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04.10-3/17/95-00231

CORRECTIVE ACTION PLAN
OPERABLE UNIT NO. 5, SITE 2

MARINE CORPS BASE,
CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0174

MARCH 17, 1995

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared By:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

DIVISION OF ENVIRONMENTAL MANAGEMENT
CERTIFICATION FOR THE SUBMITTAL OF A CORRECTIVE ACTION PLAN
UNDER 15A NCAC 2L.0106(1)

Responsible Party: Department of the Navy, LANTDIV
Address: Naval Facilities Engineering Command
City: Norfolk, State: VA, Zip Code: 23511

Site Name: Marine Corps Base, Camp Lejeune
Address: Operable Unit No. 5
City: Camp Lejeune, Co.: Onslow, Zip Code: 28542

Groundwater Section Incident Number: _____

I, Don P. Joiner, a Professional Engineer/~~Licensed Geologist~~ (circle one) for Baker Environmental, Inc. do hereby certify that the information indicated below is enclosed as part of the required Corrective Action Plan (CAP) and that to the best of my knowledge the data, site assessments, engineering plans and other associated materials are correct and accurate.

(Each item must be initialed by hand by the certifying licensed professional)

1. N/A A listing of the names and addresses of those individuals required to be notified to meet the notification requirements of 15A NCAC 2L .0114(b) are enclosed. Copies of letters and certified mail receipts are also enclosed.

2. DPJ A Professional Engineer or Licensed Geologist has prepared, reviewed, and certified all applicable parts of the CAP in accordance with 15A NCAC 2L .0103(e).

3. DPJ A site assessment is attached or on file with the appropriate Regional Office which provides the information required by 15A NCAC 2L .0106(g).

4. DPJ A description of the proposed corrective action and supporting justification is enclosed.

5. DPJ A schedule for the implementation of the CAP is enclosed.

6. DPJ A monitoring plan is enclosed which has the capacity to evaluate the effectiveness of the remedial activity and the movement of the contaminant plume, and which meets the requirements of 15A NCAC 2L .0110 and .0106(1).

7. DPJ The activity which resulted in the contamination incident is not permitted by the State as defined in 15A NCAC 2L.0106(e).

(OVER)

In addition, the undersigned also certifies that to the best of my knowledge and professional judgement and in accordance with the requirements of 15A NCAC 2L.0106(1), the following determinations have been made and are documented in the CAP:

8. N/A all free product has been removed to the extent practicable in accordance with 15A NCAC 2L .0106(f). (See guidance document).

9. DPJ all sources of contamination have been removed or controlled in accordance with 15A NCAC .0106(f) and (l). (See guidance document).

10. DPJ the contaminant has the capacity to degrade and attenuate under the site-specific conditions.

11. DPJ the time and direction of contaminant travel can be predicted with reasonable certainty.

12. DPJ the migration of the contaminant will not result in any violation of the standards specified in 15A NCAC 2L .0202 at any existing or foreseeable receptor.

13. DPJ the contaminants have not and will not migrate onto adjacent properties, or adjacent properties are served by public water supplies which cannot be influenced by contaminants migrating off-site, or adjacent landowners have consented in writing to a request allowing the contaminant upon their property.

14. DPJ all necessary access agreements needed to monitor groundwater quality have been or can be obtained.

(Please Affix Seal and Signature)

N/A - Not applicable because this site is progressing under the Superfund process, with its own notification (community relations) requirements.

NORTH CAROLINA PROFESSIONAL SEAL 16808 ENGINEER DON P JOINER

Don P Joiner

3/17/95

Note: Any modifications made to this form may result in the return of your submittal.

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/kg	microgram per kilogram
µg/L	Microgram per Liter
ARARs	Applicable or Relevant and Appropriate Requirements
Baker	Baker Environmental, Inc.
bgs	Below Ground Surface
BTEX	benzene, toluene, ethylbenzene, and total xylenes
CAP	Corrective Action Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	contaminant of potential concern
CTO	Contract Task Order
cu.yd.	cubic yard
DoN	Department of the Navy
EPIC	Environmental Photographic Interpretation Center
FFA	Federal Facilities Agreement
FSA	Former Storage Area
FSP	Field Sampling Plan
HI	Hazard Index
HQ	Hazard Quotient
IAS	Initial Assessment Study
ICR	Incremental Cancer Risk
IDW	Investigative Derived Wastes
LA	Lawn Area
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
MCB	Marine Corps Base
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
mg/kg	milligram per kilogram
MPA	Mixing Pad Area
msl	Mean Sea Level
Navy CLEAN	Comprehensive Long-Term Environmental Action Navy Program

NC DEHNR	North Carolina Department of Environmental, Health and Natural Resources
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCWQS	North Carolina Water Quality Standards
NPL	National Priorities List
NPW	Net Present Worth
O&M	Operation and Maintenance
PAH	polynuclear aromatic hydrocarbon
PCB	Polychlorinated Biphenyls
ppm	parts per million
PRAP	Proposed Remedial Action Plan
RAA	Remedial Action Alternative
RCRA	Resource Conservation and Recovery Act
RGO	remedial goal option
RI/FS	Remedial Investigation/Feasibility Study
RI	Remedial Investigation
RL	remediation level
ROD	Record of Decision
STP	Sewage Treatment Plant
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TCE	trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TCRA	time-critical removal action
TOC	Total Organic Carbon
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

CORRECTIVE ACTION PLAN

1.0 INTRODUCTION

This report presents the Corrective Action Plan (CAP) for Operable Unit No. 5 of the Marine Corps Base (MCB) Camp Lejeune, Onslow County, North Carolina. Operable Unit No. 5 is located at the intersection of Holcomb Boulevard and Brewster Boulevard, within MCB Camp Lejeune (Figure 1-1). Operable Unit No. 5 consists of one site, Site 2 (Former Nursery/Day Care Center). This CAP has been prepared by Baker Environmental, Inc. (Baker) for the Department of the Navy's Naval Facilities Engineering Command Atlantic Division (LANTDIV).

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 was to ensure that environmental impacts associated with past and present activities at the MCB were thoroughly investigated and appropriate CERCLA response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives were developed and implemented as necessary to protect public health and the environment.

Site 2 is generally divided into the Building 712 Area and the Former Storage Area (FSA). The Building 712 Area includes the Lawn Area (LA), Mixing Pad Area (MPA), and the Railroad Drainage Ditches. Site 2 is characterized by a relatively flat topography. It is underlain by unconsolidated deposits of sand, silt, and clay. Groundwater was encountered approximately 6 feet below the surface. The water table is relatively flat, with an estimated groundwater hydraulic gradient of 0.005 feet/feet. Shallow groundwater flow is to the northeast (Figure 1-2).

1.1 Site History/Purpose of CAP

From 1945 to 1958, Building 712 was used for the storing, handling, and dispensing of pesticides. Building 712 was later used as a children's day care center. Chemicals known to have been used include: chlordane, DDT, diazinon, and 2,4-D. Chemicals known to have been stored on site include dieldrin, lindane, malathion, silvex, and 2,4,5-T.

The mixing pads consist of two concrete slabs, each approximately 5 feet by 5 feet in size. The pads are located behind Building 712. The former mixing pads are in an area of suspected contamination. Above ground horizontal storage tanks were detected near the mixing pad area in a 1952 aerial photograph included in the Environmental Photographic Interpretation Center (EPIC) Study (EPIC, 1992). The tanks may have been used to store the chemicals/product. Contamination is believed to have occurred as a result of small spills, washout and excess product disposal. During the years of operation, it is reasonable to assume several gallons per year were involved; therefore, estimated quantity involved is on the order of 100 to 500 gallons of liquids containing various concentrations of product. Solid residues in cracks and crevasses may total 1 to 5 pounds. Potential discharges to Overs Creek are undocumented (Water and Air Research, 1983).

The FSA was used to store bulk materials and vehicles. The following items, within the FSA, were identified in aerial photos included in the EPIC Study:

- A railroad siding, extending from the main line into the FSA;
- A crane, possibly located on the railroad siding, that was apparently used to unload materials from railroad cars; and
- An area of possibly stained surface soil, present along the eastern border of this area.

The purpose of this report is to describe and provide supporting documentation for a CAP to monitor groundwater over an extended period of time in accordance with 15A NCAC 2L .0106(l), and the NC DEHNR, "Groundwater Section Guidelines for the Investigation and Remediation of Soils and Groundwater." NC DEHNR, Division of Environmental Management [DEM] - Groundwater Section, March 1993, revised November 1994.

1.2 Investigation and Study History

Investigations at Site 2 date back to 1983. The studies/investigations that have been conducted within Site 2 include:

- Initial Assessment Study of MCB Camp Lejeune (Water and Air Research, 1983)
- Confirmation Study for Site 2 (Environmental Science and Engineering, Inc., 1984 and 1986)
- Remedial Investigation/Feasibility Study (RI/FS) for Site 2 (Baker, 1994)

A copy of the RI/FS was provided to NC DEHNR during June 1994.

1.3 Nature and Extent of Contamination

RI activities included a soil (surface and subsurface) investigation, groundwater investigation (two rounds of groundwater sampling), and surface water/sediment investigation. Based on the results of the environmental investigations conducted at Site 2 during the RI, the following conclusions with respect to the nature and extent of contamination at the site were developed:

- Soil in the vicinity of the former mixing pads has been impacted by pesticide contamination. Detected pesticides include 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, heptachlor, alpha-chlordane, and gamma-chlordane. Concentrations of these contaminants range from less than 10 µg/kg to 3,000,000 µg/kg. Soil in this area has also been impacted by semivolatile organic compound (SVOC) contamination. The majority of these are polycyclic aromatic hydrocarbons (PAHs). The maximum SVOC concentration is 14,000 µg/kg. SVOC may be associated with past use of fuel (possibly diesel fuel) as a carrying agent for herbicides or for use in cleaning and operating spraying equipment.
- Pesticide contamination was detected in low concentrations (less than 100 µg/kg) throughout the remainder of Site 2. These concentrations are similar to base-specific background levels and are several orders-of-magnitude lower than

pesticide contaminant concentrations detected in the vicinity of the former mixing pads.

- Shallow groundwater in the Former Storage Area has been impacted by volatile organic compound (VOC) contamination. Ethylbenzene (2 - 190 µg/L) and xylenes (total) (1 - 1,800 µg/L) were detected in groundwater samples collected from shallow monitoring wells in the Former Storage Area. The area of highest VOC concentration is at monitoring well 2GW3. VOCs have been detected in this monitoring well during previous investigations. The extent of VOC contamination appears to be limited to the vicinity of the Former Storage Area.

- Inorganics were detected in groundwater samples collected from shallow monitoring wells at the site. One of these analytes exceeded Federal and North Carolina groundwater quality standards. The distribution of detected inorganics in shallow groundwater followed no discernible pattern. The highest concentrations of inorganics were detected in background monitoring wells (2GW9, 2GW8). The concentrations of detected inorganics is much greater in the unfiltered (total) samples than in the filtered (dissolved) samples. This indicates that the inorganics detected in groundwater samples at Site 2 are due predominantly to the presence of soil particles entrained in the groundwater samples and are not attributable to site operations. Some inorganics (arsenic, lead, barium, beryllium, and vanadium) were nonetheless retained as chemicals of concern in the baseline risk assessment.

- Trichloroethene (TCE) was detected at a low concentration (5 µg/L) in deep monitoring well 2GW3D. The extent of this contamination is unknown; however, deep groundwater quality in the Mainside of MCB Camp Lejeune is impacted by other operable units (OU Nos. 1 and 2). The presence of TCE in the deep aquifer is not likely associated with Site 2. TCE was not detected in this monitoring well during the second round of groundwater sampling.

- Sediment in the Railroad Drainage Ditch Area has been impacted by pesticide contamination. These contaminants include 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane. The maximum concentrations of pesticide contamination (250,000 µg/kg) are present in the immediate vicinity of the former mixing pads. PAHs were also detected in low concentrations (less than 200 µg/kg) in sediment from this area.

- Trace levels (less than 3 µg/L) of pesticides (4,4'-DDD and 4,4'-DDT) were detected in surface water samples collected in the Railroad Track Drainage Ditches. Carbon disulfide, a VOC, was detected (7 µg/L) in surface water from Overs Creek. Copper was also detected (7 µg/L) above applicable Federal and State surface water standards in Overs Creek.

1.4 Initial Remedial Actions

The laboratory analytical data generated during the RI indicate the presence of elevated concentrations of pesticides in soil and sediment near the former washing/mixing pads. Pesticide concentrations in several samples in this area exceeded the benchmark risk-based concentrations prepared by USEPA Region III (January 28, 1993). The benchmark risk-based concentration is a

value that equates to a 1E-6 cleanup action level. The pesticide concentrations were evaluated with respect to Removal Action Criteria outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The NCP lists a number of criteria that are considered in evaluating the appropriateness of a removal action. Section 300.415 paragraph (b)(2)(i) of 40 CFR directly applied to the conditions at Site 2.

300.415(b)(2)(i) "Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants."

The presence of pesticide contaminants in this area in concentrations exceeding USEPA benchmark risk-based concentrations indicated that they may have posed an imminent and substantial endangerment to public health, or welfare, or the environment. It was for this reason that a time-critical removal action (TCRA) to address contaminated soils was considered an appropriate measure.

Beginning in July, 1994, DoN began excavating contaminated soils and transporting them to an off-site hazardous waste incinerator. After the removal of contaminated soil was completed, confirmation sample test results revealed that the TCRA was successful. Approximately 1000 cubic yards of soil were removed from the site in order to meet the incremental lifetime cancer risk (ICR) goal of 1E-6. After implementation of the TCRA, soil is no longer a media of concern.

2.0 OBJECTIVES OF CAP

2.1 Goals

The proposed remedial action identified in this CAP is the overall strategy for the entire operable unit in that it addresses the media of concern, which is groundwater. The primary objectives of the selected remedy are: (1) to prevent future human exposure to the contaminated groundwater and (2) to insure, through monitoring, that there is no human or environmental exposure due to migration of the contaminant plume off site.

The major components of the selected remedy for this operable unit include:

- Restricting the installation of any new potable water supply wells within the vicinity of Site 2.
- Implementing a long-term groundwater monitoring program to monitor groundwater quality in site monitoring wells and nearby potable water supply wells.

In addition, the RI identified pesticide contaminated soil in the Mixing Pad Area, and sediment along the railroad tracks that may pose a threat to human health and the environment. This material was removed from Site 2 through a TCRA, which was conducted prior to implementing the groundwater remedial alternative at the site. The locations of the contaminated soil and sediment addressed in the TCRA are shown on Figure 2-1.

Surface water and sediment outside of the areas to be included in the TCRA will not be addressed under this action for the following reasons:

- The overall risk to human health posed by contaminants in the Railroad Track Drainage Ditches and Overs Creek are acceptable.

- Based on a comparison of surface water and sediment data to EPA Region IV, NOAA, Surface Water and Sediment Screening Values, adverse impacts to the benthic or fish communities are low.

- The groundwater remedial alternative and the removal of contaminated soil and sediment at the site will prevent future potential contamination of Overs Creek.

In summary, the primary objectives of the CAP are: (1) to prevent future human exposure to the contaminated groundwater, and (2) to insure, through monitoring, that there is no human or environmental exposure due to migration of the contaminant plume off site.

2.2 Remediation Levels

This section presents the Remediation Levels (RLs) chosen for OU No. 5. RLs are chosen by the risk manager for the Contaminants of Concern (COC), presented in Table 2-1, and may be considered required levels for the remedial actions to achieve.

The final COC are selected from that group of groundwater COC that were detected in concentrations exceeding the remedial goal options (RGO) defined in the risk assessment. The final COC and their associated RLs are presented in Table 2-2. This list was based on a comparison of contaminant-specific applicable or relevant and appropriate requirements (ARARs) and the Site-specific risk-based RGOs. If a COC had an ARAR, the most conservative of the risk-based RGO and the ARAR was selected for the RL.

In order to determine the final COC for OU No. 5, the contaminant concentrations detected at each site were compared to the RLs. The contaminants which exceeded at least one of the RLs were retained as final COC. The contaminants that did not exceed any of the RLs were no longer considered as COC with respect to the RI/FS and this CAP.

The final groundwater COC are trichloroethene, ethylbenzene, xylene (total), and lead. Contaminant source areas have been identified based on past operations and supporting analytical data. The groundwater monitoring results suggest that the sources of groundwater contamination are, or were, present in localized areas within Site 2. Organic contaminants were detected in wells located in the FSA. The source is or was most likely the result of previous site operations since the general groundwater flow is to the north and east. This source has been removed. The concentrations of organic and inorganic contaminants detected above Federal and North Carolina groundwater quality standards and inorganic chemicals of concern are presented in Figures 2-2 and 2-3, respectively.

2.3 Schedule

Target Startup / Completion

The corrective action for OU 5, Site 2 is scheduled to commence in 1995, and will continue for five years. At the conclusion of this first five year period, the groundwater situation will be re-evaluated; if the contamination persists, the proposed plan will continue for up to 25 additional years. If, however, there is no contamination evident after the first five years, the monitoring may be

discontinued. Thus, this CAP may end in the year 2000, but it is possible that the plan may not be concluded until 2025.

3.0 EXPOSURE ASSESSMENT

3.1 Human Health Risk Assessment

The human health risk assessment was conducted for several environmental media including surface soil, subsurface soil, groundwater, surface water, and sediments. Contaminants of potential concern (COPC) for each of these media were selected based on prevalence, mobility, persistence, and toxicity.

At the time when RI laboratory analytical results became available and were initially compiled, MCB Camp Lejeune/DoN determined that a TCRA was appropriate for the pesticide-contaminated soil and sediment in the vicinity of the MPA. Because a TCRA was implemented, the baseline risk assessment (included in the RI Report) considered risks to human health and the environment at this site under two scenarios:

- Risks to human health and the environment without (or before) the TCRA.
- Risks to human health and the environment with (or after) the TCRA.

Table 3-1 lists the COPC which were identified and assessed for each media. Note that COPC with respect to before and after the TCRA are presented on the table. For soil, groundwater, and sediment COPC included VOCs, SVOCs, pesticides, and inorganics. The surface water COPC included pesticides and inorganics.

The exposure routes evaluated in the human health risk assessment included ingestion, dermal contact, and particulate inhalation of surface soils; future potential ingestion and dermal contact of groundwater; and ingestion and dermal contact of surface water and sediments. Several exposed populations were evaluated in the risk assessment with respect to both current and future potential scenarios for the operable unit. For surface soil, current civilian base personnel and future on-site residents (adults and children) were retained as potential exposed populations. For groundwater future on-site residents (adults and children) were retained as potential exposed populations. Adults and adolescents were retained for current surface water and sediment exposures, while adults and children (1-6 years) were retained for future evaluation. In addition, subsurface soil was evaluated for the future construction worker.

As part of the risk assessment, incremental cancer risks (ICRs) and hazard indices (HIs) were calculated for each of the potentially exposed populations. An ICR refers to the cancer risk that is over and above the background cancer risk in unexposed individuals. ICRs are determined by multiplying the intake level with the cancer potency factor. The calculated risks are probabilities which are typically expressed in scientific notation (e.g., 1E-4). For example, an ICR of 1E-4 means that one additional person out of ten thousand may be at risk of developing cancer due to excessive exposure at the site if no actions are conducted. The USEPA acceptable target risk range is 1E-4 to 1E-6. Potential concern for noncarcinogenic effects of a single contaminant in a single medium is expressed as the hazard quotient (HQ). By adding the HQs for all contaminants within a medium or across all media to which a given population may reasonably be exposed, the HI can be generated. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media. The HI refers to

noncarcinogenic effects and is a ratio of the level of exposure to an acceptable level for all COPC. An HI greater than or equal to unity indicates that there may be a concern for noncarcinogenic health effects. Table 3-2 presents a summary of ICRs and HIs calculated for Site 2 with respect to before and after the TCRA.

After completion of the TCRA, total risk for civilian base personnel and construction worker receptors will have ICRs less than 1E-6 and HIs less than 1.0. Site risks remain (i.e., ICR greater than 1.0E-04 and HI greater than 1.0) for the child resident and adult resident (future) receptors due to groundwater contamination.

The total site risk at Overs Creek indicates that contamination from Site 2 is not appreciably migrating to the creek, and that adverse human health risks are not expected to occur due to contamination at Overs Creek.

Total risks remaining after the TCRA are attributable to contamination in the shallow groundwater on site. Therefore, the FS focused on developing remedial action alternatives for mitigating these risks. As groundwater was determined to be the media of concern at this site, groundwater COPC were reclassified as COCs in the FS.

3.2 Ecological Risk Assessment

An ecological risk assessment was conducted at Site 2 in conjunction with the RI. The objective of this risk assessment was to determine if past reported disposal activities are adversely impacting the ecological integrity of the terrestrial and aquatic habitats on, or adjacent to the site.

The results of the ecological risk assessment indicated the following:

- Pesticides in sediments along the drainage ditch and Overs Creek result in a potential decrease in the viability of aquatic receptors under both the no TCRA and the TCRA scenarios.

- Pesticides in the soil in the MPA result in a potential decrease in the viability of terrestrial receptors under the no TCRA scenario. Under the TCRA scenario, there is no decrease in the viability of terrestrial receptors.

- There is no decrease in viability of aquatic or terrestrial receptors in the FSA under either the no TCRA scenario or the TCRA scenario.

4.0 EVALUATION OF REMEDIAL ALTERNATIVES

4.1 Description of Alternatives

Soil and sediment in the vicinity of the MPA exhibit elevated concentrations of pesticide contaminants. However, these are being addressed in the TCRA. After the contaminated soils/sediments are removed, the potential human health risks associated with these two media will be reduced to an acceptable level, as indicated by an ICR value between 1E-4 to 1E-6 and an HI below 1.0. The remedial action alternatives (RAAs) were therefore developed to address contaminated groundwater at Site 2. Groundwater contamination is restricted to shallow groundwater in the FSA, near monitoring well 2GW3, where elevated levels of ethylbenzene (190

µg/L) and total xylenes (1800 µg/L) were detected. Figure 4-1 shows the general location of shallow groundwater contamination.

Six groundwater RAAs were developed and evaluated in the FS. A glossary of evaluation criteria is presented on Table 4-1. A brief overview of each of the RAAs is included below. All costs and implementation times are estimated.

The following groundwater RAAs were developed and evaluated for Site 2:

- RAA No. 1 No Action
- RAA No. 2 Institutional Controls/Long-Term Groundwater Monitoring
- RAA No. 3 Collection/Treatment/Discharge to a Sewage Treatment Plant
- RAA No. 4 Collection/Discharge to a Sewage Treatment Plant
- RAA No. 5 Collection/Discharge to Site 82 (Operable Unit No. 2)
- RAA No. 6 In Situ Treatment

Common Elements - Common elements between the RAAs are listed below.

- RAAs 2 through 6 will include institutional controls such as a long-term groundwater monitoring, and restrictions on the future use of the site and on the installation of potable water supply wells near the site. The monitoring activities will be conducted to gauge the effectiveness of the selected remedy. Restrictions will be placed on the operable unit to prohibit the installation of any new potable water supply wells in this area.

- RAAs 3 through 5 will include the extraction of contaminated groundwater followed by on-site or off-site treatment and discharge.

A description of each alternative as well as the estimated capital costs, annual operation and maintenance (O & M) costs, the net present worth (NPW) and timeframe to implement the alternative follows. The NPW is calculated over a period of 30 years, at a 5 percent interest rate:

- **RAA No. 1: No Action**

  Capital Cost: $0
  Annual O&M Costs: $0
  NPW: $0
  Months to Implement: None

  The No Action RAA is required under CERCLA to establish a baseline for comparison. Under this RAA, no further action at the operable unit will be implemented.

- **RAA No. 2: Institutional Controls/Long-Term Groundwater Monitoring**

  Capital Cost: $0
  Annual O&M Costs: $57,000 for Years 1 and 2, $28,550 for Years 3 through 5, and $15,475 for Years 6 through 30
  NPW: $350,000

Months to Implement: 3

RAA No. 2 will include the institutional controls that are common with RAA Nos. 2 through 6, as mentioned previously. The long-term monitoring program will consist of quarterly sampling and analysis of the groundwater from 12 existing monitoring wells and 3 nearby operational water supply wells for a period of two years. Samples will be collected semiannually during years three to five. Restrictions will be implemented which will restrict the installation of any new potable water supply wells within the vicinity of Site 2. After five years, the site will be reviewed, and the long-term monitoring program may be adjusted to annual sampling.

- **RAA No. 3: Collection/Treatment/Discharge to a Sewage Treatment Plant**

Capital Cost: $303,000
Annual O&M Costs: $162,760 for Years 1 and 2, $134,210 for Years 3 through 5, and $119,935 for Years 6 through 30
NPW: $1.89 million
Months to Implement: 15

Under RAA No. 3, the contaminated groundwater plume originating in the FSA near monitoring well 2GW3 will be extracted and treated on site. A network of three shallow extraction wells will be placed along the boundary of the plume. Each extraction well will be installed to a depth of 35 feet and pumped at a rate of approximately 5 gallons per minute (gpm). The extracted groundwater will be treated on site via a combination of applicable treatment options (or treatment train), and then discharged through a force main to a sanitary sewer which discharges to the Hadnot Point Sewage Treatment Plant (STP). The treatment train may consist, but not be limited to, filtration, neutralization, precipitation, air stripping, and activated carbon adsorption.

The overall objective of this RAA is to reduce the COC in the groundwater to drinking water standards for Class I aquifers and to mitigate the potential for further migration of the existing groundwater plume. The cone of influence created by the extraction wells is expected to reach the downgradient boundary of the plume. Groundwater extraction and treatment will be employed until the remediation objectives are met. In addition, this RAA includes the same institutional controls as Groundwater RAA No. 2.

- **RAA No. 4: Collection/Discharge to a Sewage Treatment Plant**

Capital Cost: $210,000
Annual O&M Costs: $106,220 for Years 1 and 2, $177,670 for Years 3 through 5, and $63,395 for Years 6 through 30
NPW: $1.3 million
Months to Implement: 15

Under RAA No. 4, the contaminated groundwater plume originating in the FSA near monitoring well 2GW3 will be extracted via an extraction well system as

discussed for RAA No. 3, and discharged untreated through a force main to a sanitary sewer, which discharges to the Hadnot Point STP.

The overall objective of this RAA is to reduce the COC in the groundwater to drinking water standards for Class I aquifers and to mitigate the potential for further migration of the existing groundwater plume. The cone of influence created by the extraction wells is expected to reach the downgradient boundary of the plume. Groundwater extraction and treatment will be employed until the remediation objectives are met. In addition, this RAA includes the same institutional controls as Groundwater RAA Nos. 2 and 3.

- **RAA No. 5: Collection/Discharge to Site 82 (O.U. No.2)**

Capital Cost: $323,000
Annual O&M Costs: $108,220 for Years 1 and 2, $79,670 for Years 2 through 5, and $65,395 for Years 6 through 30
NPW: $1.44 million
Months to Implement: 15

Under RAA No. 5, the contaminated groundwater plume originating in the FSA near monitoring well 2GW3 will be extracted via an extraction well system as discussed for RAA No. 3, and discharged untreated through a force main to a groundwater treatment system to be constructed at Site 82. At Site 82, the extracted groundwater will be treated via a treatment train similar to the one mentioned in RAA No. 3 (with the exception of size). Treated groundwater will be discharged to Wallace Creek.

The overall objective of this RAA is to reduce the COC in the groundwater to drinking water standards for Class I aquifers and to mitigate the potential for further migration of the existing groundwater plume. In addition, this RAA includes the same institutional controls as Groundwater RAA Nos. 2, 3, and 4.

- **RAA No. 6: In Situ Treatment**

Capital Cost: $124,000
Annual O&M Costs: $113,440 for Years 1 and 2, $84,890 for Years 3 through 5, and $70,615 for Years 6 through 30
NPW: $1.32 million
Months to Implement: 15

Under RAA No. 6, the contaminated groundwater plume originating in the FSA near monitoring well 2GW3 will be remediated via an air sparging and soil vapor extraction system. In this method, air will be injected into the groundwater through air sparging wells. The air acts to strip and remove the VOC contaminants from the groundwater. Soil venting wells will be placed to control air flow and to collect vapors within the vadose zone. The collected vapors would be treated to remove the contaminants prior to the air being vented to the atmosphere. No groundwater is removed in this alternative, therefore, groundwater does not have to be discharged to a STP or a watercourse.

The objective of this RAA is to reduce the COC in the groundwater to levels that meet drinking water standards for Class I aquifers, and to reduce the potential for further migration of the existing groundwater plume at Site 2. In addition, this RAA includes the same institutional controls as Groundwater RAA Nos. 2, 3, 4, and 5.

4.2 Summary of Analysis of Alternatives

In the FS, a detailed analysis was performed on the groundwater RAAs using the nine evaluation criteria in order to select a site remedy.

Table 4-2 presents a summary of this detailed analysis for the RAAs. A brief summary of each alternative's strengths and weaknesses with respect to the evaluation criteria follows. A glossary of the evaluation criteria has previously been noted in Table 4-1.

Overall Protection of Human Health and the Environment

RAA No. 1 (No Action) does not provide protection to human health or the environment. Under the Institutional Controls/Long-Term Groundwater Monitoring RAA (No. 2), institutional controls will provide protection to human health, although the potential for further migration of the contaminated groundwater still exists. All of the remaining Groundwater RAAs provide protection of human health and the environment. RAA Nos. 3, 4, 5, and 6 provide protection through preventing further migration of the contaminated groundwater plume and providing treatment. It should be noted that RAAs Nos. 3, 4, 5, and 6 may result in complete restoration of the plume over time; however, remediation will continue for many years.

Compliance with ARARs

Site-specific ARARs are summarized on Table 4-3, Table 4-4 (contaminant-specific), Table 4-5 (location-specific), and Table 4-6 (action-specific). RAA Nos. 1 and 2 will potentially exceed federal and state ARARs associated with the contaminants remaining in groundwater. RAA Nos. 3, 4, and 5 will potentially meet all of their respective ARARs for the treated effluent. In time, RAA Nos. 3, 4, 5, and 6 will meet the groundwater remediation objectives.

Long-Term Effectiveness and Permanence

RAA No. 1 will not reduce potential risks due to exposure to contaminated groundwater. Risks will be reduced under RAA Nos. 2 through 6 through the implementation of the institutional controls and/or treatment. Enforcing potable water supply well restrictions is effective in eliminating direct exposure to groundwater. RAAs 3 through 6 will provide additional long-term effectiveness and permanence because they use a form of treatment to reduce the potential hazards posed by the COC present in the groundwater aquifer.

All of the RAAs will require a 5-year review.

Reduction of Toxicity, Mobility, or Volume Through Treatment

No form of treatment is included under RAA Nos. 1 and 2. RAA Nos. 1 and 2 do not satisfy the statutory preference for treatment, whereas the other RAAs do satisfy the preference. All of the

"treatment" RAAs (RAA Nos. 3 through 6) will provide reduction of toxicity, mobility and/or volume of contaminants in the groundwater aquifers.

Short-Term Effectiveness

Risks to community and workers are not increased with the implementation of RAA Nos. 1 and 2. Current impacts, which are negligible from existing conditions will continue under these two RAAs. Under RAA Nos. 3, 4, 5, and 6, risks to the community and workers will be slightly increased due to a temporary increase in dust production and volatilization during the installation of the piping for the groundwater treatment system or piping system (during treatment operations for the workers). In addition, aquifer drawdown will occur under RAA Nos. 3, 4, and 5. This drawdown, however, should not result in any significant environmental effects.

Implementability

No construction, operation, or administrative activities are associated with RAA No. 1. There are no construction or operation activities associated with RAA No. 2 other than groundwater sampling, which is easily performed. RAA No. 3 will require operation of a groundwater pump and treatment system. RAA Nos. 4 and 5 will require operation of a groundwater extraction system only. RAA No. 6 will require operation of an in situ treatment system.

Cost

Costs for RAAs 1 through 6 are summarized below.

	Remedial Action Alternatives					
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Capital Costs	$0	$0	$303,000	$210,000	$323,000	$124,000
O&M Costs						
Years 1 & 2	$0	$57,100	$162,760	$106,220	$108,220	$113,440
Years 3-5	$0	$28,550	$134,210	$77,670	$79,670	$84,890
Years 6-30	$0	$15,475	$119,935	$63,395	$65,395	$70,615
Present Worth	$0	$350,000	$1,890,000	$1,300,000	$1,440,000	$1,320,000

4.3 Detailed Analysis of Selected Remedy

A selected remedy must satisfy the statutory requirements of CERCLA Section 121 which include:

- Be protective of human health and the environment.
- Comply with ARARs.
- Be cost-effective.
- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.

- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element, or provide an explanation as to why this preference is not satisfied.

The preferred RAA for Site 2 is Groundwater RAA No. 2, Institutional Controls with Long-Term Monitoring. The principal components of this RAA include institutional controls such as long-term groundwater monitoring, aquifer use restrictions, and land use restrictions. Based on available information, this alternative appears to provide the best balance with respect to the nine CERCLA evaluation criteria used to evaluate alternatives.

The evaluation of how the selected remedy for Site 2 satisfies these nine evaluation criteria in the NCP is presented below.

Protection of Human Health and the Environment

The selected remedy provides protection to human health and the environment through groundwater monitoring (to insure there is no off site migration of groundwater contaminants) and restriction on construction of new potable water supply wells. These restrictions, if carefully enforced, prevent groundwater ingestion and exposure, thereby satisfying the requirement to be protective of human health and the environment.

Compliance With Applicable or Relevant and Appropriate Requirements

The selected remedy will not immediately meet the federal and North Carolina groundwater standards, although long-term achievement of these standards is possible through natural biodegradation processes. Institutional controls are sufficient to protect human health and the environment and, therefore, compliance with chemical-specific ARARs may be impractical. Due to the isolated nature of the contaminated groundwater, the selected remedy will insure, through the long-term groundwater monitoring program, that no off-site migration of groundwater contaminants occurs. The selected remedy meets location-specific and action-specific ARARs.

There are a number of site-specific factors which contribute to the effectiveness/ appropriateness of the selected remedy. These factors, which support the decision to not cleanup the groundwater, include the following:

- There are no sources of groundwater contamination or free product remaining on the site.

- Organic contaminants which exceed the North Carolina groundwater standards (ethylbenzene and total xylenes) have the capacity to degrade and/or attenuate naturally under site-specific conditions. These contaminants have only been detected in concentrations exceeding the North Carolina groundwater standards in monitoring well 2GW3. Detected concentrations of ethylbenzene and total xylenes in monitoring well 2GW3 have decreased between Round 1 and Round 2 sampling events (Figure 2-2). In addition, contamination is limited to the shallow aquifer, which is not utilized as a source of drinking water.

- Inorganics were detected in groundwater samples collected from shallow monitoring wells at the site. Several of these analytes, based on total metals analysis, exceeded

federal and/or North Carolina groundwater quality standards. The distribution of detected inorganics in shallow groundwater followed no discernible pattern that would indicate a likely source. Many of the highest concentrations of inorganics were detected in background monitoring wells 2GW9 and 2GW8. The concentrations of detected inorganics is much greater in the unfiltered (total) samples than in the filtered (dissolved) samples. This indicates that the inorganics detected in groundwater samples at Site 2 may be due predominantly to the presence of soil particles entrained in the groundwater samples and may not be attributable to site operations. Some inorganics (arsenic, lead, barium, beryllium, and vanadium) were nonetheless retained as chemicals of concern in the baseline risk assessment.

- The existing groundwater monitoring network (12 monitoring wells) completely encircles the site. The selected remedy includes long-term monitoring of groundwater quality through collection of groundwater samples from these monitoring wells.

- The groundwater monitoring network can be utilized to predict time and direction of groundwater contaminant travel with reasonable certainty.

- The groundwater monitoring network will be utilized to ensure that groundwater contaminant migration will not result in any violation of applicable groundwater standards at any existing or foreseeable receptor.

- The groundwater monitoring network will be utilized to ensure that groundwater contaminants have not and will not migrate onto adjacent properties.

- The groundwater monitoring network will be utilized to ensure that groundwater contaminants will not discharge to surface waters in violation of applicable surface water standards.

- The long-term groundwater monitoring program included in the selected remedy will sufficiently track the degradation and attenuation of contaminants and contaminant byproducts within and downgradient of the plume and to detect contaminants and contaminant byproducts prior to their reaching any existing one year's time of travel upgradient of the receptor and no greater than the distance the groundwater at the contaminated site is predicted to travel in five years.

Cost Effectiveness

The selected remedy is highly cost-effective because it provides adequate protection of human health and the environment at a relatively low cost. The only RAA that incurs less cost is the No Action RAA, which may not be effective at protecting human health and the environment.

Utilization of Permanent Solutions and Alternative Treatment Technologies

The selected remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. Restricting the installation of additional potable supply wells is a permanent solution to potential groundwater exposure, if carefully enforced. Due to the isolated

nature of the contaminated groundwater and the lack of evidence of a contaminant source, use of alternative treatment technologies was deemed impracticable from an engineering and administrative standpoint.

Preference for Treatment as a Principal Element

The selected remedy does not satisfy the statutory preference for treatment as a principal element. Due to the isolated nature of the contaminated groundwater, the limited extent of contamination, and the minimal risks to the community and workers, use of treatment was deemed impracticable.

5.0 PROPOSED CORRECTIVE ACTION PLAN

This section of the CAP focuses on the selected remedy for Site 2. The major treatment components, engineering controls, and institutional controls of the remedy are discussed along with the estimated costs to implement the remedial action. In addition, the remediation objectives to be attained at the conclusion of the remedial action are discussed.

5.1 Remedy Description

The selected remedy for Site 2 is RAA No. 2, Institutional Controls/Long-Term Groundwater Monitoring. The major components of the selected remedy include:

- Implementing a long-term groundwater monitoring program to monitor on-site wells and nearby potable water supply wells. Under this program, groundwater from 12 existing monitoring wells and 3 nearby operational water supply wells will be collected and analyzed for the following parameters:

  - VOCs
  - Barium (total and filtered)
  - Beryllium (total and filtered)
  - Cadmium (total and filtered)
  - Chromium (total and filtered)
  - Lead (total and filtered)
  - Manganese (total and filtered)
  - Total suspended solids
  - Total dissolved solids

- Restricting the installation of new potable water supply wells in the vicinity of Site 2.

Based on the results of the RI/FS and all other available site information, the selected remedy is expected to meet the remediation objective of reducing the risk to human health due to groundwater exposure. The source of groundwater contamination has been removed and long-term groundwater monitoring will insure that there is no exposure to human health due to potential off-site migration of groundwater contaminants. In addition, restrictions on the installation of new potable water supply wells in the vicinity of Site 2 will prevent potential human health exposure.

The direction of groundwater movement has been established as flowing to the northeast based on a relatively flat hydraulic gradient (0.005 feet/feet). The flow velocity has been estimated in the RI

report (pp. 5-8 to 5-10) as 0.04 to 8.3 m/yr. Consistent with the requirements of 15A NCAC 2L .0106 for corrective action with respect to groundwater, Groundwater modeling calculations were performed to show that the contaminants (xylene at 1.8 mg/l) will not migrate onto adjacent properties or into a surface water body at a level that would violate NC WQS. A conservative model and assumptions were utilized as described in Appendix A. The calculated concentration at Owens Creek is 6.71E-44 mg/l. This value is so small that it is extraordinarily unlikely that any contaminant will migrate off-site or impact Owens Creek. Therefore, the proposed corrective action is an acceptable alternative.

5.2 Estimated Costs

The estimated capital cost associated with the selected remedy is $0. Annual O&M costs of approximately $57,100 are projected for administration of institutional controls and the quarterly sampling of the monitoring wells and supply wells for years 1 and 2. Approximately $28,550 are projected for the semiannual sampling in years 3 through 5 and $15,475 for the annual sampling in years 6 through 30. This annual cost is for 30 years. Assuming an annual percentage rate of 5 percent, these costs equate to a NPW of approximately $350,000. Table 5-1 presents the sources of information and subtotal costs for the major components of the selected remedy.

5.3 USEPA/State Acceptance

As documented in the Record of Decision (ROD), USEPA Region IV and the NC DEHNR have reviewed the Proposed Remedial Action Plan (PRAP) for Operable Unit 5. Both agencies are in agreement with the selected remedy (RAA No. 2, Institutional Controls/Long-Term Groundwater Monitoring) outlined in this ROD.

Because North Carolina groundwater standards (15A NCAC 2L.0106) for ethylbenzene, xylene, and total metals (barium, beryllium, cadmium, chromium, lead, and manganese) were exceeded in shallow monitoring wells, the Corrective Action Plan is being submitted to the NC DEHNR in accordance with 15A NCAC 2L.0106(k) and (l).

5.4 Community Acceptance

The selected remedy (RAA No.2, Institutional Controls/Long-Term Groundwater Monitoring) was presented to the community during the public comment period and during a public meeting. The limited number of Community comments, and the nature of these comments (refer to Section 11.0 - Responsiveness Summary of the ROD) indicate that the selected remedy has achieved community acceptance.

6.0 PERMITS

Because of the remedial alternative selected for Site 2, no permits will be required. However, because this alternative will result in a hazardous substance remaining on-site, a five-year review will be required in accordance with CERCLA. North Carolina Administrative Code, Title 15A, subchapter 2L, section .0106 (h) requirements will be followed with respect to the submission of monitoring results to the State.

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TABLES

TABLE 2-1

SUMMARY OF RGOs, BASIS OF GOAL AND CORRESPONDING RISK FOR GROUNDWATER COC
FUTURE CONSTRUCTION WORKER
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium	Contaminant of Concern	RGO	Unit	Basis of Goal	Corresponding Risk		Detected Concentration Range (µg/L)
					Carcinogenic	Noncarcinogenic	
Groundwater	Acenaphthene	50,637	µg/L	Noncarcinogenic Risk		HI = 1.0	ND - 2J
	Arsenic	50	µg/L	NCWQS			ND - 23.6
	Barium	2,000	µg/L	MCL/NCWQS			46 - 1,420
	Beryllium	4	µg/L	NCWQS			1 - 2
	4,4'-DDD	94	µg/L	Carcinogenic Risk	ICR = $1.0E^{-06}$		ND - 4J
	4,4'-DDT	50	µg/L	Carcinogenic Risk	ICR = $1.0E^{-06}$		ND - 9.4
	2,4-Dimethylphenol	16,923	µg/L	Noncarcinogenic Risk		HI = 1.0	ND - 6
	Ethylbenzene	29	µg/L	NCWQS			ND - 190
	Lead	15	µg/L	MCL/NCWQS			ND - 15.5
	2-Methylnaphthalene	24,211	µg/L	Noncarcinogenic Risk*		HI = 1.0	ND - 17
	Naphthalene	24,211	µg/L	Noncarcinogenic Risk		HI = 1.0	ND - 15
	Phenol	487,364	µg/L	Noncarcinogenic Risk		HI = 1.0	ND - 3
	Trichloroethene	2.8	µg/L	NCWQS			ND - 5
	Vanadium	5,908	µg/L	Noncarcinogenic Risk		HI = 1.0	9 - 89
	Xylene (total)	530	µg/L	NCWQS			ND - 1800J

Notes: RGO = Remediation Goal Option
ICR = Incremental Lifetime Cancer Risk. An ICR of $1.0E^{-06}$ indicates that, for a lifetime exposure, one additional case of cancer may occur per one million exposed individuals. USEPA considers ICRs of $1.0E^{-04}$ to $1.0E^{-06}$ to be protective of public health (USEPA,. 1989a).
HI = Hazard Index. A HI equal to or exceeding 1.0 suggests that noncarcinogenic health effects could occur.
NCWQS = North Carolina Water Quality Standards
MCL = Maximum Contaminant Level
ND = Not Detected
* Naphthalenes toxicity factor was used as a surrogate for 2-methylnaphthalene.

TABLE 2-2

FINAL COC AND REMEDIATION LEVELS
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium	Final Contaminant of Concern	Remediation Level (μg/L)	Basis of Remediation Level
Groundwater			
	Ethylbenzene	29	NCWQS
	Trichloroethene	2.8	NCWQS
	Xylene (total)	530	NCWQS
	Lead	15.5	MCL/NCWQS

Units: µg/L = microgram per liter

TABLE 3-1

SUMMARY OF CHEMICALS OF POTENTIAL CONCERN
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical of Potential Concern	Lawn and Mixing Pad Areas		Lawn and Mixing Pad Areas Time-Critical Removal Action		Former Storage Area		Former Storage Area Time-Critical Removal Action	
	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil
Volatile Organics								
Ethylbenzene						X		X
Toluene					X	X	X	X
Xylene (total)	X	X	X	X	X	X	X	X
Semivolatile Organics								
Acenaphthene		X						
Anthracene		X						
Fluoranthene		X						
Fluorene		X						
2-Methylnaphthalene		X						
Naphthalene		X						
N-Nitrosodiphenylamine		X						
Phenanthrene		X						
Pyrene		X						
Pesticides								
alpha-Chlordane	X	X	X	X				
gamma-Chlordane	X	X	X	X				
4,4'-DDD	X	X	X	X	X	X	X	X
4,4'-DDE	X	X	X	X	X	X	X	X
4,4'-DDT	X	X	X	X	X	X	X	X
Dieldrin	X							
Heptachlor	X	X						
Inorganics								
Arsenic	X	X	X			X		X

TABLE 3-1 (Continued)

SUMMARY OF CHEMICALS OF POTENTIAL CONCERN
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical of Potential Concern	Groundwater	Surface Water Drainage Ditches	Sediment Railroad Drainage Ditches	Sediment Time-Critical Removal Action Railroad Drainage Ditches	Sediment Overs Creek
Volatile Organics					
Ethylbenzene	X		X		
Trichloroethene	X				
Xylene (total)	X		X		
Semivolatile Organics					
Acenaphthene	X				
2-Methylnapthalene	X		X		
2,4-Dimethylphenol	X				
Naphthalene	X		X		
Phenol	X				
Pesticides					
alpha-Chlordane			X	X	
gamma-Chlordane			X	X	
4,4'-DDD	X	X	X	X	X
4,4'-DDE			X	X	X
4,4'-DDT	X	X	X	X	X
Dieldrin			X	X	
Endofulfan II			X		
Inorganics					
Arsenic	X	X	X		X
Barium	X				
Beryllium	X	X			
Lead	X				
Vanadium	X				

Note:X = denotes chemical was retained as a chemical of potential concern

TABLE 3-2

TOTAL SITE INCREMENTAL LIFETIME CANCER RISK AND HAZARD INDICES
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Receptors	Lawn and Mixing Pad Areas		Lawn and Mixing Pad Areas – Time Critical Removal Action		Former Storage Area		Former Storage Area – Time Critical Removal Action		Overs Creek	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Civilian Base Personnel	1E-4	1.3	5E-7	0.008	3E-7	0.004	3E-8	3E-4	--	--
Construction Worker	6E-7	0.1	1E-10	6E-5	4E-8	.005	4E-8	.005	--	--
Child Resident	2E-3	111	3E-4	11	3E-4	12	3E-4	11	--	--
Adult Resident	2E-3	23	7E-4	5	7E-4	5	7E-4	5	--	--
Trespassing Child	--	--	--	--	--	--	--	--	1E-7	1E-3
Trespassing Adult	--	--	--	--	--	--	--	--	9E-8	3E-4

Notes: ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index

Shading indicates that risk level is not within or fell above acceptable levels.

TABLE 4-1

GLOSSARY OF EVALUATION CRITERIA

- **Overall Protection of Human Health and Environment** - addresses whether or not an alternative provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment engineering controls or institutional controls.

- **Compliance with ARARs** - addresses whether or not an alternative will meet all of the applicable or relevant and appropriate requirements (ARARs) or other Federal and State environmental statutes.

- **Long-term Effectiveness and Permanence** - refers to the magnitude of residual risk and the ability of an alternative to maintain reliable protection of human health and the environment over time once cleanup goals have been met.

- **Reduction of Toxicity, Mobility, or Volume through Treatment** - is the anticipated performance of the treatment options that may be employed in an alternative.

- **Short-term Effectiveness** - refers to the speed with which the alternative achieves protection, as well as the remedy's potential to create adverse impacts on human health and the environment that may result during the construction and implementation period.

- **Implementability** - is the technical and administrative feasibility of an alternative, including the availability of materials and services needed to implement the chosen solution.

- **Cost** - includes capital and operation and maintenance costs. For comparative purposes, presents present worth values.

- **USEPA/State Acceptance** - indicates whether, based on review of the RI and FS reports and the PRAP, the USEPA and State concur with, oppose, or have no comments on the preferred alternative.

- **Community Acceptance** - evaluates the issues and concerns the public may have regarding each of the RAAs. This criterion is addressed in the ROD once the comments on the RI/FS reports and the PRAP have been received.

TABLE 4-2

SUMMARY OF DETAILED ANALYSIS - GROUNDWATER RAAs
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls/Long-Term Groundwater Monitoring	RAA No. 3 Collection/Treatment/ Discharge to a STP	RAA No. 4 Collection/Discharge to a STP	RAA No. 5 Collection/Discharge to Site 82	RAA No. 6 In-Situ Treatment
OVERALL PROTECTIVENESS • Human Health Protection	No reduction in risk.	Institutional controls provide protection against risk from groundwater ingestion.	Groundwater plume treated. Pump and treat provides protection against future potential risk from groundwater ingestion.	Groundwater plume treated. Pump and treat provides protection against future potential risk from groundwater ingestion.	Groundwater plume treated. Pump and treat provides protection against future potential risk from groundwater ingestion.	Groundwater plume treated. In-situ treatment provides protection against future potential risk from ingestion.
• Environmental Protection	Allows continued contamination of the groundwater.	Allows continued contamination of the groundwater. Potential natural attenuation of organic contaminants over time.	Migration of contaminated groundwater is reduced by pump and treat.	Migration of contaminated groundwater is reduced by pump and treat.	Migration of contaminated groundwater is reduced by pump and treat.	Level of groundwater contamination is reduced by in situ treatment.
COMPLIANCE WITH ARARs • Chemical-Specific ARARs	Will exceed Federal and/or NC groundwater quality ARARs.	Will exceed Federal and/or NC groundwater quality ARARs.	Should meet Federal and NC groundwater quality ARARs in time.	Should meet Federal and NC groundwater quality ARARs in time.	Should meet Federal and NC groundwater quality ARARs in time.	Should meet Federal and NC groundwater quality ARARs in time.
• Location-Specific ARARs	Not applicable.	Not applicable.	Will meet location-specific ARARs.	Will meet location-specific ARARs.	Will meet location-specific ARARs.	Will meet location-specific ARARs.
• Action-Specific ARARs	Not applicable.	Not applicable.	Will meet action-specific ARARs.	Will meet action-specific ARARs.	Will meet action-specific ARARs.	Will meet action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE • Magnitude of Residual Risk	As migration of groundwater continues, potential risks may increase.	Risk reduced to human health since the use of the groundwater aquifer is restricted.	Risk reduced by extracting contaminated groundwater.	Risk reduced by extracting contaminated groundwater.	Risk reduced by extracting contaminated groundwater.	Risk reduced by in-situ treatment of contaminated groundwater.
• Adequacy and Reliability of Controls	Not applicable - no controls.	Institutional controls are reliable if strictly enforced.	Groundwater pump and treat is reliable.	Groundwater pump and treat is reliable.	Groundwater pump and treat is reliable.	In-situ treatment demonstrated for COCs
• Need for 5-year Review	Review would be required to ensure adequate protection of human health and the environment is maintained.	Review would be required to ensure adequate protection of human health and the environment is maintained.	Review not needed once remediation goals are met.	Review not needed once remediation goals are met.	Review not needed once remediation goals are met.	Review not needed once remediation goals are met.

TABLE 4-2 (Continued)

SUMMARY OF DETAILED ANALYSIS - GROUNDWATER RAAs
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls/Long-Term Groundwater Monitoring	RAA No. 3 Collection/Treatment/ Discharge to a STP	RAA No. 4 Collection/Discharge to a STP	RAA No. 5 Collection/Discharge to Site 82	RAA No. 6 In-Situ Treatment
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT • Treatment Process Used	None.	None.	Treatment train for metals removal, air stripping, and activated carbon.	Physical and biological treatment at STP.	Treatment train at Site 82 for metals removal, air stripping, and activated carbon.	In-situ air sparging and soil venting for VOC removal.
• Amount Destroyed or Treated	None.	None.	Majority of contaminants in groundwater.	Majority of contaminants in groundwater.	Majority of contaminant in groundwater plumes.	Majority of contaminant in groundwater plumes.
• Reduction of Toxicity, Mobility or Volume	None.	None.	Reduced volume and toxicity of contaminated groundwater.	Reduced volume and toxicity of contaminated groundwater.	Reduced volume and toxicity of contaminated groundwater.	Reduced volume and toxicity of contaminated groundwater.
• Residuals Remaining After Treatment	Not applicable - no treatment.	Not applicable - no treatment.	Minimal residuals after goals are met.	Minimal residuals after goals are met.	Minimal residuals after goals are met.	Minimal residuals after goals are met.
• Statutory Preference for Treatment	Not satisfied.	Not satisfied.	Satisfied.	Satisfied.	Satisfied.	Satisfied.
SHORT-TERM EFFECTIVENESS • Community Protection	Risks to community not increased by remedy implementation.	Risks to community not increased by remedy implementation.	Potential risks to public health and environment during extraction and treatment due to equipment failure.	Potential risks to public health and environment during extraction and treatment due to equipment failure.	Potential risks to public health and environment during extraction and treatment due to equipment failure.	Potential risks to public health and environment during extraction and treatment due to equipment failure.
• Worker Protection	No significant risk to workers.	No significant risk to workers.	Protection required during treatment.	Protection required during treatment.	Protection required during treatment.	Protection required during treatment.
• Environmental Impacts	None	None	None	None	None	None
• Time Until Action is Complete	Not applicable.	Risks from potential groundwater ingestion reduced within 3 to 6 months due to institutional controls.	Thirty years used to determine NPW costs. Time for completion of remediation is unknown.	Thirty years used to determine NPW costs. Time for completion of remediation is unknown.	Thirty years used to determine NPW costs. Time for completion of remediation is unknown.	Thirty years used to determine NPW costs. Time for completion of remediation is unknown.

TABLE 4-2 (Continued)

SUMMARY OF DETAILED ANALYSIS - GROUNDWATER RAAs
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

Evaluation Criteria	RAA No. 1 No Action	RAA No. 2 Institutional Controls/Long-Term Groundwater Monitoring	RAA No. 3 Collection/Treatment/ Discharge to a STP	RAA No. 4 Collection/Discharge to a STP	RAA No. 5 Collection/Discharge to Site 82	RAA No. 6 In-Situ Treatment
IMPLEMENTABILITY						
• Ability to Construct and Operate	No construction or operation activities.	No construction or operation activities.	Installation and treatment technologies proven.	Installation and treatment technologies proven.	Installation and treatment technologies proven.	Installation and treatment technologies proven.
• Ability to Monitor Effectiveness	No monitoring. Failure to detect contamination will result in potential ingestion of contaminated groundwater.	Proposed monitoring will give notice of failure before significant exposure occurs.	Adequate system monitoring.	Adequate system monitoring.	Adequate system monitoring.	Requires indirect monitoring of system performance.
• Availability of Services and Capacities; Equipment	None required.	None required.	Groundwater extraction and treatment equipment is readily available.	Groundwater extraction equipment is readily available.	Groundwater extraction equipment is readily available.	System components readily available.
COSTS Net Present Worth	$0	$350,000	$1.89 million	$1.3 million	$1.44 million	$1.32 million

RAA = Remedial Aciton Alternative STP = Sewage Treatment Plant ARARs = Applicable or Relevant and Appropriate Requirements

TABLE 4-3

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CONTAMINANT-SPECIFIC CRITERIA OPERABLE UNIT NO. 5 (SITE 2) 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.	Remedial actions (e.g., air stripping) may result in release of hazardous air pollutants. The treatment design may elect to control equipment air emissions using the same or similar methods.
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.	Relevant and appropriate requirements for remedial actions requiring discharge to the atmosphere.
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 groundwater treatment.

TABLE 4-3 (Continued)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
AND TO BE CONSIDERED CONTAMINANT-SPECIFIC CRITERIA
OPERABLE UNIT NO. 5 (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
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.
North Carolina Groundwater Standards Applicable Statewide	Establishes maximum contaminant concentrations to protect groundwater. These standards are mandatory.	Potentially relevant and appropriate for remedial actions requiring discharge to groundwater.
North Carolina DEHNR Regulations	Standards for protection of health of consumers using public drinking water supplies. Establishes MCLs for given contaminants.	Potentially relevant and appropriate in developing remediation goals for contaminated groundwater used as a potable water supply.
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.	Potentially relevant and appropriate for remedial actions requiring discharge to the atmosphere.

TABLE 4-4

CONTAMINANT-SPECIFIC ARARs AND TO BE CONSIDERED CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

Groundwater Contaminant of Concern	MCL [1] (µg/L)	NCWQS [2] (µg/L)	Federal Health Advisories [3] (µg/L)	
			For a 10 kg Child Longer Term	For a 70 kg Adult Lifetime
Acenaphthene	--	--	--	--
Arsenic	50	50	--	2[4]
Barium	2,000	2,000	--	2,000
Beryllium	--	4	400	0.8[4]
4,4'-DDD	--	--	--	--
4,4'-DDT	--	--	--	--
2,4-Dimethylphenol	--	--	--	--
Ethylbenzene	700	29	1,000	700
Lead	15	15	--	--
2-Methylnaphthalene	--	--	--	--
Naphthalene	--	--	400	20
Phenol	--	--	6,000	4,000
Trichloroethene	5	2.8	--	300[4]
Vanadium	--	--	--	--
Xylene (total)	10,000	530	40,000	10,000

Notes: [1] MCL = Safe Drinking Water Act Maximum Contaminant Level (MCL for lead is an Action Level)

[2] NCWQS = North Carolina Water Quality Standards for Class GA Groundwater

[3] Health Advisories - to be considered criteria

[4] Level at 10-04 cancer risk

-- No ARAR available or established

TABLE 4-5

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED LOCATION-SPECIFIC CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
FEDERAL AND STATE/ LOCATION-SPECIFIC		
National Historic Preservation Act of 1966 16 USC 470, 40 CFR 6.301(b), and 36 CFR 800	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.	No known historic properties are within or near OU No. 5, therefore, this act will not be considered as an ARAR.
Archeological and Historic Preservation Act 16 USC 469 and 40 CFR 6.301(c)	Establishes procedures to provide for preservation of historical and archeological data which might be destroyed through alteration of terrain.	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 16 USC 461467 and 40 CFR 6.301(a)	Requires action to avoid undesirable impacts on landmarks on the National Registry of Natural Landmarks.	No known historic sites, buildings or antiquities are within or near OU No. 5, therefore, this act will not be considered as an ARAR.
Fish and Wildlife Coordination Act 16 USC 661-666	Requires action to protect fish and wildlife from actions modifying streams or areas affecting streams.	Overs Creek and the drainage ditch adjacent to the railroad tracks are located near and within the operable unit boundaries, respectively. If remedial actions are implemented that modify this creek or drainage channel, this will be an applicable ARAR.
Federal Endangered Species Act 16 USC 1531, 50 CFR 200, and 50 CFR 402	Requires action to avoid jeopardizing the continued existence of listed endangered species or modification of their habitat.	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). Therefore, this will be considered as an ARAR.
North Carolina Endangered Species Act GS 113-331 to 113-337	Per the North Carolina Wildlife Resources Commission. Similar to the Federal Endangered Species Act, but also includes State special concern species, State significantly rare species, and the State watch list.	Since the American alligator has been sighted in nearby surface water features, this will be considered as an ARAR.
Rivers and Harbors Act of 1899 (Section 10 Permit) 33 USC 403	Requires permit for structures or work in or affecting navigable waters.	No remedial actions will affect the navigable waters of the New River. Therefore, this act will not be considered as an ARAR.
Executive Order 11990 on Protection of Wetlands Executive Order Number 11990 and 40 CFR 6	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.	Based on a review of Wetland Inventory Maps, the lower reaches of Overs Creek has areas of wetlands. Therefore, this will be an applicable ARAR.

TABLE 4-5 (Continued)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED LOCATION-SPECIFIC CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
Executive Order 11988 on Floodplain Management Executive Order Number 11988, and 40 CFR 6	Establishes special requirements for Federal agencies to evaluate the adverse impacts associated with direct and indirect development of a floodplain.	Based on the Federal Emergency Management Agency's Flood Insurance Rate Map for Onslow County, the site is primarily within a minimal flooding zone (outside the 500-year floodplain). The creek is within the 100-year floodplain (FEMA, 1987). Therefore, this may be an ARAR for the operable unit.
Wilderness Act 16 USC 1131 and 50 CFR 35.1	Requires that federally owned wilderness area are not impacted. Establishes nondegradation, maximum restoration, and protection of wilderness areas as primary management principles.	No known federally owned wilderness areas near the operable unit exist, therefore, this act will not be considered as an ARAR.
National Wildlife Refuge System 16 USC 668, and 50 CFR 27	Restricts activities within a National Wildlife Refuge.	No known National Wildlife Refuge areas near the operable unit exist, therefore, this will not be considered as an ARAR.
Scenic Rivers Act 16 USC 1271, and 40 CFR 6.302(e)	Requires action to avoid adverse effects on designated wild or scenic rivers.	No known wild or scenic rivers near the operable unit exist, therefore, this act will not be considered as an ARAR.
Coastal Zone Management Act 16 USC 1451	Requires activities affecting land or water uses in a coastal zone to certify noninterference with coastal zone management.	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) 33 USC 404	Prohibits discharge of dredged or fill material into wetland without a permit.	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 40 CFR 264.18	Limitations on where on-site storage, treatment, or disposal of RCRA hazardous waste may occur.	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. Therefore, these requirements may be an applicable ARAR for the operable unit.

TABLE 4-6

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED ACTION-SPECIFIC CRITERIA OPERABLE UNIT NO. 5 (SITE 2) 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.	Remedial actions may include off-site treatment and disposal of contaminated groundwater. 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. Extraction and treatment and/or movement of RCRA hazardous waste may trigger LDR requirements for the waste. Reinjection of treated groundwater into or above an underground source of drinking water may be exempt from LDRs given the treatment of the groundwater meets exemption requirements.
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.	To be considered (TBC) as remedial action may include air stripping.

TABLE 4-6 (Continued)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED ACTION-SPECIFIC CRITERIA OPERABLE UNIT NO. 5 (SITE 2) MCB CAMP LEJEUNE, NORTH CAROLINA

ARAR Citation	Requirement	Consideration in the FS
General Pretreatment Regulations for Existing and New Sources of Pollutants (40 CFR Part 403)	Regulations promulgated under the Clean Water Act. Includes provisions for effluent discharge to Publicly Owned Treatment Works (POTW). Discharge of pollutants that pass through or interfere with the POTW, contaminate sludge, or endanger health/safety of POTW workers is prohibited. These regulations should be used in conjunction with local POTW pretreatment program requirements.	Applicable for remedial actions involving discharge to a sanitary sewer.
North Carolina Water Pollution Control Regulations (Title 15, Chapter 2, Section .0100)	Regulates point-source discharges through the North Carolina permitting program. Permit 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 to the ditches on site. The base currently has a North Carolina permit for surface water discharge to the ditch to the north of the site. This permit may need to be modified.
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.
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 sediment).

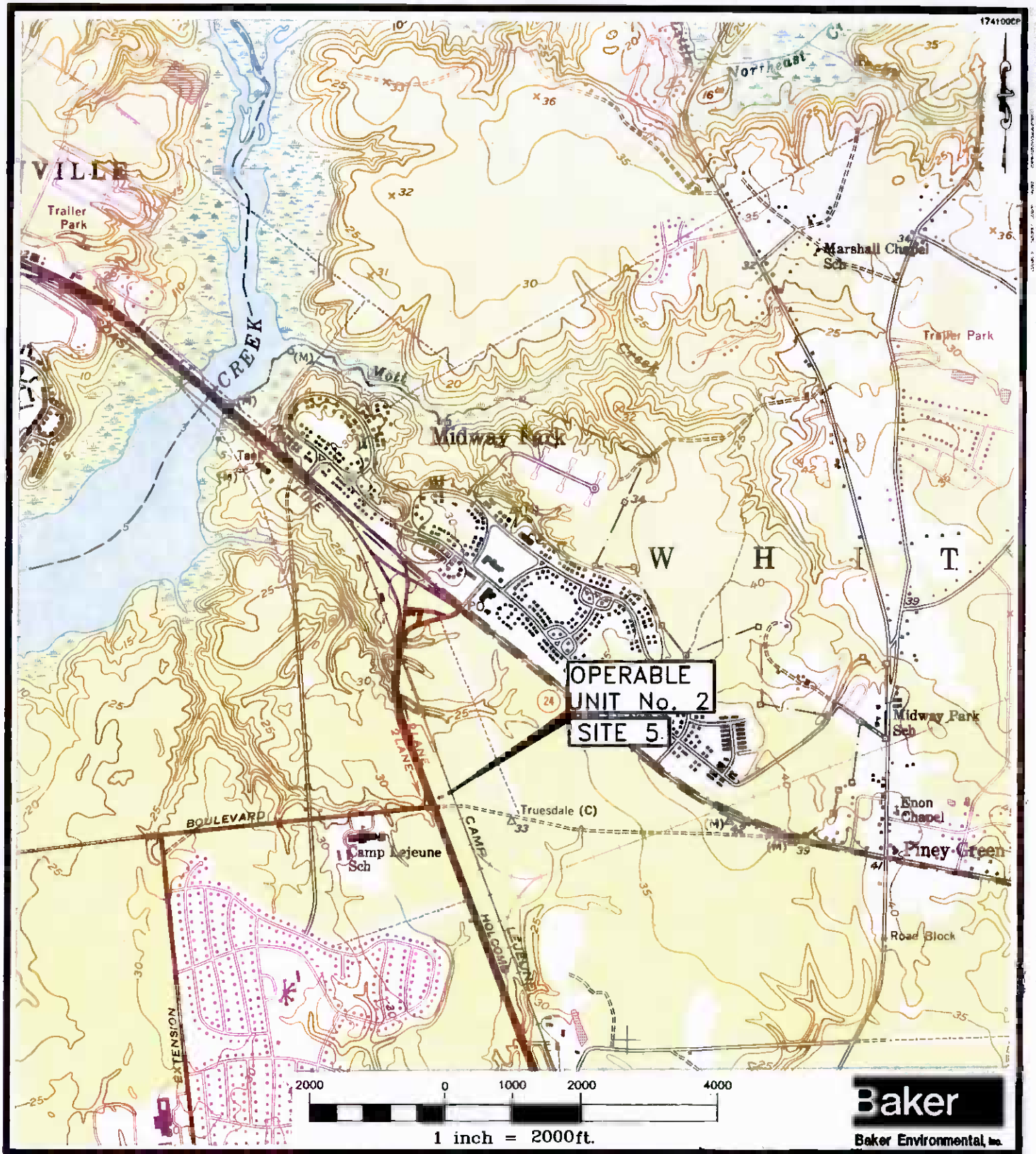
TABLE 5-1

DETAILED COSTING EVALUATION
GROUNDWATER REMEDIAL ACTION ALTERNATIVE NO. 2
OPERABLE UNIT NO. 5, (SITE 2)
MCB CAMP LEJEUNE, NORTH CAROLINA

O&M Cost Estimate 16-Jun-94

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Basis or Comments	Source
Groundwater Monitoring - Years 1-2						15 wells sampled quarterly.	
Labor	Hours	360	$35	$12,600		15 wells x 2 samplers x 3 hrs/well x 4 events	Engineering estimate
Lab. Analysis -TCL VOA/Metals	Sample	60	$375	$22,500		15 Samples; quarterly	Basic Ordering Agreement
Misc. Expenses	Sample Event	4	$2,500	$10,000		Incl. travel, lodging, supplies, - 2 people	Engineering estimate
Reporting	Sample Event	4	$3,000	$12,000		1 report per sampling event	Engineering estimate
Groundwater Monitoring - Years 3-5						15 wells sampled semiannually	
Labor	Hours	180	$35	$6,300		15 wells x 2 samplers x 3 hrs/well x 2 events	Engineering estimate
Lab. Analysis -TCL VOA/Metals	Sample	30	$375	$11,250		15 samples; semiannually	Basic Ordering Agreement
Misc. Expenses	Sample Event	2	$2,500	$5,000		Incl. travel, lodging, supplies, - 2 people	Engineering estimate
Reporting	Sample Event	2	$3,000	$6,000		1 report per sampling event	Engineering estimate
Groundwater Monitoring - Years 6-30						15 wells sampled annually	
Labor	Hours	90	$40	$3,600		15 wells x 2 samplers x 3 hrs/well x 1 event	Engineering estimate
Lab. Analysis -TCL VOA/Metals	Sample	15	$375	$5,625		15 samples; annually	Basic Ordering Agreement
Misc. Expenses	Sample Event	1	$27500	$2,750		Incl. travel, lodging, supplies, - 2 people	Engineering estimate
Reporting	Sample Event	1	$3,500	$3,500		1 report per sampling event	Engineering estimate
Total Annual O&M Costs, Years 1-2					$57,100	For years 1 and 2	
Total Annual O&M Costs, Years 3-5					$28,550	For years 3 through 5	
Total Annual O&M Costs, Years 6-30					$15,475	For years 6 through 30	
Approximate Present Worth Value					$350,000		

FIGURES

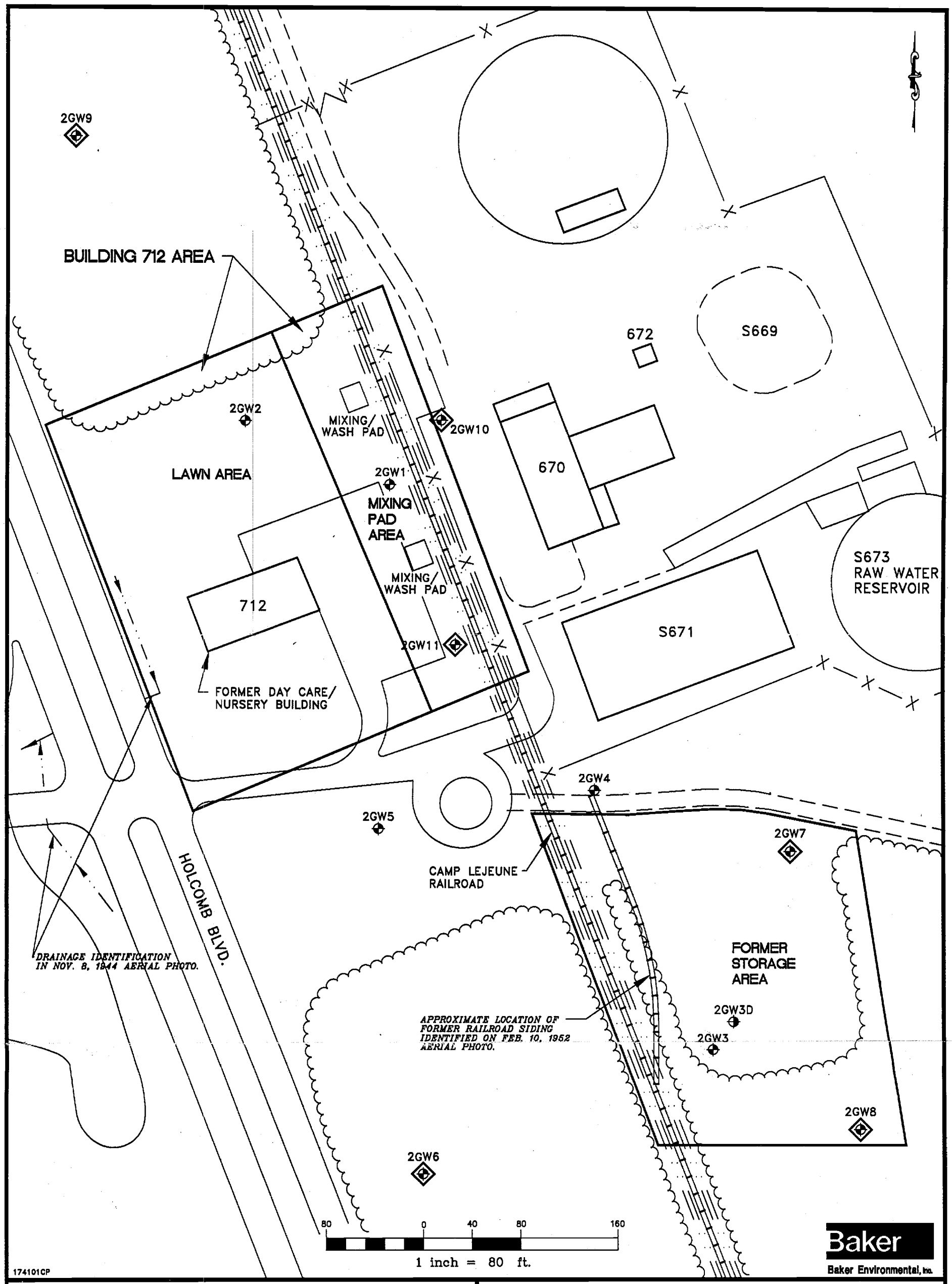


SOURCE: CAMP LEJEUNE QUADRANGLE,
7.5 MINUTE TOPOGRAPHIC MAP,
1952, PHOTOREVISED 1971

FIGURE 1-1
LOCATION MAP-OPERABLE UNIT No. 2
SITE 5
CORRECTIVE ACTION PLAN CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00131BB01Y



LEGEND

2GW1 EXISTING SHALLOW MONITORING WELL

2GW3D NEWLY INSTALLED SHALLOW MONITORING WELL

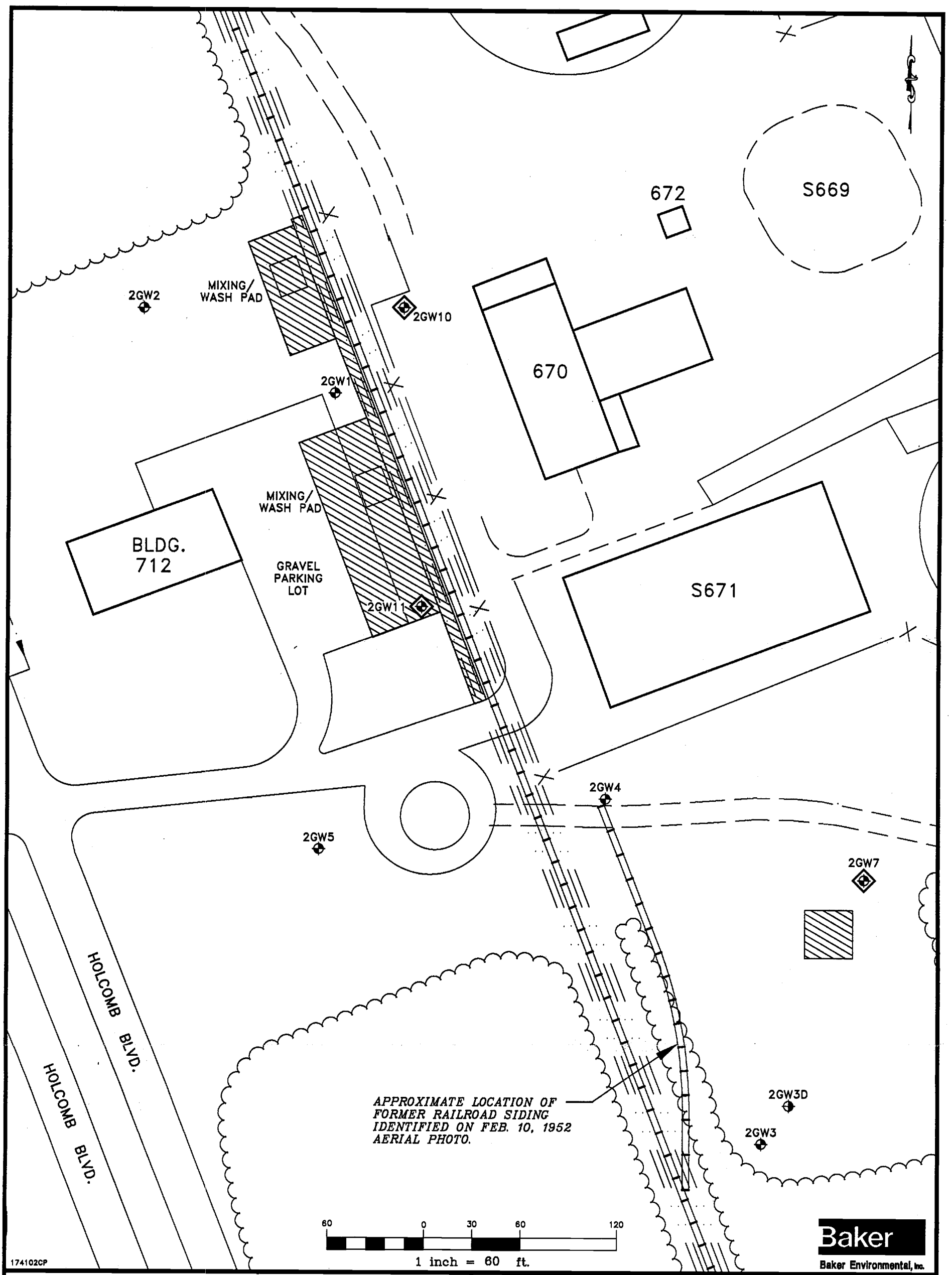
2GW3D NEWLY INSTALLED DEEP MONITORING WELL

SOURCE: LANTDIV, FEB. 1992

FIGURE 1-2
SITE PLAN
OPERABLE UNIT No.5, SITE 2
CORRECTIVE ACTION PLAN CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00231BB022



LEGEND

2GW1 – NEWLY INSTALLED SHALLOW MONITORING WELL

2GW3D – EXISTING DEEP MONITORING WELL

2GW7 – EXISTING SHALLOW MONITORING WELL

– PROPOSED AREAS (APPROXIMATE) TO BE INCLUDED IN TIME CRITICAL REMOVAL ACTION

SOURCE: LANTDIV, FEB. 1992

FIGURE 2–1
APPROXIMATE AREAS INCLUDED IN
TIME CRITICAL REMOVAL ACTION
OPERABLE UNIT No.5, SITE 2
CORRECTIVE ACTION PLAN CTO–0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

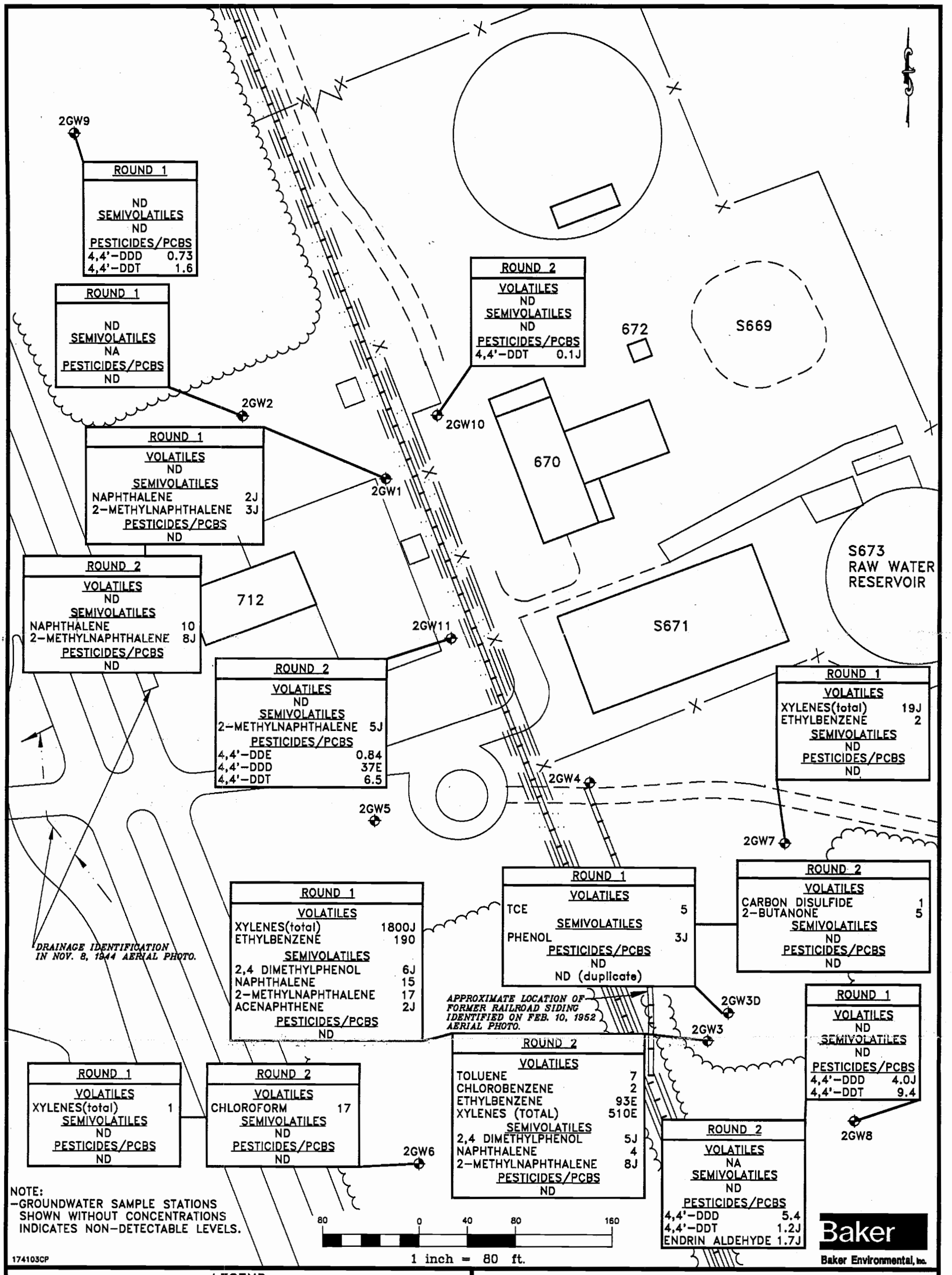
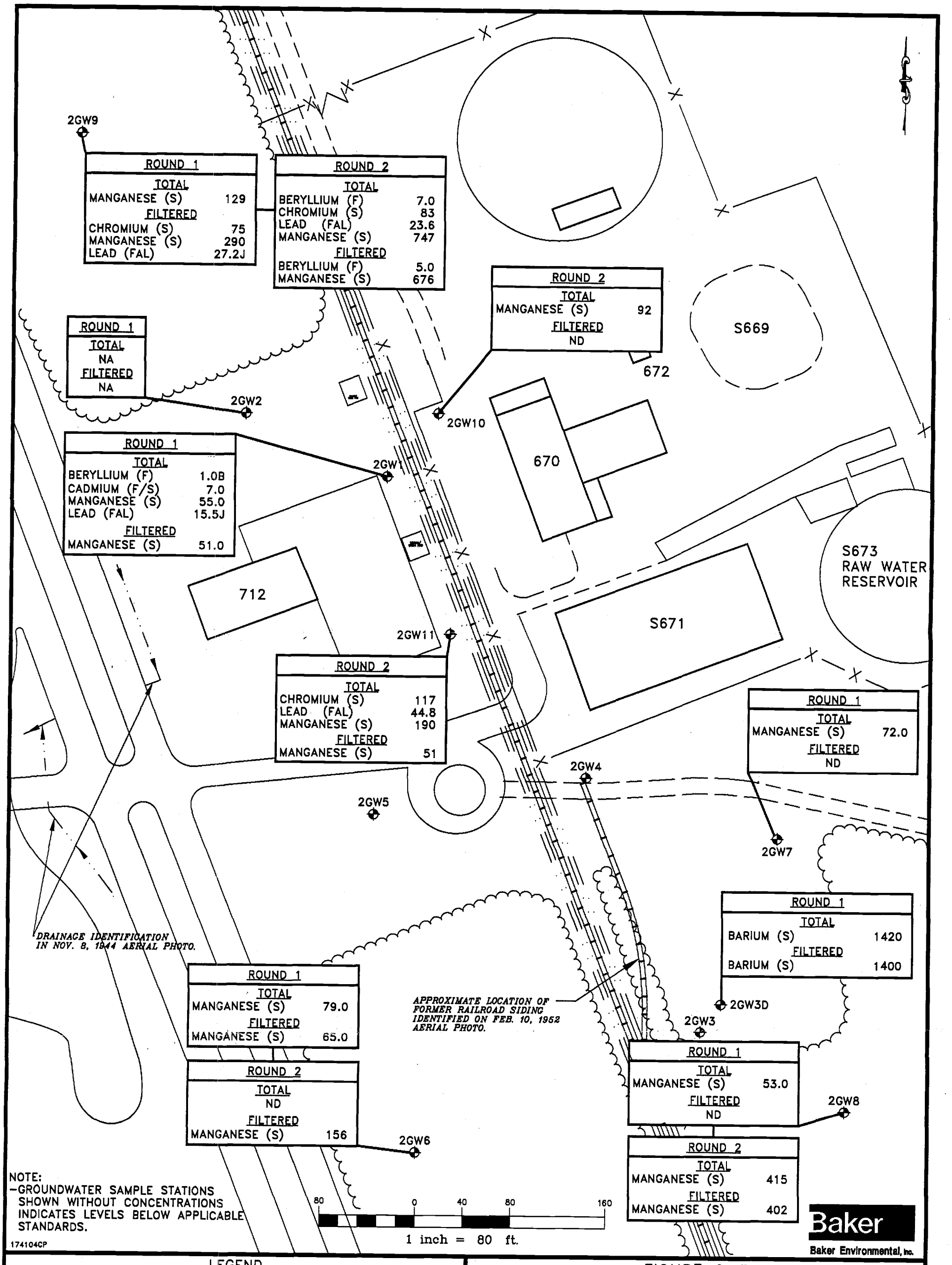


FIGURE 2-2
POSITIVE DETECTIONS OF ORGANIC COMPOUNDS IN GROUNDWATER
OPERABLE UNIT No.2, SITE 2
CORRECTIVE ACTION PLAN CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

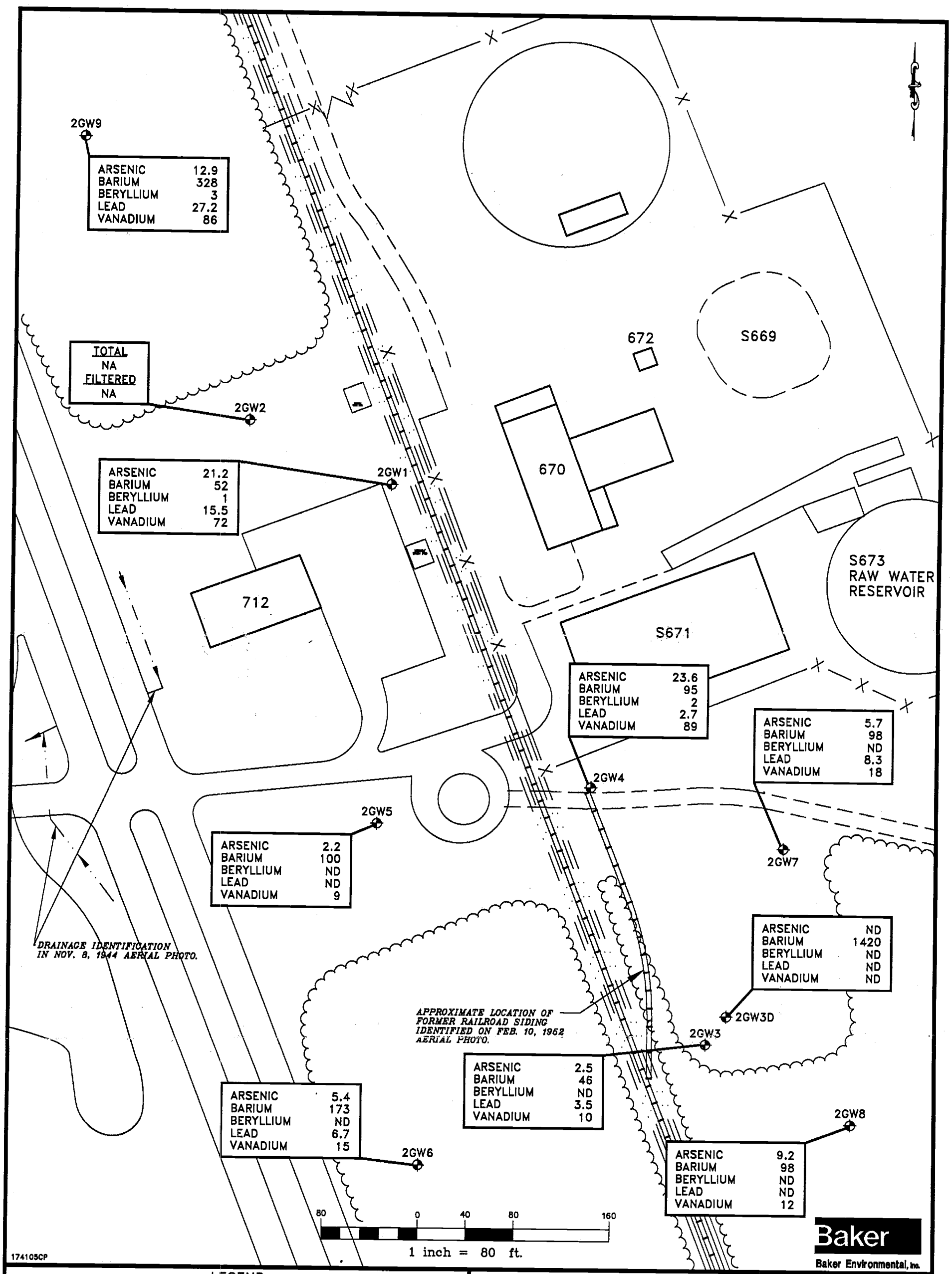
2GW1 ⊕	GROUNDWATER WELL
(F)	EXCEEDS FEDERAL STANDARD
(S)	EXCEEDS STATE STANDARD
(FAL)	FEDERAL ACTION LEVEL
ND	NOT DETECTED ABOVE APPLICABLE STANDARDS
NA	NOT ANALYZED
J	ESTIMATED CONCENTRATIONS

CONCENTRATIONS EXPRESSED IN ug/l(ppb)

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-3

POSITIVE DETECTIONS ABOVE APPLICABLE FEDERAL AND STATE STANDARDS FOR TOTAL AND FILTERED INORGANIC ANALYTES IN GROUNDWATER
OPERABLE UNIT No.5, SITE 2
CORRECTIVE ACTION PLAN CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

2GW1 GROUNDWATER WELL

ND NOT DETECTED

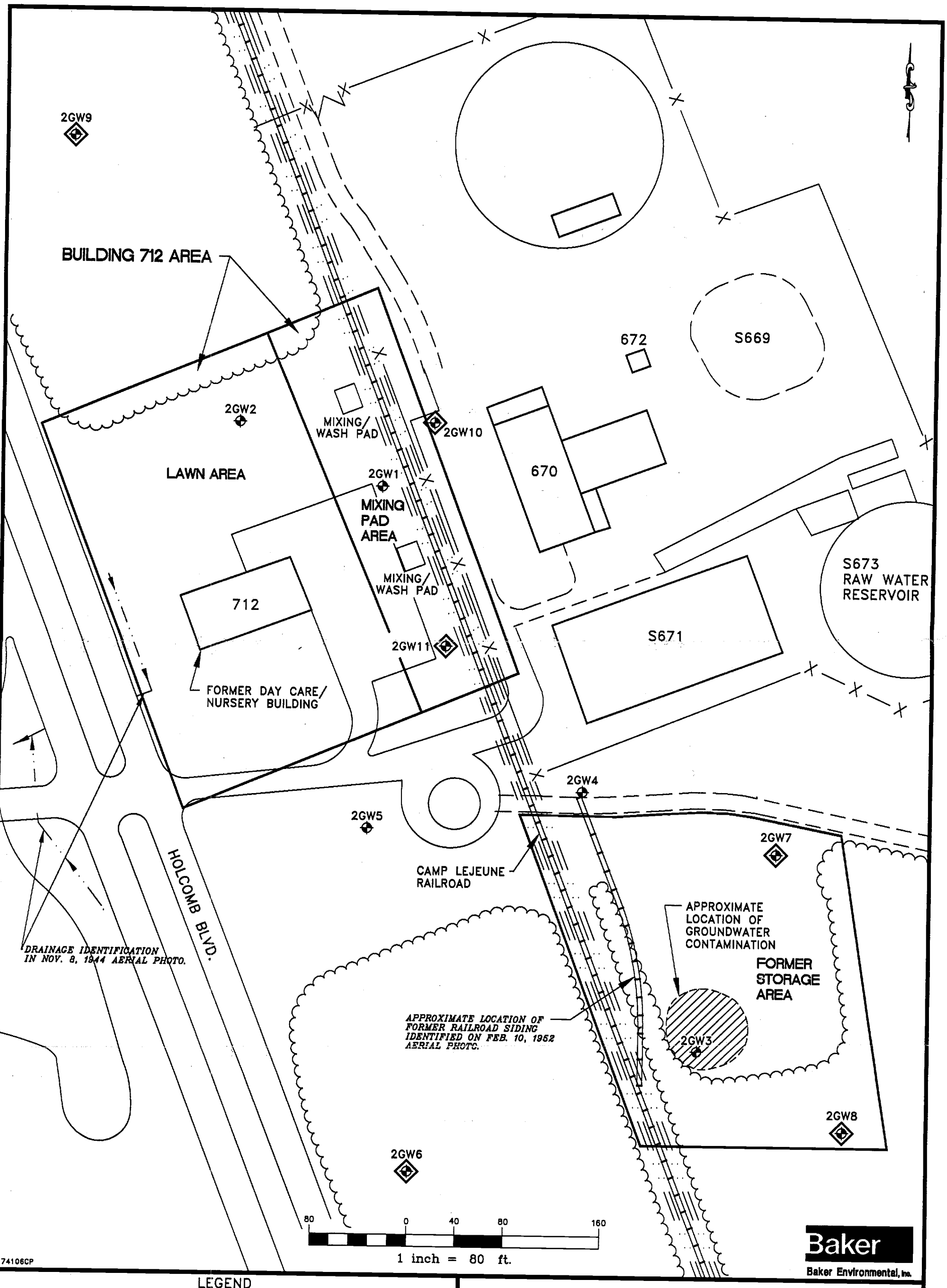
NA NOT ANALYZED

TOTAL INORGANIC CONCENTRATIONS EXPRESSED IN ug/L

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-4
INORGANIC CONCENTRATIONS OF
COCs IN GROUNDWATER
OPERABLE UNIT No.5, SITE 2
CORRECTIVE ACTION PLAN CTO-0174

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

2GW1 EXISTING SHALLOW MONITORING WELL

2GW3D NEWLY INSTALLED SHALLOW MONITORING WELL

SOURCE: LANTDIV, FEB. 1992

FIGURE 4-1
APPROXIMATE LOCATION OF
SHALLOW GROUNDWATER CONTAMINATION
OPERABLE UNIT No.5, SITE 2
CORRECTIVE ACTION PLAN CTO-0174
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

APPENDIX A
2-D Horizontal Flow with a Slug Source (Model)

APPENDIX A

2-D Horizontal Flow With A Slug Source (Model)

A two-dimensional groundwater modeling technique was utilized to provide theoretical support for the proposed course of action in the Corrective Action Plan for Operable Unit No. 5., Site 2, Marine Corps Base, Camp Lejeune, North Carolina. The technique was taken from the U. S. Environmental Protection Agency (USEPA) document "Water Quality Assessment: A Screening Procedure For Toxic And Conventional Pollutants In Surface And Ground Water; Revised 1985" (USEPA, 1985); (Henceforth referred to as "WQA"). This model provides for two-dimensional projections of contaminant concentrations (as opposed to linear projections) at a specific location down gradient of the point of injection after a specified duration of time.

As with any modeling technique, several assumptions must be made in order to calculate the parameter(s) in question. For this particular technique, the following assumptions are inherent to the model:

- The waste was instantaneously discharged at one point.
- The resulting concentration of the contaminant in the aquifer is uniform with depth at the point where the waste was discharged.
- The saturated thickness of the aquifer is uniform.
- The hydraulic properties of the aquifer are relatively homogeneous.
- The density and viscosity of the pollutant are the same as the native water in the aquifer.
- Regional flow in the aquifer is uniform and horizontal.
- The effect of the source of contamination on the seepage velocity is negligible compared to the uniform regional flow rate.

In addition to the assumptions listed above, several engineering assumptions were made to account for existing data and provide a realistic estimate of downgradient concentrations. These parameters are identified below and in Table A-1.

The modeling equation, equation VII-85 (WQA, part II, page 411) is:

$$c(x,y,t) = \{(c_0Q')/[b4\pi pt(D_xD_y)^{.5}]\} \exp \{-kt-[(xR_d-v_xt)^2/4D_xtR_d]-[(yR_d)^2/4D_ytR_d]\}$$

where:

c_0	=	initial concentration of the contaminant being discharged (mg/l)
Q'	=	volume of contaminant being discharged (m^3)
b	=	saturated thickness of the aquifer (m)
p	=	effective porosity (decimal percent, unitless)
t	=	time (days)
D_x,D_y	=	Dispersion coefficients in x and y directions, respectively (m^2/day)
v_x	=	seepage velocity of the regional flow in the x direction (m/day)

x,y	=	location of point of interest (m), where source is located at x=0, y=0
k	=	first-order decay constant of the contaminant in aquifer (per day)
R_d	=	retardation factor for linear, equilibrium adsorption (unitless)

For Site 2 of Operable Unit No. 5, the origin for our model is monitoring well 2GW3, where the primary COC's are ethylbenzene and xylenes (total). Of these two contaminants, xylenes (total) represent the contaminant present in the highest concentration; 1,800 µg/l (Baker: Final Remedial Investigation Report for Operable Unit No. 5, Site 2, Marine Corps Base, Camp Lejeune, North Carolina, June 14, 1994; table 4-9, page 4-65). For simplicity, the model is based on this one contaminant.

In order to calculate the retardation factor (R_d) using equation VII - 55 (WQA, part 2, pg. 377):

$$R_d = 1 + (\rho_b K_d) / p$$

We must first estimate the parameter K_d, the distribution coefficient (mg/l). This parameter is synonymous with K_p, the partition coefficient (WQA, part 2, page 377) under the assumptions made here. K_p can be estimated using equation II-17 (WQA, part 1, page 51):

$$K_p = K_{OC} [\, 0.2(1-f)x^S_{OC} + fx^f_{OC}]$$

where:

K_{OC}	=	partition coefficient expressed on an organic carbon basis
f	=	mass fraction of fine sediments (d < 50 µm)
x^S_{OC}	=	organic carbon content of coarse sediment fraction
x^f_{OC}	=	organic carbon content of fine sediment fraction

Substituting in the appropriate values (see Table A-1) gives a $K_p = K_d$ value of 1.58, after which a value of $R_d = 7.32$ is calculated from equation VII-55 above and the data in Table A-1.

Using the derived R_d and assuming the first-order decay constant (k) is equal to zero, (i.e. the contaminant does not decay in the aquifer; a conservative estimate), we then calculate the concentration of the contaminant in question at our point of interest: Overs Creek. The x and y distances from the point of discharge to Overs Creek were scaled from the USGS 7.5 minute topographic map of the Camp Lejeune Quadrangle using an assumed meridian passing through the estimated point of discharge (Site 2) as the x axis. The x and y values appear in Table A-1.

Substituting the values calculated above and the values in Table A-1 into equation VII-85 results in a concentration after 5 years (t = 1825 days) of $c(550,200,1825) = 6.71 * 10^{-44}$ mg/l. The fact that this value is so small tells us that it is extraordinarily unlikely that any contaminant will migrate off site or impact Overs Creek, therefore the proposed course of action (i.e. long-term monitoring and institutional controls) is an acceptable alternative.

TABLE A-1
INPUT VALUES FOR TWO-DIMENSIONAL HORIZONTAL FLOW
WITH A SLUG SOURCE
CTO 0174 - OPERABLE UNIT NO. 5, SITE 2
CAMP LEJEUNE, NORTH CAROLINA

Variable	Description (units)	Valu e	Source
c_0	Initial contaminant concentration (mg/l)	1.8	*Final R.I., pg. 4-16
Q'	Volume of contaminant discharged (m^3)	.3786	Engineering estimate
b	Saturated thickness of aquifer (m)	30.48	Engineering estimate
p	Effective porosity (decimal percent, unitless)	0.4	Engineering estimate
t	Time (days)	1825	5-year value
D_x	Dispersion coefficient in x direction (m^2/day)	4	Engineering estimate
D_y	Dispersion coefficient in y direction (m^2/day)	4	Engineering estimate
v_x	Seepage velocity of regional flow (m/day)	0.011	*Final R.I., pages 5-8, 5-9, 5-10
x	x coordinate of point of interest (m)	550	USGS 7.5 min. topo map - Camp Lejeune Quadrangle
y	x coordinate of point of interest (m)	200	USGS 7.5 min. topo map - Camp Lejeune Quadrangle
k	First-order decay constant of the contaminant in the aquifer (per day)	0	Engineering estimate
R_d	Retardation factor (unitless)	7.32	**Derived
ρ_b	soil bulk density (g/ml)	1.6	*Final R.I., table 3-3, page 3-9
log K_{OC}	Partition coefficient (organic basis) (ml/g)	2.84	*Final R.I., page 5-2
x^s_{OC},x^f_{OC}	Organic carbon content of coarse, fine sediment fractions, respectively. (decimal percent)	0.01, 0.03	Engineering estimate
f	mass fraction of fine sediments (d < 50 μm) (decimal percent)	0.01	Engineering estimate