monitoring well in the intermediate zone (GW14DW). The wells were installed to a depth of 14, 62, and 127 feet bgs, respectively. In February 1995, a round of groundwater samples were collected from all existing and newly-installed monitoring wells and analyzed for VOCs via EPA Method 601/602. No VOCs were detected south of the suspected source area in the GW14 cluster. VOC levels in well GW02 and GW03 were lower than previous sampling rounds for reasons unknown.

At this point of the RI, groundwater remediation was being considered by the DoN. In order to design an effective groundwater collection and treatment system, it was imperative that the source area be better defined. The suspected source area to date was the area near shallow monitoring well GW02, where the highest levels of VOCs had always been detected. The DoN, MCB Camp Lejeune, North Carolina DEHNR, and EPA Region IV agreed that groundwater and soil north of well cluster GW02 should be investigated to better define the source area.

A second geophysical survey was conducted north of well cluster GW02 and GW03 in January 1995. The results of this study indicated a substantial amount of buried metallic debris, just north of well GW02. In addition, nine shallow groundwater samples were collected for VOC analysis via the

hydropunching technique in order to establish the "northern" boundary of the shallow aquifer VOC plume. Monitoring wells GW15 and GW15IW were constructed near the area where the highest VOC levels were observed. These two wells were installed at depths of 13 feet and 60 feet bgs in the shallow aquifer and upper zone of the Castle Hayne aquifer, respectively. In March 1995, another round of samples were collected from a selected number of Castle Hayne monitoring wells for VOC analysis. The highest levels of VOCs were now detected in well GW15IW, which represents the upper zone of the Castle Hayne aquifer. VOCs were also detected in shallow wells GW15, GW02, and GW14, as well as in wells GW13D, GW02DW and GW02DD.

The following conclusions were developed following this particular investigation:

1. The source of VOC contamination is likely near the area of well cluster GW15.

2. The extent of shallow groundwater contamination is defined; the source is near well GW15 and extends approximately to the eastern and southern fence line.

3. Groundwater contamination in the upper zone of the Castle Hayne aquifer is also defined; the highest levels were detected in well GW15IW. Offsite contamination in the upper zone of the Castle Hayne is minimal; wells GW14IW and GW13DW exhibited only low levels of VOCs.

4. Groundwater contamination at a depth of approximately 100 feet bgs is not as defined as the shallow aquifer or the upper zone of the Castle Hayne aquifer. Deep groundwater near cluster GW15 may be contaminated. To what degree the deeper portion of the Castle Hayne is contaminated was unknown at the time. However, wells GW2DD and GW14, which are downgradient of the suspected source area, did not exhibit significant contamination.

5. Deep groundwater east, north, and west of the suspected source area is not defined. Based on the "pattern" of shallow and intermediate groundwater contamination, deep groundwater contamination north and west of the site is not anticipated. Deep groundwater contamination east and southeast of cluster GW15 may be contaminated, but the degree of contamination is questionable.

6. Deep groundwater quality at the bottom zone of the Castle Hayne (greater than 125 feet to approximately 200 feet bgs) is unknown.

During this stage of the RI, a treatability study (TS) was being implemented to evaluate the effectiveness of a technology known as "in well aeration." The TS focused on remediating the VOCs in-situ as opposed to the more common approach of extracting or collecting groundwater for subsequent physical/chemical treatment and discharge. The TS approach focused on the area near well cluster GW15. During the scoping of the TS, it was determined that the vertical extent of contamination needed to be better defined before completing the final details of the TS. Therefore, as part of the TS, another groundwater investigation was conducted in September 1995. During this investigation, groundwater samples were collected via the hydropunch technique near well cluster GW15 at depths of 50, 60, and 70 feet bgs. From this boring, a well was constructed at a depth of 120 feet bgs (GW15DW) in what is referred to as the intermediate zone of the Castle Hayne Aquifer. Another well (GW15UW) was installed to a depth of 37 feet bgs to characterize VOC levels in the upper zone of the Castle Hayne, specifically, in the zone just below shallow well GW15.

The results of the September 1995 TS groundwater investigation indicated that elevated VOCs were detected in the upper zone of the Castle Hayne between 37 and 70 feet bgs. Monitoring well GW15 exhibited high levels of contamination, similar to those levels detected during the March 1995 sampling round. VOC levels decreased from the 70 foot to 120 foot depth.

A number of data limitations were identified following the September 1995 study. Specifically, concerns were raised about whether the vertical extent of VOC contamination has been adequately identified. In order to complete the characterization of VOCs in the Castle Hayne aquifer, the following study objectives were established:

- Characterize the vertical and horizontal extent of groundwater contamination in the Castle Hayne aquifer; and
- Determine probable contaminant migration pathways in the Castle Hayne aquifer.

In order to meet the above-mentioned objectives, three deep monitoring wells were constructed during the period March 20 through April 18, 1996. All three wells were constructed to monitor groundwater quality at the bottom zone of the Castle Hayne aquifer. Well GW15BCH was installed near the suspected source area. Monitoring well GW02BCH was installed south of the suspected source area, and well GW03BCH was constructed southeast of the suspected source area. The bottom of the well screens were set at a depth of 230 feet bgs.

One round of samples were collected using dedicated bailers, between April 19 and 20, 1996, from the three newly-installed deep wells and from existing deep wells GW02DD, GW03DW, and GW15DW for analysis of Target Compound List (TCL) volatile organics (CLP protocols, Level IV data quality). No VOCs were detected in the three newly installed wells.

Extensive surface water/sediment and ecological investigations were conducted in 1992 and in 1994. Surface water/sediment samples were collected from on-site standing water (i.e., pools of water formed in low-lying portions of the site), downslope drainage areas, Everett Creek, the New River, and the unnamed tributary to the New River. Fish and shellfish samples were collected from the unnamed tributary, Everett Creek, and the New River. A benthic macroinvertebrate study was also conducted in these surface waters to evaluate environmental stress factors which may be associated with the site or base-wide activities. All samples were analyzed for full TCL organics and TAL inorganics.

1.4 Nature and Extent of Contamination

The analytical results for this RI are presented in tables at the end of Section 4 of the Final RI Report for Operable Unit No. 14 (December 1996). The results are also illustrated on figures, which can be found at the end of Section 4. These tables and figures may assist the reader of this FS to better understand the nature and extent of contamination at Site 69. A limited number of figures have been included in this FS to illustrate the extent of VOC contamination in the shallow and Castle Hayne Aquifers. In addition, Table 1-1 of this FS provides a summary of the RI results for all media.

1.4.1 Groundwater

Groundwater contamination is most prevalent in the shallow aquifer in the area of shallow well GW15 (see Figure 1-3). Samples collected from well GW02, which historically exhibited VOC levels in the

ppm range, have exhibited much lower levels over the last few years. Based on the most recent rounds of sampling, it appears that the VOC contamination in the shallow aquifer emanates very close to well GW15 and extends horizontally to the south and to the east of the suspected source area. VOC contamination has been detected at low concentrations in well GW14, which is located approximately 300 feet south of well GW15. Based on the low levels detected in these wells, it is unlikely that VOCs are significantly elevated offsite.

VOCs have migrated vertically from the source area (i.e., near well cluster GW15) into the Castle Hayne aquifer. The upper zone of the aquifer has exhibited the most elevated levels of VOCs (see Figure 1-4). The highest levels were detected in wells GW15UW and GW15IW (note that well GW15 UW was converted to a UVB in-well aeration system as part of the Phase II TS). VOCs have also migrated to the intermediate zone of the aquifer (see Figure 1-5). The extent of contamination in the intermediate zone is believed to be limited near the suspected source area. VOC levels below 120 feet are likely to be lower in concentration since deep well GW15BCH did not exhibit VOC contamination (see Figure 1-6). In summary, VOC levels near the suspected source area decrease significantly from the shallow aquifer to the intermediate zone of the Castle Hayne.

Shallow groundwater also exhibited total metals including iron, manganese, lead, and chromium above Federal Maximum Contaminant Levels (MCLs) and North Carolina Water Quality Standards (NCWQS). The distribution of these contaminants throughout the site does not suggest a pattern that could be correlated with a plume. The contaminant levels and distribution are very similar to other sites investigated at MCB Camp Lejeune, indicating that the shallow geologic conditions and sampling methods may have elevated the concentration of total metals due to suspended solids, rather than a specific disposal event. Total metals in the deep groundwater were limited to only iron and manganese, at much lower levels than observed in shallow groundwater. Dissolved metals detected above the MCLs or NCWQS were limited to only iron and manganese.

1.4.2 Soil

Soil samples from monitoring well borings did not exhibit significant concentrations of VOCs. Since no subsurface exploratory trenching was performed to investigate the presence of buried drums (because of the possibility of encountering CWM), the source of shallow groundwater contamination could not be determined. However, geophysical investigations conducted on site revealed buried metallic debris just north of well cluster 69-GW15, which indicated elevated levels of VOCs. It should be noted that the VOC contaminant levels in wells 69-GW02 and 69-GW03 have deceased over time, indicating that the source of the groundwater contamination may have migrated from the vadose zone.

Metal concentrations in soil were not significantly elevated above base-specific background levels. The metal concentrations in soil are similar to those levels detected at other sites within MCB Camp Lejeune. No apparent source or area of concern (AOC) was noticeable which would account for the elevated total metals observed in shallow groundwater. Therefore, this supports the belief that total metals are elevated due to geologic conditions/sampling methods rather than disposal activities.

Pesticides were detected in only a few surface soil samples, but at levels which are typically found throughout MCB Camp Lejeune. The pesticides are likely related to historical pest control activities. Low levels of Aroclor 1260 (94 µg/kg) were detected in one surface soil sample. This contaminant was not detected in subsurface soils. The contaminants acetophenone and hydroxyacetophenone, which are degradation compounds of the ingredient used in tear gas, were detected in low

concentrations in two on-site surface soil samples. These contaminants may be present due to the ongoing training exercises involving the use of tear gas in the surrounding area of the site. No other chemical surety degradation compounds were detected. Additionally, no chemical surety agents were detected by the U.S. Army TEU during sample screening.

1.4.3 Surface Water/sediments

Surface water samples collected from the on-site standing pools of water exhibited elevated levels of 1,2-DCE (55 µg/L), TCE (4 µg/L), vinyl chloride (8 µg/L), and chloroform (2 µg/L). These same contaminants were also detected in shallow groundwater in the southeast portion of the site. The standing pools are located in this general area of the site, indicating that the source of this contamination is associated with the groundwater. Sediment samples collected from one of the two pools also exhibited 1,2-DCE. Surface water samples collected from the drainage area to the northeast of the site exhibited low levels of toluene (1 µg/L), xylene (10 µg/L), and ethylbenzene (1 µg/L). Groundwater was not contaminated in this area, therefore, the presence of these contaminants may be due to past localized spills of fuel products.

Surface water samples collected from the New River, the unnamed tributary, and Everett Creek did not exhibit organic contamination. Metals were detected, but not at levels indicative of a problem due to disposal activities. Sediment samples collected from the unnamed tributary did exhibit low levels of benzo(a)pyrene, pesticides (DDE and DDD), Aroclor 1260, and metals (arsenic, chromium, and lead) in one sample station. The presence of these constituents are not believed to have migrated from Site 69 due to the distance as well as the limited degree of soil and groundwater contamination exhibiting these contaminants. Sediment samples collected from the New River and Everett Creek exhibited metals, but these detections are not likely associated with Site 69.

1.5 Human Health Risk Assessment

The baseline human health risk assessment was based on possible exposure pathways under current and future potential exposure scenarios. Under current conditions, the exposed population considered base personnel who may be exposed to site contaminants during military training operations (Site 69 is in a remote area of the base where military training occurs). The exposure medium is primarily associated with surface soil. Groundwater was not considered as an exposure medium since the Base is serviced by a public (Base) water supply system. In addition, there are no supply wells which have been impacted by Site 69. Future potential exposure scenarios involved construction personnel and residential. For the residential scenario, groundwater and surface soil were identified as exposure media. It should be noted that the future residential exposure pathway to soil or groundwater is extremely unlikely given that the Site is suspected of containing buried CWM. For the future construction pathway, subsurface soil was identified as the exposure medium.

The total site incremental carcinogenic risk (ICR) and hazard index (HI) values associated with current and future receptors at this site are presented in Table 6-47 of the Final RI Report. Given the absence of chemicals of potential concern (COPCs) in the surface soil, current land use (fenced area with restricted access), and that groundwater in this area is not used for potable purposes, there are no current risks posed to any population from this site. Under the future potential risk exposure scenario, the total site ICR estimated for children (3E-04) and adults (6E-04) exceeded the USEPA's upper bound risk range (1E-04). The total site ICR estimated for construction workers (6E-08) was less than the USEPA's lower bound target risk range (1E-06). Additionally, the total site HI for children (26) and adults (11) exceed unity. The total site HI estimated for the construction worker (<0.01) did not

exceed unity. The total site risk under the future potential exposure scenarios was driven by exposure to shallow groundwater. It should be noted that the estimated ICRs and HIs for exposure to subsurface soil do not account for the possibility of exposure to CWM since CWM-related contaminants could not be quantified during the RI.

1.6 Ecological Risk Assessment

Overall, metals and pesticides appear to be the most significant site related COPCs that have the potential to affect the integrity of the aquatic ecosystems at OU No. 14. For the terrestrial ecosystems, metals appear to be the most significant site related COPCs that have the potential to affect terrestrial receptors at OU No. 14.

Potential adverse impacts to threatened or endangered species are low due to the absence of critical habitats or noted observations at the site. Biohabitats maps did not indicate a significant impact to ecological resources on or near the Site 69.

Copper and silver exceeded the ARARs/TBCs in surface water and cadmium, mercury, benzo(a)pyrene, 4,4'-DDE, 4,4'-DDT, and PCB-1260 exceeded NOAA sediment screening criteria. The silver quotient ratio was slightly high. However, although silver was above the base-wide and median concentrations, it is not related to the site. In addition, silver was detected in the New River in upstream samples at concentrations similar to those found in Everett Creek. The sediment exceedences indicated concentrations above the base-wide and median concentration for cadmium, mercury, 4,4'-DDE, 4,4'-DDT, and PCB-1260.

The potential risks to aquatic receptors due to the above exceedences in the surface waters around the site was evaluated by conducting biosurveys and fish tissue analysis. Fish populations were sampled and were representative of estuarine and tidal freshwater systems. The predominant fish species were croaker, Easter mosquito, and pinfish. There were no anomalies observed on the fish. The fish community appeared healthy and not impacted due to site contaminants.

Fish tissues were sampled and the following were detected: organics (benzene, toluene, and 2-methylphenol), pesticides (4,4'-DDE and 4,4'-DDD), PCBs (1254 and 1260), and metals (aluminum, beryllium, cadmium, iron, selenium, silver, and zinc). The levels detected in the fish tissue were low when compared to published background values, and did not indicate that these COPCs were site related.

Benthic invertebrates were sampled and were representative of estuarine and tidal freshwater species. The predominant species included capitellids followed by tubificids, spionids, goniadids, and bivalves. Diversity and density were characteristic of salinity ranges of zero to 15 ppt in regional surface waters.

No COPCs exceeded soil toxicity reference levels and based on the comparison of chronic daily intakes and terrestrial reference values, there does not appear to be an impact to terrestrial organisms including rabbits, deer, quail, fox, and raccoon from the site.

1.7 Conclusions

1. Shallow groundwater has been impacted with volatile organic compounds by former disposal operations. The VOC contamination, which is dominated by 1,2-DCE, is present in the southern portion of the site, near monitoring wells 69-GW02 and 69-GW15. In this area,

VOCs are above State and Federal drinking water standards. VOCs were also detected in offsite shallow wells, but at much lower levels. Off-site contaminant levels are below Federal and State drinking water standards. The horizontal extent of the VOC plume in the shallow aquifer has been defined, and is primarily present under the former disposal area.

2. The vertical extent of VOC contamination (i.e., primarily 1,2-DCE) in groundwater appears to be centered in the upper portion of the Castle Hayne Aquifer. VOC levels in the upper portion of the Castle Hayne appear to decrease rapidly as the plume migrates offsite to the east-southeast. Offsite VOC levels in the upper portion of the Castle Hayne are below State and Federal groundwater standards.

3. Groundwater quality in the intermediate zone of the Castle Hayne Aquifer has been slightly impacted by the VOCs. Low levels of 1,2-DCE were detected in wells GWO3DD and GW15DW at concentrations below State and Federal drinking water standards. No off-site intermediate zone wells exhibited contamination.

4. Target VOCs have not migrated to the deep zone of the Castle Hayne Aquifer.

5. Although VOCs are present in both the shallow and Castle Hayne Aquifers, the vertical and horizontal extent of contamination is limited in area. Based on existing data, the plume is estimated to cover an area of approximately three to four acres centering near well cluster GW15.

6. The source of the VOCs may be associated with buried waste near well cluster 69-GW15. This area contains a significant amount of buried metallic debris, based on the results of the geophysical surveys. It is possible that the source of VOCs are within the fill area and may continue to impact groundwater quality; however, VOC levels in downgradient wells 69-GW02 and 69-GW03 appear to be decreasing.

7. Elevated total metals in shallow groundwater are not believed to be indicative of past disposal operations. This conclusion is based on the following: metal concentrations in soil are similar to levels typically encountered throughout MCB Camp Lejeune; there is no pattern or plume to suggest that the total metals are elevated due to a source; total metals in groundwater are similar to some of the background wells throughout the base; and dissolved metals in groundwater are not elevated.

8. Onsite ponded water in the southern portion of the site is contaminated with VOCs. The ponded water appears to be hydraulically connected to the shallow aquifer.

9. Offsite surface water bodies have not been impacted by the site.

10. Under current human health exposure scenarios, there are no adverse human health risks mainly because groundwater in this area is not utilized for potable supply, and because access to the site is restricted.

11. Under future potential human health exposure scenarios involving residential use of the area, adverse human health risks would result due to groundwater exposure. Future residential use of the area is unlikely since the site is suspected of containing buried CWM.

12. There are no significant ecological risks to aquatic or terrestrial receptors associated with Site 69. Although environmental media concentrations exceeded ARARs/TBCs, aquatic biosurveys indicate fish and benthic macroinvertebrate populations that are representative of typical estuarine and tidal freshwater systems that are not adversely impacted by contaminant sources.

13. Based on the human health and ecological risk assessments, groundwater is the only medium of concern at Site 69. Although there is no current groundwater exposure pathway that would result in adverse human health risks, VOCs are migrating into the Castle Hayne Aquifer. The Castle Hayne is utilized extensively throughout MCB Camp Lejeune and the surrounding communities as a source of water.

1.8 Post RI Treatability Study

In February 1996, a Treatability Study (TS) was initiated to evaluate an *in situ* groundwater treatment technology at Site 69.

The Department of Navy (DoN) conducted this two phase treatability study to determine the technical and economic feasibility of using an innovative in-well aeration technology at Site 69. Two aeration well systems were installed: a UVB system in the upper Castle Hayne aquifer; and a KGB system in the shallow aquifer. The objectives of the Phase I study (six months of actual operation) were to show that a groundwater circulation cell could be created at the site which would mobilize and transport contaminants to the UVB and KGB systems for treatment; experimentally (via dye test) determine the zone of influence (ZOI) of each circulation cell; and show that contaminants were being removed by monitoring for target volatile organic compounds (VOCs) in the off-gases, and in groundwater.

Mathematical models were used to predict the ZOI of each system. The ZOI is typically defined as the distance between the upgradient and the downgradient stagnation points of the circulation cell. The models predicted that the ZOI of the KGB would be 93 ft, and that of the UVB would be 368 ft. In February 1996, the two systems were installed, and were in operation by March 1996. The KGB system was installed in the shallow Castle Hayne aquifer to 12 ft. below ground surface (bgs) where the target contaminants were vinyl chloride (VC), 1,2-dichloroethene (DCE), trichloroethene (TCE), tetrachloroethene (PCE), and 1,1,2,2-tetrachloroethane (1,1,2,2-TCA). The UVB was installed in the upper Castle Hayne aquifer to 74 ft bgs where the target VOCs were VC, DCE, and TCE. Additional monitoring wells were installed within the estimated ZOI of each systems to monitor changes in groundwater VOCs, and other physical/chemical parameters. These wells were also used as injection and monitoring stations for the dye test.

The UVB dye test was successful, and validated that a circulation cell was established. It also indicated that at a minimum, a 188 ft ZOI was created by the UVB system. The KGB dye test did not provide any results. The test failed again when repeated with a different dye. Groundwater monitoring data indicated that a circulation cell may have been established at the KGB site, but the preliminary transducer test was inconclusive in determining this. Consequently, the ZOI of the KGB circulation cell could not be validated.

During six months of operation, the UVB well did not mobilize significant contaminants to the well for treatment. On average, concentration of target VOCs were reduced by 16% in groundwater monitoring wells within the ZOI of the UVB. Primarily, these reductions may be due to dilution and *in situ* biodegradation in the circulation cell. Additional monitoring data over the next three to six

months would help evaluate this further. During the same time, the KGB well mobilized and removed at least 10.10 kg of target VOCs by stripping. On average, concentration of target VOCs were reduced by 15% in groundwater monitoring wells within the estimated ZOI of the KGB.

A round of groundwter samples were collected from selected TS wells at the end of the Phase I TS. The results show that groundwater in the upper zone of the Castle Hayne Aquifer remain high near well clusters 17 and 18 (see Figure 1-8). The results also show that Voc levels decreased significatnly in all directions from the source area.

To complete a technical and economic evaluation of these systems for Site 69, the following recommendations were made at the end of the Phase I study:

(i) Relocate the UVB well to the area of high contamination in order to determine its treatment rate and efficiency as a remediation system.

(ii) Continue operation of the KGB system. Use a modified well development method to remove sediments and improve operation of the KGB well.

(iii) Conduct frequent (every two weeks) sampling and analysis of off-gases from both systems to determine the removal rates of target VOCs.

(iv) Sample groundwater from selected wells in the immediate vicinity of both systems.

(v) Operate both systems (Phase II study) for at least three months.

The Phase II study was initiated in June 1997, and both systems were in operation by the second week of August 1997. Plugging problem continued with the KGB system, and in October 1997, it was decided to shut down the KGB system. The UVB system was monitored until December 1997.

The UVB system operated satisfactorily after initial problems with flow rates and pumps. It reduced the concentration of VOCs at the unit well by 99% in 16 weeks of operation. In the time frame of 16 weeks, the UVB system did not reduce contamination levels at well MW17-UW (56 ft from the UVB), but marginally reduced contamination levels in well MW15-IW (19 ft from the UVB).

At the conclusion of the Phase II monitoring, a round of groundwater samples were collected from selected TS monitoring wells (see Figure 1-8). The results confirmed that the highest VOC levels are in the upper zone of the Castle Hayne Aquifer near the source area.

The following conclusions can be drawn form the data obtained and field observations made during the Phase II study:

<u>The KGB System</u>

1. The KGB system failed to operate and perform consistently due to frequent plugging from the sand and sediments. This problem resulted from the formation material being substantially finer than the sand pack.

2. Every time after the well was redeveloped, the KGB system did operate adequately for a period of up to two weeks. Data collected during this period showed that volatile contaminants were being removed in the off-gas.

3. The zone of influence of the KGB system could not be determined because it appears to be smaller than the monitoring wells positioned for such measurements.

4. For the above reasons, the KGB system failed to meet the objectives of the treatability study.

5. The perched water table (shallow aquifer) still contains dissolved phase chlorinated hydrocarbons that migrate continually into the confined aquifer through various pathways in the aquitard. This process is increased when high water tables occur because of the increase in the vertical gradient downward.

The UVB-400 System

1. The UVB-400 system was successful in reducing the high concentrations observed in well 15UW after the Phase II study. Concentrations of target VOCs in the well were reduced by 99%. A high ratio (85%) of recirculated water to fresh water entering the cell from the capture zone is causing excessive dilution of the contaminants, particularly near the UVB well. The treatment is predominantly via dilution, particularly if the fresh water entering the cell is not highly contaminated.

2. In its present position, the UVB system will effectively treat contamination in well 15IW. However, an asymptotic decrease in the concentration of contaminants will not be seen until at least a year of operation. This is based on the fact that it will take a maximum of seven years of operation to reduce the concentrations of target compounds to less than 5 ppb in well 15IW.

3. The slow treatment rate observed at wells 15IW, 17IW, and 17UW may be due to two factors: (a) Well 15IW is probably located immediately below the source area, and contaminants are being released from the source at a significant rate, and (b) mobilization of contaminants is being controlled by molecular diffusion from the sand/clay formation. In addition, monitoring well nest 17UW and 17IW may be at the fringe of the UVB-400 circulation cell.

4. Pressure transducer test conducted at well cluster MW17 indicated that at a minimum, the circulation cell is influencing a radial distance of 56 ft from the UVB. However, this test does not directly validate that contaminants from these wells are being mobilized to the well for treatment.

5. Off-gas data indicted that the air stripping mechanism of the UVB system was functioning properly at an air to water ratio of 182:1, and a stripping efficiency of 98%. Approximately 8.3 lb of VOCs were removed during the Phase II study.

6. The spread of contamination in the upper Castle Hayne aquifer is not uniform. Areas of high contamination appear scattered. This could be because some buried drums are leaking while others are not. Also, contaminants from these leaky drums tend to migrate along the trenches in which they were buried, probably due to favorable geologic conditions. As a result of this complex setting from geologic as well as from contamination point of views, it is difficult to

design, position and operate a single in-situ treatment system efficiently in the upper Castle Hayne aquifer.

7. The groundwater recirculation rate attainable at the UVB-400 site (7.42 gpm) is less than that attainable at the UVB-250 site (20 gpm). The reason for such a variation is not clearly known since the hydraulic conductivities at both wells were comparable. A possible reason could be blockage of the influent screen.

8. The chlorinated hydrocarbons in the area around monitoring well 15IW has been reduced by 16 percent. This is based on laboratory analysis of groundwater sample showing 9,980 ppb total volatiles on August 28, 1997 and of 8,400 ppb on December 12, 1997.

9. All other monitoring areas (except 15IW and 17UW) show little or no chlorinated hydrocarbon contamination.

SECTION 1.0 TABLES

TABLE 1-1

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
					(µg/kg)	(µg/kg)					
Surface Soils	Volatiles	Methylene Chloride	NE	NE	5J	105	69-CSA-SB23-00	15/25	NA	NA	Widespread
		Acetone	NE	NE	31J	340J	69-CSA-SB09-00	5/25	NA	NA	Scattered
		1,2-Dichloroethene (total)	NE	NE	4J	4J	69-CSA-SB20-00	1/25	NA	NA	Southern Area
		2-Butanone	NE	NE	10.9J	10.9J	69-CSA-SB23-00	1/25	NA	NA	Southeast Area
		1,1,1-Trichloroethane	NE	NE	2J	2J	69-CSA-SB18-00	1/25	NA	NA	Southwest Area
		Trichloroethene	NE	NE	3J	3J	69-CSA-SB21-00	1/25	NA	NA	Southern Area
		4-Methyl-2-pentanone	NE	NE	1J	12J	69-CSA-SB11-00	6/25	NA	NA	Scattered
		Tetrachloroethene	NE	NE	2J	2J	69-CSA-SB21-00	1/25	NA	NA	Southern Area
		Xylenes (total)	NE	NE	5J	5J	69-CSA-SB23-00	1/25	NA	NA	Southeast Area
	Semivolatiles	bis(2-Ethylhexyl)phthalate	NE	NE	43J	48J	69-CSA-SB10-00	4/25	NA	NA	Central Area
		di-n-Butylphthalate	NE	NE	36J	280J	69-CSA-SB06-00	23/25	NA	NA	Widespread
	Pesticides/ PCBs	beta-BHC	NE	NE	11J	11J	69-CSA-SB25-00	1/25	NA	NA	Central Area
		4,4'-DDE	NE	NE	4.8J	4.8J	69-CSA-SB17-00	1/25	NA	NA	Southeast Central
		Endosulfan II	NE	NE	3.4J	3.4J	69-CSA-SB15-00	1/25	NA	NA	Central Area
		4,4'-DDT	NE	NE	13.3J	13.3J	69-CSA-SB17-00	1/25	NA	NA	Southeast Central
		Aroclor 1260	NE	NE	94J	94J	69-CSA-SB19-00	1/25	NA	NA	Southwest Area
	Chemical Surety Degradation Compounds	Acetophenone	NE	NE	51J	51J	69-CSA-SB17-00	1/35	NA	NA	Southeast Central
		Hydroxyacetophenone	NE	NE	120J	160J	69-CSA-SB17-00	2/35	NA	NA	Southeast Central

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Surface Soils (Cont.)				Base Background (mg/kg)	(mg/kg)	(mg/kg)				Base Background	
	Inorganics	Aluminum	NE	17.7-9,570	368	3370	69-CSA-SB12-00	25/25	NA	0	Widespread
		Barium	NE	0.65-20.8	3	6.8	69-CSA-SB21-00	17/25	NA	0	Widespread
		Calcium	NE	4.25-10,700	35.8	101	69-CSA-SB19-00	8/25	NA	0	Scattered
		Chromium	NE	0.33-12.5	1.6	3.6	69-CSA-SB18-00	18/25	NA	0	Widespread
		Iron	NE	69.7-9,640	235	2360	69-CSA-SB12-00	25/25	NA	0	Widespread
		Lead	NE	0.47-142	1.1J	12.5	69-CSA-SB17-00	25/25	NA	0	Widespread
		Magnesium	NE	2.55-610	12.9	67.7	69-CSA-SB18-00	24/25	NA	0	Widespread
		Manganese	NE	0.87-66	1.3	15.5	69-CSA-SB01-00	22/25	NA	0	Widespread
		Potassium	NE	1-416	66.1	66.4	69-CSA-SB13-00	2/25	NA	0	Scattered
		Selenium	NE	0.075-1.3	1.1	1.1	69-CSA-SB21-00	1/25	NA	0	Southern Area
		Silver	NE	0.0435-4.3	0.09J	10.2J	69-CSA-SB25-00	4/25	NA	1	Central Area
		Vanadium	NE	0.305-18.2	3.9	5.3	69-CSA-SB12-00	3/25	NA	0	Scattered
		Zinc	NE	0.3-28.3	1.5	66	69-CSA-SB19-00	12/25	NA	1	Scattered
		Total Cyanide	NE	NE	1.1	2.3	69-CSA-SB15-00	12/25	NA	NA	Scattered

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
					(µg/kg)	(µg/kg)					
Sub-surface Soil	Volatiles	Methylene chloride	NE	NE	6J	58	69-GW11-02	7/20	NA	NA	Widespread
		Acetone	NE	NE	13J	45000	69-GW12-01	8/20	NA	NA	Widespread
		1,2-Dichloroethene (total)	NE	NE	2J	2J	69-DA-HP01	1/20	NA	NA	Central Area
		1,1,1-Trichloroethane	NE	NE	2J	2J	69-GW11-02	1/20	NA	NA	Southeast of Site
		1,1,2-Trichloroethane	NE	NE	3J	3J	69-DA-HP02	1/20	NA	NA	Central Area
		Ethylbenzene	NE	NE	2J	2J	69-GW12DW-01	2/20	NA	NA	Scattered
	Semivolatiles	bis(2-Ethylhexyl)phthalate	NE	NE	53J	53J	69-GW11-02	1/10	NA	NA	Southeast of Site
		Diethylphthalate	NE	NE	260J	260J	69-GW02DW-03	1/10	NA	NA	Southern Area
		di-n-Butylphthalate	NE	NE	53J	120J	69-GW09-05	5/10	NA	NA	Scattered
	Pesticides	4,4'-DDE	NE	NE	1.2J	1.2J	69-GW10-01	1/10	NA	NA	Central Area
		Endrin	NE	NE	1.2J	1.2J	69-GW02DW-01	1/10	NA	NA	Southern Area
		4,4'-DDD	NE	NE	5.7J	5.7J	69-GW10-01	1/10	NA	NA	Central Area
		4,4'-DDT	NE	NE	1.6J	1.6J	69-GW02DW-01	1/10	NA	NA	Southern Area
				Base Background (mg/kg)	(mg/kg)	(mg/kg)				Base Background	
	Inorganics	Aluminum	NE	16.9-11,000	832	9990	69-GW09-05	10/10	NA	0	Widespread
		Arsenic	NE	0.033-15.4	1.15	2.9	69-GW09-05	2/10	NA	0	Scattered
		Barium	NE	0.65-22.6	3.8	14.6	69-GW09-05	7/10	NA	0	Widespread
		Beryllium	NE	0.01-0.31	0.36	0.36	69-GW09-05	1/10	NA	1	Northeast of Site
		Cadmium	NE	0.155-1.2	0.74	0.74	69-GW09-05	1/10	NA	0	Northeast of Site
		Calcium	NE	4.75-4,410	29.2	688	69-GW09-05	8/10	NA	0	Widespread
		Chromium	NE	0.65-66.4	1.76	17.7	69-GW09-05	8/10	NA	0	Widespread
		Copper	NE	0.47-9.5	5.1	5.1	69-GW09-05	1/10	NA	0	Northeast of Site

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Sub-surface Soil (Cont.)	Inorganics (Cont.)			Base Background (mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)			Base Background	
		Iron	NE	63.3-90,500	354	19900	69-GW09-05	10/10	NA	0	Widespread
		Lead	NE	0.465-21.4	1.78	6	69-GW09-05	10/10	NA	0	Widespread
		Magnesium	NE	2.85-852	26.9	574	69-GW09-05	10/10	NA	0	Widespread
		Manganese	NE	0.395-19.9	1.6	39	69-GW09-05	10/10	NA	2	Widespread
		Mercury	NE	0.01-0.68	0.04	0.07	69-GW11-02	2/10	NA	0	Scattered
		Nickel	NE	0.45-4.7	3.4	3.9	69-GW09-05	3/10	NA	0	Scattered
		Potassium	NE	1.05-1,250	149	516J	69-GW09-05	3/10	NA	0	Scattered
		Silver	NE	0.175-1	0.43J	0.43J	69-GW09-02	1/10	NA	0	Northeast of Site
		Sodium	NE	5.4-141	130	130	69-GW09-05	1/10	NA	0	Northeast of Site
		Vanadium	NE	0.34-69.4	4.4	22.6	69-GW09-05	4/10	NA	0	Scattered
		Zinc	NE	0.32-26.6	3.4	13.7	69-GW09-05	3/10	NA	0	Scattered
		Total Cyanide	NE	NE	1.2	2.6	69-GW09-05	3/10	NA	NA	Scattered
			MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
Shallow Ground-water	Volatiles	Vinyl Chloride	2	0.15	5	55J	69-GW15-01	3/32	2	2	Southern Area
		Chloroform	80	0.19	6	6	69-GW04	1/32	0	1	East Central Area
		Carbon Disulfide	NE	NE	1J	1J	69-GW10-01	1/32	NA	NA	Central Area
		1,1-Dichloroethane	NE	700	1J	1J	69-GW03-01	1/32	NA	0	Southeast Area
		1,2-Dichloroethene (total)	70	NE	2J	2,400	69-GW02-01	8/32	4	NA	Scattered
		Trans-1,2-Dichloroethene	100	70	230	230	69-GW02	1/32	1	1	Southern Area
		Trichloroethene	5	2.8	1J	150J	69-GW15-01	6/32	5	5	Southern Area
		Tetrachloroethene	NE	0.7	1J	33J	69-GW15-01	2/32	NA	2	Southern Area

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Shallow Ground-water (Cont.)	Volatiles (Cont.)		MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
		1,1,2,2-Tetrachloroethane	NE	NE	1J	22J	69-GW02-01	3/32	NA	NA	Scattered
		Toluene	1,000	1,000	1J	4J	69-GW03-01	2/32	0	0	Southeast Area
		Chlorobenzene	NE	50	25J	25J	69-GW03-01	1/32	NA	0	Southeast Area
	Semi-Volatiles	1,4-Dichlorobenzene	NE	NE	2J	2J	69-GW03-01	1/12	NA	NA	Southeast Area
	Pesticides/PCBs	alpha-BHC	NE	NE	0.056	0.056	69-GW03-01	1/12	NA	NA	Southeast Area
		delta-BHC	NE	NE	2.3	2.3	69-GW03-01	1/12	NA	NA	Southeast Area
	Inorganics	Aluminum	50-200[1]	NE	304	211,000	69-GW12-01	12/12	12	NA	Widespread
		Antimony	6	NE	8.59J	8.59J	69-GW06-01	1/6	1	NA	Widespread
		Arsenic	50	50	2.94J	19.9	69-GW10-01	6/12	0	0	Widespread
		Barium	2,000	2,000	29.6	850	69-GW12-01	12/12	0	0	Widespread
		Beryllium	4	NE	2.1	10.6	69-GW12-01	5/12	2	NA	Widespread
		Cadmium	5	5	3.12	11.4	69-GW12-01	3/12	1	1	Scattered
		Calcium	NE	NE	2,010	38,700	69-GW08-01	12/12	NA	NA	Widespread
		Chromium	100	50	15.1	159	69-GW12-01	10/12	1	3	Widespread
		Cobalt	NE	NE	25.9	25.9	69-GW12-01	1/12	NA	NA	Southeast of Site
		Copper	1,000 [1]	1,000	16.5	70.8	69-GW12-01	3/12	0	0	Scattered
		Iron	300 [1]	300	1,610	99,500J	69-GW04-01	12/12	12	12	Widespread
		Lead	15 [2]	15	4.4	188	69-GW12-01	11/12	5	5	Widespread
		Magnesium	NE	NE	371	13,200	69-GW12-01	12/12	NA	NA	Widespread
		Manganese	50 [1]	50	13	912	69-GW08-01	12/12	9	9	Widespread
		Mercury	2	1.10	0.068	0.936	69-GW12-01	6/12	0	0	Widespread
		Nickel	100	100	16.7	99.8	69-GW12-01	4/12	0	0	Scattered

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Shallow Ground-water (Cont.)	Inorganics (Cont.)		MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
		Potassium	NE	NE	1,410J	7,610	69-GW12-01	10/12	NA	NA	Widespread
		Selenium	50	50	3.81J	5.28J	69-GW12-01	3/12	0	0	Scatterd
		Sodium	NE	NE	4,130	14,100	69-GW02-01	12/12	NA	NA	Widespread
		Vanadium	NE	NE	17.2	210	69-GW12-01	10/12	NA	NA	Widespread
		Zinc	5,000 (1)	2,100	52.1	9,120J	69-GW04-01	10/12	1	1	Widespread
Castle Hayne Aquifer	Volatiles	Vinyl Chloride	2	0.015	8.37J	8.37J	69-GW02-DW-01	1/18	1	1	Southern Area
		1,2-Dichloroethene (total)	70	NE	788	2,500	69-GW15IW-01	2/18	2	NA	Southern Area
		Trans-1,2-Dichloroethene	100	70	8	8	69-GW02DW	1/18	0	0	Southern Area
		Trichloroethene	5	2.8	29.4	2,600	69-GW15IW-01	2/18	2	2	Southern Area
		1,1,2-Trichloroethane	5	NE	13	13	69-GW15IW	1/18	1	NA	Cetral Area
	Inorganics	Aluminum	50-200 (1)	NE	3,030	4,680J	69-GW12DW-01	2/2	2	NA	Southeast Area
		Arsenic	50	50	3.54J	3.54J	69-GW12DW-01	1/2	0	0	Southeast of Site
		Barium	2,000	2,000	42.3	58	69-GW12DW-01	2/2	0	0	Southeast Area
		Beryllium	4	NE	0.89	0.89	69-GW12DW-01	1/2	0	NA	Southeast of Site
		Calcium	NE	NE	59,300	180,000	69-GW12DW-01	2/2	NA	NA	Southeast Area
		Chromium	100	50	20.7	20.7	69-GW12DW-01	1/2	0	0	Southeast of Site
		Iron	300 (1)	300	5,820	10,900	69-GW12DW-01	2/2	2	2	Southeast Area
		Lead	15 (2)	15	3.1	3.1	69-GW02DW-01	1/2	0	0	Southern Area
		Magnesium	NE	NE	2,590	4,890	69-GW12DW-01	2/2	NA	NA	Southeast Area
		Manganese	50 (1)	50	53.7	114	69-GW12DW-01	2/2	2	2	Southeast Area
		Mercury	2	1.10	0.174	0.174	69-GW02DW-01	1/2	0	0	Southern Area
		Potassium	NE	NE	1,660	1,850	69-GW02DW-01	2/2	NA	NA	Southeast Area

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
Castle Hayne Aquifer (Cont.)	Inorganics (Cont.)	Sodium	NE	NE	10,900	33,000	69-GW02DW-01	2/2	NA	NA	Southeast Area
		Zinc	5,000 (1)	2,100	31.1	31.1	69-GW02DW-01	1/2	0	0	Southern Area
			AWQC (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			AWQC	NCWQS	
Surface Water On-Site and Drainage Areas	Volatiles	Vinyl Chloride	2	525	8J	8J	69-OS-SW01	1/7	1	0	Southern Area
		Acetone	NE	NE	3J	9J	69-DA-SW04	2/7	NA	NA	N and S of Site
		1,2-Dichloroethene (total)	NE	NE	13	55	69-OS-SW01	2/7	NA	NA	Southern Area
		Chloroform	5.7	NE	2J	2J	69-OS-SW01	1/7	0	NA	Southern Area
		Trichloroethene	2.7	NE	4J	4J	69-OS-SW01	1/7	NA	NA	Southern Area
		Toluene	6800	NE	1J	1J	69-OS-SW02 and 69-DA-SW01	2/7	0	NA	Widespread
		Ethylbenzene	3100	NE	1J	1J	69-DA-SW01	1/7	0	NA	Northeast of Site
		Xylenes (total)	NE	NE	10	10	69-DA-SW04	1/7	NA	NA	Southeast of Site
	Semi-Volatiles	di-n-Butylphthalate	2700	NE	1J	1J	69-DA-SW01	1/7	0	NA	Northeast of Site

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Surface Water On-Site and Drainage Areas (Cont.)	Inorganics		AWQC (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			AWQC	NCWQS	
		Aluminum	NE	NE	487	29,200	69-DA-SW02	7/7	NA	NA	Widespread
		Arsenic	0.018	NE	4.1	32.8	69-DA-SW03	2/7	2	NA	Southern Area
		Barium	1,000	NE	45.1	373	69-DA-SW02	7/7	0	NA	Widespread
		Beryllium	NE	.117	1.6	6.0	69-DA-SW02	2/7	NA	2	N and S of Site
		Calcium	NE	NE	3,080	73,000	69-DA-SW01	7/7	NA	NA	Widespread
		Chromium	NE	NE	23.8	23.8	69-DA-SW02	1/7	NA	NA	North of Site
		Copper	NE	NE	22.8	35.9	69-DA-SW03	3/7	NA	NA	Scattered
		Iron	300	NE	1,090	38,400	69-DA-SW03	7/7	7	NA	Widespread
		Lead	NE	NE	3.1	85.8	69-DA-SW02	6/7	NA	NA	Widespread
		Magnesium	4	NE	885	143,000	69-DA-SW01	7/7	7	NA	Widespread
		Manganese	50	NE	73.4	421	69-DA-SW02	7/7	7	NA	Widespread
		Mercury	0.14	NE	0.43	0.43	69-DA-SW02	1/7	1	NA	North of Site
		Nickel	610	NE	17.8	17.8	69-DA-SW02	1/7	0	NA	North of Site
		Potassium	NE	NE	365	37,600	69-DA-SW01	6/7	NA	NA	Widespread
		Silver	NE	NE	0.74J	2.3J	69-DA-SW04	3/7	NA	NA	N and S of Site
		Sodium	NE	NE	4,900	1,460,000	69-DA-SW01	7/7	NA	NA	Widespread
		Vanadium	NE	NE	23.3	24	69-DA-SW02	2/7	NA	NA	N and S of Site
		Zinc	NE	NE	96	4,370	69-OS-SW01	7/7	NA	NA	Widespread

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
New River Surface Water	Inorganics		AWQC (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			AWQC	NCWQS	
		Aluminum	NE	NE	554	1,840	69-NR1-SW06	3/3	NA	NA	N and E of Site
		Barium	1,000	NE	11.7JB	15.2JB	69-NR1-SW06	3/3	0	NA	N and E of Site
		Calcium	NE	NE	95,700	110,000	69-NR1-SW06 & 69-NR2-SW06	3/3	NA	NA	N and E of Site
		Iron	300	NE	682	1,330	69-NR2-SW06	3/3	3	NA	N and E of Site
		Magnesium	NE	NE	267,000	308,000	69-NR1-SW06	3/3	NA	NA	N and E of Site
		Manganese	50	NE	19.2J	21.7J	69-NR2-SW06	3/3	0	NA	N and E of Site
		Potassium	NE	NE	84,900	111,000	69-NR1-SW06	3/3	NA	NA	N and E of Site
		Silver	NE	NE	3.5JB	4.5JB	69-NR1-SW06	2/3	NA	NA	N and E of Site
		Sodium	NE	NE	3,080,000	5,830,000	69-NR2-SW06	3/3	NA	NA	N and E of Site
		Thallium	1.7	NE	11.3JB	11.3JB	69-NR2-SW06	1/3	1	NA	East of Site
Unnamed Tributary Surface Water	Inorganics	Aluminum	NE	NE	881	3,490	69-UT3-SW06	3/3	NA	NA	N and W of Site
		Barium	1,000	NE	15.2JB	23B	69-UT1-SW06	3/3	0	NA	N and W of Site
		Cadmium	NE	NE	3JB	3JB	69-UT1-SW06	1/3	NA	NA	West of Site
		Calcium	NE	NE	1,380B	92,300	69-UT3-SW06	3/3	NA	NA	N and W of Site
		Cobalt	NE	NE	8JB	8JB	69-UT1-SW06	1/3	NA	NA	West of Site
		Copper	NE	NE	7JB	7JB	69-UT1-SW06	1/3	NA	NA	West of Site
		Iron	300	NE	740	1,840	69-UT3-SW06	3/3	3	NA	N and W of Site
		Lead	NE	NE	2B	2B	69-UT2-SW06	1/3	NA	NA	West of Site
		Magnesium	NE	NE	846B	257,000	69-UT3-SW06	3/3	NA	NA	N and W of Site
		Manganese	50	NE	9JB	17.7J	69-UT2-SW06	3/3	0	NA	N and W of Site

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Unnamed Tributary Surface Water (Cont.)	Inorganics (Cont.)		AWQC (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			AWQC	NCWQS	
		Potassium	NE	NE	385B	86,000	69-UT3-SW06	3/3	NA	NA	N and W of Site
		Sodium	NE	NE	4,790JB	2,220,000	69-UT3-SW06	3/3	NA	NA	N and W of Site
		Vanadium	NE	NE	4.2JB	10JB	69-UT1-SW06	2/3	NA	NA	N and W of Site
		Zinc	NE	NE	18B	18B	69-UT1-SW06	1/3	NA	NA	West of Site
Everett Creek Surface Water	Inorganics	Aluminum	NE	NE	445	501	69-EC3-SW06	2/3	NA	NA	Southeast of Site
		Barium	1,000	NE	10.4JB	22.2JB	69-EC1-SW06	3/3	0	NA	South of Site
		Calcium	NE	NE	26,400	85,200	69-EC1-SW06	3/3	NA	NA	South of Site
		Copper	NE	NE	2.6JB	2.6JB	69-EC1-SW06	1/3	NA	NA	Southwest of Site
		Iron	300	NE	490	667	69-EC1-SW06	3/3	3	NA	South of Site
		Lead	NE	NE	1.4B	2.3J	69-EC3-SW06	2/3	NA	NA	Southeast of Site
		Magnesium	NE	NE	73,800	229,000	69-EC1-SW06	3/3	NA	NA	South of Site
		Manganese	50	NE	14.3JB	32.5	69-EC1-SW06	3/3	0	NA	South of Site
		Potassium	NE	NE	22,600	88,700	69-EC1-SW06	3/3	NA	NA	South of Site
		Silver	NE	NE	3.2J	4.1J	69-EC3-SW06	2/3	NA	NA	Southeast of Site
		Sodium	NE	NE	727,000	2,130,000	69-EC1-SW06	3/3	NA	NA	South of Site

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			NOAA ER-L (µg/kg)	NOAA ER-M (µg/kg)	(µg/kg)	(µg/kg)			NOAA ER-L	NOAA ER-M	
Sediment On-Site and Drainage Areas	Volatiles	Methylene Chloride	NE	NE	8J	48	69-DA-SD04-06	5/7	NA	NA	Widespread
		Acetone	NE	NE	9J	850J	69-OS-SD02-06	3/7	NA	NA	Southern Area
		1,2-Dichloroethene (total)	NE	NE	9J	9J	69-OS-SD01-06	1/7	NA	NA	Southern Area
		2-Butanone	NE	NE	36J	36J	69-DA-SD01-06	1/7	NA	NA	Northeast of Site
		4-Methyl-2pentenone	NE	NE	9J	17	69-OS-SD02-06	3/7	NA	NA	Scattered
		Toluene	NE	NE	18J	18J	69-DA-SD04-06	1/7	NA	NA	Southeast of Site
	Semi-Volatiles	di-n-Butylphthalate	NE	NE	110J	110J	69-OS-SD03-06 and 69-OS-SD02-06	2/7	NA	NA	Southeast Area
	Pesticides/PCBs	alpha-BHC	NE	NE	3.1J	3.1J	69-OS-SD02-06	1/7	NA	NA	Southeast Area
		beta-BHC	NE	NE	23.4J	23.4J	69-OS-SD02-06	1/7	NA	NA	Southeast Area
		delta-BHC	NE	NE	54.5J	54.5J	69-OS-SD02-06	1/7	NA	NA	Southeast Area
		4,4'-DDE	2.2	27	13.3J	13.3J	69-DA-SD02-06	1/7	1	0	Northeast of Site
		4,4'-DDD	2	20	1.5J	13.9J	69-DA-SD04-06	3/7	2	0	N and S of Site
		4,4'-DDT	1.58	46.1	2.1J	6.6J	69-DA-SD04-06	2/7	2	0	Southeast Area
		Aroclor 1254	22.7[3]	180[3]	79J	79J	69-OS-SD01-06	1/7	1	0	Southern Area
	Chemical Surety Material	Acetophenone	NE	NE	60J	960J	69-DA-SD01-06	2/7	NA	NA	Scattered

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Sediment On-Site and Drainage Areas	Inorganics		NOAA ER-L (mg/kg)	NOAA ER-M (mg/kg)	(mg/kg)	(mg/kg)			NOAA ER-L	NOAA ER-M	
		Aluminum	NE	NE	1,050	23,700	69-DA-SD04-06	7/7	NA	NA	Widespread
		Barium	NE	NE	6.8	131	69-DA-SD04-06	4/7	NA	NA	Scattered
		Beryllium	NE	NE	0.94	2	69-DA-SD04-06	2/7	NA	NA	N and S of Site
		Calcium	NE	NE	107	5,600	69-DA-SD04-06	5/7	NA	NA	Widespread
		Chromium	81	370	2.9	21.5	69-DA-SD04-06	3/7	0	0	Scattered
		Copper	34	270	21.7	21.7	69-OS-SD02-06	1/7	0	0	Southeast Area
		Iron	NE	NE	369	8,930	69-DA-SD04-06	7/7	NA	NA	Widespread
		Lead	46.7	218	3.1J	45.5	69-DA-SD04-06	7/7	0	0	Widespread
		Magnesium	NE	NE	28	5,190	69-DA-SD01-06	7/7	NA	NA	Widespread
		Manganese	NE	NE	1.4	44.1	69-DA-SD04-06	6/7	NA	NA	Widespread
		Mercury	0.15	0.71	0.5	0.56	69-DA-SD01-06	2/7	2	0	N and S of Site
		Potassium	NE	NE	104	452J	69-DA-SD02-06	2/7	NA	NA	N and S of Site
		Silver	1	3.7	0.26J	74.5J	69-DA-SD01-06	3/7	2	2	Scattered
		Sodium	NE	NE	1,410	17,800	69-DA-SD01-06	2/7	NA	NA	Northeast of Site
		Zinc	150	410	15.7	551	69-DA-SD04-06	6/7	1	1	Widespread

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Everett Creek Sediment	Volatiles		NOAA ER-L (µg/kg)	NOAA ER-M (µg/kg)	(µg/kg)	(µg/kg)			NOAA ER-L	NOAA ER-M	
		Methylene Chloride	NE	NE	1,200J	1,200J	69-EC3-SD-03	1/5	NA	NA	Southeast of Site
		Acetone	NE	NE	240	4,600	69-EC3-SD-03	2/5	NA	NA	Southeast of Site
		Carbon Disulfide	NE	NE	35	35	69-EC3-SD-612	1/5	NA	NA	Southeast of Site
		2-Butanone	NE	NE	5,300	5,300	69-EC3-SD-03	1/5	NA	NA	Southeast of Site
	Semi-Volatiles	Bis(2-Ethylhexyl)phthalate	NE	NE	85J	130J	69-EC4-SD-6122	2/5	NA	NA	Southeast of Site
	Pesticides	4,4'-DDE	2	15	6.6J	6.6J	69-EC4-SD-6122	1/5	1	0	Southeast of Site
	Inorganics		NOAA ER-L (mg/kg)	NOAA ER-M (mg/kg)	(mg/kg)	(mg/kg)			NOAA ER-L	NOAA ER-M	
		Aluminum	NE	NE	888J	32,700	69-EC3-SD-03	5/5	NA	NA	South of Site
		Arsenic	8.2	70	4.4B	5.3B	69-EC4-SD-6122	3/5	0	0	South of Site
		Barium	NE	NE	13JB	26.4B	69-EC3-SD-03	3/5	NA	NA	South of Site
		Beryllium	NE	NE	0.13JB	0.96B	69-EC3-SD-03	5/5	NA	NA	South of Site
		Cadmium	1.2	9.6	0.52JB	5.2JB	69-EC1-SD-06	5/5	4	0	South of Site
		Calcium	NE	NE	627JB	5,500B	69-EC1-SD-06	5/5	NA	NA	South of Site
		Chromium	81	370	3.6J	43.8	69-EC3-SD-03	5/5	0	0	South of Site
		Cobalt	NE	NE	1.3B	7JB	69-EC1-SD-06	4/5	NA	NA	South of Site
		Copper	34	270	6.5JB	16.2JB	69-EC1-SD-06	3/5	0	0	South of Site
		Iron	NE	NE	4,150J	28,900	69-EC3-SD-03	5/5	NA	NA	South of Site
		Lead	46.7	218	7.5J	30.8	69-EC1-SD-06	4/5	0	0	South of Site

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Everett Creek Sediment (Cont.)	Inorganics (Cont.)		NOAA ER-L (mg/kg)	NOAA ER-M (mg/kg)	(mg/kg)	(mg/kg)			NOAA ER-L	NOAA ER-M	
		Magnesium	NE	NE	313JB	7,250	69-EC3-SD-03	5/5	NA	NA	South of Site
		Manganese	NE	NE	4.1J	85.9	69-EC3-SD-612	5/5	NA	NA	South of Site
		Mercury	0.15	0.71	0.17B	0.17B	69-EC1-SD-06	1/5	1	0	Southwest of Site
		Potassium	NE	NE	129JB	4,290	69-EC3-SD-03	5/5	NA	NA	South of Site
		Sodium	NE	NE	1,100JB	21,800	69-EC3-SD-03	5/5	NA	NA	South of Site
		Vanadium	NE	NE	7.2JB	48.8	69-EC3-SD-03	5/5	NA	NA	South of Site
		Zinc	150	410	31.8	62	69-EC1-SD-06	3/5	0	0	South of Site

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
New River Sediment	Volatiles		NOAA ER-L (µg/kg)	NOAA ER-M (µg/kg)	(µg/kg)	(µg/kg)			NOAA ER-L	NOAA ER-M	
		Acetone	NE	NE	22	120	69-NR3-SD-612	3/5	NA	NA	N and SE of Site
	Semi-Volatiles	Bis(2-Ethylhexyl)phthalate	NE	NE	47J	92J	69-NR2-SD-062	2/5	NA	NA	East of Site
			NOAA ER-L (mg/kg)	NOAA ER-M (mg/kg)	(mg/kg)	(mg/kg)			NOAA ER-L	NOAA ER-M	
	Inorganics	Aluminum	NE	NE	3,450	16,200	69-NR1-SD-06	5/5	NA	NA	N and E of Site
		Arsenic	8.2	70	1.6B	5.6	69-NR2-SD-6122	4/5	0	0	N and E of Site
		Barium	NE	NE	4.6B	12.5B	69-NR1-SD-06	3/5	NA	NA	N and SE of Site
		Beryllium	NE	NE	0.24JB	0.37JB	69-NR2-SD-6122	4/5	NA	NA	N and E of Site
		Cadmium	1.2	96	0.53BJ	1.2J	69-NR3-SD-612	3/5	0	0	N and E of Site
		Calcium	NE	NE	376B	525JB	69-NR2-SD-062	5/5	NA	NA	N and E of Site
		Chromium	81	370	6.2	17.7	69-NR1-SD-06	5/5	0	0	N and E of Site
		Cobalt	NE	NE	0.58B	1.2B	69-NR1-SD-06 and 69-NR3-SD-612	5/5	NA	NA	N and E of Site
		Copper	34	270	1.6JB	2.5JB	69-NR3-SD-612	3/5	0	0	N and SE of Site
		Iron	NE	NE	4,320J	14,500	69-NR3-SD-612	5/5	NA	NA	N and E of Site
		Lead	46.7	218	3.6	6	69-NR1-SD-06	5/5	0	0	N and E of Site
		Magnesium	NE	NE	808JB	1,120B	69-NR1-SD-06	5/5	NA	NA	N and E of Site
		Manganese	NE	NE	13.6J	28.9	69-NR2-SD-6122	5/5	NA	NA	N and E of Site
		Potassium	NE	NE	614B	1,040B	69-NR1-SD-06	3/5	NA	NA	N and E of Site
		Sodium	NE	NE	1,240J	2,560J	69-NR3-SD-612	5/5	NA	NA	N and E of Site
		Vanadium	NE	NE	10.3B	35.3	69-NR1-SD-06	5/5	NA	NA	N and E of Site
		Zinc	150	410	7	10.7	69-NR3-SD-612	3/5	0	0	N and SE of Site

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Unnamed Tributary Sediment	Volatiles		NOAA ER-L (µg/kg)	NOAA ER-M (µg/kg)	(µg/kg)	(µg/kg)			NOAA ER-L	NOAA ER-M	
		Acetone	NE	NE	39J	65	69-UT3-SD-6122	3/5	NA	NA	N and W of Site
		Carbon Disulfide	NE	NE	18J	88	69-UT2-SD-06	4/5	NA	NA	N and W of Site
		Toluene	NE	NE	2J	2J	69-UT1-SD-06	1/5	NA	NA	West of Site
	Semi-Volatiles	Diethylphthalate	NE	NE	500J	500J	69-UT2-SD-612	1/5	NA	NA	Northwest of Site
		Bis(2-Ethylhexyl)phthalate	NE	NE	52J	81J	69-UT3-SD-062	2/5	NA	NA	North of Site
		Benzo(a)pyrene	430	1600	290J	2,500	69-UT2-SD-612	2/5	1	1	Northwest of Site
	Pesticides/PCBs	4,4'-DDE	2.2	27	10J	250	69-UT2-SD-612	3/5	3	2	Northwest of Site
		4,4'-DDD	2	20	14J	150	69-UT2-SD-612	3/5	3	2	N and W of Site
		PCB-1260	22.7[3]	180[3]	360	360	69-UT3-SD-6122	1/5	1	1	North of Site

TABLE 1-1 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Unnamed Tributary Sediment (Cont.)			NOAA ER-L (mg/kg)	NOAA ER-M (mg/kg)	(mg/kg)	(mg/kg)			NOAA ER-L	NOAA ER-M	
	Inorganics	Aluminum	NE	NE	1,240	23,400	69-UT2-SD-612	5/5	NA	NA	N and Wof Site
		Arsenic	8.2	70	4.7B	7.1	69-UT3-SD-6122	4/5	0	0	N and Wof Site
		Barium	NE	NE	14.2B	23.1B	69-UT2-SD-612	2/5	NA	NA	Northwest of Site
		Beryllium	NE	NE	0.52JB	0.61JB	69-UT3-SD-6122	2/5	NA	NA	North of Site
		Cadmium	1.2	9.6	1.8JB	2.1J	69-UT3-SD-062	3/5	3	0	North of Site
		Calcium	NE	NE	264B	6,270	69-UT2-SD-06	5/5	NA	NA	N and W of Site
		Chromium	81	370	3.3	22.4	69-UT3-SD-6122	3/5	0	0	N and W of Site
		Cobalt	NE	NE	1.4B	2.1B	69-UT3-SD-6122	2/5	NA	NA	North of Site
		Copper	34	270	7.2B	24.1	69-UT2-SD-612	4/5	0	0	N and W of Site
		Iron	NE	NE	3,530	17,900	69-UT2-SD-612	5/5	NA	NA	N and W of Site
		Lead	46.7	218	1	34.1	69-UT2-SD-612	5/5	0	0	N and W of Site
		Magnesium	NE	NE	48.9B	6,670	69-UT2-SD-612	5/5	NA	NA	N and W of Site
		Manganese	NE	NE	2.9J	69.3	69-UT2-SD-612	5/5	NA	NA	N and W of Site
		Potassium	NE	NE	81.1B	2,040	69-UT3-SD-6122	3/5	NA	NA	N and W of Site
		Sodium	NE	NE	122JB	21,100	69-UT2-SD-06	5/5	NA	NA	N and W of Site
		Vanadium	NE	NE	25.8	41.1B	69-UT2-SD-612	4/5	NA	NA	N and W of Site
		Zinc	150	410	22.4	24.6	69-UT3-SD-6122	2/5	0	0	North of Site

(1) SMCL = Secondary Maximum Contaminant Level
(2) Action Level
(3) For Total PCBs
NE = No Criteria Established
NA = Not Applicable

J = Value is Estimated
B = Compounds detected in Method Blank associated with this sample.

N = North
E = East
W = West
S = South

SECTION 1.0 FIGURES

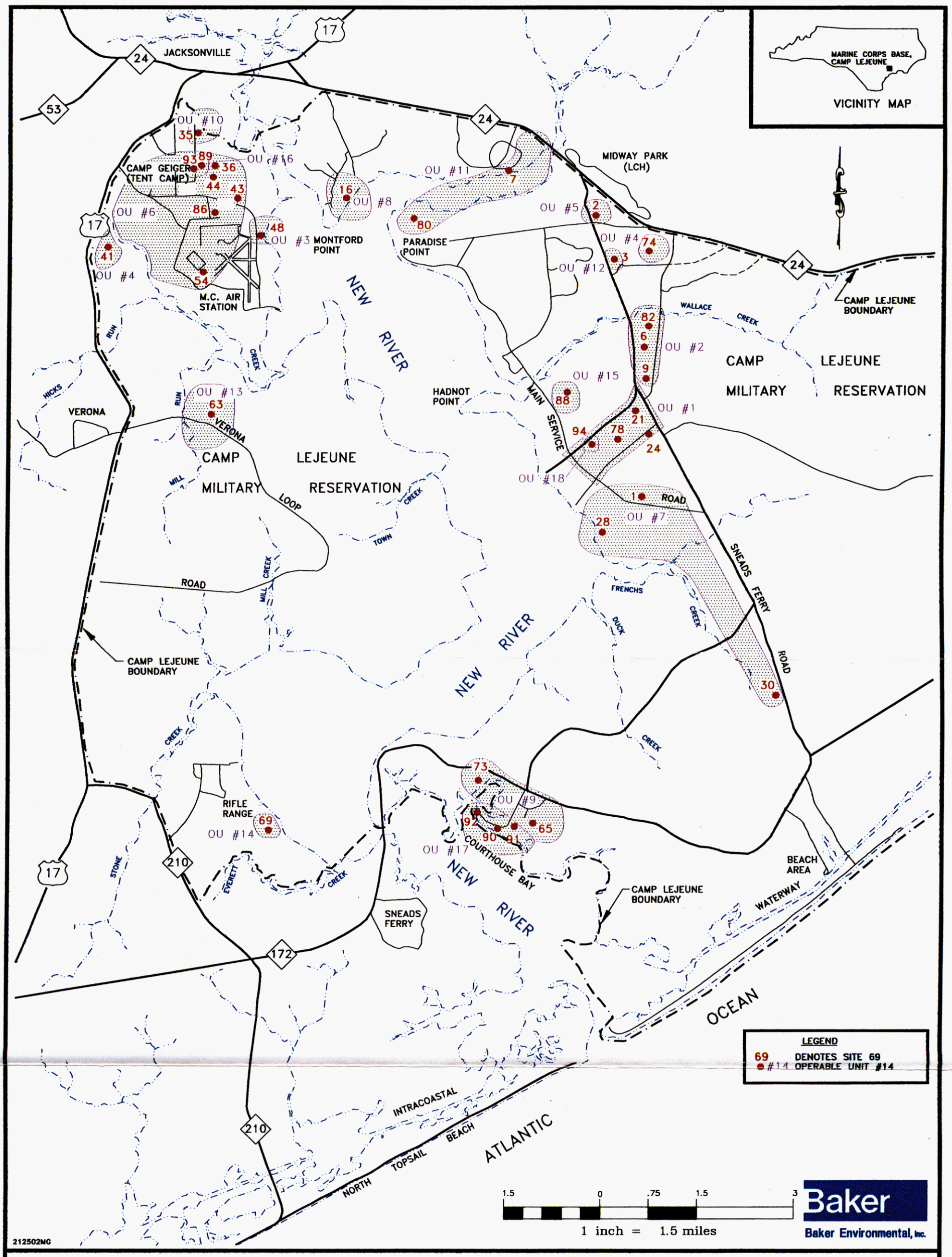
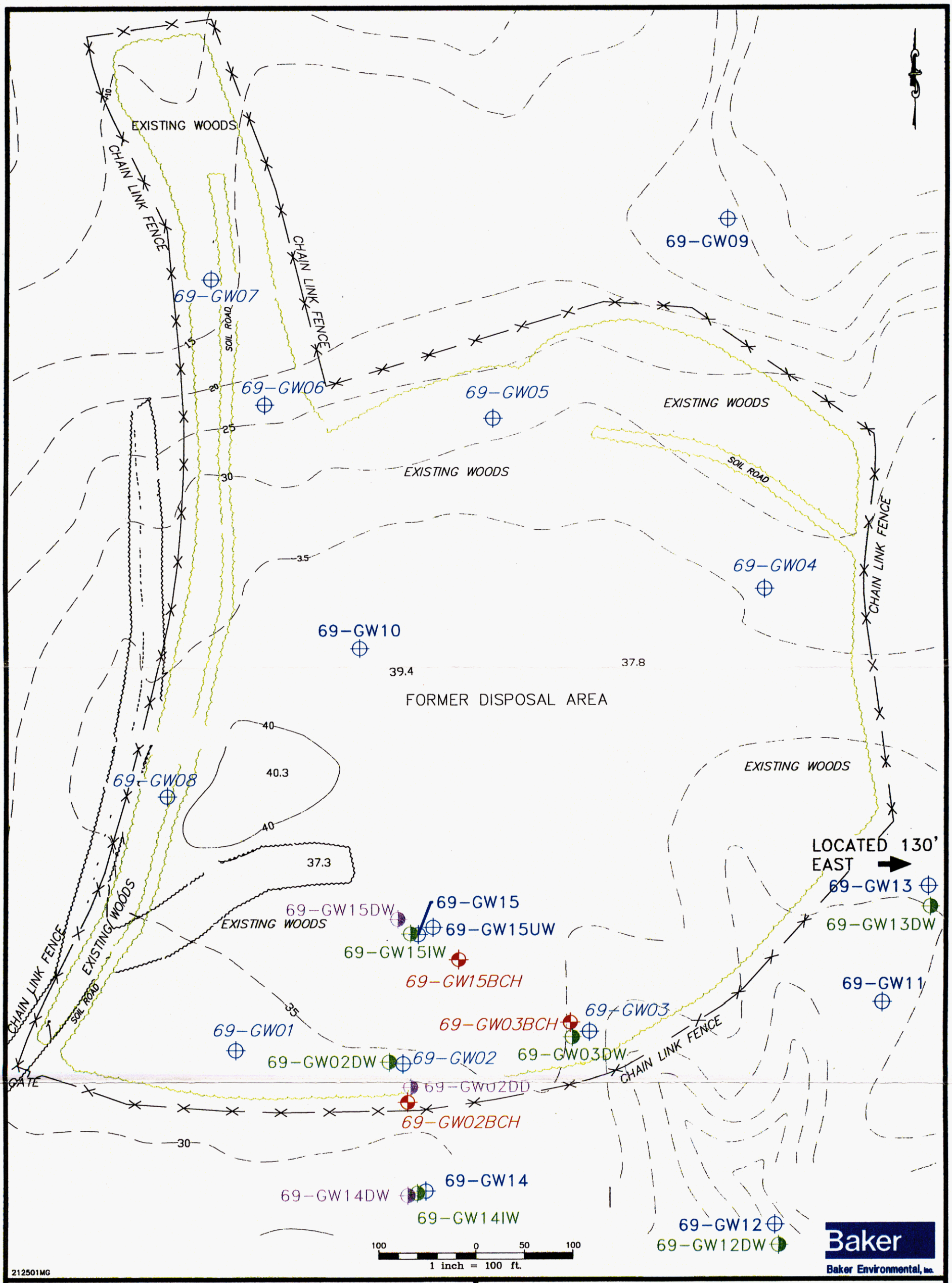


FIGURE 1-1
OPERABLE UNITS AND SITE LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE
FEASIBILITY STUDY CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

02308DDB1Y



LEGEND

69GW15BCH — DEEP ZONE CASTLE HAYNE WELLS

69GW09 — SHALLOW WELLS

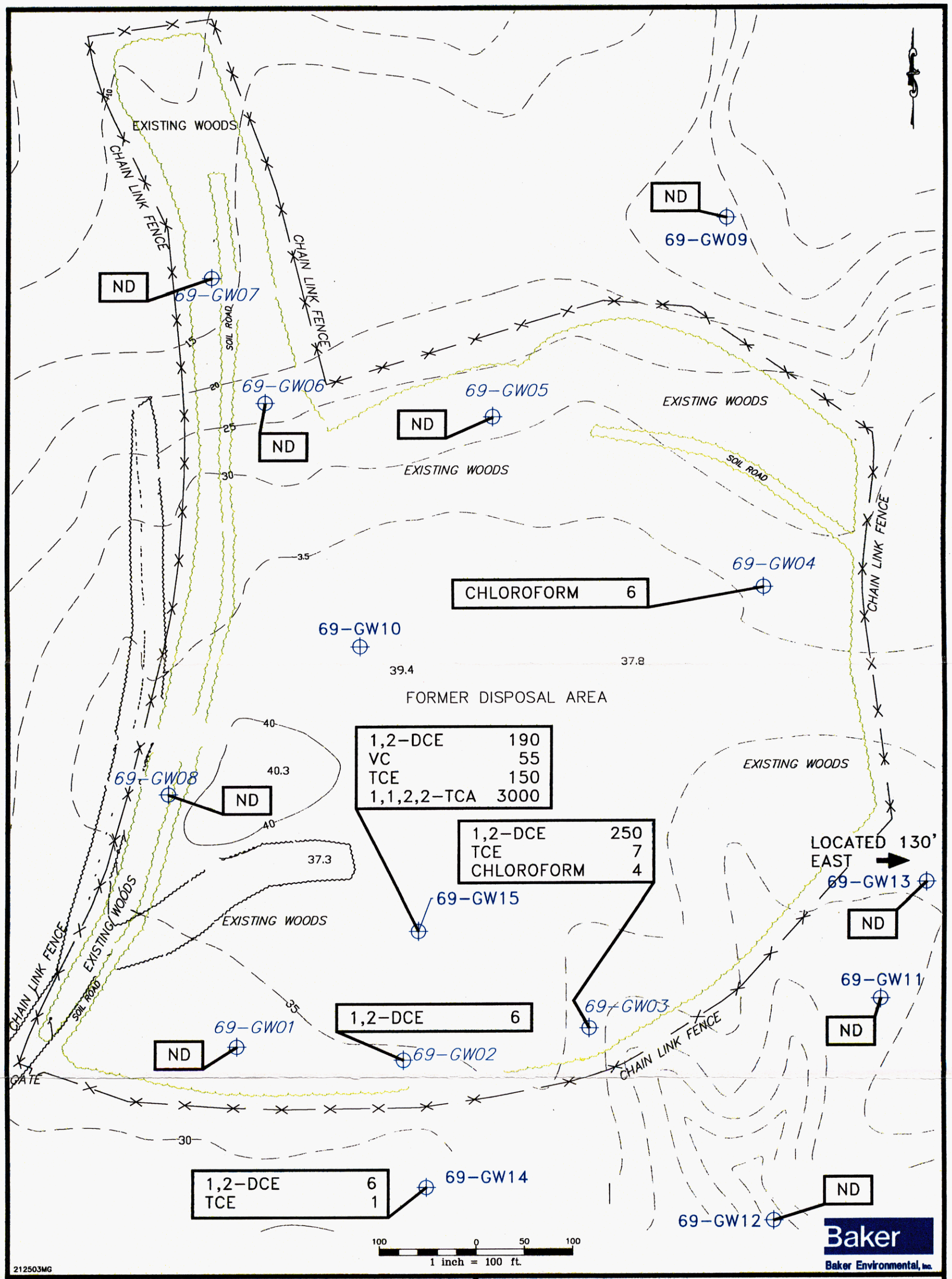
69GW02DW — UPPER ZONE CASTLE HAYNE WELLS

69-GW02DD — INTERMEDIATE ZONE CASTLE HAYNE WELLS

30 — TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 1-2
RI MONITORING WELL LOCATIONS AND GENERAL SITE ARRANGEMENT
SITE 69 – RIFLE RANGE CHEMICAL DUMP
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

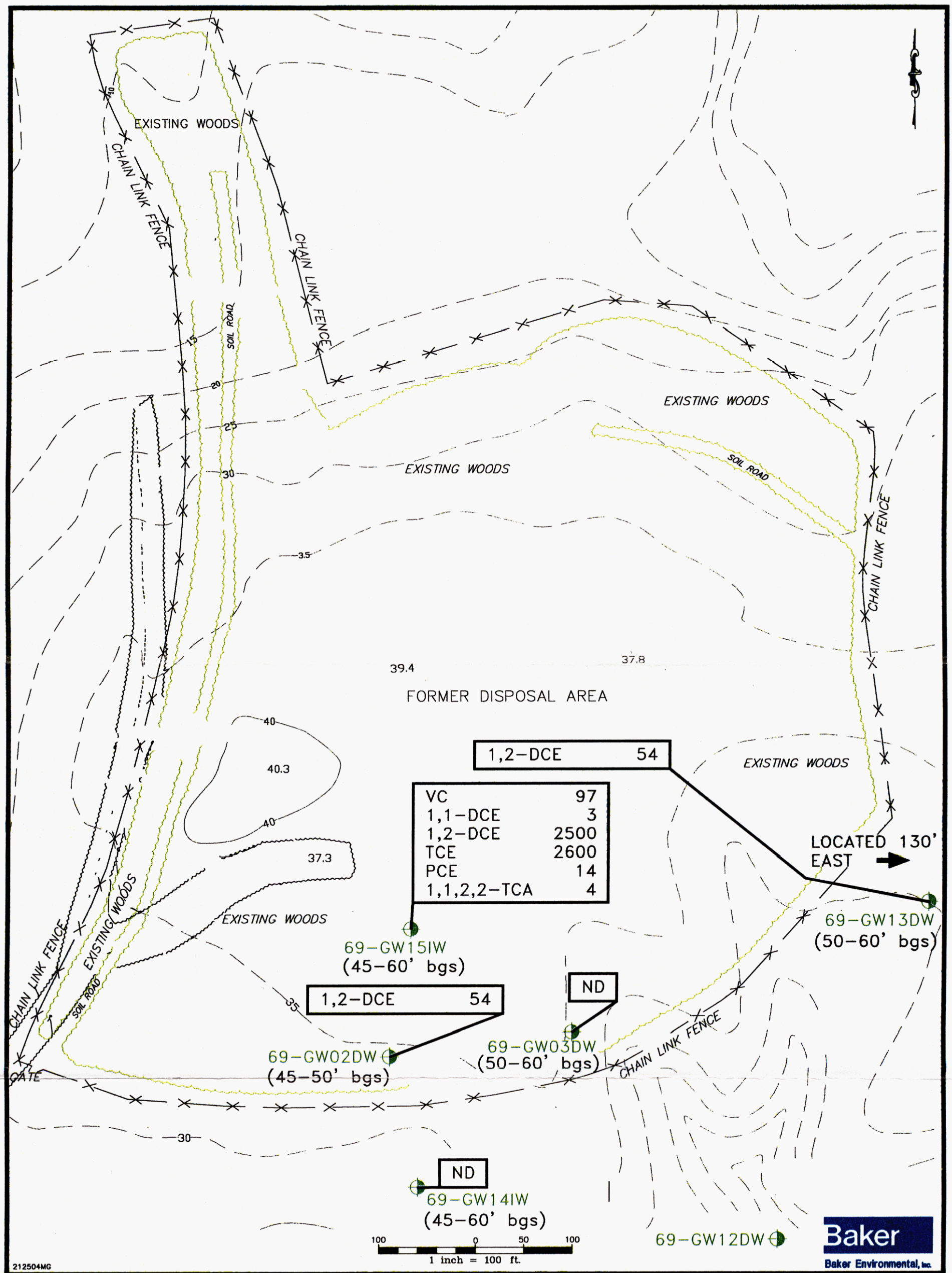
69GW09 SHALLOW WELLS

30 TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL ANALYTICAL RESULTS ARE REPORTED IN ug/L (ppb).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 1-3
EXTENT OF VOC CONTAMINATION IN THE SHALLOW AQUIFER (1995)
SITE 69 – RIFLE RANGE CHEMICAL DUMP
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

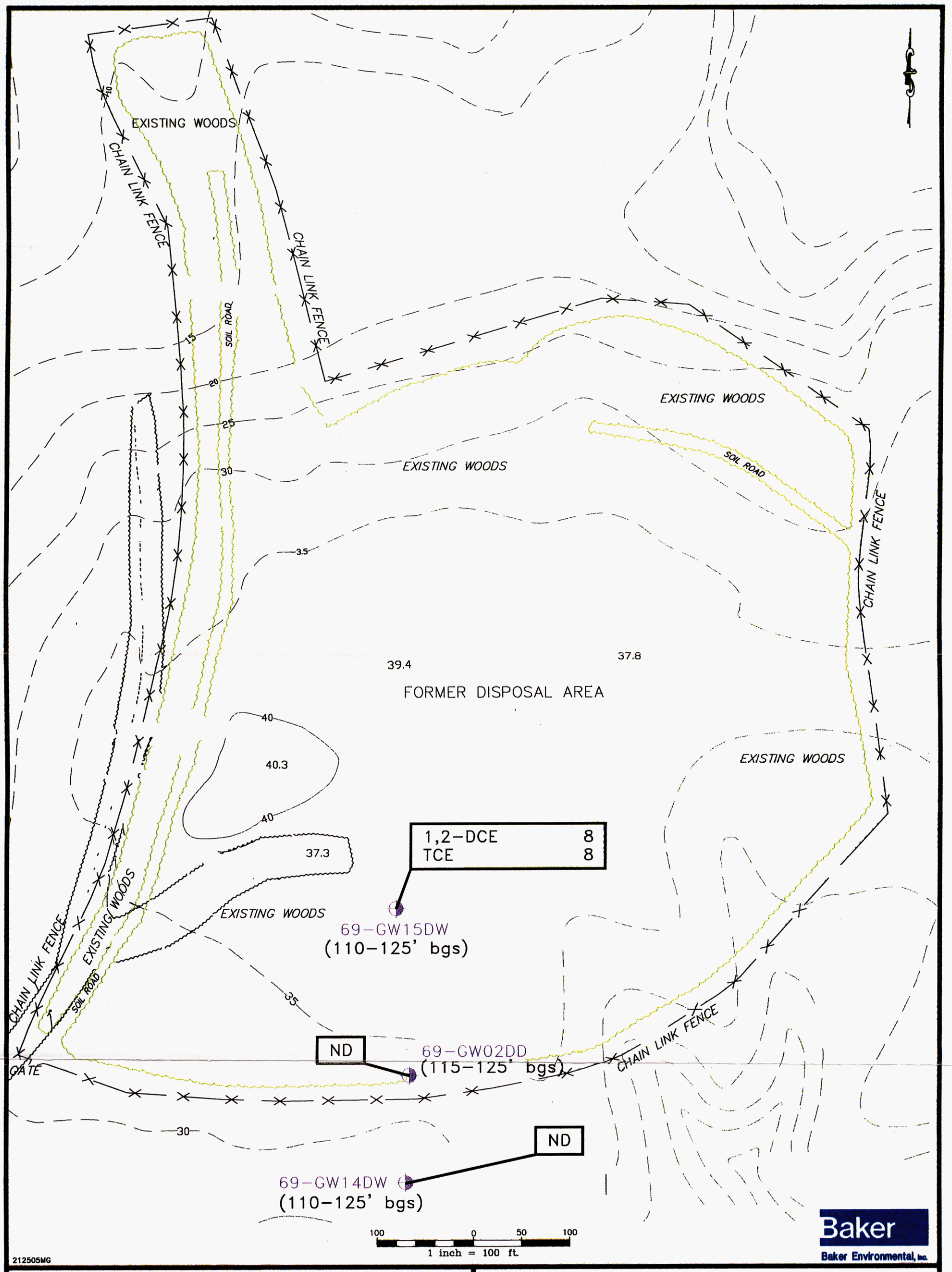
69GW02DW — UPPER ZONE CASTLE HAYNE WELLS (WELL DEPTH SCREEN SHOWN)

30 — TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL ANALYTICAL RESULTS ARE REPORTED IN ug/L (ppb).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 1-4
EXTENT OF VOC CONTAMINATION IN THE UPPER ZONE - CASTLE HAYNE AQUIFER
SITE 69 - RIFLE RANGE CHEMICAL DUMP
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

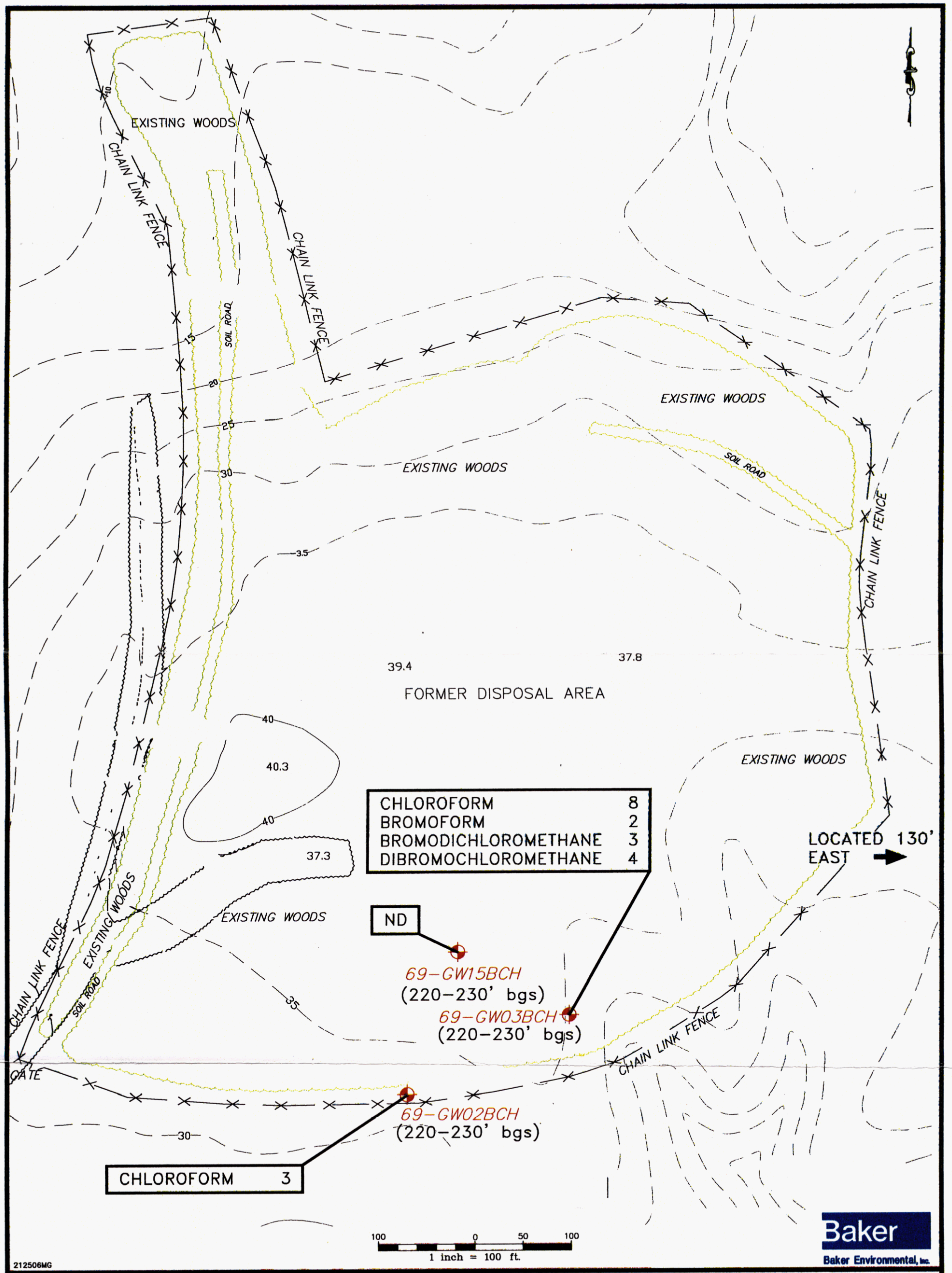
69-GW02DD INTERMEDIATE ZONE CASTLE HAYNE WELLS (WELL DEPTH SCREEN SHOWN)

30 TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL ANALYTICAL RESULTS ARE REPORTED IN ug/L (ppb).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 1-5
EXTENT OF VOC CONTAMINATION IN THE INTERMEDIATE ZONE - CASTLE HAYNE AQUIFER
SITE 69 - RIFLE RANGE CHEMICAL DUMP
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

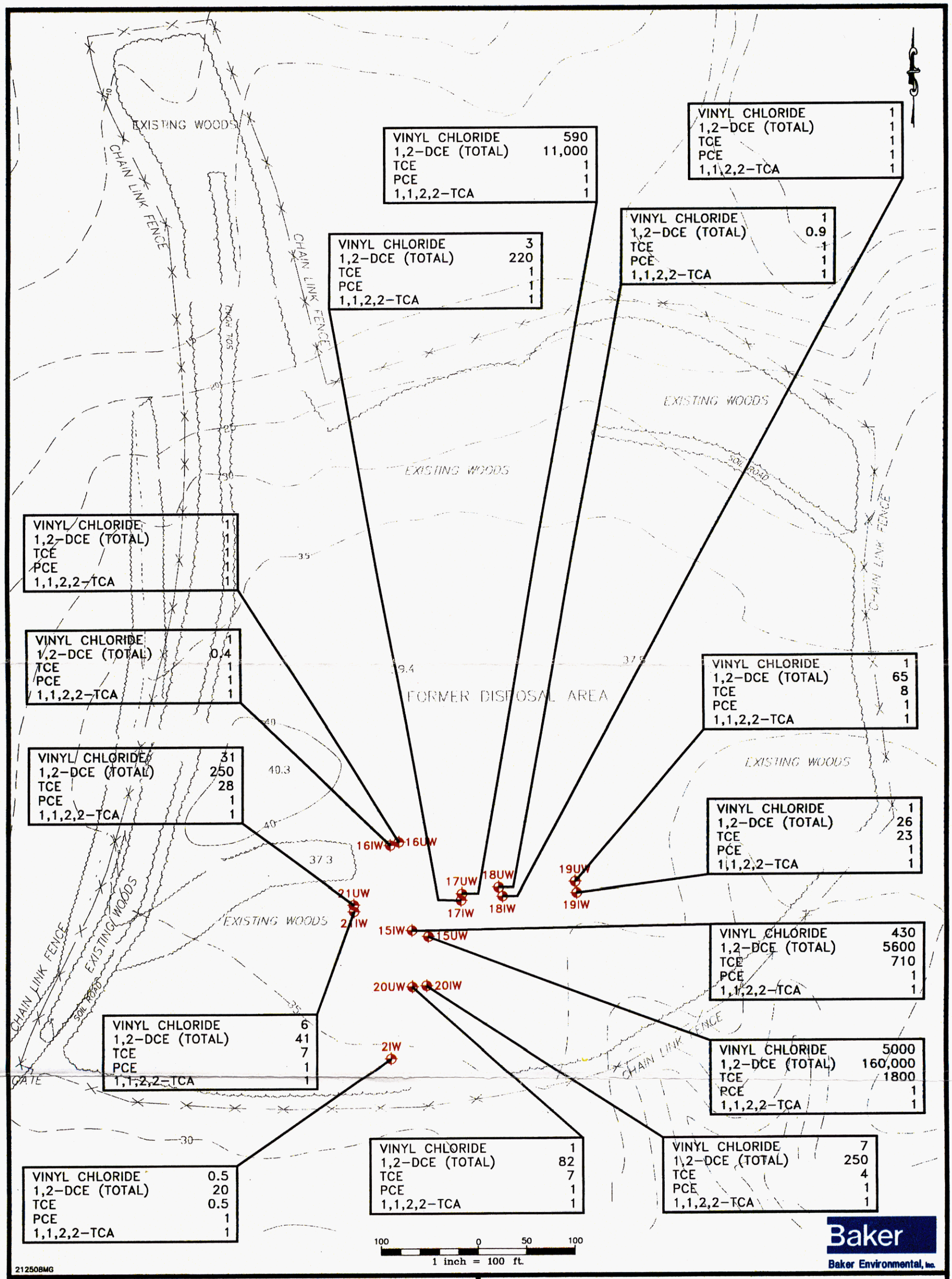
69GW15BCH — DEEP ZONE CASTLE HAYNE WELLS (WELL SCREEN DEPTH SHOWN)

30 — TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL ANALYTICAL RESULTS ARE REPORTED IN ug/L (ppb).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 1-6
EXTENT OF VOC CONTAMINATION IN THE BOTTOM ZONE AQUIFER
SITE 69 – RIFLE RANGE CHEMICAL DUMP
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



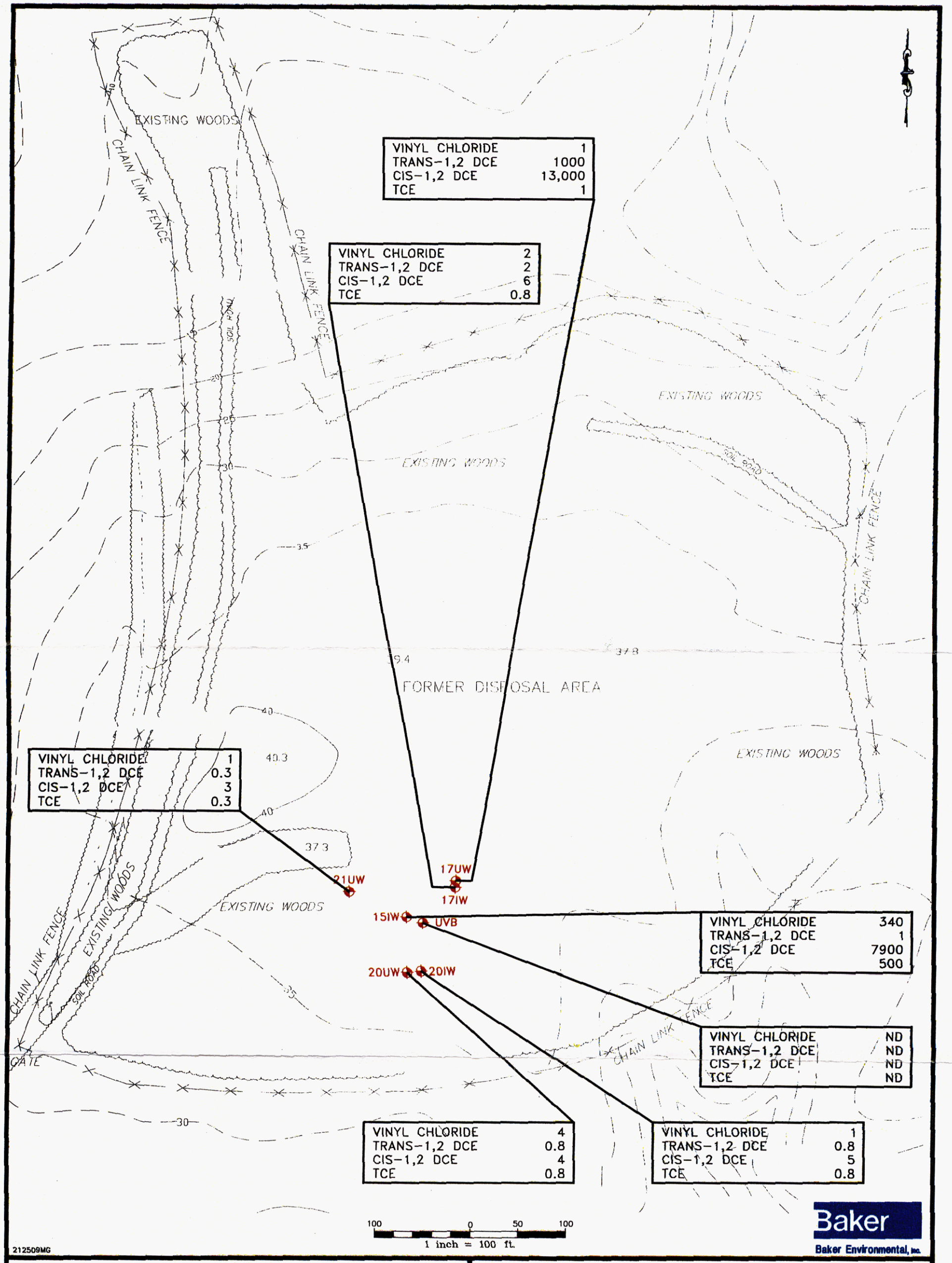
LEGEND

30 – TOPOGRAPHIC ELEVATION LINES (FEET, MSL)
UW – UPPER CASTLE HAYNE AQUIFER
IW – INTERMEDIATE ZONE, CASTLE HAYNE AQUIFER
– MONITORING WELL

ALL RESULTS ARE GIVEN IN ug/L.

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 1-7
POST RI GROUNDWATER RESULTS
(OCTOBER, 1996)
SITE 69 – RIFLE RANGE CHEMICAL DUMP
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

- 30 — TOPOGRAPHIC ELEVATION LINES (FEET, MSL)
- UW — UPPER CASTLE HAYNE AQUIFER
- IW — INTERMEDIATE ZONE, CASTLE HAYNE AQUIFER
- ⊕ — MONITORING WELL

ALL RESULTS ARE GIVEN IN ug/L.

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 1-8
POST RI GROUNDWATER RESULTS
(DECEMBER, 1997)
SITE 69 – RIFLE RANGE CHEMICAL DUMP
FEASIBILITY STUDY CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

2.0 DEVELOPMENT OF REMEDIATION GOAL OPTIONS, REMEDIATION LEVELS, AND REMEDIAL ACTION OBJECTIVES

This section presents the development of remediation goal options (RGOs), remediation levels (RLs), and remedial action objectives (RAOs) for OU No. 14 (Site 69). RGOs are chemical-specific concentration goals established for specific medium and land use combinations for the protection of human health and the environment. There are two general sources of chemical-specific RGOs: (1) concentrations based on applicable or relevant and appropriate requirements (ARARs) and, (2) risk-based concentrations for the protection of public health and the environment. The selection of RGOs includes: identifying the media of concern, selection of contaminants of concern (COCs), evaluation of ARARs, and identification of site-specific information for the exposure pathway information (i.e., exposure frequency, duration, or intake rate data). The development of RGOs for OU No. 14 via these criteria is detailed in Sections 2.1 through 2.5. The resulting RLs, areas that require remediation, and the remedial action objectives are presented in Sections 2.6, 2.7, and 2.8, respectively.

2.1 Media of Concern Identified by the Human Health and Ecological Risk Assessment

The results of the baseline human health and ecological risk assessment indicate that there would be no unacceptable risks to human health posed by exposure to soil, groundwater, surface water, or sediments under current land usage. Currently, the only human exposure pathway is associated with soil (e.g., military personnel who may come into contact with the soil during training exercises).

Under future potential land use scenarios (i.e., residential and construction), soil and groundwater are the media of concern which would result in unacceptable risks to human health. For purposes of this FS, soil includes the material within the landfill. As mentioned previously in Section 1.0, the material within the landfills could not be completely characterized since no intrusive investigations (e.g., test pitting) could be conducted because of suspected CWM. Site 69 is suspected of receiving CWM, which may be buried within the site. Therefore, exposure to the landfill materials under a future land use scenario is potentially a human health concern. For these reasons, the soil/fill materials at Site 69 has been included as media of concern.

In summary, the following media of concern have been identified:

- Shallow and deep (Castle Hayne) groundwater
- Soil/landfill material

2.2 Contaminants of Concern

COCs initially selected and evaluated in the baseline risk assessment (RA) were selected on the basis of frequency of detection, prevalence above background concentrations, toxicity, and comparison to established criteria or standards. The COCs identified for groundwater, soil, surface water, and sediment for both the human health and ecological RAs are listed in Table 2-1. COCs that do not exceed a regulatory or a risk-based RGO will be eliminated from further consideration as a COC. In addition, an evaluation will be conducted on the remaining set of contaminants to determine areas and media of concern for the operable unit. A final set of COCs will be identified which then will be the basis for a set of remedial action objectives applicable to OU No. 14.

2.3 Remediation Goal Options

RGOs are based on Federal and State criteria or risk-based concentrations. Federal and State criteria will be identified and evaluated in Section 2.3.1. Site specific risk-based RGOs for the COCs at OU No. 14 will be developed in Section 2.3.2. The results from both of these sections will be used to develop the initial set of RGOs for the operable unit.

2.3.1 Applicable or Relevant and Appropriate Federal and State Requirements

Under Section 121(d)(1) of CERCLA, remedial actions must attain a degree of cleanup which assures protection of human health and the environment. Additionally, CERCLA remedial actions that leave any hazardous substances, pollutants, or contaminants on site must meet, upon completion of the remedial action, a level or standard of control that at least attains standards, requirements, limitations, or criteria that are "applicable or relevant and appropriate" under the circumstances of the release. These requirements are known as "ARARs" or applicable or relevant and appropriate requirements. ARARs are derived from both Federal and State laws. CERCLA's definition of "Applicable Requirements" is:

> ...cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant or contaminant, remedial action, location, or other circumstance at a CERCLA site. Drinking water criteria may be an applicable requirement for a site with contaminated groundwater that is used as a drinking water source.

CERCLA's definition of "Relevant and Appropriate Requirements" is:

> ...cleanup standards, standards of control and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

There are three types of ARARs. The first type, chemical-specific ARARs, are requirements which set health or risk-based concentration limits or ranges for specific hazardous substances, pollutants, or contaminants. Federal Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (SDWA) are examples of chemical-specific ARARs.

The second type of ARARs, location-specific, set restrictions on activities based upon the characteristics of the site and/or the nearby suburbs. Examples of this type of ARAR include Federal and State citing laws for hazardous waste facilities and sites on the National Register of Historic Places.

The third classification of ARARs, action-specific, refers to the requirements that set controls or restrictions on particular activities related to the management of hazardous substances, pollutants, or contaminants. RCRA regulations for closure of hazardous waste storage units, RCRA incineration standards, and pretreatment standards under the Clean Water Act (CWA) for discharges to publicly-owned treatment works (POTWs) are examples of action-specific ARARs.

Subsection 121(d) of CERCLA requires that Federal and State substantive requirements that qualify as ARARs be complied with by remedies. Federal, State, or local permits do not need to be obtained for removal or remedial actions implemented on site, but their substantive requirement must be obtained. "On site" is interpreted by the USEPA to include the areal extent of contamination and all suitable areas in reasonable proximity to the contamination necessary for implementation of the response action.

ARARs can be identified only on a site-specific basis. They depend on the detected contaminants at a site, specific site characteristics, and particular remedial actions proposed for the site. ARARs identified for OU No. 14 are presented in the following sections.

2.3.1.1 Chemical-Specific ARARs

The following criteria were used in the selection of chemical-specific ARARs: the North Carolina Water Quality Standards (NCWQSs) applicable to groundwaters; the Federal MCLs and secondary MCLs, Federal risk-based Health Advisories (HAs); the PCB Spill Cleanup Policy under the Toxic Substances Control Act (TSCA); NCWQSs applicable to surface waters and the Region IV Surface Water/Sediment Screening Values (SSVs). A brief description of each these standards/guidance is presented below.

North Carolina Water Quality Standards (Groundwater) - Under the North Carolina Administrative Code (NCAC), Title 15A, Subchapter 2L, Section .0200, (15A NCAC 2L.0200) the NC DEHNR has established groundwater standards (NCWQSs) for three classifications of groundwater within the State: GA, GSA, and GC. Class GA waters are those groundwaters in the State naturally containing 250 milligram per liter (mg/L) or less of chloride. These waters are an existing or potential source of drinking water supply for humans. Class GSA waters are those groundwaters in the State naturally containing greater than 250 mg/L of chloride. These waters are an existing or potential source of water supply for potable mineral water and conversion to fresh water. Class GC water is defined as a source of water supply for purposes other than drinking. The shallow and Castle Hayne Aquifers under Site 69 are Class GA groundwaters.

The water quality standards for the groundwaters are the maximum allowable concentrations resulting from any discharge of contaminants to the land or water of the State, which may be tolerated without creating a threat to human health or which would otherwise render the groundwater unsuitable for its intended best usage. If the water quality standard of a substance is less than the practical quantitation limit, the substance shall not be permitted in detectable concentrations. If naturally occurring substances exceed the established standard, the standard will be the naturally occurring concentration as determined by the State. Substances which are not naturally occurring, and for which no standard is specified, are not permitted in detectable concentrations for Class GA or Class GSA groundwaters (15A-NCAC-2L.0202).

The NCWQSs for substances in Class GA and Class GSA groundwaters are established as the lesser of:

- Systemic threshold concentration (based on reference dose and average consumption)
- Concentration which corresponds to an incremental lifetime cancer risk of 1.0E-6
- Taste threshold limit value

- Odor threshold limit value
- Federal MCL
- National Secondary Drinking Water Standard (or secondary MCL)

Note that the water quality standards for Class GA and Class GSA groundwaters are the same except for chloride and total dissolved solids concentrations (15A NCAC 2L.0202).

The Class GA groundwater NCWQSs for the Site 69 groundwater COCs are referred to in Table 1-1.

Federal Maximum Contaminant Levels - MCLs are enforceable standards for public water supplies promulgated under the SDWA and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. These standards are designed for prevention of human health effects associated with a lifetime exposure (70-year lifetime) of an average adult (70 kg) consuming 2 liters of water per day. MCLs also consider the technical feasibility of removing the contaminant from the public water supply.

Secondary MCLs are nonenforceable guidelines established under the SDWA. The secondary MCLs are set to control contaminants in drinking water that primarily affect the aesthetic qualities relating to public acceptance of drinking water.

USEPA Region IV Sediment Screening Values - In the absence of promulgated sediment quality criteria, USEPA Region IV uses the Sediment Screening Values (SSVs) compiled by the National Oceanic and Atmospheric Administration (NOAA) for evaluating the potential for chemical constituents in sediments to cause adverse biological effects (USEPA, 1992b).

North Carolina Water Quality Standards (NCWQS) - The NCWQSs for surface water are the standard concentrations, that either alone or in combination with other wastes, in surface waters that will not render waters injurious to aquatic life or wildlife, recreational activities, public health, or impair the waters for any designated use.

USEPA Region IV Surface Water Screening Values (WQSV) - The USEPA Region IV Surface Water Screening Values for hazardous waste sites are intended to serve as preliminary screening tools for the review of chemical data associated with hazardous waste sites. These screening values are considered dynamic in that they will be updated by the USEPA as more information and other sources become available with the addition of media, parameters, screening levels, or changes in the screening levels. Exceedences of the screening levels indicates a need for more investigation, such as site-specific toxicity tests, literature reviews, etc.

Ambient Water Quality Criteria (AWQC) - AWQC are nonenforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. They may also be used for identifying the potential for human health risks. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of water alone (2 liters/day). The AWQCs for the protection of human health for potential carcinogenic substances are based on the USEPA's specified incremental

cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 (i.e. the 10E-7 to 10E-5 range).

A summary of contaminant-specific ARARs and their applicability to the areas of concern are provided in Table 2-2.

2.3.1.2 Location-Specific ARARs

Potential location-specific ARARs identified for OU No. 14 are listed in Table 2-3. An evaluation determining the applicability of these location-specific ARARs with respect to OU No. 14 is also presented and summarized in Table 2-3. Based on this evaluation, specific sections of the following location-specific ARARs may be applicable to OU No. 14:

- Fish and Wildlife Coordination Act
- Federal Endangered Species Act
- North Carolina Endangered Species Act
- Executive Order 11990 on Protection of Wetlands
- Executive Order 11988 on Floodplain Management

Please note that the citations listed in Table 2-3 should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided in the table as a general reference.

2.3.1.3 Action-Specific ARARs

Action-specific ARARs are typically evaluated following the development of alternatives since they are dependent on the type of action being considered. Therefore, at this step in the FS process, potential action-specific ARARs have only been identified and not evaluated for OU No. 14. A set of potential action-specific ARARs are listed in Table 2-4. These ARARs are based on RCRA, CWA, SDWA, and Department of Transportation (DOT) requirements. Note that the citations listed in Table 2-4 should not be interpreted to indicate that the entire citation is an ARAR. The citation listing is provided in the table as a general reference.

These ARARs will be evaluated after the remedial action alternatives have been identified for OU No. 14. Additional action-specific ARARs may also be identified and evaluated at that time.

2.3.2 Risk-Based Remediation Goal Options

In conjunction with the RGOs based on Federal and State criteria (Section 2.3.1), risk-based RGOs were developed for the groundwater COCs. The methodology used for the derived RGOs was in accordance with USEPA risk assessment guidance (USEPA, 1989a) (USEPA, 1991a). For noncarcinogenic effects, an action level was calculated that corresponds to a HI of 1.0, or unity, which is the level of exposure to a contaminant from all significant exposure pathways in a given medium below which it is unlikely for even sensitive populations to experience health effects. For carcinogenic effects, an action level was calculated that corresponds to 1.0E-04 (one in ten thousand) ICR over a lifetime as a result of exposure to the potential carcinogen from all significant exposure pathways for a given medium. A 1.0E-04 risk level was used as an end point for determining action levels for remediation. Based on the NCP (40 CFR 300.430), for known or suspected carcinogens, acceptable exposure levels are generally concentrations that represent an ICR between 1.0E-04 and

1.0E-06. The action levels for OU No. 14 are representative of acceptable incremental risks based on current and probable future use of the area.

Three steps were involved in estimating the risk-based RGOs for OU No. 14 COCs. These steps are generally conducted for a medium and land-use combination and involved identifying: (1) the most significant exposure pathways and routes, (2) the most significant exposure parameters, and (3) equations. The equations included calculations of total intake from a given medium and were based on identified exposure pathways and associated parameters.

2.3.2.1 Derivation of Risk Equations

The determination of chemical-specific RGOs was performed in accordance with USEPA guidance (USEPA, 1989a). Reference doses (RfDs) were used to evaluate noncarcinogenic contaminants, while cancer slope factors (CSFs) were used to evaluate carcinogenic contaminants.

Potential exposure pathways and receptors used to determine RGOs are site-specific and consider the current and future land use of a site. The following exposure scenario was used in the determination of RGOs for OU No. 14:

- Ingestion of groundwater (future resident)

The potential risk estimated in the human health risk assessment indicated that the majority of the site-specific risk at Site 69 is likely to occur from future potential exposure to groundwater. Currently, soil does not appear to pose an appreciable risk with respect to both dermal contact and incidental ingestion at any of the sites. For this FS, the most conservative exposure pathway (i.e., groundwater ingestion) was used in the development of RGOs. The RGOs were calculated for future (adult and children) receptors in order to provide site-specific RGOs from which remedial alternatives could be generated.

Consistent with USEPA guidance, noncarcinogenic health effects were estimated using the concept of an average annual exposure. The action level incorporated the exposure time and/or frequency that represented the number of days per year and number of years that exposure occurs. This is used with a term known as the averaging time, which converts the daily exposure to an annual exposure. Carcinogenic health effects were calculated as an incremental lifetime cancer risk, and therefore represented the exposure duration (years) over the course of a potentially exposed individual's lifetime (70 years).

The estimation methods and models used in this section were consistent with current USEPA risk assessment guidance (USEPA, 1989a, 1991a). Exposure estimates associated with groundwater ingestion are presented below. RGOs were developed, with site-specific inputs, for groundwater COCs presented in the human health risk assessment. However, in order to determine if a medium at a site requires remediation, estimated RGOs were compared to site-specific contaminant levels. This assessment was conducted to assure that media and contamination at each site would be addressed on a site-specific basis. The following sections present the equations and inputs used in the estimation of groundwater RGOs developed for OU No. 14.

Ingestion of Groundwater

Currently there are no receptors who are exposed to groundwater contamination at Site 69 since groundwater is obtained from "noncontaminated" supply wells, pumped to water treatment plants, and distributed via a potable water system. However, it is assumed for the purposes of calculating remediation goals, that potable wells would pump groundwater from the site area for public consumption. Groundwater ingestion RGOs are characterized using the following equation:

$$Cw = \frac{TR \text{ or } THI * BW * AT_C \text{ or } AT_{nc} * DY}{CSF \text{ or } 1/RfD * EF * ED * IR}$$

Where:

Cw	=	contaminant concentration in groundwater (mg/L)
TR	=	total lifetime risk
THI	=	total hazard index
BW	=	body weight (kg)
AT_c	=	averaging time carcinogens (yr)
AT_{nc}	=	averaging time noncarcinogens (yr)
DY	=	days per year (day/year)
CSF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$
RfD	=	reference dose (mg/kg-day)
EF	=	exposure frequency (day/year)
ED	=	exposure duration (yr)
IR	=	ingestion rate (L/day)

Future On-Site Residents

Exposure to COCs via ingestion of groundwater was retained as a potential future exposure pathway for both children and adults.

An ingestion rate (IR) of 1.0 liter/day was used for the amount of water consumed by a 1 to 6 year old child weighing 15 kg. This ingestion rate provides a health conservative exposure estimate (for systemic, noncarcinogenic toxicants) designed to protect young children who could potentially be more affected than adolescents, or adults. This value assumes that children obtain all the tap water they drink from the same source for 350 days/year [which represents the exposure frequency (EF)]. An averaging time (AT) of 2,190 days (6 years x 265 days/year) is used for noncarcinogenic compound exposure.

The IR for adults was 2 liters/day (USEPA, 1989a). The exposure duration (ED) used for the estimation of adult CDIs was 30 years (USEPA, 1989a), which represents the national upper-bound (90th percentile) time at one residence. The averaging time for noncarcinogens was 10,950 days. An AT of 25,550 days (70 years x 365 days/year) was used to evaluate exposure for both children and adults to potential carcinogenic compounds.

Table 2-5 presents a summary of the input parameters for the ingestion of groundwater scenarios.

2.3.2.2 Summary of Site-Specific Risk-Based Remediation Goal Options

The risk-based RGOs for the cleanup of a specific medium are used in the FS to identify areas of concern. COCs were chosen based on available toxicity data and frequency of detection and available ARARs. RGOs were generated for contaminants with available toxicity data. Separate RGOs for future adult residents and children have been calculated. In addition, both carcinogenic and noncarcinogenic RGOs have been calculated. Calculations are provided in Appendix A of this report.

Ingestion of Groundwater

The groundwater ingestion RGOs were estimated for the groundwater at Site 69. Currently, there are no receptors who are exposed to contaminated groundwater. Base personnel receive potable water via a base water distribution. However, a hypothetical future ingestion RGO was estimated for the COCs. In order to estimate conservative RGOs for subpopulations (i.e., adult resident and child resident), specific input variables were developed for each subpopulation. Tables 2-6 and 2-7 present the RGOs calculated for the carcinogenic and noncarcinogenic COCs in the groundwater, respectively.

2.4 Comparison of Remediation Goal Options to Maximum Contaminant Concentrations in Groundwater

Generally, RGOs are not required for a contaminant in a medium with a cumulative cancer risk of less than 1.0E-04, where a HI is less than or equal to 1.0, or where the RGOs are clearly defined by ARARs. In order to decrease uncertainties in the estimation of the reasonable maximum exposure (RME), which is the maximum exposure that is reasonably expected to occur at the site, the maximum concentration of a contaminant in a media can be compared to the estimated risk-based RGO if chemical-specific criteria are not available.

The carcinogenic and noncarcinogenic risk-based RGOs for groundwater ingestion with respect to future residential receptors (adult and children) are compared to the maximum groundwater contaminant concentrations detected at Site 69 from groundwater samples collected during the RI in Table 2-8. Additionally, the NCWQSs and MCLs are presented in this table.

As shown in this table, the maximum concentration of trichloroethane (29.4 μg/L) exceeded the NCWQS (2.8 μg/L) and the Federal MCL (5 μg/L). Additionally, the maximum concentration of Total-1,2-dichloroethene (2,400 μg/L) exceeded the NCWQS and Federal MCL (70 μg/L) as well as the risk-based RGO for adults (730 μg/L) and children (313 μg/L).

The maximum concentrations of arsenic (20 μg/L), barium (8.5 μg/L), beryllium (10.6 μg/L), chromium (249 μg/L), nickel (100 μg/L), manganese (912 μg/L), vanadium (210 μg/L), and zinc (12,100 μg/L) exceeded either the NCWQS, Federal MCL, or risk-based RGO.

Identification of remedial alternatives should not solely be placed on RGOs based on chemical-specific criteria or risk-based levels. Comparison of the maximum contaminant concentration to RGOs was performed to provide an upper-bound conservative estimation and aid in the screening and identification of remedial alternatives. They should not be the final tool in the remedial decisions.

2.5 Uncertainty Associated with Risk-Based RGOs

The uncertainties associated with calculating risk-based RGOs are summarized below. The RGO estimations presented in this section are quantitative in nature, and their results are highly dependent upon the accuracy of the input. The accuracy with which input values can be quantified is critical to the degree of confidence that the decision maker has in the action levels.

Most scientific computation involves a limited number of input variables, which are tied together by a scenario to provide a desired output. Some RGO inputs are based on literature values rather than measured values. In such cases the degree of certainty may be expressed as whether the estimate was based on literature values or measured values, not on how well defined the distribution of the input was. Some RGOs are based on estimated parameters.

The toxicity factors, CSFs and RfDs, have uncertainties built into the assumptions used to calculate these values. Because the toxicity factors are determined from high doses administered to experimental animals and extrapolated to low doses to which humans may be exposed, uncertainties exist. Thus, toxicity factors could either overestimate or underestimate the potential effects on humans. However, because human data exists for very few chemicals, risks are based on these values. In addition, the exposure assumption (e.g., 10 events per year, etc.) also have uncertainties associated with them.

Although RGOs are believed to be fully protective for the RME individual(s), the existence of the same contaminants in multiple media or of multiple chemicals affecting the same population(s), may lead to a situation where, even after attainment of all RGOs, protectiveness is not fully achieved (i.e., cumulative risk may fall outside the risk range).

2.6 Remediation Levels

This section presents the remediation levels (RLs) chosen for Site 69 groundwater. RLs are chosen by the risk manager for the COCs and are addressed in the FS and the ROD. These numbers derived from the RGOs are no longer goals and should be considered required levels for the remedial actions to achieve, if possible.

The RLs associated with Site 69 are presented in Table 2-9. This list was based on a comparison of contaminant-specific ARARs (or ARAR-based RGOs) and the site-specific risk-based RGOs. If a COC had an ARAR, the most limiting (or conservative) ARAR was selected as the RL for that contaminant. If a COC did not have an ARAR, the most conservative risk-based RGO was selected for the RL.

In order to determine the final COCs for groundwater at Site 69, the contaminant concentrations detected at each site were compared to the RLs presented in Table 2-9. The contaminants which exceeded at least one of the RLs have been retained as final COCs. The contaminants that did not exceed any of the RLs are no longer considered as COCs with respect to this FS. The final COCs for Site 69 and their associated RLs are presented in Table 2-10.

2.7 Areas of Concern Requiring Remediation and/or Institutional Controls

The results of the baseline human health RA and the ecological risk assessment were evaluated to determine the areas of concern (AOC) within OU No. 14 that may warrant remediation or institutional

controls to protect the public health and the environment. This determination is presented below for each site.

2.7.1 Site 69 Areas of Concern

Shallow and deep groundwater, and soil (primarily the landfill material) are media at Site 69 which could potentially pose unacceptable future human health or ecological risks. As mentioned previously, these media do not present unacceptable risks to human health or the environment, at present. A summary of areas of concern are provided in Table 2-11.

Shallow and deep groundwater have been combined as one AOC because of their hydraulic connection to one another (the aquifers are interconnected to each other and are contaminated by the same source). Shallow groundwater within the southeast portion of the former disposal area has exhibited elevated VOCs (mainly 1,2-DCE, TCE, and vinyl chloride) and to a limited degree, total metals (mainly iron and manganese). As mentioned previously, the total metals may be elevated as a result of sampling techniques/geologic conditions and not because of former disposal activities. Although there is no current human receptor associated with groundwater, future potential exposure to groundwater could occur under a residential land use scenario, or via migration of VOCs to potable supply wells in the Castle Hayne. Although no base supply wells are in danger of being contaminated, new wells or off-base wells could potentially be contaminated over time.

The following objectives have been identified for groundwater:

- Prevent future potential exposure to contaminated groundwater.
- Protect uncontaminated groundwater for future potential beneficial use.
- Restore contaminated groundwater for future potential beneficial use.

Soil, including the landfill material, has been identified as the second AOC at Site 69. The soil/landfill material does not currently result in unacceptable human health risks, but may result in unacceptable risks under a future potential scenario involving residential land use or construction. The fact that the site is suspected to contain CWM results in a risk from a safety as well as a health standpoint. Therefore, soil has been included as an AOC.

The following remedial action objectives have been identified for soil at Site 69:

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

- Prevent or reduce potential migration of VOC contaminants to shallow groundwater.

TABLE 2-1

CONTAMINANTS OF CONERN (COC) IN ENVIRONMENTAL MEDIA FOR
OPERABLE UNIT NO. 14 (SITE 69)
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment	Biota
Total 1,2-Dichloroethene			X	X	X	
Trichloroethene			X	X		
1,1,2,2-Tetrachloroethane			X			
Toluene				X	X	X
Vinyl Chloride				X		
Ethylbenzene				X		
Xylene (Total)				X		
4,4'-DDE					X	X
4,4'-DDT					X	
4,4'-DDD					X	X
PCB-1254					X	
alpha-BHC					X	
beta-BHC					X	
delta-BHC					X	
Arsenic			X	X		
Barium			X	X	X	
Beryllium			X	X	X	X
Cadmium				X		X
Chromium		X	X	X	X	
Copper			X	X	X	
Lead		X	X	X	X	
Nickel			X	X		
Manganese		X	X	X	X	
Mercury			X	X	X	
Selenium			X			X
Vanadium			X	X	X	
Zinc			X	X	X	X

X - Selected as COC

TABLE 2-2

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CONTAMINANT-SPECIFIC CRITERIA OPERABLE UNIT NO. 14 MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
FEDERAL/CONTAMINANT-SPECIFIC		
Safe Drinking Water Act a. Maximum Contaminant Levels (MCLs) 40 CFR 141.11-141.16 b. Maximum Contaminant Level Goals (MCLGs) 40 CFR 141.50-141.51	Standards for protection of drinking water sources serving at least 25 persons. MCLs consider health factors, as well as economic and technical feasibility of removing a contaminant; MCLGs do not consider the technical feasibility of contaminant removal. For a given contaminant, the more stringent of MCLs or MCLGs is applicable unless the MCLG is zero, in which case the MCL applies.	Relevant and appropriate in developing remediation levels for contaminated groundwater used as a potable water supply.
Reference Doses (RfDs), EPA Office of Research and Development	Presents non-enforceable toxicity data for specific chemicals for use in public health assessments to characterize risks due to exposure to contaminants.	To be considered (TBC) requirement in the public health assessment.
Carcinogenic Potency Factors, EPA Environmental Criteria and Assessment Office; EPA Carcinogen Assessment Group	Presents non-enforceable toxicity data for specific chemicals for use in public health assessments to compute the individual incremental cancer risk resulting from exposure to carcinogens.	TBC requirement in the public health assessment.
Health Advisories, EPA Office of Drinking Water	Non-enforceable guidelines for chemicals that may intermittently be encountered in public water supply systems. Available for short- or long-term exposure for a child and/or adult.	TBC requirement in the public health assessment.
National Emissions Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR Part 61)	Standards promulgated under the Clean Air Act for significant sources of hazardous pollutants, such as vinyl chloride, benzene, trichloroethylene, dichlorobenzene, asbestos, and other hazardous substances. Considered for any source that has the potential to emit 10 tons of any hazardous air pollutant or 25 tons of a combination of hazardous air pollutants per year.	No remedial actions that may result in release of hazardous air pollutants are anticipated. Therefore, these standards will not be considered as an ARAR.

TABLE 2-2 (Continued)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
AND TO BE CONSIDERED CONTAMINANT-SPECIFIC CRITERIA
OPERABLE UNIT NO. 14
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
National Ambient Air Quality Standards (40 CFR 50)	Standards for the following six criteria pollutants: particulate matter; sulfur dioxide; carbon monoxide; ozone; nitrogen dioxide; and lead. The attainment and maintenance of these standards are required to protect the public health and welfare.	Not enforceable and therefore not an ARAR. May be a TBC for excavation activities.
EPA Ambient Water Quality Criteria (Section 304(a)(1) of CWA)	Non-enforceable criterion for water quality for the protection of human health from exposure to contaminants in drinking water and from ingestion of aquatic biota and for the protection of fresh-water and salt-water aquatic life.	Potentially relevant and appropriate for discharge of treated groundwater to a surface water.
STATE/CONTAMINANT-SPECIFIC		
State of North Carolina Department of Environment, Health, and Natural Resources Division of Environmental Management 15A NCAC 2B.0200 - Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina	Surface water quality standards based on water use and criteria class of surface water.	Relevant and appropriate for remedial actions requiring discharge to surface water.
North Carolina Anti-Degradation Policy for Surface Water (Water Quality Standards Title 15A, Chapter 2, Subchapter 2B)	Provides for an anti-degradation policy for surface water quality. Pursuant to this policy, the requirements of 40 CFR 131.12 are adopted by reference in accordance with General Statute 150B-14(b).	This policy is a TBC requirement for remedial actions requiring discharge to surface water.
State of North Carolina Department of Environment, Health and Natural Resources Division of Environmental Management 15A NCAC 2L.0200 - Classifications and Water Quality Standards Applicable to Groundwaters of North Carolina	Establishes groundwater classifications and maximum contaminant concentrations to protect groundwater. These standards are mandatory.	Potentially relevant and appropriate for remedial actions requiring discharge to groundwater.

TABLE 2-2 (Continued)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CONTAMINANT-SPECIFIC CRITERIA OPERABLE UNIT NO. 14 MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
North Carolina DEHNR Toxic Air Pollutant Rule Statutory Authority G.S. 143-215.107(a)(1),(3),(4),(5); 143-B-282	A facility shall not emit any toxic air pollutants (as listed in Rule .1104) that may cause or contribute beyond the premises (contiguous property boundary) to any significant ambient air concentration that may adversely affect human health.	No remedial actions that may result in release of hazardous air pollutants are anticipated. Therefore, these standards will not be considered as an ARAR.
North Carolina Driking Water Act 130A NCGS 311-327	All public water supply systems will be located, constructed, and operated so that safe water is available to all persons served by these systems.	The shallow aquifer is not part of a drinking water supply system. Therefore, this Act will not be considered an ARAR.

TABLE 2-3

LOCATION-SPECIFIC ARARs EVALUATED FOR OPERABLE UNIT NO. 14
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
National Historic Preservation Act of 1966 - requires action to take into account effects on properties included in or eligible for the National Register of Historic Places and to minimize harm to National Historic Landmarks.	16 USC 470, 40 CFR 6.301(b), and 36 CFR 800	No known historic properties are within or near OU No. 14, therefore, this act will not be considered as an ARAR.
Archeological and Historic Preservation Act - establishes procedures to provide for preservation of historical and archeological data which might be destroyed through alteration of terrain.	16 USC 469 and 40 CFR 6.301(c)	No known historical or archeological data is known to be present at the site, therefore, this act will not be considered as an ARAR.
Historic Sites, Buildings and Antiquities Act - requires action to avoid undesirable impacts on landmarks on the National Registry of Natural Landmarks.	16 USC 461467 and 40 CFR 6.301(a)	No known historic sites, buildings or antiquities are within or near OU No. 14, therefore, this act will not be considered as an ARAR.
Fish and Wildlife Coordination Act - requires action to protect fish and wildlife from actions modifying streams or areas affecting streams.	16 USC 661-666	Everett Creek and the Unnamed Tributory are located near Site 69. If remedial actions are implemented that modify these creeks, this will be an applicable ARAR.
Federal Endangered Species Act - requires action to avoid jeopardizing the continued existence of listed endangered species or modification of their habitat.	16 USC 1531, 50 CFR 200, and 50 CFR 402	Many protected species have been cited near and on MCB Camp Lejeune such as the American alligator, the Bachmans sparrow, the Black skimmer, the Green turtle, the Loggerhead turtle, the piping plover, the Red-cockaded woodpecker, and the rough-leaf loosestrife (LeBlond, 1991),(Fussell, 1991),(Walters, 1991). In addition, the alligator has been sighted on Base. Therefore, this will be considered as an ARAR.

TABLE 2-3 (Continued)

LOCATION-SPECIFIC ARARs EVALUATED FOR OPERABLE UNIT NO. 14
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
North Carolina Endangered Species Act - per the North Carolina Wildlife Resources Commission. Similar to the Federal Endangered Species Act, but also includes State special concern species, State significantly rate species, and the State watch list.	GS 113-331 to 113-337	Since the American alligator has been sighted within MCB Camp Lejeune, this will be considered as an ARAR.
Rivers and Harbors Act of 1899 (Section 10 Permit) - requires permit for structures or work in or affecting navigable waters.	33 USC 403	There are no navigable waters in the vicinity of Sites 42 and 74. Therefore, this act will not be considered as an ARAR.
Executive Order 11990 on Protection of Wetlands - establishes special requirements for Federal agencies to avoid the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists.	Executive Order Number 11990, and 40 CFR 6	Based on a review of Wetland Inventory Maps, Site 69 is not surrounded by wetlands. Therefore, this will not be an applicable ARAR.
Executive Order 11988 on Floodplain Management - establishes special requirements for Federal agencies to evaluate the adverse impacts associated with direct and indirect development of a floodplain.	Executive Order Number 11988, and 40 CFR 6	Based on the Federal Emergency Management Agency's Flood Insurance Rate Map for Onslow County, OU No. 14 is not located within a minimal flooding zone (outside the 500-year floodplain). Therefore, this is not an ARAR.
Wilderness Act - requires that federally owned wilderness area are not impacted. Establishes nondegradation, maximum restoration, and protection of wilderness areas as primary management principles.	16 USC 1131 and 50 CFR 35.1	No known federally owned wilderness areas near the operable unit, therefore, this act will not be considered as an ARAR.

TABLE 2-3 (Continued)

LOCATION-SPECIFIC ARARs EVALUATED FOR OPERABLE UNIT NO. 14
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
National Wildlife Refuge System - restricts activities within a National Wildlife Refuge.	16 USC 668 and 50 CFR 27	No known National Wildlife Refuge areas near the operable unit, therefore, this will not be considered as an ARAR.
Scenic Rivers Act - requires action to avoid adverse effects on designated wild or scenic rivers.	16 USC 1271 and 40 CFR 6.302(e)	No known wild or scenic rivers near the operable unit, therefore, this act will not be considered as an ARAR.
Coastal Zone Management Act - requires activities affecting land or water uses in a coastal zone to certify noninterference with coastal zone management.	16 USC 1451	No activities will affect land or water uses in a coastal zone, therefore, this act will not be considered as an ARAR.
Clean Water Act (Section 404) - prohibits discharge of dredged or fill material into wetland without a permit.	33 USC 404	No actions to discharge dredged or fill material into wetlands will be considered for the operable unit, therefore, this act will not be considered as an ARAR.
RCRA Location Requirements - limitations on where on-site storage, treatment, or disposal of RCRA hazardous waste may occur.	40 CFR 264.18	These requirements may be applicable if the remedial actions for the operable unit includes the on-site storage, treatment, or disposal of RCRA hazardous waste. On-site storage treatment or disposal of RCRA hazardous waste is not anticipated. Therefore, these requirements will not be considered an ARAR.
North Carolina Hazardous Waste Management Rules	15A NCAC 13A.009 and .0012	These requirements may be applicable if hazardous waste will be excavated, stored or treated on site. Therefore, these location and land disposal requirements may be applicable ARARs for Site 69.

TABLE 2-3 (Continued)

LOCATION-SPECIFIC ARARs EVALUATED FOR OPERABLE UNIT NO. 14
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Potential Location-Specific ARAR	General Citation	ARAR Evaluation
North Carolina Solid Waste Management Rules	15A NCAC 13B.1600	A solid waste landfill facility will not be sited at Site 69. Therefore, these rules will not be considered an ARAR for Site 69.
North Carolina Recordation of Inactive Hazardous Substance or Waste Disposal Site Statute	N.C.G.S. 130A-310.8	Site 69 is no longer an active dump. Therefore, the State requirements for recordation of inactive hazardous sites may apply. This requirement may be an applicable ARAR for Site 69.
North Carolina Coastal Management	15A NCAC 7H	Site 69 may be in a coastal management zone. Therefore, these requirements may be applicable for Site 69.

TABLE 2-4

POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
OPERABLE UNIT NO. 14
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
FEDERAL AND STATE/ACTION-SPECIFIC		
OSHA Requirements (29 CFR Parts 1910, 1926, and 1904)	Regulations provide occupational safety and health requirements applicable to workers engaged in on-site field activities.	Required for site workers during construction and operation of remedial activities. Applicable to all actions at the site.
DOT Rules for Hazardous Materials Transportation (49 CFR Parts 107 and 171.1-500)	Regulates the transport of hazardous waste materials including packaging, shipping, and placarding.	Applicable for any action requiring off-site transportation of hazardous materials.
Resource Conservation and Recovery Act (RCRA) Subtitle C		
Identification and Listing of Hazardous Waste (40 CFR Part 261)	Regulations concerning determination of whether or not a waste is hazardous based on characteristics or listing.	Primary site contaminants are not considered to be listed wastes. However, contaminated media may be considered hazardous by characteristic.
Treatment, Storage, and Disposal of Hazardous Waste (40 CFR Parts 262-265, and 266)	Regulates the treatment, storage, and disposal of hazardous waste.	During remediation, treatment, storage, and disposal activities may occur. Materials may be classified as hazardous wastes.
RCRA Subtitle D	Regulates the treatment, storage, and disposal of solid waste and materials designated by the State as special waste.	Applicable to remedial actions involving treatment, storage, or disposal of materials classified as solid and/or special waste.
RCRA Land Disposal Restrictions (LDRs) Requirements (40 CFR Part 268)	Restricts certain listed or characteristic hazardous waste from placement or disposal on land (includes injection wells) without treatment. Provides treatment standards and Best Demonstrated Available Technology (BAT).	LDRs may prohibit or govern the implementation of certain remedial alternatives. Excavation and treatment, disposal, or movement of RCRA hazardous waste out of the area of contamination may trigger LDR requirements for the waste.
Control of Air Emissions from Superfund Air Strippers at Superfund Ground Water Sites (OSWER Directive 9355.0-28)	Guidance that establishes criteria as to whether air emission controls are necessary for air strippers. A maximum 3 lbs/hr or 15 lbs/day or 10 tons/yr of VOC emissions is allowable; air pollution controls are recommended for any emissions in excess of these quantities.	Remedial actions involving air stripping are not anticipated. Therefore this guidance will not be considered.
Monitored Natural Attenuation (OSWER Directive 9200.4-17	Guidance that establishes criteria for implementing monitored natural attenuation of contaminated media.	Applicable to remedial actions involving monitored natural attenuation.

TABLE 2-4 (Continued)

POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
OPERABLE UNIT NO. 14
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
Clean Air Act (40 CFR 50, 52, 60; 40 USC 7410	Regulates air emissions	Activities which produce air emissions are related to air strippers, and my be subject to this Act.
North Carolina Water Pollution Control Regulations		
Treated Groundwater Discharge (Title 15, Chapter 2, Section .0100)	Regulates point-source discharges through the North Carolina permitting program. Substantive requirements include compliance with corresponding water quality standards, establishment of a discharge monitoring system, and completion of regular discharge monitoring records.	May be applicable for actions requiring discharge of treated groundwater to surface water.
Water Quality and Groundwater Corrective Actions (Title 15A, Chapter 2L)	Provides guidance on water quality and groundwater corrective actions.	Applicable to all actions implemented for groundwater remediation.
Well and Injection Well Construction (Title 15A, Chapter 2C, Section .0100-.0200)	Regulates well construction and injection well construction.	Applicable to any activity which requires the construction of wells or injection wells.
Waste Water Discharge (Title 15A, Chapter 2H, Sections .0100 and .0200	Regulates waste water discharge.	Applicable to any activity which requires the discharge of wastewater.
North Carolina Waste Management Regulations (Title 15A, Chapter 13)	Regulates the management of hazardous and solid waste.	Applicable to any activity which generates hazardous or solid waste.
North Carolina Air Emissions Controls (Title 15A, Chapters 2D, 2H.0600, 2Q	Regulates air emissions.	Applicable to any activity which produces air emissions
North Carolina Sedimentation Control (Title 15A, Chapter 2H, Section .1000	Regulates methods of controlling sedimentation due to earth moving activities.	Applicable to any activity where land is disturbed.
Protection of Archaeological Resources (32 CFR Parts 229 and 229.4; 43 CFR Parts 107 and 171.1-5)	Develops procedures for the protection of archaeological resources.	Applicable to any excavation on site. If archaeological resources are encountered during soil excavation, they must be reviewed by Federal and State archaeologists.
Safe Drinking Water Act (40 CFR Parts 144, 146, 147, 268)	Regulates underground injection of wastes and in situ groundwater remediation wells.	No injection of wastes, or injection of substances required for in situ groundwater remediation is anticipated. Therefore, these regulations are not being considered as ARARs.

TABLE 2-4 (Continued)

POTENTIAL ACTION-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
OPERABLE UNIT NO. 14
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
Clean Water Act (40 CFR Parts 122, 125, 136, 264, 270, 403; 33 CFR Parts 320-330; 33 USC 403)	Regulates discharges to waters of the United States, direct discharge to the ocean, discharge to POTWs, and dredge/fill activities.	Applicable to any activity which requires discharge to waters of the United States, the ocean, POTWs, or requires dredge/fill activities.
Clean Air Act (40 CFR 50, 52, 60; 40 USC 7410)	Regulates air emissions.	Remedial activities at Site 69 which produce air emissions are related to air strippers and may be subject to this Act.
North Carolina Sedimentation Pollution Control Act of 1973 (Chapter 113A)	Regulates stormwater management and erosion/sedimentation control practices that must be followed during land disturbing activities.	Applicable for remedial actions involving land disturbing activities (i.e., excavation of soil and waste).

TABLE 2-5

INGESTION OF GROUNDWATER
RGO PARAMETERS
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Ingestion of Groundwater Input Parameters			
Input Parameter	Description	Value	Rationale
C_w	Exposure Concentration	Calculated	USEPA, 1989a
TR	Total Lifetime Risk	1.0E-04	USEPA, 1991a
THI	Total Hazard Index	1.0	USEPA, 1991a
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All 70 yr	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 6 yr Adult 30 yr	USEPA, 1989a
DY	Days Per Year	365 days/yr	USEPA, 1989a
CSF	Carcinogenic Slope Factor	Chemical Specific	IRIS, HEAST, USEPA
RfD	Reference Dose	Chemical Specific	IRIS, HEAST, USEPA
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr	USEPA, 1989a
ED	Exposure Duration	Child 6 yr Adult 30 yr	USEPA, 1991b
IR	Ingestion Rate	Child 1 L/day Adult 2 L/day	USEPA, 1989a

TABLE 2-6

INGESTION OF GROUNDWATER CARCINOGENIC RGOs
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Carcinogenic RGO	
	Adult Resident	Child Resident
Trichloroethene	774	1,659
1,1,2,2-Tetrachloroethane	43	91
Arsenic	5	11
Beryllium	2	4

Notes: RGO = Remedial Goal Options
Remediation Goal Options concentrations expressed in μg/L (ppb).
Remediation Goal Options based on a risk of 1.0E-04.

TABLE 2-7

INGESTION OF GROUNDWATER NONCARCINOGENIC RGOs
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Noncarcinogenic RGO	
	Adult Resident	Child Resident
Total 1,2-dichloroethene	730	313
Trichloroethene	219	94
Arsenic	11	5
Barium	2,555	1,095
Beryllium	78	183
Chromium	183	78
Copper	1,354	580
Nickel	313	730
Manganese	78	183
Mercury	11	5
Selenium	183	78
Vanadium	256	110
Zinc	10,950	4,693

Notes: RGO = Remedial Goal Options
Remediation Goal Options concentrations expressed in μg/L (ppb).
Remediation Goal Options based on a risk of 1.0E-04.

TABLE 2-8

COMPARISON OF GROUNDWATER INGESTION RISK-BASED RGOs AND GROUNDWATER CRITERIA TO MAXIMUM GROUNDWATER CONTAMINANT LEVELS AT SITE 69 FEASIBILITY STUDY CTO-0212 MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	NCWQS[1]	Federal MCL[2]	RGO[3]		Maximum Groundwater Concentration (RI only)
			Adult	Child	Site 69
Trichloroethene	2.8	5	219	94	150
1,1,2,2-Tetrachloroethane	NE	NE	43	91	22
Total 1,2-dichloroethene	70	70	730	313	2,400
Arsenic	50	50	5	11	20
Barium	2,000	2,000	2,555	1,095	850
Beryllium	NE	4	2	4	10.6
Chromium	50	100	183	78	159
Copper	1,000	1,300[5]	1,354	580	70.8
Lead	15	15[5]	NE	NE	188
Manganese	50	50[4]	5,110	2,190	912
Mercury	1.1	2	11	5	0.936
Nickel	100	100	11	5	100
Selenium	50	50	183	78	5.28
Vanadium	NE	NE	256	110	210
Zinc	2,100	5,000[4]	10,950	4,693	9,120

Notes: Concentrations expressed in microgram per liter (μg/L).
[1] NCWQS = North Carolina Water Quality Standards for Groundwater
[2] MCL = Safe Drinking Water Act Maximum Contaminant Level
[3] RGO = Risk-based Remediation Goal Options
[4] SMCL = Secondary Maximum Contaminant Level
[5] Action Level
NE = No Criteria Established
ND = Not Detected

TABLE 2-9

REMEDIATION LEVELS FOR COCs
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium	Contaminant of Concern	RL[1]	Basis of Goal	Corresponding Risk
Groundwater	Trichloroethene	2.8	NCWQS[2]	
	1,1,2,2-Tetrachloroethane	43	Risk-Ingestion	ICR[3] = 1.0E-04
	Total 1,2-Dichloroethene	70	NCWQS	
	Arsenic	50	NCWQS	
	Barium	2,000	NCWQS	
	Beryllium	4	MCL[4]	
	Chromium	50	NCWQS	
	Copper	1,000	NCWQS	
	Lead	15	NCWQS	
	Manganese	50	NCWQS	
	Mercury	1.1	NCWQS	
	Nickel	100	NCWQS	
	Selenium	50	NCWQS	
	Vanadium	110	Risk-Ingestion	HI[5] = 1.0
	Zinc	2,100	NCWQS	

Notes:
(1) RL = Remediation Level
Groundwater/expressed as μg/L (ppb).
(2) NCWQS = North Carolina Water Quality Standard
(3) ICR = Incremental Cancer Risk
(4) MCL = Maximum Contaminant Level
(5) HI = Hazard Index

TABLE 2-10

COCs THAT EXCEEDED REMEDIATION LEVEL AT SITE 69
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	RL[1]
Trichloroethene	2.8
Total 1,2-Dichloroethene	70
Beryllium	4
Chromium	50
Lead	15
Manganese	50
Vanadium	110
Zinc	2,100

Notes: [1] RL = Remediation Level
Groundwater RLs expressed as μg/L (ppb).

TABLE 2-11

REMEDIAL ACTION OBJECTIVES FOR OPERABLE UNIT NO. 14
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Site	Media	Remedial Action Objective
Site 69	Groundwater	• Prevent future potential exposure to contaminated groundwater. • Protect uncontaminated groundwater for future potential beneficial use. • Restore contaminated groundwater for future potential beneficial use.
	Soil and Waste (Landfilled Material)	• Prevent future potential exposure to buried soil (including landfill materials). • Prevent or reduce potential migration of VOC contaminants to shallow groundwater.

3.0 IDENTIFICATION AND PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES

This section includes the identification and preliminary screening of remedial action technologies that may be applicable for the remediation of the groundwater and soils at OU No. 14. Section 3.1 identifies a set of general response actions which correspond to the remedial action objectives. Section 3.2 identifies a set of remedial technologies and process options applicable to groundwater and soil. Section 3.3 presents the preliminary screening of the remedial technologies and process options. Section 3.4 presents a summary of the preliminary screening, and Section 3.5 presents the process option evaluation.

3.1 General Response Actions

General response actions are broad-based medium-specific categories of actions that can be identified to satisfy the remedial action objectives of an FS. The general response actions that will satisfy the remedial action objectives identified for OU No. 14 are listed in Table 3-1. As shown on the table, six general response actions have been identified for the groundwater objectives: no action, institutional controls, containment actions, collection/discharge, in situ treatment, and physical/chemical treatment actions. Five general response actions have also been identified for the soil objectives: no action, institutional controls, in situ treatment, removal, and containment.

A brief description of each of the above-mentioned general response actions follows.

3.1.1 No Action

The NCP requires the evaluation of the no action response action as part of the FS process. A no action response provides the baseline assessment for the comparison with other remedial alternatives that have a greater level of response. A no action alternative may be considered appropriate when there is no adverse or unacceptable risks to human health or the environment, or when the response action may cause a greater environmental or health danger than the no action alternative itself.

3.1.2 Institutional Controls

Institutional controls are actions that can be implemented at a site as part of a complete remedial alternative to minimize exposure to potential hazards. With respect to groundwater, institutional controls may include monitoring programs or ordinances which restrict placement of supply wells. With respect to soil, institutional controls may include monitoring, access restrictions, and deed restrictions.

3.1.3 Containment Actions

Containment measures include various technologies which contain and/or isolate the contaminants at a site. Containment measures are designed to isolate so as to prevent direct exposure with or migration of the contaminated media without disturbing or removing the waste from the site. Containment actions generally serve to cover, seal, chemically stabilize, or provide an effective barrier against specific areas of contamination.

3.1.4 Collection/Discharge Actions

Collection/discharge actions are typically associated with groundwater or surface water. For this FS, groundwater collection/discharge actions at Site 69 will be addressed. For groundwater, collection actions may include extraction wells or subsurface drains. Discharge actions are those means for discharging groundwater that has been treated. Discharge actions may be directed on site or off site.

3.1.5 Removal Actions

Removal actions involve the excavation of soil or drums using mechanical equipment for subsequent treatment and/or disposal. For this FS, removal actions are limited due to the suspected CWM at each site.

3.1.6 Treatment Actions

3.1.6.1 Ex Situ Treatment

Ex situ treatment actions would involve physical and/or chemical means of reducing the toxicity or destroying contaminants that are present in soil or groundwater. Treatment actions at OU No. 14 would only be applicable to the groundwater once it has been collected via either extraction wells or subsurface drains. Treatment actions that involve extensive excavation cannot be implemented for soil at the former disposal areas due to the presence of suspected CWM. Treatment actions for groundwater are normally conducted on site, but off-site treatment actions are also considered.

3.1.6.2 In Situ Treatment

In situ treatment takes place without excavation (applicable to soil) or extraction (applicable to groundwater). In situ treatment could be performed chemically, biologically, or physically. For this FS, soil treatment actions are limited to in situ actions due to the suspected CWM within the site. Under U.S. Army policy, CWM, which is buried but does not possess human health or ecological risks, should not be removed.

3.2 Identification of Remedial Action Technologies and Process Options

In this step, an extensive set of potentially applicable technology types and process options will be identified for each of the general response actions identified for the media of concern at OU No. 14. The term "technology type" refers to general categories of technologies such as chemical treatment, thermal treatment, biological treatment, and in situ treatment. The term "technology process option" refers to specific processes within each technology type, for example, rotary kiln, fluidized bed, and multiple hearth incineration are process options of thermal treatment. Several technology types may be identified for each general response action, and numerous technology process options may exist within each technology type.

Remedial action technologies potentially applicable to OU No. 14 are listed in Table 3-2 with respect to their corresponding general response action. The applicable process options associated with each of the listed technologies are also listed on the table.

SECTION 3.0 TABLES

TABLE 3-1

GENERAL RESPONSE ACTIONS FOR OPERABLE UNIT NO. 14
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	Area of Concern	Remedial Action Objective	General Response Action
Groundwater	Site 69 - Surficial and Castle Hayne Aquifers (Site 69, AOC No. 1)1.	1. Prevent future potential exposure to contaminated groundwater. 2. Protect uncontaminated groundwater for future potential beneficial use. 3. Restore contaminated groundwater for future potential beneficial use.	• No Action • Institutional Controls • Containment Actions • Collection/Discharge • Physical/Chemical Treatment • In Situ Treatment
Soil	Site 69 - Soil and Landfill Material (Site 69, AOC No. 2)	1. Prevent future potential exposure to buried soil (including landfill material). 2. Prevent potential migration of contaminants to shallow groundwater.	• No Action • Institutional Controls • In Situ Treatment • Removal • Containment

TABLE 3-2

POTENTIAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS IDENTIFIED FOR OPERABLE UNIT NO. 14 FEASIBILITY STUDY, CTO-0212 MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology	Process Option
Groundwater	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Groundwater and Surface Water Monitoring
		Aquifer-Use	Restrictions in Base Master Plan
			Deed Restrictions
	Containment Actions	Capping	Clay/Soil Cap
			Asphalt/Concrete Cap
			Soil Cover
			Multilayered Cap
		Vertical Barriers	Grout Curtain
			Slurry Wall
			Sheet Piling
			Rock Grouting
		Horizontal Barriers	Grout Injection
			Block Displacement
		Extraction	Extraction Wells
		Subsurface Drains	Interceptor Trenches
	Collection/Discharge Actions	Extraction	Extraction Wells
			Extraction/Injection Wells
		Subsurface Drains	Interceptor Trenches
		On-Site Discharge	Reinjection
			Infiltration Galleries
			Surface Water
		Off-Site Discharge	POTW
			Base STP
			Surface Water
	Treatment Actions	Biological Treatment	Aerobic
			Anaerobic
		Physical/Chemical Treatment	Air Stripping
			Steam Stripping
			Carbon Adsorption
			Reverse Osmosis
			Ion Exchange
			Chemical Reduction
			Chemical Oxidation
			Electrochemical Iron Generation

TABLE 3-2 (Continued)

POTENTIAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS IDENTIFIED FOR OPERABLE UNIT NO. 14 FEASIBILITY STUDY, CTO-0212 MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology	Process Option
Groundwater (Cont.)	Treatment Actions (Cont.)	Physical/Chemical Treatment (Cont.)	Neutralization
			Precipitation
			Oil/Water Separator
			Filtration
			Flocculation
			Sedimentation
			Chemical Dechlorination
		Engineered Wetland Treatment	Constructed Wetlands
		Off-Site Treatment	POTW
			RCRA Facility
			Sewage Treatment Plant
		In-Situ Treatment	Biodegradation
			Air Sparging
			In Situ Air Stripping
Soil	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Monitoring
		Access Restrictions	Restrictions in Base Master Plan
			Deed Restrictions
			Fencing
	Containment Actions	Capping	Clay/Soil Cap
			Asphalt/Concrete Cap
			Soil Cover
			Multilayered Cap
		Surface Controls	Grading
			Revegetation
	Removal Actions	Excavation	Soils Excavation
	Treatment Actions	In Situ Treatment	Biodegradation
			Vapor Extraction
			Soil Flushing
			Chemical Immobilization • Polymerization • Stabilization
			Chemical Detoxification • Oxidation • Reduction • Neutralization • Hydrolysis

TABLE 3-2 (Continued)

POTENTIAL SET OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS IDENTIFIED FOR OPERABLE UNIT NO. 14 FEASIBILITY STUDY, CTO-0212 MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology	Process Option
Soil (Cont.)	Treatment Actions (Cont.)	In Situ Treatment (Cont.)	Vitrification
			Heating
			Artificial Ground Freezing

TABLE 3-3

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
No Action	No Action	Not Applicable	No action - contaminated groundwater remains as is.	Potentially applicable to any site; required by the NCP.	Retained
Institutional Controls	Monitoring	Groundwater and Surface Water Monitoring	Ongoing monitoring of groundwater or surface water.	Potentially applicable.	Retained
	Aquifer-Use Restrictions	Restrictions in Base Master Plan	Prohibit the use of the contaminated aquifer as a drinking water source.	Potentially applicable.	Retained
		Deed Restrictions	Limit the future use of land including placement of wells.	Not applicable to a military installation not on closure list.	Eliminated
Containment Actions	Capping	Clay/Soil Cap Asphalt/Concrete Cap Soil Cover Multilayered Cap	Capping material placed over areas of contamination.	Not implementable since regrading and construction activities may result in exposure to CWM. Not applicable for contaminated groundwater based on depth of the contamination, site hydrology, and lack of no impermeable liner.	Eliminated
	Vertical Barriers	Grout Curtain	Pressure injection of grout in a regular pattern of drilled holes to contain contamination.	The heterogeneity of the fill material at the site may prevent a "gap-free" curtain. No continuous confining layer under the sites to which the wall should adjoin.	Eliminated
		Slurry Wall	Trench around areas of contamination. The trench is filled with a soil bentonite slurry to limit migration of contaminants.	The heterogeneity of the fill material at the site may prevent a "gap-free" curtain. No continuous confining layer under the sites to which the wall should adjoin.	Eliminated
		Sheet Piling	Interlocking sheet pilings installed via drop hammer around areas of contamination.	No continuous confining layer under the site to which the wall should adjoin.	Eliminated
		Rock Grouting	Specialty operation for sealing fractures, fissures, solution cavities, or other voids in rock to control flow of groundwater.	No rock at the site.	Eliminated

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Containment Actions (Continued)	Horizontal Barriers	Grout Injection	Pressure injection of grout to form a bottom seal across a site at a specific depth.	Technique is in the experimental stage. Depth of the contaminated groundwater at the sites would limit its use.	Eliminated
		Block Displacement	Continued pumping of grout into specially notched holes causing displacement of a block of contaminated earth.	Depth of contaminated groundwater would limit its use. Technique is in the experimental stage.	Eliminated
	Extraction	Extraction Wells	Series of wells used to extract contaminated groundwater.	Potentially applicable	Retained
	Subsurface Drains	Interceptor Trenches	Perforated pipe installed in trenches backfilled with porous media to collect contaminated groundwater.	Depth of the contaminated groundwater will limit its use. Applicable to only the shallow groundwater. May not be effective in containing existing vertical migration in the Castle Hayne.	Retained
Collection Actions	Extraction	Extraction Wells	Series of wells used to extract contaminated groundwater at a pumping rate which would create a cone of influence sufficient to contain contaminant migration.	Potentially applicable	Retained
		Extraction/Injection Wells	Injection wells inject uncontaminated groundwater to enhance collection of contaminated groundwater via the extraction wells. Or the injection wells can also inject material into an aquifer to remediate groundwater.	Potentially applicable	Retained
	Subsurface Drains	Interceptor Trenches	Perforated pipe installed in trenches backfilled with porous media to collect contaminated groundwater.	Depth of the contaminated groundwater will limit its use. Applicable to only the shallow groundwater. May not be effective in containing existing vertical migration in the Castle Hayne.	Retained

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment Actions	Biological Treatment	Aerobic	Degradation of organics using microorganisms in an aerobic environment.	Potentially applicable to organic contaminants of concern.	Retained
		Anaerobic	Degradation of organics using microorganisms in an anaerobic environment.	Potentially applicable to organic contaminants of concern.	Retained
	Physical/Chemical Treatment	Air Stripping	Mixing large volumes of air with water in a packed column to promote transfer of VOCs to air. Applicable to volatile organics.	Potentially applicable for VOCs.	Retained
		Steam Stripping	Mixing large volumes of steam with water in a packed column to promote transfer of VOCs to air. Applicable to a wide range of organics.	Not required for organic contaminants of concern.	Retained
		Carbon Adsorption	Adsorption of contaminants onto activated carbon by passing water through carbon column. Applicable to wide range of organics.	Potentially applicable	Retained
		Reverse Osmosis	Using high pressure to force water through a membrane leaving contaminants behind. Applicable to dissolved solids (organic and inorganic).	Not applicable for most of the constituents of concern.	Eliminated
		Ion Exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water. Applicable for inorganics, not organics.	Potentially applicable	Retained

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment Actions (Continued)	Physical/Chemical Treatment (Continued)	Chemical Reduction	Addition of a reducing agent to lower the oxidation state of a substance to reduce toxicity/solubility. Not applicable to metals of concern.	Potentially applicable	Retained
		Chemical Oxidation	Addition of an oxidizing agent to raise the oxidation state of a substance. Applicable to organics and some metals, primarily iron and manganese.	Potentially applicable	Retained
		Electrochemical Generation	Electrical currents are used to put ferrous and hydroxyl ions into solution for subsequent removal via precipitation. Applicable to metals removal.	Potentially applicable	Retained
		Neutralization	Addition of an acid or base to a waste in order to adjust its pH. Applicable to acidic or basic waste streams.	Although pH is not a concern at the operable unit, neutralization may be applicable in a treatment train with precipitation.	Retained
		Precipitation	Materials in solution are transferred into a solid phase for removal. Applicable to particulates and metals.	Potentially applicable for inorganics.	Retained
		Oil/Water Separation	Materials in solution are transferred into a separate phase for removal. Applicable to petroleum hydrocarbons.	Not necessary for the contaminants of concern. No free phase product detected at the sites.	Eliminated
		Filtration	Removal of suspended solids from solution by forcing the liquid through a porous medium. Applicable to suspended solids.	Potentially applicable.	Retained

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment Actions (Continued)	Physical/Chemical Treatment (Continued)	Flocculation	Small, unsettleable particles suspended in a liquid medium are made to agglomerate into larger particles by the addition of flocculating agents. Applicable to particulates and inorganics.	Potentially applicable.	Retained
		Sedimentation	Removal of suspended solids in an aqueous waste stream via gravity separation. applicable to suspended solids.	Potentially applicable	Retained
		Chemical Dechlorination (KPEG)	Process which uses specially synthesized chemical reagents to destroy hazardous chlorinated molecules or to toxify them to form other less harmful compounds. Applicable to PCBs, chlorinated hydrocarbons and dioxins.	Not applicable to the groundwater contaminants of concern.	Eliminated
	Thermal Treatment	Incineration • Rotary Kiln • Fluidized Bed	Combustion of waste at high temperatures. Different incinerator types can be applicable to pumpable organic wastes, combustible liquids, soils, slurries, or sludges.	Not implementable on groundwater waste streams due to volume of groundwater.	Eliminated
	Engineered Wetland Treatment	Constructed Wetlands	An engineered complex of plants, substrates, water, and microbial populations. Contaminants are removed via plant uptake, biodegradation (organics only), precipitation, and sorption processes.	Not aplicable at Site 69 due to land constraints.	Eliminated

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment Actions (Continued)	Off-site Treatment	POTW	Extracted groundwater discharged to Jacksonville POTW for treatment.	Not implementable since this POTW will not accept contaminated groundwater.	Eliminated
		RCRA Facility	Extracted groundwater discharged to licensed RCRA facility for treatment and/or disposal.	Not implementable due to large volume of groundwater.	Eliminated
		Sewage Treatment Plant	Extracted groundwater discharged to Base STP for treatment.	Not implementable due to large volume of groundwater.	Eliminated
	In Situ Treatment	Biodegradation	System of introducing nutrients and oxygen to waste for the stimulation or augmentation of microbial activity to degrade contamination. Applicable to a wide range of organic compounds.	Potentially applicable to shallow aquifer. This technology is at the experimental stage for treatment of deeper aquifers and contaminants of concern.	Retained
		Air Sparging	The injection of air under pressure in groundwater to remove VOCs via volatilization. Air bubbles migrate into the vadose zone where they can be extracted or treated by other methods. Introduction of air also may promote degradation of contaminants through biological transformation.	Potentially applicable as a shallow aquifer technology at Site 69.	Retained
		Dual-Phase Vacuum Extraction	Extraction of a two-phase air-water stream under high vacuum using wells screened above and below the water table.	Potentially applicable to Site 69 shallow groundwater. Pilot test are required.	Retained

TABLE 3-3 (Continued)

PRELIMINARY SCREENING OF GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment Actions (Continued) (Continued)	In Situ Treatment (Continued)	Natural Attenuation	Natural subsurface processes, including dilution, volatilization, biodegradation, adsorption, and chemical reactions. Process option includes groundwater monitoring combined with modeling to demonstrate on-going contaminant degradation via natural attenuation.	Potentially applicable.	Retained
		In-Well Aeration (a.k.a. UVB, vacuum vaporizer well, in-situ air stripping)	Process of inducing air into a well by applying a vacuum. Results in an in-well airlift pump effect that serves to strip volatiles from groundwater inside the well.	Potentially applicable at Site 69. Pilot tests show some effectiveness.	Retained; but only in the Castle Hayne Aquifer.
Discharge Actions	On-Site Discharge	Reinjection • Injection Wells • Infiltration Galleries	Treated water reinjection into the site aquifer via use of shallow infiltration galleries (trenches) or via deep injection wells.	Deep injection wells potentially applicable. Site geology and low water table may prohibit the use of infiltration galleries.	Retained
	Off-Site Discharge	POTW	Treated water discharged to Jacksonville POTW.	Not implementable due to distance	Eliminated
		Surface Water	Treated water discharged to New River.	Potentially applicable	Retained
		Base STP	Treated water discharged to closest Base STP.	Not implementable due to distance.	Eliminated

TABLE 3-4

PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
No Action	No Action	Not Applicable	No Action - contaminated soil remains untreated.	Potentially applicable to any site; required by NCP.	Retained
Institutional Controls	Monitoring	Monitoring	Periodic sampling and analyses.	Potentially applicable	Retained
	Access Restrictions	Restrictions in Base Master Plan	Limit future land use in areas with potential soil contamination.	Potentially appplicable	Retained
		Deed Restrictions	Limit future land use in areas with potential soil contamination.	Not applicable to a military installation not on base closure list.	Eliminated
		Fencing	Limit access by installing fencing around contaminated areas.	Fencing already exists, but may need repaired.	Retained
Containment Actions	Capping	Clay/Soil Cap	Compacted impermeable clay layer covered with soil installed over contaminated area.	Cannot be implemented at site due to risks associated with land clearing/ regrading and uncovering CWM.	Eliminated
		Asphalt/Concrete Cap	Spray a layer of asphalt over contaminated areas or seal the area with concrete.	Cannot be implemented at site due to risks associated with land clearing/ regrading and uncovering CWM.	Eliminated
		Soil Cover	Soil layer placed on existing ground surface to seal off contamination from aboveground surface.	Cannot be implemented at site due to risks associated with land clearing/ regrading and uncovering CWM.	Eliminated
		Multilayered Cap	Clay and synthetic membrane placed over contaminated area. Areas then covered with soil and revegetated.	Cannot be implemented at site due to risks associated with land clearing/ regrading and uncovering CWM.	Eliminated
	Surface Controls	Grading	Modifying the natural topography and run-off characteristics on and around contaminated areas to control infiltration and erosion due to surface water.	Cannot be implemented at site due to risks involved with uncovering CWM.	Eliminated
		Revegetation	Establish a vegetative cover over contaminated areas to stabilize the ground surface.	No excavation, regrading, or capping can be implemented. Revegetation is not required.	Eliminated
Removal Actions	Excavation	Soils Excavation	Mechanically remove contaminated soils from ground.	Cannot be implemented due to the presence of suspected CWM.	Eliminated

TABLE 3-4 (Continued)

PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment Actions	In Situ Treatment	Biodegradation	System of introducing nutrients and oxygen to waste for the stimulation or augmentation of microbial activity to degrade contamination. Applicable to a wide range of organic compounds.	Potentially applicable in suspected VOC disposal area at Site 69.	Retained
		Vapor Extraction (Single Phase)	Volatile compounds are removed from subsurface soils by mechanically drawing or venting air through the soil matrix.	Potentially applicable to the VOC contaminated soils at Site 69.	Retained
		Dual-Phase Vacuum Extraction	Extraction of a two-phase air-water stream under high vacuum using wells screened above and below water table.	Potentially applicable to Site 69 VOC-contaminated soils. Pilot tests are required.	Retained
		Soil Washing	An aqueous solution is injected into or sprayed onto the affected area and is collected downgradient, then treated.	Cannot be effectively implemented due to unknown subsurface characteristics of the dump areas.	Eliminated
		Chemical Immobilization • Polymerization • Precipitation	Techniques which render contaminants insoluble and thereby prevent migration.	Cannot be effectively implemented due to unknown subsurface characteristics of the dump areas.	Eliminated
		In Situ Chemical Detoxification • Oxidation • Reduction • Neutralization • Hydrolysis	Techniques which destroy, degrade, or reduce the toxicity of contaminants by the use of various treatment agents.	Cannot be effectively implemented due to unknown subsurface characteristics of the dump areas.	Eliminated
		Vitrification	Emerging technology; contaminated soil is converted into a durable glass and crystalline form by melting the soil by electrical heat.	Not applicable to VOCs.	Eliminated
		Heating	Emerging technology; destroys or removes organic contaminants in soil through thermal decomposition, vaporization, and distillation.	Not applicable to VOCs.	Eliminated

TABLE 3-4 (Continued)

PRELIMINARY SCREENING OF SOIL TECHNOLOGIES AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Description	Site-Specific Applicability	Screening Results
Treatment Actions (Continued)	In Situ Treatment (Continued)	Artificial Ground Freezing	Emerging technology; involves installing freezing loops in the ground with a self-contained refrigeration system that pumps coolant around the loops. Soils around the wastes are frozen. Temporary treatment.	Not applicable to VOCs.	Eliminated

TABLE 3-5

POTENTIAL SET OF POTENTIAL TECHNOLOGIES/PROCESS OPTIONS THAT PASSED THE PRELIMINARY SCREENING FEASIBILITY STUDY, CTO-0212 MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology	Process Option
Groundwater	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Groundwater and Surface Water Monitoring
		Aquifer-Use Restrictions	Restrictions in Base Master Plan
	Containment/Collection Actions	Extraction	Extraction Wells
		Subsurface Drains	Interceptor Trenches
	Treatment Actions	Biological Treatment	Aerobic
			Anaerobic
		Physical/Chemical Treatment	Air Stripping
			Carbon Adsorption
			Ion Exchange
			Chemical Reduction
			Chemical Oxidation
			Electrochemical Iron Generation
			Neutralization
			Precipitation
			Filtration
			Flocculation
			Sedimentation
		In Situ Treatment	Air Sparging
			Biodegradation
			Dual-Phase Vacuum Extraction
			Natural Attenuation
			In Situ Air Stripping (In-Well Aeration)
	Discharge Actions	On-Site Discharge	Injection Wells
		Off-Site Discharge	Pipeline to New River
Soils	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Monitoring
		Access Restrictions	Restrictions in Base Master Plan
			Fencing
	Treatment Actions	In Situ Treatment	Biodegradation
			Extraction (Single Phase)
			Dual-Phase Vacuum Extraction

TABLE 3-6

SUMMARY OF GROUNDWATER PROCESS EVALUATION
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
No Action	No Action	Not Applicable	• Evaluation not necessary since only one process option	• Evaluation not necessary since only one process option	Evaluation not necessary since only one process option	Retained
Institutional Controls	Monitoring	Groundwater and Surface Water Monitoring	• Effective in evaluating groundwater conditions due to treatment or to monitor migration over time	• Easily implemented	Low O&M; no capital	Retained
	Aquifer-Use Restrictions	Restrictions in Base Master Plan	• Effective in preventing future potential exposure to contaminated groundwater	• Easily implemented	Negligible Cost	Retained
Collection/ Containment Actions	Extraction	Extraction Wells	• Effective for collecting and/or containing a contaminated groundwater plume • Potential exposures during implementation	• Easily implemented • Equipment readily available • No permits requires	Low to moderate capital; low O&M	Retained
	Subsurface Drains	Interceptor Trenches	• Effective for collecting a contaminated groundwater plume • Potential exposures to unknown buried wastes during implementation • Applicable for only shallow groundwater plumes • Slower recovery than extraction wells • More effective for low permeability soils than extraction wells	• Equipment readily available • Requires extensive excavation/trenching • Requires more area than extraction wells • May require handling and treatment of contaminated soil and/or waste material.	Moderate capital; low O&M	Retained

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS EVALUATION
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
Treatment Actions	Biological Treatment	Aerobic	• Will not likely achieve discharge requirements alone. • Elevated VOCs may be toxic to organisms • Fluctuation in VOC concentrations will impact effectiveness	• Equipment or vendors should be easily obtainable • Will require bench-scale testing	Moderate capital; moderate O&M	Eliminated
		Anaerobic	• Will not likely achieve discharge requirements alone. • Elevated VOCs may be toxic to organisms • Fluctuation in VOC concentrations will impact effectiveness	• Equipment or vendors should be easily obtainable • Will require bench-scale testing	Moderate capital; moderate O&M	Eliminated
	Physical/ Chemical Treatment	Air Stripping	• Can potentially meet effluent goals for organics • Feasible for large volume of moderate to low soluble VOC-contaminated water • Lower efficiency in cold weather • Proven and widely used technology • Potential exposures during implementation • May require pretreatment for metals	• Equipment and vendors readily available • Many mobile units available • May require bench-scale testing • Off-gas and/or tower scale treatment may be required • May require air emissions treatment	Low to moderate capital; low to moderate O&M	Retained
		Steam Stripping	• Can potentially meet effluent goals • Feasible for large volumes of VOC-contaminated water • Lower efficiency in cold weather • May require pretreatment for metals • Typically used for less volatile or highly soluble compounds	• Readily available, not as common as air stripping • Off-gas and/or tower scale treatment may be required • May require emissions treatment	Moderate capital; moderate to high O&M	Eliminated

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS EVALUATION
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
Treatment Actions (Continued)	Physical/ Chemical Treatment (Continued)	Carbon Adsorption	• Can potentially meet effluent goals • Applicable to a wide variety of organics and inorganics • Can be used as a polishing step following air stripping • Proven and widely used technology	• Equipment readily available • Many fabricated mobile units available • May require bench-scale testing • Spent carbon must be properly handled	Moderate capital; low to high O&M (depending on contaminant loading requirements)	Retained
		Ion Exchange	• Effective and reliable; proper pretreatment required • Typically used as a polishing step for removal of selected dissolved metals • Insensitive to variations in flow rates • Pretreatment for oil and grease required	• Full-scale industrial use for recovery of valuable metals • Equipment is widely available • Regeneration solutions are generally readily available • Bench-testing required	Moderate to high capital; low to high O&M (depending on contaminant loading)	Retained
		Chemical Oxidation	• Reliable and proven on industrial wastewaters for metals (manganese, iron) treatment. Can be used alone or in conjunction with precipitation	• Well-demonstrated at hazardous waste sites in pilot- and full-scale • Readily available, conventional equipment required • Bench-scale testing may be required	Low to moderate capital; moderate O&M	Retained
		Electrochemical Iron Generation	• Not significantly impacted by varying concentrations • Less sludge may be produced	• Emerging technology - bench or pilot testing required • Used in combination with precipitation	Low to moderate capital; moderate O&M	Retained

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS EVALUATION
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
Treatment Actions (Continued)	Physical/ Chemical Treatment (Continued)	Neutralization	• Can be used in a treatment train for pH adjustment	• Widely used and well demonstrated • Simple and readily available equipment/materials • Bench-scale studies may be required	Low capital; low to moderate O&M	Retained
		Precipitation	• Effective, reliable, permanent, and conventional technology • Typically used for removal of heavy metals • Followed by solids-separation method • Generates sludge which can be voluminous, difficult to dewater, and may require treatment	• Widely used and well demonstrated • Equipment is basic and easily designed • Compact, single units that are deliverable to the site • May require bench- or pilot-scale tests	Low capital; moderate O&M	Retained
		Filtration	• Conventional, proven method of removing suspended solids from wastewater • Does not remove other contaminants • Pretreatment for oil and grease required • Generates a sludge which requires proper handling	• Equipment is relatively simple to install and no chemicals are required • Package units available	Low capital; low O&M	Retained
		Flocculation	• Well established technology • Applicable to any aqueous waste stream where particles must be agglomerated into larger more settleable particles prior to other types of treatment • Performance depends on the variability of the composition of the waste being treated.	• Equipment is readily available and easy to operate • Can be easily integrated into more complex treatment systems	Low capital; moderate O&M	Retained

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS EVALUATION
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
Treatment Actions (Continued)	Physical/ Chemical Treatment (Continued)	Sedimentation	• Effective for removing suspended solids and precipitated materials from wastewater • Performance depends on density and particle size of the solids; effective charge on the suspended particles; types of chemicals used in pretreatment; surface loading; upflow rate; and reinjection time • Feasible for large volumes of water to be treated	• Sedimentation tanks demonstrated and proven successful at hazardous waste sites • Effluent streams include the effluent water, scum, and settled solids	Moderate capital; moderate O&M	Retained
	In Situ Treatment	Air Sparging	• Site geologic conditions are not favorable • A reduction in groundwater VOCs levels is anticipated • Shallow groundwater water table is high (3-5 ft-bgs) and deep aquifer is located beneath a semi-confining layer making capture of vapors difficult	• Emerging technology • Equipment and materials should be readily available • Pilot test required • May reduce the remediation time	Low to moderate capital; low to moderate O&M	Eliminated
		Natural Attenuation	• Effectively detects contaminant increases and decreases so that exposure can be avoided • The existence of PCE, TCE, DCE, and VC, as well as other indicator parameters (e.g., methane) suggests that natural attenuation is occurring • Natural attenuation processes have demonstrated effective reduction of various chlorinated solvents over time	• Easily implemented • Minimal mechanical equipment required • Requries long-term monitoring of groundwater	• Low to moderate capital • Moderate O&M	Retained because of its effectiveness and implementability

TABLE 3-6 (Continued)

SUMMARY OF GROUNDWATER PROCESS EVALUATION
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
Treatment Actions (Continued)	Attenuation (Continued)	In-Well Aeration (In Situ Air Stripping)	• Pilot tests demonstrated some VOC contaminant reduction, but mainly within a short distance from the treatment unit • Technology should decrease VOC levels	• Site geologic/ hydrogeologic conditions may impact movement of VOCs toward the treatment unit • Electrical power outages have caused system disruptions during the TS • Access to Site 69 area of concern should not be a great problem	Low to moderate capital; low O&M	Retained
		Dual-Phase Vacuum Extraction	• Site geologic conditions appear to be favorable in shallow aquifer • Should enhance groundwater removal and stripping of VOCs	• Emerging technology • Equipment and materials should be readily available • Pilot test required • May reduce the remediation time	Low to moderate capital; low to moderate O&M	Retained
Discharge Actions	On-Site Discharge	Reinjection - Injection Wells	• Injection wells effectiveness is highly dependent on site geology • Wells tend to clog in time • Potential exposures during implementation	• Easily installed • Equipment readily available • No permits required • Require pilot test • Significant maintenance	Moderate capital; moderate O&M	Eliminated
	Off-Site Discharge	Pipeline to River	• Effective and reliable discharge method	• Need State approval • Distance to New River from operable unit is favorable for Site 69 (0.25 miles)	Moderate capital; low O&M	Retained

TABLE 3-7

SUMMARY OF SOIL PROCESS OPTION EVALUATIONS
FEASIBILITY STUDY CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

General Response Action	Remedial Action Technology	Process Option	Evaluation			Evaluation Results
			Effectiveness	Implementability	Cost	
No Action	No Action	Not Applicable	Evaluation not necessary since only one process option	Evaluation not necessary since only one process option	No capital; low O&M	Retained
Institutional Controls	Monitoring	Monitoring	Useful to evaluate site conditions over time	Regulatory agencies should receive annual sampling reports	No capital; low O&M	Retained
	Access Restrictions	Restrictions in Base Master Plan	• Does not provide treatment of soil • No exposures during implementation • Effectiveness dependent on continued future implementation	• Easily implemented • Legal requirements	Negligible cost	Retained
		Fencing	• Does not meet remediation goals alone • Minimal to low exposures during implementation	• Easily implemented • No legal requirements	Low capital, Low O&M	Retained
Excavation/ Treatment Actions (Cont)	In Situ Treatment	Biodegradation	• More suited to nonchlorinated organic contaminants and may not meet VOC remediation goals • Treatment can be inconsistent due to variations in biological activity	• Elevated VOCs may be toxic to microorganisms • Requires treatability studies • Dependent upon site hydrogeology (clay soil content at Site 69 may prohibit degradation)	Moderate capital; Moderate O&M	Eliminated
		Vapor Extraction (single phase)	• Site geological conditions are not favorable. Shallow groundwater table is high (3-5 ft. bgs) • Applicable to VOCs	• Equipment readily available • Easy to install (vapor extraction wells) • Dependent upon site geology • Pilot studies required	Low capital; Low to Moderate O&M	Eliminated

TABLE 3-8

FINAL SET OF POTENTIAL REMEDIAL ACTION TECHNOLOGIES
AND PROCESS OPTIONS
FEASIBILITY STUDY, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Media	General Response Action	Remedial Action Technology	Process Option
Groundwater	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Groundwater
		Aquifer-Use Restrictions	Restrictions in Base Master Plan
	Collection Actions	Extraction	Extraction Wells
			Interceptor Trenches
	Discharge Actions	Off-Site Discharge	New River
	Treatment Actions	Physical/Chemical Treatment	Air Stripping
			Carbon Adsorption
			Chemical Oxidation
			Electrochemical Iron Generation
			Neutralization
			Precipitation
			Filtration
			Sedimentation
			Flocculation
			Ion Exchange
		In Situ Treatment	Dual-Phase Vacuum Extraction
			Natural Attenuation
			In Situ Air Stripping
Soil	No Action	No Action	Not Applicable
	Institutional Controls	Monitoring	Monitoring
		Access Restrictions	Restrictions in Base Master Plan
			Fencing

4.0 DETAILED ANALYSIS OF SITE 69 REMEDIAL ALTERNATIVES

4.1 Soil (SO) Alternatives

Site 69 soil (SO) (including buried waste) alternatives were developed based on the remedial action objectives (RAOs) and general response actions identified in Section 2.0 as well as on the remedial technologies and representative process options retained for further consideration in Section 3.0. As shown in Table 2-11, the RAOs for the soil and waste (landfilled material) at this site are as follows:

1. Prevent future potential exposure to buried contaminated soil and waste.
2. Prevent potential migration of contaminants to groundwater.

Information concerning subsurface soil contamination and buried waste materials is limited. Subsurface soil samples were only collected from six soil borings associated with monitoring well installation. The subsurface investigation was limited because of the potential for chemical agents (e.g., nerve, blood, and blistering agents) to be present within the landfill.

Although a capping alternative is often considered for former landfill sites, a capping alternative was not developed for this site because of implementability and effectiveness concerns. Results of the human health risk assessment indicate that the surface soils currently do not pose an unacceptable risk to base personnel. Therefore, a cap is not necessary to eliminate contact with the surface soil. As indicated in Tables 3-3 and 3-4 in Section 3.3, installation of a low-permeability cap would require extensive clearing, grubbing, and regrading activities that would disturb the landfill contents. Since the landfill may contain Chemical Warfare Materiel (CWM) and other hazardous wastes, implementation of a cap would pose a significant risk to human health and the environment during construction. Furthermore, the waste materials are not underlain by a continuous low-permeability liner, and the water table is very close to the ground surface. These conditions would limit the ability of cap to protect groundwater. Any contaminants present in the landfill could continue to leach to groundwater even after the cap is installed. For these reasons, capping technologies were eliminated from further consideration in Section 3.3.

Because of the hazardous nature of the landfill contents, only in situ technologies are considered feasible for remediation of contaminated soils within the landfill. As discussed in Section 3.0, dual-phase vacuum extraction (DPVE) is considered to be the most feasible technology for remediation of the vadose zone because of the shallow water table on site (2 to 4 feet below ground surface). Since the DPVE system is also designed to remediate shallow groundwater and is integrated with a groundwater treatment system, remediation of the soil via DPVE technology is included under Alternative 69GW-4 in Section 4.2.4.

The soil remedial alternatives developed for Site 69 and evaluated in Sections 4.2.1 and 4.2.2 are listed below:

- Alternative 69SO-1 - No Action
- Alternative 69SO-2 - Institutional Controls

A comparison of these soil alternatives is presented in Section 4.2.3.

4.1.1 Alternative 69SO-1 - No Action

Description: The No Action Alternative is required by the NCP to provide a baseline comparison for other remediation alternatives. Under the No Action Alternative, no remedial action would be performed to reduce the toxicity, mobility, or volume of soil contamination or waste at Site 69, which was used for chemical waste disposal from 1950 to 1976.

Overall Protection: Since no actions would be taken, exposure pathways would be unaffected by this alternative. During its operation, the site received a variety of waste materials including polychlorinated biphenyls (PCBs), solvents, pesticides, calcium hypochlorite, high-test hypochlorite (HTH), chemical agent training and test kits for chemical warfare, and possible drums of chemical surety agents, such as mustard gas.

Waste materials that may be present within the landfill, such as the chemical training agents, pose a potential risk with respect to direct exposures resulting from disturbances to the buried materials. The site is currently not used for residential purposes, and there are no plans to convert the area to residential use. However, there is currently no official land use category for the site designated in the Base Master Plan.

There are no construction activities planned for this area. However, there are also currently no official institutional controls in place to prohibit potential construction activities from occurring at the site in the future. Thus, under this alternative, the risk of future invasive construction activities occurring at the site (by a work crew unfamiliar with the potential landfill contents) would not be reduced, and RAO Number 1 for this site would not be achieved.

Based on the results of the groundwater investigations, chlorinated solvents, particularly trichloroethene (TCE), 1,2-dichloroethene (DCE), and vinyl chloride, are major contaminants of concern with respect to leaching from the subsurface soils to groundwater. The results of the groundwater investigation suggest that a source of volatile organic contamination is present at the site. This alternative would not provide any protection against further migration of volatile organic compounds (VOCs) within the landfill to groundwater. Thus, RAO Number 2 would not be achieved by this alternative.

Compliance with ARARs: State and federal contaminant-specific ARARs are not available for soils. Furthermore, there are no location- or action-specific ARARs associated with this alternative since no remedial actions would be taken.

Long-term Effectiveness and Permanence: There would be no remedial action taken under this alternative. Results of the baseline risk assessment indicate that no unacceptable adverse health effects would be expected from exposure to the surface soils at Site 69 under current military, future residential, and future construction use scenarios. Results of the baseline risk assessment also indicate that no unacceptable adverse health effects would be expected from exposure to the subsurface soils at Site 69 under a future construction use scenarios. However, the potential still exists for waste materials and chemical training agents to be present within the landfill, which pose a potential risk to any personnel involved with invasive construction activities at the site. Hence, this alternative would not provide a permanent, long-term remedy with respect to attainment of RAO Number 1.

There would be no remedial action taken under this alternative to prevent leaching of contaminants to groundwater (RAO Number 2).

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of contaminants in the soils through active treatment. For any contamination sorbed to soil particles, there may be a gradual reduction in toxicity and volume of contamination in the long term through natural processes, such as volatilization and dispersion (i.e., leaching). However, mobile contaminants in the soils, namely the chlorinated VOCs, would continue to migrate vertically to the underlying groundwater.

Short-term Effectiveness: This alternative would not involve remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: There would be no implementability concerns associated with this alternative since no actions would be taken.

Cost: There are no costs associated with this alternative.

4.1.2 Alternative 69SO-2 - Institutional Controls

Description: Under this alternative, institutional controls would be implemented to limit access and control future use of the site, which was used for chemical waste disposal from 1950 to 1976. These institutional controls would consist of maintenance of an existing fence and designation of the area as a restricted, or limited-use area. No remedial action would be performed to reduce the toxicity, mobility, or volume of soil contamination or waste at the site.

Under this alternative, the existing 6-foot high chain-link fence encompassing the site would be maintained to restrict site access. In addition, several warning signs would be posted along the fence to indicate that wastes are buried at the site and that construction activities are prohibited within the fenced area.

The site is currently not used for residential purposes, and there are no plans to convert the area to residential use. However, there is currently no official land use category for the site designated in the Base Master Plan. Under this alternative, the site would be given a land use category in the Base Master Plan that would prohibit residential use of the area as well as invasive construction activities.

Overall Protection: Based on the results of the groundwater investigations, chlorinated solvents, particularly trichloroethene (TCE), 1,2-dichloroethene (DCE), and vinyl chloride, are major contaminants of concern with respect to leaching from the subsurface soils to groundwater. The results of the groundwater investigation suggest that a source of volatile organic contamination may be present at the site. This alternative would not provide any protection against further migration of volatile organic compounds (VOCs) within the landfill to groundwater. Thus, RAO Number 2 would not be achieved by this alternative.

Compliance with ARARs: State and federal contaminant-specific ARARs are not available for soils. Furthermore, there are no location- or action-specific ARARs associated with this alternative since no remedial actions would be taken.

Long-term Effectiveness and Permanence: There would be no remedial action taken under this alternative. Results of the baseline risk assessment indicate that no unacceptable adverse health effects would be expected from exposure to the surface soils at Site 69 under current military, future

residential, and future construction use scenarios. Results of the baseline risk assessment also indicate that no unacceptable adverse health effects would be expected from exposure to the subsurface soils at Site 69 under a future construction use scenarios. However, the potential still exists for waste materials and chemical training agents to be present within the landfill, which pose a potential risk to any personnel involved with invasive construction activities at the site. With respect to attainment of RAO Number 1, this alternative would provide a permanent, long-term solution through maintenance of the existing perimeter fence and installation of warning signs as well as strict enforcement of the revised Base Master Plan.

There would be no remedial action taken under this alternative to prevent leaching of contaminants to groundwater (RAO Number 2).

Reduction of Toxicity, Mobility, or Volume: This alternative would not reduce the toxicity, mobility, or volume of contaminants in the soils through active treatment. For any contamination sorbed to soil particles, there may be a gradual reduction in toxicity and volume of contamination in the long term through natural processes, such as volatilization and dispersion (i.e., leaching). However, mobile contaminants in the soils, namely the chlorinated VOCs, would continue to migrate vertically to the underlying groundwater.

Short-term Effectiveness: This alternative would not involve any remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: This alternative would be both technically and administratively straightforward to implement. Appropriate access restrictions and land use designations could be readily incorporated into the Base Master Plan.

Periodic (e.g., annual) inspection and maintenance of the fencing would be required under this alternative.

Cost: The estimated costs of this alternative are as follows:

- Capital: $0
- Annual operation and maintenance: $900
- Net present worth (30-year): $13,800

4.1.3 Comparison of Site 69 Soil Alternatives

The soil alternative comparison for Site 69, based on the seven criteria, is provided in the following sections.

Overall Protection: The potential exists for waste materials and chemical training agents to be present within the landfill. Alternative 69SO-1 would not reduce the risk of future invasive construction activities occurring at the site (by a work crew unfamiliar with the potential landfill contents), whereas Alternative 69SO-2 would reduce this risk through the use of institutional controls. Thus, only Alternative 69SO-2 would achieve RAO Number 1 for soil and waste at this site.

Neither Alternative 69SO-1 nor 69SO-2 would prevent migration of contaminants to groundwater (RAO Number 2).

Compliance with ARARs: There are no State or federal contaminant-, location-, or action-specific ARARs associated with Alternatives 69SO-1 and 69SO-2 since no remedial actions would be taken under either alternative.

Long-term Effectiveness and Permanence: With respect to attainment of RAO Number 1, only Alternative 69SO-1 would provide a permanent, long-term solution through maintenance of the perimeter fence, installation of warning signs, and revisions to the Base Master Plan to restrict site access, prohibit future invasive construction activities, and limit the area to non-residential uses.

Neither Alternative 69SO-1 nor 69SO-2 would provide a long-term, permanent solution with respect to protection of groundwater (RAO Number 2).

Reduction of Toxicity, Mobility, or Volume: Neither Alternative 69SO-1 nor 69SO-2 would reduce the toxicity, mobility, or volume of contaminants in the soils through active treatment.

Short-term Effectiveness: Neither Alternative 69SO-1 nor 69SO-2 would involve any remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: There would be no implementability concerns associated with Alternative 69SO-1, since no actions would be taken. Alternative 69SO-2 would be both technically and administratively straightforward to implement. Periodic (e.g., annual) inspection and maintenance of the fencing would be required under this alternative.

Cost: There are no costs associated with Alternative 69SO-1. The estimated 30-year present worth cost of Alternative 69SO-2 is $13,800.

4.2 Site 69 Groundwater (GW) Alternatives

Groundwater (GW) (including associated surface water and sediments) alternatives were developed based on the RAOs and general response actions identified in Section 2.0 as well as on the remedial technologies and representative process options retained for further consideration in Section 3.0. As shown in Table 2-11, the RAOs for the groundwater at this site are as follows:

1. Prevent future potential exposure to contaminated groundwater.
2. Protect uncontaminated groundwater for future potential beneficial use.
3. Restore contaminated groundwater for future potential beneficial use.

The groundwater remedial alternatives developed for Site 69 and evaluated in Sections 4.2.1 through 4.2.5 are listed below:

- Alternative 69GW-1 - No Action
- Alternative 69GW-2 - Institutional Controls and Natural Attenuation
- Alternative 69GW-3 - Groundwater Extraction and Physical Treatment with Institutional Controls and Monitoring
- Alternative 69GW-4 - Dual-Phase Vacuum Extraction with Groundwater Extraction and Physical Treatment, Institutional Controls and Monitoring

- Alternative 69GW-5 - In Situ Air Stripping with Institutional Controls and Monitoring

As noted in Section 4.1, remediation of the soil via dual-phase vacuum extraction (DPVE) technology is included under Alternative 69GW-4. In terms of remediation strategy, Alternatives 69GW-3 and 69GW-5 were developed to provide relatively passive groundwater remediation/containment options with low capital and operating costs, whereas, Alternative 69GW-4 was designed to provide a more aggressive groundwater/soil remediation system with a higher capital and operating cost but potentially shorter treatment time.

A comparison of the five groundwater alternatives is presented in Section 4.2.6.

4.2.1 Alternative 69GW-1 - No Action

Description: Under this alternative, no actions would be taken to contain or treat contaminated groundwater at Site 69.

With respect to the key risk contributors, groundwater contamination generally consists of chlorinated solvents, particularly trichloroethene (TCE), 1,2-dichloroethene (DCE), and vinyl chloride. The extent of VOC contamination is shown in Figures 1-3 through 1-8. The results of the groundwater investigation suggest that a source of volatile organic contamination is present at the site, and that there is a potential risk of leaching of the VOCs from the subsurface soils to groundwater.

Shallow groundwater generally flows radially from the center of the site, whereas deeper groundwater in the Castle Hayne Aquifer flows in a general easterly direction towards the New River. Groundwater on site currently is not used for any purpose. Potable water throughout the Base is supplied by wells located in the mid and lower regions of the Castle Hayne Aquifer. The shallow aquifer is not used as a potable water supply on Base. However, both the shallow and upper Castle Hayne Aquifers are classified as GA waters under the North Carolina Water Quality Standards (NCWQS), which are current or potential sources of drinking water. There are no groundwater production wells located downgradient of the site.

Overall Protection: Exposure pathways would be unaffected by the implementation of this alternative. This alternative would not actively restore contaminated groundwater to drinking water standards through extraction and treatment. Contaminated groundwater would be allowed to migrate. Because the maximum concentration of 1,2-DCE greatly exceeded its NCWQS value (i.e., 2,400 μg/L compared to 70 μg/L), it is unlikely that the groundwater would eventually decrease below the NCWQS through natural processes, such as dilution and dispersion. In fact, groundwater contaminant concentrations could potentially increase over time if a substantial contaminant source is still present in the subsurface soil.

With respect to achievement of RAOs, this alternative would not prevent future potential exposure to contaminated groundwater (RAO Number 1), protect uncontaminated groundwater (RAO Number 2), or restore contaminated groundwater for future potential beneficial use (RAO Number 3).

Compliance with ARARs: Contaminated groundwater exceeds federal Maximum Contaminant Levels (MCLs) established pursuant to the Safe Drinking Water Act (SDWA) and the NCWQS for the VOCs of concern. There are no location- or action-specific ARARs associated with this alternative.

Long-term Effectiveness and Permanence: This alternative would not attain the RAOs and would not provide a permanent, long-term solution for the site. If the groundwater in the shallow or deep aquifers at the site were to be used for drinking water purposes, the total incremental cancer risk associated with potable use would exceed 1×10^{-4} by a factor of six, and the hazard index would exceed 1 by about an order of magnitude. These risk estimates are based on the assumption that an individual would be exposed (i.e., through ingestion) over a 30-year period to the contaminant concentrations detected in the aquifers.

Reduction of Toxicity, Mobility, or Volume: No reduction of toxicity, mobility, or volume would be provided by this alternative. The toxicity of contaminated groundwater may be reduced over time through natural dilution and dispersion, depending on the nature and extent of the contaminant source(s). However, based on the groundwater investigation results, there could potentially be a significant source of solvent contamination within the landfill.

Short-term Effectiveness: This alternative would not involve remedial actions that would pose a risk to human health or the environment during implementation.

Implementability: There would be no implementability concerns associated with this alternative since no actions would be taken.

Cost: There are no costs associated with this alternative.

4.2.2 Alternative 69GW-2 - Institutional Controls and Natural Attenuation

Under this alternative, a long-term groundwater monitoring program, along with aquifer use restrictions, will be implemented as institutional controls. In addition, remedial actions associated with the in-situ, naturally occurring biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization/destruction of the VOCs in groundwater are expected in the form of natural attenuation. "Natural attenuation" refers to the "naturally occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in these media" (Weidemeier, 1995).

The purpose of the groundwater monitoring program is to track the groundwater contaminated plume's migration over time, to evaluate any fluctuations in COC levels in the groundwater, and to identify the amount of contaminant reduction that has occurred through time. For cost estimating purposes, 5 years of quarterly sampling, followed by 25 years of semiannual sampling will be assumed. In turn, the cost estimate for this alternative also incorporates the reduction of analytical costs by 50 percent starting in the sixth year of the program.

For costing purposes, a total of 24 wells have been preliminarily identified for inclusion in the long-term monitoring program, although this number may change during the program, as required, based on additional information. As shown on Figure 4-1, the wells will monitor: the shallow aquifer; and the upper zone, intermediate zone, deep zone, and bottom portion of the Castle Hayne Aquifer. The wells are also positioned to evaluate the source area (near well clusters GW15 and GW17), upgradient areas, and downgradient areas (including offsite). All wells will be analyzed for VOCs.

The source of contaminants will not be removed from Site 69 due to U. S. Army policy regarding CWM. This policy states that CWM should not be disturbed or removed unless there is potential for impacts to the public health or safety. Under current conditions, buried CWM is not posing an imminent health risk. A waiver may be required to implement this alternative because the potential source will remain in place.

For purposes of evaluating the effectiveness of natural attenuation, groundwater samples will also include laboratory analyses of the following parameters: nitrate, sulfate, methane, ethane, ethene, and chloride. Field analyses will be conducted on groundwater samples to determine the levels of oxygen, iron II, alkalinity, oxidation-reduction potential (ORP), pH, temperature, conductivity, major cations, and hydrogen. The natural attenuation parameters (both the laboratory and field parameters) are identified and described in more detail on Table 4-1. Over time, the results will be used to predict the kind and amount of contaminant reduction that has occurred, as well as, the amount of contaminant reduction that is expected.

As previously mentioned, additional monitoring wells may be added to the program, if necessary. Likewise, if the analytical results indicate that the groundwater quality has improved, the monitoring program may be refined to include fewer sampling locations or less frequent sampling events. Under this alternative, a Long-Term Monitoring Program will be developed.

Biodegradation may occur as an aerobic, anaerobic, or cometabolic process. Aerobic processes involve oxidation-reduction reactions in which oxygen is the electron receptor. Anaerobic processes involve iron-reducing, denitrifying, and sulfate-reducing reactions. Cometabolic processes involve carbon dioxide-reducing reactions and result in the accumulation of methane as a final product. Technical literature indicates that chlorinated solvent contamination can undergo natural attenuation through one or a combination of these biodegradation processes. At Site 69, the following evidence suggests that natural attenuation processes are successfully degrading the chlorinated solvent contamination in the surficial and intermediate aquifers:

- PCE, TCE, and DCE have all been detected within the estimated boundary of contaminated groundwater at Site 69. In addition, the detection of vinyl chloride (VC) at Site 69 further documents the degradation process.

- The locations and concentrations of the chlorinated compounds within each well are positioned as to suggest that the daughter products detected are the direct result of the VOC degradation. Figures 1-3 through 1-8 depict the breakdown products and show that contaminant levels decrease as the plume extends from the source area.

Based upon this information, the natural attenuation alternative appears to be a justifiable remedial option for the chlorinated solvent contamination detected in the surficial and intermediate aquifers. In an effort to provide additional evidence that natural attenuation is occurring, RAA 2 incorporates the option of performing a contaminant fate and transport model. The cost estimate accounts for annual modeling, as new results become available.

In addition, the Base Master Plan will provide restrictions on the use of the site.

Until RLs are met, the NCP [40 CFR 300.430(f)(4)] requires the lead agency to review the effects of this alternative no less often than once every five years.

Overall Protection of Human Health and the Environment: Under this alternative, contaminants in the surficial and Castle Hayne Aquifers will remain. However, very little offsite contamination has been detected and the vertical extent of contamination is limited to the source area only. Although the results of the human health risk assessment indicate that the chlorinated solvent contaminants within the groundwater may pose potential risks to future residents via the ingestion of groundwater, institutional controls should eliminate/restrict the use of the site. In addition, the location and former uses associated with Site 69 make the site an unlikely candidate for future residential development.

Current technical literature indicates that chlorinated solvents are capable of naturally attenuating, provided the appropriate conditions are present at the site. The groundwater contamination at Site 69 appears to be naturally attenuating as PCE, TCE, DCE, and VC have been detected. Thus, the contamination in the groundwater is expected to naturally attenuate over time.

Based on this information, additional physical groundwater treatment may not be necessary to provide a justifiable solution for the groundwater contamination. This alternative ensures the protection of human health and the environment through the combination of natural attenuation, monitoring, and land use restrictions. Thus, this alternative will mitigate the potential for direct exposure and provide overall protection of human health and the environment.

Compliance With ARARs: Under this alternative, no physical effort will be made to enhance or reduce contaminant concentrations to levels below chemical-specific ARARs. Natural attenuation processes; however, are expected to eventually achieve these ARARs. Thus, this alternative offers the potential to remediate the groundwater over an extended period of time. The North Carolina Recordation of Inactive Hazardous Substances or Waste Disposal Site Statute (a location-specific ARAR) may apply to Site 69 because of its history as a disposal site. A State waiver will be required to comply with the OSWER Directive regarding monitored natural attenuation because the potential source of contaminations will not be removed.

Long-Term Effectiveness and Permanence: Allowing the groundwater to naturally attenuate is a justifiable solution because the potential human health and ecological risks appear to be insignificant at present and minimal in the future; and the data collected to date documents that chlorinated solvent contamination appears to be naturally attenuating. Through monitoring and aquifer use restrictions, Alternative 69-GW2 provides a means for monitoring contaminant concentrations over time, prohibiting future potable use of the surficial and intermediate aquifers, and proving that natural attenuation is indeed occurring. As a result, this alternative will ensure the safety of potential receptors over time and will provide long-term effectiveness and permanence.

Under this alternative, 5-year reviews by the lead agency will be required to ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume Through Treatment: Alternative 69-GW02 does not provide additional physical treatment processes; however, some reduction in toxicity, mobility, and volume through natural attenuation is anticipated. Thus, this alternative satisfies the statutory preference for treatment.

Short-Term Effectiveness: The only activities that may increase risks to the workers include periodic groundwater sampling. However, proper material handling procedures and appropriate personal protective equipment should sufficiently protect the workers against these risks. RAA 2 will not create any additional environmental impacts. The time required for the action to be complete is unknown, but 30 years of monitoring was assumed for cost estimating purposes.

Implementability: This alternative is a technically implementable alternative since groundwater monitoring and restrictions in the Base Master Plan have been easily implemented in the past. If water quality appears to be deteriorating, additional remedial actions could easily be implemented or incorporated under Alternative 69-GW02.

In terms of administrative feasibility, this alternative will not require additional coordination with other agencies. However, semiannual reports must be submitted to document sampling procedures. All required services, materials, and/or technologies should be readily available.

Cost: The are not capital costs associated with this alternative. The projected annual O&M costs are approximately $63,000 for quarterly sampling in years 1-5, and $24,000 for semiannual sampling in years 6-30. Assuming an annual percentage rate of 5 percent, the NPW of this alternative is $535,000. Appendix B presents the cost estimate for Alternative 69-GW02.

4.2.3 Alternative 69GW-3 - Groundwater Extraction and Physical Treatment, Institutional Controls, and Monitoring

Groundwater Extraction and Treatment

Under this alternative, a groundwater extraction, treatment, and discharge system would be constructed for the shallow and upper Castle Hayne Aquifers, and operated on site.

The groundwater extraction system would be used to extract and contain groundwater contaminated above the cleanup goals developed for the shallow and upper Castle Hayne Aquifers (i.e., NCWQS), as discussed in Section 2.0. If possible, the system would be operated until groundwater cleanup goals are achieved. However, these levels may be impossible to achieve since it has been demonstrated that groundwater contaminant levels typically reach asymptotic levels, which may exceed NCWQS. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached, which exceed NCWQS for some contaminants, then the cleanup goals would be re-evaluated at that time.

Groundwater would be pumped using a series of downgradient well pairs located near the downgradient edge of the contaminant plume and a well pair located near the plume center. Each well pair would consist of a shallow well (approximately 25 feet deep) and an upper Castle Hayne well (approximately 60 feet deep). All pumping wells would be connected to a common header pipe that discharges to a common treatment system.

The conceptual pumping well arrangement, shown in Figure 4-2, includes four upper Castle Hayne extraction wells each pumping at 19 gpm and four new shallow extraction wells with flow rates of approximately 3 gpm.

The downgradient set of extraction wells was developed based on the pumping rate necessary to contain the plume, the number of wells needed to achieve the pumping rate, and the optimum spacing between the wells to capture the groundwater. The design of this portion of the extraction system is basically a containment-type system, designed to contain contaminated groundwater rather than attempt to aggressively restore it to the cleanup goals. With this approach, the groundwater is extracted at a rate equal to the natural flow through the contaminated portion of the shallow and upper Castle Hayne Aquifers. It has been estimated that a flow rate of 66 gpm would be required to contain the current extent of contamination in the shallow and upper Castle Hayne Aquifers.

In addition to capturing groundwater near the downgradient edge of the plume, the groundwater collection system was also designed to pump water from the immediate source area to prevent the spread of the highly contaminated groundwater. An extraction rate of 22 gpm was estimated for this area (one shallow well pumping at 3 gpm and one Castle Hayne well pumping at 19 gpm). Hence, the total flowrate for the conceptual extraction system is 88 gpm.

The groundwater treatment system included under this alternative has been sized to accommodate a total flowrate of 100 gpm. However, during a remedial design phase, additional capacity for potential future increases in groundwater flowrates could be designed into the system.

The conceptual groundwater treatment system used for costing purposes for Site 69 is presented in Figure 4-3. The actual treatment components would be determined during the remedial design phase. The primary component of the groundwater treatment system would consist of air stripping for the removal of volatile organic contaminants. Based on the State of North Carolina's regulations for groundwater treatment using air strippers (15 NCAC 2D.0518), contaminated air generated by the air stripper would not require treatment.

Based on available data and experience at other MCB Camp Lejeune sites, it appears that a pretreatment system may be needed for the removal of suspended solids and nuisance metals from groundwater, such as iron and manganese, to prevent fouling (clogging) of the air stripper. An acid (e.g., sulfuric acid) or sequesterant (e.g., polyphosphate chemicals) addition system would be included in the system with only a modest increase in capital and operating cost, which would help keep dissolved iron and manganese in solution. With this type of system, a low-profile air stripper would be desirable because, if necessary, it could be disassembled and cleaned periodically much easier than could a packed tower.

If a more aggressive pretreatment system is needed for the removal of suspended solids and nuisance metals from groundwater, capital and operating costs would increase by more than twofold. In this case, the pretreatment could consist of equalization, flocculation/precipitation, clarification, filtration, and sludge dewatering.

A low-profile air stripper with sequesterant addition system was assumed for costing purposes. This type of system would be mounted on a concrete pad. If a more sophisticated metals removal system is required, then construction of a building to house the treatment system would likely be required. A groundwater treatment pilot test, approximately one month in duration, would enable the need for metals pretreatment to be better assessed.

Construction of the groundwater extraction and treatment system would require improvement of the access road to the site. This would involve construction of approximately 9,000 feet of 12-foot wide gravel road. In addition, an electrical power line would need to be installed along this road to provide power for the system.

The treated groundwater would be discharged to the New River, which is located approximately 1,200 feet from the site. The estimated influent concentrations, effluent standards, and percent removals required to meet the effluent standards for the primary contaminants of concern are shown in Table 4-2. Influent concentrations were estimated using a flow-weighted average of the maximum contaminant concentrations detected in the shallow and upper Caste Hayne Aquifers. As shown in Table 4-2, removal of only 1,2-DCE (99 percent removal) and TCE (81 percent removal) from the groundwater would be required to meet the effluent standards.

Groundwater Monitoring

Under this alternative, a groundwater sampling program would be initiated for the site. The groundwater sampling program would incorporate the periodic sampling of existing groundwater monitoring wells. Wells in the path of the contaminated groundwater would be sampled as well as

several downgradient wells. For costing purposes, it was assumed that, on average, eight monitoring wells would be periodically sampled (e.g., four per aquifer). Initially, groundwater sampling would be conducted on a semi-annual basis (i.e., two times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to an annual basis. However, for costing purposes, it was assumed that semi-annual sampling would be conducted for a 30-year period.

Institutional Controls

In addition to the environmental monitoring program, institutional controls would be implemented under this alternative to restrict groundwater usage in the vicinity of the site. Groundwater is currently not being used in the vicinity of the site, and there are no plans to for installing any supply wells in the area. However, there is currently no official land use designation for the site in the Base Master Plan. Under this alternative, the site would be given land use restrictions in the Base Master Plan that would prohibit installation of potable water supply wells in the vicinity of the site (e.g., within a 1,000-foot radius).

Overall Protection: The intent of this alternative is to contain the groundwater contaminated above the groundwater cleanup goals until these goals are achieved. Thus, this alternative is also intended to eventually restore the contaminated groundwater to cleanup goals. Any groundwater located downgradient of the extraction system, or outside of its capture zone, that is contaminated below groundwater cleanup goals would be allowed to migrate. Contamination concentrations in this downgradient area would gradually decrease through natural dilution and dispersion. The groundwater monitoring program would be used to verify that contaminant concentrations are decreasing.

Among other factors, the time to achieve groundwater cleanup goals is dependent on the nature and extent of the source, which is difficult to characterize within a landfill. Therefore, the time to achieve the cleanup goals cannot accurately be predicted at this time. It is possible that cleanup goals could require 10 to 20 years, or longer, to achieve. Furthermore, it may be impossible to achieve NCWQS since it has been demonstrated that groundwater contaminant concentrations typically reach asymptotic levels, which may exceed NCWQS. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached, which exceed NCWQS for some contaminants, then the cleanup goals would be re-evaluated at that time.

With respect to achievement of RAOs, this alternative would prevent future potential exposure to contaminated groundwater through institutional controls and monitoring (RAO Number 1). This alternative would also protect uncontaminated groundwater (RAO Number 2), and would attempt to restore contaminated groundwater for future potential beneficial use (RAO Number 3). The groundwater monitoring program would be used to assess whether or not contaminant concentrations are decreasing.

Compliance with ARARs: Contaminated groundwater exceeds federal Maximum Contaminant Levels (MCLs) established pursuant to the Safe Drinking Water Act (SDWA) and the NCWQS for the VOCs of concern. The intent of this alternative is to restore groundwater in the shallow and upper Castle Hayne Aquifers to their beneficial use through extraction and treatment, at which point the groundwater levels would be in compliance with MCLs and NCWQS.

Construction activities and groundwater discharge would need to comply with the following location-specific ARARs:

- Fish and Wildlife Coordination Act
- Federal Endangered Species Act
- North Carolina Endangered Species Act
- Executive Order 11990 on Protection of Wetlands
- Executive Order 11988 on Floodplain Management

Because of the history of Site 69 as a disposal site, the North Carolina Recordation of Inactive Hazardous Substance or Waste Disposal Site Statute (a location-specific ARAR) may also be considered an ARAR.

Treated groundwater resulting from groundwater treatment would comply with all pertinent local, state, and federal location- and action-specific ARARs before being discharged to the environment. Specifically, discharge of treated groundwater to the New River would require compliance with the substantive requirements of the North Carolina Water Pollution Control Regulations (Title 15, Chapter 2, Section 0100). Excavation activities would require compliance with the North Carolina Sedimentation Pollution Control Act of 1973 (Chapter 113A), which regulates stormwater management and erosion/sedimentation control practices.

Long-term Effectiveness and Permanence: This alternative would attain RAO Number 1 since periodic environmental sampling is a reliable means of tracking contaminant migration, and potential unacceptable risks associated with groundwater use would be permanently mitigated through provision and enforcement of institutional controls.

With respect to RAO Numbers 2 and 3, the intent of this alternative is to provide a permanent, long-term solution for the site. The proposed groundwater extraction and treatment system would prevent groundwater contaminated above the cleanup goals from migrating downgradient (RAO Number 2). Periodic groundwater sampling of monitoring wells is a reliable means of tracking contaminant migration and for verifying that contaminated groundwater is effectively being contained by the extraction and treatment system. Incremental cancer risks and hazard indices associated with potable use of groundwater would be within acceptable levels following groundwater restoration to the cleanup levels (RAO Number 3).

The USEPA 5-year site review would be required to evaluate monitoring results and ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume: The volume and toxicity of the contaminated groundwater would be permanently reduced. Air stripping transfers contaminants from the aqueous to the vapor phase where they are eventually oxidized in the atmosphere. Migration of contaminated groundwater (mobility) in the shallow and upper Castle Hayne Aquifers would be contained by the extraction system.

Short-term Effectiveness: During installation of the underground piping, there would be a potential risk to workers associated with digging through waste materials. However, these risks would be minimized through environmental monitoring and health and safety procedures as well as through special monitoring procedures performed by the U.S. Army Technical Escort Unit (TEU).

Another short-term effectiveness concern associated with this alternative is the discharge of air stripper emissions. These emissions would be effectively monitored through sampling and analysis to ensure protection of potential human receptors, such as nearby military personnel involved with training operations.

Implementability: Air stripping and groundwater extraction wells are commonly used technologies for groundwater remediation for treatment of volatile organic contaminants. Equipment and services for these systems are offered by numerous commercial vendors. The most common problem associated with air strippers is clogging and channeling in the packing materials in packed towers and clogging of air diffusers in low-profile diffused aeration strippers. This problem could be minimized by the use of sequesterants, periodic shut-down and cleaning, and if necessary, through installation of a pretreatment system to remove suspended solids and any nuisance metals that may cause clogging.

An environmental monitoring program could be readily implemented at the site. Appropriate land use designations could also be readily incorporated into the Base Master Plan.

Cost: The estimated costs of this alternative are as follows:

- Capital: $1,047,000
- Annual operation and maintenance: $67,700
- Net present worth (30-year): $2,088,000

Detailed cost spreadsheets are provided in Appendix B.

4.2.4 Alternative 69GW-4 - Dual-Phase Vacuum Extraction with Groundwater Extraction and Physical Treatment, Institutional Controls, and Monitoring

Groundwater Extraction System - Upper Castle Hayne Aquifer

A groundwater extraction, treatment, and discharge system would be constructed for the upper Castle Hayne Aquifer and operated on site.

The groundwater extraction system would be used to extract and contain groundwater contaminated above the cleanup goals developed for the upper Castle Hayne Aquifer (i.e., NCWQS), as discussed in Section 2.0. If possible, the system would be operated until groundwater cleanup goals are achieved. However, these levels may be impossible to achieve since it has been demonstrated that groundwater contaminant levels typically reach asymptotic levels, which may exceed NCWQS. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached, which exceed NCWQS for some contaminants, then the cleanup goals would be re-evaluated at that time.

Groundwater would be pumped using a series of downgradient wells located near the downgradient edge of the contaminant plume and a well located near the plume center. Each upper Castle Hayne well would be installed to an approximate 60-foot depth. All pumping wells would be connected to a common header pipe that discharges to a common treatment system.

The conceptual pumping well arrangement, shown in Figure 4-4, includes four upper Castle Hayne extraction wells each pumping at 19 gpm.

The downgradient set of extraction wells was developed based on the pumping rate necessary to contain the plume, the number of wells needed to achieve the pumping rate, and the optimum spacing between the wells to capture the groundwater. The design of this portion of the extraction

system is basically a containment-type system, designed to contain contaminated groundwater rather than attempt to aggressively restore it to the cleanup goals. With this approach, the groundwater is extracted at a rate equal to the natural flow through the contaminated portion of the upper Castle Hayne Aquifer. It has been estimated that a flow rate of 57 gpm would be required to contain the current extent of contamination in the upper Castle Hayne Aquifer.

In addition to capturing groundwater near the downgradient edge of the plume, the groundwater collection system was also designed to pump water from the immediate source area to prevent the spread of the highly contaminated groundwater. An extraction rate of 19 gpm was estimated for this area (one Castle Hayne well pumping 19 gpm). Hence, the total flowrate for the conceptual pumping well extraction system is 76 gpm.

Dual-Phase Vacuum Extraction System - Source Area and Shallow Aquifer

Under this alternative, an area approximately 100 feet by 300 feet (30,000 square feet) of contaminated soil and shallow groundwater would be remediated using a dual-phase vacuum extraction (DPVE) system, which removes contaminated soil gas and shallow groundwater for subsequent treatment.

DPVE is a method to remediate soil and groundwater using only a single extraction system. This method is well-suited for shallow aquifers with low hydraulic conductivities and for sites with high water tables (shallow vadose zones), such as Site 69. The system uses high vacuum, typically greater than 20 inches Hg, to strip the vadose zone of VOCs, while simultaneously removing groundwater (in liquid and vapor form) from the shallow aquifer. Because of this high vacuum, a DPVE well can increase the water yield of a shallow well (less than 20-foot depth) by a factor of two to ten times compared to that of a submersible pump system.

The dual phase vacuum extraction and treatment system would consist of several major components. The extraction system would include the extraction wells (each 20 feet deep) and underground interconnecting well piping. A conceptual DPVE well arrangement is shown in Figure 4-4. As shown in Figure 4-4, three extraction wells and a radius of influence of 50-feet were assumed for costing purposes. Radii of influence can range from about 20 feet to more than 100 feet. In addition, it was assumed that the DPVE system would produce 9 gpm from each extraction well, compared to 3 gpm using a conventional submersible pump. A DPVE pilot test would be required to determine the actual radius of influence (i.e., optimum well spacings) and groundwater yield for Site 69.

The extracted two-phase air-water stream is first sent to an air/water separator. The vapor phase is usually treated using activated carbon, and the water stream is pumped to an on-site facility for treatment and disposal. The two-phase mixing action results in a significant degree (e.g., 90 percent) of VOC stripping within the DPVE system, reducing the treatment system size requirement for the extracted groundwater.

The DPVE treatment system would include the following major components:

- Air/water separator system
- Liquid ring vacuum pump system with associated air/water separator and heat exchanger
- A vapor-phase carbon adsorption system with associated pre-treatment heat exchanger

A schematic of a typical DPVE system is shown in Figure 4-5. The liquid ring vacuum pump system would entrain vapor and liquid from the extraction wells. This two-phase stream would be entrained in the air/water separator and split into a liquid and vapor stream. The liquid would collect in the separator tank and would be pumped to the on-site groundwater treatment system. The equipment for the DPVE treatment system would be located on the concrete pad with the groundwater treatment system.

Separated vapors would continue through the vacuum pump system and would be discharged through the carbon adsorption system. The treated vapor would then be vented to atmosphere. If high VOC concentrations make activated carbon treatment cost-prohibitive, a catalytic oxidation system could be used for off-gas treatment. A DPVE pilot test would be required to determine the actual contaminant concentrations in the extracted groundwater and vapor at Site 69 and other design data, such as air flow rates.

A concern with using the DPVE technology at Site 69 is the potential for chemical warfare agents to exist within the source area. A list of the potential chemical agents and their properties is provided in Table 4-3. As shown in Table 4-3, many of the compounds have low volatilities and, therefore, if extracted, would remain in a liquid, or aqueous phase. However, some of the chemicals, such as hydrogen cyanide, cyanogen chloride, and phosgene, are quite volatile and could be discharged to the atmosphere if present within the landfill. The expected behavior of the various chemical agents upon volatilization, mixing with water, condensation, and heating is currently being evaluated through coordination with the Chemical and Biological Defense Command (CBDC) (formerly USACMDA) and the U.S. Army Chemical Demilitarization and Remediation Activity, which is a branch of the CBDC. The mission of the U.S. Army Chemical Demilitarization and Remediation Activity is to provide oversight over chemical munition destruction. They also perform some destruction of chemicals and remedial actions.

Following this evaluation, a soil boring or test pit program to determine the presence of any of these materials in the source area may be needed prior to implementation of this alternative.

Groundwater monitoring results were used to estimate the remediation source area of concern. Soil cleanup goals were not developed in Section 2.0 since the source area is within a landfill, and the RAOs are based on groundwater protection rather than soil cleanup. In other words, the objective of the soil cleanup is to substantially reduce the source of groundwater contamination and thus the degree of contaminant leaching to groundwater. Hence, the degree of cleanup and achievement of the RAOs would be based on evaluation of actual environmental monitoring results (i.e., via ongoing monitoring of contaminant levels in groundwater and in the extracted vapors from the DPVE system) rather than on attainment of theoretical soil cleanup goals calculated through modeling.

Groundwater Treatment System

The groundwater treatment system included under this alternative has been sized to accommodate a total flowrate of 125 gpm. However, during a remedial design phase, additional capacity for potential future increases in groundwater flowrates could be designed into the system.

Except for size, the conceptual groundwater treatment system used for costing purposes for Site 69 is identical to that included under Alternative 69GW-3 (Figure 4-3). The actual treatment components would be determined during the remedial design phase. The primary component of the groundwater treatment system would consist of air stripping for the removal of volatile organic

contaminants. Based on the State of North Carolina's regulations for groundwater treatment using air strippers (15 NCAC 2D.0518), contaminated air generated by the air stripper would not require treatment.

Based on available data, it appears that a pretreatment system may be needed for the removal of suspended solids and nuisance metals from groundwater, such as iron and manganese, to prevent fouling (clogging) of the air stripper. An acid (e.g., sulfuric acid) or sequesterant (e.g., polyphosphate chemicals) addition system would be included in the system with only a modest increase in capital and operating cost, which would help keep dissolved iron and manganese in solution. With this type of system, a low-profile air stripper would be desirable because, if necessary, it could be disassembled and cleaned periodically much easier than could a packed tower.

If a more aggressive pretreatment system is needed for the removal of suspended solids and nuisance metals from groundwater, capital and operating costs would increase by more than twofold. In this case, the pretreatment could consist of equalization, flocculation/precipitation, clarification, filtration, and sludge dewatering.

A low-profile air stripper with sequesterant addition system was assumed for costing purposes. This type of system would be mounted on a concrete pad. If a more sophisticated metals removal system is required, then construction of a building to house the treatment system would likely be required. A groundwater treatment pilot test, approximately one month in duration, would enable the need for metals pretreatment to be better assessed.

Construction of the groundwater extraction and treatment systems would require improvement of the access road to the site. This would involve construction of approximately 9,000 feet of 12-foot wide gravel road. In addition, an electrical power line would need to be installed along this road to provide power for the system.

The treated groundwater would be discharged to the New River, which is located approximately 1,200 feet from the site. Expected effluent standards are shown in Table 4-1. A pilot test would be needed to predict influent concentrations associated with the DPVE and conventional submersible pumping systems.

Groundwater Monitoring

As with Alternative 69GW-3, a groundwater sampling program would be initiated for the site. The groundwater sampling program would incorporate the periodic sampling of existing groundwater monitoring wells. Wells in the path of the contaminated groundwater would be sampled as well as several downgradient wells. For costing purposes, it was assumed that, on average, eight monitoring wells would be periodically sampled (e.g., four per aquifer). Initially, groundwater sampling would be conducted on a semi-annual basis (i.e., two times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to an annual basis. However, for costing purposes, it was assumed that semi-annual sampling would be conducted for a 30-year period.

Institutional Controls

As with Alternative GW-3, institutional controls would be implemented under this alternative to restrict land usage in the vicinity of the site. Groundwater is currently not being used in the vicinity of the site, and there are no plans to for installing any supply wells in the area. However, there is currently no official land use restrictions for the site in the Base Master Plan. Under this alternative,

the site would be given a land use restriction in the Base Master Plan that would prohibit installation of potable water supply wells in the vicinity of the site (e.g., within a 1,000-foot radius).

Overall Protection: This alternative is intended to aggressively remediate the contaminated groundwater in the shallow aquifer to the cleanup goals as well as to contain the contaminated groundwater in the shallow and upper Castle Hayne Aquifers until these goals are achieved. Any groundwater located downgradient of the extraction system, or outside of its capture zone, that is contaminated below groundwater cleanup goals would be allowed to migrate. Contamination concentrations in this downgradient area would gradually decrease through natural dilution and dispersion. The groundwater monitoring program would be used to verify that contaminant concentrations are decreasing.

Another major objective of this alternative is to remediate any potential VOC contamination in the overlying unsaturated soils that are the source of the groundwater contamination.

Among other factors, the time to achieve groundwater cleanup goals is dependent on the nature and extent of the source, which is difficult to characterize within a landfill. The intent of this alternative is to minimize the treatment time required through active source remediation. However, the time to achieve the cleanup goals cannot accurately be predicted at this time. Even with active source remediation measures, it is possible that cleanup goals could require a very long time to be achieved (e.g., more than 10 years). Furthermore, it may be impossible to achieve NCWQS since it has been demonstrated that groundwater contaminant concentrations typically reach asymptotic levels, which may exceed NCWQS. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached, which exceed NCWQS for some contaminants, then the cleanup goals would be re-evaluated at that time.

With respect to achievement of RAOs, this alternative would prevent future potential exposure to contaminated groundwater through institutional controls and monitoring (RAO Number 1). This alternative would also protect uncontaminated groundwater (RAO Number 2), and would attempt to restore contaminated groundwater for future potential beneficial use (RAO Number 3). The groundwater monitoring program would be used to assess whether or not contaminant concentrations are decreasing.

Compliance with ARARs: Contaminated groundwater exceeds federal Maximum Contaminant Levels (MCLs) established pursuant to the Safe Drinking Water Act (SDWA) and the NCWQS for the VOCs of concern. The intent of this alternative is to restore groundwater in the shallow and upper Castle Hayne Aquifers to their beneficial use through extraction and treatment, at which point the groundwater levels would be in compliance with MCLs and NCWQS.

Construction activities and groundwater discharge would need to comply with the following location-specific ARARs:

- Fish and Wildlife Coordination Act
- Federal Endangered Species Act
- North Carolina Endangered Species Act
- Executive Order 11990 on Protection of Wetlands
- Executive Order 11988 on Floodplain Management

Because of the history of Site 69 as a disposal site, the North Carolina Recordation of Inactive Hazardous Substance or Waste Disposal Site Statute (a location-specific ARAR) may also be considered an ARAR.

Treated groundwater resulting from groundwater treatment would comply with all pertinent local, state, and federal location- and action-specific ARARs before being discharged to the environment. Specifically, discharge of treated groundwater to the New River would require compliance with the substantive requirements of the North Carolina Water Pollution Control Regulations (Title 15, Chapter 2, Section 0100). Excavation activities would require compliance with the North Carolina Sedimentation Pollution Control Act of 1973 (Chapter 113A), which regulates stormwater management and erosion/sedimentation control practices.

Contaminated air generated by the DPVE system would be treated to comply with the North Carolina Air Quality Regulations (15 NCAC 2D.0518).

Long-term Effectiveness and Permanence: This alternative would attain RAO Number 1 since periodic environmental sampling is a reliable means of tracking contaminant migration, and potential unacceptable risks associated with groundwater use would be permanently mitigated through provision and enforcement of institutional controls. With respect to RAO Numbers 2 and 3, the intent of this alternative is to provide a permanent, long-term solution for the site.

The proposed groundwater extraction and treatment systems would prevent groundwater contaminated above the cleanup goals from migrating downgradient (RAO Number 2). Periodic groundwater sampling of monitoring wells is a reliable means of tracking contaminant migration and for verifying that contaminated groundwater is effectively being contained by the extraction and treatment system. Incremental cancer risks and hazard indices associated with potable use of groundwater would be within acceptable levels following groundwater restoration to the cleanup levels (RAO Number 3).

The USEPA 5-year site review would be required to evaluate monitoring results and ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume: The volume and toxicity of the contaminated groundwater would be permanently reduced. The air stripper would transfer contaminants from the aqueous to the vapor phase where they would eventually be oxidized in the atmosphere. The DPVE system would produce a more concentrated contaminated vapor-phase discharge, which would be treated before being discharged to the atmosphere. Migration of contaminated groundwater (mobility) in the shallow and upper Castle Hayne Aquifers would be contained by the extraction system.

Short-term Effectiveness: During installation of the underground piping, there would be a potential risk to workers associated with digging through waste materials. However, these risks would be minimized through environmental monitoring and health and safety procedures as well as through special monitoring procedures performed by the U.S. Army Technical Escort Unit (TEU).

Another short-term effectiveness concern associated with this alternative is the discharge of air stripper and DPVE system emissions. These emissions would be monitored through sampling and analysis to ensure protection of potential human receptors, such as nearby military personnel involved with training operations. However, as previously discussed, a concern with using the DPVE technology at Site 69 is the potential for chemical warfare agents to exist within the source area, which is currently under evaluation.

Implementability: DPVE technology is innovative, but is very similar to soil vapor extraction (SVE) technology, which has been used extensively. The technologies for DPVE are all demonstrated and commercially available. The DPVE system should be relatively easy to implement. The equipment that comprises the system consists of commonly-used items such as extraction wells, PVC piping, valves, and pumps. However, the presence of buried waste would make installation of a DPVE system difficult. The implementation of this alternative is primarily dependent on the radius of influence of the extraction system, initial and final exhaust concentrations, obtainable flow rates, water level changes, and vacuum well pressures. This information would need to be obtained by performing an on-site pilot test.

The major operational requirements include periodic (e.g., monthly) replacement of the carbon canisters used to treat soil gas and on-site treatment of the water collected in the air-water separator. Periodic monitoring of off-gas contaminant concentrations, water level checks in the air-water separator, and servicing of the air compressor would also need to be performed. In general, operation and maintenance requirements would be the highest at system startup and should decline over time.
Air stripping and groundwater extraction wells are commonly used technologies for groundwater remediation for treatment of volatile organic contaminants. Equipment and services for these systems are offered by numerous commercial vendors. The most common problem associated with air strippers is clogging and channeling in the packing materials and clogging of air diffusers in low-profile diffused aeration strippers. This problem could be minimized by the use of sequesterants, periodic shut-down and cleaning, and if necessary, through installation of a pretreatment system to remove suspended solids and any nuisance metals that may cause clogging.

An environmental monitoring program could be readily implemented at the site. Appropriate groundwater use designations could also be readily incorporated into the Base Master Plan.

Cost: The estimated costs of this alternative are as follows:

- Capital: $1,238,000
- Annual operation and maintenance: $98,200
- Net present worth (15-year): $2,337,000
- Net present worth (30-year): $2,748,000

The estimated cost does not include the cost of performing an on-site pilot test, which would most likely range from approximately $100,000 to $200,000. Detailed cost spreadsheets are provided in Appendix B. The 15-year present worth cost of this alternative was estimated for comparison purposes since the DPVE system may significantly reduce the treatment time needed to achieve the groundwater cleanup levels.

4.2.5 Alternative 69GW-5 - In Situ Air Stripping with Institutional Controls and Monitoring

Under this alternative, a groundwater treatment system would be constructed for the shallow and upper Castle Hayne Aquifers and operated on site.

The groundwater treatment system would be used to treat and contain groundwater contaminated above the cleanup goals developed for the shallow and upper Castle Hayne Aquifers (i.e., NCWQS), as discussed in Section 2.0. If possible, the system would be operated until groundwater cleanup goals are achieved. However, these levels may be impossible to achieve since it has been

demonstrated that groundwater contaminant levels typically reach asymptotic levels, which may exceed NCWQS. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached, which exceed NCWQS for some contaminants, then the cleanup goals would be re-evaluated at that time.

In Situ Air Stripping System

In situ air stripping is an innovative technology that was developed and patented by a German company, IEG Technologies Corporation in 1992. IEG's in situ stripping technology is called UVB (German: Unterdruck Verdampfer Brunnen), which in English is translated as vacuum vaporize well.

The patented technology is based on a double screened well which can simultaneously mobilze and treat contaminants from the unsaturated zone, capillary fringe, and the saturated zone. At Site 69, the UVB technology was designed (as part of the TS) to provide *in situ* remediation of chlorinated hydrocarbon contaminants only in the saturated zone. The UVB system creates a circulation cell that transports the dissolved and residual mobile-phase hydrocarbons to a central well casing for treatment. The treatment methodology is primarily air stripping for VOCs, and secondarily, bioremediation for semi- to non-volatile hydrocarbons. Water leaving the well is enriched with dissolved oxygen (DO) due to in-well stripping which enhances *in situ* biodegradation. The process flow diagram for this technology is shown on Figure 4-6.

The combination of these approaches makes this technology an effective alternative to other conventional remediation methods for groundwater. An obvious advantage of this *in situ* method is that it accomplishes treatment without groundwater extraction, hence no surface treatment is required.

Vertical groundwater circulation in the saturated zone is established by creating a pressure differential (using a mechanical pump and/or an air-lift pump) across the two screens in the well. In a standard circulation mode, groundwater enters the well through the lower screen and leaves through the upper screen. In a reverse circulation mode groundwater enters the well through the upper screen and leaves through the lower screen. Between its travel within the casing from one screen to the other, the groundwater passes through one or many in-well treatment systems. These, for example, may include an air stripper/aerator and/or an *in situ* bioreactor, depending on the type of contaminants being treated. VOCs in the off-gases are usually processed in an above-ground granular activated carbon (GAC) unit. Off-gas bioreactors or thermal oxidizers are used when appropriate. Groundwater leaving the treatment well can be supplemented with nutrients, additional dissolved oxygen, and co-substrates to further facilitate *in situ* biodegradation of contaminants in the aquifer.

An upgradient capture zone, and a downgradient release zone are calculated for a given circulation cell. Part of the groundwater flow entering the well casing is from the newly captured upgradient groundwater, while the remaining portion of water entering the casing at the same time is recirculating in the cell around the remediation well. An equal portion of treated groundwater leaving the well casing exits the circulation cell through the downgradient release zone. As the system operates over time, the VOC concentrations in groundwater fluctuate initially due to soil flushing and mobilization, then decrease gradually until an asymptotic level is reached.

The conceptual pumping well arrangement, shown in Figure 4-7, includes three UVB system in the upper zone of the Castle Hayne Aquifer. Groundwater in the upper Castle Hayne Aquifer would be treated using a series of wells located near the plume center (near well cluster GW15 and GW17). Each well would be approximately 70 feet deep and 10 inches in diameter, which is much larger than a typical groundwater extraction or monitoring well.

Groundwater Monitoring

As with Alternatives 69GW-3 and 69GW-4, a groundwater sampling program would be initiated for the site. The groundwater sampling program would incorporate the periodic sampling of existing groundwater monitoring wells. Wells in the path of the contaminated groundwater would be sampled as well as several downgradient wells. For costing purposes, it was assumed that, on average, eight monitoring wells would be periodically sampled (e.g., four per aquifer). Initially, groundwater sampling would be conducted on a semi-annual basis (i.e., two times per year) until a stable or decreasing trend in contaminant levels is observed. Once a reliable trend is established, the frequency of monitoring would be reduced to an annual basis. However, for costing purposes, it was assumed that semi-annual sampling would be conducted for a 30-year period.

Institutional Controls

As with Alternatives GW-3 and GW-4, institutional controls would be implemented under this alternative to restrict land usage in the vicinity of the site. Groundwater is currently not being used in the vicinity of the site, and there are no plans to for installing any supply wells in the area. However, there is currently no official land use designation for the site in the Base Master Plan. Under this alternative, the site would be given a groundwater use category in the Base Master Plan that would prohibit installation of potable water supply wells in the vicinity of the site (e.g., within a 1000-foot radius).

Overall Protection: This alternative is intended to remediate the contaminated groundwater in the upper zone of the Castle Hayne Aquifer to the cleanup goals. Any groundwater located downgradient of the extraction system, or outside of its capture zone, that is contaminated below groundwater cleanup goals would be allowed to migrate. Contamination concentrations in this downgradient area would gradually decrease through natural dilution and dispersion. The groundwater monitoring program would be used to verify that contaminant concentrations are decreasing. Groundwater in the shallow aquifer would remain contaminated. During the treatability study, the *in situ* remediation system installed to treat the shallow aquifer was not effective in establishing a capture zone at this site. Since shallow groundwater contamination is limited to the source area and offsite shallow groundwater is below state and federal drinking water standards, no remediation of the shallow aquifer is proposed or feasible using this technology.

Among other factors, the time to achieve groundwater cleanup goals in the Castle Hayne Aquifer is dependent on the nature and extent of the source, which is difficult to characterize within a landfill. The intent of this alternative is to minimize the treatment time required through active source remediation. However, the time to achieve the cleanup goals cannot accurately be predicted at this time. Even with active source remediation measures, it is possible that cleanup goals could require a very long time to be achieved (e.g., more than 10 years). Furthermore, it may be impossible to achieve NCWQS since it has been demonstrated that groundwater contaminant concentrations typically reach asymptotic levels, which may exceed NCWQS. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation

system. If the performance curves indicate that asymptotic levels have been reached, which exceed NCWQS for some contaminants, then the cleanup goals would be re-evaluated at that time.

With respect to achievement of RAOs, this alternative would prevent future potential exposure to contaminated groundwater through institutional controls and monitoring (RAO Number 1). This alternative would also protect uncontaminated groundwater (RAO Number 2), and would attempt to restore contaminated groundwater for future potential beneficial use (RAO Number 3). The groundwater monitoring program would be used to assess whether or not contaminant concentrations are decreasing.

Compliance with ARARs: Contaminated groundwater exceeds federal Maximum Contaminant Levels (MCLs) established pursuant to the Safe Drinking Water Act (SDWA) and the NCWQS for the VOCs of concern. The intent of this alternative is to restore groundwater in the upper Castle Hayne Aquifer to their beneficial use through in situ treatment, at which point the groundwater levels would be in compliance with MCLs and NCWQS.

Construction activities and groundwater discharge would need to comply with the following location-specific ARARs:

- Fish and Wildlife Coordination Act
- Federal Endangered Species Act
- North Carolina Endangered Species Act
- Executive Order 11990 on Protection of Wetlands
- Executive Order 11988 on Floodplain Management

Because of the history of Site 69 as a disposal site, the North Carolina Recordation of Inactive Hazardous Substance or Waste Disposal Site Statute (a location-specific ARAR) may also be considered an ARAR.

Contaminated air generated by the in situ air stripping system would be treated to comply with the North Carolina Air Quality Regulations (15 NCAC 2D.0518).

Long-term Effectiveness and Permanence: This alternative would attain RAO Number 1 since periodic environmental sampling is a reliable means of tracking contaminant migration, and potential unacceptable risks associated with groundwater use would be permanently mitigated through provision and enforcement of institutional controls.

With respect to RAO Numbers 2 and 3, the intent of this alternative is to reduce the level of contamination in the source area. The proposed groundwater treatment systems would reduce groundwater contaminated above the cleanup goals from migrating downgradient (RAO Number 2). Periodic groundwater sampling of monitoring wells is a reliable means of tracking contaminant migration and for verifying that contaminated groundwater is effectively being contained by the in situ treatment system. Incremental cancer risks and hazard indices associated with potable use of groundwater would be within acceptable levels following groundwater restoration to the cleanup levels (RAO Number 3).

The USEPA 5-year site review would be required to evaluate monitoring results and ensure that adequate protection of human health and the environment is maintained.

Reduction of Toxicity, Mobility, or Volume: The volume and toxicity of the contaminated groundwater would be reduced. The in situ air stripping action would transfer contaminants from the aqueous to the vapor phase where they would then be treated before being discharged to the atmosphere. Migration of contaminated groundwater (mobility) in the Castle Hayne Aquifer would be contained by the pumping action created by the in situ treatment system.

Short-term Effectiveness: During installation of the vacuum vaporizer wells, there would be a potential risk to workers associated with digging through waste materials. However, these risks would be minimized through environmental monitoring and health and safety procedures as well as through special monitoring procedures performed by the U.S. Army Technical Escort Unit (TEU).

Another short-term effectiveness concern associated with this alternative is the discharge of the contaminated off-gas emissions. These emissions would be monitored through sampling and analysis to ensure protection of potential human receptors, such as nearby military personnel involved with training operations.

Implementability: The implementation of this alternative is primarily dependent on the radius of influence of the extraction system, the ability to draw contaminants toward the treatment system, initial and final exhaust concentrations, obtainable flow rates, water level changes, and vacuum well pressures. Although a radius of influence was generated during the treatability study, the ability to move VOCs toward the system is questionable.

The major operational requirement includes periodic (e.g., monthly) replacement of the carbon canisters used to treat the withdrawn off-gas. Periodic monitoring of off-gas contaminant concentrations, water level checks in the treatment wells, and servicing of the air blower would also need to be performed. In general, operation and maintenance requirements would be the highest at system startup and should decline over time.

An environmental monitoring program could be readily implemented at the site. Appropriate land use designations could also be readily incorporated into the Base Master Plan.

Cost: The estimated costs of this alternative are as follows:

- Capital: $246.,000
- Annual operation and maintenance: $39,000
- Net present worth (30-year): $853,000

Detailed cost spreadsheets are provided in Appendix B.

4.2.6 Comparison of Site 69 Groundwater Alternatives

The groundwater alternative comparison for Site 69, based on the seven criteria, is provided in the following sections.

Overall Protection: Alternatives 69GW-1 and 69GW-2 would not contain or restore contaminated groundwater at the site, whereas, the intent of Alternatives 69GW-3 and 69GW-4 is to contain the groundwater contaminated above the groundwater cleanup goals (RAO Number 2) and eventually restore this groundwater to the cleanup goals (RAO Number 3). Alternative 69GW-05 is designed

to remediate the most contaminated area of the plume in order to mitigate migration of highly concentrated VOCs. Alternative 69GW-4, by implementing the most aggressive source remediation measures, may achieve these objectives in a shorter time period than would Alternative 69GW-3. Cleanup levels may not be achievable under Alternative 69GW-5. Pilot-scale testing would provide more site-specific information that could be used to better compare the effectiveness of Alternatives 69GW-3 and 69GW-4.

With respect to achievement of RAO Number 1, Alternatives 69GW-2 through 69GW-5 would prevent future potential exposure to contaminated groundwater through institutional controls and monitoring, whereas, Alternative 69GW-1 may not achieve this objective.

Compliance with ARARs: Under Alternatives 69GW-1 and 69GW-2, contaminated groundwater would continue to exceed federal Maximum Contaminant Levels (MCLs) established pursuant to the Safe Drinking Water Act (SDWA) and the NCWQS for the VOCs of concern. The intent of Alternatives 69GW-3, and 69GW-4 is to restore the groundwater in the shallow and upper Castle Hayne Aquifers to their beneficial use through extraction and treatment, at which point the groundwater levels would be in compliance with MCLs and NCWQS. A waiver of state and federal groundwater and drinking water standards would be plausible on the basis that it is technically impracticable to permanently restore the aquifer from an engineering perspective.

Long-term Effectiveness and Permanence: Alternatives 69GW-2 through 69GW-5 would all attain RAO Number 1 since periodic environmental sampling is a reliable means of tracking contaminant migration, and potential unacceptable risks associated with groundwater use would be permanently mitigated through provision and enforcement of institutional controls.

With respect to RAO Numbers 2 and 3, only Alternatives 69GW-3 and 69GW-4 would potentially provide a permanent, long-term solution for the site. Alternative 69GW-4 would possibly provide a greater degree of long-term protection to groundwater than would Alternatives 69GW-3 and 69GW-5 by implementing aggressive source remediation measures, although the amount of additional protection cannot be quantified without further source characterization and pilot testing.

Reduction of Toxicity, Mobility, or Volume: No reduction of toxicity, mobility, or volume would be provided by Alternatives 69GW-1 and 69GW-2. Under Alternatives 69GW-3, 69GW-4, and 69GW-5, the volume, mobility, and toxicity of the contaminated groundwater would be reduced. However, Alternative 69GW-4 would provide a greater degree of reduction in volume, mobility, and toxicity than would Alternatives 69GW-3 and 69GW-5 through implementation of the DPVE source remediation system.

Short-term Effectiveness: Alternatives 69GW-1 and 69GW-2 would not involve remedial actions that would pose a risk to human health or the environment during implementation.

Under Alternatives 69GW-3, 69GW-4, and 69GW-5, there would be a potential risk to workers associated with digging through waste materials during installation of the underground piping and/or wells. However, these risks would be minimized through environmental monitoring and health and safety procedures as well as through special monitoring procedures performed by the U.S. Army Technical Escort Unit (TEU).

Under Alternatives 69GW-3, 69GW-4, and 69GW-5, there would also be short-term effectiveness concerns associated with the discharge of air emissions. However, the treatability study for alternative 69GW-5 did show adequate capture and treatment of VOCs via the carbon unit.

Implementability: There would be no implementability concerns under Alternative 69GW-1 since no actions would be taken.

Under Alternative 69GW-2, an environmental monitoring program could be readily implemented at the site, and appropriate land use designations could be readily incorporated into the Base Master Plan.
Alternatives 69GW-3 and 69-GW-4 would be significantly more difficult to implement than Alternatives 69GW-1 and 69GW-2 because of the invasive excavation and drilling required as well as the construction and maintenance requirements for the extraction and treatment systems.

Alternative 69GW-4 would be more difficult to implement than Alternative 69GW-3 because, in addition to the air stripper system, it includes construction, operation, and maintenance of the source remediation DPVE system. Alternative 69GW-5 would be easier to implement than Alternatives 69GW-3 and 69GW-4 with respect to the amount of aboveground process equipment required.

Cost: The estimated 30-year net present worth costs of the four alternatives are as follows:

- Alternative 69GW-1 $0
- Alternative 69GW-2 $535,000
- Alternative 69GW-3 $2,088,000
- Alternative 69GW-4 $2,337,000 (15-year)
- Alternative 69GW-4 $2,748,000 (30-year)
- Alternative 69GW-5 $853,000

5.0 REFERENCES

40 CFR 300. 1993. National Contingency Plan.

Baker Environmental, Incorporated (Baker). 1994. Draft. Remedial Investigation Report for Operable Unit No. 4 (Sites 41, 69 and 74), Marine Corps Base, Camp Lejeune, North Carolina. Draft. Prepared for the Department of the Navy Atlantic Division Naval Facilities Engineering Command, Norfolk, Virginia. April 1994.

Brown, Richard A., Ph.D., and Frank Jasiulewicz, PG. 1992. Air Sparging: A New Model for Remediation, Pollution Engineering, July 1, 1992, pp. 52 - 55.

Eakes, Wallace, 1982. Trip Report for IAS Team. March 31, 1982.

ESE, 1990. Final Site Summary Report, Marine Corps Base, Camp Lejeune, North Carolina. Prepared for Naval Facilities Engineering Command Atlantic Division. ESE Project No. 49-02036.

Federal Facility Agreement (FAA) between USEPA Region IV, the NC DEHNR, and U.S. DON for MCB Camp Lejeune and Marine Corps Air Station, New River, North Carolina. December 6, 1988.

Greenhorne & O'Mara, Inc. 1992. Preliminary Draft Report - Wellhead Monitoring Study - Engineering Study 92-34. Prepared for the Department of the Navy Civil Branch. December 1992.

Johnson, R.L., P.C. Johnson, D.B. McWhorter, R.E. Hinchee, and I. Goodman. 1993. "An Overview of In Situ Air Sparging", GWMR, Fall 1993, pp. 127 - 135.

Means Site Work & Landscape Cost Data, 1993. 12th Annual Edition. R.S. Means Company, Inc. Construction Consultants & Publishers, Kingston, MA.

North Carolina Administrative Code, Title 15A, Subchapter 2B, Section .0200. 1991. Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina. North Carolina Department of Environment, Health, and Natural Resources.

North Carolina Administrative Code, Title 15A, Subchapter 2L, Section .0200. 1993. Classifications and Water Quality Standards Applicable to the Groundwaters of North Carolina. North Carolina Department of Environment, Health, and Natural Resources.

Rich, Gerald and Kenneth Cherry. 1987. Hazardous Waste Treatment Technologies. Third Printing. Pudvan Publishing Co., Northbrook, Illinois.

Scudder, L.L. 1982. Memorandum From Environmental law Counsel to Assistant Chief of Staff, Facilities. Office of the Staff Judge Advocate, MCB Camp Lejeune, North Carolina, October 6, 1982.

U.S. Army Chemical Materiel Destruction Agency (USACMDA), 1993. Non-Stockpile Chemical Materiel Program Survey and Analysis Report. November, 1993.

USEPA. 1992b. Region IV Waste Management Screening Values for Hazardous Waste Sites.

USEPA. 1991a. Role of Baseline Risk Assessment in Superfund Remedy Selection Decisions. U.S. Department of Commerce. OSWER Directive 9355.0-30. April 1991.

USEPA. 1991b. Human Health Evaluation Manual, Supplemental Guidance "Standard Default Exposure Factors." Office of Solid Waste and Emergency Response, Washington, D.C. March 25, 1991. OSWER Directive 9285.6-03.

USEPA, 1991c. Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites. Office of Solid Waste and Emergency Response, Washington, D.C. February 1991. EPA/540/P-91.001.

USEPA. 1990b. Handbook of In Situ Treatment of Hazardous Waste Contaminated Soils. Risk Reduction Engineering Laboratory, Cincinnati, Ohio. USEPA/440/2-90/001.

USEPA. 1990c. Technologies of Delivery or Recovery for the Remediation of Hazardous Waste Sites. University of Cincinnati, Cincinnati, Ohio. USEPA/600/2-89/066.

USEPA. 1989a. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. December 1989. EPA/540/1-89-002.

USEPA. 1989b. Guide to Treatment Technologies for Hazardous Wastes at Superfund Sites. Office of Environmental Engineering and Technology Demonstration, Washington, DC. USEPA/540/2-89/052.

USEPA. 1988a. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Interim Final. Office of Emergency and Remedial Response, Washington, DC. USEPA/540/G-89004.

USEPA. 1988b. CERCLA Compliance With Other Laws Manual: Draft Guidance. Office of Emergency and Remedial Response, Washington, DC. USEPA/540/6-89-006.

USEPA. 1988c. Technology Screening Guide for Treatment of CERCLA Soils and Sludges. Office of Solid Waste and Emergency Response, Washington, DC. USEPA/540/2-88/004.

USEPA. 1988d. Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites. Office of Emergency and Remedial Response, Washington, DC. EPA/540/G-88/003. December, 1988.

USEPA. 1987b. Compendium of Costs of Remedial Technologies at Hazardous Waste Sites. EPA/600/2-87-087.

APPENDIX A
RISK-BASED ACTION LEVEL CALCULATION

INGESTION OF GROUND...ER ACTION LEVEL
FEASABILITY STUDY
CTO-0212
MCB CAMP LEJEUNE
CHILD RESIDENT

C = TR or THI * BW * ATc or ATnc * DY / IRw * EF * ED * CSF or 1/RfD

Where:	INPUTS
C = contaminant concentration in water ((ug/L)	
TR = total lifetime risk	1E-04
THI = total hazard index	1
CSF = carcinogenic slope factor	specific
RfD = reference dose	specific
IRw = daily water ingestion rate (L/Day)	1
EF = exposure frequency (days/yr)	350
ED = exposure duration (yr)	6
BW = body weight (kg)	15
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	6
DY = days per year (day/year)	365

Note: Inputs are scenario and site specific

Contaminant	Concentration Carcinogen (ug/l)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Carc Time (years)	Days per year (day/yr)	Slope Factor (mg/kg-day)-1	Target Excess Risk
Trichloroethene	1659	1	350	6	15	70	365	1.10E-02	1.0E-04
1,1,2,2-Tetrachlorethane	91	1	350	6	15	70	365	2.00E-01	1.0E-04
Heptachlor	4	1	350	6	15	70	365	4.50E+00	1.0E-04
4,4'-DDD	76	1	350	6	15	70	365	2.40E-01	1.0E-04
alpha-Chlordane	14	1	350	6	15	70	365	1.30E+00	1.0E-04
beta-BHC	10	1	350	6	15	70	365	1.80E+00	1.0E-04
Arsenic	11	1	350	6	15	70	365	1.70E+00	1.0E-04
Beryllium	4	1	350	6	15	70	365	4.30E+00	1.0E-04

Contaminant	Concentration Noncarcinogen (ug/L)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Noncarc Time (years)	Days per year (day/yr)	Reference Dose (mg/kg-day)	Target Hazard Index
Total 1,2-Dichloroethene	313	1	350	6	15	6	365	2.00E-02	1
Trichloroethene	94	1	350	6	15	6	365	6.00E-03	1
Heptachlor	8	1	350	6	15	6	365	5.00E-04	1
alpha-chlordane	1	1	350	6	15	6	365	6.00E-05	1
Arsenic	5	1	350	6	15	6	365	3.00E-04	1
Barium	1095	1	350	6	15	6	365	7.00E-02	1
Beryllium	78	1	350	6	15	6	365	5.00E-03	1
Cadmium	16	1	350	6	15	6	365	1.00E-03	1
Chromium	78	1	350	6	15	6	365	5.00E-03	1
Copper	580	1	350	6	15	6	365	3.71E-02	1
Nickel	5	1	350	6	15	6	365	3.00E-04	1
Manganese	2190	1	350	6	15	6	365	1.40E-01	1
Mercury	5	1	350	6	15	6	365	3.00E-04	1
Selenium	78	1	350	6	15	6	365	5.00E-03	1
Vanadium	110	1	350	6	15	6	365	7.00E-03	1
Zinc	4693	1	350	6	15	6	365	3.00E-01	1

File Name: GWIC.WQ1

INGESTION OF GROUND...ER ACTION LEVEL
FEASABILITY STUDY
CTO-0212
MCB CAMP LEJEUNE
ADULT RESIDENT

C = TR or THI * BW * ATc or ATnc * DY / IRw * EF * ED * CSF or 1/RfD

Where:	INPUTS
C = contaminant concentration in water ((ug/L)	
TR = total lifetime risk	1E-04
THI = total hazard index	1
CSF = carcinogenic slope factor	specific
RfD = reference dose	specific
IRw = daily water ingestion rate (L/Day)	2
EF = exposure frequency (days/yr)	350
ED = exposure duration (yr)	30
BW = body weight (kg)	70
ATc = averaging time for carcinogen (yr)	70
ATnc = averaging time for noncarcinogen (yr)	30
DY = days per year (day/year)	365

Note: Inputs are scenario and site specific

Contaminant	Concentration Carcinogen (ug/l)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Carc Time (years)	Days per year (day/yr)	Slope Factor (mg/kg-day)-1	Target Excess Risk
Trichloroethene	774	2	350	30	70	70	365	1.10E-02	1.0E-04
1,1,2,2-Tetrachlorethane	43	2	350	30	70	70	365	2.00E-01	1.0E-04
Heptachlor	2	2	350	30	70	70	365	4.50E+00	1.0E-04
4,4'-DDD	35	2	350	30	70	70	365	2.40E-01	1.0E-04
alpha-Chlordane	7	2	350	30	70	70	365	1.30E+00	1.0E-04
beta-BHC	5	2	350	30	70	70	365	1.80E+00	1.0E-04
Arsenic	5	2	350	30	70	70	365	1.70E+00	1.0E-04
Beryllium	2	2	350	30	70	70	365	4.30E+00	1.0E-04

Contaminant	Concentration Noncarcinogen (ug/L)	Ingestion Rate (L/day)	Exposure Frequency (day/year)	Exposure Duration (year)	Body Weight (kg)	Average Noncarc Time (years)	Days per year (day/yr)	Reference Dose (mg/kg-day)	Target Hazard Index
Total 1,2-Dichloroethene	730	2	350	30	70	30	365	2.00E-02	1
Trichloroethene	219	2	350	30	70	30	365	6.00E-03	1
Heptachlor	18	2	350	30	70	30	365	5.00E-04	1
alpha-chlordane	2	2	350	30	70	30	365	6.00E-05	1
Arsenic	11	2	350	30	70	30	365	3.00E-04	1
Barium	2555	2	350	30	70	30	365	7.00E-02	1
Beryllium	183	2	350	30	70	30	365	5.00E-03	1
Cadmium	37	2	350	30	70	30	365	1.00E-03	1
Chromium	183	2	350	30	70	30	365	5.00E-03	1
Copper	1354	2	350	30	70	30	365	3.71E-02	1
Nickel	11	2	350	30	70	30	365	3.00E-04	1
Manganese	5110	2	350	30	70	30	365	1.40E-01	1
Mercury	11	2	350	30	70	30	365	3.00E-04	1
Selenium	183	2	350	30	70	30	365	5.00E-03	1
Vanadium	256	2	350	30	70	30	365	7.00E-03	1
Zinc	10950	2	350	30	70	30	365	3.00E-01	1

File Name: GWIAR.WQ1

APPENDIX B
REMEDIAL ALTERNATIVE COST ESTIMATES

ESTIMATED COSTS

SITE 69: RIFLE RANGE CHEMICAL DUMP
ALTERNATE SO-2: INSTITUTIONAL CONTROLS (FENCING)
O & M AND CAPITAL COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
O & M COST ESTIMATE							
Fence Maintenance	LS	1	$ 900	$ 900	$ 900	Engineering Estimate	1 - person 20 hours/year at $20/hour + $500/year materials = $900
CAPITAL COST ESTIMATE							
Fence Construction							
Existing Fence - No Capital Costs					$ -		
ANNUAL O & M COSTS (Years 1 - 30)					$ 900		
TOTAL CAPITAL COSTS					$ -		
TOTAL COST - ALTERNATE SO-2					$ 13,835		

ESTIMATED COSTS

SITE 69: RIFLE RANGE CHEMICAL DUMP
ALTERNATE GW-2: GROUNDWATERING MONITORING
O & M AND CAPITAL COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
O & M COST ESTIMATE (BIANNUAL SAMPLING - YEARS 1 - 30)							
Groundwater Monitoring							
Labor	Hours	96	$ 40	$ 3,840		Engineering Estimate	Biannual sampling of 8 locations: 2 samplers, 3 hours each location, 2 events per year
Laboratory Analyses - VOCs	Sample	30	$ 155	$ 4,650		Baker Average 1994 BOAs	Biannual sampling of 8 locations: GW Samples - 8 from wells, 7 QA/QC
Misc. Expenses	Sample Event	2	$ 1,886	$ 3,772		1994 JTR, Vendor Quotes	Includes travel, lodging, air fare, supplies, truck rental, equipment, cooler shipping
Report	Sample Event	2	$ 1,500	$ 3,000		Engineering Estimate	1 - report per sampling event
Well Maintenance	Year	1	$ 632	$ 632		Engineering Estimate	Includes repainting and annualized cost of replacing 1 - well every 5 - years
					$ 15,894		

(Continued Next Page)

ESTIMATED COSTS
(CONTINUED)

SITE 69: RIFLE RANGE CHEMICAL DUMP
ALTERNATE GW-2: GROUNDWATERING MONITORING
O & M AND CAPITAL COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS / COMMENTS
CAPITAL COST ESTIMATE No Capital Costs					$ -		
ANNUAL O & M COSTS (Years 1 - 30)					$ 15,894		
TOTAL CAPITAL COSTS					$ -		
TOTAL COST - ALTERNATE GW-2					$ 244,330		

SITE 69: RIFLE RANGE CHEMICAL DUMP
ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS AND NATURAL ATTENUATION
O & M COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS/COMMENTS
O & M COST ESTIMATE (QUARTERLY SAMPLING - YEARS 1 - 5) Groundwater Monitoring							
Labor	Hours	576	$40	$23,040		Engineering Estimate	Quarterly sampling of 24 locations 2 samplers, 3 hours per location 4 events per year
Laboratory Analysis - VOCs	Sample	124	$155	$19,220		Baker Average 1994 BOAs	Quarterly sampling of 24 locations GW samples - 24 from wells, 7 QA/QC
Misc. Expenses	Sample Event	4	$1,886	$7,544		1994 JTR, Vendor Quote	Includes travel, lodging, air fare, supplies, truck rental, equipment, cooler shipping
Fate and Transport Modeling	Year	1	$6,240	$6,240		Engineering Estimate	200 hrs initial year, 80 hrs subsequent years, $60/hr, annualized
Report	Sample Event	4	$1,500	$6,000		Engineering Estimate	One report per sampling event
Well Maintenance	Year	1	$632	$632		Engineering Estimate	Includes repainting and annualized cost of replacing 1 well every five years
Subtotal O & M Cost					$62,676		
CAPITAL COST ESTIMATE							
No Capital Costs					0		
ANNUAL O & M COSTS (Years 1 - 5)					$62,676		
TOTAL CAPITAL COSTS					$0		

SITE 69: RIFLE RANGE CHEMICAL DUMP
ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS AND NATURAL ATTENUATION
O & M COST ESTIMATE

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS/COMMENTS
O & M COST ESTIMATE (SEMIANNUAL SAMPLING - YEARS 6 - 30) Groundwater Monitoring							
Labor	Hours	144	$40	$5,760		Engineering Estimate	Semiannual sampling of 12 locations 2 samplers, 3 hours per location 2 events per year
Laboratory Analysis - VOCs	Sample	38	$155	$5,890		Baker Average 1994 BOAs	Semiannual sampling of 12 locations GW samples - 12 from wells, 7 QA/QC
Misc. Expenses	Sample Event	2	$1,886	$3,772		1994 JTR, Vendor Quote	Includes travel, lodging, air fare, supplies, truck rental, equipment, cooler shipping
Fate and Tranasport Modeling	Year	1	$4,800	$4,800		Engineering Estimate	80 hrs per year, $60/hr
Report	Sample Event	2	$1,500	$3,000		Engineering Estimate	One report per sampling event
Well Maintenance	Year	1	$632	$632		Engineering Estimate	Includes repainting and annualized cost of replacing 1 well every five years
Subtotal O & M Cost					$23,854		
CAPITAL COST ESTIMATE							
No Capital Costs					0		
ANNUAL O & M COSTS (Years 1 - 5)					$62,676		
ANNUAL O & M COSTS (Years 6 - 30)					$23,854		
TOTAL CAPITAL COSTS					$0		

SITE 69: RIFLE RANGE CHEMICAL DUMP
ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS AND NATURAL ATTENUATION
30 YEAR PRESENT WORTH COST ESTIMATE

COST COMPONENT	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
Total Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O & M Cost	$0	$62,676	$62,676	$62,676	$62,676	$62,676	$23,854	$23,854	$23,854	$23,854	$23,854
Total Annual Cost	$0	$62,676	$62,676	$62,676	$62,676	$62,676	$23,854	$23,854	$23,854	$23,854	$23,854
Discount Factor at 5%	1.0000	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107	0.6768	0.6446	0.6139
Present Worth Cost	$0	$59,693	$56,847	$54,140	$51,564	$49,107	$17,800	$16,953	$16,144	$15,376	$14,644

COST COMPONENT	YEAR										
	11	12	13	14	15	16	17	18	19	20	21
Total Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O & M Cost	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854
Total Annual Cost	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854
Discount Factor at 5%	0.5847	0.5568	0.5303	0.5051	0.4810	0.4581	0.4363	0.4155	0.3957	0.3769	0.3589
Present Worth Cost	$13,947	$13,282	$12,650	$12,049	$11,474	$10,928	$10,408	$9,911	$9,439	$8,991	$8,561

COST COMPONENT	YEAR									
	22	23	24	25	26	27	28	29	30	
Total Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	
O & M Cost	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	
Total Annual Cost	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	$23,854	
Discount Factor at 5%	0.3418	0.3256	0.3101	0.2953	0.2812	0.2678	0.2551	0.2429	0.2314	
Present Worth Cost	$8,153	$7,767	$7,397	$7,044	$6,708	$6,388	$6,085	$5,794	$5,520	$534,762

ALTERNATIVE 69GW-3

INDIRECT COSTS AND SUMMARY OF TOTAL COSTS - 100 GPM SYSTEM

TOTAL INDIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE	% OF COST	BASIS OF ESTIMATE
1. ENGINEERING AND DESIGN	$60,262	8%	OF TOTAL DIRECT COST
2. DESIGN AND CONSTRUCTION ADMIN.	$37,664	5%	OF TOTAL DIRECT COST
3. HEALTH AND SAFETY	$22,598	3%	OF TOTAL DIRECT COST
4. CONTINGENCY ALLOWANCE	$112,992	15%	OF TOTAL DIRECT COST
5. OTHER DIRECT COSTS A. START-UP AND SHAKE-DOWN	$60,262	8%	OF TOTAL DIRECT COST

SUMMARY OF COSTS:

TOTAL INDIRECT CAPITAL COST	$293,778		—
TOTAL DIRECT CAPITAL COST	$753,277		
TOTAL CAPITAL COSTS	$1,047,055		
TOTAL ANNUAL O&M COSTS	$67,717		
PRESENT WORTH OF ALTERNATIVE	$2,088,027		

ALTERNATIVE 69GW-3

SUMMARY OF DIRECT COSTS - 100 GPM PUMP AND TREAT SYSTEM

TOTAL DIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE		BASIS OF ESTIMATE
DIRECT CAPITAL COST FOR SPECIAL REQUIREMENTS	$47,500		REFER TO DIRECT CAPITAL COST ESTIMATE FOR SPECIAL REQUIREMENTS
DIRECT CAPITAL COST FOR DIVISION 1 - GENERAL REQUIREMENTS	$147,000		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 1
DIRECT CAPITAL COST FOR DIVISION 2 - SITE WORK	$178,564		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 2
DIRECT CAPITAL COST FOR DIVISION 3 - CONCRETE	$22,877		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 3
DIRECT CAPITAL COST FOR DIVISION 4 - MASONRY	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 4
DIRECT CAPITAL COST FOR DIVISION 5 - METALS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 5
DIRECT CAPITAL COST FOR DIVISION 6 - WOOD AND PLASTICS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 6
DIRECT CAPITAL COST FOR DIVISION 7 - THERMAL AND MOISTURE PROTECTION	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 7
DIRECT CAPITAL COST FOR DIVISION 8 - DOORS, WINDOWS, AND GLASS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 8
DIRECT CAPITAL COST FOR DIVISION 9 - FINISHES	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 9
DIRECT CAPITAL COST FOR DIVISION 10 SPECIALTIES	$0		NO DIVISION 10 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 11 EQUIPMENT	$102,071		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 11
DIRECT CAPITAL COST FOR DIVISION 12 FURNISHINGS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 12
DIRECT CAPITAL COST FOR DIVISION 13 SPECIAL CONSTRUCTION	$0		NO DIVISION 13 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 14 CONVEYING SYSTEM	$0		NO DIVISION 14 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 15 MECHANICAL	$49,748		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 15
DIRECT CAPITAL COST FOR DIVISION 16 ELECTRICAL	$205,518		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 16
TOTAL DIRECT CAPITAL COST	$753,277		—

ALTERNATIVE 69GW-3

DIRECT COST BREAKDOWN BY DIVISION - 100 GPM PUMP AND TREAT SYSTEM

DIRECT COST BREAKDOWN: SPECIAL REQUIREMENTS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
A. EROSION AND SEDIMENT CONTROL PLAN - IMPLEMENTATION					
1. GENERAL CONTRACT	1	JOB	$20,000.00	$20,000	ESTIMATED - PREVIOUS PROJECTS
B. OFFICE FACILITIES (INCLUDES PHONE SERVICE)					
1. GENERAL CONTRACT	1	JOB	$15,000.00	$15,000	ESTIMATED - PREVIOUS PROJECTS
C. PROGRESS ESTIMATES/ADMIN					
1. GENERAL/TRENCH CONTRACT	1	JOB	$12,500.00	$12,500	ESTIMATED, 52 HRS, $80/HR
SUBTOTAL SPECIAL REQUIREMENTS				$47,500	

DIRECT COST BREAKDOWN: DIVISION 1 - GENERAL REQUIREMENTS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
1A. SUBMITTALS (WORK PLAN, HEALTH AND SAFETY PLAN, ERROSION AND SEDIMENT CONTROL PLAN, ETC.)					
1. GENERAL CONTRACT	1	JOB	$40,000.00	$40,000	ESTIMATED - PREVIOUS PROJECTS
1B. MOBILIZATION/DEMOBILIZATION					
1. GENERAL CONTRACT	1	JOB	$100,000.00	$100,000	ESTIMATED - PREVIOUS PROJECTS
1C. DECONTAMINATION PAD	1	JOB	$7,000.00	$7,000	ESTIMATED - PREVIOUS PROJECTS
SUBTOTAL DIVISION 1				$147,000	

DIRECT COST BREAKDOWN: DIVISION 2 - SITE WORK

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
2A. CLEARING AND GRUBBING	3	ACRE	$2,625.00	$7,875	MEANS SITE, 1993: 021-104-0010
2B. EXCAVATION					
1. BASE SLAB	60	CY	$1.97	$118	MEANS SITE, 1993: 022-238-0200
2. INFLUENT/EFFLUENT PIPING TRENC	500	CY	$5.08	$2,540	MEANS SITE, 1993: 022-238-0200
3. EXCAVATION FOR MANHOLE	15	CY	$5.08	$76	MEANS SITE, 1993: 022-238-0200
2C. BACKFILL					
1. AROUND SLAB	20	CY	$6.85	$137	MEANS SITE, 1993: 022-238-0200, 022-226-8050
2. INFLUENT/EFFLUENT PIPING TRENC	500	CY	$6.85	$3,425	MEANS SITE, 1993: 022-238-0200, 022-226-8050
3. EXCAVATION FOR MANHOLE	15	CY	$6.85	$103	MEANS SITE, 1993: 022-238-0200, 022-226-8050
4. ROADWAY	9000	SY	$6.00	$54,000	MEANS SITE, 1994: 022-308-0100
2D. FENCING AND GATES	200	LF	$15.45	$3,090	MEANS SITE, 1993 028-308-0500
2E. EXTRACTION WELLS					
1. SHALLOW EXTN WELL INSTALL	4	EACH	$9,000.00	$36,000	PREVIOUS CONTRACT
2. DEEP EXTRACTION WELL INSTALL	4	EACH	$15,000.00	$60,000	PREVIOUS CONTRACT
2F. SITE REVEGETATION	3	ACRE	$2,000.00	$6,000	ESTIMATE
2G. PIPING INSTALLATION					
1. 1" HDPE INFLUENT PIPING	400	LF	$2.50	$1,000	
2. 4" PVC EFFLUENT PIPING	1200	LF	$3.50	$4,200	
SUBTOTAL DIVISION 2				$178,564	

DIRECT COST BREAKDOWN: DIVISION 3 - CONCRETE

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
3A. CONCRETE FORMWORK 1. 6"-SLAB ON GRADE	240	LF	$3.00	$720	MEANS SITE, 1994: 031-170-3000
3B. CONCRETE REINFORCEMENT 1. 6"-SLAB ON GRADE	3	TONS	$2,000.00	$6,000	MEANS SITE, 1994: 032-107-0600
3C. JOINTS IN CONCRETE	150	LF	$2.71	$407	MEANS SITE, 1994: 031-132-0100
3D. CAST-IN-PLACE CONCRETE 1. 6"-SLAB ON GRADE	65	CY	$150.00	$9,750	MEANS SITE, 1994: 033-130-4700
3E. PRECAST CONCRETE 1. PRECAST MANHOLE	3	EACH	$2,000.00	$6,000	ESTIMATED
SUBTOTAL DIVISION 3				$22,877	

DIRECT COST BREAKDOWN: DIVISION 4 - MASONRY

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 4				$0	

DIRECT COST BREAKDOWN: DIVISION 5 - METALS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 5				$0	

DIRECT COST BREAKDOWN: DIVISION 6 - WOOD AND PLASTICS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 6				$0	

DIRECT COST BREAKDOWN: DIVISION 7 - THERMAL AND MOISTURE PROTECTION

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 7				$0	

DIRECT COST BREAKDOWN: DIVISION 8 - DOORS, WINDOWS, AND GLASS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 8				$0	

DIRECT COST BREAKDOWN: DIVISION 9 - FINISHES

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 9				$0	

DIRECT COST BREAKDOWN: DIVISION 10 - SPECIALTIES

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 10				$0	

DIRECT COST BREAKDOWN: DIVISION 11 - EQUIPMENT

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
11A. CHEMICAL MAKE-UP TANK W/MIXE	1	EACH	$4,000.00	$4,000	VENDOR QUOTE
CHEMICAL FEED PUMP - 50 GAL.					
TANK/MIXER/PUMP INSTALLATION	24	HOURS	$47.73	$1,146	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11B. MIXING TANK W/MIXER- 625 GAL.	1	EACH	$5,800.00	$5,800	VENDOR QUOTE
TANK/MIXER INSTALLATION	16	HOURS	$47.73	$764	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11C. EQUALIZATION TANK - 10,000 GAL.	1	EACH	$8,000.00	$8,000	VENDOR QUOTE
TANK INSTALLATION	26	HOURS	$47.73	$1,241	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11D. CENTRIFUGAL PUMPS					
1. FEED PUMPS - 100 GPM	2	EACH	$5,000.00	$10,000	PREVIOUS CONTRACT
PUMP INSTALLATION	96	HOURS	$47.73	$4,582	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11E. WELL PUMPS					
1. EXTRACTION WELL PUMPS	8	EACH	$3,500.00	$28,000	VENDOR QUOTE
PUMP INSTALLATION	72	HOURS	$47.73	$3,437	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11F. LOW PROFILE AIR STRIPPING UNITS	1	UNITS	$32,000.00	$32,000	VENDOR QUOTE FOR PRE-ENGINEERED AND PRE-FABRICATED TREATMENT PACKAGE;
INC: BLOWER; SUMP; START-UP; TRAINING; SUBMITTAL PACKAGE O&M MANUALS					
AIR STRIPPER INSTALLATION	65	HOURS	$47.73	$3,102	RICHARDSONS ENGINEERING SERVICES, 1986
SUBTOTAL DIVISION 11				$102,071	

DIRECT COST BREAKDOWN: DIVISION 12 - FURNISHINGS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 12				$0	

DIRECT COST BREAKDOWN: DIVISION 13 - SPECIAL CONSTRUCTION

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 13				$0	

DIRECT COST BREAKDOWN: DIVISION 14 - CONVEYING SYSTEM

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 14				$0	

DIRECT COST BREAKDOWN: DIVISION 15 - MECHANICAL

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
15A. BASIC MECHANICAL REQUIREMENT	1	LS	$5,000.00	$5,000	ESTIMATED
15B. PIPING AND APPURTENANCES					
1. HDPE PIPE, 1" DIA.	30	LF	$12.25	$368	MEANS SITE, 1993 151-551-4460
2. PVC PIPE, 4" DIA.	1000	LF	$16.55	$16,550	MEANS SITE, 1993 151-551-4480
3. PVC PIPE, 2" DIA.	25	LF	$12.25	$306	MEANS SITE, 1993 151-551-4460
4. FITTINGS	1	LS	$17,223.75	$17,224	ASSUMED 100% PIPE COST
15C. VALVES AND APPURTENANCES					
1. GATE VALVES	15	EACH	$100.00	$1,500	MEANS SITE, 1992
2. CHECK VALVES	8	EACH	$100.00	$800	MEANS SITE, 1992
15D. FLOWMETER	1	EACH	$1,500.00	$1,500	VENDOR QUOTE
INSTALLATION	1	LS	$1,500.00	$1,500	100% FLOWMETER COST
15E. PLUMBING	1	LS	$5,000.00	$5,000	ESTIMATED
SUBTOTAL DIVISION 15				$49,748	

DIRECT COST BREAKDOWN: DIVISION 16 - ELECTRICAL

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
16A. ELECTRICAL SYSTEM					
1. GENERAL ELECTRICAL WORK	1	LS	25%	$25,518	ESTIMATED AT 25% OF DIV 11 COSTS
2. INSTALLED COST OF ELECTRICAL	9,000	LF	$20.00	$180,000	MEANS ELECTRICAL, 1994 - OVERHEAD ROUTIN
SUBTOTAL DIVISION 16				$205,518	

ALTERNATIVE 69GW-3

CONCEPTUAL DESIGN - GROUNDWATER AT 100 GPM

30 YEAR PRESENT WORTH COST ESTIMATE

COST COMPONEN	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
1. Capital Cost	$1,047,055	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$0	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717
3. Annual Expenditures	$1,047,055	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717
4. Discount Factors Discount 5 %	1.0000	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107	0.6768	0.6446	0.6139
5. Present Worth	$1,047,055	$64,492	$61,421	$58,496	$55,711	$53,058	$50,531	$48,125	$45,833	$43,651	$41,572

COST COMPONEN	YEAR										
	11	12	13	14	15	16	17	18	19	20	21
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717
3. Annual Expenditures	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717
4. Discount Factors Discount 5 %	0.5847	0.5568	0.5303	0.5051	0.4810	0.4581	0.4363	0.4155	0.3957	0.3769	0.3589
5. Present Worth	$39,593	$37,707	$35,912	$34,202	$32,573	$31,022	$29,545	$28,138	$26,798	$25,522	$24,306

COST COMPONEN	YEAR									TOTAL PRESENT WORT FOR 30 YEARS
	22	23	24	25	26	27	28	29	30	
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	
2. O & M Cost	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	
3. Annual Expenditures	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	$67,717	
4. Discount Factors Discount 5 %	0.3418	0.3256	0.3101	0.2953	0.2812	0.2678	0.2551	0.2429	0.2314	
5. Present Worth	$23,149	$22,047	$20,997	$19,997	$19,045	$18,138	$17,274	$16,452	$15,668	$2,088,027

MCB Camp Lejeune North Carolina
Operable Unit Number 4 Site 69
Groundwater Treatment System - Alternative 69GW-3
Estimate of Annual Operation & Maintenance Costs - 100 GPM Facility

Item No.	Description	Unit	Unit Cost	Hours Per Day	Days Per Year	Total Annual Cost
1	Routine Operations	Hours	$29.10	4	180	$20,952
2	Sampling	Hours	$29.10	8	12	$2,794
	Total Items 1-2					*$23,746*
Item No.	**Sampling**	**Unit**	**Unit Cost**		**Samples Year**	**Cost Per Year**
4	NPDES Metals	Sample	$305.00		12	$3,660
5	Miscellaneous	Sample	$50.00		12	$600
6	TCL Volatiles	Sample	$210.00		12	$2,520
7	TCL Semi-Volatiles	Sample	$450.00		12	$5,400
8	PCBs/Pesticides	Sample	$175.00		12	$2,100
	Total Items 4-8					*$14,280*
	Electrical Costs Cost /KWH =	**$0.10**	**Size**	**Efficiency**	**Utilization**	**Cost Per Year**
6	Influent Pumps	Horsepower	1	70%	50%	$229
7	Chemical Feed	Horsepower	0.25	40%	50%	$33
8	Air Compressor	Horsepower	10	70%	30%	$1,372
9	Mixers/Agitators	Horsepower	2	60%	50%	$392
11	Air Blower	Horsepower	5	70%	80%	$1,830
12	Groundwater Pumps	Horsepower	4	60%	40%	$627
13	Miscellaneous	Horsepower	2	70%	50%	$457
	Total Items 6-13					*$4,940*
	Treatment Reagents	**Unit**	**Unit Cost**	**GPM (lb/min)**	**Annual Consumption**	**Annual Cost**
14	Sequestering Agent	Ton	$285.00		12	$3,420
	Total Item 14					*$3,420*
	Disposal				**Annual Volume**	**Annual Cost**
	Total					*$0*
	Other Costs	**Description**				**Annual Cost**
16	Equipment Maintenance	Percentage of Division of 11 Cost			3%	$3,062
17	GW Monitoring	Lump Sump Cost / Yr				$15,894
18	Administrative	Percentage of Routine Labor Items			10%	$2,375
	Total Items 16-18					*$21,331*

Total Annual O&M Cost	**$67,717**

ALTERNATIVE 69GW-4

INDIRECT COSTS AND SUMMARY OF TOTAL COSTS - 125 GPM SYSTEM IN OPERATION FOR 15 YEARS

TOTAL INDIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE	% OF COST	BASIS OF ESTIMATE
1. ENGINEERING AND DESIGN	$71,264	8%	OF TOTAL DIRECT COST
2. DESIGN AND CONSTRUCTION ADMIN.	$44,540	5%	OF TOTAL DIRECT COST
3. HEALTH AND SAFETY	$26,724	3%	OF TOTAL DIRECT COST
4. CONTINGENCY ALLOWANCE	$133,620	15%	OF TOTAL DIRECT COST
5. OTHER DIRECT COSTS A. START-UP AND SHAKE-DOWN	$71,264	8%	OF TOTAL DIRECT COST

SUMMARY OF COSTS:

TOTAL INDIRECT CAPITAL COST	$347,412		—
TOTAL DIRECT CAPITAL COST	$890,799		
TOTAL CAPITAL COSTS	$1,238,211		
TOTAL ANNUAL O&M COSTS	$98,183		
PRESENT WORTH OF ALTERNATIVE	$2,336,676		

ALTERNATIVE 69GW-4

SUMMARY OF DIRECT COSTS - 125 GPM PUMP AND TREAT SYSTEM WITH DPVE

TOTAL DIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE		BASIS OF ESTIMATE
DIRECT CAPITAL COST FOR SPECIAL REQUIREMENTS	$225,921		REFER TO DIRECT CAPITAL COST ESTIMATE FOR SPECIAL REQUIREMENTS
DIRECT CAPITAL COST FOR DIVISION 1 - GENERAL REQUIREMENTS	$147,000		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 1
DIRECT CAPITAL COST FOR DIVISION 2 - SITE WORK	$139,864		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 2
DIRECT CAPITAL COST FOR DIVISION 3 - CONCRETE	$22,877		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 3
DIRECT CAPITAL COST FOR DIVISION 4 - MASONRY	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 4
DIRECT CAPITAL COST FOR DIVISION 5 - METALS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 5
DIRECT CAPITAL COST FOR DIVISION 6 - WOOD AND PLASTICS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 6
DIRECT CAPITAL COST FOR DIVISION 7 - THERMAL AND MOISTURE PROTECTION	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 7
DIRECT CAPITAL COST FOR DIVISION 8 - DOORS, WINDOWS, AND GLASS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 8
DIRECT CAPITAL COST FOR DIVISION 9 - FINISHES	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 9
DIRECT CAPITAL COST FOR DIVISION 10 SPECIALTIES	$0		NO DIVISION 10 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 11 EQUIPMENT	$100,312		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 11
DIRECT CAPITAL COST FOR DIVISION 12 FURNISHINGS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 12
DIRECT CAPITAL COST FOR DIVISION 13 SPECIAL CONSTRUCTION	$0		NO DIVISION 13 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 14 CONVEYING SYSTEM	$0		NO DIVISION 14 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 15 MECHANICAL	$49,748		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 15
DIRECT CAPITAL COST FOR DIVISION 16 ELECTRICAL	$205,078		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 16
TOTAL DIRECT CAPITAL COST	$890,799		—

ALTERNATIVE 69GW-4

DIRECT COST BREAKDOWN BY DIVISION - 125 GPM PUMP AND TREAT SYSTEM WITH DPVE

DIRECT COST BREAKDOWN: SPECIAL REQUIREMENTS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
A. EROSION AND SEDIMENT CONTROL PLAN - IMPLEMENTATION					
1. GENERAL CONTRACT	1	JOB	$20,000.00	$20,000	ESTIMATED - PREVIOUS PROJECTS
B. OFFICE FACILITIES (INCLUDES PHONE SERVICE)					
1. GENERAL CONTRACT	1	JOB	$15,000.00	$15,000	ESTIMATED - PREVIOUS PROJECTS
C. PROGRESS ESTIMATES/ADMIN					
1. GENERAL/TRENCH CONTRACT	1	JOB	$12,500.00	$12,500	ESTIMATED, 52 HRS, $80/HR
D. DPVE SYSTEM					
Well Installation					
1. Construct Well, 20'/well	80	LF	$15.00	$1,200	EPA/600/R-92/173
2. Well Casing, 2'/well	8	LF	$5.00	$40	EPA/600/R-92/173
3. Well Screen, 18'/well	72	LF	$7.00	$504	EPA/600/R-92/173
4. Screen Backfill	2	CY	$20.00	$40	EPA/600/R-92/173
5. Bentonite Casing Seal	6	CF	$12.10	$74	1993 Site Means 071-301-0300
Piping and Valving					
1. System Extraction Piping, 4"	386	LF	$34.53	$13,319	1993 Mechanical Means 151-701-3360/3190
2. Gasket and bolt set, 4" piping	28	EA	$51.50	$1,442	1993 Mechanical Means 151-720-0670
3. Groundwater Piping, 1"	200	LF	$4.60	$920	1993 Mechanical Means 151-701-0580/1240
4. Threaded couplings, 1"	46	EA	$24.50	$1,120	1993 Mechanical Means 151-716-5710
5. Tracing	386	LF	$2.65	$1,022	Richardson 1993 Process Plant/Const Stds
6. Trap	5	EA	$500.00	$2,500	Richardson 1993 Process Plant/Const Stds
7. Insulation	386	LF	$3.04	$1,173	1993 Mechanical Means 155-651-7835
8. Valves, 6"	2	EA	$1,470.00	$2,940	Vendor Estimate
9. Valves, 4"	12	EA	$860.00	$10,320	Vendor Estimate
10. Valve/Gate Boxes	6	EA	$128.50	$771	1993 Site Means 026-690-8800
11. Tees, 6"	41	EA	$370.00	$15,223	1993 Mechanical Means 151-720-0420
12. Tees, 4"	3	EA	$270.00	$810	1993 Mechanical Means 151-720-0400
13. 90 deg. Elbows, 4"	8	EA	$174.00	$1,392	1993 Mechanical Means 151-720-0110
14. Central Header Pipe - 6"	150	LF	$60.16	$9,024	1993 Mechanical Means 151-701-3380/3190
15. Gasket and bolt set, 6" piping	103	EA	$70.00	$7,200	1993 Mechanical Means 151-720-0690
16. 90 deg. Elbows, 6"	3	EA	$260.00	$780	1993 Mechanical Means 151-720-0130
Treatment System Equipment					
1. Vacuum Pump System	1	EA	$75,000.00	$75,000	Vendor Estimate
2. Instrumentation/Control	1	EA	3.00%	$5,143	3% of Capital Costs
3. Vacuum Breaker	1	EA	$225.00	$225	EPA/600/R-92/173
4. Air/Water Separator	1	EA	$2,150.00	$2,150	EPA/600/R-92/173
5. Groundwater Pump	1	EA	$2,500.00	$2,500	Vendor Estimate
6. 1800 Gal Water Collection Tank	1	EA	$2,270.00	$2,270	1993 Mechanical Means 132-051-3100/3120
7. Vapor Phase Activated Carbon Unit	2	EA	$8,000.00	$16,000	Vendor Estimate
8. Install Carbon Unit	80	HR	$41.50	$3,320	1993 Means Mechanical
SUBTOTAL SPECIAL REQUIREMENTS				$225,921	

DIRECT COST BREAKDOWN: DIVISION 1 - GENERAL REQUIREMENTS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
1A. SUBMITTALS (WORK PLAN, HEALT AND SAFETY PLAN, ERROSION AND SEDIMENT CONTROL PLAN, ETC.)					
1. GENERAL CONTRACT	1	JOB	$40,000.00	$40,000	ESTIMATED - PREVIOUS PROJECTS
1B. MOBILIZATION/DEMOBILIZATION					
1. GENERAL CONTRACT	1	JOB	$100,000.00	$100,000	ESTIMATED - PREVIOUS PROJECTS
1C. DECONTAMINATION PAD	1	JOB	$7,000.00	$7,000	ESTIMATED - PREVIOUS PROJECTS
SUBTOTAL DIVISION 1				$147,000	

DIRECT COST BREAKDOWN: DIVISION 2 - SITE WORK

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
2B. CLEARING AND GRUBBING	3	ACRE	$2,625.00	$7,875	MEANS SITE, 1993: 021-104-0010
2D. EXCAVATION					
2. BASE SLAB	60	CY	$1.97	$118	MEANS SITE, 1993: 022-238-0200
3. INFLUENT/EFFLUENT PIPING TREN	500	CY	$5.08	$2,540	MEANS SITE, 1993: 022-238-0200
3. EXCAVATION FOR MANHOLE	15	CY	$5.08	$76	MEANS SITE, 1993: 022-238-0200
2E. BACKFILL					
1. AROUND SLAB	20	CY	$6.85	$137	MEANS SITE, 1993: 022-238-0200, 022-226-8050
2. INFLUENT/EFFLUENT PIPING TREN	500	CY	$6.85	$3,425	MEANS SITE, 1993: 022-238-0200, 022-226-8050
3. EXCAVATION FOR MANHOLE	15	CY	$6.85	$103	MEANS SITE, 1993: 022-238-0200, 022-226-8050
4. ROADWAY	9000	SY	$2.70	$24,300	MEANS SITE, 1994: 022-308-0100
2F. FENCING AND GATES	200	LF	$15.45	$3,090	MEANS SITE, 1993 028-308-0500
2G. EXTRACTION WELLS					
1. SHALLOW EXTN WELL INSTALL	3	EACH	$9,000.00	$27,000	PREVIOUS CONTRACT
2. DEEP EXTRACTION WELL INSTAL	4	EACH	$15,000.00	$60,000	PREVIOUS CONTRACT
2H. SITE REVEGETATION	3	ACRE	$2,000.00	$6,000	ESTIMATE
2L PIPING INSTALLATION					
1. 1" HDPE INFLUENT PIPING	400	LF	$2.50	$1,000	
2. 4" PVC EFFLUENT PIPING	1200	LF	$3.50	$4,200	
SUBTOTAL DIVISION 2				$139,864	

DIRECT COST BREAKDOWN: DIVISION 3 - CONCRETE

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
3A. CONCRETE FORMWORK					
1. 6"-SLAB ON GRADE	240	LF	$3.00	$720	MEANS SITE, 1994: 031-170-3000
3B. CONCRETE REINFORCEMENT					
1. 6"-SLAB ON GRADE	3	TONS	$2,000.00	$6,000	MEANS SITE, 1994: 032-107-0600
3C. JOINTS IN CONCRETE	150	LF	$2.71	$407	MEANS SITE, 1994: 031-132-0100
3D. CAST-IN-PLACE CONCRETE					
1. 6"-SLAB ON GRADE	65	CY	$150.00	$9,750	MEANS SITE, 1994: 033-130-4700
3E. PRECAST CONCRETE					
1. PRECAST MANHOLE	3	EACH	$2,000.00	$6,000	ESTIMATED
SUBTOTAL DIVISION 3				$22,877	

DIRECT COST BREAKDOWN: DIVISION 4 - MASONRY

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 4				$0	

DIRECT COST BREAKDOWN: DIVISION 5 - METALS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 5				$0	

DIRECT COST BREAKDOWN: DIVISION 6 - WOOD AND PLASTICS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 6				$0	

DIRECT COST BREAKDOWN: DIVISION 7 - THERMAL AND MOISTURE PROTECTION

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 7				$0	

DIRECT COST BREAKDOWN: DIVISION 8 - DOORS, WINDOWS, AND GLASS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 8				$0	

DIRECT COST BREAKDOWN: DIVISION 9 - FINISHES

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 9				$0	

DIRECT COST BREAKDOWN: DIVISION 10 - SPECIALTIES

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 10				$0	

DIRECT COST BREAKDOWN: DIVISION 11 - EQUIPMENT

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
11A. CHEMICAL MAKE-UP TANK W/MIX	1	EACH	$4,000.00	$4,000	VENDOR QUOTE
CHEMICAL FEED PUMP - 50 GAL.					
TANK/MIXER/PUMP INSTALLATIO	24	HOURS	$47.73	$1,146	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11B. MIXING TANK W/MIXER- 625 GAL.	1	EACH	$5,800.00	$5,800	VENDOR QUOTE
TANK/MIXER INSTALLATION	16	HOURS	$47.73	$764	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11C. HOLDING TANK - 1,000 GAL.	1	EACH	$3,000.00	$3,000	VENDOR QUOTE
TANK INSTALLATION	26	HOURS	$47.73	$1,241	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11E. EQUALIZATION TANK - 10,000 GAL.	1	EACH	$8,000.00	$8,000	VENDOR QUOTE
TANK INSTALLATION	26	HOURS	$47.73	$1,241	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11F. CENTRIFUGAL PUMPS					
FEED PUMPS - 125 GPM	2	EACH	$5,000.00	$10,000	PREVIOUS CONTRACT
PUMP INSTALLATION	96	HOURS	$47.73	$4,582	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11G. WELL PUMPS					
EXTRACTION WELL PUMPS	4	EACH	$3,500.00	$14,000	VENDOR QUOTE
PUMP INSTALLATION	72	HOURS	$47.73	$3,437	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11G. LOW PROFILE AIR STRIPPING UNIT	1	UNITS	$40,000.00	$40,000	VENDOR QUOTE FOR PRE-ENGINEERED AND PRE-FABRICATED TREATMENT PACKAGE;
INC: BLOWER; SUMP; START-UP TRAINING; SUBMITTAL PACKA O&M MANUALS					
AIR STRIPPER INSTALLATION	65	HOURS	$47.73	$3,102	RICHARDSONS ENGINEERING SERVICES, 1986
SUBTOTAL DIVISION 11				$100,312	

DIRECT COST BREAKDOWN: DIVISION 12 - FURNISHINGS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 12				$0	

DIRECT COST BREAKDOWN: DIVISION 13 - SPECIAL CONSTRUCTION

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 13				$0	

DIRECT COST BREAKDOWN: DIVISION 14 - CONVEYING SYSTEM

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 14				$0	

DIRECT COST BREAKDOWN: DIVISION 15 - MECHANICAL

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
15A. BASIC MECHANICAL REQUIREMEN	1	LS	$5,000.00	$5,000	ESTIMATED
15B. PIPING AND APPURTENANCES					
1. HDPE PIPE, 1" DIA.	30	LF	$12.25	$368	MEANS SITE, 1993 151-551-4460
2. PVC PIPE, 4" DIA.	1000	LF	$16.55	$16,550	MEANS SITE, 1993 151-551-4480
3. PVC PIPE, 2" DIA.	25	LF	$12.25	$306	MEANS SITE, 1993 151-551-4460
4. FITTINGS	1	LS	$17,223.75	$17,224	ASSUMED 100% PIPE COST
15C. VALVES AND APPURTENANCES					
1. GATE VALVES	15	EACH	$100.00	$1,500	MEANS SITE, 1992
2. CHECK VALVES	8	EACH	$100.00	$800	MEANS SITE, 1992
15D. FLOWMETER	1	EACH	$1,500.00	$1,500	VENDOR QUOTE
INSTALLATION	1	LS	$1,500.00	$1,500	100% FLOWMETER COST
15E. PLUMBING	1	LS	$5,000.00	$5,000	ESTIMATED
15F. VENTILATION EQUIPMENT					
SUBTOTAL DIVISION 15				$49,748	

DIRECT COST BREAKDOWN: DIVISION 16 - ELECTRICAL

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
16A. ELECTRICAL SYSTEM					
1. GENERAL ELECTRICAL WORK	1	LS	25%	$25,078	ESTIMATED AT 25% OF DIV 11 COSTS
2. INSTALLED COST OF ELECTRICAL	9,000	LF	$20.00	$180,000	MEANS ELECTRICAL, 1994 - OVERHEAD ROUTIN
SUBTOTAL DIVISION 16				$205,078	

ALTERNATIVE 69GW-4

CONCEPTUAL DESIGN - GROUNDWATER AT 125 GPM IN OPERATION FOR 15 YEARS

EAR PRESENT WORTH COST ESTIMATE

COST COMPONENT	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
1. Capital Cost	$1,238,211	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$0	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183
3. Annual Expenditures	$1,238,211	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183
4. Discount Factors Discount 5 %	1.0000	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107	0.6768	0.6446	0.6139
5. Present Worth	$1,238,211	$93,508	$89,055	$84,815	$80,776	$76,929	$73,266	$69,777	$66,454	$63,290	$60,276

COST COMPONENT	YEAR										
	11	12	13	14	15	16	17	18	19	20	21
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$98,183	$98,183	$98,183	$98,183	$98,183	$15,894	$15,894	$15,894	$15,894	$15,894	$15,894
3. Annual Expenditures	$98,183	$98,183	$98,183	$98,183	$98,183	$15,894	$15,894	$15,894	$15,894	$15,894	$15,894
4. Discount Factors Discount 5 %	0.5847	0.5568	0.5303	0.5051	0.4810	0.4581	0.4363	0.4155	0.3957	0.3769	0.3589
5. Present Worth	$57,406	$54,672	$52,069	$49,589	$47,228	$7,281	$6,934	$6,604	$6,290	$5,990	$5,705

COST COMPONENT	YEAR									TOTAL PRESENT WORT FOR 30 YEARS
	22	23	24	25	26	27	28	29	30	
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	
2. O & M Cost	$15,894	$15,894	$15,894	$15,894	$15,894	$15,894	$15,894	$15,894	$15,894	
3. Annual Expenditures	$15,894	$15,894	$15,894	$15,894	$15,894	$15,894	$15,894	$15,894	$15,894	
4. Discount Factors Discount 5 %	0.3418	0.3256	0.3101	0.2953	0.2812	0.2678	0.2551	0.2429	0.2314	
5. Present Worth	$5,433	$5,175	$4,928	$4,694	$4,470	$4,257	$4,054	$3,861	$3,678	$2,336,676

ALTERNATIVE 69GW-4

INDIRECT COSTS AND SUMMARY OF TOTAL COSTS - 125 GPM SYSTEM IN OPERATION FOR 30 YEARS

TOTAL INDIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE	% OF COST	BASIS OF ESTIMATE
1. ENGINEERING AND DESIGN	$71,264	8%	OF TOTAL DIRECT COST
2. DESIGN AND CONSTRUCTION ADMIN.	$44,540	5%	OF TOTAL DIRECT COST
3. HEALTH AND SAFETY	$26,724	3%	OF TOTAL DIRECT COST
4. CONTINGENCY ALLOWANCE	$133,620	15%	OF TOTAL DIRECT COST
5. OTHER DIRECT COSTS A. START-UP AND SHAKE-DOWN	$71,264	8%	OF TOTAL DIRECT COST

SUMMARY OF COSTS:

TOTAL INDIRECT CAPITAL COST	$347,412		---
TOTAL DIRECT CAPITAL COST	$890,799		
TOTAL CAPITAL COSTS	$1,238,211		
TOTAL ANNUAL O&M COSTS	$98,183		
PRESENT WORTH OF ALTERNATIVE	$2,747,530		

ALTERNATIVE 69GW-4

SUMMARY OF DIRECT COSTS - 125 GPM PUMP AND TREAT SYSTEM WITH DPVE

TOTAL DIRECT CAPITAL COST

COST COMPONENT	COST ESTIMATE		BASIS OF ESTIMATE
DIRECT CAPITAL COST FOR SPECIAL REQUIREMENTS	$225,921		REFER TO DIRECT CAPITAL COST ESTIMATE FOR SPECIAL REQUIREMENTS
DIRECT CAPITAL COST FOR DIVISION 1 - GENERAL REQUIREMENTS	$147,000		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 1
DIRECT CAPITAL COST FOR DIVISION 2 - SITE WORK	$139,864		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 2
DIRECT CAPITAL COST FOR DIVISION 3 - CONCRETE	$22,877		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 3
DIRECT CAPITAL COST FOR DIVISION 4 - MASONRY	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 4
DIRECT CAPITAL COST FOR DIVISION 5 - METALS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 5
DIRECT CAPITAL COST FOR DIVISION 6 - WOOD AND PLASTICS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 6
DIRECT CAPITAL COST FOR DIVISION 7 - THERMAL AND MOISTURE PROTECTION	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 7
DIRECT CAPITAL COST FOR DIVISION 8 - DOORS, WINDOWS, AND GLASS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 8
DIRECT CAPITAL COST FOR DIVISION 9 - FINISHES	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 9
DIRECT CAPITAL COST FOR DIVISION 10 SPECIALTIES	$0		NO DIVISION 10 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 11 EQUIPMENT	$100,312		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 11
DIRECT CAPITAL COST FOR DIVISION 12 FURNISHINGS	$0		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 12
DIRECT CAPITAL COST FOR DIVISION 13 SPECIAL CONSTRUCTION	$0		NO DIVISION 13 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 14 CONVEYING SYSTEM	$0		NO DIVISION 14 WORK ANTICIPATED
DIRECT CAPITAL COST FOR DIVISION 15 MECHANICAL	$49,748		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 15
DIRECT CAPITAL COST FOR DIVISION 16 ELECTRICAL	$205,078		REFER TO DIRECT CAPITAL COST ESTIMATE FOR DIVISION 16
TOTAL DIRECT CAPITAL COST	$890,799		—

ALTERNATIVE 69GW-4

DIRECT COST BREAKDOWN BY DIVISION - 125 GPM PUMP AND TREAT SYSTEM WITH DPVE

DIRECT COST BREAKDOWN: SPECIAL REQUIREMENTS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
A. EROSION AND SEDIMENT CONTROL PLAN - IMPLEMENTATION					
1. GENERAL CONTRACT	1	JOB	$20,000.00	$20,000	ESTIMATED - PREVIOUS PROJECTS
B. OFFICE FACILITIES (INCLUDES PHONE SERVICE)					
1. GENERAL CONTRACT	1	JOB	$15,000.00	$15,000	ESTIMATED - PREVIOUS PROJECTS
C. PROGRESS ESTIMATES/ADMIN					
1. GENERAL/TRENCH CONTRACT	1	JOB	$12,500.00	$12,500	ESTIMATED, 52 HRS, $80/HR
D. DPVE SYSTEM					
Well Installation					
1. Construct Well, 20'/well	80	LF	$15.00	$1,200	EPA/600/R-92/173
2. Well Casing, 2'/well	8	LF	$5.00	$40	EPA/600/R-92/173
3. Well Screen, 18'/well	72	LF	$7.00	$504	EPA/600/R-92/173
4. Screen Backfill	2	CY	$20.00	$40	EPA/600/R-92/173
5. Bentonite Casing Seal	6	CF	$12.10	$74	1993 Site Means 071-301-0300
Piping and Valving					
1. System Extraction Piping, 4"	386	LF	$34.53	$13,319	1993 Mechanical Means 151-701-3360/3190
2. Gasket and bolt set, 4" piping	28	EA	$51.50	$1,442	1993 Mechanical Means 151-720-0670
3. Groundwater Piping, 1"	200	LF	$4.60	$920	1993 Mechanical Means 151-701-0580/1240
4. Threaded couplings, 1"	46	EA	$24.50	$1,120	1993 Mechanical Means 151-716-5710
5. Tracing	386	LF	$2.65	$1,022	Richardson 1993 Process Plant/Const Stds
6. Trap	5	EA	$500.00	$2,500	Richardson 1993 Process Plant/Const Stds
7. Insulation	386	LF	$3.04	$1,173	1993 Mechanical Means 155-651-7835
8. Valves, 6"	2	EA	$1,470.00	$2,940	Vendor Estimate
9. Valves, 4"	12	EA	$860.00	$10,320	Vendor Estimate
10. Valve/Gate Boxes	6	EA	$128.50	$771	1993 Site Means 026-690-8800
11. Tees, 6"	41	EA	$370.00	$15,223	1993 Mechanical Means 151-720-0420
12. Tees, 4"	3	EA	$270.00	$810	1993 Mechanical Means 151-720-0400
13. 90 deg. Elbows, 4"	8	EA	$174.00	$1,392	1993 Mechanical Means 151-720-0110
14. Central Header Pipe - 6"	150	LF	$60.16	$9,024	1993 Mechanical Means 151-701-3380/3190
15. Gasket and bolt set, 6" piping	103	EA	$70.00	$7,200	1993 Mechanical Means 151-720-0690
16. 90 deg. Elbows, 6"	3	EA	$260.00	$780	1993 Mechanical Means 151-720-0130
Treatment System Equipment					
1. Vacuum Pump System	1	EA	$75,000.00	$75,000	Vendor Estimate
2. Instrumentation/Control	1	EA	3.00%	$5,143	3% of Capital Costs
3. Vacuum Breaker	1	EA	$225.00	$225	EPA/600/R-92/173
4. Air/Water Separator	1	EA	$2,150.00	$2,150	EPA/600/R-92/173
5. Groundwater Pump	1	EA	$2,500.00	$2,500	Vendor Estimate
6. 1800 Gal Water Collection Tank	1	EA	$2,270.00	$2,270	1993 Mechanical Means 132-051-3100/3120
7. Vapor Phase Activated Carbon Unit	2	EA	$8,000.00	$16,000	Vendor Estimate
8. Install Carbon Unit	80	HR	$41.50	$3,320	1993 Means Mechanical
SUBTOTAL SPECIAL REQUIREMENTS				$225,921	

DIRECT COST BREAKDOWN: DIVISION 1 - GENERAL REQUIREMENTS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
1A. SUBMITTALS (WORK PLAN, HEALT AND SAFETY PLAN, ERROSION AND SEDIMENT CONTROL PLAN, ETC.)					
1. GENERAL CONTRACT	1	JOB	$40,000.00	$40,000	ESTIMATED - PREVIOUS PROJECTS
1B. MOBILIZATION/DEMOBILIZATION					
1. GENERAL CONTRACT	1	JOB	$100,000.00	$100,000	ESTIMATED - PREVIOUS PROJECTS
1C. DECONTAMINATION PAD	1	JOB	$7,000.00	$7,000	ESTIMATED - PREVIOUS PROJECTS
SUBTOTAL DIVISION 1				$147,000	

DIRECT COST BREAKDOWN: DIVISION 2 - SITE WORK

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
2B. CLEARING AND GRUBBING	3	ACRE	$2,625.00	$7,875	MEANS SITE, 1993: 021-104-0010
2D. EXCAVATION					
2. BASE SLAB	60	CY	$1.97	$118	MEANS SITE, 1993: 022-238-0200
3. INFLUENT/EFFLUENT PIPING TREN	500	CY	$5.08	$2,540	MEANS SITE, 1993: 022-238-0200
3. EXCAVATION FOR MANHOLE	15	CY	$5.08	$76	MEANS SITE, 1993: 022-238-0200
2E. BACKFILL					
1. AROUND SLAB	20	CY	$6.85	$137	MEANS SITE, 1993: 022-238-0200, 022-226-8050
2. INFLUENT/EFFLUENT PIPING TREN	500	CY	$6.85	$3,425	MEANS SITE, 1993: 022-238-0200, 022-226-8050
3. EXCAVATION FOR MANHOLE	15	CY	$6.85	$103	MEANS SITE, 1993: 022-238-0200, 022-226-8050
4. ROADWAY	9000	SY	$2.70	$24,300	MEANS SITE, 1994: 022-308-0100
2F. FENCING AND GATES	200	LF	$15.45	$3,090	MEANS SITE, 1993 028-308-0500
2G. EXTRACTION WELLS					
1. SHALLOW EXT'N WELL INSTALL	3	EACH	$9,000.00	$27,000	PREVIOUS CONTRACT
2. DEEP EXTRACTION WELL INSTAL	4	EACH	$15,000.00	$60,000	PREVIOUS CONTRACT
2H. SITE REVEGETATION	3	ACRE	$2,000.00	$6,000	ESTIMATE
2I. PIPING INSTALLATION					
1. 1" HDPE INFLUENT PIPING	400	LF	$2.50	$1,000	
2. 4" PVC EFFLUENT PIPING	1200	LF	$3.50	$4,200	
SUBTOTAL DIVISION 2				$139,864	

DIRECT COST BREAKDOWN: DIVISION 3 - CONCRETE

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
3A. CONCRETE FORMWORK					
1. 6"-SLAB ON GRADE	240	LF	$3.00	$720	MEANS SITE, 1994: 031-170-3000
3B. CONCRETE REINFORCEMENT					
1. 6"-SLAB ON GRADE	3	TONS	$2,000.00	$6,000	MEANS SITE, 1994: 032-107-0600
3C. JOINTS IN CONCRETE	150	LF	$2.71	$407	MEANS SITE, 1994: 031-132-0100
3D. CAST-IN-PLACE CONCRETE					
1. 6"-SLAB ON GRADE	65	CY	$150.00	$9,750	MEANS SITE, 1994: 033-130-4700
3E. PRECAST CONCRETE					
1. PRECAST MANHOLE	3	EACH	$2,000.00	$6,000	ESTIMATED
SUBTOTAL DIVISION 3				$22,877	

DIRECT COST BREAKDOWN: DIVISION 4 - MASONRY

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 4				$0	

DIRECT COST BREAKDOWN: DIVISION 5 - METALS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 5				$0	

DIRECT COST BREAKDOWN: DIVISION 6 - WOOD AND PLASTICS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 6				$0	

DIRECT COST BREAKDOWN: DIVISION 7 - THERMAL AND MOISTURE PROTECTION

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 7				$0	

DIRECT COST BREAKDOWN: DIVISION 8 - DOORS, WINDOWS, AND GLASS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 8				$0	

DIRECT COST BREAKDOWN: DIVISION 9 - FINISHES

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 9				$0	

DIRECT COST BREAKDOWN: DIVISION 10 - SPECIALTIES

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 10				$0	

DIRECT COST BREAKDOWN: DIVISION 11 - EQUIPMENT

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
11A. CHEMICAL MAKE-UP TANK W/MIX	1	EACH	$4,000.00	$4,000	VENDOR QUOTE
CHEMICAL FEED PUMP - 50 GAL.					
TANK/MIXER/PUMP INSTALLATIO	24	HOURS	$47.73	$1,146	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11B. MIXING TANK W/MIXER- 625 GAL.	1	EACH	$5,800.00	$5,800	VENDOR QUOTE
TANK/MIXER INSTALLATION	16	HOURS	$47.73	$764	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11C. HOLDING TANK - 1,000 GAL.	1	EACH	$3,000.00	$3,000	VENDOR QUOTE
TANK INSTALLATION	26	HOURS	$47.73	$1,241	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11E. EQUALIZATION TANK - 10,000 GAL.	1	EACH	$8,000.00	$8,000	VENDOR QUOTE
TANK INSTALLATION	26	HOURS	$47.73	$1,241	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11F. CENTRIFUGAL PUMPS					
FEED PUMPS - 125 GPM	2	EACH	$5,000.00	$10,000	PREVIOUS CONTRACT
PUMP INSTALLATION	96	HOURS	$47.73	$4,582	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11G. WELL PUMPS					
EXTRACTION WELL PUMPS	4	EACH	$3,500.00	$14,000	VENDOR QUOTE
PUMP INSTALLATION	72	HOURS	$47.73	$3,437	RICHARDSONS ENGINEERING SERVICES, 1986 AND MEANS, 1993 PLUMBER W/ 1.15 H&S FACTO
11G. LOW PROFILE AIR STRIPPING UNIT INC: BLOWER; SUMP; START-UP TRAINING; SUBMITTAL PACKA O&M MANUALS	1	UNITS	$40,000.00	$40,000	VENDOR QUOTE FOR PRE-ENGINEERED AND PRE-FABRICATED TREATMENT PACKAGE;
AIR STRIPPER INSTALLATION	65	HOURS	$47.73	$3,102	RICHARDSONS ENGINEERING SERVICES, 1986
SUBTOTAL DIVISION 11				$100,312	

DIRECT COST BREAKDOWN: DIVISION 12 - FURNISHINGS

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 12				$0	

DIRECT COST BREAKDOWN: DIVISION 13 - SPECIAL CONSTRUCTION

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 13				$0	

DIRECT COST BREAKDOWN: DIVISION 14 - CONVEYING SYSTEM

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
SUBTOTAL DIVISION 14				$0	

DIRECT COST BREAKDOWN: DIVISION 15 - MECHANICAL

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
15A. BASIC MECHANICAL REQUIREMEN	1	LS	$5,000.00	$5,000	ESTIMATED
15B. PIPING AND APPURTENANCES					
1. HDPE PIPE, 1" DIA.	30	LF	$12.25	$368	MEANS SITE, 1993 151-551-4460
2. PVC PIPE, 4" DIA.	1000	LF	$16.55	$16,550	MEANS SITE, 1993 151-551-4480
3. PVC PIPE, 2" DIA.	25	LF	$12.25	$306	MEANS SITE, 1993 151-551-4460
4. FITTINGS	1	LS	$17,223.75	$17,224	ASSUMED 100% PIPE COST
15C. VALVES AND APPURTENANCES					
1. GATE VALVES	15	EACH	$100.00	$1,500	MEANS SITE, 1992
2. CHECK VALVES	8	EACH	$100.00	$800	MEANS SITE, 1992
15D. FLOWMETER	1	EACH	$1,500.00	$1,500	VENDOR QUOTE
INSTALLATION	1	LS	$1,500.00	$1,500	100% FLOWMETER COST
15E. PLUMBING	1	LS	$5,000.00	$5,000	ESTIMATED
15F. VENTILATION EQUIPMENT					
SUBTOTAL DIVISION 15				$49,748	

DIRECT COST BREAKDOWN: DIVISION 16 - ELECTRICAL

COST COMPONENT	QUANTITY	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
16A. ELECTRICAL SYSTEM					
1. GENERAL ELECTRICAL WORK	1	LS	25%	$25,078	ESTIMATED AT 25% OF DIV 11 COSTS
2. INSTALLED COST OF ELECTRICAL	9,000	LF	$20.00	$180,000	MEANS ELECTRICAL, 1994 - OVERHEAD ROUTIN
SUBTOTAL DIVISION 16				$205,078	

ALTERNATIVE 69GW-4

CONCEPTUAL DESIGN - GROUNDWATER AT 125 GPM IN OPERATION FOR 30 YEARS

YEAR PRESENT WORTH COST ESTIMATE

COST COMPONENT	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
1. Capital Cost	$1,238,211	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$0	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183
3. Annual Expenditures	$1,238,211	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183
4. Discount Factors Discount 5 %	1.0000	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107	0.6768	0.6446	0.6139
5. Present Worth	$1,238,211	$93,508	$89,055	$84,815	$80,776	$76,929	$73,266	$69,777	$66,454	$63,290	$60,276

COST COMPONENT	YEAR										
	11	12	13	14	15	16	17	18	19	20	21
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. O & M Cost	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183
3. Annual Expenditures	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183
4. Discount Factors Discount 5 %	0.5847	0.5568	0.5303	0.5051	0.4810	0.4581	0.4363	0.4155	0.3957	0.3769	0.3589
5. Present Worth	$57,406	$54,672	$52,069	$49,589	$47,228	$44,979	$42,837	$40,797	$38,855	$37,004	$35,242

COST COMPONENT	YEAR									TOTAL PRESENT WORT FOR 30 YEARS
	22	23	24	25	26	27	28	29	30	
1. Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	
2. O & M Cost	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	
3. Annual Expenditures	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	$98,183	
4. Discount Factors Discount 5 %	0.3418	0.3256	0.3101	0.2953	0.2812	0.2678	0.2551	0.2429	0.2314	
5. Present Worth	$33,564	$31,966	$30,444	$28,994	$27,613	$26,298	$25,046	$23,853	$22,717	$2,747,530

SITE 69: RIFLE RANGE CHEMICAL DUMP
ALTERNATIVE 69GW-5: IN SITU AIR SPARGING
DIRECT COST BREAKDOWN

COST COMPONENT	QUANTIT	UNITS	UNIT COST	TOTAL COST	REFERENCE/SOURCE
Erosion and Sediment Control Plan - Implementation	1	Job	$20,000	$20,000	Estimated - Previous Projects
Office Facilities (Includes Phone Service)	1	Job	$15,000	$15,000	Estimated - Previous Projects
Trenching	1	Job	$12,500	$12,500	Estimated, 52 Hrs, $80/Hr.
Well System - Deep Well Construction (10" Wells)	3	Each	$25,000	$75,000	Estimated for 10" Wells
Submittals (Work Plan, HASP, ESC Plan, etc.)	1	Job	$20,000	$20,000	Estimated - Previous Projects
Mobilization/Demobilization	1	Job	$10,000	$10,000	Estimated - Previous Projects
Decontamination Pad	1	Job	$2,000	$2,000	Estimated - Previous Projects
Clearing and Grubbing	3	Acre	$2,625	$7,875	Means Site, 1993: 021-104-0010
Installation of Electrical System	1000	LF	$20	$20,000	Means Electrical, 1994 - Overhead Routing
TOTAL DIRECT CAPITAL COST				$182,375	

SITE 69: RIFLE RANGE CHEMICAL DUMP
ALTERNATIVE 69GW-5: IN SITU AIR SPARGING
DIRECT AND INDIRECT COST SUMMARY

COST COMPONENT	COST ESTIMATE	% OF COST	BASIS OF ESTIMATE
Total Direct Cost	$182,375	---	---
Engineering and Design	$10,943	6%	of Total Direct Cost
Design and Construction Admin	$9,119	5%	of Total Direct Cost
Health and Safety	$5,471	3%	of Total Direct Cost
Contingency Allowance	$27,356	15%	of Total Direct Cost
Other Direct Costs	$10,943	6%	of Total Direct Cost
TOTAL INDIRECT COST	$63,831		
TOTAL CAPITAL COST	$246,206		

SITE 69: RIFLE RANGE CHEMICAL DUMP
ALTERNATIVE 69GW-5: IN SITU AIR SPARGING
ANNUAL OPERATION & MAINTENANCE COSTS (YEARS 1 - 30)

COST COMPONENT	UNIT	UNIT COST	QUANTITY	DURATION	TOTAL COST
Routine operations	Hrs	29.1	4	52 weeks	$6,053
Air Sampling	Sample	600	3	4 per year	$7,200
Electrical Costs	LS	4800	1	1 per year	$4,800
Carbon Replacement	LB	2	2000	1 year	$4,000
Equipment Maintenance	%	---	1%	of Capital	$1,824
Groundwater Monitoring				See Page 4	$14,964
Administrative	%	---	10%	of Routine Operations	$605
TOTAL O & M COSTS					$39,446

SITE 69: RIFLE RANGE CHEMICAL DUMP
ALTERNATIVE 69GW-5: IN SITU AIR SPARGING
O & M COST ESTIMATE FOR GROUNDWATER MONITORING

COST COMPONENT	UNIT	QUANTITY	UNIT COST	SUBTOTAL COST	TOTAL COST	SOURCE	BASIS/COMMENTS
O & M COST ESTIMATE							
(SEMIANNUAL SAMPLING - YEARS 1 - 30)							
Groundwater Monitoring							
Labor	Hours	96	$40	$3,840		Engineering Estimate	Semiannual sampling of 8 locations 2 samplers, 3 hours per location 2 events per year
Laboratory Analysis - VOCs	Sample	24	$155	$3,720		Baker Average 1994 BOAs	Semiannual sampling of 8 locations GW samples - 8 from wells, 4 QA/QC
Misc. Expenses	Sample Event	2	$1,886	$3,772		1994 JTR, Vendor Quote	Includes travel, lodging, air fare, supplies, truck rental, equipment, cooler shipping
Report	Sample Event	2	$1,500	$3,000		Engineering Estimate	One report per sampling event
Well Maintenance	Year	1	$632	$632		Engineering Estimate	Includes repainting and annualized cost of replacing 1 well every five years
Subtotal O & M Cost					$14,964		
CAPITAL COST ESTIMATE							
No Capital Costs					0		
ANNUAL O & M COSTS (Years 1 - 5)					$14,964		
TOTAL CAPITAL COSTS					$0		

SITE 69: RIFLE RANGE CHEMICAL DUMP
ALTERNATIVE 69GW-5: IN SITU AIR SPARGING
30 YEAR PRESENT WORTH COST ESTIMATE

COST COMPONENT	YEAR										
	0	1	2	3	4	5	6	7	8	9	10
Total Capital Cost	$246,206	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O & M Cost	$0	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446
Total Annual Cost	$246,206	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446
Discount Factor at 5%	1.0000	0.9524	0.9070	0.8638	0.8227	0.7835	0.7462	0.7107	0.6768	0.6446	0.6139
Present Worth Cost	$246,206	$37,568	$35,777	$34,073	$32,452	$30,906	$29,434	$28,034	$26,697	$25,427	$24,216

COST COMPONENT	YEAR										
	11	12	13	14	15	16	17	18	19	20	21
Total Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O & M Cost	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446
Total Annual Cost	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446
Discount Factor at 5%	0.5847	0.5568	0.5303	0.5051	0.4810	0.4581	0.4363	0.4155	0.3957	0.3769	0.3589
Present Worth Cost	$23,064	$21,963	$20,918	$19,924	$18,973	$18,070	$17,210	$16,390	$15,609	$14,867	$14,157

COST COMPONENT	YEAR									
	22	23	24	25	26	27	28	29	30	
Total Capital Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	
O & M Cost	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	
Total Annual Cost	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	$39,446	
Discount Factor at 5%	0.3418	0.3256	0.3101	0.2953	0.2812	0.2678	0.2551	0.2429	0.2314	
Present Worth Cost	$13,483	$12,844	$12,232	$11,648	$11,092	$10,564	$10,063	$9,581	$9,128	$852,571