✓ 04.07 - 2/12/93 - 00255

DRAFT

TREATABILITY STUDY EVALUATION FOR SITES 6 AND 9

CAMP LEJEUNE MARINE CORPS BASE
JACKSONVILLE, NORTH CAROLINA

CONTRACT TASK ORDER 0133

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

FEBRUARY 12, 1993

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

1.0 INTRODUCTION

This report presents the Treatability Study (TS) Evaluation Report associated with the Remedial Investigation/Feasibility Study (RI/FS) for Sites 6 and 9. These sites are located within Marine Corps Base (MCB) Camp Lejeune, North Carolina, and collectively are being addressed as Operable Unit No.2. This TS Report has been prepared by Baker Environmental, Inc. (Baker) under the Department of the Navy (DoN) Atlantic Division Naval Facilities Engineering Command (LANTDIV) CLEAN Program for Contract Task Order (CTO) 0133.

The objectives of this TS Evaluation Report are: (1) to determine whether TSs are required for Sites 6 and 9, based on available information/data to evaluate the feasibility of potential technologies; (2) to identify potential TSs required to support the FS, Proposed Remedial Action Plan (PRAP), and the selected alternative identified by the Record of Decision (ROD); (3) to determine whether a TS is needed to provide additional information to support the design of the alternative; and (4) to identify uncertainties associated with performing TSs versus not performing TSs.

Note that this evaluation report does not address Site 48 (the MCAS Mercury Dump) or Site 69 (Rifle Range Chemical Dump) at MCB Camp Lejeune, which are also included under CTO-0133. Based on the preliminary results of the RI conducted by Baker in 1992, it does not appear that an FS will be required for Site 48 since no potential contaminants of concern from the site have been identified to cause a potential risk to human health or the environment. The RI/FS for Site 69 is currently on hold.

The following TS Evaluation Report is organized into five sections including this Introduction (Section 1.0). Section 2.0 (Site Background) contains background information including site location, site use history, and contaminants and media of concern at Sites 6 and 9. In addition, this section discusses the preliminary remediation goals established for Operable Unit No. 2, and the potential areas of concern which may require remediation. Section 3.0 identifies and evaluates a set of potentially applicable TSs. Section 4.0 recommends the TSs to be performed for Operable Unit No.2. Section 5.0 presents an outline of the "follow-up" activities that must be performed in order to conduct any of the recommended TSs. The references are presented in Section 6.0.

2.0 SITE BACKGROUND

Operable Unit No. 2 at MCB Camp Lejeune consists of two sites: Site 6 (Storage Lots 201 and 203) and Site 9 (Fire Fighting Training Pit at Piney Green Road). The site-specific background information pertaining to both of these sites and a brief summary of the contaminants and media of concern at these sites are discussed below.

2.1 Site 6 (Storage Lots 201 and 203)

This section summarizes the location, description, and history of Site 6.

2.1.1 Site Location and Description

Site 6 is located between Holcomb Boulevard and Piney Green Road, approximately 2 miles east of the New River and 2 miles south of State Route 24. The site consists of two storage areas (Lots 201 and 203), a ravine area, and surrounding wooded areas. The site encompasses approximately 225 acres.

Wallace Creek flows in a western direction along the northern border of Site 6 and discharges into the New River. Bear Head Creek flows in a western direction in the southern portion of the site and discharges into Wallace Creek downstream of Site 6. To the east is Piney Green Road, which parallels the site. Holcomb Boulevard parallels the site to the west. Site 9 is located south of the site across Bear Head Creek.

2.1.2 Site Use History

Storage Lot 201 is currently used to store military equipment, vehicles, lumber, hydraulic oils, and other "nonhazardous" supplies. This lot reportedly contained two pesticide storage areas and a PCB storage area.

Storage Lot 203 is currently inactive, although it had served as a waste disposal area from as early as the 1940s. The reports of actual disposal activities are vague. The pesticide "DDT" was reported to have been disposed at the southeast portion of the lot, and PCB transformers were reportedly stored in the northeast portion of the lot. The lot was also used for open storage of various debris including radio/communication parts, shredded tires, lubricants, petroleum products, corrosives, expended demolition kit training materials, ordnance, sheet metal debris, and wire cables. The lot currently shows evidence of some of these past storage activities; the surface of Lot 203 is littered with drums and debris. Approximately 40 full and empty 55-gallon drums are still present on the surface of the lot.

The ravine is currently littered with items such as battery packs, empty unlabeled drums, tires, wire cables, commodes, and respirator cartridges. Based on the EPIC study conducted by United States Environmental Protection Agency (USEPA), this area may have at one time been part of Lot 203 and its associated storage/disposal activities. It appears that trucks emptied contents into this ravine from the Lot 203 area.

The wooded areas surrounding the two storage lots are randomly littered with debris including shell ~~rocket~~ casings and empty and/or rusted drums. Based on the most recent data collected by Baker (during a soil gas investigation in February 1993), the wooded area between Lot 203 and Wallace Creek may be a primary area of concern. Various drums and metal containers were identified in this area. The soil gas results indicated high levels of volatile organic compounds (VOCs) in the area north of monitoring well 6GW1 (between Lot 203 and Wallace Creek). *

2.1.3 Contaminants and Media of Concern

During the RI conducted by Baker in 1992, soil, groundwater, surface water, and sediment samples were collected throughout Site 6. Based on the analytical data, it appears that all of the media may be impacted to some degree. A brief summary of the potential contaminants of concern detected in each of the media are discussed below. Note that additional soil and groundwater samples are currently being collected at Site 6 to further define the extent of groundwater contamination and the location of the source area(s); therefore, the following discussion and the conclusions of this TS evaluation may be revised at a later date.

2.1.3.1 Soil

The potential contaminants of concern detected in the soil (surface and subsurface) within various portions of Site 6 include pesticides (DDD, DDE, DDT), PCBs, and the inorganics: arsenic, barium, cadmium, chromium, and manganese.

At Lot 201, the maximum concentrations of the detected contaminants of concern are: DDD (2500 ug/kg); DDE (1400 ug/kg); DDT (8100 ug/kg); PCBs (1800 ug/kg); arsenic (26.3 mg/kg); barium (737 mg/kg); chromium (21.6 mg/kg); and manganese (19.0 mg/kg).

At Lot 203, the maximum concentrations of the detected contaminants of concern are: DDE (700 ug/kg); PCBs (42,000 ug/kg); arsenic (23.9 mg/kg); barium (103 mg/kg); cadmium (9.3 mg/kg); chromium (42.9 mg/kg); and manganese (182 mg/kg).

For the wooded areas, the maximum concentrations of the detected contaminants of concern: DDD (12,000 ug/kg); DDE (4,200 ug/kg); DDT (6,400 ug/kg); PCBs (26,000 ug/kg); arsenic (17.4 mg/kg); barium (26.3 mg/kg); cadmium (51.9 mg/kg); chromium (54.6 mg/kg); and manganese (2,990 mg/kg).

2.1.3.2 Groundwater

The potential contaminants of concern detected in the groundwater at the site included various VOCs and several inorganic contaminants. The potential contaminants of concern include: tetrachloroethene (PCE); trichloroethene (TCE); 1,1,2,2-tetrachloroethane (1,1,2,2-PCA); vinyl chloride; 1,1-dichloroethene (1,1-DCE); 1,2-dichloroethane (1,2-DCA); and the inorganic compounds arsenic, barium, chromium, and manganese. TCE appears to be the most prevalent VOC in the groundwater, with a maximum detected concentration of 58,000 µg/L. Maximum concentration of PCE detected was 630 µg/L.

The inorganic contaminant, manganese was detected in the majority of the groundwater samples with a maximum concentration of 1430 µg/L. Chromium, the next most commonly detected inorganic, had a maximum detected concentration of 201 µg/L. Barium and arsenic had maximum detected concentrations of 1020 µg/L and 67.8 µg/L, respectively.

The area of VOC contamination appears to be located in the wooded area north of Lot 203. The deeper monitoring wells indicated higher levels of contamination in this area as compared to the shallow wells. No contaminants of concern were detected in the monitoring wells (shallow or deep) located within Lot 201 or in the wooded areas east and south of Lot 201. The inorganic contamination appears to be random across the site.

2.1.3.3 Surface Water

Surface water samples were collected in Wallace Creek, the ravine leading to Wallace Creek, and Bear Head Creek. The potential contaminants of concern detected in surface water samples collected from Wallace Creek include TCE, PCE, vinyl chloride, arsenic, copper, nickel, and zinc. The maximum detected concentration of each of these compounds are: TCE (98 µg/L); PCE (4.0 µg/L); vinyl chloride (6.0 µg/L); arsenic (3.7 µg/L); copper (129 µg/L); nickel (1380 µg/L); and zinc (111 µg/L). The highest levels of organic concentrations were found at sampling locations directly north of the ravine outlet area at WC07. Metal contaminant concentrations were the greatest at sampling location WC03 which denotes a sample taken from 3" to 12" below the water surface in the middle of the stream. Sampling location WC03 is located upstream of Site 6. Elevated concentrations of inorganics were found throughout Wallace Creek.

The potential contaminants of concern detected in the ravine leading to Wallace Creek include arsenic, copper, and zinc. The maximum detected concentration of these compounds are: arsenic (10.5 µg/L); copper (9 µg/L); and zinc (495 µg/L). These elevated concentrations were found at sampling locations RV-2, RV-5, RV-6 and RV-8, which cover the entire length of the ravine. It can be concluded that elevated levels of metal concentrations occur along the entire length of the ravine.

The contaminants of concern detected in Bear Head Creek include copper and nickel. Their maximum detected concentrations are: copper (55.8 µg/L) and nickel (244 µg/L). These elevated metal concentrations were found downstream from Sites 6 and 9 where Bear Head Creek discharges into Wallace Creek.

2.1.3.4 Sediment

The initial potential contaminants of concern detected in the sediments collected from Wallace Creek, Bear Head Creek, and the ravine include pesticides, PCBs polyaromatic hydrocarbons (PAHs), TCE, and inorganics such as arsenic, barium, chromium, cadmium, manganese, nickel, selenium, and zinc.

The maximum detected concentrations of DDD, DDE, and DDT are 220 ug/kg (Bear Head Creek), 83 ug/kg (Wallace Creek), and 1200 ug/kg (Wallace Creek), respectively. The highest level of PCBs (2000 ug/kg) was detected in Wallace Creek. Bear Head Creek had the highest concentration of TCE: 150 ug/kg.

The PAHs detected in the sediment samples included: anthracene, fluorene, phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, and benzo(a)pyrene. The majority of the PAHs were detected in the ravine. Maximum detected concentrations of some of these PAHs included: pyrene (2100 ug/kg), benzo(a)pyrene (2100 ug/kg), phenanthrene (1600 ug/kg), and fluoranthene (1500 ug/kg).

The maximum detected levels of the inorganic contaminants of concern included: arsenic (10.2 mg/kg - Wallace Creek); barium (110 mg/kg - Wallace Creek); cadmium (5.9 mg/kg - ravine); chromium (28.5 mg/kg - Wallace Creek); manganese (288 mg/kg - ravine); nickel (10.7 mg/kg - Wallace Creek); selenium (2.9 mg/kg - Bear Head Creek); and zinc (926 mg/kg - Wallace Creek). Based on this data, it appears that the highest levels of contaminants in the sediments were found throughout Wallace Creek.

2.2 Site 9 - Fire Training Area at Piney Green Road

This section summarizes the location, description, and history of Site 9.

2.2.1 Site Location and Description

Site 9 is a two-acre area located between Piney Green Road and Holcomb Boulevard along the southern border of Site 6. Bear Head Creek is located approximately 500 feet to the north of the site. The site is bordered by local (unnamed) streets.

The site consists of an asphalt-lined fire training pit, a below-ground oil/water separator, three above ground fuel storage tanks, and a fire tower (smoke house).

2.2.2 Site Use History

The fire training pit is and has previously been used (since the 1960s) to conduct training exercises for extinguishing fires. Fuels (stored in the above ground tanks) are used to create the 'training' fires. Until 1981, the pit was unlined. Flammable liquids including used oil, solvents, and contaminated fuels (nonleaded) were burned in the pit. Approximately 30,000 to 40,000 gallons of jet fuels (JP-4 and JP-5) per year were used during the training exercises.

2.2.3 Contaminants and Media of Concern

During the RI conducted by Baker in 1992, soil and groundwater samples were collected throughout Site 9. Based on the analytical data, neither media appears to be impacted at the site. A brief summary of the potential contaminants of concern detected in the media are discussed below.

2.2.3.1 Soil

The primary contaminants detected in the soil (surface and subsurface) within various portions of the site included minimal occurrences of pesticides such as DDD, DDE, and DDT. Chromium was the only inorganic contaminant of concern detected. The maximum detected levels of DDD, DDE, and DDT were 50 ug/kg, 650 ug/kg, and 570 ug/kg, respectively. The maximum concentration of chromium detected was 6.4 mg/kg. The pesticides were detected at soil boring SB1 (in between the large above ground storage tanks and the propane tanks), at soil boring SB24 (along the northern edge of the concrete-lined pit), and at soil boring SB31 (along the western of the concrete-line pit). Chromium was detected at soil boring SB1, at monitoring well 9-GW08 to the east of the site, and at the background monitoring well 9-GW04.

2.2.3.2 Groundwater

No organic contaminants of concern were detected above the detection limits in any of the groundwater samples collected at Site 9 from seven shallow wells and one deep well. The inorganic contaminants of concern (barium, chromium, and manganese) were detected at random locations throughout the site. The maximum detected concentrations of barium, chromium, and manganese were 1060 µg/L, 214 µg/L, and 174 µg/L, respectively.

2.3 Summary of Contaminants and Media of Concern

Based on the review of the analytical results from the samples collected from both Sites 6 and 9 (i.e., Operable Unit No.2), the following potential contaminants of concern have been identified for each of the media sampled.

Soil

- Pesticides (4,4'-DDD, 4,4'-DDE, and 4,4'-DDT)
- PCBs
- Inorganics (arsenic, barium, cadmium, chromium, and manganese)

Groundwater

- VOCs (TCE, PCE, 1,1-DCE, 1,2-DCA, 1,1,2,2-PCA, vinyl chloride)
- Inorganics (arsenic, barium, chromium, and manganese)

Surface Water

- VOCs (TCE, PCE, and vinyl chloride)
- Inorganics (arsenic, copper, nickel, and zinc)

Sediments

- PAHs
- Pesticides (4,4'-DDD, 4,4'-DDE, and 4,4'-DDT)
- PCBs (Arochlor 1260)
- Inorganics (arsenic, barium, chromium, cadmium, manganese, nickel, selenium, and zinc)

2.4 Potential Remediation Goals

The individual preliminary remediation goals established for each of the potential contaminants of concern are listed on Table 1 with respect to each media. The basis for each goal (e.g., maximum contaminant level, risk-based, etc.) is also listed on the table. The analytical results from the RI were compared to these remediation goals to determine what media at the Operable Unit may require remediation. The following section discusses the results of this comparison.

2.5 Potential Areas of Concern Requiring Remediation

Several areas of concern can be identified at Sites 6 and 9 based on a comparison of the available analytical data with the remediation goals presented on Table 1. A discussion of the potential areas of concern per media are discussed below.

TABLE 1

POTENTIAL REMEDIATION GOALS

Preliminary Remediation Goals					Corresponding Risk	
					Chemical-Specific Risk	
Medium	Contaminant of Concern	Remediation Goal	Units	Basis of Goal[1]	Carcinogenic	Non-Carcinogenic
Soil						
	4,4-DDD	21,000	ug/kg	Risk - Dermal[2]	$1x10^{-4}$	
	4,4-DDE	15,000	ug/kg	Risk - Dermal	$1x10^{-4}$	
	4,4-DDT	15,000	ug/kg	Risk - Dermal	$1x10^{-4}$	
	PCBs	25,000	ug/kg	TSCA-Industrial	NA	
	Arsenic	5.39	mg/kg	Risk - Dermal		HI = 1.0
	Barium	1,200	mg/kg	Risk - Dermal		HI = 1.0
	Cadmium	8.96	mg/kg	Risk - Dermal		HI = 1.0
	Chromium	89.8	mg/kg	Risk - Dermal		HI = 1.0
	Manganese	1.8	mg/kg	Risk - Dermal		HI = 1.0
Groundwater						
	1,1-Dichloroethene	7	µg/L	NC GWS		
	1,2-Dichloroethane	5	µg/L	MCL		
	1,1,2,2-Tetrachloroethane	7.2	µg/L	Risk - Ingestion	$1x10^{-4}$	
	Tetrachloroethene (PCE)	0.7	µg/L	NC GWS		
	Trichloroethene (TCE)	2.8	µg/L	NC GWS		
	Vinyl Chloride	0.015	µg/L	NC GWS		
	Arsenic	50	µg/L	NC GWS		
	Barium	1,000	µg/L	NC GWS		
	Chromium	50	µg/L	NC GWS		
	Manganese	50	µg/L	NC GWS		
Surface Water	Trichloroethene	2.7	µg/L	Fed AWQC		
	Tetrachloroethene	0.8	µg/L	Fed AWQC		
	Vinyl Chloride	2	µg/L	Fed AWQC		
	Arsenic	0.018	µg/L	Fed AWQC		
	Copper	2.9	µg/L	Fed AWQC		
	Nickel	8.3	µg/L	NC WQC		
	Zinc	86	µg/L	NC WQC		

(1) MCL = Federal Maximum Contaminant Level
NC GWS = North Carolina Groundwater Standard
TSCA = Toxic Substances Control Act
FED AWQC = Federal Ambient Water Quality Criteria for Human Health or Aquatic Life
NC WQC = North Carolina Water Quality Criteria for Tidal Saltwater - Human Health or Aquatic Life
(2) Risk-based action levels assume 100 percent absorption.
(3) Background level used since the toxicity data not available for evaluation.

TABLE 1 (Continued)

POTENTIAL REMEDIATION GOALS

Preliminary Remediation Goals					Corresponding Risk	
					Chemical-Specific Risk	
Medium	Contaminant of Concern	Remediation Goal	Units	Basis of Goal(1)	Carcinogenic	Non-Carcinogenic
Sediment						
	Benzene	333,364,400	ug/kg	Risk - Dermal	$1x10^{-4}$	
	Trichloroethene	Not Detected	ug/kg	Background(3)		
	Total Xylenes	13,810,810,810	ug/kg	Risk - Dermal		HI = 1.0
	4,4-DDD	80,563,060	ug/kg	Risk - Dermal	$1x10^{-4}$	
	4,4-DDE	56,868,040	ug/kg	Risk - Dermal	$1x10^{-4}$	
	4,4-DDT	1,339,650	ug/kg	Risk - Dermal		HI = 1.0
	PCBs	1,611,260	ug/kg	Risk - Dermal		HI = 1.0
	Fluorene	920,720,720	ug/kg	Risk - Dermal		HI = 1.0
	Phenanthrene	Not Detected	ug/kg	Background(3)		
	Anthracene	69,054,054,050	ug/kg	Risk - Dermal		HI = 1.0
	Fluoranthene	9,207,207,210	ug/kg	Risk - Dermal		HI = 1.0
	Pyrene	920,720,720	ug/kg	Risk - Dermal		HI = 1.0
	Chrysene	555,607,330	ug/kg	Risk - Dermal	$1x10^{-4}$	
	Benzo (a) pyrene	5,556,070	ug/kg	Risk - Dermal	$1x10^{-4}$	
	Benzo (b) fluoranthene	55,560,730	ug/kg	Risk - Dermal	$1x10^{-4}$	
	Benzo (a) anthracene	55,560,730	ug/kg	Risk - Dermal	$1x10^{-4}$	
	Indeno (1,2,3-cd) pyrene	55,560,730	ug/kg	Risk - Dermal	$1x10^{-4}$	
	Arsenic	20,716.22	mg/kg	Risk - Dermal		HI = 1.0
	Barium	4,833,783.78	mg/kg	Risk - Dermal		HI = 1.0
	Chromium	345,270.27	mg/kg	Risk - Dermal		HI = 1.0
	Cadmium	34,527.03	mg/kg	Risk - Dermal		HI = 1.0
	Manganese	34,520.27	mg/kg	Risk - Dermal		HI = 1.0
	Nickel	1,381,081.08	mg/kg	Risk - Dermal		HI = 1.0
	Selenium	345,270.27	mg/kg	Risk - Dermal		HI = 1.0
	Zinc	20,716,216.22	mg/kg	Risk - Dermal		HI = 1.0

(1) MCL = Federal Maximum Contaminant Level
NC GWS = North Carolina Groundwater Standard
TSCA = Toxic Substances Control Act
FED AWQC = Federal Ambient Water Quality Criteria for Human Health or Aquatic Life
NC WQC = North Carolina Water Quality Criteria for Tidal Saltwater - Human Health or Aquatic Life

(2) Risk-based action levels assume 100 percent absorption.

(3) Background level used since the toxicity data not available for evaluation.

2.5.1 Soil

Based on the existing analytical data, it appears that limited, if any, soil remediation may be required at the site (note that this may change following additional soil investigations at Site 6). No pesticide concentrations were detected above the risk-based remediation goals. Only three samples contained PCB concentration exceeding the proposed remediation goal of 25 mg/kg. These samples were collected from Soil Boring SB22-SA, SB24-SA, and SB15-B at concentrations of 29 mg/kg, 42 mg/kg, and 26 mg/kg, respectively. Borings SB22-SA and SB24-SA are located within Lot 203, one boring is west of the suspected PCB storage area, and the other boring is located near the northern border of Lot 203, where the fence juts in towards the lot. Boring SB15-B is located in the wooded area east of Lot 201, adjacent to Piney Green Road.

Concentrations of the inorganic contaminants of concern (with the exception of chromium) were elevated above the risk-based remediation goals at various locations within Lot 201, Lot 203, and the wooded areas. Chromium levels did not exceed the remediation goals in any sample to date. The inorganic concentrations detected in background soil samples (6-201N-SB11 and 6-201N-SB12) were below the remediation goals except for manganese. Manganese was detected at SB11 at a concentration of 3.10 mg/kg.

All of Site 9 soil samples had contaminants of concern concentration below the remediation goals. Therefore, no areas within Site 9 will require soil remediation.

Note that at this time, no VOCs have been identified as potential contaminants of concern in the soils. Additional investigative activities (both soil and groundwater) are planned for the wooded area north of Lot 203 to further define the extent of groundwater contamination and to identify the source(s) of contamination. The results from this additional sampling may alter the list of contaminants of concern for this site.

2.5.2 Groundwater

Based on the existing analytical data, a groundwater plume contaminated with VOCs (e.g., TCE and PCE) is located in the wooded area north of Lot 203. This plume has migrated into the deeper portion of the aquifer and is believed to have migrated horizontally over a large area with respect to inorganic groundwater contamination, it is not apparent whether there is widespread inorganic contamination as a result of former waste disposal activities. No "single" inorganic plume contaminated with the metal contaminants of concern can be identified since the concentrations exceeding the remediation goals were random across both sites. Background wells (6MW8 and 6MW9) did not exceed the remediation goals for inorganics except for manganese at 64 µg/L in 6MW9.

2.5.3 Surface Water

Wallace Creek has random areas of concentrations of metals and organics that exceed the chemical-specific surface water remediation goals. From the review of the analytical data, it appears that the surface water in Wallace Creek between the sampling location WC07 and WC11 (near the outlet of the ravine into Wallace Creek) may be an area of concern with respect to VOC contamination.

By reviewing the analytical data, it appears that the surface water of the ravine area contains levels of metals that exceed the surface water remediation goals. The highest concentrations of metals occur at the bottom portion of the ravine where it drains into Wallace Creek. It should be noted that water present in the ravine is from surface runoff as opposed to groundwater discharge.

Bear Head Creek has metals that exceed the remediation goals at downstream locations near its confluence with Wallace Creek. From the analytical data, this appears to be the only surface water area of concern in Bear Head Creek.

2.5.4 Sediment

All of the detected concentrations of the potential contaminants of concern in sediment are below the remediation goals (Table 1), therefore, no areas of concern have been identified as requiring remediation. There are no regulatory standards or criteria established for sediment (Federal or State), therefore, the majority of the remediation goals presented on Table 1 were estimated from a preliminary baseline risk assessment conducted as part of the RI. Based on the results from the preliminary risk assessment, the detected concentrations of these contaminants do not appear to cause a risk to human health or the environment. As a result, sediment will not be considered as a media of concern requiring remediation.

3.0 TREATABILITY STUDIES - DEFINITION AND JUSTIFICATION

Under the Superfund Amendments and Reauthorization Act of 1986 (SARA), the USEPA or lead agency is required to select remedial actions involving treatment that "permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants". As such, TSs provide valuable site-specific data necessary to support remedial action alternatives (USEPA, 1989a).

3.1 Definition and Types of Treatability Studies

3.1.1 Definition

TSs are laboratory or field tests designed to provide critical data needed to evaluate and, ultimately, to implement one or more technologies. TSs serve two-primary purposes: (1) to aid in the selection of a remedy, and (2) to aid in the implementation of a selected remedy (USEPA, 1989a). TSs conducted during the RI/FS phase provide additional data to evaluate whether a potential technology can meet the expected cleanup goals for a site. Another purpose of performing TSs during the RI/FS phase is to gain information regarding scale-up, costing, etc. TSs conducted during the remedial design/remedial action (RD/RA) phase establish the design and operating parameters for optimization of technology performance (USEPA, 1989a). TSs involve testing one or more technologies to gain qualitative and/or qualitative information for assessing their performance on specific wastes at the site.

3.1.2 Types (or Tiers) of Treatability Studies

During the technology screening phase of the RI/FS, as many as three types (or tiers) of treatability testing may be conducted: (1) laboratory screening, (2) bench-scale testing, and (3) pilot-scale testing (USEPA, 1989a).

3.1.2.1 Laboratory Screening

Laboratory screening is used to establish the potential of a technology to meet performance goals and can also be used to identify parameters for investigation during bench- or pilot-scale testings. Jar tests or beaker studies are examples of this TS tier. Note that little, if any, design or cost data is generated from this type of testing (USEPA, 1989a).

3.1.2.2 Bench-scale Testing

Bench-scale testing is used to determine the technology's performance (i.e., verify that the technology can meet the expected cleanup goals) (USEPA, 1989a). Bench-scale testing is typically performed in a laboratory, in which comparatively small volumes of waste are tested for the individual parameters of a treatment technology (USEPA, 1988a). Bench-top unit operations are indicative of this TS tier. Bench-scale testing can provide cost and design information (USEPA, 1989a).

3.1.2.3 Pilot-scale Testing

Pilot-scale testing is used to provide quantitative performance, cost, and design information. This testing can also provide data required to optimize performance (USEPA, 1989a).

Pilot studies are intended to simulate the physical as well as chemical parameters of a full-scale process. Therefore, the treatment unit size and the volume of waste to be processed in pilot-scale studies are significantly greater than that of benchscale studies (USEPA, 1988a). A mobile pilot-scale unit operation at a site is indicate of this TS tier (USEPA, 1989a). Pilot units are designed as small as possible to minimize costs, yet large enough to get the data required for scaling up. Because substantial quantities of material may be processed in a pilot test and because of the material's potential hazardous characteristics, special precautions may be required in handling, transporting, and disposing the processed waste (USEPA, 1988a). Pilot-scale testing are typically performed during the remedial design implementation phase (USEPA, 1989a).

The decision to conduct a pilot-scale TS instead of a bench-scale TS should take into account the technologies under consideration, performance goals, and the site characteristics. For a technology that is well developed and tested, bench studies are typically sufficient to evaluate the performance on new wastes. Pilot-scale studies should be limited to situations in which bench-scale studies or field sampling of physical or chemical parameters provide insufficient information to evaluate a technology, or else when there is a need to investigate secondary effects of the treatment technology, such as air emissions (USEPA, 1988a). In addition, a pilot-scale TS is conducted whenever a bench-scale TS is not feasible (e.g., evaluation of in-situ technologies).

3.2 Justification For Using a Treatability Study

The need for a TS is determined based on site- and technology-specific data needs that may not be available. TSs may be needed for applicable technologies for which no or limited performance information is available in the literature with respect to the waste types and site conditions of concern.

The need for and tier of treatability testing required are risk management decisions in which the costs and time required to conduct TSs are weighed against the risk inherent in the selection of a treatment alternative (USEPA, 1989a). Typically, treatability testing should be considered when sufficient information is not available through either literature searches or site-specific performance data to support both the full development and evaluation of all treatment alternatives and the remedial design of the selected alternative.

4.0 IDENTIFICATION AND EVALUATION OF POTENTIAL TREATABILITY STUDIES

Based on an evaluation of the available analytical data and physical information collected during the RI, target remediation goals and remedial action objectives were identified. For each objective, general response actions (e.g., containment, treatment, etc.) were developed. Remedial technologies associated with each response action were then evaluated and screened with respect to site-specific and contaminant-specific applicability. Potential feasible technologies were then reviewed in order to determine the appropriate data requirements needed to evaluate the technology for further consideration. The data required to fully evaluate a technology are typically gathered as part of the RI (e.g., water table elevation data can be used to evaluate the feasibility of soil vapor extraction) or through literature searches (e.g., percent removal data for air stripping is widely available). However, not all data required to evaluate a technology is available either by field collection or literature searches. In cases where information to assess the performance of the technology is limited, a TS may be useful to determine the feasibility of the alternative. TSs should not be done to evaluate technologies that, based on site-specific factors, would not be considered as a final alternative.

Potential TSs have been identified and evaluated for the potential areas of concern at Operable Unit No. 2 as discussed in the following sections. Note that the analytical results from additional ongoing sampling at Site 6 may affect the results of this TS evaluation, and therefore, a revised evaluation report may be required at a later date.

4.1 Identification of Potential Treatability Studies

Based on the available data for Sites 6 and 9, and the comparison of the data with the remediation goals, it appears that the only potential TSs that may be pertinent for the sites are related to groundwater. Since the potential areas of concern with respect to contaminated soils and surface water appear to be limited, it would not be cost-effective to conduct TSs for either of these two media. If remediation is necessary for either soils or surface water, technologies other than treatment options (e.g., containment via soil capping) may be the most appropriate. Therefore, the remainder of this report will focus only on potential TSs related to groundwater treatment technologies.

As part of the FS being conducted for Operable Unit No. 2, an initial set of technologies have been identified and preliminarily screened based on contaminant-specific and site-specific applicability. A set of groundwater treatment technologies which appear, at this time, to be potentially applicable to the groundwater contamination (VOCs) at Site 6 are listed on Table 2. These technologies include: carbon adsorption, air stripping, vapor extraction, biological treatment, in-situ bioremediation, and thermal treatment. Typical data needs to fully evaluate the potential of each of these technologies are also identified on Table 2, in addition to a listing of what data are currently not available (i.e., data limitations).

Based on a review of the data limitations identified on Table 2, it appears that the majority of necessary information for all of the identified technologies are available either through literature or through the RI. Most of the data requirements that are not available at this time, appear to be easily acquired through additional sampling (if determined to be necessary) such as oil and grease concentrations, total organic content, water hardness, viscosity, phosphorous concentration, and chemical oxygen demand. In addition, significant data is available from literature on the effectiveness of carbon adsorption, air stripping, biological treatment (ex situ) and thermal treatment for treating VOCs.

Based on this information, Baker has evaluated that the most pertinent technologies that may require TSs in order to gain sufficient "evaluation" information are vapor extraction and in-situ bioremediation. Table 3 presents a summary of the important data requirements which are not currently available for both of these technologies. In the next section, these two technologies will be further evaluated. The results of this evaluation will be used to recommend what TS(s) should be conducted for Operable Unit No. 2.

4.2 Evaluation of Potential Treatability Studies

Vapor extraction or in-situ biodegradatoin TSs were evaluated based on several factors including:

- Applicable contaminants;
- By products generated from the TS;
- Estimated duration of the TS;
- Information/data which would be generated by the TS;

TABLE 2

POTENTIALLY APPLICABLE GROUNDWATER TREATMENT TECHNOLOGIES AND DATA NEEDS

Treatment Technology	Typical Data Requirements for Evaluation	Data Available?, If So, Source
Carbon Adsorption	Organic Concentrations	Yes - RI
	Total Suspended Solids	Yes - RI
	Oil and Grease Concentrations	No
	Microbial Plate Count	No
	Total Organic Content	No
	Total Dissolved Iron	Yes - RI
	Total Dissolved Manganese	Yes - RI
	Contaminant Solubility	Yes - Literature
	Contaminant Molecular Weight	Yes - Literature
Air Stripping	Volatile Organics Concentrations	Yes - RI
	Nonvolatile Organics Concentrations	Yes - RI
	Contaminant Removal Efficiencies	Yes - Literature
	Hardness	No
	Contaminant Solubility	Yes - Literature
	Contaminant Vapor Pressure	Yes - Literature
	Henry's Law Constant	Yes - Literature
	Boiling Point	Yes - Literature
	Temperature	Yes - Field Analysis
	Total Suspended Solids	Yes - RI
	Total Dissolved Iron	Yes - RI
	Total Dissolved Manganese	Yes - RI
Vapor Extraction	Volatile Organic Concentrations	Yes - RI
	Soil Moisture Content	Yes - RI
	Contaminant Vapor Pressure	Yes - Literature
	Soil Permeability	Yes - RI and Literature
	Soil Porosity	Yes - RI and Literature
	Particle-Size Distribution	Yes - RI
	Depth of Contamination	Yes - RI
	Depth to Water Table	Yes - RI
	Priority Pollutant Concentrations	Yes - RI
	Henry's Law Constant	Yes - Literature
	Contaminant Solubility	Yes - Literature
	Organic Carbon Content	Yes - Literature
	Air/Water Partition Coefficient	Yes - Literature
	Soil Type	Yes - RI
	Contaminant Removal Efficiencies	Yes*

* Data are available from case studies only. May require additional site-specific studying.

TABLE 2 (Continued)

POTENTIALLY APPLICABLE GROUNDWATER TREATMENT TECHNOLOGIES AND DATA NEEDS

Treatment Technology	Typical Data Requirements for Evaluation	Data Available?, If So, Source
Thermal Treatment	Heat Value	No
	Viscosity	No
	Total Solids Content	Yes - RI
	Particle-Size Distribution of Solid Phases	Yes - RI
	Total Chlorine, Fluorine	Yes - RI
	Total Sulfur, Total Nitrogen	Yes (Nitrogen only)
	Phosphorus	No
	Volatile Organic Concentrations	Yes - RI
	Semivolatile Organic Concentrations	Yes - RI
	PCBs, Dioxin Concentrations	Yes - RI (PCB only)
	Inorganic Concentrations	Yes - RI
	Destruction Efficiency	Yes* - Literature
Biological Treatment	pH	Yes - RI
	Dissolved Oxygen	No
	Chemical Oxygen Demand	Yes
	Biological Oxygen Demand	Yes
	Culture Studies	No
	Microbial Toxicity/Growth Inhibition Tests	No
	Destruction Efficiency	Yes*
In-Situ Biodegradation	Soil Permeability	Yes - RI
	Contaminant Concentrations	Yes - RI
	Inorganics Concentrations	Yes - RI
	Salt Concentrations	No
	Contaminant Toxicity	No
	Hydraulic Conductivity	Yes - RI
	Site Stratigraphy	Yes - RI
	Temperature	Yes - RI
	Destruction Efficiency	Yes* - Literature
	Contaminant Biodegradability Refractory Index	Yes - Literature
	Total Organic Content of Groundwater	No
	Solubility	Yes - Literature
	Culture Studies	No
	Particle-Size Distribution	Yes - RI
	Soil Moisture Content	Yes - RI
	Soil pH	Yes - RI
	Soil Porosity/Permeability	Yes - RI
	Microbial Community	No

* Data are available from case studies only. May require additional site-specific studying.

TABLE 3

CRITICAL DATA REQUIREMENTS NOT CURRENTLY AVAILABLE FOR VAPOR EXTRACTION OR IN-SITU BIODEGRADATION

Treatment Technology	Critical Data Requirements
Vapor Extraction	Contaminant Removal Efficiencies Duration to Remediate to Meet Remediation Goals
In-Situ Bioremediation	Removal Rates Microbial Community Culture Studies Salt Concentrations Contaminant Toxicity Total Organic Content of Groundwater Duration to Remediate to Meet Remediation Goals

- How the information could be used to support the technology/alternative evaluation; and

- Estimated costs to perform the TS.

A summary of this evaluation is presented below.

Based on applicable contaminants, both technologies appear to be applicable to the potential contaminants of concern (i.e., PCE, TCE, 1,1-DCE, 1,2-DCA, 1,1,2,2-PCA, and vinyl chloride). In addition, both of these technologies are applicable to treating groundwater and soil. Therefore, if the results from the additional sampling in the wooded area north of Lot 203 identifies VOC-contaminated soils, both technologies may still be applicable.

The by-products generated from a TS for vapor extraction would include treated air emissions. An in-situ biodegradation TS would generate a treated effluent which is typically recycled back into the biodegradation system.

The in-situ biodegradation TS would probably require a longer duration than the vapor extraction TS since the degradation rates of the contaminants of concern are expected to be slower than their volatilization rates. An exact estimate of how long either test has not been determined since both TSs would be dependent of site conditions.

Pertinent information/data can be gained from conducting a TS for vapor extraction such as expected contaminant removal rates (volatilization) and expected limitations due to site-specific geology. Similar information/data could also be gained from conducting a TS for in-situ biodegradation (i.e., contaminant removal rates in terms of biodegradation and site-specific limitations).

The information gained from either TS could then be used to determine if the technology will be effective for the site. The results could also be used to aid in the design phase if the technology is implemented since site-specific limitations of the system will be identified.

The estimated costs to perform either of the TSs should be comparable. The vapor extraction TS may be slightly lower in costs since no additives (nutrients, etc.) are needed and the required equipment may be less extensive. Both TSs could be in the range of $100,000 to perform. This estimation is based only on available literature. No formal cost estimation has been prepared.

5.0 RECOMMENDED TREATABILITY STUDIES FOR OPERABLE UNIT NO. 2

Based on the results of the TS evaluation, Baker is recommending that a pilot-scale TS for vapor extraction may be required if the source of groundwater contamination north of Lot 203 is located and soil is significantly impacted with volatile contaminants. The primary reasons for this recommendation are due to the fact that critical data limitations exists, and that since vapor extraction is an in situ technology, it is highly dependent on site-specific characteristics that can not be determined only on literature or laboratory results. A TS would be necessary to monitor VOC removal efficiencies along with the effects of site-specific geologic characteristics on the performance of the technology.

Soil vapor extraction appears to be more applicable to the site than in situ biodegradation since the groundwater contamination at the site is located in both the shallow and deeper portions of the aquifer. The effectiveness of in situ biodegradation may be limited for the deeper portion of the aquifer.

Note that during the design phase, regardless of what remedial action alternative is selected for the operable unit, additional TSs may be required to determine specific design parameters for a treatment system. It is expected that these additional TSs may be laboratory-scale studies.

6.0 FOLLOW UP ACTIVITIES

Prior to conducting a TS, various activities associated with subcontractor procurement, plan preparation, and regulatory requirements must first be considered or scoped. Other activities are required during the performance of the TS such as sampling, analysis and reporting. This section briefly discusses the abovementioned activities in addition to estimating their duration and potential schedule with respect to other work activities associated with CTO-0133.

6.1 Activities to be Conducted Prior to the Execution of a TS

Prior to conducting a TS, several other activities must be performed as listed below:

- Prepare the TS Project Plans, which include the TS Work Plan, Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), and Health and Safety Plan (HSP). The purpose of the Work Plan is to present a description of the work activities that are to be conducted during the TS. In addition, the Work Plan assigns responsibilities and establishes the project schedule.

  The purpose of the SAP is to ensure that samples obtained for characterization and testing are representative and that the quality of the analytical data generated is known. The SAP addresses field sampling, waste characterization, and sampling and analysis of the treated wastes and residuals from the testing unit.

  The QAPP details the QA objectives (precision, accuracy, representativeness, completeness, and comparability) for critical measurements, and the quality control procedures established to achieve the desire QA objectives.

  The HSP identifies the hazards associated with each phase of site or facility operations (e.g., chemical exposure, fires, electrical hazards) and prescribes appropriate protective measures.

- Identify qualified contractors

- Prepare and submit request for bid to qualified contractors (minimum of three contractors should be identified).

- Evaluate the bid responses received and select a TS contractor.

- Comply with regulatory requirements for testing and residuals management. TSs involving CERCLA wastes are subject to certain permitting and operating requirements under CERCLA.

6.2 Activities to be Conducted During the Execution of a TS

During the execution of a TS, several activities must be performed. First, a sampling and analysis program must be conducted. This program will typically consist of routine collection of samples from the influent and effluent waste steams of the treatment process. Upon receipt of the analytical results from the laboratory, the data then needs to be evaluated. Following data evaluation/analysis activities, a TS Report will be prepared to describe the TS and present conclusions about the technology being evaluated. The TS Report may follow the format identified in USEPA TS guidance.

6.3 Estimated Duration and Schedule of TS Activities

This section will be completed in the Final TS Evaluation Report.

7.0 REFERENCES

Baker Environmental, Inc. (Baker). 1992. Remedial Investigation/Feasibility Work Plan for Sites 6,9,48, and 69. Camp Lejeune Marine Corps Base, Jacksonville, North Carolina. Final. Prepared for the Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

United States Environmental Protection Agency (USEPA). 1990. Assessing UST Corrective Action Technologies: Early Screening of Clean-Up Technologies for the Saturated Zone. USEPA Risk Reduction Engineering Laboratory, Cincinnati, Ohio. EPA/600/2-90/027.

USEPA. 1989 (a). Guide for Conducting Treatability Studies Under CERCLA. Interim Final. USEPA Office of Research and Development and Office of Emergency and Remedial Response. Washington, D.C.

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

USEPA. 1988 (a). Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. Interim Final. USEPA Office of Emergency and Remedial Response. Washington, D.C. EPA/540/G-89/004.

USEPA. 1988 (b). Technology Screening Guide for Treatment of CERCLA Soils and Sludges. USEPA Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/2-88/004.