DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 49TH FIGHTER WING (ACC)
HOLLOMAN AIR FORCE BASE, NEW MEXICO

26 NOV 1996

MEMORANDUM FOR NEW MEXICO ENVIRONMENT DEPARTMENT
Hazardous and Radioactive Materials Bureau
RCRA Permits Program
Attn: Mr. Jerry Bober
2044 Galisteo
P.O. Box 26110
Santa Fe NM 87502-6110

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HAFB RED 96

FROM: 49 CES/CD
550 Tabosa Ave
Holloman AFB NM 88330-8458

SUBJECT: Closure Plan Revisions for Holloman Air Force Base Sewage Lagoons

1. Page replacements are attached for the Sewage Lagoons Closure Plan, originally submitted in June 1996. These page replacements reflect refinements in the proposed closure process, the "Restore to Natural Contours" alternative.

2. Please direct questions to Dr. Fred Fisher or Mr. Warren Neff of the Civil Engineer Environmental Flight, 49 CES/CEV, at (505) 475-3931/5062.

HOWARD E. MOFFITT
Deputy Base Civil Engineer

Attachment:
Page Replacements for Closure Plan

cc (with Atch):

Ms. Stephanie Kruse
Hazardous and Radioactive Materials Bureau
New Mexico Environment Dept
2044 Galisteo
P.O. Box 26110
Santa Fe NM 87502-6110

Mr. Gene Keepper
US EPA Region VI
1445 Ross Avenue, Suite 900
Dallas TX 75202-2733

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Headquarters, Air Combat Command
Langley Air Force Base,
Virginia

Sewage Lagoons Closure Plan

Sewage Lagoons Closure Project

June 1996

49 CES/CEV
Holloman Air Force Base,
New Mexico

DCN 96-670-008-07

SEWAGE LAGOONS CLOSURE PLAN

SEWAGE LAGOONS CLOSURE PROJECT
HOLLOMAN AIR FORCE BASE, NM

Prepared for:

49 CES/CEV
Holloman Air Force Base, NM

and

HQ ACC/CEVR
Langley Air Force Base, VA

Prepared by:

Foster Wheeler Environmental Corporation
143 Union Blvd., Suite 1010
Lakewood, Colorado 80203
303/988-2202

Radian International
8501 North Mopac Blvd.
Austin, Texas 78720
512/454-4797

Under Contract No. DACW45-94-D-0003 with:

U.S. Army Corps of Engineers
Omaha District
Omaha, Nebraska

June 1996

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ACRONYMS

ACC	Air Combat Command
AFB	Air Force Base
AOC	Area of Contamination
CERCLA	Compreshesive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
DERA	Defense Environmental Restoration Account
DOC	Dissolved Organic Carbon
DoD	Department of Defense
DRMO	Defense Reutilization Marketing Office
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
FFCA	Federal Facilities Compliance Agreement
FONPA	Finding of No Practicable Alternative
FONSI	Finding of No Significant Impact
FS	Feasibility Study
HHSs	Human Health Standards
HQ	Headquarters
HSWA	Hazardous and Solid Waste Amendments
HWIR	Hazardous Waste Identification Rule
HWMR	Hazardous Waste Management Regulations
IRP	Installation Restoration Program
HWMUs	Hazardous Waste Management Units
LTM	Long-term Monitoring
MCLs	Maximum Contaminant Levels
NEPA	National Environmental Protection Act
NMED	New Mexico Environment Department
NMSU	New Mexico State University
NMSWB	New Mexico Surface Water Bureau
NPDES	National Pollutant Discharge Elimination System
PAR	Project Assessment Report
PCBs	Polychlorinated biphenyls
PCCP	Post-Closure Care Permit
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SMCLs	Secondary Drinking Water Maximum Contaminant Levels
SWMUs	Solid Waste Management Unit
TAC	Tactical Air Command

ACRONYMS
(Continued)

TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
USAF	United States Air Force
USFWS	U.S. Fish and Wildlife Service
WSMR	White Sands Missile Range

Section 1
INTRODUCTION

The primary objective of the sewage lagoons closure plan is to describe clean closure activities for the Holloman Air Force Base (AFB) sewage lagoons. This objective is in accordance with the 1988 Federal Facilities Compliance Agreement (FFCA), which was signed by the New Mexico Environment Department (NMED), United States Environmental Protection Agency (EPA) Region VI, and Holloman AFB. In addition, this closure plan intends to 1) show how the Holloman AFB sewage lagoons differ from a typical Resource Conservation and Recovery Act (RCRA) unit, 2) summarize all investigations that have occurred at the sewage lagoons, and 3) demonstrate that the nature and extent of contamination have been determined, and show that no further sampling is necessary prior to proceeding with closure activities.

This closure document supersedes the sewage lagoon closure plans that were submitted to NMED and EPA Region VI in November 1985, January 1989, July 1990, and May 1995. Some pages, specifically those that discuss the *Corrective Measures Study*, were revised in November 1996 as indicated at the bottom of the pages.

In March 1995 a *Project Assessment Report* (PAR) (Radian, March 1995b) was submitted to NMED and EPA Region VI to provide a historical description of the regulatory status of the sewage lagoons and to summarize previous media investigations. The PAR should be read prior to reviewing this closure plan in order to understand fully the previous work performed at the sewage lagoons.

1.1 Closure Concept

The Holloman AFB sewage lagoons differs from that of a typical RCRA unit. Unlike other RCRA units that are designed to treat or dispose of hazardous wastes, the Holloman AFB sewage lagoons were never intended to treat hazardous wastes. From the time the lagoons were created, their primary function has been to treat domestic wastewater prior to discharge to Lake Holloman. Any hazardous wastes that have entered the lagoons have done so through releases prior to 1985. Therefore, because there are no wastes records that are typically associated with a RCRA unit, it is difficult to evaluate the amount of waste that must be remediated without first conducting a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or RCRA Corrective Action-like investigation to characterize the underlying soils, sludge, and surface water. Consequently, this closure plan follows a RCRA Corrective Action-like format in establishing closure activities for the sewage lagoons. This closure plan outlines the procedures that were used to determine the appropriate remedial alternatives for closing the sewage lagoons.

This closure plan provides a historical look at the investigations conducted at the sewage lagoons and provides details as to the nature and extent of contamination associated with the lagoons. The plan also summarizes and references other documents that support this plan. The selection of the proposed remedial alternative was based on discussions and comments received at the 3 April 1996 stakeholders meeting defining clean closure as closure that excludes exposure or risk in a residential setting. Other comments received at the stakeholders meeting was the desire to keep water in Pond G to maintain the aquatic habitat it has developed over the past years since it has been part of the wastewater treatment system. The *Corrective Measures Study,* provided as Appendix C to this report, discusses these issues and others mentioned at the stakeholders meeting and pro-

vides the basis for selecting the proposed closure alternative.

1.2 Background

The current domestic wastewater treatment facility at Holloman AFB consists of seven sewage lagoons (Ponds A through G) that discharge through a ditch to Lake Holloman, which during low evaporation periods can overflow to Lake Stinky. This document describes closure of the sewage lagoons; however, it does not address the ditch or lakes.

The distinction between the lagoons and the lakes is a result of the water bodies' different regulatory classifications and the requirements of the FFCA. In 1994, NMED and EPA Region VI determined that the lakes and the ditch would be regulated under the Hazardous and Solid Waste Amendments (HSWA) program as two solid waste management units (SWMUs). The sewage lagoons, however, are regulated as hazardous waste management units (HWMUs). The rationale for this determination was that no information exists to suggest that hazardous wastes were ever discharged into the ditch, Lake Holloman, or Lake Stinky.

This position was presented in an EPA Region VI letter to NMED (David Neleigh, personal communication, 4 April 1994) and an NMED letter to Holloman AFB (Barbara Hoditschek, personal communication, 6 April 1994). The NMED letter stated that the ditch, Lake Holloman, and Lake Stinky would be regulated by EPA Region VI under the HSWA corrective action program, and the seven sewage lagoons would be regulated by NMED under the New Mexico Hazardous Waste Management Regulations (HWMR-7), Part V, 40 CFR 265. Since this time, NMED has received authorization to run the HSWA program in New Mexico. In addition, NMED has confirmed that the sewage lagoons have lost interim status under RCRA because of two Notices of Noncompliance that cited Holloman AFB in violation of 40 CFR 264 and 265. The Notices of Noncompliance cited the Base's failure to submit a complete Part A permit application and failure to establish a groundwater monitoring program.

1.3 Organization of Closure Plan

The sewage lagoons closure plan consists of seven sections, including this introduction. Section 2 presents the issues that may affect selection of the final closure methodology for the sewage lagoons. Section 3 presents a facility description, including Base location, regional environmental setting, physical description of the sewage lagoons, the lagoon system usage, and groundwater quality. Section 4 summarizes the history of investigations and removal activities that have occurred at the lagoons between 1981 and 1993. Included in Section 4 are summaries of sludge, soil, biota, and surface water sampling; groundwater monitoring; and risk assessment results. Section 5 summarizes the 1994 investigation, and describes the purpose of the investigation and the constituents, media, and sample locations that were monitored. Section 6 summarizes recent documentation and regulatory issues applicable to the closure of the sewage lagoons. Section 7 presents a bibliography of documents prepared for the sewage lagoons closure project, and references.

Appendix A summarizes the analytical results from 1990 to 1995. Appendix B presents the 1994/95 investigation sampling plan. Appendix C presents the *Corrective Measures Study.* Appendix D lists all the documents available related to the sewage lagoons.

based on the carcinogenic risks and noncancer hazards to human health, and on ecological risks from current and potential future activities at the sewage lagoons and lakes.

Site-specific human health risk assessments were updated for Ponds A through G. The lakes and the ditch connecting the sewage lagoons and lakes were also evaluated; however, this closure plan only addresses the sewage lagoons. Four exposure scenarios were evaluated in the addendum, including: 1) current on-site worker (chronic and subchronic) for Ponds A through G; 2) current/future recreational use identified as hunters for Pond G (chronic and subchronic); 3) current/future trespasser identified as a teenager for Pond G (subchronic); and 4) future beef consumer at Lake Stinky (chronic). The fourth exposure scenario will not be addressed in this closure plan since it relates only to Lake Stinky. The results of the risk assessment addendum indicated there were no unacceptable risks identified at the sewage lagoons. All carcinogenic risk estimates were less than or within the acceptable risk range of 10^{-4} to 10^{-6}. All noncarcinogenic risk estimates were below the hazard quotient of 1. Section 4 of the *Risk Assessment Addendum* (Radian and Foster Wheeler, March 1996) presents a summary of the human health risks for Ponds A through G.

The ecological risk assessment evaluation presented in the *Risk Assessment Addendum* (Radian and Foster Wheeler, March 1996) replaces the ecological risk assessment presented previously in the December 1993 risk assessment report. Biological tissue data were available for the addendum which were not available in 1993. Risks to the environment were considered for Pond G, the ditch, and the lakes. Ponds A through F were not evaluated because it was known that these sewage lagoons would be drained and closed, and would no longer serve as an aquatic habitat. The following assessment endpoint species were evaluated: mosquito fish, mallards, mergansers, black-necked stilts, and killdeer. Tissue samples were available for all endpoint species except the mergansers and killdeer. Two approaches were used to evaluate the data: 1) using food uptake modeled from food source samples collected; and 2) using body burden tissue data collected for the mosquito fish, one mallard, and black-necked stilts. The results of the assessment indicated that DDD and DDE (derivatives of DDT) are the only constituents of concern. However, as described in the *Site Characterization Report* (Radian and Foster Wheeler, June 1995), these constituents are no longer entering the system and since 1990 have been decreasing in concentration through natural attenuation. A more detailed description of the results of the ecological risk assessment can be found in Section 6 of the *Risk Assessment Addendum* (Radian and Foster Wheeler, March 1996).

6.1.5 Biological Resources Report

Holloman AFB has prepared a *Biological Resources Report* (Radian and Foster Wheeler, June 1996) that presents an assessment of the impacts of closure alternatives to threatened and endangered (both Federal and State) species. The following closure alternatives are addressed in the *Biological Resources Report*:

1) No action—let lagoon dry out;

2) Dewater sludge, backfill Ponds A through F, and construct 120 acres of new wetlands; and

3) Dewater sludge, dredge Pond G, backfill Ponds A through F, and construct 120 acres of new wetlands.

These alternatives are similar, but not the same as the alternatives presented in the *Corrective Measures Study*. The review of the effects of dredging Pond G in the *Biological Resources Report* helped eliminate this alternative for consideration in the *Corrective Measures Study*.

The Biological Resources Report was submitted to the USFWS, NMED, and EPA Region VI in June of 1996.

A list of 21 animal and two plant threatened, endangered and sensitive species (Table 2-2) have been identified as potentially occurring near the lagoons. These were selected to determine if the proposed action at Holloman AFB would result in the loss of sensitive habitat for endangered and threatened species. Of the 23 species assessed, only eight have actually been sighted in the project area, and three of these occur as migrants.

Based on the results of the risk assessment, contaminants in the sewage lagoons are not causing unacceptable risk to human or ecological receptors. However, ducks and black-necked stilts may have increased levels of DDE in their tissues, either as a result of foraging in the lagoons or because DDT and breakdown products have become common contaminants in the ecosystem as a whole. Because contamination is more concentrated in Ponds A through F, it would be preferable to close these lagoons and construct wetlands west of Pond G to replace surface water that would be lost. It is very important to note that Pond G, an impounded playa, is a larger and more ecologically valuable pond that should remain open. Pond G provides sensitive habitat to some of the bird species and also supports associated wetlands.

The species observed in the project area do not depend heavily on Ponds A through F for forage or cover. However, without the development of additional waterbodies to replace these sewage lagoons, species abundance may decrease with the loss of forage. In addition, the loss of evaporative surface would result in increased water levels in the lakes. Under the proposed action, Holloman AFB plans to construct at least 120 acres of wetland habitat southwest of Pond G to help compensate for this loss. The additional wetlands would provide a cleaner, healthier aquatic system and would result in increased forage and cover.

6.1.6 Corrective Measures Study

A *Corrective Measures Study* (CMS) (Radian, June 1996, revised November 1996) was prepared to identify, develop, and evaluate alternatives for closure of the sewage lagoons. The CMS was prepared to comply with RCRA and CERCLA requirements for closure of the lagoons. Because the closure of the sewage lagoons is being carried out as part of the IRP program and is funded by DERA (DoD implementation of CERCLA), CERCLA requirements had to be met. The CMS is presented in Appendix C. The closure objectives and closure criteria for the sewage lagoons are presented in Section 2 of this closure plan.

It should be noted that a risk assessment has shown that the constituents in sludge do not pose unacceptable risks to human health or the environment. One of the primary objectives of the closure is to ensure the control of disease vectors and odors that may be associated with the sludge.

Ponds A Through F

The proposed alternative for Ponds A through F involves containment of the sludge through the addition of a soil cover. The proposed alternative was selected by evaluating the ability of each alternative to meet the closure and other evaluation criteria. The proposed alternative protects human health and the environment by eliminating potential exposure pathways to any constituents in sludge.

In the proposed alternative, the water will be drained from the lagoons; the sludge will be dewatered; the berms that are above grade around the lagoons will be removed; and the resulting soil will be placed in the lagoons as a soil cover over the dewatered sludge so the site can be restored to the approximate natural contours. More detailed descriptions of these actions are provided below.

The first step for the alternative for Ponds A through F involves shutting off the influent to Ponds A and B and redirecting the flow to the new WWTP. This step has already been completed. The water from Ponds D, E, and F has been pumped into Ponds A and B. Because of the high water table and the cool weather, the evaporation of the remaining water in Ponds A, B, and C will be very slow in the winter months. It is estimated that it will take more than 6 months for the water in the lagoons to infiltrate and evaporate. Therefore, Holloman AFB is exploring options to remove the remaining water. Any discharges from the lagoons will comply with the Clean Water Act and the New Mexico Water Quality Control Commission regulations.

Once the surface water has been removed, the sludge will be dewatered. Natural evaporation will play an important role in dewatering the sludge, which ranges in thickness from 2 to 48 in. within Ponds A through F. Mixing and turning the sludge with a dozer or front-end loader will help with the natural dewatering process. This process will be expedited by mixing in soil with the sludge. Soil or a commercial chemical additive may be mixed with the sludge to reduce odors. A soil cover that is at least 12 in. thick will be added to Ponds A through F once the sludge is dewatered sufficiently.

The south berms which are elevated as much as 10 ft above grade will be broken down and used to provide the soil cover. This soil will be spread and compacted using standard backfilling techniques and standard earthmoving equipment. The finished surface of the compacted backfill will be graded to provide for adequate drainage. The area will be vegetated. Approximately 200,000 yd^3 of soil from the abovegrade berms will be placed in the lagoons as a soil cover over the sludge.

Care will be taken throughout the closure to minimize erosion and control dust. All equipment will be decontaminated using a decontamination pad. Rinse water from decontamination procedures will be stored on site and will be released to the surface if analyses indicate that no constituent concentrations pose a potential risk. Although this alternative will minimize the need for maintenance, semiannual maintenance of the vegetative cover will be carried out to ensure the integrity of the cover. Monitoring of storm water runoff will be conducted in accordance with the general provisions of Sector L of the multi-sector general permit (MSGP) reported in the 29 September 1995 *Federal Register*.

After the closure is completed, the land use for the area where Ponds A through F are located will be restricted open space. The area will be fenced and will remain a restricted area because it is in a designated runway clear zone. This land use cannot be changed unless the potential risks associated with the new land use are reevaluated and the land use designation is changed in the Base Comprehensive Plan.

Pond G

The proposed alternative for Pond G is the no action alternative. Pond G is an important wildlife habitat, and the risk assessment results have indicated no unacceptable human health or ecological risks. There is a slight potential for black-necked stilts to have increased levels of DDE in their tissues; however, the *Site Characterization Report* (Radian and Foster Wheeler, June 1995) has shown that concentrations of DDT and its derivatives are decreasing rapidly. The results presented in the *Biological Resources Report* (Radian and Foster Wheeler, June 1996) indicated that adverse effects on wildlife habitat would likely be associated with removal of sludge from Pond G.

A pipeline will be constructed from the new WWTP to Pond G. The pipeline will ensure that the lagoon receives water and continues to provide the ecological habitat that it does currently. The evaluation of this alternative indicates that it

will meet the closure objectives and satisfy the closure criteria.

6.1.7 Decision Documents

The sewage lagoons are being closed under the IRP and are funded through DERA. As such, a decision document must be prepared and signed by the Air Force and NMED prior to closure. The decision document will be a short, concise report that summarizes the approved approach to closure for the sewage lagoons. It will be prepared following the review and approval of this closure plan by NMED.

6.2 Wildlife and Wetland Issues Pertaining to Closure

Holloman AFB may address a series of issues pertaining to wildlife and wetlands prior to final closure of the sewage lagoons. These issues are not part of the closure plan, but may have an effect on the closure activities

6.2.1 Clean Water Act

In accordance with 40 CFR Section 300.400(e)(1), no federal or state permits are required for CERCLA actions. As the sewage lagoons are being closed with DERA funds (DoD implementation of CERCLA), no permits will be obtained for closure activities. However, the closure activities will follow the intent of any such permitted requirements. Two requirements that could be impacted by the closure of the sewage lagoons are the storm water construction permit and the 404 permit.

Appropriate measures to prevent erosion and runoff of sediments and wastes during storm events will be taken during the closure activities. The Base will meet the substantive requirements for storm water pollution prevention described in the 9 September 1992 *Federal Register* (page 41176, Final NPDES General Permits for Storm Water Runoff from Construction Sites).

Any disturbance of the wetlands adjacent to the sewage lagoons (i.e., south of Pond E) during the closure activities will comply with the substantive requirements of Section 404 of the Clean Water Act. The specific requirements applicable for this site are found in the nationwide Permit 26 for isolated waters (33 CFR 330, Appendix A).

6.2.2 NEPA

Holloman AFB conducted an EA as required by the National Environmental Protection Act (NEPA) for construction of the new wastewater treatment plant. This EA determined that closing Pond G was a significant impact. The assessment is presented in the 13 April 1995 *Wastewater Treatment Plant for Holloman Air Force Base New Mexico, Final Environmental Assessment* GeoMarine, 1995).

The closure of the sewage lagoons is DERA funded (CERCLA action) and, therefore, formal NEPA documentation and compliance is not required. However, CERCLA actions must consider NEPA, and this is accomplished collectively through the WWTP EA and the *Biological Resources Report* (Radian and Foster Wheeler, June 1996).

6.2.3 Fish and Wildlife Coordination Act

Holloman AFB has coordinated with the USFWS throughout the investigation of the sewage lagoon. Coordination with USFWS will continue through closure activities.

6.3 Initiation of Closure

After approval of the closure plan by NMED, the Base will begin closure procedures. It is expected that clean closure will be achieved; however, if it is not, a post-closure care plan will be prepared and submitted to NMED. It will include documentation on how to maintain the integrity of the soil cover and long-term groundwater monitoring.

A preliminary schedule for closure is presented in Table 6-2. After closure is completed, an independent registered professional engineer will prepare and seal documentation describing the actual closure activities. This certification will also be signed by Holloman AFB and submitted to NMED.

As noted in the schedule presented in Table 6-2, wastewater stopped entering the sewage lagoons in July 1996. Interim closure measures are already in progress to prevent the exposure of disease vectors that potentially exist and control odors. These interim measures will involve dewatering the sludge by mixing in soil from the berms and covering the dewatered sludge with approximately 6 in. of soil.

Table 6-2
Schedule for Closure

Activity	Dates
Date when wastewater (nonhazardous waste) no longer received in the sewage lagoons	July 1996
Public Notice	Initiated by NMED
Start of Closure	Date of NMED approval of closure plan
Design Completion	30 days after start of closure
Begin Closure Actions	90 days after start of closure
Complete Dewatering of Lagoons	180 days after start of closure
Complete Final Cover	270 days after start of closure
Written Certification of Closure	330 days after start of closure

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Section 2
CLOSURE ISSUES

A closure plan was originally submitted to NMED and EPA Region VI on 22 November 1985. This plan proposed that an administrative, rather than physical, closure be performed to allow for continued treatment of nonhazardous wastes in the sewage lagoons. However, EPA interpreted this plan as a delisting petition and determined that it was unsatisfactory for a closure plan.

Following review of the 1985 closure plan, NMED and EPA Region VI agreed that the sewage lagoons must be closed in accordance with 40 CFR Part 265, Subparts G and K, which present two options for closure: "clean closure" or "closure in-place." Clean closure involves removal of all hazardous wastes and hazardous waste constituents. Closure in-place involves leaving wastes and waste constituents in-place and closing the facility as a landfill. This would include a permanent cap and a postclosure care permit. The closure plan submitted in January 1989 incorporated the closure in-place concept.

During meetings in January 1991 with NMED and EPA Region VI, Holloman AFB requested that the sewage lagoons be allowed to undergo clean closure supported by a site-specific demonstration (i.e., risk assessment). The basis for this request is the discussion of site-specific demonstration of clean closure in the preamble of the final rule for *Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities* (52 *Federal Register* 8704, 8706, 19 March 1987). The agencies agreed in the January 1991 meetings that clean closure by site-specific demonstration would be an option for the sewage lagoons, assuming that any lagoon that could not meet the site-specific health-based standard would undergo closure in-place. This position was confirmed by NMED in a 17 August 1992 letter to Holloman AFB. This revised closure plan advocates clean closure of the sewage lagoons by site-specific demonstration.

A stakeholders closure meeting between representatives of NMED, EPA Region VI, and the Audubon Society was held on 3 April 1996. During that meeting, NMED stated that clean closure would be accomplished if no risks were identified for a residential scenario, even if sludge was left in place. The proposed closure alternative presented in Section 6.1.6 and Appendix C are based on discussions and comments from the 3 April 1996 stakeholders meeting. The closure objectives and criteria are as follows.

Closure Objectives

- Ensure the protection of human health and the environment at the sewage lagoons after closure;
- Provide an adequate habitat for the wildlife associated with the sewage lagoons; and
- Ensure that closure eliminates disease vectors and odors that may be associated with the sewage lagoons and that the closure is aesthetically suitable.

Closure Criteria

- Protect human health and the environment;
- Comply with applicable waste management standards; and
- Prevent human exposure to constituents in soil and/or sludge that would lead to an unacceptable risk for a residential exposure scenario.

2.1 New Wastewater Treatment Facility

Headquarters Air Combat Command (HQ ACC) gave approval to Holloman AFB to construct a new wastewater treatment plant (WWTP)

that will replace the existing sewage lagoon system. HQ ACC also requested the United States Army Corps of Engineers (USACE) Albuquerque District to hire a contractor to design the facility. Construction was expected to begin in late 1994, but delays occurred because the environmental assessment (EA) prepared for the new wastewater treatment plant project revealed the proposed evaporation ponds had significant impacts on wetlands and wildlife habitat (Geo-Marine, 1995). New effluent disposal alternatives were developed and analyzed to eliminate these impacts and to reduce the potential for future RCRA compliance problems. The design was completed and construction of the new wastewater treatment system began in May 1995. The facility will go on line in July 1996 ahead of schedule. Upon start-up of the new WWTP, domestic wastewater will be diverted from the existing sewage lagoons to the new facility and discharge of wastewater to the sewage lagoons will cease.

2.2 Land Disposal Restrictions

If NMED determines that the sludge in the sewage lagoons is hazardous waste, land disposal restrictions could apply if the waste is removed from the sewage lagoons. As discussed below, NMED is currently studying whether or not the sludge will be considered a listed hazardous waste according to the mixture rule interpretation. Results from the 1994/95 investigation indicate that no characteristically hazardous wastes exist within the ponds.

In response to a December 1984 RCRA Section 3007 request for information by EPA Region VI, Holloman AFB identified, through interviews, the hazardous wastes in Table 2-1 as having entered the sewage lagoons. In the February 1987 EPA Notice of Noncompliance (Docket Number RCRA VI-661-H), the EPA restated the information from the 3007 request that these wastes were identified as having entered the sewage lagoon system. The 22 November 1985 closure plan presented information that indicated several of the listed wastes previously identified by Holloman AFB as having entered the sewage lagoons had been incorrectly identified as listed wastes. Considering the Department of Defense's (DoD) practice of using the DRMO (Defense Reutilization Marketing Office) for redistributing pure chemicals, it is highly unlikely that any pure or off-spec "U" or "P" listed wastes were flushed to the sewer drains. It is more likely that the spent chemicals or "F" listed wastes entered the sewer system. As such, the list of hazardous wastes presented in Table 2-1 and cited in the FFCA should probably be limited to only the "F" listed wastes.

In April 1994, Holloman AFB requested a determination from NMED as to whether the sludge in the sewage lagoons is considered a listed hazardous waste according to the mixture rule [40 CFR 261.3(a)(2)(iv)]. Holloman AFB stated that the waste should not be considered listed hazardous waste because extensive investigation of surface water, sludge, and underlying soils in the sewage lagoons has, in most cases, failed to detect the constituents associated with the listed wastes presented in Table 2-1. Of those detected, the concentrations found were well below levels of concern. NMED agreed with this position in a 1 September 1994 conference call. However, in subsequent discussions, NMED has indicated that they have not reached a decision on this issue. No written documentation exists as to NMED's position on this issue. However, during the 3 April 1996 stakeholders meeting, both EPA and NMED indicated the sludge was a listed waste by definition, as a result of the mixture and derived from rules.

2.3 Regulatory Considerations Other than RCRA

Regulatory considerations other than RCRA center on the habitat that the sewage lagoons provide for area wildlife. Ponds A and B were constructed in 1943, Ponds C through F between 1955 and 1959, and Pond G in its current

Table 2-1
Listed Wastes Allegedly Disposed of in Sewage Lagoons

EPA Waste Code[a]	Description	Source Identified in Interviews
F001	Halogenated degreasing solvents	Corrosion Control (Bldg. 308) and DMEL
F003	Nonhalogenated degreasing solvents	NDI
U228	Trichloroethene	Flightline Area
U161	Methyl isobutyl ketone	NDI
U227	1,1,2-trichloroethane	Bldg. 308 and AGE
U188	Phenol	Bldg. 308
U154	Methanol	Hospital, Dental Clinic, NMSU PRL, Photo Labs, Solar Observatory, Dyna Corp.
U002	Acetone	Hospital, Dental Clinic, NMSU PRL
U122	Formaldehyde	Hospital, Dental Clinic, Photo Lab, Dyna Corp.
U165	Naphthalene	NMSU PRL
U220	Toluene	NMSU PRL
U239	Xylene	NMSU PRL
U003	Acetonitrile	NMSU PRL
U211	Carbon tetrachloride	Flightline Area
U233	Propionic acid [b]	Photo Labs One Time Use
P095	Phosgene	Flightline Area
P012	Arsenic trioxide	West Area Photo Lab
P106	Sodium cyanide	Test Group (Bldg. 824)

Source: 1984 Response to RCRA 3007 Request and 1987 Notice of Noncompliance and Interview Notes.

Notes: NDI = Non destructive inspection. NMSU PRL = New Mexico State University Primate Research Lab.

[a] Considering DoD's practice of using the DRMO for redistributing chemicals, it is highly unlikely that "P" and "U" listed wastes (pure or off-spec chemicals) were discharged to the sewer system. It is more likely that the spent chemicals or "F" listed wastes were discharged to the sewer system.
[b] U233 [2-(2,4,5-trichlorophenoxy) propionic acid)] was eliminated from 40 CFR 261.33 by USEPA in 1984 and replaced with a reference to F027 (relating to tri-, tetra-, and pentachlorophenol formulations).

form in 1970. Pond G was a playa lake prior to being included as part of the wastewater treatment facility in 1970. These ponds, as well as Lake Holloman, now contain water year round, and as such have become habitat for wildlife in the desert environment.

2.3.1 Wetlands

When Holloman AFB decided to construct a new wastewater treatment facility to replace the facility, the closure of the sewage lagoons and the jurisdictional status of Pond G with respect to regulation as a wetland was discussed. The USACE determined that Pond G was currently exempt from regulation under Section 404 of the Clean Water Act because it was functioning as a part of the wastewater treatment system; however, if Pond G was disconnected from the wastewater treatment system, it would lose the exemption and would be subject to a Section 404 permit in order to dredge the site. In addition, Lake Holloman is a playa lake which is classified as Waters of the United States by 40 CFR 122.2.

The new wastewater treatment facility will discharge to Pond G and to Lake Holloman through two separate National Pollutant Discharge Elimination System (NPDES) permitted outfalls. Both water bodies will be considered waters of the United States. At this time, Holloman AFB believes that discharging to Pond G will help preserve the wildlife habitats associated with Lake Holloman and Pond G. The EA prepared for the construction of the new wastewater treatment plant identified the loss of Pond G (65 acres of wetlands) as a significant impact (Geo-Marine, 1995). The selected alternatives include construction of up to 170 acres of wetlands. Currently, 120 acres of new wetlands are under construction, of which 14 acres are jurisdictional wetlands subject to regulation under Section 404 of the Clean Water Act.

2.3.2 Endangered Species

Lake Holloman has been classified as a wildlife habitat area owing to the migratory waterfowl that inhabit the lake during the spring and fall migrations. Endangered species have also been sighted in the area. The U.S. Fish and Wildlife Service (USFWS) is charged with protecting migratory waterfowl (under the Migratory Bird Treaty Act) and endangered species (under the Endangered Species Act). The USFWS is concerned about the potential bioaccumulation of hazardous constituents in lake organisms and the subsequent endangerment of migratory waterfowl (USFWS, 1994). They are also concerned about the impact to area wildlife if water is removed from all the sewage lagoons (especially Pond G).

During 1991, the USFWS conducted an investigation to assess whether harmful concentrations of contaminants could be present in water and biota at the sewage lagoons or Lake Holloman (USFWS, 1994). The objective of the study was to make an initial determination of the concentrations of organic and inorganic contaminants within biotic and abiotic components of the sewage lagoons and Lake Holloman aquatic ecosystems. Birds were collected from Ponds A, B, and G, and from Lake Holloman.

A summary of the results was presented in the draft *Preliminary Survey of Contaminants Present in Biota, Pore-Water, and Sediment, at the Holloman AFB WWTP* (USFWS, 10 January 1994). This report has not been finalized. The results primarily indicated that risks resulting from the presence of potentially toxic substances in aquatic systems were difficult to assess. Some of the analytical results collected from sediment samples indicated that the concentrations could cause some adverse biological effects; however, there were no analyses to determine if the constituents were bioavailable. Tissue samples collected contained generally low concentrations of these constituents.

In April 1993, Holloman AFB requested a list of threatened and endangered species that potentially inhabit the sewage lagoons and lakes

area, and opened informal consultation with USFWS under Section 7 of the Endangered Species Act. Table 2-2 presents an updated list of endangered species (as of May 1995) potentially present at or near the sewage lagoons. The Base informed the USFWS of plans to construct a new wastewater treatment plant to replace the current sewage lagoons. This plan indicated Ponds A through F would be eliminated as water bodies, Pond G and Lake Holloman would receive treated wastewater and would continue to allow seasonal water overflow from Lake Holloman to Lake Stinky. The Mesilla Valley Audubon Society has requested that Lake Stinky be preserved as a shorebird habitat.

Holloman AFB has collected biota samples from the sewage lagoons and lakes. These data were used to prepare an ecological risk assessment that evaluated if a threat to the local environment exists as a result of the sewage lagoons. This is discussed in Section 4.3.

In addition, The *Biological Resources Report* (Radian and Foster Wheeler, June 1996) has been prepared to determine alternative closure methods for the sewage lagoons and how they might affect the existing biota's habitat. This report integrates those issues raised during the 3 April 1996 stakeholders meeting; specifically, the preservation of shorebird habitat.

The conclusions of this meeting were considered when selecting the proposed closure alternative presented in Section 6.1.6.

2.4 Funding for Closure

The sewage lagoons are included in the Installation Restoration Program (IRP) being conducted at Holloman AFB, and are designated IRP Site 49. The IRP was established to investigate past hazardous waste disposal sites at DoD installations. Implementation of the IRP generally follows the provisions of the Superfund Amendments and Reauthorization Act (SARA). These regulations mandate that the provisions of the National Contingency Plan apply to federal facilities.

As a DoD facility, Holloman AFB receives funding for the IRP from the Defense Environmental Restoration Account (DERA). Consequently, investigation and remediation activities at the sewage lagoons must be coordinated through the IRP. To date, over $10 million have been spent performing initial removal actions of sludge contaminated with polychlorinated biphenyls (PCBs) from Ponds A and B, and on characterizing the sewage lagoons, the ditch, and Lakes Holloman and Stinky. The majority of these funds were spent on the removal activities in Ponds A and B. These funds exclude the 1981, 1983, and 1984 investigations performed internally by USAF.

2.5 Federal Facilities Closure and Property Transfer Policy

As described later in Section 3 of this report, the mission of this Base is such that closure of the AFB in the near future is very unlikely. Holloman AFB supports a variety of unique and critical missions and has available a large relatively unencumbered air space to provide realistic combat training. If Holloman AFB were to close, CERCLA Section 120(h)(3)(B)(ii) requires closing bases to warrant a covenant in the deed that during closure or before property transfer:

1) All remedial action necessary to protect human health and the environment with respect to any such substance remaining on the property has been taken before the date of such transfer, and

2) Any additional remedial action found to be necessary after the data of such transfer shall be conducted by the United States.

Table 2-2
Threatened, Endangered, and Sensitive Species Potentially Present at Sewage Lagoons and Lakes Area

Species	Observed	Habitat Use	Federal Status	State Status
White-Faced Ibis	yes	migrant	C2[a]	none
Bald Eagle	yes	winter resident/migrant	Endangered	Endangered
Northern Goshawk	yes	migrant	C2	none
Ferruginous Hawk	yes	winter resident/migrant	C2	none
Northern Aplomado Falcon	no	migrant/resident	Endangered	Endangered
Peregrine Falcon	yes	migrant	Endangered	Endangered
Whooping Crane	no	migrant	Endangered	Endangered
Western Snowy Plover	yes	resident breeder/migrant	C2	none
Interior Least Tern	no	migrant	Endangered	Endangered
Loggerhead Shrike	yes	resident breeder/migrant	C2	none
Southwestern Willow Flycatcher	no	resident/migrant	Proposed Endangered	Threatened
Baird's Sparrow	no	migrant/winter resident	C2	Threatened
Burrowing Owl	no[b]	resident breeder	C2	none
Neotropic Cormorant	no	migrant	None	Threatened
Greater Western Mastiff Bat	no	forages over water for insects	C2	None
New Mexico Jumping Mouse	no	wetland habitats and permanent ditches	C1	Threatened
Occult Little Brown Bat	no	forages over water for insects	C2	none
Small Footed Bat	no	forages over water for insects	C2	none
Swift Fox	no	open desert and grassland	C2	none
Texas Horned Lizard	no	desert grasslands/shrub lands, playas	C2	none
White Sands Pup Fish	no	alkaline springs, seeps, pools, and streams in Tularosa Basin	C2	Threatened
Gramma Grass Cactus	yes	relatively well-drained soils with alkali sacaton	C2	Endangered
Gypsum Scalebroom Grass	no	Alkali/gypsum playas in southern Otero County	C2	Endangered

Note: This list is based on approximately one year of monthly field observations by the NM Natural Heritage Program, recorded observations by Mesilla Valley Audubon Society, and USFWS guidance. About 140-150 other bird species have been observed using Lake Holloman or Pond G. The Federal and State status are as of May 1995.

[a]Category Two (proposed for study).
[b]Observed on Base but not in Lake Holloman/Lagoon G area.

Section 3
FACILITY DESCRIPTION

Holloman AFB is situated in south-central New Mexico, in the northwest central portion of Otero County. The Base occupies about 53,000 acres including lands around Lakes Holloman and Stinky that were recently transferred from the Bureau of Land Management (BLM). The main cantonment area is located in the northeast quarter of Section T.17S, R.8E. The High Speed Test Track extends northward into T.15S. The Base is situated approximately seven miles west of Alamogordo, NM, the only town of appreciable size within 50 miles of the Base. The remote location and the large DoD presence (White Sands Missile Range, Fort Bliss, and Holloman AFB) has helped Holloman AFB to avoid many problems (e.g., encumbered air space and urban encroachment) associated with other bases.

The desert terrain of the area surrounding Holloman AFB has limited development in the immediate vicinity of the Base. There are no farming operations, residential communities, or large industrial operations located adjacent to the Base. Future land use in the area is not expected to differ significantly from current land use. Holloman AFB is an active military installation and is expected to remain active for the foreseeable future. No transfer of military property to the public domain is anticipated. Public access to the Base is restricted.

3.1 Holloman AFB Mission

The host organization of Holloman AFB is the 49th Fighter Wing, whose mission it is to support national security objectives worldwide with F-117 stealth fighters and HH-60 helicopters. The helicopters are associated with the 48th Rescue Squadron. Additionally, the wing provides fighter fundamentals training using T-38 and AT-38 aircraft to U.S. and selected allied nation air crews. Training in F-4 aircraft is provided to the German Air Force (GAF). The Base is in the process of constructing support facilities for the GAF PA-200 Tornado fighter bombers. The 49th Material Maintenance Group deploys worldwide to provide physical infrastructure to remote air bases.

Over 30 tenant organizations are present on base, including the 46th Test Group, the Army Air Operations Directorate, Primate Research Lab, and the DRMO.

The 46th Test Group sponsors a variety of activities, including operating a variety of test bed aircraft and operating the 10-mile-long high speed test track. The test track is used for ground testing ejection seats, missiles, and other defense activities. Army Air operates aircraft in support of WSMR located to the north and west of Holloman AFB. The Primate Research Lab, formerly operated by New Mexico State University (NMSU), is now privately operated and performs medical research. DRMO is directly responsible for operating the Holloman AFB treatment, storage, and disposal facility.

3.2 Physiography

Holloman AFB is located in the Tularosa Basin in the southern part of New Mexico, as shown in Figure 3-1. The basin is approximately 120 miles long and 35 miles wide, extending from the southern end of Chupadera Mesa almost to the Texas Border. In the vicinity of the Base, the Tularosa Basin is bound 8 miles to the east by the Sacramento Mountains and 20 miles to the west by the San Andres Mountains.

Elevations within the Tularosa Basin range from 4400 ft above mean sea level (ft-msl) at the northeast corner to 4000 ft-msl in the southwest corner, sloping downward to the southwest. Elevations at the Base range from approximately

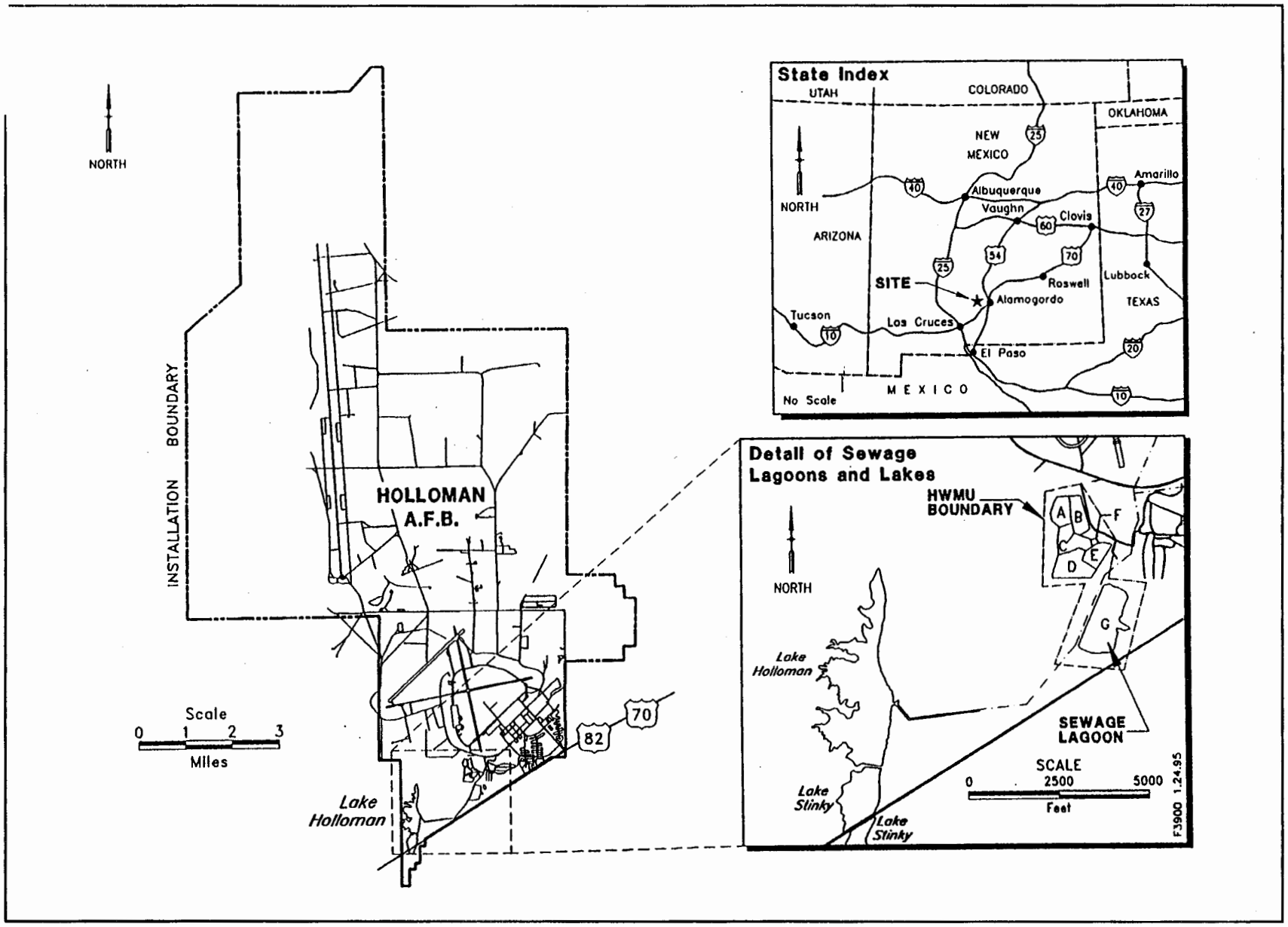

Figure 3-1. Location of Holloman AFB

3900 to 4100 ft-msl, excluding Tularosa Peak. Elevations in the Sacramento Mountains reach 12,000 ft-msl and range from 7000 to 9000 ft-msl within the San Andres Mountains.

The Tularosa Basin is a closed basin with regard to surface drainage. No surface water leaves the basin, and there is very little surface water in the basin. Surface water is either lost to evaporation or infiltration. Lake Lucero is the low point in the Basin, but has no direct surface water connection with Holloman AFB.

The Base is crossed by several southwest-trending "arroyos," or intermittent stream beds, including Lost River (the largest), Dillard Draw, Malone Draw, Ritas Draw and Hay Dray. Lost River is fed by groundwater seeps and springs resulting from LaLuz Creek/Fresnal Canyon Watershed. The river appears and disappears along its course as groundwater adds to and evapotranspiration and infiltration recapture the river's volume. Within the Base's boundaries, there is a very low volume of water in the Lost River.

3.3 Geology

The subsurface conditions at the sewage lagoons were defined by direct sampling and observation of the drilling operations of soil and monitor well borings drilled between 1987 and 1993. Figures 3-2 and 3-3 illustrate and describe the general stratigraphy of the site.

The sediments consist of sand, silt, and clay, and are subdivided into six very broadly definable units that appear to be continuous across the site (Figure 3-2). This interpretation is supported by available data; however, irregularities exist on a smaller scale because of the discontinuous nature of alluvial and lacustrine deposits.

Area soils are either Holloman-Gypsum Land-Yesum or Mead silty clay loam soil complexes. The Mead silty clay loam is found in low-lying areas and is sometimes associated with wetlands. The soil complexes grade into the upper sand unit, which consists of 6 to 40 ft of sand, silt, or silty sand. Clay lenses are common in the upper sand unit, and a discontinuous middle clay unit underlies the upper sand layer. The middle clay is reddish brown with abundant gypsum crystals, and ranges from 10 to 40 ft thick where present. A lower sand unit consisting of interbedded sand, clay, and silt lies beneath the middle clay. This unit is lithologically heterogeneous and ranges from 10 to 20 ft thick.

3.4 Surrounding Wildlife

Wildlife surrounding the Holloman AFB lagoons and lakes consists generally of waterfowl (e.g., mallards and mergansers), shorebirds (e.g., killdeer), and raptors. A sufficient number of mallards reside in the area to support seasonal hunting activities. In addition, migratory birds occasionally inhabit the sewage lagoons, especially Pond G. Fish are not endemic to the lagoon system. The mosquito fish were introduced to control the population of mosquitos, and are now thought to be an important food source. The mosquito fish are routinely found in Lake Holloman, Pond G, and the ditch. The upper sewage lagoons are poor habitat for fish and are unlikely to support healthy fish populations.

3.5 Physical Description of Sewage Lagoons

As illustrated in Figure 3-4, the sewage lagoons are located in the southwestern corner of the Base. They consist of seven aeration/ evaporation lagoons and receive approximately 1.2 million gal. of residential and industrial wastewater per day. The first three sewage lagoons, Ponds A, B, and C, are aerated. Ponds A and B are generally operated in parallel fashion and, occasionally, in sequence to increase residence time. Afterward, the wastewater flows in series from Pond C through Ponds D, E, and G. Pond F is a sump that recirculates wastewater from Pond E back to the headworks of the system when needed. Discharge from the last sewage lagoon (Pond G) flows via an open ditch to Lake Holloman.

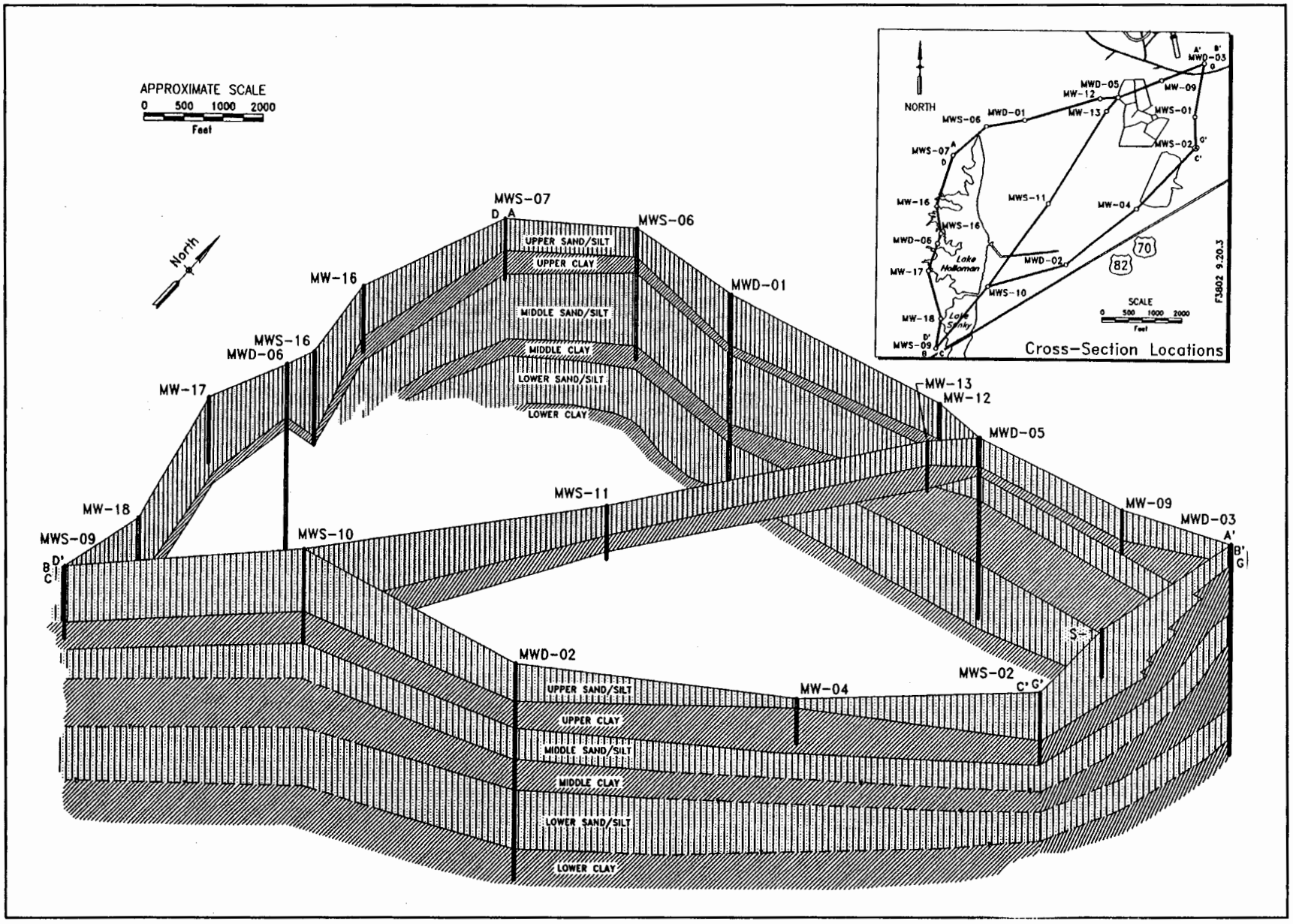

Figure 3-2. Stratigraphic Fence Diagram

Approximate Feet BGL	General Stratigraphic Section	Unit	Average Thickness (feet)	Lithologic Description
		UPPER SAND/SILT	12	SAND AND SILT – light tan to dark brown, poorly graded quartzose, minor gypsum crystals, dark accessory minerals, loose, dry to moist, rare green staining near base of unit
12		UPPER CLAY	6	CLAY – reddish–brown to greenish–gray, slightly silty, poorly graded, plastic, firm to friable, contains scattered pockets of small gypsum crystals, semi–continuous, becoming thinner in the north portion of site
18		MIDDLE SAND/SILT	10	SAND AND SILT – reddish–brown to light gray, moderately to poorly graded, slightly clayey in zones, minor dark accessory minerals, loose, wet to saturated, minor gypsum crystals, rare pockets of carbon coated material
28		MIDDLE CLAY	25	CLAY – reddish–brown to greenish–gray, poorly graded, becoming more greenish–gray westward, medium to high plasticity, slightly to moderately sandy, common pockets of medium to large gypsum crystals, moderately stiff to firm, wet to saturated
53		LOWER SAND/SILT	15	SAND AND SILT – brown to grayish–green, fine to medium grained, moderately to poorly graded, becoming more clayey near base, minor gypsum crystals, common dark accessory minerals, wet to saturated
68		LOWER CLAY	>8	CLAY – grayish–green, silty, poorly graded moderate to high plasticity, thin interbedded layers of fine grained silty sand, minor gypsum crystals, wet to saturated

Figure 3-3. Site Stratigraphy

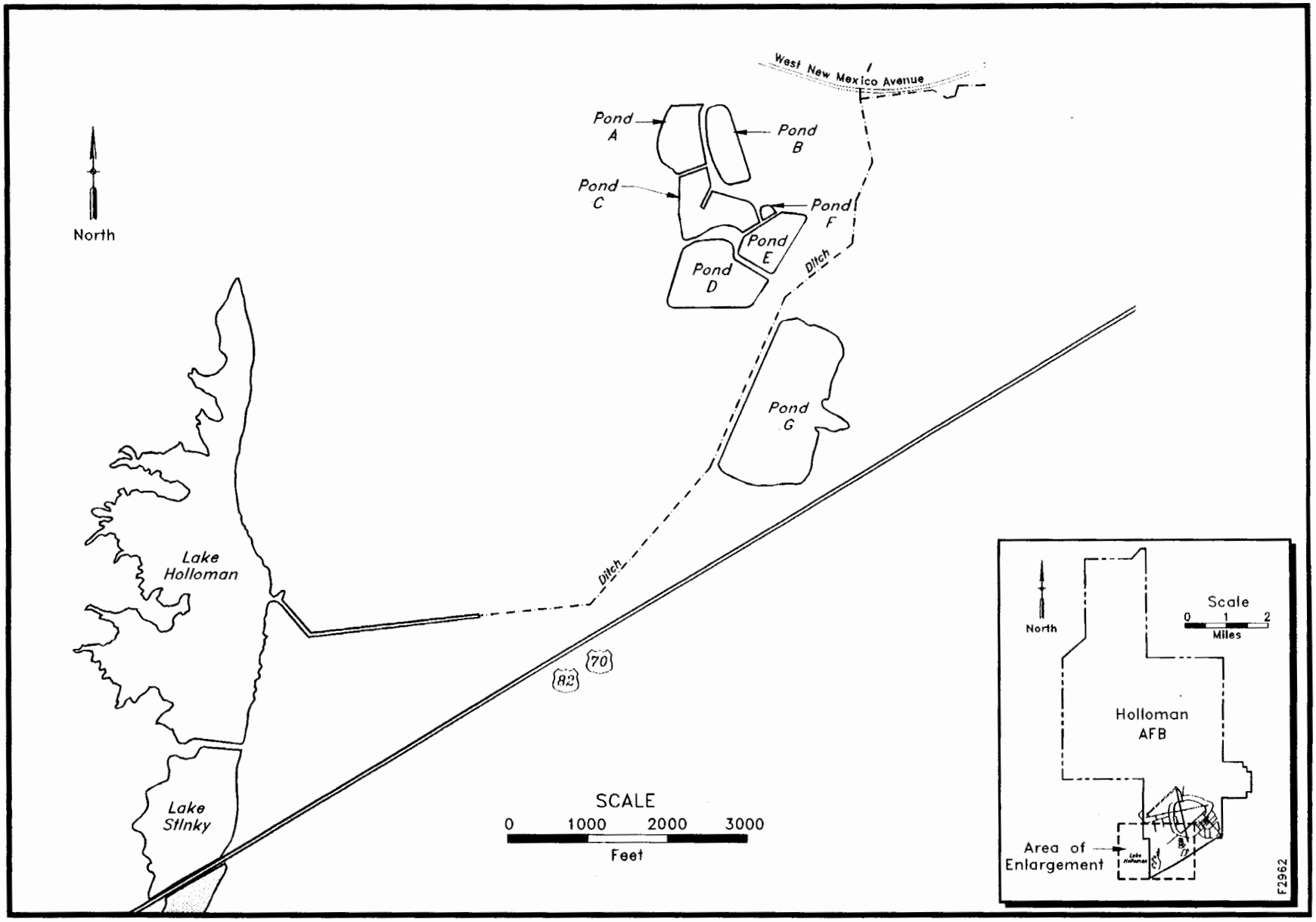

Figure 3-4. Location of Sewage Lagoons

Lake Holloman was formed by constructing a nonengineered dam to collect surface water drainage and wastewater discharge. The original dam was constructed in 1964 and upgraded to the present size in 1968. The 166-acre lake was intended to be the final impoundment for evaporation; however, because of seasonal low evaporation and increased wastewater generation from the Base activities, water from Lake Holloman occasionally overflows into Lake Stinky, a small salina. Any overflow into Lake Stinky eventually dissipates through evaporation.

3.5.1 Lagoon System Dimensions

Table 3-1 presents the surface area and capacity of the seven sewage lagoons within the lagoon system, as well as each pond's year of construction. The edges of Ponds A through F are steeply sloped and lined to prevent bank erosion. The edges of Pond G are not lined. All seven sewage lagoons are diked to prevent overflow. None of the ponds have bottom liners.

3.5.2 Approximate Depth of Sludge

A preliminary investigation in October 1991 was performed to determine the water depth and sludge thickness in Ponds C, D, E, F, and G, as well as Lakes Holloman and Stinky. At the time of the study, Lake Stinky was dry. Results of this investigation are documented in the *Conceptual Plan for Sludge and Soil Sampling: Sewage Lagoon Investigation* (Radian, 1991c). Similar measurements were conducted during the 1994 investigation. As with the 1991 measurements, Lake Stinky was dry in 1994. No measurements were collected from Pond F during the 1994 investigation. Measurements from the more recent 1994 investigation are presented in Table 3-2.

3.6 Groundwater Quality

Groundwater quality in the Tularosa Basin is potable at the Boles and San Andres water well fields located at the foot of the Sacramento Mountains, 14 miles southeast of Holloman AFB. Groundwater becomes progressively more mineralized as it flows downgradient toward the interior of the basin. This decrease in water quality can be attributed to slow groundwater migration from recharge to discharge areas and the presence of readily soluble minerals in the Bolson sediments. Total dissolved solids (TDS) exceed 100,000 mg/L in some portions of the Tularosa Basin (USGS, 1985).

The groundwater beneath Holloman AFB is designated as unfit for human consumption, based on New Mexico Water Quality Control Commission Regulations (NM WQCC 82-1, as amended through August 18, 1991 Parts 3-100 through 3-103) because it exceeds New Mexico human health standards (HHSs) for TDS and sulfate. Average values of other groundwater quality parameters measured at Holloman AFB (chloride, fluoride, and nitrate-nitrite) also exceed HHSs and, except for fluoride, also exceed federal primary and secondary drinking water maximum contaminant levels (MCLs and SMCLs, respectively). Water quality parameters reflect that the groundwater in this area is not potable under natural conditions.

Although EPA guidelines for groundwater classification are not recognized by the State of New Mexico, the EPA guidelines (1986) classify the groundwater beneath Holloman AFB as a Class III B aquifer. Class III groundwater, characterized by having a TDS concentration greater than 10,000 mg/L, is not considered a potential source of drinking water. Class III B groundwater is characterized by a low degree of interconnection to adjacent surface waters or groundwater of a higher class. The average measured TDS value of groundwater at Holloman AFB is greater than 10,000 mg/L (Radian, 1992a). Because the Tularosa Basin is a closed basin, its groundwater does not discharge or connect to any adjacent aquifers. Adjacent surface waters include groundwater surfacing in Malone Draw and Lakes Holloman

Table 3-1
Sewage Lagoon Construction Dates and Dimensions

Pond	Year Constructed[a]	Surface Area (acres)	Capacity (million gal.)
A	1943	10.1	16.1
B	1943	11.2	16.1
C	1955-1959	12.5	21.3
D[b]	1955-1959	18.7	28.5
E	1955-1959	7.8	12.5
F	1955-1959	0.5	1.6
G	1970	39.8	64.6

[a]Ponds C, D, E, and F were constructed during the stated time interval; however, no dates were available to indicate the sequence of completion.
[b]Pond D was reconstructed in 1980.

Table 3-2
1994 Investigation Water Depth and Sludge Thickness Measurements

Pond	No. of Sample Locations	Water Depth (ft)			Sludge Thickness (in)		
		Minimum	Maximum	Average	Minimum	Maximum	Average
A	6	4.8	7.3	6.0	6	13	8.5
B	6	5.8	7.0	6.4	9	30	16.3
C	13	3.3	6.8	5.4	2	28	17.3
D	10	3.6	6.6	5.4	0.25	12	2.5
E	16	2.2	6.5	4.9	2	24	11.8
F[a]	4	5.0	5.0	5.0	6	10	7.5
G	19	1.1	4.6	3.4	1	16	4.6
Lake Holloman	25	0	6.2	3.5	0	18	5.2

[a]October 1991 measurements.

and Stinky. The TDS in Lake Holloman range from a winter low of 12,400 mg/L to a summer high of 17,000 mg/L; therefore, groundwater at Holloman AFB is not interconnected with surface water of a higher class. During the 1993 groundwater investigation, TDS concentrations ranged from 11,000 to 12,000 mg/L in Lake Holloman and were 14,000 mg/L in Lake Stinky as reported in *Results of Confirmation Sampling and Comparison to Appendix IX Sampling Assessment Monitoring Program* (Radian, 1992a).

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Section 4
PREVIOUS INVESTIGATIONS

Over the past 15 years, several investigations have taken place in and around the sewage lagoons that provide analytical insight into the nature and extent of contamination connected with the sewage lagoons. These investigations have analyzed the soil, sludge, surface water, biota, groundwater, and human and ecological risks associated with the sewage lagoons. This closure plan intends to incorporate this information into the knowledge base that will serve as the basis for determining potential risk stemming from the sewage lagoons and for selecting a strategy for final closure.

A summary of the median and maximum concentrations of constituents detected in each sewage lagoon between 1990 and 1995 are reported in Appendix A of this report. The *Site Characterization Report* (Radian and Foster Wheeler, June 1995) appendices include a summary of analytical data for each individual investigation. Presented below is a summary of the investigative activities that have occurred. Where applicable, emphasis is placed on 1) the purpose of the sampling, 2) the analytical results and conclusions of the sampling, and 3) the recommendations stemming from the sampling event. In particular, the significance of each sampling event is presented with regards to the contaminants observed and how the findings contribute to final closure of the sewage lagoons. Additional information may be obtained from the documents cited in each section. Information is presented chronologically and by type of investigation.

4.1 Sludge, Soil, Surface Water, and Biota Investigations

Several environmental investigations and one removal project have taken place within the sewage lagoons since 1981. The investigations have analyzed contaminants associated with sewage lagoon sludges and soils, as well as the solubility and bioavailability of these contaminants. The removal project involved a voluntary removal of approximately 4000 tons of sludge from Ponds A and B. Twelve of these investigations are presented below. The most recent investigations, the 1994 investigation, is presented in Section 5 of this report and detailed in the *Site Characterization Report* (Radian and Foster Wheeler, June 1995). Appendix A presents the location of surface water, groundwater, sludge, and soil samples collected from 1990 through 1994 in each of the lagoons. Results from these investigations were used to determine potential risk and to support closure activities.

4.1.1 1981 Water and Sludge Sampling—EP Toxicity

In November 1981, water and sludge samples were collected from the sewage lagoons and Lake Holloman for analysis by the EP toxicity procedure. This evaluation was conducted to determine whether the wastewater that the sewage lagoon received contained levels of heavy metals or other constituents that would cause the wastewater to be classified as hazardous waste. Samples of both the wastewater and sludge were collected and analyzed. Most of the constituents were below detectable levels and none exceeded the EP toxicity criteria defined in 40 CFR 261.24. The data was presented in the January 1982 report, *Evaluation for Hazardous Waste at Holloman AFB Sewage Treatment Plant* (HAFB, 1982). The following conclusions were made:

1) The wastewater and sludge samples appear not to be contaminated by the heavy metals arsenic, barium, cadmium, chromium, lead, mercury, selenium, or silver. (Detectable levels of arsenic, cadmium, chromium, and silver, were found in the

wastewater, but at concentrations less than 10 percent of the regulatory limits. No contamination was detected in the sludge.) Chromium levels in the wastewater did fluctuate during a 24-hour period but were well within EPA standards thought to be applicable.

2) The sludge samples collected from the sewage lagoons did not exceed EPA criteria for EP toxicity, corrosivity, or reactivity. (Since the sewage lagoons receive only wastewater, there is very little chance for ignitability problems.)

4.1.2 1983 Water and Sludge Sampling—Chromium and Organics

In October 1983, sludge and wastewater samples were collected from Ponds A and B. This sampling event was primarily in response to an EPA letter issued on 31 March 1983. Chromium was becoming an increasing concern of the EPA, and this sampling event was intended to substantiate the earlier findings of low concentrations of chromium in the wastewater. Organic compounds (1,1,1-trichloroethane, trichloroethylene, and total organic halogens) and chromium were targeted for testing.

Analytical results were presented in the 22 December 1983 document, *Report to EPA Regarding Holloman Air Force Base Lagoons and T-38 Washrack Oil-Water Separator* (HAFB, 1983). The conclusions were essentially the same as the January 1982 report, although chromium was detected in the wastewater stream. However, chromium was not detected in the sludge contained in Ponds A or B. (Samples were analyzed by the EP toxicity method, which has a chromium detection limit of 50 µg/L.) Theoretical calculations were presented, and it was found that, by means of a mass balance, the amount of chromium present in the wastewater was significantly below allowable amounts established in the EP toxicity criteria.

4.1.3 1984 Priority Pollutant Sampling

In response to a 15 August 1984 request by EPA Region VI, Holloman AFB proposed a protocol outlining sampling and analytical procedures for the list of 129 priority pollutants (Holloman AFB, 1984). The protocol was developed to test for the listed wastes that were suspected of being discharged to the sewage lagoons. In December 1984, a total of 11 sludge and wastewater samples were collected from Ponds A, B, and C and analyzed for priority pollutants. Eight heavy metals and five pesticides were analyzed using EP toxicity and total extraction procedures. Analyses were conducted for purgeable organics (EPA Method 624), base/neutral and acid compounds (EPA Method 625), pesticides and PCBs (EPA Method 608), cyanides, and total phenols.

The analytical results of the December 1984 sampling were presented both in a meeting to EPA Region VI in April 1985 and in the March 1986 report, *Evaluation for 129 Priority Pollutants, Holloman AFB Sewage Ponds* (Holloman Air Force Base, 1986). Of the 11 sludge and 6 water samples that were analyzed, one pollutant (PCBs) was found in concentrations that warranted some concern. Sludge concentrations of PCB-1254 ranged from nondetect to 130 ppm. A bioassay study was recommended by USFWS to investigate the possibility of PCBs accumulating in the indigenous biological organisms and transferring to larger animals via the food chain.

4.1.4 1987 Appendix IX Sampling in Support of Delisting Petition

In 1987, Holloman AFB contracted with Computrac, Inc., to prepare a preliminary delisting petition to delist the waste in the sewage lagoons. The purpose of the preliminary report was to determine whether delisting was a feasible option, prior to conducting an extensive sampling plan. In support of the preparation of this preliminary delisting petition, a comprehensive sampling and analysis program on one sludge and one surface

water sample from each sewage lagoon, Lake Holloman, and Lake Stinky was recommended, using EPA-approved protocols. The sampling effort was conducted in July 1987. The results of the analyses indicated that several metals (antimony, barium, cadmium, and mercury) were present in concentrations that could negatively affect the delisting petition. Furthermore, these concentrations were not limited to individual water bodies but were found throughout the sewage lagoon system. None of the organic constituents identified as potential problems by EPA in earlier samples (chloroform, PCB-1254, and benzo(a)-pyrene) were detected in these new samples. Since only one sludge sample and one surface water sample were taken from each water body, no definitive conclusions were drawn from this sampling event. However, the delisting petition was abandoned.

Analytical results are presented in an 18 August 1987 report, *Analytical Summary of Holloman Air Force Base Delisting Assessment* (Computrac, 1987).

4.1.5 May 1988 Preliminary Investigation for Sludge Removal

As the probability of a cost effective successful delisting was decreasing, HQ Tactical Air Command (TAC) (currently HQ ACC) began exploring the possibility of developing a revised closure scenario that would include the removal of the sludge mounds in Ponds A and B. The removal of the sludge required determining the height and areal extent of the mounds and the regions of PCB contamination. The mounds were contoured and a total of 18 depth-integrated samples (9 from each sludge mound) were collected in May 1988. These were composited into six samples and submitted for laboratory analysis of PCBs and other organic and inorganic constituents. Results showed the PCB concentrations in the sludge ranged from 24 to 63 ppm.

4.1.6 August 1988 Additional Investigation for Sludge Removal

The May 1988 investigation estimated the size of the sludge mounds approximately 10 times greater than the size originally estimated during the preliminary delisting petition. Consequently, a more extensive sampling plan was developed to better define the overall extent of contamination with respect to volatile and semivolatile organic constituents, PCBs, and metals. In August 1988, a total of 45 locations in Pond A and 40 locations in Pond B were sampled. In addition, four points near the periphery of each sewage lagoon were sampled. Samples were again analyzed for PCBs and other organic and inorganic constituents. Results of the sampling effort were included in the *Draft A-E Quality Control Summary Report (A-E QCSR) for Additional Sampling at Sewage Lagoons* (Radian, 1989).

Of the seven PCB species quantified by Method 8080, only two were detected: PCB-1254 and PCB-1260. The total PCB concentrations (arithmetic sum of PCB-1254 and PCB-1260) ranged from 1.6 to 190 ppm. Concentrations of the two PCB compounds were added to present a worst-case scenario to evaluate the extent of contamination for sludge removal. No volatile organic compounds were detected in any sludge sample by Method 8240 analysis, which was consistent with previous sample results. Nineteen semivolatile organic compounds were detected at low concentrations by Method 8270. The majority of the compounds were polynuclear aromatic hydrocarbons. Twelve metals were detected in the sludge samples, but no EP toxicity metals were detected above regulatory limits in soils beneath the sludge mounds.

On the basis of these results, HQ TAC concluded that PCBs were the most significant contaminants of concern, and by removing the PCB-contaminated sludges, nearly all other known hazardous constituents would also be removed. A closure plan was developed to provide an 80

percent confidence level for removal of all sludge with a PCB concentration of 25 ppm or greater.

4.1.7 1990 Sludge Removal Project

In January 1990, Holloman AFB began the removal of 1316 tons of sludge from Pond B and 2663 tons from Pond A. The project was completed in October 1990. Subsequent to sludge removal, verification sampling was conducted from a 37-point sampling grid and samples were analyzed for PCBs. A single sludge sample collected from a point outside the removal zone was found to contain 27 ppm PCBs; however, follow-up sampling of three points surrounding this location showed that the sludge contained less than 18 ppm PCBs. Western Technologies performed additional confirmation sampling in Pond A after the sludge was removed. No concentrations higher than 11 ppm were detected. Analytical data is presented in *Holloman Air Force Base Hazardous Waste Sewage Sludge Removal, Contractor's Chemical Quality Control Summary Report* (Western Technologies, 1991).

4.1.8 1990 Surface Water Sampling

In October 1990, surface water samples were collected from the sewage lagoons and analyzed. The objective of this effort was to obtain accurate surface water quality data for input to the risk assessment being prepared.

Two samples were collected from the wastewater treatment facility headworks, and five samples were collected from Ponds B, C, D, E, and G, and Lake Holloman. Sample locations were chosen to represent the areal distribution and variation of water quality within each impoundment.

Samples were analyzed for semivolatile organic compounds, pesticides, PCBs, and metals. Organolead was also detected at less than five times the reporting limit; however, these low concentrations have been a risk driver. There is some uncertainty with the results of the organolead since the reported values are greater than the total lead concentrations reported. The equipment rinsate results also reported similar concentrations of organolead. Holloman AFB personnel are not aware of any spills of aviation gasoline (leaded) to the sewage lagoon system that could have led to detecting the concentrations of organolead reported. The uncertainty of organic lead was addressed in the additional sampling of sludge and surface water performed during the 1994 investigation. The recent samples did not detect any organolead in surface water samples. Analytical results from this 1990 sampling are presented in a December 1990 *Draft A-E Quality Control Summary Report (A-E QCSR) for Sewage Lagoon Surface Water Sampling* (Radian, 1990).

4.1.9 March 1990 Sludge and Soil Sampling at Pond C

As part of the March 1990 verification sampling, sludge and soil samples were collected from Pond C. Sampling in Pond C focused on the area around the influent points from Ponds A and B. A total of six locations, three at each area approximately 25 ft in a radial distance from the influent point, were selected to collect samples of sludge and underlying soil. Analytical results of the investigation are reported in the June 1991 report entitled *A-E Sampling and Quality Control Summary Report (A-E QCSR) for Field Investigation to Support Sewage Lagoon Closure* (Radian, 1991a).

No PCBs were detected in any of the soil or sludge samples collected from Pond C. Pesticides (4,4'-DDD and 4,4'-DDE) were detected in two sludge samples at concentrations ranging from 6 to 16 ppm. By analyzing underlying soil samples, it was concluded that these compounds had not migrated to the underlying soil.

4.1.10 1991 U.S. Fish and Wildlife Biota Sampling

During the summer of 1991, the USFWS conducted an investigation of the Holloman AFB

sewage lagoons and Lake Holloman to determine whether migratory birds were being exposed to organic and inorganic contamination present in these surface waters. Eleven sediment, 1 pondwater, and 35 biological samples were collected from several locations at the sewage lagoons and Lake Holloman. The samples were assayed for various metals, metalloids, and organic compounds.

Study results indicate that risks resulting from the presence of potentially toxic substances in aquatic systems were difficult to assess. Sediment samples revealed the potential for adverse biological effects; however, no analyses were performed to determine the bioavailability of the contaminants. Collected tissue samples contained generally low concentrations of these constituents. Analytical results of the investigation are reported in a draft survey report entitled *Preliminary Survey of Contaminants Present in Biotic, Pore-Water and Sediments at the Holloman AFB WWTF* (USFWS, 1994). This report has not been finalized by the USFWS.

4.1.11 1991-1992 Sewage Lagoon Investigation in Support of the PCCP Application

In June 1991, Holloman AFB submitted a postclosure care permit (PCCP) application for the sewage lagoons. The purpose of the PCCP was to allow the Base to continue treating nonhazardous waste at the sewage lagoons under the "delay of closure" option. NMED declared that the PCCP application was administratively complete; however, the document has never been technically reviewed by NMED. One condition for review, as stated in a letter from NMED dated 22 May 1991, was that a sampling and analysis program be conducted in all impoundments downstream of Pond C.

Following NMED's condition, the Base performed a two-phase investigation of the sewage lagoons during October 1991 and February/March 1992. The objectives of the investigation were the following:

- To support review of the PCCP application;
- To characterize the sewage lagoons and provide a preliminary estimate of the nature and extent of contamination and the resulting effect on final closure; and
- To provide a Phase I RFI report for Lakes Holloman and Stinky as required by the HSWA permit.

On the basis of the preliminary October 1991 investigation in which the depth of sludge and water was measured in each of the sewage lagoons, a sampling protocol was prepared and agreed on by HAFB, NMED, EPA Region VI, USACE, and HQ ACC. This was documented in the *Conceptual Plan for Sludge and Soil Sampling* (Radian, 1991b). The sampling plan was accepted by NMED in a letter dated 18 November 1991 and by EPA Region VI in a letter dated 17 December 1991. Both of these are presented in Appendix E of the *Project Assessment Report* (Radian and Foster Wheeler, March 1995).

The site was then investigated in February and March 1992 by sampling and analyzing the sludge and underlying soil in the sewage lagoons, lakes, and ditch for Appendix IX constituents. The results of the investigation were documented in Sections 4 through 6 of the *Site Characterization Report* (Radian, 1992b). This investigation indicated that the primary contaminants in the sludge samples from the sewage lagoons and lakes were metals and organochloride pesticides. Metals detected in the soil were not significantly different from background levels and pesticides were significantly below proposed Subpart S action levels.

4.1.12 1993 Background Sampling

During February and March 1993, Base-wide background soil samples were collected. These samples represented background metal

concentrations for Basewide investigative activities. To characterize background soil conditions, 10 sampling locations were selected from the Holloman-Gypsum Land-Yesum soil complex. Each sample location was carefully selected to avoid collecting samples affected by historical waste management practices. These background soil samples were representative of surface soil throughout the Base. Analytical results from this investigation are combined with background groundwater data that were collected concurrently, and are presented in Appendix B-1 in the December 1993 *Draft Final Phase 1-Groundwater Assessment Monitoring Report, Sewage Lagoons and Lakes Investigation* (Radian, 1993a).

4.1.13 1993 Biota Sampling

Biota samples were collected to prepare an ecological risk assessment in response to the USFWS's request. Biota samples were collected in all sewage lagoons and lakes, as well as in the ditch connecting Pond G and Lake Holloman. All biota sampling started downstream (Lake Stinky) and moved upstream, so that contaminants potentially stirred up during sampling activities would not interfere with analytical results from the samples collected. Table 4-1 presents a summary of biological samples collected.

Biota samples were analyzed for chlorinated pesticides, PCBs, semivolatile organic compounds, polychlorinated dioxins and furans, and some metals. Analytical results were evaluated as part of the ecological risk assessment. Analytical data are reported in Appendix D of the March 1996 *Risk Assessment Addendum* (Radian and Foster Wheeler, March 1996). The conclusions drawn from this data are presented in Sections 5 and 6 of the same report.

4.2 Groundwater Investigations

Groundwater investigation activities were initiated as part of the FFCA to comply with RCRA regulations for surface impoundments. In July 1989 a groundwater monitoring system, which consisted of eight new and two existing wells, was installed. Four additional background wells were installed in 1991, and five more in 1993. Figure 4-1 presents the location of monitored groundwater wells. Presented below is a chronological summary of groundwater sampling events that have occurred for the sewage lagoon system.

4.2.1 August 1989-January 1991 Detection Monitoring Program

Background concentrations were developed on a 5-month accelerated schedule with samples collected during August, September, November, and December 1989. Following the determination of background concentrations, semiannual detection monitoring began in January 1990. The second round was performed in July 1990 (a resample was also collected in September 1990), and the third in January 1991.

The groundwater detection monitoring program was performed in accordance with 40 CFR 265.92(d)(1) and (2) and the FFCA. Wells were monitored for the groundwater indicator parameters specified in 40 CFR 265.92(b)(3)—pH, specific conductance, purgeable organic halides, and total organic carbon (TOC). Each time the wells were monitored, static water level and total well depth measurements were obtained. Immiscible organic layers were also looked for, but were never found. The following wells were monitored during the program: MW-1, S-2, MW-2, MW-3, MW-4, MW-5, MW-6, MW-7, MW-8, and S-4. See Figure 4-7 for locations.

Holloman AFB was notified by EPA Region VI in January 1991 that a significant increase in TOC had been detected and assessment monitoring would be necessary. EPA's evaluation of monthly and semiannual sampling events indicated a statistically significant increase in TOC between upgradient and downgradient wells. Holloman AFB requested EPA's evaluation in

Table 4-1
Biological Samples Collected from the Sewage Lagoons and Lakes in 1993
Holloman AFB

Sample Location	Biological Sample			Media Sampled
	Plankton	Benthos	Vertebrates	
Pond A	Rotifers	Chironomids, Corixids	None	Surface Water, Near Surface Sediment
Pond B	None	None	None	Surface Water
Pond C	Rotifers	Corixids	YOY Black-Neck Stilts (3)	Surface Water
Pond D	Rotifers	None	None	Surface Water
Pond E	Rotifers	Chironomids	None	Surface Water, Near Surface Sediment
Pond F	Rotifers	None	None	Surface Water
Pond G	Rotifers	Corixids	Gambusia (2), Whole Salamander (4), Salamander Muscle, Salamander Organs, YOY Mallard Muscle (2), YOY Mallard Organs, YOY Mallard Carcass	Surface Water
Ditch	Rotifers	Chironomids, Lotic insects	Gambusia	Surface Water
Lake Holloman (Lower)	Rotifers	None	Gambusia	Surface Water
Lake Holloman (Middle)	Rotifers	None	Gambusia	Surface Water
Lake Holloman (Upper)	Rotifers	None	Gambusia	Surface Water
Lake Stinky (North)	Mixed	None	None	Surface Water
Lake Stinky (South)	Mixed	Ostracods	None	Widgeon Grass
Runoff Ditch	None	None	Gambusia	None
Runoff Ditch	None	None	Gambusia	None

YOY = Young of Year

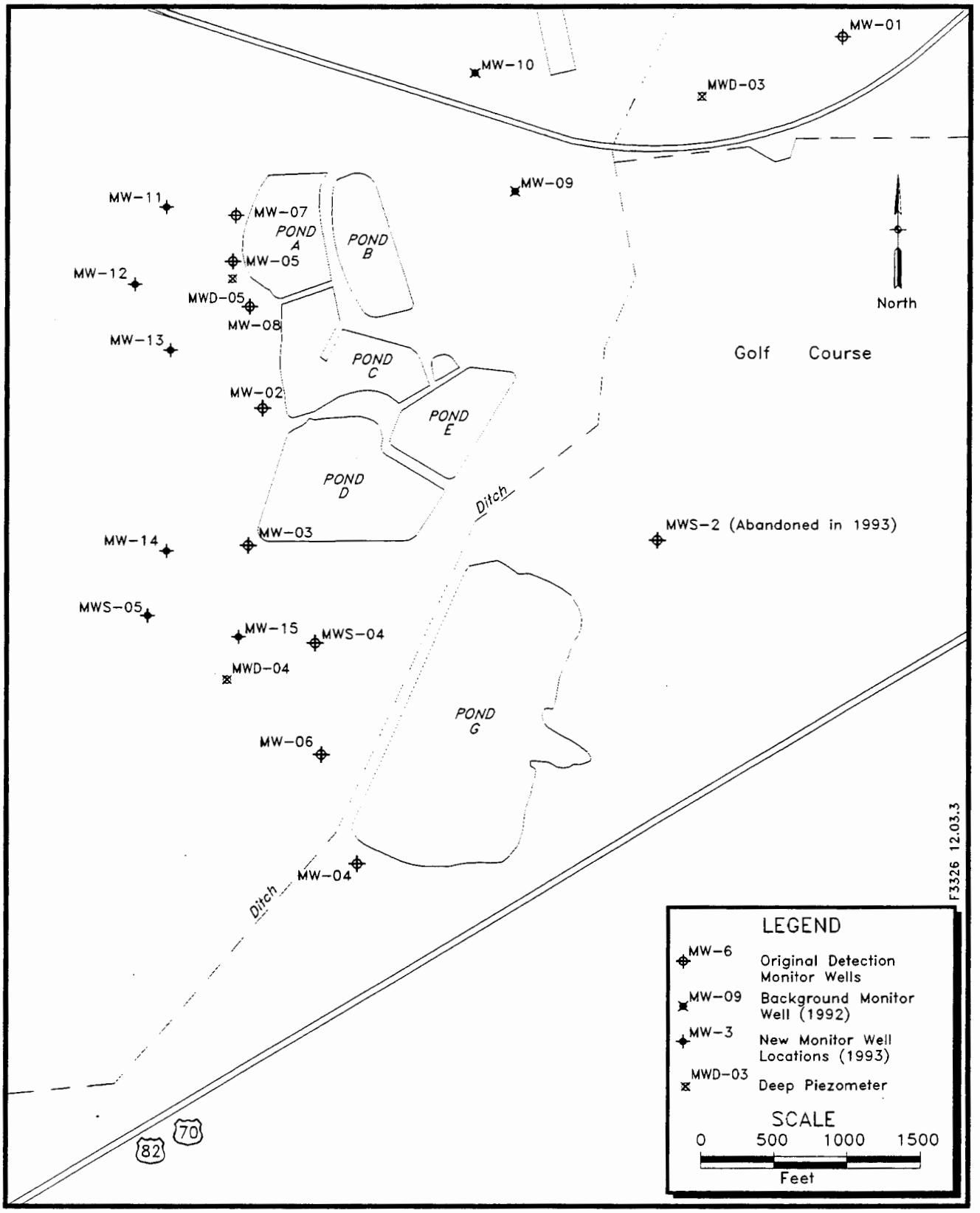

Figure 4-1. Location of Monitoring Wells

writing during a 31 January 1991 meeting. The EPA provided this in a 3 May 1991 letter to Holloman AFB. An assessment monitoring plan was submitted in September 1991.

4.2.2 1991 and 1992 Groundwater Assessment Monitoring

The first step in assessment monitoring was to determine whether the elevated downgradient TOC values were indicative of a release of organic hazardous waste/waste constituents. Samples were collected in September 1991 from the monitor well network and analyzed for Appendix IX organic constituents and TOC.

Subsequent discussion of the Appendix IX sampling results with NMED concluded that organochlorine pesticides were the only contaminants of concern, and that confirmation sampling should be conducted to confirm the presence of these constituents in the groundwater. The occurrence of volatile and semivolatile compounds was attributed to laboratory contamination. The confirmation sampling was conducted in February 1992 for SW-846 Method 8080 compounds. Results of the confirmation sampling indicated that two organochlorine pesticides, alpha-BHC and delta-BHC, are present in the groundwater in monitor wells MW-5 and MW-7, respectively. In addition, the following organochlorine pesticides were detected during either the Appendix IX or confirmation sampling rounds: aldrin, dieldrin, beta-BHC, gamma-BHC, 4,4'-DDD, endosulfan I, endosulfan sulfate, endrin, heptachlor, and heptachlor epoxide. Aldrin and dieldrin were above the action levels. However, since these constituents were not present in both sampling rounds in comparable wells, their presence in the groundwater was not confirmed. Analytical results are presented in Sections 4 and 5 and Appendix B of the April 1992 report entitled *Results of Confirmation Sampling and Comparison to Appendix IX Sampling Assessment Monitoring Programs* (Radian, 1992a).

TOC and dissolved organic carbon (DOC) were also detected in several samples. Results showed no strong correlation between the presence of TOC/DOC and organic contaminants. A cause of elevated TOC levels is the location of monitor wells with respect to the sewage lagoons, and the impact of biological activity associated with wastewater treatment on water quality of the uppermost aquifer. TOC concentrations in domestic wastewater of greater than 100 mg/L are commonly found as a result of biological decomposition (Metcalf and Eddy, Inc., 1991).

The following recommendations for the groundwater monitoring program were made: 1) Modify the RCRA groundwater monitoring network to include two upgradient monitors wells installed in February 1992 (MW-9 and MW-10) and abandon piezometer S-2 (found to have a variable gradient), and 2) install additional wells southwest of Ponds A and C to determine whether organochlorine pesticides have migrated beyond monitoring wells MW-5 and MW-7.

4.2.3 1992 Geoprobe and Piezometer Sampling

Groundwater samples were collected in December 1992 at 14 downgradient locations of Ponds A and D to determine lateral extent of groundwater contamination from organochlorine pesticides. The results were used to determine where additional permanent monitoring wells were to be installed and added to the groundwater monitoring network system. A Geoprobe® screen point groundwater sampler or a piezometer were used to collect samples. Results from this investigation are reported in the *Sampling and Quality Control Summary Report (A-E SQCSR) Sewage Lagoons and Lakes Investigation, Draft Final* (Radian, 1993c).

4.2.4 1993 Background Groundwater Sampling

Four new monitor wells were installed in areas upgradient of potential contamination and in

areas unaffected by past waste management practices. Samples were collected from these 4 wells and 10 existing background monitor wells. Samples were analyzed for total metals using unfiltered groundwater and for dissolved metals using 0.45-micron filtered groundwater. Analytical results from the background investigation are presented as Appendix B-1 in the *Draft Final Phase 1-Groundwater Assessment Monitoring Report for the Sewage Lagoons and Lakes Investigation* (Radian, 1993a).

4.2.5 1993 Groundwater Assessment Monitoring—Phase 1

The primary objectives of the Phase 1 assessment monitoring were to define the lateral extent of Method 8080 pesticides in the uppermost aquifer and to make recommendations for future monitoring requirements. In addition, Appendix IX parameters were collected from newly installed monitor wells and deep piezometers to evaluate potential lateral and vertical migration of other constituents that may have gone undetected in previous sampling.

Three new monitor wells (MW-11 through MW-13) were installed downgradient of Pond A and two new monitor wells (MW-14 and MW-15) were installed downgradient of Pond D. In addition, one existing piezometer (MWS-05) was added to the network downgradient of Pond D. Three deep piezometers (MWD-03 through MWD-05) were sampled to assess the potential for vertical migration of constituents.

Data evaluation criteria to ascertain the presence or absence of constituents were based on the first determination false positives (see the long-term monitoring plan, Radian, 1995a, for additional information).

The presence of Method 8080 pesticides was considered to be certain only in monitor wells MW-03 (heptachlor epoxide) and MW-04 (4,4'-DDD) immediately downgradient of the sewage lagoons. The presence of Method 8080 pesticides in other wells is considered either uncertain or unlikely. The lateral extent of pesticides has been defined downgradient of monitor wells MW-05 and MW-07 (Pond A) and MW-03 (Pond D). The extent of 4,4'-DDD in MW-04 (Pond G) is unknown because of the lack of monitor wells located further downgradient. However, on the basis of results from monitor wells downgradient of Ponds A and D, it is anticipated that the presence of pesticides will be uncertain or unlikely further downgradient of MW-04.

The metals analyses indicate cadmium concentrations in the wells downgradient of Pond A to be higher than background concentrations for the entire base. Analysis of samples from monitoring wells MW-11, MW-12, and MW-13 detected higher average concentrations than background for mercury and tin, but all downgradient results were within the range of concentrations measured for background. For MW-14, MW-15, and MWS-05, data for antimony, tin, and cadmium showed lower average concentrations than background, but some individual concentrations were above the upper tolerance limits.

Analytical results are presented in the December 1993 report, *Phase I Groundwater Assessment Monitoring Report* (Radian, 1993b). Appendix C, Sections 3 through 5 of that report present the results and conclusions.

4.2.6 1995 Long-Term Groundwater Monitoring

Ten wells were sampled during September and October 1995 for organochlorine pesticides and metals during the 1995 long-term monitoring (LTM) sampling event for the sewage lagoons. The analytical results of this sampling were compared with established alternate concentration levels for each analyte. The results of this comparison are presented in *1995 Sampling Report, Sewage Lagoons Long-Term Groundwater Monitoring Program* (Radian, February 1996). Analytical data

is summarized in Appendix A of that report. No analyte was detected at levels above its respective alternate concentration level. If clean closure is achieved, long-term groundwater monitoring will be discontinued.

4.3 Risk Assessment

Since 1991 three quantitative risk assessments have been performed on the sewage lagoon system. The first looked at the entire system as a single component. The second assessment looked at the sewage lagoons, lakes, and ditch as individual units. The third assessment updated the second assessment using the 1994 investigation results and completely reassessed the ecological risks. Presented below are summaries of the three risk assessments.

4.3.1 1991 Risk Assessment for Entire Sewage Lagoon System

A quantitative risk assessment was conducted for the sewage lagoons at Holloman AFB to determine the health risk associated with exposure to existing contamination. The contaminants included in the risk assessment were those identified from environmental sampling conducted at the site prior to 1991 and for which toxicity data were available. Four potential exposure scenarios were identified: 1) occupational exposure to workers at the sewage lagoons, 2) exposure of children living on Base and playing at the sewage lagoons, 3) recreational exposure of birders at Lakes Holloman and Stinky, and 4) recreational exposure of hunters at the lakes. At the time the risk assessment was performed, HQ ACC was considering using the lagoons in the new wastewater treatment system. However, since this time, HQ ACC has decided that Ponds A-F will be closed. Pond G will revert back to a waters of the United States and become a permitted discharge point for the new wastewater treatment system.

The risk assessment considered both carcinogenic and noncarcinogenic effects. The carcinogenic risks estimated for all exposure scenarios were found to be well below 1 in 1 million (10^{-6}). The estimates of noncarcinogenic effects associated with occupational and recreational activities at the sewage lagoons and lakes indicated little likelihood of adverse effects. Exposure for children playing at the sewage lagoons was found to be unacceptable, however, due primarily to the now disproven concentration of organolead in the surface water. The presence of organolead was suspect because it was detected at concentrations higher than those reported for total lead, and it was also found in the equipment rinsate samples. Later during the 1994 investigation, organolead was not detected; therefore, the risk has been disproven.

This risk assessment is reported in *Risk Assessment for the Sewage Lagoon System* (Radian, February 1991).

4.3.2 1993 Risk Assessment for Each Sewage Lagoon, Lake, and Ditch

Separate risk assessments for each of the seven sewage lagoons (Ponds A, B, C, D, E, F, and G), the ditch from Pond G to Lake Holloman, and Lakes Holloman and Stinky were conducted to evaluate current and potential future effects on human health and the environment and to support closure of the sewage lagoons as a HWMU. Recommendations for the sites included four general categories: 1) continued current operation, 2) continued current operation with access control, 3) additional sampling suggested, and 4) closure suggested.

The individual risk assessments present an assessment of the carcinogenic risks and noncancer hazards to human health and the environment associated with current and potential future activities at the sewage lagoons and lakes. At the request of NMED, a baseline risk assessment was conducted that assumed residential development and domestic water use over the entire contaminant source area (i.e., sewage lagoons) with little or no remedial activity. Highly conservative, worst-case

exposure scenarios were evaluated as the baseline assessment. Although these exposures are not likely to ever occur, they were used as a screening tool to determine whether risks/hazards are potentially present at the site.

To ensure adequate characterization of the risk/hazard that may realistically be incurred at or near the sewage lagoons and lakes, site-specific risk assessments considered four populations in eight exposure scenarios: six chronic and two subchronic scenarios. These potential exposure scenarios evaluated included:

1) Occupational exposure at Ponds A through G and the ditch;

2) Teenager recreational exposure at Pond G;

3) Bird watcher/recreational hunter exposure at Pond G;

4) Current agricultural exposure at Lakes Holloman and Stinky;

5) Future agricultural exposure at Ponds A through G; and

6) Future construction worker exposure at Ponds A through F.

Target risks were set at 10^{-6} for carcinogens and a hazard quotient of 1 for noncarcinogens. These benchmark values are designed to protect human health and are considered to be *de minimis* risks.

Numerous uncertainties are associated with the results of this risk assessment. Human health risks/hazards associated with Ponds A and E, as well as the ditch were based primarily on single sediment/soil samples in which heptachlor epoxide was detected. Although the levels were high, they were not confirmed hits and do not necessarily represent site conditions. The organolead results that drive the recreational and agricultural hazards at Lake Holloman were obtained during a surface water sampling investigation, and the origin of the organolead is unknown and could not have been related to past waste disposal practices at the sewage lagoons. As discussed previously, the concentrations of organolead were suspect since their values were higher than the total lead concentrations reported and organolead was reported in the equipment rinsate. Additional samples were collected from the sewage lagoons and lakes in October 1994 to address these uncertainties. No organolead was detected in these surface water samples.

The ecological risks were calculated using modeled data. Biota sample results were received after the ecological risk assessment was performed in 1993. The results and conclusion for this risk assessment are recorded in *Holloman Risk Assessment, Sewage Lagoon and Lakes Investigation* (Radian, December 1993).

4.3.3 1996 Risk Assessment Addendum

This risk assessment was an addendum to the 1993 risk assessment discussed previously. Additional data were collected to address the uncertainties identified in the 1993 risk assessment, and during that time more details on the construction of the new wastewater treatment plant were defined. The issues affecting the risk assessment were: 1) Ponds A through F would not be used in the new wastewater treatment facility, and 2) ecological risks were recalculated using biological data.

Site-specific risk assessments were updated for each component of the sewage lagoons and lakes. The evaluation is presented in a report entitled *Risk Assessment Addendum, Sewage Lagoons Closure Project* (Radian and Foster Wheeler, March 1996).

Data from the 1994 investigation, along with the supportable data from previous investiga-

tions were used to calculate the risks to human health. The exposure pathways evaluated included:

1) Current on-site worker at Ponds A through G;

2) Current/future recreational hunters at Pond G, the ditch, and the lakes;

3) Current/future teenager trespasser at Pond G; and

4) Future beef consumer at Lake Stinky.

The calculated human health risks were evaluated using the National Contingency Plan's acceptable risk range of 10^{-4} to 10^{-6}. All human health risks derived for the sewage lagoons were below or within this range.

Ecological risks were evaluated for Pond G only, since Ponds A through F are planned to be closed and will no longer serve as a habitat for aquatic wildlife. The potential for adverse ecological effects was evaluated using a combination of basic uptake modeling from lower trophic levels to higher trophic levels, and actual biological tissue sample data taken from the sewage lagoons and lakes. The potential for adverse effects was estimated by comparing chemical concentrations in the media at Pond G with safe concentrations determined from literature studies. Adverse effects were defined as attributes that may threaten the survivorship and productivity of the aquatic food chain. DDD and DDE (derivatives of DDT) were the only constituents found to have the potential to cause adverse effects in Pond G. These results were within the 1 to 10 EQ range, indicating only slight cause for concern. DDT is no longer used at the Base and these constituents have been decreasing in concentrations (an order of magnitude between 1992 and 1994) over time as documented in the *Site Characterization Report* (Radian and Foster Wheeler, June 1995). It is unlikely that the survivorship and productivity of the aquatic food chains are threatened.

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Section 5
1994 INVESTIGATION

The 1994 investigation served as the final sampling event prior to closure, and aided in selecting an appropriate closure alternative. The investigation's strategy was based on previous investigations and was intended to address identified data limitations. In particular, the sampling was intended to further define the nature and extent of contamination within the sewage lagoons; answer uncertainties identified in the risk assessment for each lagoon; provide analysis for developing cleanup standards if appropriate; help select an appropriate remedial alternative if necessary; and define the volume of sludge potentially requiring remedial action.

In March 1995 additional sampling in association with the 1994 investigation was conducted. Ponds A and B were sampled to determine the presence of any characteristically hazardous wastes and to gather data for the CMS. Additional samples were collected from Ponds C and D to supplement the 1994 investigation. These samples are expected to be the final samples collected prior to closure. The 1994 investigation's field sampling plan is presented in Appendix B of the closure plan.

5.1 Monitored Constituents

On the basis of the types of contaminants detected during previous sampling events, sludge and soil samples were analyzed for organochlorine pesticides and metallic constituents in Ponds C through G. Samples from Ponds A and B were analyzed for toxicity characteristic leaching procedure (TCLP) metals, PCBs, and reactive sulfides. Surface water samples were analyzed for organolead.

5.2 Monitored Media

A total of 122 sludge and soil samples were collected from the sewage lagoons and lake system in October 1994. Sludge samples were collected from Ponds C, D, E, and G and Lake Holloman; surface soil samples were collected from Lake Stinky and the ditch. Soil samples were collected in these latter areas because no sludge was present. In March 1995 a total of 25 sludge samples were collected from Ponds A, B, C, and D.

In addition to the sludge and soil samples, surface water samples were collected from Ponds C, D, E, and G, Lake Holloman, and the Ditch. A total of 35 sample locations were selected from these areas. In order to reevaluate the results of previous samples collected for the 1991 risk assessment, these surface water samples were collected and analyzed for organolead and total lead.

5.3 Sample Locations

Sample locations for the sludge, soil, and surface water samples were selected through probability kriging, a geostatistical procedure. This procedure allows for the use of nonparametric statistics to generate estimates of unknown concentrations. Nonparametric statistics are a group of "distribution-free" techniques that can be applied without prior information about the actual underlying statistical distribution of the concentrations of interest. A full description of the geostatistical procedures used to identify sample locations is presented in Appendix B.

5.4 Analytical Results

Analytical results from the 1994 investigation are presented in the *Site Characterization Report* (Radian and Foster Wheeler, June 1995). Results are summarized in Section 5 of that report. Results indicate the following:

- Heptachlor epoxide was not detected in the samples collected. Previously, unconfirmed reporting of heptachlor epoxide suggested that a potential risk existed. Method 8080 was supplemented by GC/MS to determine if heptachlor epoxide was present. In all cases, GC/MS analysis did not detect heptachlor epoxide as being present. Since no heptachlor epoxide is present, no risk exists for this constituent.
- Organolead was not detected in the samples collected. In 1990, organolead levels reported in the surface water were greater than the total lead concentrations and were similar to levels found in equipment rinsates, making the data questionable. Further sampling has been unable to detect organolead in the surface water; therefore this risk was not present.
- Kepone was not detected at or above concentrations posing a risk. Previous analyses of kepone had too much interference in the sample matrix, which caused a high reporting limit. Another analytical method specific for kepone was used to lower the interferences and the reporting limits.
- Pesticide concentrations in the sludge throughout the sewage lagoon system have decreased from the previous investigations. These declining concentrations indicate better pesticide management on the Base and a decrease of pesticides entering the sewage lagoons. In addition, most organochlorine pesticides have not been used at the Base since 1985.
- Samples collected in Ponds A, B, and C for TCLP metals and reactive sulfide did not indicate that the sludge was characteristically hazardous. Sulfides are expected to be present in domestic sewage sludge in anaerobic conditions.

Section 7
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APPENDIX A

Analytical Summary of Sewage Lagoons Investigations

Appendix A

Analytical Summary of Sewage Lagoons Investigations

This appendix summarizes the analytical results from all surface water, sludge, and soil investigations conducted at the Holloman AFB sewage lagoons between 1990 and 1995. The data collected in Ponds A and B during 1988 to define the extent of PCB concentrations greater than 25 ppm is not included in this summary because the sludge was removed in 1990 and many of the 1988 sample locations were within the area of removal. Therefore, the 1988 data is no longer representative of the sludge currently in Ponds A and B.

The *Site Characterization Report* (Radian and Foster Wheeler, June 1995) presents a summary of data collected by individual investigations in Appendices A through F.

Table A-1 outlines the media analyzed, and the analyses performed for all surface water, sludge, soil, sediment, and groundwater investigations for 1990 to 1995. The remainder of this appendix presents an analytical summary of all groundwater, surface water, sludge, and soil investigations conducted at the sewage lagoons between 1990 and 1995. Results are provided by pond, media, analyses, and constituent. In addition, Figures A-1 through A-11 show the location of sludge and soil samples collected from each sewage lagoon. Figure A-12 shows the groundwater monitoring locations.

Tables A-2 through A-8 summarize the analytical data for surface water, sludge, and soil samples. Table A-9 summarizes groundwater assessment monitoring data collected from 1992 and 1993 for the sewage lagoons. Table A-10 summarizes the results of the 1995 long-term groundwater monitoring program. Each table provides the frequency of detection, the median concentration, the maximum concentration, and the sample location, along with year, for maximum detections. Analytical flags are also presented with the data. The flags may vary depending on the laboratory used, and therefore a summary of the analytical flags is presented as follows:

1990 Sampling Event

B	=	Parameter was also detected in the blank sample; result is uncorrected
C	=	Confirmed on second column or by GC/MS
G	=	Indicates an estimated GC value due to interference
h	=	Sample analyzed 4 days past allowable holding time
J	=	Result is less than the method specified detection limit. These results should be considered approximate.
@	=	Result is less than five times the method detection limit. Studies have shown that the uncertainty of the analysis will increase exponentially as the MDL is approached. These results should be considered approximate.
X	=	Not confirmed on second column

1992 and 1993 Sampling Events

X	=	Qualitative confirmation of analyte on both columns. Quantification differed by a factor of two or more between columns. Value determined by the first column is reported.
@	=	Measured result is less than five times the detection limit
C	=	Presence and quantitation of the analyte confirmed by second column analysis
D	=	Secondary dilution required for this analyte
J	=	Detected below the method detection limit
B	=	Analyte detected in laboratory blank analysis, no blank subtraction performed
G	=	Indicates an estimated GC value due to interference

1994 Sampling Event

T	=	Primary column concentration is the preferred result
V	=	Second column concentration is the preferred result
J	=	Result is less than the reporting limit

Although the 1993 investigation focused on biological sampling, surface water and sediment samples were collected from the sewage lagoons. Sampling consisted of single surface water samples from each lagoon, along with two sediment samples from Ponds A and E. The sediment samples were collected from the near surface sediment (upper few inches of sludge) to compare the constituents found in the lagoons' benthic organisms with their immediate environment. These sediment samples are included with the sludge samples in the analytical summary tables, and can be identified by those maximum sludge concentrations noted with a [93] sampling date. The location of sediment and surface water samples collected in 1993 are not identified in Figure A-1 through A-11 due to their composite nature.

The data set for the median and maximum concentrations included detected, non-detect, and J-flagged data (concentrations below the reporting limit). J-flagged data are counted as "hits" or detections in the summary tables even though they are below the reporting limit. Reporting limits vary for each constituent between samples due to matrix interferences. For example, some samples were diluted and therefore would have a higher reporting limit than those that were not diluted. The median concentration is derived by ordering the values reported for each constituent in a particular media and pond in descending order and then identifying that value that is in the middle. For example if there were 15 samples collected, the 8th value in descending order would be the median. If there are 14 samples, the median value would be the average of the 7th and 8th value in descending order. In some cases the median value is below the reporting limit. If a median or maximum value is nondetect, the value is reported as less than the reporting limit (i.e., <0.5 means that the constituent was not detected and the reporting limit was 0.5). In some cases, the median or maximum value may be a flagged value that is less than the reporting limit (i.e., J flagged data), in this case the value will be reported as the flagged value (i.e., 0.038J means that 0.038 is a value that is less than the reporting limit).

Table A-1
Summary of Analytical Investigations and Analyses Performed

Year of Investigation	Report A 1995	Report B 1994	Report C[a] 1993	D 1993	Report E[a] 1992	Report F[a] 1992	Report G 1991	Report H 1991
Matrices								
Surface Water		X		X				X
Groundwater	X		X			X		
Soil		X			X		X	
Sludge		X			X		X	
Sediment				X				
Analyses Performed								
Metals	X	X (TCLP)	X	X	X	X	X	X
SW8240			X		X	X	X	
SW8270		X	X	X	X	X	X	X
SW8280			X		X	X		
SW8080	X	X	X	X	X	X	X	X
SW8150			X		X	X	X	
SW8140			X		X	X		
Cyanide			X		X	X	X	X
Sulfide		X	X		X	X		
Total Organic Carbon					X	X		
Organolead		X						X
Chromium VI								X
Kepone		X						

[a]Investigation included Appendix IX analyses.

Report Key:

A = 1995 Sampling Report, Sewage Lagoons Long-Term Groundwater Monitoring Program.
B = Site Characterization Report, June 1995.
C = Phase 1 Groundwater Assessment Monitoring Report - December 1993.
D = Results of surface water and sediment samples collected during biota sampling submitted in the Risk Assessment Addendum, March 1996.
E = Site Characterization Report: Sewage Lagoons Investigation - August 1992 (Ponds C, D, E, F, G, Lake Holloman, Ditch, Lake Stinky).
F = Assessment Monitoring Results: Appendix IX and Confirmation Detection and Compliance Monitoring - April 1992
G = QCSR for Field Investigation to Support Sewage Lagoon Closure - June 1991 (Ponds A, B, and C)
H = QCSR for Sewage Lagoon Surface Water Sampling - June 1991 (Headworks, Ponds B, C, D, E, G, and Lake Holloman)

Pond A

Table A-2
Analytical Summary For Pond A

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
E130.2 - Hardness (mg/L)												
Hardness, as CaC03	1/1	2400	2400	A-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
E160.1 - Total Dissolved Solids (mg/L)												
Total dissolved solids	1/1	5500	5500	A-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
SW6010 - Metals (mg/kg)												
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	17/18	6900	130000	A-5 [90]
Antimony	NA	NA	NA	NA	1/1	5.7 @	5.7 @	A-01 [93]	0/18	ND	ND	NA
Barium	NA	NA	NA	NA	1/1	64	64	A-01 [93]	18/18	78	120	A-3 [90]
Beryllium	NA	NA	NA	NA	1/1	0.17 @	0.17 @	A-01 [93]	17/18	0.65 @	0.99 @	A-1 [90]
Cadmium	NA	NA	NA	NA	1/1	0.68 @	0.68 @	A-01 [93]	0/18	ND	ND	NA
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	18/18	99500	140000	A-3 [90]
Chromium	NA	NA	NA	NA	1/1	24	24	A-01 [93]	18/18	7.5	11	A-5 [90]
Cobalt	NA	NA	NA	NA	1/1	2 @	2 @	A-01 [93]	15/18	3.3 @	5.2 @	A-1 [90]
Copper	NA	NA	NA	NA	1/1	40	40	A-01 [93]	18/18	5.4 @	21	A-2 [90]
Iron	NA	NA	NA	NA	NA	NA	NA	NA	18/18	6450	9500	A-5 [90]
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	18/18	32000	52000	A-3 [90]
Manganese	NA	NA	NA	NA	NA	NA	NA	NA	18/18	165	250	A-1 [90]
Nickel	NA	NA	NA	NA	1/1	4.4 @	4.4 @	A-01 [93]	16/18	7.1 @	10 @	A-5 [90]
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	18/18	1300 @	2900	A-2 [90]
Silicon	NA	NA	NA	NA	NA	NA	NA	NA	18/18	195 @	410	A-2 [90]
Silver	NA	NA	NA	NA	1/1	14	14	A-01 [93]	0/18	ND	ND	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	18/18	2300	5900	A-1 [90]
Thallium	NA	NA	NA	NA	1/1	0.61 @	0.61 @	A-01 [93]	13/18	46 @	94 @	A-6 [90]
Tin	NA	NA	NA	NA	1/1	3.9 @	3.9 @	A-01 [93]	0/18	ND	ND	NA
Vanadium	NA	NA	NA	NA	1/1	13	13	A-01 [93]	18/18	18	26	A-2 [90]
Zinc	NA	NA	NA	NA	1/1	68	68	A-01 [93]	18/18	27	44	A-5 [90]
SW7060 - Arsenic (mg/kg)												
Arsenic	NA	NA	NA	NA	1/1	4.5 @	4.5 @	A-01 [93]	18/18	4.5 @	6.0 @	A-5 [90]

Table A-2
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
SW7421 - Lead (mg/kg)												
Lead	NA	NA	NA	NA	1/1	12	12	A-01 [93]	18/18	9.2	39	A-5 [90]
SW7471 - Mercury (mg/kg)												
Mercury	NA	NA	NA	NA	1/1	0.38	0.38	A-01 [93]	NA	NA	NA	NA
SW7740 - Selenium (mg/kg)												
Selenium	NA	NA	NA	NA	1/1	0.73 @	0.73 @	A-01 [93]	11/18	0.67	1.3	A-2 [90]
TCLP Metals												
Arsenic	NA	NA	NA	NA	0/7	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	7/7	0.38	0.6 B	05A [95]	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	0/7	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	0/7	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	0/7	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	0/7	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	0/7	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	1/7	ND (0.02)	ND (0.02)	06A	NA	NA	NA	NA
SW7841 - Thallium (mg/kg)												
Thallium	NA	NA	NA	NA	1/1	0.065 @	0.065 @	A-01 [93]	NA	NA	NA	NA
SW8080 - Organochlorine Pesticides and PCBs (µg/L or µg/kg)												
delta-BHC	1/1	0.037 X@	0.037 X@	A-01 [93]	0/1	ND	ND	NA	0/18	ND	ND	NA
gamma-Chlordane	0/1	ND	ND	NA	1/1	490 JX	490 JX	A-01 [93]	0/18	ND	ND	NA
4,4'-DDD	1/1	0.028 X@	0.028 X@	A-01 [93]	0/1	ND	ND	NA	0/18	ND	ND	NA
4,4'-DDE	0/1	ND	ND	NA	1/1	630 X@	630 X@	A-01 [93]	0/18	ND	ND	NA
4,4'-DDT	1/1	0.02 X@	0.02 X@	A-01 [93]	0/1	ND	ND	NA	0/18	ND	ND	NA
Dieldrin	1/1	0.015 X@	0.015 X@	A-01 [93]	0/1	ND	ND	NA	0/18	ND	ND	NA
Endosulfan I	0/1	ND	ND	NA	1/1	530 XJ	530 XJ	A-01 [93]	0/18	ND	ND	NA
Endosulfan II	0/1	ND	ND	NA	1/1	1.1 XJ	1.1 XJ	A-01 [93]	0/18	ND	ND	NA
Endosulfan Sulfate	1/1	0.013 JB	0.013 JB	A-01 [93]	1/1	420 XJB	420 XJB	A-01 [93]	0/18	ND	ND	NA
Endrin	1/1	0.095 X@	0.095 X@	A-01 [93]	0/1	ND	ND	NA	0/18	ND	ND	NA

Table A-2
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
Heptachlor	1/1	0.012 X@	0.012 X@	A-01 [93]	1/1	230 XJ	230 XJ	A-01 [93]	0/18	ND	ND	NA
Heptachlor epoxide	1/1	0.01 G@	0.01 G@	A-01 [93]	1/1	180000 X	180000 X	A-01 [93]	0/18	ND	ND	NA
PCB-1254	NA	NA	NA	NA	NA	NA	NA	NA	1/18	<42	<220	A-1 [90]
SW8240 - Volatile Organic Compounds (µg/kg)												
Acetone	NA	NA	NA	NA	NA	NA	NA	NA	18/18	34 @	97	A-4 [90]
Methylene chloride	NA	NA	NA	NA	NA	NA	NA	NA	17/18	8 @	14 @	A-2 [90]
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA	NA	NA	2/18	<7	<7	A-2 [90]
SW8270 - Semivolatile Organic Compounds (mg/kg)												
Benzo(a)pyrene	NA	NA	NA	NA	1/1	0.11 J	0.11 J	A-01 [93]	0/18	ND	ND	NA
Benzo(b)fluoranthene	NA	NA	NA	NA	1/1	0.14 JX	0.14 JX	A-01 [93]	0/18	ND	ND	NA
Benzo(k)fluoranthene	NA	NA	NA	NA	1/1	0.14 JX	0.14 JX	A-01 [93]	0/18	ND	ND	NA
4-Chloroaniline	NA	NA	NA	NA	1/1	1.7 J	1.7 J	A-01 [93]	0/18	ND	ND	NA
Diethylphthalate	NA	NA	NA	NA	1/1	0.12 J	0.12 J	A-01 [93]	0/18	ND	ND	NA
bis(2-Ethylhexyl)phthalate	NA	NA	NA	NA	1/1	6.5 @	6.5 @	A-01 [93]	11/18	0.09 J	0.39 J	A-5 [90]
Fluoranthene	NA	NA	NA	NA	1/1	0.12 J	0.12 J	A-01 [93]	0/18	ND	ND	NA
Molecular sulfur	NA	NA	NA	NA	1/1	62	62	A-01 [93]	0/18	ND	ND	NA
Pyrene	NA	NA	NA	NA	1/1	0.12 J	0.12 J	A-01 [93]	0/18	ND	ND	NA
SW8280 - Polychlorinated Dibenzo-Dioxins (PCDD) (µg/kg)												
PCDD	NA	NA	NA	NA	1/1	0.76	0.76	A-01 [93]	NA	NA	NA	NA

Hits = Frequency of detection (i.e. 1/15 means 1 out of 15 samples reported a detected concentration)
NA = Not applicable, or not analyzed
ND = Not detected
[90] = Year that the sample reporting the maximum value was collected
< = Value reported after < is the reporting limit

Legend for Analytical Flags varies with each year of sampling as shown below.

Table A-2
(Continued)

1990 Sampling Event

B - Parameter was also detected in the blank sample; result is uncorrected
C - Confirmed on second column or by GC/MS
G - Indicates an estimated GC value due to interference
h - Sample analyzed 4 days past allowable holding time
J - Result is less than the method specified detection limit. These results should be considered approximate.
@ - Result is less than five times the method detection limit. Studies have shown that the uncertainty of the analysis will increase exponentially as the MDL is approached. These results should be considered approximate
X - Not confirmed on second column

1992 and 1993 Sampling Events

X - Qualitative confirmation of analyte on both columns. Quantification differed by a factor of two or more between columns. Value determined by the first column is reported.
@ - Measured result is less than five times the detection limit
C - Presence and quantitation of the analyte confirmed by second column analysis
D - Secondary dilution required for this analyte
J - Detected below the method detection limit
B - Analyte detected in laboratory blank analysis, no blank subtraction performed
G - Indicates an estimated GC value due to interference.

1994 Sampling Event

T - Primary column concentration is the preferred result
V - Second column concentration is the preferred result
J - Result is less than the reporting limit

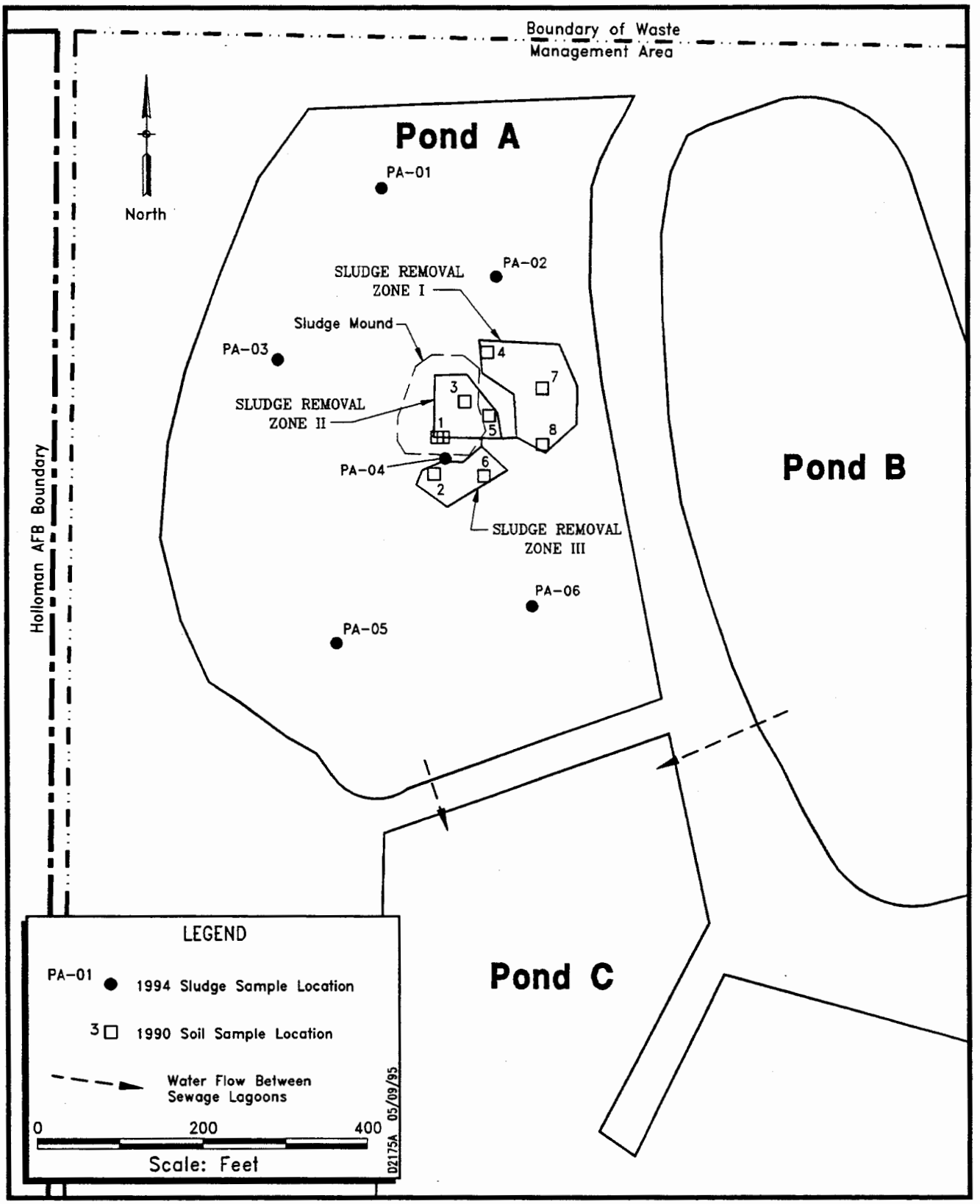

Figure A-1. Pond A Sludge and Soil Sample Locations

Pond B

Table A-3
Analytical Summary For Pond B

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
E130.2 - Hardness (mg/L)												
Hardness, as CaC03	1/1	1600	1600	B-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
E160.1 - Total Dissolved Solids (mg/L)												
Total dissolved solids	1/1	3800	3800	B-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
E239.1 - Organic Lead (mg/L)												
Lead (organic) [a]	4/8	<0.1	0.13 @	B-2 [90]	NA	NA	NA	NA	NA	NA	NA	NA
SW6010 - Metals (mg/L or mg/kg)												
Aluminum	4/8	0.0265	0.11 @	HW-1 [90]	NA	NA	NA	NA	14/14	11500	20000	B-4 [90]
Antimony	1/8	<0.028	0.078 @	B-5 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Barium	7/8	0.0325 @	0.04	B-6 [90]	NA	NA	NA	NA	14/14	50.5	160	B-4 [90]
Beryllium	0/8	ND	ND	NA	NA	NA	NA	NA	14/14	0.565 @	0.82 @	B-3 [90]
Boron	8/8	0.32 @	0.74	HW-2 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	8/8	360	410	B-6 [90]	NA	NA	NA	NA	14/14	82500	200000	B-5 [90]
Chromium	1/8	<0.004	0.0046 @	B-5 [90]	NA	NA	NA	NA	14/14	12	17	B-4 [90]
Cobalt	0/8	ND	ND	NA	NA	NA	NA	NA	14/14	4 @	6.2	B-3 [90]
Copper	2/8	<0.005	0.0075 @	HW-1 [90]	NA	NA	NA	NA	14/14	6.3 @	9.1 @	B-4 [90]
Iron	8/8	0.09	0.19	HW-1 [90]	NA	NA	NA	NA	14/14	8150	14000	B-4 [90]
Magnesium	8/8	180	200	B-1 [90]	NA	NA	NA	NA	14/14	18000	49000	B-4 [90]
Manganese	8/8	0.0495	0.092	B-6 [90]	NA	NA	NA	NA	14/14	135	250	B-4 [90]
Nickel	0/8	ND	ND	NA	NA	NA	NA	NA	14/14	8.05 @	13	B-4 [90]
Potassium	8/8	11.5	13	B-1 [90]	NA	NA	NA	NA	14/14	2300	5200	B-4 [90]
Silicon	8/8	14.5	17	B-1 [90]	NA	NA	NA	NA	14/14	1310 @	6000	B-6 [90]
Silver	2/2	0.0168 @	0.026	HW-1 [90]	NA	NA	NA	NA	0/14	ND	ND	NA
Sodium	8/8	540	580	B-1 [90]	NA	NA	NA	NA	14/14	1035	4300	B-2 [90]
Vanadium	8/8	0.0088 @	0.011 @	HW-1 [90]	NA	NA	NA	NA	14/14	26	39	B-4 [90]
Zinc	8/8	0.0155 @	0.033	HW-1 [90]	NA	NA	NA	NA	14/14	25	40	B-4 [90]

Table A-3
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
SW7060 - Arsenic (mg/L or mg/kg)												
Arsenic	2/8	<0.006	<0.006	B-1 [90]	NA	NA	NA	NA	10/14	2.4 @	10	B-2 [90]
SW7196 - Chromium VI (mg/L)												
Chromium VI	1/8	<0.01	<0.01	B-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
SW7421 - Lead (mg/L or mg/kg)												
Lead	5/8	0.0041	<0.01	B-1 [90]	NA	NA	NA	NA	14/14	3.35	7.8	B-3 [90]
SW7470 - Mercury (mg/L)												
Mercury	5/8	0.0004 @	0.0006 @	B-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
SW7740 - Selenium (mg/L or mg/kg)												
Selenium	4/8	0.0027 @	<0.004	B-4 [90]	NA	NA	NA	NA	0/14	ND	ND	NA
TCLP Metals												
Arsenic	NA	NA	NA	NA	0/6	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	6/6	0.46 B	0.51 B	02B [95]	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	0/6	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	1/6	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	0/6	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	0/6	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	0/6	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	0/6	NA	NA	NA	NA	NA	NA	NA
SW8080 - Organochlorine Pesticides and PCBs (µg/L or µg/kg)												
alpha-BHC	1/9	<0.5	<0.5	B-1 [90]	NA	NA	NA	NA	0/14	ND	ND	NA
delta-BHC	1/9	0.017 X@	0.017 X@	B-01 [93]	NA	NA	NA	NA	0/14	ND	ND	NA
gamma-BHC	4/9	<1.5	<1.5	B-1 [90]	NA	NA	NA	NA	0/14	ND	ND	NA
Chlordane	4/8	3.6	<28	B-3 [90]	NA	NA	NA	NA	0/14	ND	ND	NA
alpha-Chlordane	1/1	0.0034 JX	0.0034 JX	B-01 [93]	NA	NA	NA	NA	0/14	ND	ND	NA
4,4'-DDD	1/9	0.043 X@	0.043 X@	B-01 [93]	NA	NA	NA	NA	0/14	ND	ND	NA
4,4'-DDE	2/9	<1.5	<6	B-3 [90]	NA	NA	NA	NA	0/14	ND	ND	NA
4,4'-DDT	1/9	0.018 JX	0.018 JX	B-01 [93]	NA	NA	NA	NA	0/14	ND	ND	NA

Table A-3
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
Dieldrin	1/9	0.022 X@	0.022 X@	B-01 [93]	NA	NA	NA	NA	0/14	ND	ND	NA
Endosulfan I	0/9	ND	ND	NA	NA	NA	NA	NA	2/14	<1.4	180 X	B-2 [90]
Endosulfan Sulfate	1/9	0.012 JB	0.012 JB	B-01 [93]	NA	NA	NA	NA	0/14	N/D	ND	NA
Endrin	1/9	0.0093 JX	0.0093 JX	B-01 [93]	NA	NA	NA	NA	0/14	ND	ND	NA
Heptachlor epoxide [b]	1/9	0.01 G@	0.01 G@	B-01 [93]	NA	NA	NA	NA	0/14	ND	ND	NA
PCB-1254	NA	NA	NA	NA	3/3	13000 C@	13000 C@	B-S1-SA [90]	0/14	ND	ND	NA
SW8240 - Volatile Organic Compounds (µg/kg)												
Acetone	NA	NA	NA	NA	NA	NA	NA	NA	6/14	<13.5	39 B@	B-5 [90]
Carbon disulfide	NA	NA	NA	NA	NA	NA	NA	NA	2/14	<6.6	<7.2	B-6 [90]
Methylene chloride	NA	NA	NA	NA	NA	NA	NA	NA	8/14	2.1 JB	6.7 J	B-5 [90]
SW8270 - Semivolatile Organic Compounds (mg/L or mg/kg)												
Dibutylphthalate	0/8	ND	ND	NA	NA	NA	NA	NA	1/14	<0.215	170 J	B-6 [90]
bis(2-Ethylhexyl)phthalate	7/8	0.0075	<0.02	B-6 [90]	NA	NA	NA	NA	4/14	<0.44	1100 @	B-2 [90]

[a]Organic lead data results for the 1990 Investigation were questionable data. The organic lead concentrations detected in surface water were greater than total lead concentrations detected. Additional sampling was conducted in the 1994 Investigation using an analytical method specific for organic lead and it was not detected. Therefore, organic lead is not present in the surface water in the sewage lagoon system.

[b] Heptachlor epoxide data was questionable since it was only detected on one of two columns using a GC methodology. Therefore, this constituent was resampled in the 1994 investigation and any sample that was detected on one column only was reanalyzed using a GC/MS methodology to determine if heptachlor epoxide was present. In all cases, no heptachlor epoxide was detected using the GC/MS methodology. Holloman AFB has verified that no heptachlor epoxide is present.

Hits = Frequency of detection (i.e. 1/15 means 1 out of 15 samples reported a detected concentration)
NA = Not applicable, or not analyzed
ND = Not detected
[90] = Year that the sample reporting the maximum value was collected
< = Value reported after < is the reporting limit

Legend for Analytical Flags varies with each year of sampling as shown below.

Table A-3
(Continued)

1990 Sampling Event

B - Parameter was also detected in the blank sample; result is uncorrected
C - Confirmed on second column or by GC/MS
G - Indicates an estimated GC value due to interference
h - Sample analyzed 4 days past allowable holding time
J - Result is less than the method specified detection limit. These results should be considered approximate.
@ - Result is less than five times the method detection limit. Studies have shown that the uncertainty of the analysis will increase exponentially as the MDL is approached. These results should be considered approximate
X - Not confirmed on second column

1992 and 1993 Sampling Events

X - Qualitative confirmation of analyte on both columns. Quantification differed by a factor of two or more between columns. Value determined by the first column is reported.
@ - Measured result is less than five times the detection limit
C - Presence and quantitation of the analyte confirmed by second column analysis
D - Secondary dilution required for this analyte
J - Detected below the method detection limit
B - Analyte detected in laboratory blank analysis, no blank subtraction performed
G - Indicates an estimated GC value due to interference.

1994 Sampling Event

T - Primary column concentration is the preferred result
V - Second column concentration is the preferred result
J - Result is less than the reporting limit

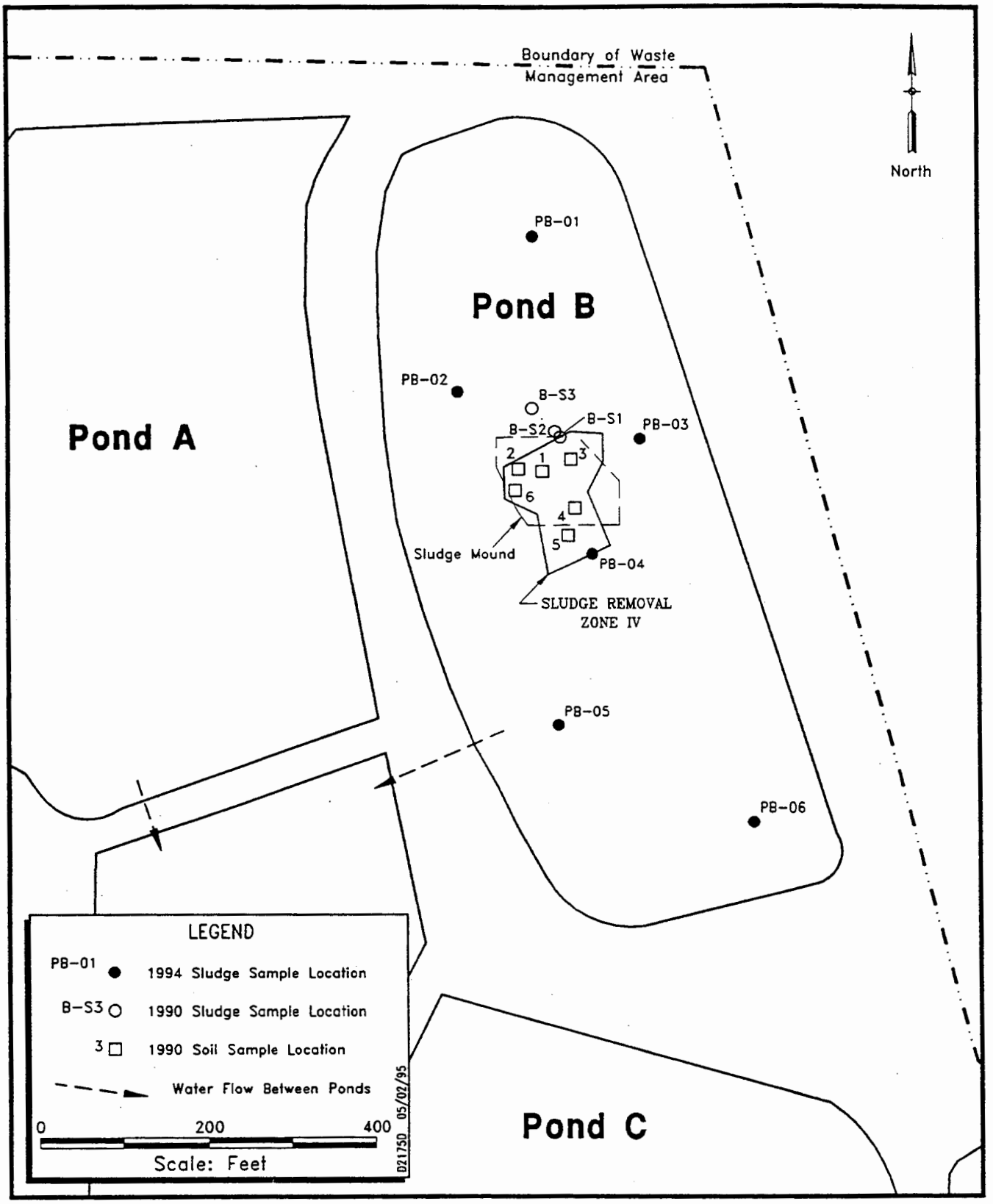

Figure A-2. Pond B Sludge and Soil Sample Locations

Pond C

Table A-4
Analytical Summary For Pond C

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
E130.2 - Hardness (mg/L)												
Hardness, as CaC03	1/1	1900	1900	C-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
E160.1 - Total Dissolved Solids (mg/L)												
Total dissolved solids	1/1	4400	4400	C-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
MRI-SOP - Kepone (mg/kg)												
Kepone	NA	NA	NA	NA	1/8	<0.07	<0.07	11C [94]	NA	NA	NA	NA
SW6010 - Metals (mg/L or mg/kg)												
Aluminum	1/5	<0.024	0.053 @	C-2 [90]	6/6	9750	13000	C-3 [90]	6/6	10500	11000	C-2 [90]
Barium	4/5	0.03 @	0.038 @	C-1 [90]	25/25	92	159	05C [94]	14/14	86	160	C-3 [90]
Beryllium	0/5	ND	ND	NA	8/25	<0.56	<2.00	C-05 [92]	6/14	0.67	<0.89	C-06 [92]
Boron	5/5	0.21 @	0.3 @	C-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	0/5	ND	ND	NA	6/19	<2.9	6 @	C-05 [92]	0/8	ND	ND	NA
Calcium	5/5	290	350	C-1 [90]	6/6	110000	120000	C-3 [90]	6/6	105000	190000	C-3 [90]
Chromium	0/5	ND	ND	NA	25/25	39.1	120	C-01 [92]	12/14	7.55 @	<15	C-2 [90]
Cobalt	0/5	ND	ND	NA	20/25	3.9	<10.0	C-05 [92]	6/14	3.9 @	4.4	C-03 [92]
Copper	0/5	ND	ND	NA	25/25	88.4	260	C-05 [92]	6/14	8.1	18	C-2 [90]
Iron	5/5	0.053 @	0.076	C-2 [90]	6/6	7050	9000	C-3 [90]	6/6	7150	8200	C-2 [90]
Magnesium	5/5	140	170	C-1 [90]	6/6	10500	13000	C-1 [90]	6/6	8850	25000	C-5 [90]
Manganese	5/5	0.063	0.077	C-2 [90]	6/6	145	210	C-1 [90]	6/6	92.5	150	C-1 [90]
Molybdenum	0/5	ND	ND	NA	0/6	ND	ND	NA	1/6	<6.35	12 @	C-2 [90]
Nickel	0/5	ND	ND	NA	21/25	10.4 J	<20.0	C-05 [92]	6/14	8.6	<8.9	C-06 [92]
Potassium	5/5	9.3	12	C-2 [90]	6/6	2350	2700 @	C-1 [90]	6/6	2700	2800	C-3 [90]
Silicon	5/5	13	16	C-1 [90]	6/6	1610	8200	C-5 [90]	6/6	1115	4000	C-4 [90]
Silver	0/5	ND	ND	NA	20/25	84.3	320	C-01 [92]	0/14	ND	ND	NA
Sodium	5/5	410	520	C-2 [90]	6/6	1150	2300	C-5 [90]	6/6	670	1200	C-5 [90]
Tin	0/5	ND	ND	NA	7/19	<39.1	<600.0	C-05 [92]	0/8	ND	ND	NA
Vanadium	5/5	0.0056 @	0.0078 @	C-2 [90]	25/25	32.3	55 @	C-01 [92]	12/14	18.5	30	C-3 [90]
Zinc	2/5	<0.003	0.013 @	C-2 [90]	25/25	121	330	C-01 [92]	12/14	15.5	210	C-2 [90]

Table A-4
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
SW7060 - Arsenic (mg/L or mg/kg))												
Arsenic	2/5	<0.003	0.0041 @	C-1 [90]	16/25	1.7 J	<3.80	C-05 [92]	11/14	1.2	2.6	C-06 [92]
SW7196 - Chromium VI (mg/L)												
Chromium VI	2/5	<0.0002	0.014	C-2 [90]	NA	NA	NA	NA	NA	NA	NA	NA
SW7421 - Lead (mg/L or mg/kg))												
Lead	5/8	0.0066	<0.01	PC-08 [94]	25/25	13	64	C-05 [92]	14/14	2.9	5.3	C-2 [90]
SW7470 Mercury (mg/L)												
Mercury	0/5	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
SW7471 - Mercury (mg/kg)												
Mercury	NA	NA	NA	NA	15/19	<0.72	1.6 @	C-01 [92]	0/8	ND	ND	NA
SW7740 - Selenium (mg/L or mg/kg)												
Selenium	0/5	ND	ND	NA	16/25	1.5 J	6.3 @	C-05 [92]	0/14	ND	ND	NA
TCLP Metals												
Arsenic	NA	NA	NA	NA	0/7	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	7/7	0.55 B	1.1 B	03C [95]	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	0/7	NA	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	0/7	NA	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	0/7	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	0/7	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	0/7	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	4/7	ND (0.01)	0.011 J	03C [95] 10C [95]	NA	NA	NA	NA
SW8080 - Organochlorine Pesticides and PCBs (µg/L or µg/kg)												
Aldrin	0/6	ND	ND	NA	0/25	ND	ND	NA	3/14	1.8	<21.0	C-01 [92]
alpha-BHC	0/6	ND	ND	NA	5/25	<16	<120	C-05 [92]	0/14	ND	ND	NA
beta-BHC	1/6	<1.5	<1.5	C-5 [90]	0/25	ND	ND	NA	2/14	<1.4	63	C-01 [92]
delta-BHC	0/6	ND	ND	NA	6/25	<16	5000 X	C-05 [92]	1/14	<1.4	<21.0	C-01 [92]
gamma-BHC	0/6	ND	ND	NA	4/25	<25	<120	C-05 [92]	0/14	ND	ND	NA
alpha-Chlordane	0/1	ND	ND	NA	1/6	70.5	<120	C-05 [92]	0/8	ND	ND	NA
gamma-Chlordane	0/1	ND	ND	NA	4/6	107.5	210 C@	C-05 [92]	0/8	ND	ND	NA
[illegible]rdane	0/5	ND	ND	NA	0/19	[illegible]	ND	NA	0/6	ND	ND	NA

Table A-4
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
4,4'-DDD	0/6	ND	ND	NA	24/25	310 C@	16000 C	C-5 [90]	9/14	56.5	180 C@	C-2 [90]
4,4'-DDE	0/6	ND	ND	NA	23/25	220 V	8100 CG	C-5 [90]	7/14	14	240 C@	C-2 [90]
4,4'-DDT	0/6	ND	ND	NA	9/25	36.0 J	360 X@	C-05 [92]	1/14	<2.7	<42.0	C-01 [92]
Dieldrin	0/6	ND	ND	NA	3/25	<31	<180	02C [94]	0/14	ND	ND	NA
Endosulfan I	0/6	ND	ND	NA	5/25	<32	4400 X	C-5 [90]	3/14	<3.9	440 X	C-2 [90]
Endosulfan Sulfate	0/6	ND	ND	NA	0/25	ND	ND	NA	3/14	<6.4	<14.0	C-03 [92]
Endrin Aldehyde	0/6	ND	ND	NA	0/25	ND	ND	NA	1/14	<2.7	<42.0	C-01 [92]
Heptachlor epoxide[a]	0/1	ND	ND	NA	0/25	ND	ND	NA	2/14	<1.4	<21.0	C-01 [92]
Kepone (Mirex)	0/1	ND	ND	NA	4/10	<103	190000 C	C-5 [90]	0/8	ND	ND	NA
SW8150 - Chlorinated Herbicides (µg/kg)												
Dichloroprop	NA	NA	NA	NA	0/6	ND	ND	NA	1/6	<85	153 C@	C-2 [90]
2,4,5-T	NA	NA	NA	NA	1/12	<87	300 X@	C-05 [92]	0/14	ND	ND	NA
SW8240 - Volatile Organic Compounds (µg/kg)												
Acetone	NA	NA	NA	NA	11/12	177.5	2300 @	C-03 [92]	11/14	17	430 J	C-01 [92]
Benzene	NA	NA	NA	NA	1/12	<38	<60	C-05 [92]	0/14	ND	ND	NA
Carbon disulfide	NA	NA	NA	NA	8/12	14 J@	110 @	C-05 [92]	8/14	<6.7	26.8	C-01 [92]
Ethyl benzene	NA	NA	NA	NA	6/12	18	43	C-04 [92]	1/14	<6.75	<53.0	C-01 [92]
Methyl ethyl ketone	NA	NA	NA	NA	7/12	30.5	310	C-05 [92]	0/14	ND	ND	NA
Methylene chloride	NA	NA	NA	NA	5/12	7.55	<60	C-05 [92]	7/14	5.7	<53.0	C-01 [92]
Tetrachloroethene	NA	NA	NA	NA	1/12	<38	<60	C-05 [92]	0/14	ND	ND	C-01 [92]
Toluene	NA	NA	NA	NA	6/12	7.6	15	C-06 [92]	7/14	0.9	<6.8	C-05 [92]
Xylenes	NA	NA	NA	NA	8/12	17	130 @	C-05 [92]	1/14	<6.7	<53.0	C-01 [92]
SW8270 - Semivolatile Organic Compounds (mg/L or mg/kg)												
Acetophenone	0/5	ND	ND	NA	2/12	<6.4	<12.0	C-05 [92]	0/14	ND	ND	NA
Di-n-octylphthalate	0/5	ND	ND	NA	0/12	ND	ND	NA	1/14	1.35	< 1.4	C-01 [92]
Dibenzofuran	0/5	ND	ND	NA	1/12	3.35	<12.0	C-05 [92]	0/14	ND	ND	NA
Dibutylphthalate	0/5	ND	ND	NA	2/12	0.32	<12.0	C-05 [92]	2/14	<1.3	<11.0	C-01 [92]
bis(2-Ethylhexyl)phthalate	2/5	<0.02	<0.02	C-5 [90]	10/12	6.25	36 B@	C-02 [92]	10/14	0.395	7.9 B	C-06 [92]
Fluoranthene	0/5	ND	ND	NA	2/12	<6.4	<12.0	C-05 [92]	0/14	ND	ND	NA
2-Methylnaphthalene	0/5	ND	ND	NA	2/12	<3.35	14 @	C-5 [90]	0/14	ND	ND	NA

Table A-4
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
Phenanthrene	0/5	ND	ND	NA	9/12	0.75	11 @	C-5 [90]	1/14	<1.3	<11.0	C-01 [92]
Phenol	0/5	ND	ND	NA	1/12	<3.35	<12.0	C-05 [92]	0/14	ND	ND	NA
Pyrene	0/5	ND	ND	NA	3/12	0.405	<12.0	C-05 [92]	1/14	<1.3	<11.0	C-01 [92]
SW9012 - Total Cyanide (mg/kg)												
Cyanide	NA	NA	NA	NA	2/6	<2.15	330	C-01 [92]	4/8	0.355	1.2 @	C-03 [92]
SW9030 - Sulfides (mg/kg)												
Sulfide	NA	NA	NA	NA	5/6	1500	2800	C-01 [92]	2/8	<34	130 @	C-01 [92]
SW9060 Total Organic Carbon (µg/kg)												
Total organic carbon	NA	NA	NA	NA	NA	NA	NA	NA	2/2	2600 @	3200 @	C-01 [92]

* Heptachlor epoxide data was questionable since it was only detected on one of two columns using a GC methodology. Therefore, this constituent was resampled in the 1994 investigation and any sample that was detected on one column only was reanalyzed using a GC/MS methodology to determine if heptachlor epoxide was present. In all cases, no heptachlor epoxide was detected using the GC/MS methodology. Holloman AFB has verified that no heptachlor epoxide is present.

Hits = Frequency of detection (i.e. 1/15 means 1 out of 15 samples reported a detected concentration)
NA = Not applicable, or not analyzed
ND = Not detected
[90] = Year that the sample reporting the maximum value was collected
< = Value reported after < is the reporting limit

Legend for Analytical Flags varies with each year of sampling as shown below.

1990 Sampling Event

B - Parameter was also detected in the blank sample; result is uncorrected
C - Confirmed on second column or by GC/MS
G - Indicates an estimated GC value due to interference
h - Sample analyzed 4 days past allowable holding time
J - Result is less than the method specified detection limit. These results should be considered approximate.
@ - Result is less than five times the method detection limit. Studies have shown that the uncertainty of the analysis will increase exponentially as the MDL is approached. These results should be considered approximate
X - Not confirmed on second column

1992 and 1993 Sampling Events

X - Qualitative confirmation of analyte on both columns. Quantification differed by a factor of two or more between columns. Value determined by the first column is reported.
@ - Measured result is less than five times the detection limit
C - Presence and quantitation of the analyte confirmed by second column analysis
D - Secondary dilution required for this analyte
J - Detected below the method detection limit
B - Analyte detected in laboratory blank analysis, no blank subtraction performed
G - Indicates an estimated GC value due to interference.

1994 Sampling Event

T - Primary column concentration is the preferred result
V - S[illegible]d column concentration is the preferred result
J - R[illegible]; less than the reporting limit

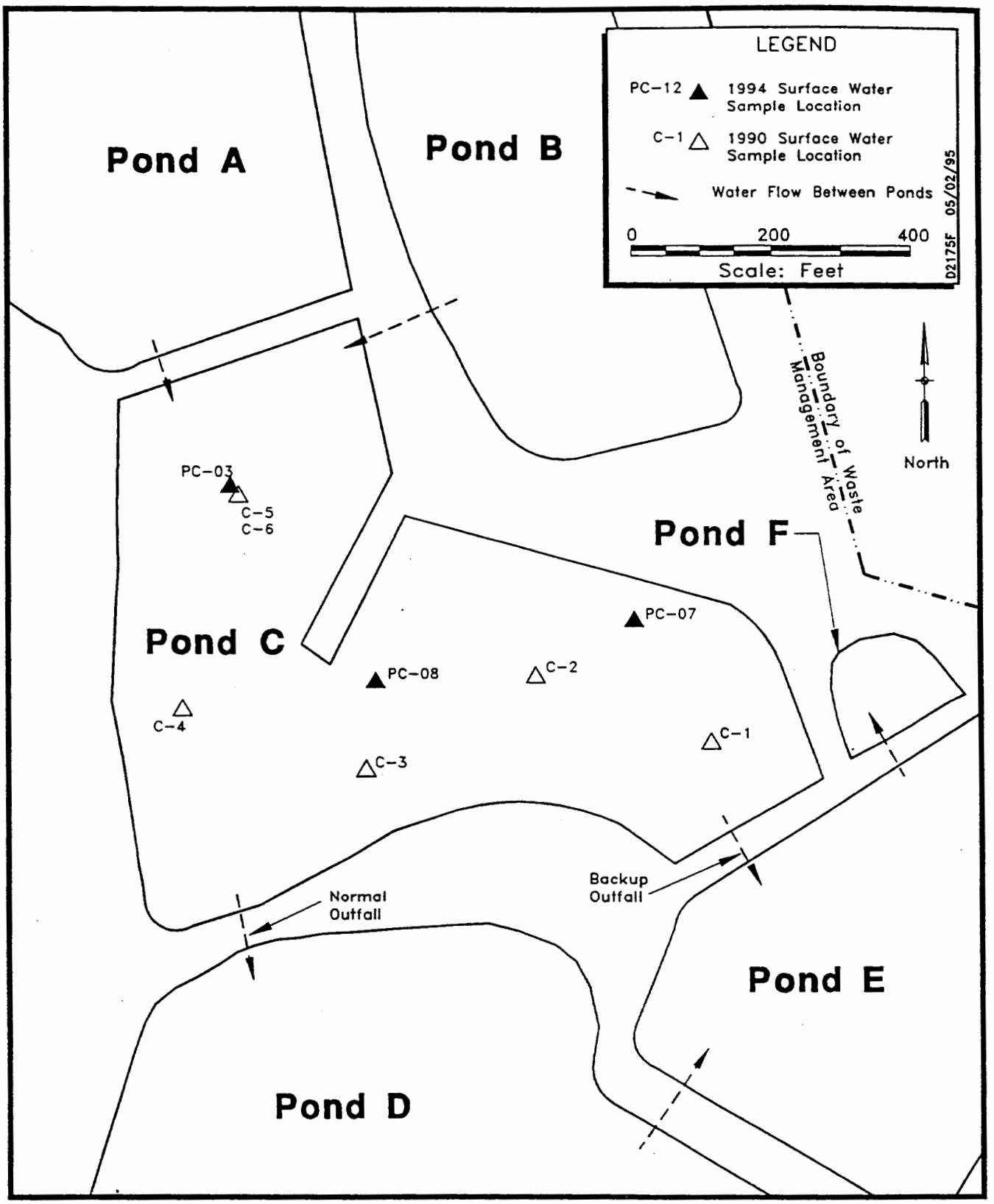

Figure A-3. Pond C Surface Water Sample Locations

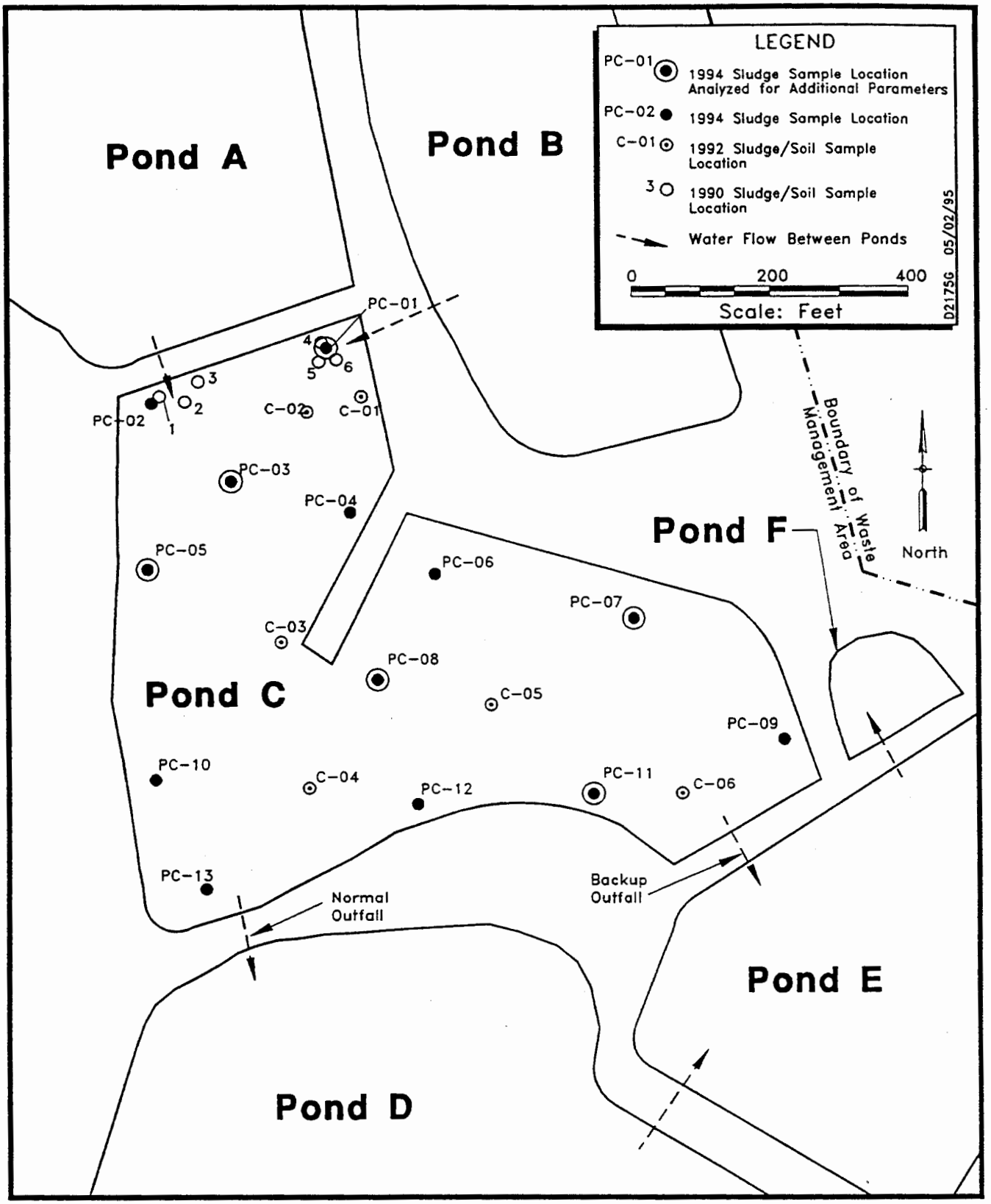

Figure A-4. Pond C Sludge and Soil Sample Locations

Pond D

Table A-5
Analytical Summary For Pond D

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
E130.2 - Hardness (mg/L or mg/kg)												
Hardness, as CaC03	1/1	2100	2100	D-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
E160.1 - Total Dissolved Solids (mg/L)												
Total dissolved solids	1/1	4600	4600	D-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
E239.1 - Organic Lead (mg/L)												
Lead (organic) *	2/6	<0.1	0.12 @	D-5 [90]	NA	NA	NA	NA	NA	NA	NA	NA
SW6010 - Metals (mg/L or mg/kg)												
Barium	6/6	0.037 @	0.039 @	D-3 [90]	10/10	50.2	91.7	PD-0D [94]	9/9	38.0	82.0	D-06 [92]
Beryllium	NA	NA	NA	NA	1/10	1.02	<1.8	PD-06 [94]	0/9	ND	ND	NA
Boron	6/6	0.29 @	0.3 @	D-4 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	6/6	330	340	D-3 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	0/6	ND	ND	NA	8/10	4.6	<8.9	PD-06 [94]	4/9	<4.8	9.4 @	D-01 [92]
Cobalt	NA	NA	NA	NA	8/10	2.55	<5.8	PD-10 [94]	0/9	ND	ND	NA
Copper	0/6	ND	ND	NA	10/10	12.05	35.5	PD-06 [94]	0/9	ND	ND	NA
Iron	6/6	0.0325 @	0.054 @	D-6 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	6/6	170	180	D-3 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	6/6	0.056	0.074	D-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	9/10	4.2 J	<23.3	PD-10 [94]	1/9	<9	<11	D-05 [92]
Potassium	6/6	12	12	D-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Silicon	6/6	15	17	D-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	9/10	2.85 J	7.5	PD-09 [94]	0/9	ND	ND	NA
Sodium	6/6	495	520	D-3 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	1/10	<2.85	<8.9	PD-06 [94]	NA	NA	NA	NA
Tin	NA	NA	NA	NA	0/10	ND	ND	NA	0/9	ND	ND	NA
Vanadium	3/6	0.0051	0.0063 @	D-3 [90]	10/10	15.75	24.9	PD-08 [94]	4/9	<10	26 @	D-01 [92]
Zinc	4/6	0.0045 @	0.0081 @	D-5 [90]	10/10	23.1	53.6	PD-08 [94]	5/9	<11	23 @	D-01 [92]

Table A-5
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
SW7060 - Arsenic (mg/L or mg/kg)												
Arsenic	3/6	<0.006	0.0062 @	D-3 [90]	8/10	2.15 J	<5.8	PD-10 [94]	9/9	0.9 @	2.9	D-01 [92]
SW7421 - Lead (mg/L or mg/kg)												
Lead	6/9	0.0047 @	<0.01	PD-08 [94]	10/10	1.25 J	6 J	PD-08 [94]	9/9	1.7	4.5	D-01 [92]
SW7470 - Mercury (mg/L)												
Mercury	3/6	0.0004	0.00074 @	D-5 [90]	NA	NA	NA	NA	NA	NA	NA	NA
SW7471 - Mercury (mg/kg)												
Mercury	NA	NA	NA	NA	0/10	ND	ND	NA	0/9	ND	ND	NA
SW7740 - Selenium (mg/L or mg/kg)												
Selenium	2/6	<0.002	0.003 @	D-5 [90]	8/10	1.3 J	<2.9	PD-05 [94]	1/9	<0.55	<0.64	D-01 [92]
SW8080 - Organochlorine Pesticides and PCBs (µg/L or µg/kg)												
Aldrin	0/7	ND	ND	NA	0/10	ND	ND	NA	0/9	ND	ND	NA
alpha-BHC	0/7	ND	ND	NA	0/10	ND	ND	PD-03 [94]	0/9	ND	ND	NA
beta-BHC	0/7	ND	ND	NA	0/10	ND	ND	NA	3/9	<3.6	26 X	D-03 [92]
delta-BHC	1/7	0.021 X@	0.021 X@	D-01 [93]	6/10	1.7 VJ	<9.7	PD-08 [94]	1/9	<1.4	17 X	D-03 [92]
gamma-BHC	1/7	<0.6	<1.5	D-3 [90]	0/10	ND	ND	NA	1/9	<3.4	21 X	D-01 [92]
Chlordane	0/6	ND	ND	NA	0/10	ND	ND	NA	NA	NA	NA	NA
alpha-Chlordane	0/1	ND	ND	NA	NA	NA	NA	NA	1/9	7.25	<13	D-04 [92]
gamma-Chlordane	1/1	0.0058 J	0.0058 J	NA	NA	NA	NA	NA	0/9	ND	ND	NA
4,4'-DDD	1/7	0.03 X@	0.03 X@	D-01 [93]	9/10	4.9 VJ	32	PD-06 [94]	2/9	<1.4	240 C	D-04 [92]
4,4'-DDE	0/7	ND	ND	NA	8/10	4.1 J	14 VJ	PD-06 [94]	1/9	<1.4	35 X@	D-04 [92]
4,4'-DDT	0/7	ND	ND	NA	6/10	9.3	97	PD-06 [94]	3/9	<2.8	52 C@	D-04 [92]
Dieldrin	1/7	0.015 X@	0.015 X@	D-01 [93]	0/10	ND	ND	NA	0/9	ND	ND	NA
Endosulfan II	0/7	ND	ND	NA	0/10	ND	ND	NA	0/9	ND	ND	NA
Endosulfan Sulfate	1/7	0.013 JB	0.013JB	D-01 [93]	1/10	15	<30	PD-06 [94]	3/9	34.5	<64	D-04 [92]
Endrin	1/7	0.0097 X@	0.0097 X@	D-01 [93]	0/10	ND	ND	NA	0/9	ND	ND	NA
Heptachlor	0/7	ND	ND	NA	1/10	<3.1	<15	PD-06 [94]	0/9	ND	ND	NA
Heptachlor epoxide[b]	1/7	0.01 X@	0.01 X@	D-01 [93]	0/10	NA	ND	NA	0/9	ND	ND	NA

Table A-5
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
Methoxychlor	1/7	<10	<25	D-3 [90]	0/10	ND	ND	NA	0/9	ND	ND	NA
SW8240 - Volatile Organic Compounds (µg/kg)												
Acetone	NA	NA	NA	NA	NA	NA	NA	NA	3/9	<130	<150	D-01 [92]
2-Hexanone	NA	NA	NA	NA	NA	NA	NA	NA	1/9	<67	<74	D-01 [92]
SW8270 - Semivolatile Organic Compounds (mg/L or mg/kg)												
Benzoic acid	1/6	<0.05	<0.1	D-1 [90]	NA	NA	NA	NA	0/9	ND	ND	NA
Butylbenzylphthalate	1/6	<0.01	<0.02	D-1 [90]	NA	NA	NA	NA	0/9	ND	ND	NA
Dibutylphthalate	1/6	<0.01	<0.02	D-1 [90]	NA	NA	NA	NA	0/9	ND	ND	NA
Diethylphthalate	1/6	<0.01	<0.02	D-1 [90]	NA	NA	NA	NA	0/9	ND	ND	NA
bis(2-Ethylhexyl)phthalate	5/6	0.01	0.02 @	D-4 [90]	NA	NA	NA	NA	4/9	<1.35	<1.5	D-01 [92]
4-Hydroxy-4-methyl-2-pentanone	0/6	ND	ND	NA	NA	NA	NA	NA	1/9	13	13	D-01 [92]
Phenol	1/6	<0.01	<0.02	D-1 [90]	NA	NA	NA	NA	0/9	ND	ND	NA
SW9030 - Sulfides (mg/kg)												
Sulfide	NA	NA	NA	NA	NA	NA	NA	NA	1/9	<33.5	82 @	D-04 [92]
SW9060 - Total Organic Carbon (mg/kg)												
Total organic carbon	NA	NA	NA	NA	NA	NA	NA	NA	6/6	2400 @	3200 @	D-01 [92]

[a]Organic lead data results for the 1990 Investigation were questionable data. The organic lead concentrations detected in surface water were greater than total lead concentrations detected. Additional sampling was conducted in the 1994 Investigation using an analytical method specific for organic lead and it was not detected. Therefore, organic lead is not present in the surface water in the sewage lagoon system.

[b] Heptachlor epoxide data was questionable since it was only detected on one of two columns using a GC methodology. Therefore, this constituent was resampled in the 1994 investigation and any sample that was detected on one column only was reanalyzed using a GC/MS methodology to determine if heptachlor epoxide was present. In all cases, no heptachlor epoxide was detected using the GC/MS methodology. Holloman AFB has verified that no heptachlor epoxide is present.

Hits = Frequency of detection (i.e. 1/15 means 1 out of 15 samples reported a detected concentration)
NA = Not applicable, or not analyzed
ND = Not detected
[90] = Year that the sample reporting the maximum value was collected
< = Value reported after < is the reporting limit

Table A-5
(Continued)

Legend for Analytical Flags varies with each year of sampling as shown below.

1990 Sampling Event

B - Parameter was also detected in the blank sample; result is uncorrected
C - Confirmed on second column or by GC/MS
G - Indicates an estimated GC value due to interference
h - Sample analyzed 4 days past allowable holding time
J - Result is less than the method specified detection limit. These results should be considered approximate.
@ - Result is less than five times the method detection limit. Studies have shown that the uncertainty of the analysis will increase exponentially as the MDL is approached. These results should be considered approximate
X - Not confirmed on second column

1992 and 1993 Sampling Events

X - Qualitative confirmation of analyte on both columns. Quantification differed by a factor of two or more between columns. Value determined by the first column is reported.
@ - Measured result is less than five times the detection limit
C - Presence and quantitation of the analyte confirmed by second column analysis
D - Secondary dilution required for this analyte
J - Detected below the method detection limit
B - Analyte detected in laboratory blank analysis, no blank subtraction performed
G - Indicates an estimated GC value due to interference.

1994 Sampling Event

T - Primary column concentration is the preferred result
V - Second column concentration is the preferred result
J - Result is less than the reporting limit

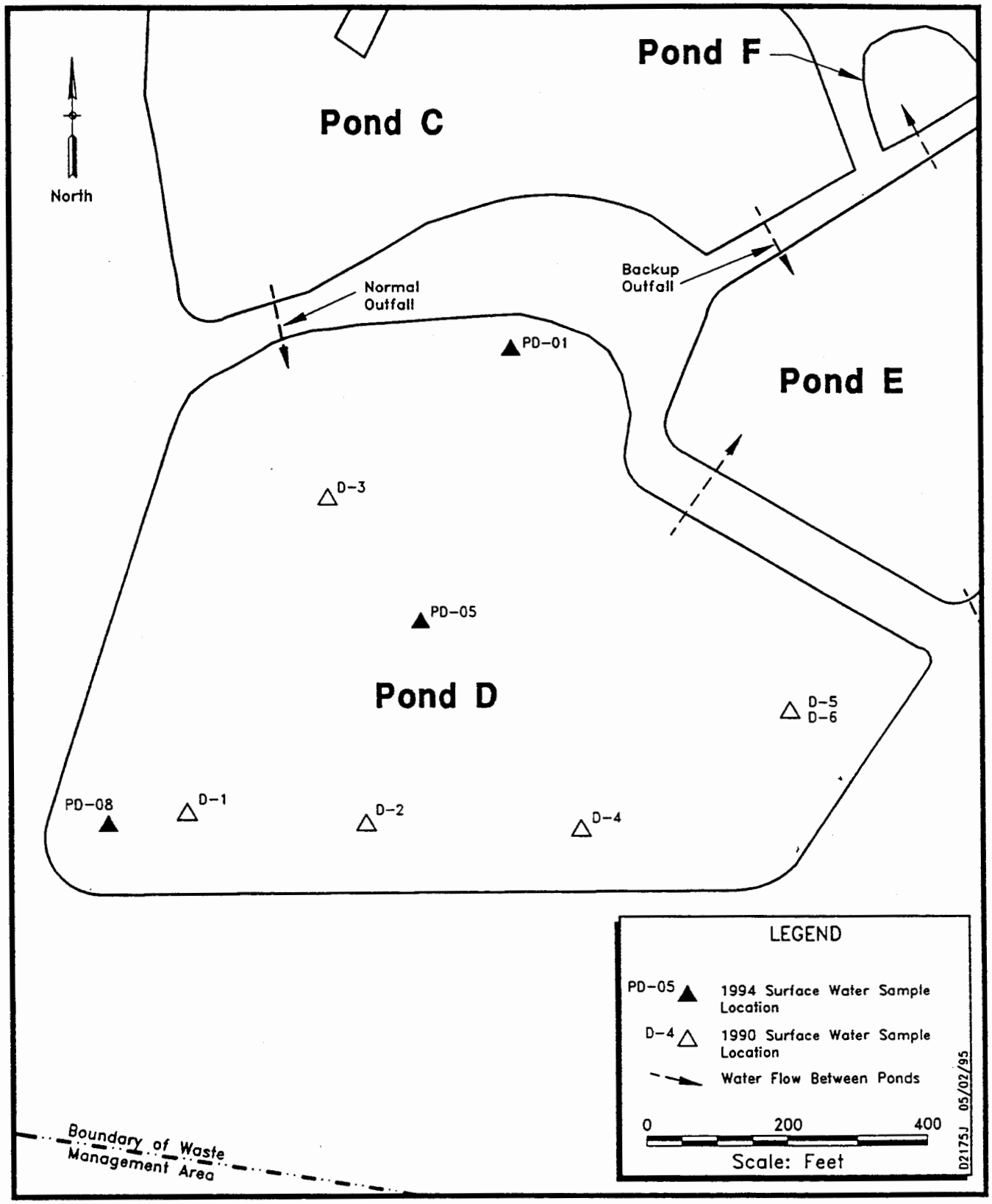

Figure A-5. Pond D Surface Water Sample Locations

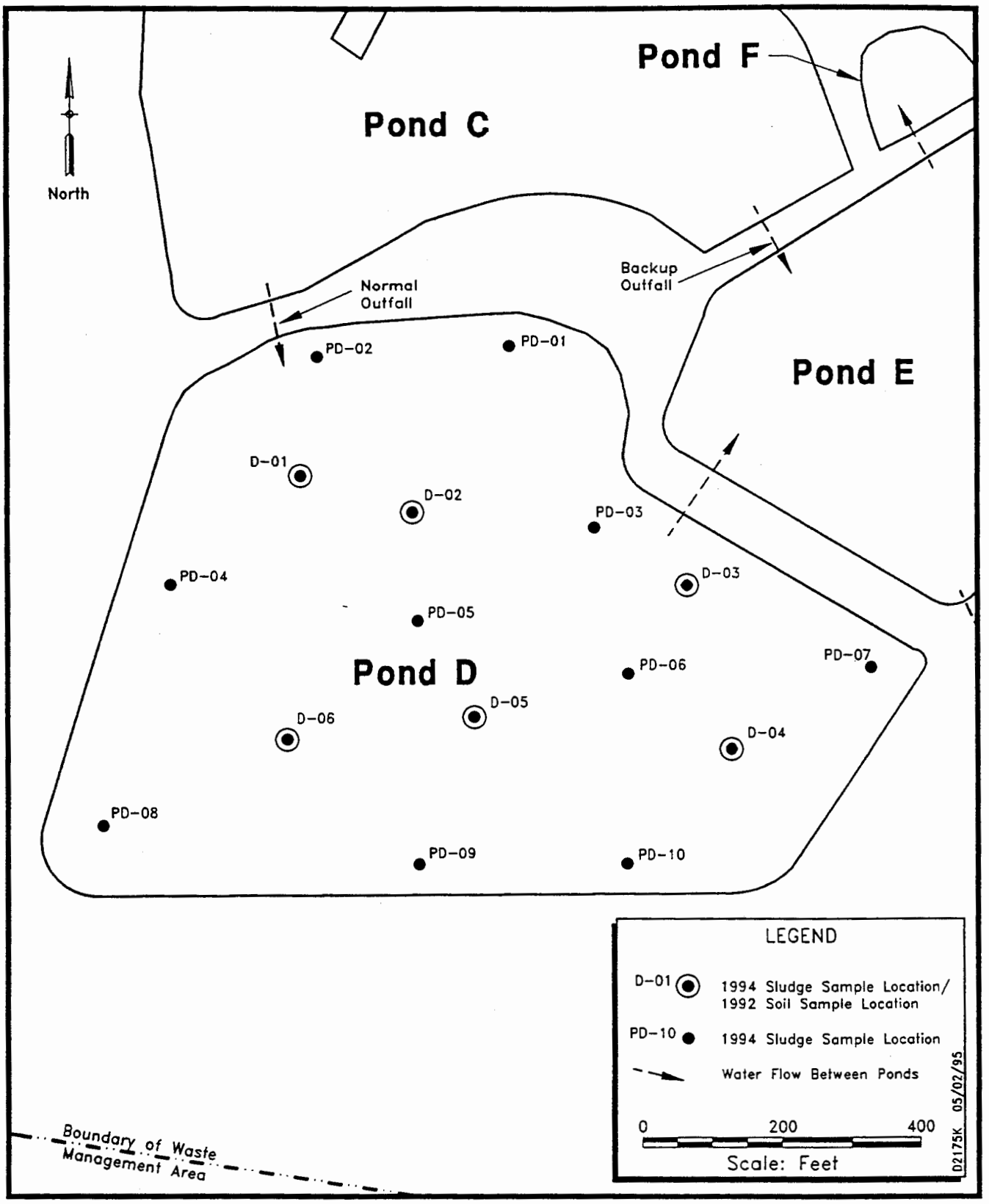

Figure A-6. Pond D Sludge and Soil Sample Locations

Pond E

Table A-6
Analytical Summary For Pond E

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
E130.2 - Hardness (mg/L)												
Hardness, as CaC03	2/2	2100	2100	E-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
E160.1 - Total Dissolved Solids (mg/L)												
Total dissolved solids	2/2	4650	4700	E-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
E239.1 - Organic Lead (mg/L)												
Lead (organic)[a]	1/6	<0.1	<0.1	E-4 [90]	NA	NA	NA	NA	NA	NA	NA	NA
SW6010 - Metals (mg/L or mg/kg)												
Antimony	0/6	ND	ND	NA	1/22	<20.6	<61.8	E-15 [94]	0/9	ND	ND	NA
Barium	6/6	0.0355 @	0.037 @	E-1 [90]	22/22	81.1	179	E-06 [94]	9/9	67	130	E-05 [92]
Beryllium	NA	NA	NA	NA	8/22	0.59	<2.1	E-15 [94]	0/9	ND	ND	NA
Boron	6/6	0.295 @	0.33 @	E-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	2/22	<1.7	<5.1	E-15 [94]	0/9	ND	ND	NA
Calcium	6/6	320	350	E-4 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	0/6	ND	ND	NA	22/22	16.5	72.4	E-15 [94]	4/9	<4.3	5.9 @	E-03 [92]
Cobalt	NA	NA	NA	NA	18/22	3.6	<5.9	E-15 [94]	1/9	<4.3	7 @	E-02 [92]
Copper	0/6	ND	ND	NA	22/22	22.55 @	75	E-01 [92]	0/9	ND	ND	NA
Iron	6/6	0.021 @	0.035 @	E-6 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	6/6	165	170	E-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	6/6	0.0355 @	0.039 @	E-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	16/22	7.25	<24.4	E-16 [94]	0/9	ND	ND	NA
Potassium	6/6	11.5	12	E-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Silicon	6/6	14	15	E-4 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	22/22	18.2 @	87.1	E-15 [94]	0/9	ND	ND	NA
Sodium	6/6	480	500	E-4 [90]	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	2/17	2.4	<10.3	E-15 [94]	NA	NA	NA	NA
Tin	NA	NA	NA	NA	2/22	46.7	<290	E-01 [92]	0/9	ND	ND	NA
Vanadium	0/6	ND	ND	NA	22/22	27.15 @	52.7	E-04 [94]	6/9	9.9 @	16 @	E-03 [92]
Zinc	0/6	ND	ND	NA	22/22	42.2	118	E-15 [94]	9/9	12 @	19 @	E-03 [92]

Table A-6
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
SW7060 - Arsenic (mg/L or mg/kg)												
Arsenic	0/6	ND	ND	NA	20/22	1.7 J	6.6	E-06 [94]	9/9	1.2 @	3.6	E-03 [92]
SW7421 - Lead (mg/L or mg/kg)												
Lead	3/9	0.0029 @	<0.01	E-03 [94]	21/22	6.45 J	21	E-01 [93]	8/9	1.6	4.5	E-03 [92]
SW7470 - Mercury (mg/L)												
Mercury	6/6	0.0005 @	0.00062	E-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
SW7471 - Mercury (mg/kg)												
Mercury	NA	NA	NA	NA	12/22	<0.275	<1	E-15 [94]	0/9	ND	ND	NA
SW7740 - Selenium (mg/L or mg/kg)												
Selenium	5/6	0.0035 @	0.0055 @	E-1 [90]	17/22	1.04	3.0 J	E-15 [94]	1/9	<0.51	1 @	E-01 [92]
SW7841 - Thallium (mg/kg)												
Thallium	NA	NA	NA	NA	1/6	<1.8	<2.2	E-05 [92]	0/9	ND	ND	NA
SW8080 - Organochlorine Pesticides and PCBs (µg/L or µg/kg)												
Aldrin	0/7	ND	ND	NA	0/22	ND	ND	NA	1/9	<1.4	2.4 X@	E-02 [92]
alpha-BHC	1/7	<0.2	<0.5	E-2 [90]	7/22	<7.9	<66	E-01 [92]	2/9	<1.4	2.4 C@	E-03 [92]
beta-BHC	0/7	ND	ND	NA	0/22	ND	ND	NA	7/9	2.7 X@	9.6 C	E-02 [92]
delta-BHC	1/7	0.021 X@	0.021 X@	E-01 [93]	2/22	<10	<66	E-01 [92]	1/9	<1.4	11 X	E-02 [92]
gamma-BHC	1/7	<0.6	<1.5	E-2 [90]	3/22	0.0092	110 C@	E-01 [92]	0/9	ND	ND	NA
alpha-Chlordane	0/1	ND	ND	NA	0/6	ND	ND	NA	2/9	<1.4	<1.4	E-01 [92]
gamma-Chlordane	1/1	0.0053 J	0.0053 J	E-01 [93]	3/6	64	540 J	E-01 [92]	1/9	<1.4	5.6 X@	E-03 [92]
Chlordane	0/6	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
4,4'-DDD	1/7	0.026 X@	0.026 X@	E-01 [93]	21/22	6.95 V	7300 CD	E-03 [92]	3/9	<1.4	83 C	E-03 [92]
4,4'-DDE	1/7	<0.6	<1.5	E-6 [90]	20/22	30 V	1800 CD	E-03 [92]	2/9	0.0014	7.5 C	E-03 [92]
4,4'-DDT	0/7	ND	ND	NA	9/22	18 V	<130	E-01 [92]	3/9	2.7 X@	4 X@	E-02 [92]
Dieldrin	1/7	0.014 X@	0.014 X@	E-01 [93]	1/22	<20	<66	E-01 [92]	0/9	ND	ND	NA
Endosulfan II	0/7	ND	ND	NA	0/22	ND	ND	NA	2/9	<4.0	<4.2	E-03 [92]
Endosulfan Sulfate	1/7	0.14 JB	0.14 JB	E-01 [93]	0/22	ND	ND	NA	5/9	1.9 J	<7.2	E-02 [92]
Endrin	1/7	0.01 X@	0.01 X@	E-01 [93]	0/22	ND	ND	NA	0/9	ND	ND	NA

Table A-6
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
Heptachlor	0/7	ND	ND	NA	1/22	<10	590 J	E-01 [93]	2/9	<1.4	2.1 X@	E-02 [92]
Heptachlor epoxide[b]	1/7	0.01 @	0.01 @	E-01 [93]	1/22	<10	78000 X	E-01 [93]	0/9	ND	ND	NA
SW8240 - Volatile Organic Compounds (µg/kg)												
Acetone	NA	NA	NA	NA	0/5	ND	ND	NA	1/9	<140	<140	E-01 [92]
Carbon disulfide	NA	NA	NA	NA	0/5	ND	ND	NA	3/9	<7	14 @	E-03 [92]
Methylene chloride	NA	NA	NA	NA	0/5	ND	ND	NA	1/9	<6.8	<7.2	E-02 [92]
Toluene	NA	NA	NA	NA	1/5	<540	<660	E-01 [92]	3/9	<6.6	<7.2	E-02 [92]
1,1,2-Trichlorotrifluoroethane	NA	NA	NA	NA	0/5	ND	ND	NA	1/1	17	17	E-05 [92]
Xylenes	NA	NA	NA	NA	1/5	<500	<590	E-05 [92]	0/9	ND	ND	NA
SW8270 - Semivolatile Organic Compounds (mg/L or mg/kg)												
Benzoic acid	1/6	<0.1	<0.1	E-2 [90]	0/6	ND	ND	NA	0/9	ND	ND	NA
Dibutylphthalate	0/6	ND	ND	NA	1/6	<5.4	<6.5	E-01 [92]	0/9	ND	ND	NA
Diethylphthalate	0/6	ND	ND	NA	1/6	<5.4	<6.5	E-01 [92]	0/9	ND	ND	NA
bis(2-Ethylhexyl)phthalate	6/6	0.006 JB	0.015 JB	E-4 [90]	6/6	7.4 @	12 @	E-05 [92]	3/9	<1.3	5.4 @	E-02 [92]
Phenanthrene	0/6	ND	ND	NA	3/6	0.81 J	<5.9	E-05 [92]	0/9	ND	ND	NA
SW9012 - Total Cyanide (mg/kg)												
Cyanide	NA	NA	NA	NA	4/5	3 @	180	E-01 [92]	6/9	0.72 @	2.9	E-04 [92]
SW9030 - Sulfides (mg/kg)												
Sulfide	NA	NA	NA	NA	3/5	470	850	E-05 [92]	4/9	<34	120 @	E-03 [92]
SW9060 - Total Organic Carbon (µg/kg)												
Total organic carbon	NA	NA	NA	NA	NA	NA	NA	NA	2/2	1700 @	2000 @	E-02 [92]

[a]Organic lead data results for the 1990 Investigation were questionable data. The organic lead concentrations detected in surface water were greater than total lead concentrations detected. Additional sampling was conducted in the 1994 Investigation using an analytical method specific for organic lead and it was not detected. Therefore, organic lead is not present in the surface water in the sewage lagoon system.

[b] Heptachlor epoxide data was questionable since it was only detected on one of two columns using a GC methodology. Therefore, this constituent was resampled in the 1994 investigation and any sample that was detected on one column only was reanalyzed using a GC/MS methodology to determine if heptachlor epoxide was present. In all cases, no heptachlor epoxide was detected using the GC/MS methodology. Holloman AFB has verified that no heptachlor epoxide is present.

Hits = Frequency of detection (i.e. 1/15 means 1 out of 15 samples reported a detected concentration)

Table A-6
(Continued)

NA = Not applicable, or not analyzed
ND = Not detected
[90] = Year that the sample reporting the maximum value was collected
< = Value reported after < is the reporting limit

Legend for Analytical Flags varies with each year of sampling as shown below.

1990 Sampling Event

B - Parameter was also detected in the blank sample; result is uncorrected
C - Confirmed on second column or by GC/MS
G - Indicates an estimated GC value due to interference
h - Sample analyzed 4 days past allowable holding time
J - Result is less than the method specified detection limit. These results should be considered approximate.
@ - Result is less than five times the method detection limit. Studies have shown that the uncertainty of the analysis will increase exponentially as the MDL is approached. These results should be considered approximate
X - Not confirmed on second column

1992 and 1993 Sampling Events

X - Qualitative confirmation of analyte on both columns. Quantification differed by a factor of two or more between columns. Value determined by the first column is reported.
@ - Measured result is less than five times the detection limit
C - Presence and quantitation of the analyte confirmed by second column analysis
D - Secondary dilution required for this analyte
J - Detected below the method detection limit
B - Analyte detected in laboratory blank analysis, no blank subtraction performed
G - Indicates an estimated GC value due to interference.

1994 Sampling Event

T - Primary column concentration is the preferred result
V - Second column concentration is the preferred result
J - Result is less than the reporting limit

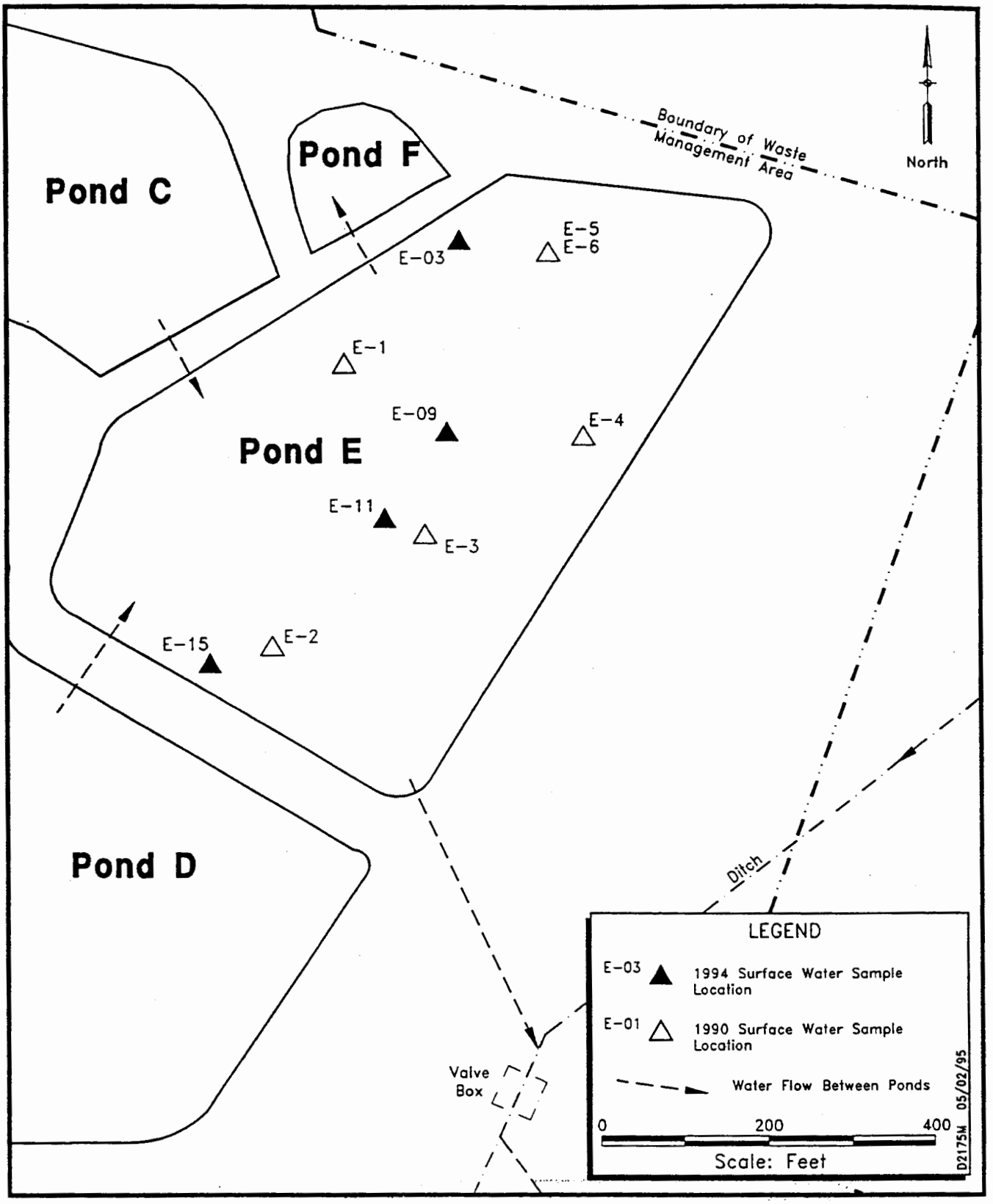

Figure A-7. Pond E Surface Water Sample Locations

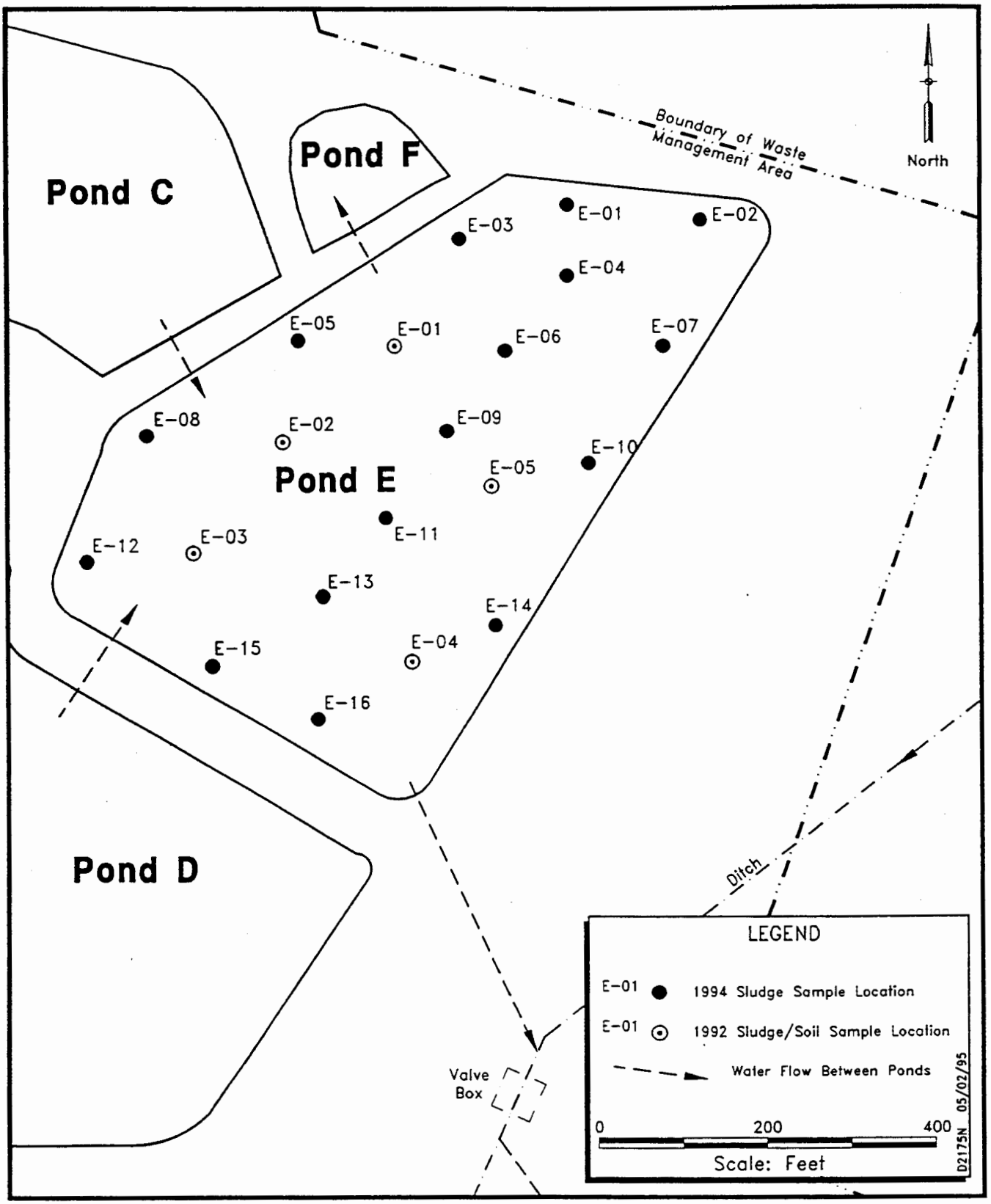

Figure A-8. Pond E Sludge and Soil Sample Locations

Pond F

Table A-7
Analytical Summary for Pond F

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
E130.2 - Hardness (mg/L)												
Hardness, as CaC03	1/1	1800	1800	F-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
E160.1 - Total Dissolved Solids (mg/L)												
Total dissolved solids	1/1	4200	4200	F-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
SW6010 - Metals (mg/kg)												
Barium	NA	NA	NA	NA	2/2	49	59	F-01 [92]	1/1	28	28	F-01 [92]
Chromium	NA	NA	NA	NA	2/2	29.5	33	F-01 [92]	0/1	ND	ND	NA
Copper	NA	NA	NA	NA	2/2	58.5	75	F-01 [92]	0/1	ND	ND	NA
Nickel	NA	NA	NA	NA	1/2	10.65	13 @	F-01 [92]	0/1	ND	ND	NA
Silver	NA	NA	NA	NA	2/2	48.5	59	F-01 [92]	0/1	ND	ND	NA
Vanadium	NA	NA	NA	NA	2/2	27.5 @	36 @	F-01 [92]	0/1	ND	ND	NA
Zinc	NA	NA	NA	NA	2/2	77.5	98	F-01 [92]	0/1	ND	ND	NA
SW7060 - Arsenic (mg/kg)												
Arsenic	NA	NA	NA	NA	2/2	3.15 @	4 @	F-01 [92]	1/1	0.96 @	0.96 @	F-01 [92]
SW7421 - Lead (mg/kg)												
Lead	NA	NA	NA	NA	2/2	13.3	17	F-01 [92]	1/1	0.5 @	0.5 @	F-01 [92]
SW7471 - Mercury (mg/kg)												
Mercury	NA	NA	NA	NA	2/2	0.355 @	0.43 @	F-01 [92]	0/1	ND	ND	NA
SW7740 - Selenium (mg/kg)												
Selenium	NA	NA	NA	NA	1/2	2.65	<2.8	F-01 [92]	0/1	ND	ND	NA
SW8080 - Organochlorine Pesticides and PCBs (µg/L or µg/kg)												
delta-BHC	1/1	0.029 X@	0.029 X@	F-01 [93]	2/2	3600 X	5000 X	F-01 [92]	1/1	2.7 X@	2.7 X@	F-01 [92]
gamma-BHC	1/1	0.012 X@	0.012 X@	F-01 [93]	1/2	70.5	76 C@	F-02 [92]	0/1	ND	ND	NA
alpha-Chlordane	1/1	0.03 G@	0.03 G@	F-01 [93]	1/2	15.15	250 X@	F-01 [92]	0/1	ND	ND	NA
gamma-Chlordane	1/1	0.01 @	0.01 @	F-01 [93]	2/2	56	64 JX	F-01 [92]	1/1	0.45 JC	0.45 JC	F-01 [92]
4,4'-DDD	1/1	0.035 @	0.035 @	F-01 [93]	2/2	620 C	11000 C	F-01 [92]	1/1	37 C	37 C	F-01 [92]
4,4'-DDE	1/1	0.12 G	0.12 G	F-01 [93]	2/2	1385 XC	1900 C	F-01 [92]	1/1	15 X	15 X	F-01 [92]
4,4'-DDT	0/1	ND	ND	NA	2/2	135 XCE	160 C@	F-01 [92]	1/1	5.8 X@	5.8 X@	F-01 [92]

Table A-7
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
Heptachlor	0/1	ND	ND	NA	1/2	51.5	<53	F-02 [92]	0/1	ND	ND	NA
SW8240 - Volatile Organic Compounds (µg/kg)												
Acetone	NA	NA	NA	NA	2/2	905 J@	1400 @	F-01 [92]	0/1	ND	ND	NA
Carbon disulfide	NA	NA	NA	NA	2/2	37.5 @	38 @	F-02 [92]	0/1	ND	ND	NA
Ethyl benzene	NA	NA	NA	NA	1/2	22.5	<33	F-01 [92]	0/1	ND	ND	NA
Methyl ethyl ketone	NA	NA	NA	NA	2/2	136.5 J	220 J	F-01 [92]	0/1	ND	ND	NA
Toluene	NA	NA	NA	NA	2/2	7.5 JB	10 JB	F-02 [92]	1/1	9.4	9.4	F-01 [92]
Xylenes	NA	NA	NA	NA	2/2	26 J@	38 @	F-02 [92]	0/1	ND	ND	NA
SW8270 - Semivolatile Organic Compounds (mg/kg)												
Dibenzofuran	NA	NA	NA	NA	1/2	3.03	<5.2	F-02 [92]	0/1	ND	ND	NA
bis(2-Ethylhexyl)phthalate	NA	NA	NA	NA	2/2	4.5 JB	5.4 JB	F-01 [92]	0/1	ND	ND	NA
Fluorene	NA	NA	NA	NA	1/2	3.01	<5.2	F-02 [92]	0/1	ND	ND	NA
Phenanthrene	NA	NA	NA	NA	2/2	2.575 J	4.6 J	F-01 [92]	0/1	ND	ND	NA
SW9030 - Sulfides (mg/kg)												
Sulfide	NA	NA	NA	NA	2/2	1450	1800	F-01 [92]	1/1	60 @	60 @	F-01 [92]
SW9060 Total Organic Carbon (mg/kg)												
Total organic carbon	NA	NA	NA	NA	NA	NA	NA	NA	1/1	1600	1600 @	F-01 [92]

Hits = Frequency of detection (i.e. 1/15 means 1 out of 15 samples reported a detected concentration)
NA = Not applicable, or not analyzed
ND = Not detected
[92] = Year that the sample reporting the maximum value was collected
< = Value reported after < is the reporting limit

Legend for Analytical Flags:
X - Qualitative confirmation of analyte on both columns. Quantification differed by a factor of two or more between columns. Value determined by the first column is reported.
@ - Measured result is less than five times the detection limit
C - Presence and quantitation of the analyte confirmed by second column analysis
D - Secondary dilution required for this analyte
J - Detected below the method detection limit
B - Analyte detected in laboratory blank analysis, no blank subtraction performed
J - Detected below the method detection limit
B - Analyte detected in laboratory blank analysis, no blank subtraction performed
G - Indicates an estimated GC value due to interference.

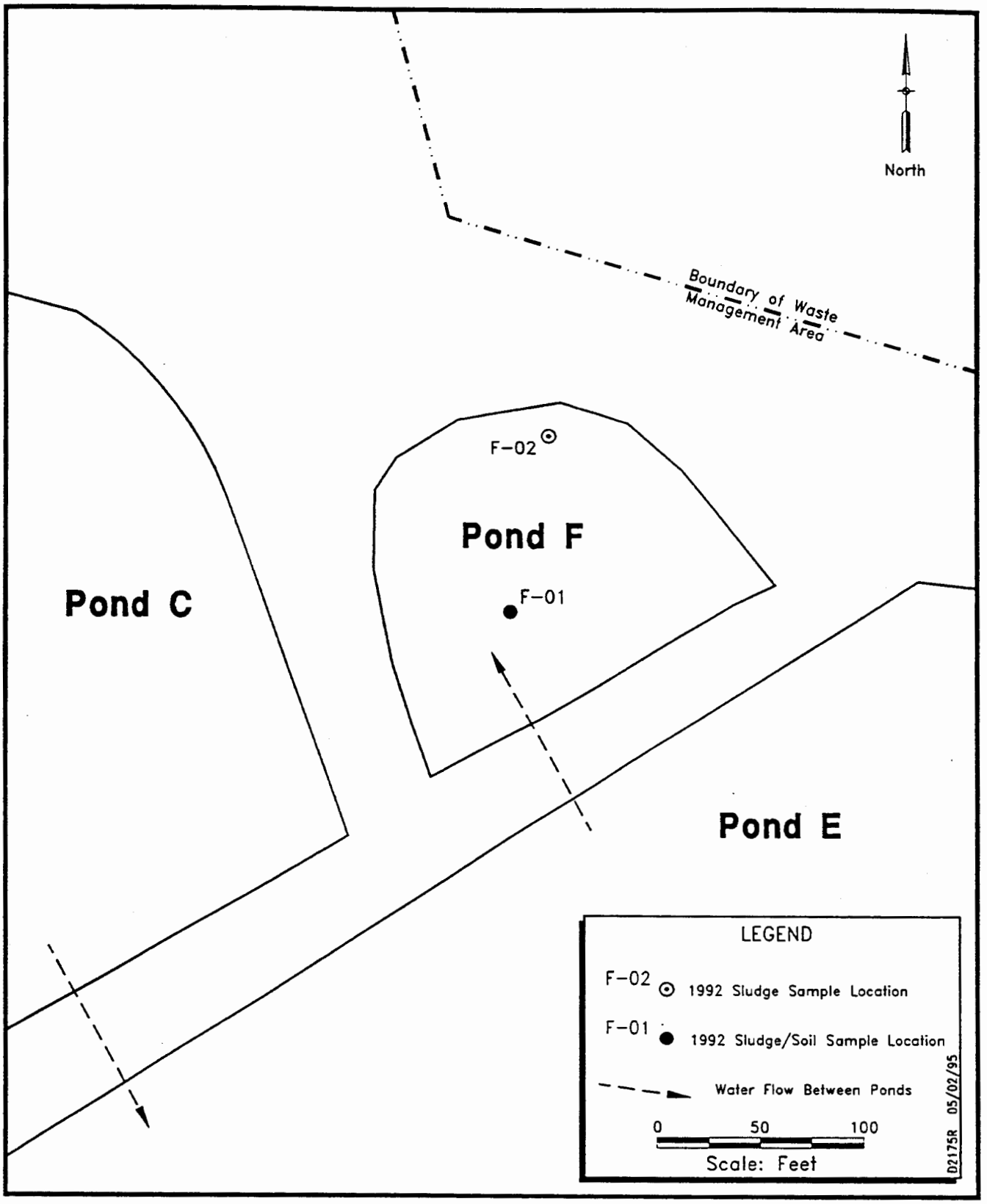

Figure A-9. Pond F Sludge and Soil Sample Locations

Pond G

Table A-8
Analytical Summary For Pond G

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
E130.2 - Hardness (mg/L)												
Hardness, as CaC03	1/1	2000	2000	G-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
E160.1 - Total Dissolved Solids (mg/L)												
Total dissolved solids	1/1	4600	4600	G-01 [93]	NA	NA	NA	NA	NA	NA	NA	NA
E239.1 - Organic Lead (mg/L)												
Lead (organic)[a]	4/14	0.14 @	0.31 @	G-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
MRI-SOP - Kepone (mg/kg)												
Kepone	NA	NA	NA	NA	1/12	<0.07	<0.07	PG-17 [94]	NA	NA	NA	NA
SW6010 - Metals (mg/L or mg/kg)												
Barium	5/5	0.036 @	0.04 @	G-2 [90]	25/25	83	156	PG-18 [94]	8/8	130	180	G-04 [92]
Beryllium	0/5	ND	ND	NA	10/25	<0.63	<1.7	PG-15 [94]	0/8	ND	ND	NA
Boron	5/5	0.33 @	0.36 @	G-2 [90]	0/25	ND	ND	NA	0/8	ND	ND	NA
Calcium	5/5	390	440	G-2 [90]	0/25	ND	ND	NA	0/8	ND	ND	NA
Chromium	0/5	ND	ND	NA	23/25	9.6	21.2	PG-15 [94]	8/8	11 @	16 @	G-05 [92]
Cobalt	0/5	ND	ND	NA	21/25	3.6 @	<6.2	G-06 [92]	2/8	4.5	<5.4	G-03 [92]
Copper	0/5	ND	ND	NA	24/25	16.4	36.8	PG-15 [94]	1/8	9	9.8 @	G-05 [92]
Magnesium	5/5	220	240	G-2 [90]	0/25	ND	ND	NA	0/8	ND	ND	NA
Manganese	5/5	0.064	0.072	G-4 [90]	0/25	ND	ND	NA	0/8	ND	ND	NA
Nickel	0/5	ND	ND	NA	20/25	8 J	<15.8	PG-19 [94]	3/8	<9.15	<11	G-03 [92]
Potassium	5/5	14	17	G-2 [90]	0/25	ND	ND	NA	0/8	ND	ND	NA
Silicon	5/5	15	16	G-2 [90]	0/25	ND	ND	NA	0/8	ND	ND	NA
Silver	0/5	ND	ND	NA	11/25	<3	6.6	PG-12 [94]	0/8	ND	ND	NA
Sodium	5/5	660	740	G-2 [90]	0/25	ND	ND	NA	0/8	ND	ND	NA
Vanadium	3/5	0.0033 @	0.0047 @	G-4 [90]	25/25	19.6	38.3	PG-18 [94]	8/8	21 @	29 @	G-04 [92]
Zinc	5/5	0.0063 @	0.014 @	G-4 [90]	25/25	39.7	68.4	PG-09 [94]	8/8	29 @	44	G-04 [92]
SW7060 - Arsenic (mg/L or mg/kg)												
Arsenic	3/5	0.0055 @	0.0072 @	G-1 [90]	25/25	2.4 J	5.2 J	PG-08 [94]	8/8	1.65 @	3.1 @	G-04 [92]

Table A-8
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
SW7421 - Lead (mg/L or mg/kg)												
Lead	5/14	<0.01	<0.02	12G [94]	25/25	15	38	G-04 [92]	8/8	4.65	120	G-04 [92]
SW7470 - Mercury (mg/L)												
Mercury	5/6	0.0002 @	0.0002 @	G-1 [90]	NA	NA	NA	NA	NA	NA	NA	NA
SW7471 - Mercury (mg/kg)												
Mercury	NA	NA	NA	NA	3/25	<0.19	<0.84	PG-15 [94]	0/8	ND	ND	NA
SW7740 - Selenium (mg/L or mg/kg)												
Selenium	0/6	ND	ND	NA	18/25	1.2 J	<3.6	PG-14 [94]	0/8	ND	ND	NA
SW8080 - Organochlorine Pesticides and PCBs (µg/L or µg/kg)												
alpha-BHC	2/6	<0.5	<0.5	G-1 [90]	4/25	<6.4	79 C@	G-03 [92]	3/8	<1.6	3.3 X@	G-02 [92]
beta-BHC	1/6	<1.5	<1.5	G-1 [90]	0/25	ND	ND	NA	4/8	<1.6	11 XB	G-05 [92]
delta-BHC	0/6	ND	ND	NA	2/25	<6.2	<70	G-06 [92]	0/8	ND	ND	NA
gamma-BHC	1/6	<1.5	<1.5	G-1 [90]	2/25	<6.4	<70	G-06 [92]	3/8	<1.6	3.1 X@	G-02 [92]
Chlordane	0/5	ND	ND	NA	3/19	<28	<320	PG-03 [94]	0/8	ND	ND	NA
alpha-Chlordane	0/1	ND	ND	NA	3/6	<39	110 X@	G-02 [92]	0/8	ND	ND	NA
gamma-Chlordane	0/1	ND	ND	NA	3/6	<39	310 X	G-02 [92]	0/8	ND	ND	NA
4,4'-DDD	0/6	ND	ND	NA	22/25	24 V	3100 C	G-02 [92]	4/8	2.7	7.5 C	G-01 [92]
4,4'-DDE	0/6	ND	ND	NA	19/25	34	450 X	G-02 [92]	2/8	<1.55	3.1 X@	G-04 [92]
4,4'-DDT	0/6	ND	ND	NA	3/25	14 V	<140	G-06 [92]	0/8	ND	ND	NA
Dieldrin	0/6	ND	ND	NA	1/25	<13	<70	G-06 [92]	0/8	ND	ND	NA
Endosulfan II	1/6	0.0009 J	0.0009 J	G-01 [93]	0/25	ND	ND	NA	0/8	ND	ND	NA
Endosulfan Sulfate	0/6	ND	ND	NA	0/25	ND	ND	NA	8/8	1.1	2.1	G-02 [92]
Heptachlor	0/6	ND	ND	NA	0/25	ND	ND	NA	1/8	<1.5	3.3 X@	G-04 [92]
Heptachlor epoxide[b]	0/6	ND	ND	NA	4/25	<6.4	<70	G-06 [92]	0/8	ND	ND	NA
Isodrin	0/6	ND	ND	NA	0/25	ND	ND	NA	1/8	<1.5	4.7 X@	G-05 [92]
Kepone (Mirex)	0/6	ND	ND	NA	1/6	<34.5	<70	G-06 [92]	0/8	ND	ND	NA
SW8240 - Volatile Organic Compounds (µg/kg)												
Acetone	NA	NA	NA	NA	1/6	<6950	<14000	G-06 [92]	4/8	135	<160	G-05 [92]

Table A-8
(Continued)

Analyte	Surface Water				Sludge				Soils			
	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location	Hits	Median	Maximum	Location
Carbon disulfide	NA	NA	NA	NA	1/6	<345	<700	G-06 [92]	4/8	<7.6	14 @	G-02 [92]
Methylene chloride	NA	NA	NA	NA	0/6	ND	ND	NA	6/8	25.5 @	37 @	G-02 [92]
Toluene	NA	NA	NA	NA	0/6	ND	ND	NA	5/8	4.3 J	<7.7	G-02 [92]
SW8270 - Semivolatile Organic Compounds (mg/L or mg/kg)												
Acetophenone	0/5	ND	ND	NA	1/6	<3.05	<6.9	G-06 [92]	0/8	ND	ND	NA
Butylbenzylphthalate	0/5	ND	ND	NA	0/6	ND	ND	NA	1/8	<1.45	<1.6	G-05 [92]
Cyclohexenone	0/5	ND	ND	NA	0/6	ND	ND	NA	1/8	1.2	1.2	G-05 [92]
Di-n-octylphthalate	0/5	ND	ND	NA	0/6	ND	ND	NA	1/8	<1.45	<1.6	G-05 [92]
bis(2-Ethylhexyl)phthalate	5/5	0.006 JB	0.01 JB	G-5 [90]	6/6	1.5 J	3.9 @	G-04 [92]	5/8	<1.45	3.6 @	G-03 [92]
SW9012 - Total Cyanide (mg/kg)												
Cyanide	NA	NA	NA	NA	2/6	<0.86	5.6 @	G-06 [92]	3/8	<0.32	0.61 @	G-04 [92]
SW9030 - Sulfides (mg/kg)												
Sulfide	NA	NA	NA	NA	5/6	660	2000	G-04 [92]	7/8	47.5 @	100 @	G-04 [92]
SW9060 - Total Organic Carbon (µg/kg)												
Total organic carbon	NA	NA	NA	NA	NA	NA	NA	NA	2/2	4800 @	4900 @	G-05 [92]

[a]Organic lead data results for the 1990 Investigation were questionable data. The organic lead concentrations detected in surface water were greater than total lead concentrations detected. Additional sampling was conducted in the 1994 Investigation using an analytical method specific for organic lead and it was not detected. Therefore, organic lead is not present in the surface water in the sewage lagoon system.

[b] Heptachlor epoxide data was questionable since it was only detected on one of two columns using a GC methodology. Therefore, this constituent was resampled in the 1994 and any sample that was detected on one column only was reanalyzed using a GC/MS methodology to determine if heptachlor epoxide was present. In all cases, no heptachlor epoxide was detected using the GC/MS methodology. Holloman AFB has verified that no heptachlor epoxide is present.

Hits = Frequency of detection (i.e. 1/15 means 1 out of 15 samples reported a detected concentration)
NA = Not applicable, or not analyzed
ND = Not detected
[90] = Year that the sample reporting the maximum value was collected
< = Value reported after < is the reporting limit

Legend for Analytical Flags varies with each year of sampling as shown below.
1990 Sampling Event
B - Parameter was also detected in the blank sample; result is uncorrected
C - Confirmed on second column or by GC/MS
G - Indicates an estimated GC value due to interference

Table A-8
(Continued)

h - Sample analyzed 4 days past allowable holding time
J - Result is less than the method specified detection limit. These results should be considered approximate.
@ - Result is less than five times the method detection limit. Studies have shown that the uncertainty of the analysis will increase exponentially as the MDL is approached. These results should be considered approximate
X - Not confirmed on second column

1992 and 1993 Sampling Events

X - Qualitative confirmation of analyte on both columns. Quantification differed by a factor of two or more between columns. Value determined by the first column is reported.
@ - Measured result is less than five times the detection limit
C - Presence and quantitation of the analyte confirmed by second column analysis
D - Secondary dilution required for this analyte
J - Detected below the method detection limit
B - Analyte detected in laboratory blank analysis, no blank subtraction performed
G - Indicates an estimated GC value due to interference.

1994 Sampling Event

T - Primary column concentration is the preferred result
V - Second column concentration is the preferred result
J - Result is less than the reporting limit

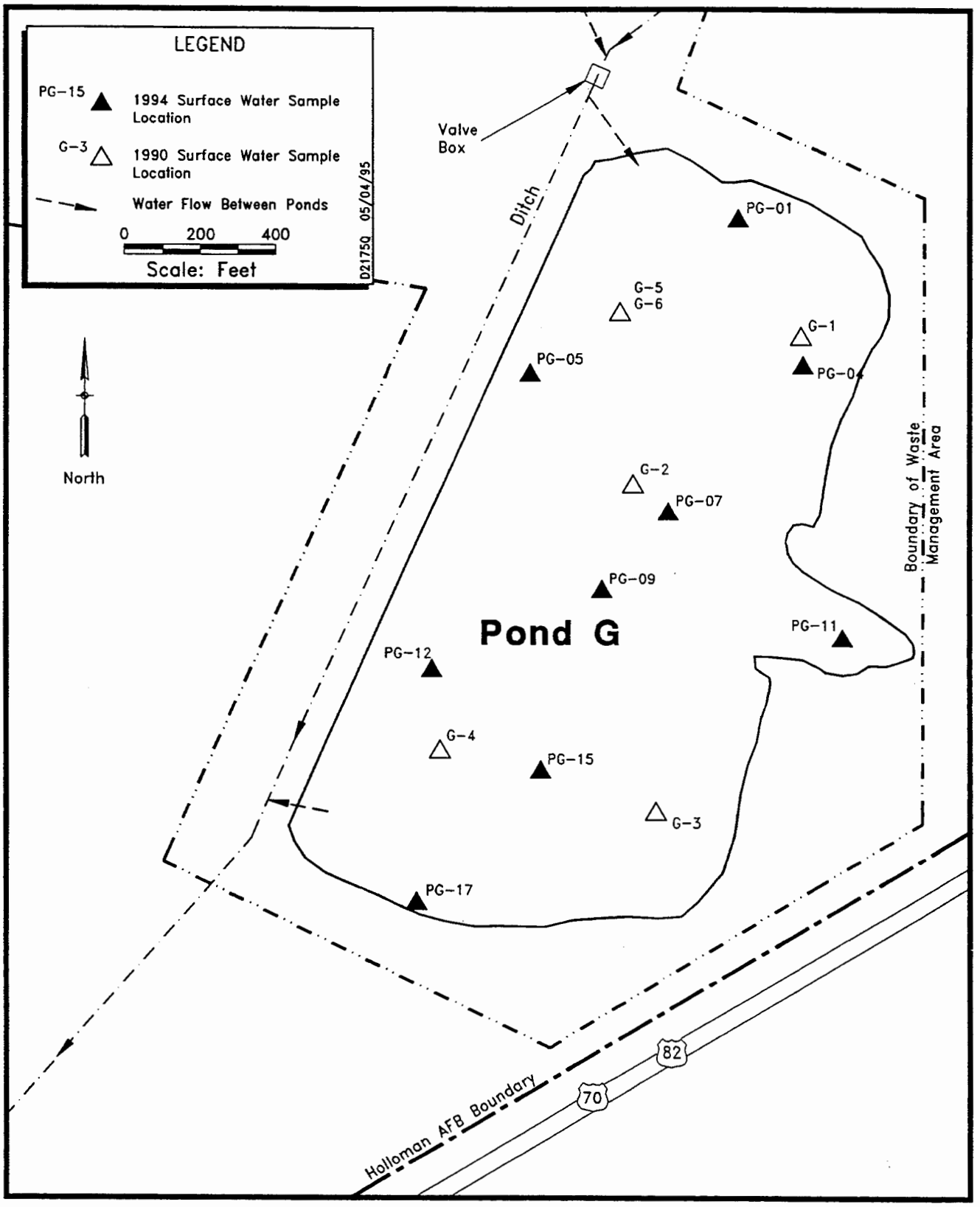

Figure A-10. Pond G Surface Water Sample Locations

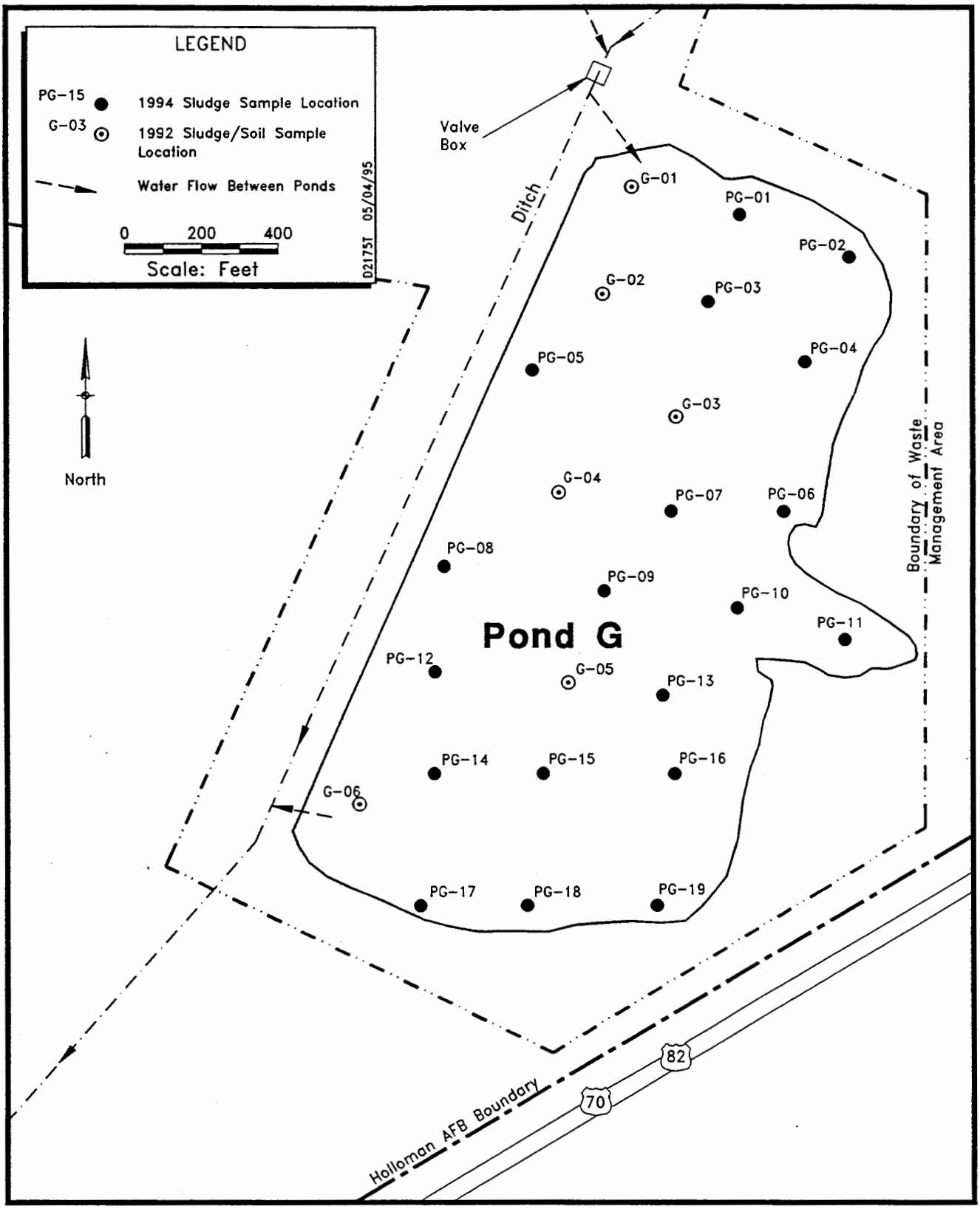

Figure A-11. Pond G Sludge and Soil Sample Locations

Groundwater

Table A-9
Analytical Summary For Groundwater Through 1993

Analyte	Groundwater			
	Hits	Median	Maximum	Location
E130.2 - Hardness (mg/L)				
Hardness, as CaC03	13/13	12000	20000	MWS-05 [93]
E160.1 - Total Dissolved Solids (mg/L)				
Total dissolved solids	13/13	35000	55000	MWS-05 [93]
SW6010 - Metals (mg/L)				
Antimony	4/13	<1.0	<1.0	MW-17 [93]
Barium	13/13	0.042 @	0.58	MW-16 [93]
Beryllium	8/13	0.00035 @	0.0036 @	MW-16 [93]
Cadmium	12/13	0.011 @	0.019 @	MW-17 [93]
Chromium	6/13	<0.01	0.043 @	MW-16 [93]
Cobalt	5/13	<0.01	0.04 @	MW-16 [93]
Copper	2/13	<0.02	<0.02	MW-16 [93]
Nickel	4/13	<0.02	<0.02	MW-16 [93]
Thallium	12/13	0.26 @	0.47 @	MW-11 [93]
Tin	9/13	0.021 @	0.73 @	MW-15 [93]
Vanadium	12/13	0.014 @	0.091 @	MW-16 [93]
Zinc	12/13	0.011 @	0.16	MW-16 [93]
SW7060 - Arsenic (mg/L)				
Arsenic	5/13	<0.016	0.032 @	MW-16 [93]
SW7421 - Lead (mg/L)				
Lead	2/13	<0.006	0.014 @	MW-16 [93]
SW7470 - Mercury (mg/L)				
Mercury	8/13	0.00001	0.00003	MW-18 [93]
SW7740 - Selenium (mg/L)				
Selenium	6/13	<0.01	0.044 @	MWD-05 [93]
SW7841 - Thallium (mg/L)				
Thallium	5/13	<0.01	<0.02	MWD-04 [93]
SW8080 - Organochlorine Pesticides and PCBs (µg/L)				
Aldrin	7/43	<0.0095	0.097 C	MW-03 [92]
alpha-BHC	19/43	<0.00975	0.1 X	MW-04 [93]
beta-BHC	17/43	<0.0096	0.03 X@	MW-13 [93]
delta-BHC	13/43	<0.0096	0.049 G	MW-16 [93]
gamma-BHC	17/43	<0.0096	0.15 G	MW-05 [93]
alpha-Chlordane	16/43	<0.0095	0.062 X	MW-02 [93]
gamma-Chlordane	24/43	<0.0097	2.7 G	MW-05 [93]
4,4'-DDD	8/43	<0.0096	0.047 @	MW-04 [93]
4,4'-DDE	8/43	<0.0095	0.026 X@	MW-05 [93]
4,4'-DDT	12/43	<0.019	0.24 C	MW-03 [92]
Dieldrin	13/43	<0.0096	0.25 C	MW-03 [92]
Endosulfan I	6/43	<0.0095	0.054 X	MW-05 [93]

Table A-9
(Continued)

Analyte	Groundwater			
	Hits	Median	Maximum	Location
Endosulfan II	11/43	<0.029	0.067 @	MW-03 [93]
Endosulfan Sulfate	24/43	0.033 JX	<0.05	MW-08 [92]
Endrin	23/43	<0.0097	0.28 C	MW-03 [92]
Endrin Aldehyde	16/43	<0.019	0.077 GB@	MW-03 [93]
Heptachlor	24/43	<0.0095	0.082 C	MW-03 [92]
Heptachlor epoxide	24/43	<0.0095	1.2 G	MW-08 [93]
Isodrin	12/43	<0.0096	0.068 X	MW-05 [93]
Kepone (Mirex)	3/43	<0.0095	0.99 X	MW-18 [93]
Methoxychlor	3/43	<0.048	0.21 G@	MW-03 [93]
SW8270 - Semivolatile Organic Compounds (mg/L)				
Cyclohexene	3/13	<0.0058	0.012	MW-13 [93]
bis(2-Ethylhexyl)phthalate	5/13	<0.0095	<0.0097	MW-14 [93]
SW9012 - Total Cyanide (mg/L)				
Cyanide	15/15	0.0043 @	0.0097 @	MW-11 [93]
SW9030 - Sulfides (mg/L)				
Sulfide	6/13	<1.0	<1.0	MWS-05 [93]

Hits = Frequency of detection (i.e. 1/15 means 1 out of 15 samples reported a detected concentration)
NA = Not applicable, or not analyzed
ND = Not detected
[92] = Year that the sample reporting the maximum value was collected
< = Value reported after < is the reporting limit

Legend for Analytical Flags:
X - Qualitative confirmation of analyte on both columns. Quantification differed by a factor of two or more between columns. Value determined by the first column is reported.
@ - Measured result is less than five times the detection limit
C - Presence and quantitation of the analyte confirmed by second column analysis
D - Secondary dilution required for this analyte
J - Detected below the method detection limit
B - Analyte detected in laboratory blank analysis, no blank subtraction performed
G - Indicates an estimated GC value due to interference.

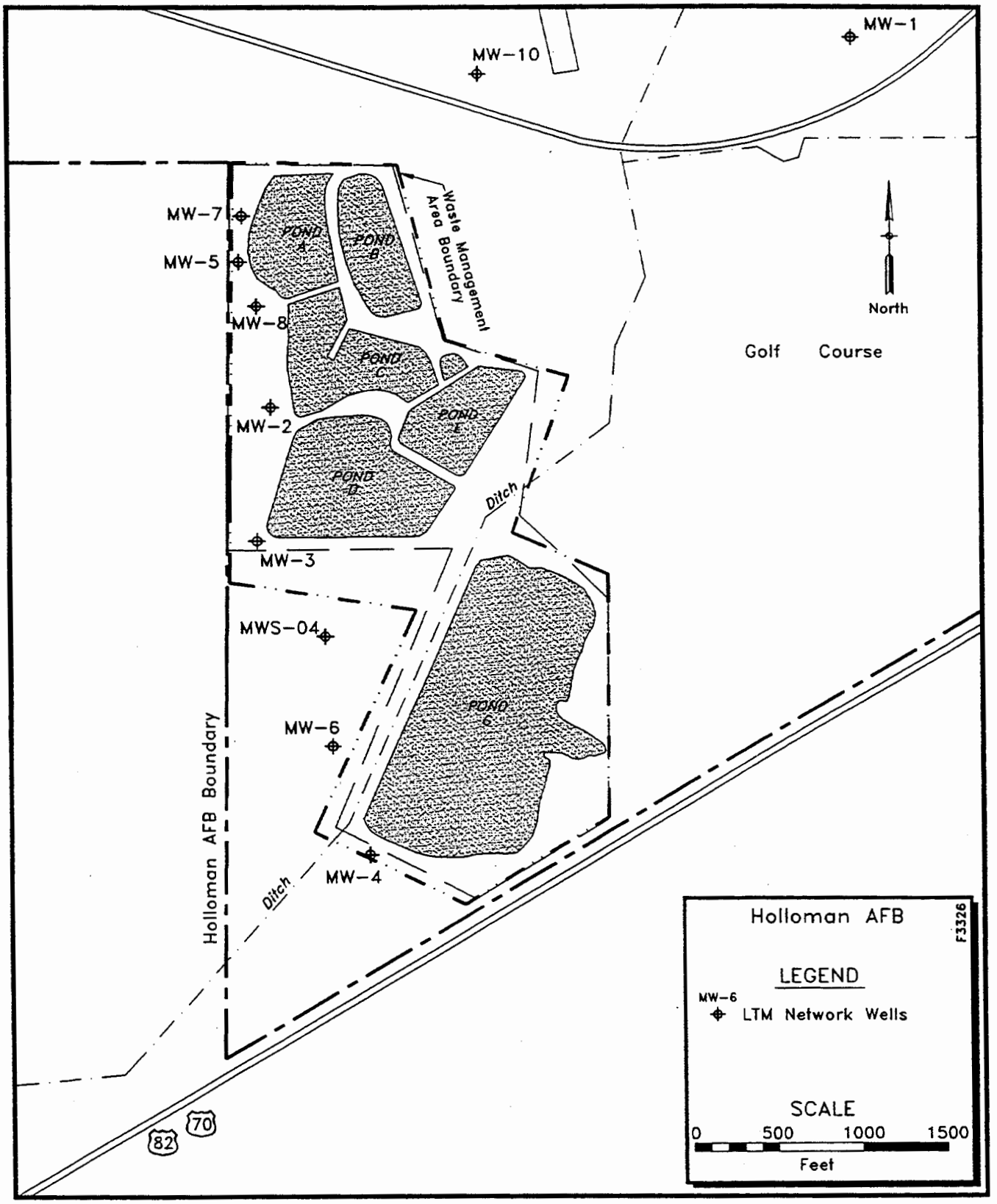

Figure A-12. Groundwater Sample Locations

Table A-10
Analytical Summary for Groundwater
1995 Long-term Groundwater Monitoring Program

Analyte	Hits	Median	Maximum	Location
Organochlorine Pesticides - SW8081 (μg/L)				
Aldrin	0/10	NA	ND (0.0035)	NA
Chlordane	0/10	NA	ND (0.046)	NA
4,4'-DDD	3/10	ND (0.0054)	0.0229	MW-04 [95]
4,4'-DDE	1/10	ND (0.0049)	0.119 P	MW-05 [95]
4,4'-DDT	0/10	NA	ND (0.0066)	NA
Dieldrin	5/10	ND (0.0048)	0.071 P	MW-05 [95]
Endosulfan I	0/10	NA	ND (0.003)	NA
Endosulfan II	2/10	ND (0.0067)	0.0254 P	MW-07 [95]
Endosulfan Sulfate	1/10	ND (0.0162)	0.0185 B	MW-01 [95] Upgradient Well
Endrin	6/10	<DL (0.0128)	0.0199 BP	MW-03 [95]
Endrin Aldehyde	0/10	NA	ND (0.0108)	NA
Heptachlor epoxide	4/10	ND (0.0092)	0.0647 P	MW-05 [95]
Isodrin	6/10	0.0108	0.0671 P	MW-08 [95]
Methoxychlor	0/10	NA	ND (0.0431)	NA
Toxaphene	0/10	NA	ND (0.0903)	NA
alpha-BHC	1/10	ND (0.0022)	0.0115	MW-03 [95]
beta-BHC	0/10	NA	ND (0.0131)	NA
delta-BHC	5/10	ND (0.0025)	0.249 P	MW-04 [95]
gamma-BHC	0/10	NA	ND (0.0018)	NA
Metals (mg/L)				
Antimony	1/10	<DL (0.0041)	0.0838	MW-06 [95]
Barium	10/10	0.0204	0.0448	MW-01 [95] Upgradient Well
Beryllium	5/10	<DL (0.0002)	0.0009	MW-10 [95] Upgradient Well
Cadmium	0/10	NA	<DL (0.0046)	NA
Chromium	5/10	<DL (0.0005)	0.0189	MW-03 [95]
Cobalt	7/10	0.0046	0.0234	MW-06 [95]

Table A-10
(Continued)

Analyte	Hits	Median	Maximum	Location
Copper	0/10	NA	<DL (0.135)	NA
Nickel	9/10	0.0122	<DL (0.058)	MW-06 [95]
Silver	3/10	<DL (0.011)	<DL (0.0222)	MW-06 [95]
Tin	5/10	0.0021 J	0.0045	MW-04 [95]
Vanadium	10/10	0.0183	0.105	MW-01 [95] Upgradient Well
Zinc	0/10	NA	<DL (0.26)	NA
Arsenic	5/10	0.0197	0.0816	MW-02 [95]
Lead	10/10	0.0059 S	0.0204 S	MWS-04 [95]
Mercury	0/10	NA	<DL (28E-06)	NA
Selenium	9/10	0.029 S	0.0721 S	MW-01 [95] Upgradient Well
Thallium	4/10	<DL (0.0012)	0.0037 S	MW-05 [95]

P = The analyte concentration was not confirmed. The results from the primary and secondary GC columns differed by greater than a factor of 3.
B = The analyte was detected in the blank within 10 times the concentration reported in the field sample.
S = The analyte concentration was obtained using the Method of Standard Addition.
ND = Not detected.
<DL = Detected below detection limit.

APPENDIX B

October 1994 Field Sampling Plan with Addendum

RCN 670-008-03-11

FIELD SAMPLING PLAN

SEWAGE LAGOONS AND LAKES CLOSURE PROJECT

Prepared for:

49 CES/CEV
Holloman Air Force Base, NM

and

HQ ACC #CES/ESVR
Langley Air Force Base, VA

Prepared by:

Enserch Environmental
143 Union Blvd.
Suite 1010
Lakewood, Colorado 80203
303/988-2202

Radian Corporation
8501 North Mopac Blvd.
P.O. Box 201088
Austin, Texas 78720
512/454-4797

Under Contract No. DACW45-94-D-0003 with:

U.S. Army Corps of Engineers
Omaha District
Omaha, Nebraska

Revision 0, 14 October 1994
Revision 1, 26 October 1994

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Section 1
INTRODUCTION

This plan was prepared for sampling sludge, soil, and surface water from the sewage lagoons and lakes at Holloman Air Force Base (AFB), New Mexico, in support of the sewage lagoon closure project. This section presents the background and scope for the sampling program.

1.1 Background

The seven aeration/evaporation lagoons are located in the southwestern corner of the Base, as shown in Figure 1-1. Wastewater generally flows in parallel through Ponds A and B. Then, water flows in series from Pond C into Ponds D, E, F, and G. Discharge from Pond G flows through an open ditch to Lake Holloman. Because of seasonal low evaporation, water from Lake Holloman flows into Lake Stinky during the winter months.

Holloman AFB submitted a Post-Closure Care Permit (PCCP) application for the sewage lagoons in June 1991 to allow continued operation of the lagoons for nonhazardous wastewater treatment prior to final closure as hazardous waste management units. The application addressed Ponds A, B, C, D, E, F, and G, and includes a delay-of-closure plan for these surface impoundments. As a condition for review of the PCCP application, the New Mexico Environment Department (NMED) required that a sampling and analysis program be conducted in all impoundments downstream of Ponds A and B, including Lakes Holloman and Stinky. These requirements, contained in a letter dated 22 May 1991, were intended to demonstrate that hazardous constituents are not present in the sludge and underlying soil at levels that would adversely affect human health and the environment.

A preliminary investigation was conducted in October 1991 to determine the water depths and sludge thicknesses in the sewage lagoons and lakes. The work focused on Ponds C, D, E, F, and G, and Lakes Holloman and Stinky. Appendix A includes a summary of the results.

A more thorough investigation of the sewage lagoons and lakes was conducted in 1992 and is documented in the *Site Characterization Report* (Radian, 1992). Samples were collected from the sludge and underlying soil in the sewage lagoons, lakes, and ditch, and were analyzed for Appendix IX constituents.

The primary contaminants in the sludge and soil samples from the sewage lagoons and lakes were metals and organochlorine pesticides. Metals detected in the soil were below background levels and pesticides were significantly below action levels.

Analytical results suggested that the ditch and lakes may be affected by a source of contaminants other than the wastes historically discharged into the wastewater treatment system. Constituents detected in Lake Stinky were not detected in the sewage lagoons, Lake Holloman, or the ditch. Also, concentrations of organochlorine pesticides detected in ditch samples from a location upstream of the sewage lagoons were higher than concentrations of the same pesticides detected in ditch samples from locations downstream of the sewage lagoons.

Analytical results were compared with proposed Resource Conservation and Recovery Act (RCRA) Subpart S risk-based action levels (40 CFR Part 264, Subpart S, Section 264.521 [proposed 27 July 1990, 55 *Federal Register* 30798 et seq.]). A summary of the results above action levels is presented in Table 1-1.

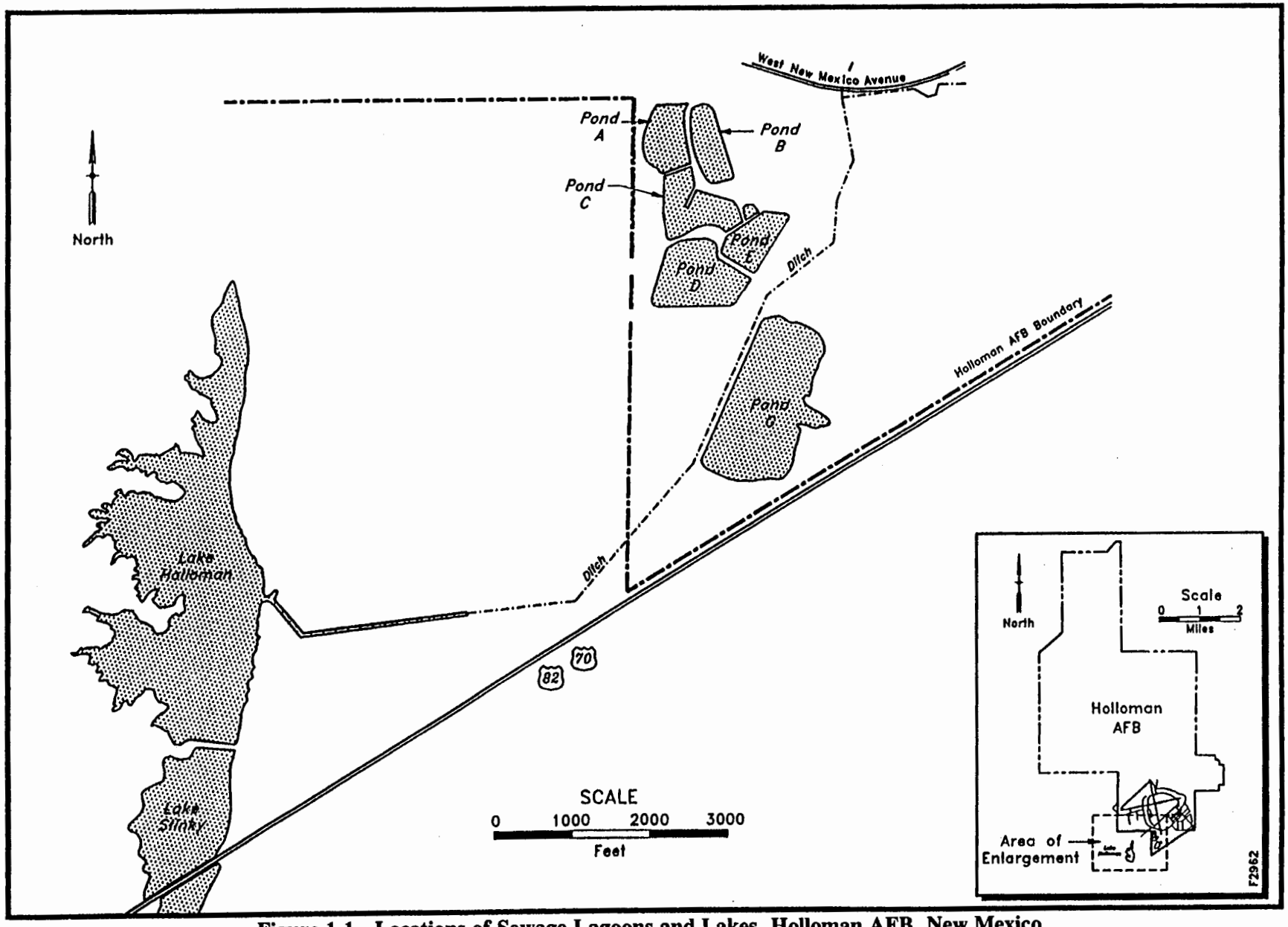

Figure 1-1. Locations of Sewage Lagoons and Lakes, Holloman AFB, New Mexico

Table 1-1
Summary of Constituents With Concentrations Above Action Levels, 1992

Location	Constituent	Sample Interval
Pond C	None	NA
Pond D	None	NA
Pond E	4,4'-DDD	Sludge
Pond F	4,4'-DDD	Sludge
Pond G	Beryllium	Sludge
	4,4'-DDD	Sludge
Lake Holloman	Dieldrin	Sludge
	Isodrin	Sludge and soil (0 to 1 ft bgl)
Lake Stinky	None	NA
Ditch from Pond G to Lake Holloman	Beryllium	Soil (0 to 1 ft bgl)

Note: Several constituents were not detected, and their reporting limits exceed the action levels. Some of these constituents include antimony, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and 2,3,7,8-TCAA.

NA = Not applicable.
bgl = Below ground level.

1.2 Risk Assessment Results

The risk assessment completed for the sewage lagoons and lakes (*Risk Assessment—Sewage Lagoons and Lakes Investigation*, Radian, 1993) suggested the possibility of unacceptable health risks for the ditch connecting Pond G with Lake Holloman based on a single analytical result for heptachlor epoxide. Although the measured result was fairly high, the result was not confirmed by the analytical method (i.e., second column confirmation by gas chromatography [GC] for EPA Method 8080). This suggests that the compound measured may have been an interferant rather than heptachlor epoxide itself. Risk assessments typically include results with some uncertainty to avoid underestimating risk; therefore, the unconfirmed result was included in the risk assessment as recommended by U.S. Environmental Protection Agency (EPA) guidance. This may have resulted in an overestimate of the risk of exposure at the ditch. Holloman AFB has committed to resampling and reanalyzing the soil from the ditch to clarify the previous result.

Possible adverse health effects were also suggested as a result of organolead concentrations in surface water in Pond G and Lake Holloman. The organolead results were up to 100 times higher than total lead results obtained. However, this may primarily reflect measurement variability for the two analytical techniques because all of the lead results are near the detection limits. Total lead was measured using graphite furnace atomic absorption (GFAA) spectroscopy; whereas organolead was measured using flame atomic absorption (FAA) spectroscopy. Detection limits for total lead were substantially lower than for organolead because spectral interferences are minimized in GFAA analysis. As described above, the organolead results were included in the risk assessment, even though there were uncertainties, to ensure that risk would not be underestimated. Holloman AFB has committed to resampling surface water to clarify the significance of the previous lead results.

1.3 Scope

The proposed sampling and analytical program will complement the 1992 sampling results and define more precisely the extent of contamination in Ponds C, D, E, and G, and in Lakes Holloman and Stinky. Sludge samples (surface soil samples for Pond D, Lake Stinky, and the ditch) will be collected from the sewage lagoons and lakes at locations determined through geostatistical analysis of existing data. These sludge and soil samples will be analyzed for organochlorine pesticides and metals. Surface water samples will also be collected in Ponds C, D, E, G, Lake Holloman, and the ditch. The surface water samples will be analyzed for total and organic lead. Because Holloman AFB anticipates remediating the entire area of Ponds A, B, and F, additional sampling is not being conducted to determine extent of contamination for those impoundments.

1.4 Purpose of Investigation

The results will be used to resolve and better define risks associated with each lagoon and lake due to uncertainties found in previous investigations. The results of this investigation will also be used in conjunction with previous investigation results to drive the decisions for closure alternatives and requirements.

Section 2
Sludge and Soil Samples

This section discusses the sludge and soil sampling locations, sample methodology, and sample analyses. At locations where the surface water will also be sampled, the surface water sample will be collected first, before disturbing the sludge or soil. This is to minimize the amount of suspended solids in these samples. Appendix B contains a detailed breakdown of all sampling locations and media, with their respective analyses.

2.1 Soil and Sludge Sample Locations

A total of 98 locations will be sampled for soil and sludge. The total number of samples, including 18 QA/QC samples and six Missouri River Division (MRD) duplicates, is 122. Prior to sampling, the sample locations will be surveyed by Southwest Engineering Inc. The surveyors will mark each sampling point. Underwater locations will be marked with a floating buoy positioned by a leader and anchor. Locations not underwater will be marked with a stake.

Samples for analyses of sludge will be collected from Ponds C, E, G, and Lake Holloman. Samples for analyses of surface soil (0 to 1 ft below ground level [bgl]) will be collected from Pond D, Lake Stinky, and the ditch from Pond G to Lake Holloman, since previous sampling indicated that little to no sludge exists in these areas. No sampling will be conducted in Ponds A, B, and F. Table 2-1 shows the numbers and depths of samples for the sewage lagoons, the lakes, and the ditch. Sample locations are shown in Figures 2-1 and 2-2. Appendix A gives the water and sludge levels in each of the lagoons and lakes as determined in the 1991 investigation.

2.2 Sample Collection Techniques

Sludge samples will be collected from a floating vessel by using a stainless steel sludge sampler (Arts Manufacturing Supply [AMS] or similar) or a PVC syringe. In areas where the sludge is too thin to sample, a stainless steel auger will be used to collect a soil sample from the 0 to 1 foot interval. The AMS sludge sampler takes 3" samples and is equipped with a butterfly valve to prevent sample escape. The PVC syringe utilizes a suction to retrieve and prevent escape of the sample.

The sampling vessel will be a flat bottomed aluminum boat with an open sampling port constructed in the center. The vessel will be equipped with outriggers to enhance stability during sampling. The vessel will be propelled with an electric trolling motor if this does not disturb the sludge and water samples. If necessary, the vessel will be manually propelled with oars.

The sampling vessel will be positioned over the sample location marker buoys. Sludge thickness and water depth will be measured using a sounding device (optimal method to be determined in the field). The sampling device will be lowered through the sample port to the top of the sludge or soil surface, and the sample withdrawn and brought on board to be composited in a stainless steel bowl. There, the entire sample interval will be homogenized and placed in precleaned bottles. At some locations, more than one sludge core may be collected to provide sufficient volume for all required analyses.

Considerable preparation and preplanning is necessary to minimize the time the field crew

Table 2-1
Number of Sludge and Soil Samples for Sewage Lagoons and Lakes

Location	Surface Area (Acres)	Number of Additional Soil and Sludge Samples	Matrix
Pond C	12	13	Sludge
Pond D	18	10	Soil (0 to 1 ft bgl)
Pond E	8	16	Sludge
Pond G	40	19	Sludge
Lake Holloman	166	25	Sludge
Lake Stinky	38	11	Soil (0 to 1 ft bgl)
Ditch from Pond G to Lake Holloman	NA	4	Soil (0 to 1 ft bgl)
Total	282	98	- -

Note: Sludge samples will be collected from the entire depth of the sludge.

NA = Not available.
bgl = Below ground level.

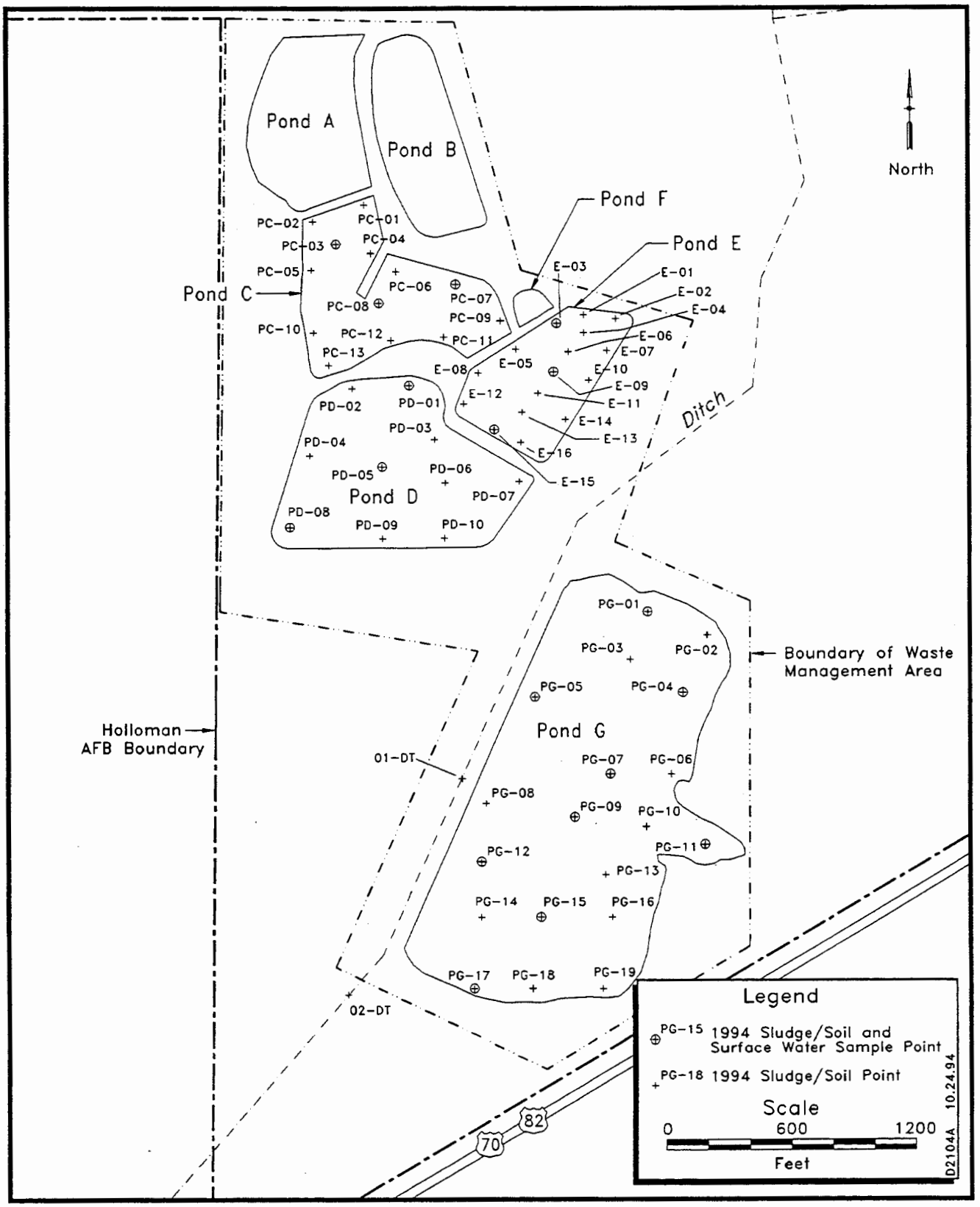

Figure 2-1. Sample Locations for the Sewage Lagoons

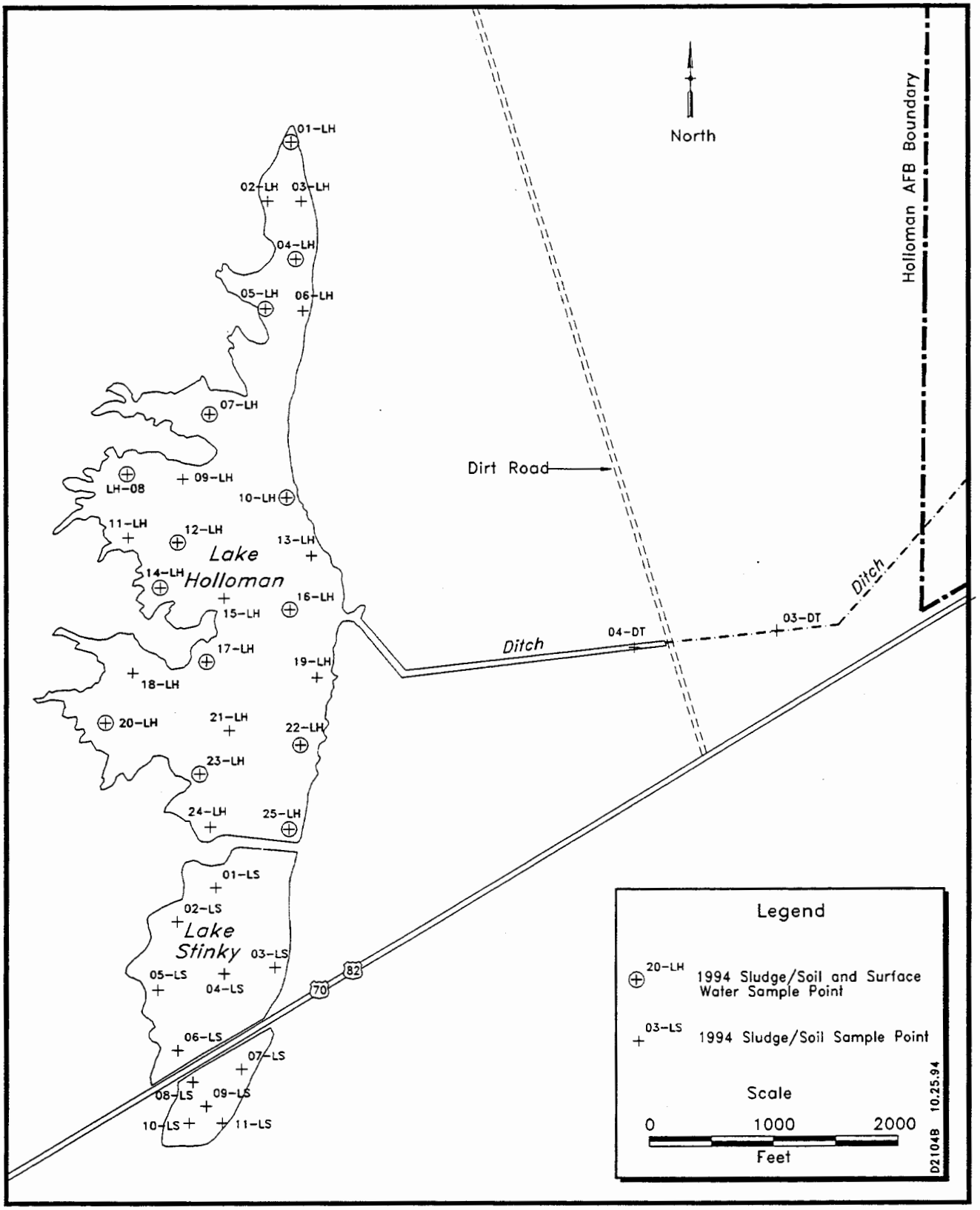

Figure 2-2. Sample Locations for Lakes Holloman and Stinky

spends in the sampling vessel. Such preparation includes prelabeling of sample containers and the use of a checklist to ensure that all needed equipment is on board the sampling vessel. The field crew must wear personal floatation devices (PFDs) whenever they are in the floating vessel as defined in the Site Safety and Health Plan.

2.3 Sludge and Soil Sample Analyses

Sludge and soil samples will be analyzed for organochlorine pesticides and metallic constituents (40 CFR, Part 264). EPA SW846 methods will be used for these constituents. Samples for analysis by method SW8270 (semivolatiles) will also be collected and extracted, but will only be analyzed to confirm any positive detections of isodrin or heptachlor epoxide in the SW8080 analyses. In addition, 37 soil and sludge samples from selected locations in Ponds C, G and Lake Holloman will be analyzed for kepone, since kepone was detected in these impoundments. Table 2-2 lists the target analytes for this sampling effort.

Sample analyses by methods SW6010, SW7060, SW7421, SW7471, SW7740, SW8080, and SW8270 will be performed by Quanterra Inc. The thallium concentration in the soil and sludge will be analzed by SW6010-trace method. These analyses will also be performed by Quanterra Inc. The kepone analyses will be performed by Midwest Research Institute (MRI). Additional information on these laboratories is located in Section 6.4. The analytical procedures and the Data Quality Objectives are described in the Sewage Lagoons and Lakes Closure Project *Quality Assurance Project Plan (QAPP)*, October, 1994.

Table 2-2
Summary of Target Analytes

Organochlorine Pesticides (Method 8080 [a])		Metals (Method 6010 [a])	
Aldrin		Antimony	
alpha-BHC		Arsenic	(SW7060)
beta-BHC		Barium	
delta-BHC		Beryllium	
gamma-BHC		Cadmium	
alpha-Chlordane		Chromium	
gamma-Chlordane		Cobalt	
4,4'-DDD		Copper	
4,4'-DDE		Lead	(SW7421)
4,4'-DDT		Mercury	(SW7471)
Dieldrin		Nickel	
Endosulfan I		Organolead	(Quanterra SOP)
Endosulfan II		Selenium	(SW7740)
Endosulfan sulfate		Silver	
Endrin		Thallium	(SW6010-Trace)
Endrin aldehyde		Tin	
Heptachlor		Vanadium	
Heptachlor epoxide	(SW8080, 8270 if needed)	Zinc	
Isodrin	(SW8080, 8270 if needed)		
Kepone	(MRI SOP)		
Methoxychlor			
Toxaphene			

[a] Unless otherwise noted.

Section 3
SURFACE WATER SAMPLES

This section discusses the locations of surface water samples to be taken and the sampling procedure to be used. Appendix B contains a detailed breakdown of all sampling locations and media, with their respective analyses.

3.1 Surface Water Sample Locations

Surface water samples will be collected from Ponds C, D, E, and G, Lake Holloman and the ditch. Table 3-1 gives the number of samples to be collected from each. The surface water samples will be collected from locations throughout the lagoons as shown in Figures 2-1 and 2-2. Before the sampling program begins, these locations will be surveyed and marked with a floating buoy positioned by a leader and anchor.

The surface water samples will be collected at the same location as the soil and sludge samples. Surface water samples will be collected *prior* to collecting sludge and soil samples to reduce the risk of agitated materials (soil and sludge) being collected in the water samples. The water sample will be collected prior to setting the vessel anchor to reduce/prevent agitation of the soil and sludge prior to collecting the water sample.

3.2 Surface Water Sample Collection Techniques

Surface water samples will be collected by a small Teflon® bailer. Since the bailer size is smaller than the required total sample volume, each sample will be composited from approximately four bailer samples using a clean, four-liter glass container. The sample will then be split into aliquots and placed in precleaned bottles for analyses. All sample handling activities will be accomplished with minimum contact using decontaminated gloves.

3.3 Surface Water Analyses

Surface water samples will be analyzed for organolead and total lead. Quanterra Inc. will perform both of these analyses.

Table 3-1
Number of Surface Water Samples for Sewage Lagoons and Lakes

Location	Surface Area (Acres)	Number of Surface Water Sample Locations
Pond C	12	3
Pond D	18	3
Pond E	8	3
Pond G	40	9
Lake Holloman	166	14
Lake Stinky	38	0
Ditch from Pond G to Lake Holloman	NA	3
Total	282	35

Note: Sludge samples will be collected from the entire depth of the sludge.

NA = Not available.
bgl = Below ground level.

Section 4
QUALITY CONTROL SAMPLES

A field quality assurance/quality control (QA/QC) program will be used to ensure that data quality objectives are met. Sample collection error will be controlled through the use of standard sample collection methods and field logbooks. Natural matrix errors will be estimated by standard QA/QC methods such as matrix spikes. Field duplicates will be collected to determine field sampling precision and accuracy. The following paragraphs discuss the field QA/QC samples for analytical soil samples, and their collection frequency and procedures.

QC Split Samples—QA and QC split samples (duplicates) will be collected for all analyses at a rate of 5 percent. The soil will be homogenized and divided equally among all containers for both normal and duplicate samples.

Matrix Spike and Matrix Spike Duplicate (MS/MSD)—QC MS/MSD samples will be collected at a rate of 5 percent for each analysis. Additional volume may be necessary for sludge samples.

QA/MRD Duplicate Samples—QA Duplicate samples to be analyzed by the USACE MRD laboratory will be collected for all analyses at the rate of 5 percent for each analyte.

Appendix B contains a detailed breakdown of all QA/QC samples by location and media. No equipment blanks will be collected for the project.

Section 5
GENERAL INFORMATION AND DEFINITIONS

This section discusses miscellaneous practical information that the field team will need to carry out this investigation.

5.1 Decontamination Procedures for Sampling Equipment

To ensure that the sampling equipment and the samples are not contaminated or cross-contaminated by materials and equipment used in the course of the investigation, the following procedures will be employed to decontaminate all sampling equipment between and before use:

- Wash with ALCONOX® detergent;
- Rinse with potable water;
- Rinse with reagent grade isopropanol;
- Triple rinse with deionized water; and
- Allow to air dry for 10 to 15 minutes.

5.2 Field Documentation

A field log book will be kept by the Field Team Leader (FTL). The field log book will serve primarily as a daily log of activities carried out during the investigation. Other observations may be included as the situation dictates for a thorough record to reconstruct the events concerning all field activities. The field log book is a bound book with sequentially numbered pages and with a unique document control number.

Field Activities will be photographed by the FTL with 35mm color slides. At a minimum, photos of each site will be taken before and after the field investigation.

The FTL will also complete A-E Daily Quality Control Reports (A-E DQCR), shown in Figure 5-1, at the end of each day. These reports will be sent to the USACE-PM and the BEC on a weekly basis.

5.3 Sample Containers, Preservation, and Holding Times

The sample containers, preservation measures, and holding times for the sludge, soil, and surface water analyses to be conducted are summarized in Table 5-1. All containers used for chemical analyses will be pre-cleaned by the supplier, I-Chem or Eagle-Picher, in accordance with EPA protocol. The sample label will be affixed to the bottle with the field sample number and the other required information in indelible ink (see Section 6.2). All soil, sludge, and surface water samples collected for organic chemical analysis will be chilled to approximately 4°C with regular ice in a plastic bag during collection and shipment. The samples will be stored upright in a durable ice chest. Sufficient packing material (e.g., vermiculite) will be used to separate the bottles, filling any voids.

5.4 List of Equipment, Containers, and Supplies

Implementation of the field activities will require specific equipment, containers, and supplies for the collection of field samples as summarized below.

Sampling Equipment

- Stainless steel hand auger;
- AMS sludge sampler;
- PVC sludge syringe;
- Teflon® bailers;
- Stainless steel compositing bowls and sampling equipment;
- Aluminum flat bottom boat with outriggers.

A-E DAILY QUALITY CONTROL REPORT

Date_____

Day	S	M	T	W	TH	F	S

COE Project Manager_____
Project_____
Job No._____
Contract No._____

SUB-CONTRACTORS ON SITE:
EQUIPMENT ON SITE:
WORK PERFORMED (INCLUDING SAMPLING):

Figure 5-1. A-E Daily Quality Control Report

Project_____ Report No._____

Job No._____ Date_____

QUALITY CONTROL ACTIVITIES (INCLUDING FIELD CALIBRATIONS):
HEALTH AND SAFETY LEVELS AND ACTIVITIES:
PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:
SPECIAL NOTES:
TOMORROW'S EXPECTATIONS:

BY_____ TITLE_____

Figure 5-1. (Continued)

Table 5-1
Summary of Sample Containers, Preservative, and Holding Time Requirements

Reference Method	Parameter	Media	Container Type, No. and Volume [a]	Preservation and Storage Requirements	Maximum Holding Time (Preparation)	Maximum Holding Time (Analysis)
SW-846:6010	Metals	Soil/Sludge	Wide mouth glass jar 250ml (1)	Cool at 4°C	6 Months	6 Months
SW-846:8080	Organochlorine Pesticides	Soil/Sludge	Wide mouth glass jar 250ml (1)	Cool at 4°C	14 Days	40 Days
SW-846:8270	Semivolatile Organics	Soil/Sludge	Wide mouth glass jar 250ml (1)	Cool at 4°C	14 Days	40 Days
	Kepone	Soil/Sludge	Wide mouth glass jar 250ml (1)	Cool at 4°C	14 Days	40 Days
	Organolead	Surface Water	Amber glass jar 1 L (3 for normal, 4 extra for MS/MSDs)	Cool at 4°C, no headspace	14 Days	40 Days
SW-846:7421	Total Lead	Surface Water	Polyethylene 500 ml	Cool at 4°C, pH < 2 with HNO_3	6 Months	6 Months

[a] Extra sample must be collected for matrix spike/matrix spike duplicate analysis.

Sampling Bottles and Shipping Materials

- 250 mL wide-mouth glass with Teflon cap;
- 1 L amber glass with Teflon cap;
- 500 mL plastic;
- Bottle mesh;
- Plastic freezer bags;
- Ice chests; and
- Packaging and shipping materials.

Decontamination Equipment

- ALCONOX® soap;
- Reagent grade water;
- Squirt bottles;
- Plastic sheeting;
- Deionized water; and
- General decontamination equipment (scrubbing utensils, paper towels, etc...)

Miscellaneous Field Gear, Chemicals, and Instrumentation

- Protective gloves;
- Saranex-coated Tyvek® and Tyvek coveralls;
- Full-face air purifying respirators (Scott) with organic vapors cartridges;
- First aid kit;
- Eye wash;
- Tape measure;
- Sounding device; and,
- HNO_3 (AR Select).

Section 6
SAMPLE SHIPPING

Sample custody procedures for this project will emphasize careful documentation of sample collection and transfer data. Elements to ensure good sample custody and sample tracking are briefly discussed in this section.

6.1 Chain of Custody

To ensure that all of the important information pertaining to each sample is recorded, the following documentation procedures will be executed. Preformatted field data and sample custody forms will be used to document the relevant information for each sample taken. A master sample inventory will be maintained on site for all samples collected. Sample chain of custody involves documenting the handling of a sample from the time of collection to the time of final disposition. Procedures used to accomplish custody control include sample labels, custody seals, chain-of-custody forms, shipment and transfer of custody, and laboratory custody.

Sample Labels

A sample label, shown in Figure 6-1, will be affixed to all sampling containers submitted for laboratory analysis. Sample labels identify the sample by documenting the sample type, sampler(s) initials, sampling locations, depth, time, and date. The unique number assigned to each sample is also noted on the sample label. Indelible ink will be used to complete all sample labels. All samples shipped to MRD laboratory will also be labeled with "LIMS No. 1619."

Custody Seals

Custody seals, shown in Figure 6-1, will be affixed to coolers to indicate tampering.

Chain-of-Custody Records

A chain-of-custody form, shown in Figure 6-2, will be used to record the number of samples collected and the corresponding laboratory analyses; indelible ink will be used. Information on this form includes time and date of sampling, sample number, type of sample, sampler's name, preservatives used, and any special instructions. Samples collected for matrix spike/matrix spike duplicate analysis will be identified on the chain-of-custody form. A copy of the chain-of-custody form will be retained by the sampler, and will be maintained in a file of field documentation.

Transfer of Custody and Shipment

Chain-of-custody forms are printed on three-part NCR (no carbon required) paper and distributed in the following manner (or internal copies are made and sent to appropriate individuals):

- **First Copy**—Sent to the laboratory with samples. This copy is retained by the laboratory when analyses are completed and the sample is disposed of.
- **Second Copy**—Sent to the laboratory with the samples. Returned to the QA Coordinator with the laboratory analytical report.
- **Third Copy**—Retained by the Field Team Leader to be placed in the project file to document the existence of the sample.

Laboratory Custody Procedures

Each laboratory conducting analyses for this program will be required to use the described chain-of-custody forms or an equivalent to document the handling of each sample. Exception will be made only if the laboratory has

ATTENTION:
BEFORE OPENING
NOTE IF CONTAINER WAS
TAMPERED WITH.

CUSTODY # _____

ATTENTION:
BEFORE OPENING
NOTE IF CONTAINER WAS
TAMPERED WITH.

8-90-12896

Field Number _____
Sample Type: _____
Client: _____
Location: _____
Preservative: _____
Sampler: _____
Date: _____
Comment: _____

6-89-31426

Figure 6-1. Example Sample Label and Custody Seal

RADIAN CORPORATION

Chain of Custody Record

Page _____ of _____

PROJECT

SITE

COLLECTED BY *(Signature)*

FIELD SAMPLE I.D.	SAMPLE MATRIX	DATE/TIME	NO. OF CONTAINERS	ANALYSES								REMARKS	SAM ID NO. *(for lab use only)*

REMARKS

RELINQUISHED BY: DATE TIME

RECEIVED BY:	DATE	TIME	RELINQUISHED BY:	DATE	TIME	RECEIVED BY:	DATE	TIME	RELINQUISHED BY:	DATE	TIME

LAB USE ONLY

RECEIVED FOR LABORATORY BY:	DATE	TIME	AIRBILL NO.	OPENED BY:	DATE	TIME	TEMP°C	SEAL #	CONDITION

REMARKS:

Figure 6-2. Sample Chain-of-Custody Record

an internal sample tracking system that satisfactorily documents continuous chain-of-custody. The laboratory will also be required to return a copy of the chain-of-custody form after receipt of samples. Upon receipt by the laboratory, sample integrity will be inspected and documented on a Chain-of-Custody Addendum (Figure 6-3). Sample temperatures will be checked and recorded, evidence of other preservative techniques will be reviewed, physical condition of each sample container will be checked, custody seals and chain-of-custody records will be reviewed for consistency, and freight bill identification numbers will be recorded. If any indication of a lack of sample integrity is found, the field task leader will be contacted to discuss implementation of corrective actions.

6.2 Sample Identification

All samples will be assigned a field sample number at the time of collection and a sample control number upon receipt by the laboratory. The field sample number will be recorded in the Sample Inventory, listed on the chain of custody, and on the attached sample label. QA duplicate samples, shipped to MRD for analysis, will be given the same field ID number as the field sample it duplicates. A unique sample control number will be assigned to each individual sample when it is received by the laboratory. A label bearing the sample control number will be affixed to each container. The sample control number will remain with the sample throughout the analysis and data entry procedures. The final report will contain a listing of the field sample numbers and the corresponding laboratory sample control numbers.

6.3 Correction to Documentation

Corrections made to laboratory data or chain-of-custody forms and related documents will be made by drawing a single line through the incorrect section and the corrected entry added. A brief explanation for the change along with the date the change was made should be recorded. Any corrections will be initialled and dated by the author of the change.

6.4 Sample Handling, Packaging, and Shipping

The FTL is responsible for ensuring that samples are properly packaged and shipped to the laboratory. All pertinent Department of Transportation (DOT) shipping regulations will be followed. Packaging and shipping requirements are discussed in this section for soils, sludge, and surface water samples. Procedures for notifying laboratories about incoming shipments are also discussed.

Samples

Soil and water samples will be kept cool with conventional ice in a plastic bag during collection and shipment. The samples will be stored upright in a durable ice chest. Sufficient packing material (e.g., vermiculite) will be used to separate the bottles, filling any intervening voids. Fresh ice will be placed in the cooler prior to shipment to ensure the samples are correctly preserved.

The ice will be placed above and around the top of the sample containers. The remaining space will be filled with additional packing material. The chain-of-custody form will be sealed in a plastic Zip-loc® bag and affixed to the top lid of the cooler. The cooler will be secured by completely wrapping it with strapping tape around both ends. If there is a drain on the cooler, it will be taped shut. The cooler will be labeled with "This Side Up" arrows on two opposing sides. A minimum of two custody seals will also be affixed to coolers to indicate tampering. These seals shall be signed and dated.

CUSTODY NUMBER: 93-0009

Chain-of-Custody Addendum

Received by: _____ Work Order(s): _____

Date: _____ _____

Unpacked Date: _____ _____

_____ _____

Number of Outer Containers Received with Chain-of-Custody: _____ Client Code: _____

(Check the appropriate answer. Add comments or explanations as needed.)

Present	_____	Yes	_____	No
Custody Number	_____	#	_____	No
Container Sealed with Tape	_____	Yes	_____	No
Seal is Intact	_____	Yes	_____	No

If seal is not intact, list airbill number of that container(s).

_____

Sample Temperature Upon Arrival: By: _____ Pyrometer # _____

The temperature of the container(s) is: (acceptable tolerance 2-6°C)

1___°C 2___°C 3___°C 4___°C 5___°C 6___°C 7___°C

When samples are received not requiring cooling: _____NA

If the temperature(s) are outside the acceptable range of 2-6°C

Client Services was notified: (_____ CSC) _____Yes

OK to analyze samples: _____Yes _____No

il samples not listed below were within the acceptable temperature tolerance of 2-6°C. Samples affected and their temperatures.

Sample ID	Temperature (°C)	Sample ID	Temperature (°C)	Sample ID	Temperature (°C)

Figure 6-3. Sample Chain-of-Custody Addendum

Condition of Bottles/Containers By: _____ (Comment any problems)

Bottles received match COC _____ Yes _____ No

Bottles received intact _____ Yes _____ No

Comments: _____

_____

_____

pH of Samples/Preservation By: _____ (Comment any problem)

Acid preserved samples are <2 pH (as indicated by * on COC) _____ Yes _____ No

Base preserved samples are >12 pH (as indicated by # on COC) _____ Yes _____ No

Water samples for cyanide checked (as indicated by √ on COC) _____ Yes _____ No

Water sulfide samples appear to be preserved with zinc acetate _____ Yes _____ No

_____ NA

If pH/preservation is ouside acceptable limits, Client Services was notified

(_____ CSC) _____ Yes Adjust _____ Yes _____ No

Sample id's and pH of samples received outside of acceptable pH range. All other samples not listed are at the appropriate pH.

Sample ID	pH	Sample ID	pH	Sample ID	pH	Sample ID	pH

Comments: _____

_____

Shipping Documentation

Freightbill is available and attached to chain-of-custody.

_____ Yes _____ No

Other Comments: _____

_____

_____

Client chain-of-custody is signed/dated with time by sample control as received, with the sample control addendum number noted in the comments section.

_____ Yes _____ No

Sample Control Addendum Verified by: _____ Date: _____

Figure 6-3. (Continued)

Samples will be shipped to the laboratory by overnight courier on a daily basis. If the laboratory makes provisions for Saturday delivery, samples may be shipped on Friday. Otherwise, samples taken on Friday, Saturday, and Sunday will be stored in the field trailer (@ 4°C) for shipment on the following Monday. The laboratories will be contacted on Friday to inform them of Saturday or Tuesday delivery and will be made aware of hold time requirements.

Laboratory Shipping Information

All sample analyses for soil, groundwater, and surface water except for the kepone analyses and the MRD duplicates will be conducted by Quanterra Inc. at the following address:

Quanterra, Inc.
4955 Yarrow St.
Arvada, CO 80002
Attn: Kevin McHugh
(303) 421-6611 (phone)
(303) 431-7171 (fax)

Samples for kepone analyses will be shipped to Midwest Research Institute at the following address:

Midwest Research Institute
425 Volkar Blvd.
Kansas City, MO 64110
Attn: Gregory
(816) 753-7600

If Saturday delivery is necessary, the Federal Express label should include the note "Hold for pickup at Jefferson St. Station."

External QA Samples required by the USACE Missouri River Division Laboratory will be shipped to the following address:

U.S. Army Engineer Division, Missouri River Division Laboratory
Attn: CEMRD-ET-LC (Laura Percifield)
420 South 18th Street
Omaha, NE 68102
(402) 444-4314

LIMS No. 2997 must be printed on all labels and chain-of custody forms sent to the USACE MRD Laboratory. Samples may be shipped to USACE MRD Laboratory for Saturday *morning* delivery.

Section 7
Management of Investigation Derived Waste

The purpose of this section is to establish procedures for handling the waste generated during the field investigation. The procedures established provide instructions for classifying and handling the various wastes expected to be generated during soil, sludge and surface water sampling, and decontamination of field equipment.

7.1 Responsibilities

Field personnel are responsible for utilizing appropriate work practices and following good housekeeping practices to minimize waste generation and to maintain proper waste segregation. During the course of the investigation, the contractor will segregate and characterize each waste that is generated. Wastes will then be disposed of appropriately.

7.2 Field Materials

Alconox and isopropanol will be used in decontamination, and will be stored in the field vehicles and field trailer. Nitric acid will be used for sample preservation and will be stored in the sample preparation and shipping area of the field trailer. Material Safety Data Sheets (MSDSs) for these items are included in the Site Health and Safety Plan (SSHP).

7.3 Waste Streams

Two waste streams will exist in this field program, equipment waste and decontamination waste.

Equipment Waste

Equipment waste includes expendable or non-repairable sampling equipment, disposable supplies, and personal protective equipment (PPE). It is estimated that no more than one 30-gallon trash bag of equipment waste, mostly PPE, will be generated per day. This waste will be managed in accordance with the *Remedial Compliance Plan* dated October 1994 for Holloman AFB investigations.

Decontamination Waste

Decontamination waste consists of wastewater generated while decontaminating sampling equipment. Decontamination water generated at the site will be discharged in the sewage lagoons.

7.4 Waste Minimization

A primary goal of this plan is to minimize, to the extent practical, the volume of waste which must be generated and stored, and the amount of material which must be removed from the site for disposal. In order to minimize the volume of wastes, the following general rules should be applied:

- Do not contaminate materials unnecessarily;
- Decontaminate and reuse material and equipment when practical; and
- Utilize volume reduction techniques when practicable.

APPENDIX A

Water Depths and Sludge Thicknesses in Sewage Lagoons
(Measured October 1991)

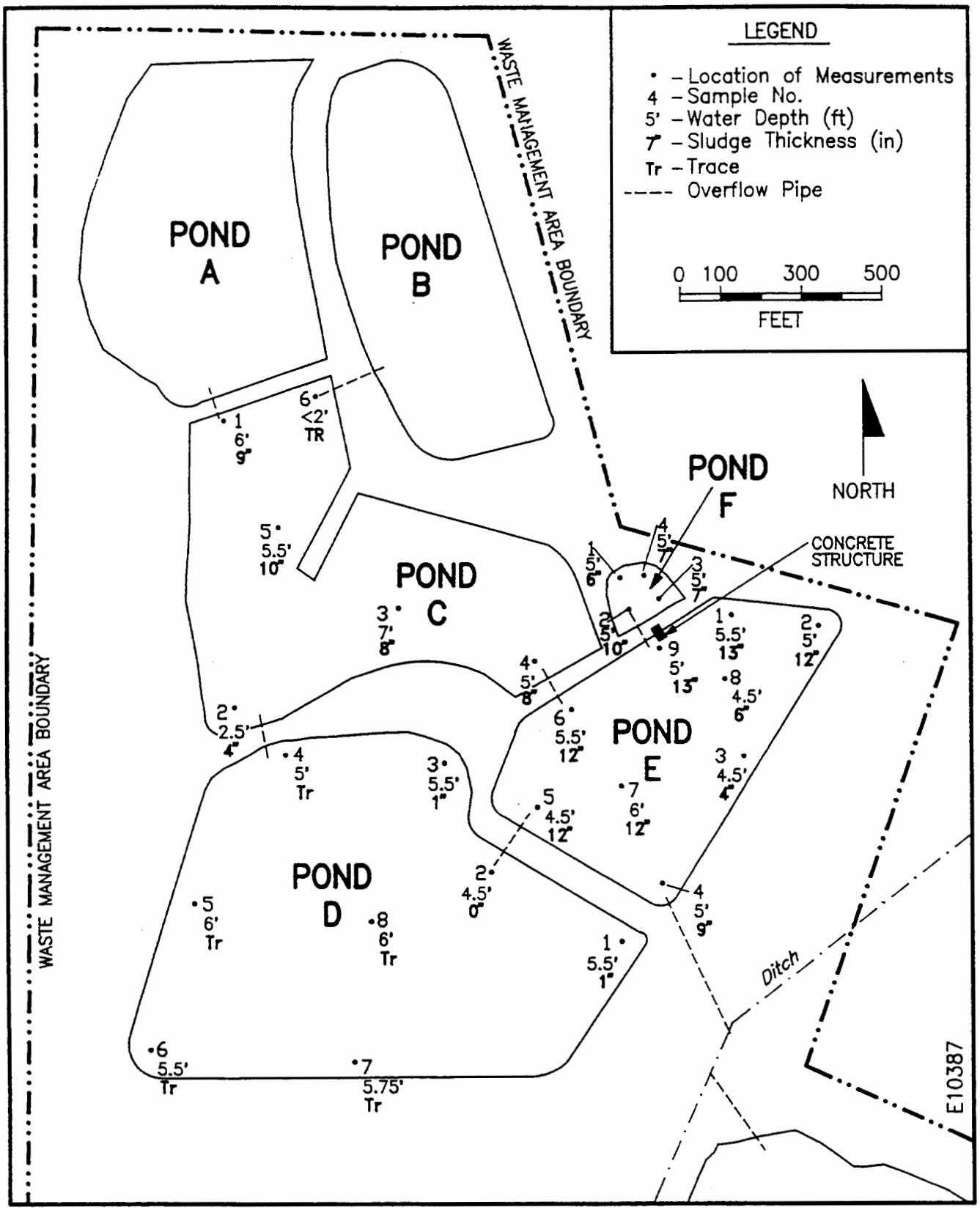

Figure 1. Sample Locations--Ponds C, D, E, and F

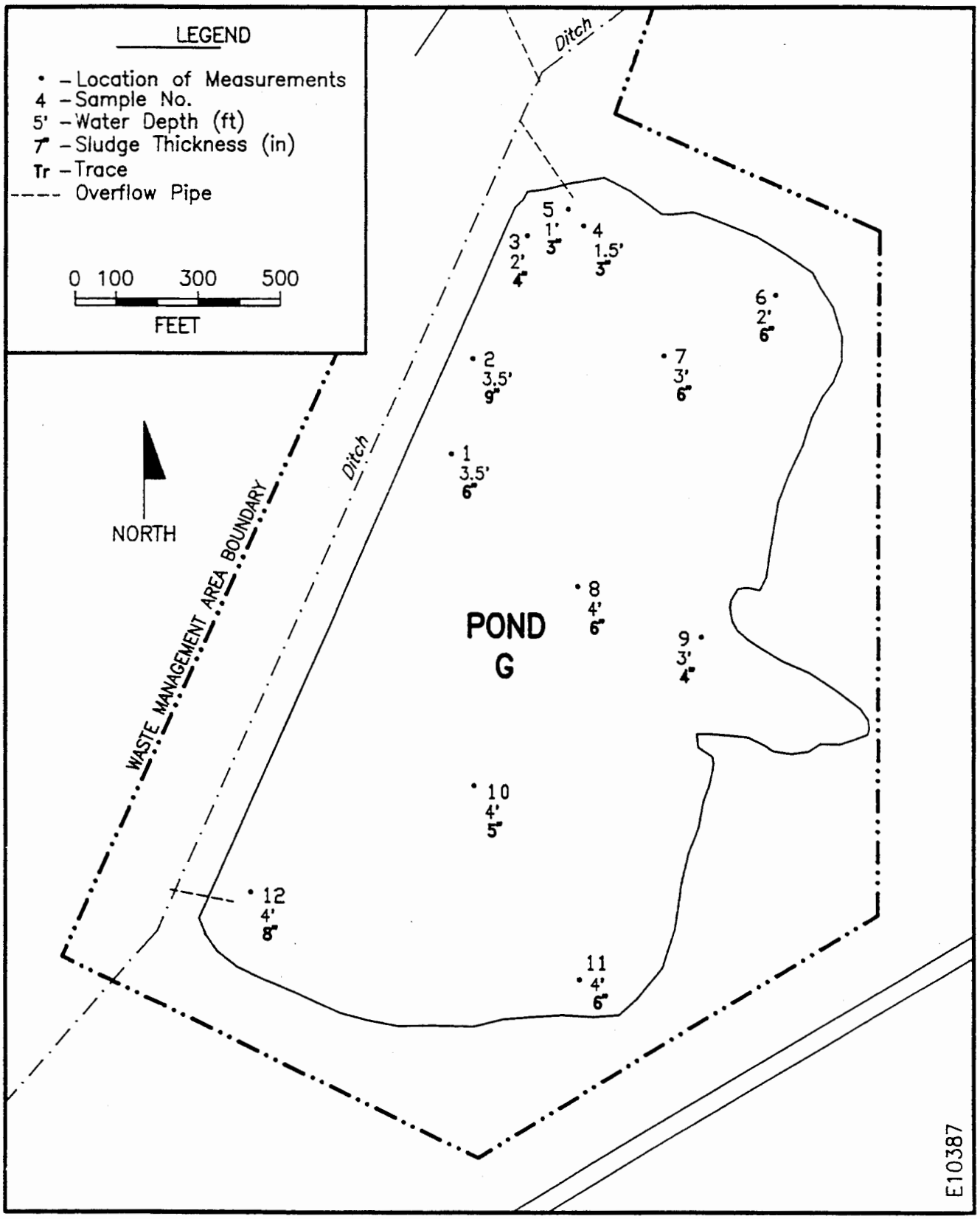

Figure 2. Sample Locations--Pond G

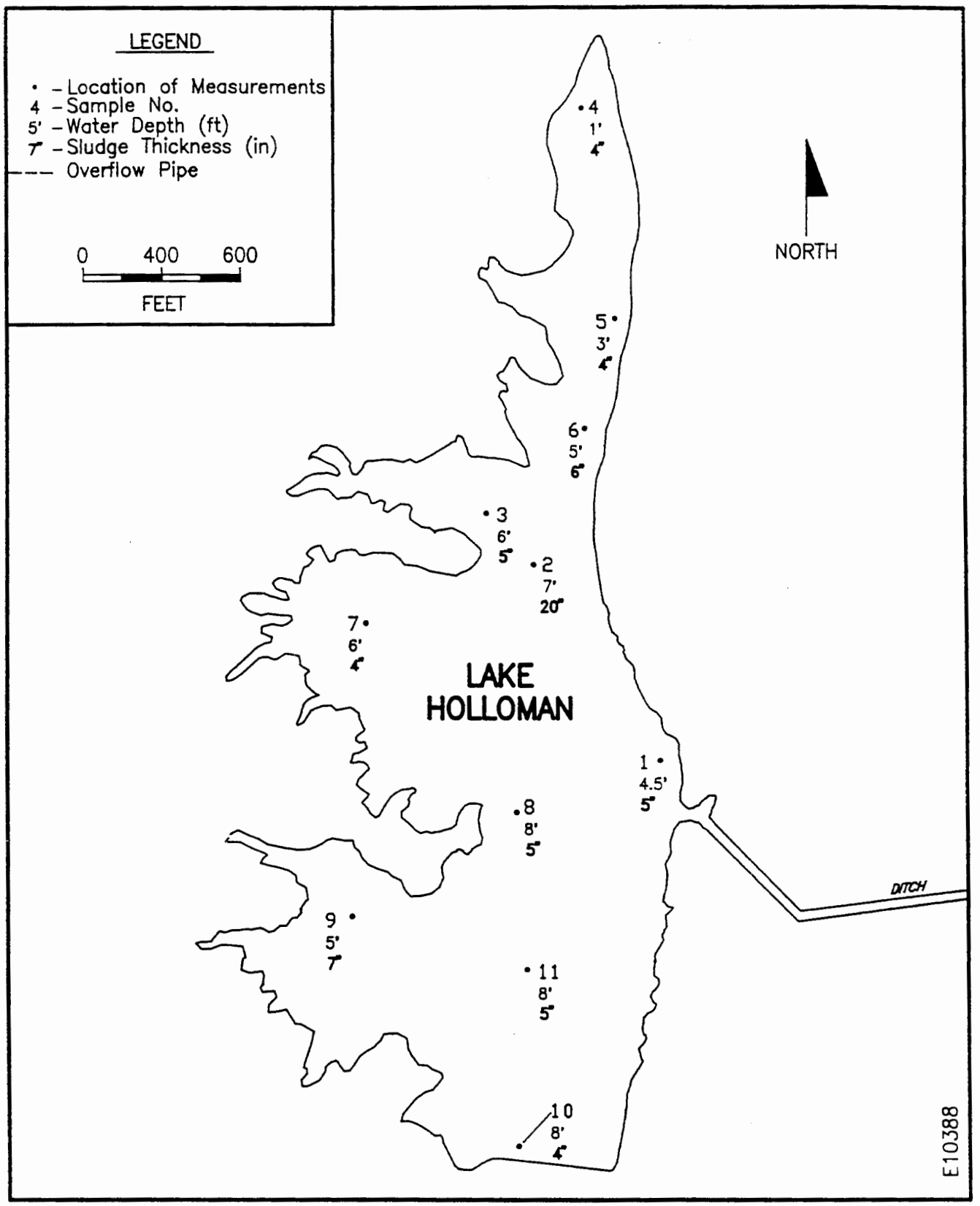

Figure 3. Sample Locations--Lake Holloman

APPENDIX B

Sample Identification Spreadsheet

Holloman Lakes and Lagoons
Sample Summary

10/25/94 Rice
Filename: Smplid.wk3

IDENTIFICATION										ANALYSES					
					Type	Sample									
Location	Year	Site	Media	Loc	Sample	Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Pond C	94	PC	SL	01	01					1	1	1	1		
Pond C	94	PC	SL	02	01					1	1	1			
Pond C	94	PC	SL	03	01					1	1	1	1		
Pond C	94	PC	SL	04	01					1	1	1			
Pond C	94	PC	SL	05	01					1	1	1	1		
Pond C	94	PC	SL	06	01					1	1	1	1		
Pond C	94	PC	SL	06	21		Duplicate			1	1	1			
Pond C	94	PC	SL	06	QA1		MRD Dup			1	1	1			
Pond C	94	PC	SL	07	01					1	1	1			
Pond C	94	PC	SL	07	01		MS/MSD			2	2	2			
Pond C	94	PC	SL	08	01					1	1	1	1		
Pond C	94	PC	SL	09	01					1	1	1			
Pond C	94	PC	SL	10	01					1	1	1	1		
Pond C	94	PC	SL	11	01					1	1	1	1		
Pond C	94	PC	SL	12	01					1	1	1			
Pond C	94	PC	SL	13	01					1	1	1	1		
										17	17	17	8	0	0

IDENTIFICATION										ANALYSES					
					Type	Sample									
Location	Year	Site	Media	Loc	Sample	Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Pond C	94	PC	WS	03	01	B								1	1
Pond C	94	PC	WS	07	01	B								1	1
Pond C	94	PC	WS	08	01	B								1	1
										0	0	0	0	3	3

IDENTIFICATION										ANALYSES					
					Type	Sample									
Location	Year	Site	Media	Loc	Sample	Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Pond D	94	PD	S	01	01	HA				1	1	1			
Pond D	94	PD	S	02	01	HA				1	1	1			
Pond D	94	PD	S	03	01	HA				1	1	1			
Pond D	94	PD	S	04	01	HA				1	1	1			
Pond D	94	PD	S	04	21	HA	Duplicate			1	1	1			
Pond D	94	PD	S	04	QA1	HA	MRD Dup			1	1	1			
Pond D	94	PD	S	05	01	HA				1	1	1			
Pond D	94	PD	S	06	01	HA				1	1	1			
Pond D	94	PD	S	07	01	HA				1	1	1			
Pond D	94	PD	S	08	01	HA				1	1	1			
Pond D	94	PD	S	08	01	HA	MS/MSD			2	2	2			
Pond D	94	PD	S	09	01	HA				1	1	1			
Pond D	94	PD	S	10	01	HA				1	1	1			
										14	14	14	0	0	0

IDENTIFICATION										ANALYSES					
					Type	Sample									
Location	Year	Site	Media	Loc	Sample	Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Pond D	94	PD	WS	01	01	B								1	1
Pond D	94	PD	WS	05	01	B								1	1
Pond D	94	PD	WS	08	01	B								1	1
										0	0	0	0	3	3

Holloman Lakes and Lagoons
Sample Summary

10/25/94 Rice
Filename: Smplid.wk3

IDENTIFICATION										ANALYSES					
					Type	Sample									
Location	Year	Site	Media	Loc	Sample	Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Pond E	94	PE	SL	01	01					1	1	1			
Pond E	94	PE	SL	02	01					1	1	1			
Pond E	94	PE	SL	03	01					1	1	1			
Pond E	94	PE	SL	04	01					1	1	1			
Pond E	94	PE	SL	04	21		Duplicate			1	1	1			
Pond E	94	PE	SL	04	QA1		MRD Dup			1	1	1			
Pond E	94	PE	SL	05	01					1	1	1			
Pond E	94	PE	SL	06	01					1	1	1			
Pond E	94	PE	SL	07	01					1	1	1			
Pond E	94	PE	SL	08	01					1	1	1			
Pond E	94	PE	SL	08	01		MS/MSD			2	2	2			
Pond E	94	PE	SL	09	01					1	1	1			
Pond E	94	PE	SL	10	01					1	1	1			
Pond E	94	PE	SL	11	01					1	1	1			
Pond E	94	PE	SL	12	01					1	1	1			
Pond E	94	PE	SL	13	01					1	1	1			
Pond E	94	PE	SL	14	01					1	1	1			
Pond E	94	PE	SL	15	01					1	1	1			
Pond E	94	PE	SL	16	01					1	1	1			
										20	20	20	0	0	0

IDENTIFICATION										ANALYSES					
					Type	Sample									
Location	Year	Site	Media	Loc	Sample	Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Pond E	94	PE	WS	03	01	B								1	1
Pond E	94	PE	WS	09	01	B								1	1
Pond E	94	PE	WS	15	01	B								1	1
										0	0	0	0	3	3

Holloman Lakes and Lagoons
Sample Summary

10/25/94 Rice
Filename: Smplid.wk3

IDENTIFICATION										ANALYSES					
Location	Year	Site	Media	Loc	Type Sample	Sample Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Pond G	94	PG	SL	01	01					1	1	1	1		
Pond G	94	PG	SL	02	01					1	1	1			
Pond G	94	PG	SL	03	01					1	1	1	1		
Pond G	94	PG	SL	04	01					1	1	1	1		
Pond G	94	PG	SL	04	21		Duplicate			1	1	1	1		
Pond G	94	PG	SL	04	QA1		MRD Dup			1	1	1	1		
Pond G	94	PG	SL	05	01					1	1	1			
Pond G	94	PG	SL	06	01					1	1	1			
Pond G	94	PG	SL	07	01					1	1	1	1		
Pond G	94	PG	SL	08	01					1	1	1	1		
Pond G	94	PG	SL	09	01					1	1	1			
Pond G	94	PG	SL	10	01					1	1	1	1		
Pond G	94	PG	SL	11	01					1	1	1	1		
Pond G	94	PG	SL	12	01					1	1	1	1		
Pond G	94	PG	SL	13	01					1	1	1	1		
Pond G	94	PG	SL	13	01		MS/MSD			2	2	2	0		
Pond G	94	PG	SL	14	01					1	1	1			
Pond G	94	PG	SL	15	01					1	1	1	1		
Pond G	94	PG	SL	16	01					1	1	1			
Pond G	94	PG	SL	17	01					1	1	1	1		
Pond G	94	PG	SL	18	01					1	1	1			
Pond G	94	PG	SL	19	01					1	1	1	1		
										23	23	23	14	0	0

IDENTIFICATION										ANALYSES					
Location	Year	Site	Media	Loc	Type Sample	Sample Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Pond G	94	PG	WS	01	01	B								1	1
Pond G	94	PG	WS	04	01	B								1	1
ond G	94	PG	WS	04	EB1	B	Eqp Blank							1	1
ond G	94	PG	WS	05	01	B								1	1
Pond G	94	PG	WS	07	01	B								1	1
Pond G	94	PG	WS	07	21	B	Duplicate							1	1
Pond G	94	PG	WS	07	QA1	B	MRD Dup							1	1
Pond G	94	PG	WS	09	01	B								1	1
Pond G	94	PG	WS	11	01	B								1	1
Pond G	94	PG	WS	11	01	B	MS/MSD								2
Pond G	94	PG	WS	12	01	B								1	1
Pond G	94	PG	WS	15	01	B								1	1
Pond G	94	PG	WS	17	01	B								1	1
										0	0	0	0	12	14

Holloman Lakes and Lagoons
Sample Summary

10/25/94 Rice
Filename: Smplid.wk3

IDENTIFICATION										ANALYSES					
					Type	Sample									
Location	Year	Site	Media	Loc	Sample	Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Lake Holloman	94	LH	SL	01	01					1	1	1	1		
Lake Holloman	94	LH	SL	02	01					1	1	1			
Lake Holloman	94	LH	SL	03	01					1	1	1	1		
Lake Holloman	94	LH	SL	04	01					1	1	1	1		
Lake Holloman	94	LH	SL	04	21		Duplicate			1	1	1	1		
Lake Holloman	94	LH	SL	04	QA1		MRD Dup			1	1	1	1		
Lake Holloman	94	LH	SL	05	01					1	1	1	1		
Lake Holloman	94	LH	SL	06	01					1	1	1			
Lake Holloman	94	LH	SL	07	01					1	1	1	1		
Lake Holloman	94	LH	SL	08	01					1	1	1	1		
Lake Holloman	94	LH	SL	09	01					1	1	1			
Lake Holloman	94	LH	SL	10	01					1	1	1	1		
Lake Holloman	94	LH	SL	11	01					1	1	1			
Lake Holloman	94	LH	SL	12	01					1	1	1	1		
Lake Holloman	94	LH	SL	13	01					1	1	1			
Lake Holloman	94	LH	SL	13	01		MS/MSD			2	2	2			
Lake Holloman	94	LH	SL	14	01					1	1	1	1		
Lake Holloman	94	LH	SL	15	01					1	1	1			
Lake Holloman	94	LH	SL	16	01					1	1	1	1		
Lake Holloman	94	LH	SL	17	01					1	1	1	1		
Lake Holloman	94	LH	SL	18	01					1	1	1			
Lake Holloman	94	LH	SL	19	01					1	1	1			
Lake Holloman	94	LH	SL	20	01					1	1	1	1		
Lake Holloman	94	LH	SL	21	01					1	1	1			
Lake Holloman	94	LH	SL	22	01					1	1	1	1		
Lake Holloman	94	LH	SL	23	01					1	1	1	1		
Lake Holloman	94	LH	SL	24	01					1	1	1			
Lake Holloman	94	LH	SL	25	01					1	1	1	1		
										29	29	29	17	0	0

IDENTIFICATION										ANALYSES					
					Type	Sample									
Location	Year	Site	Media	Loc	Sample	Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Lake Holloman	94	LH	WS	01	01	B								1	1
Lake Holloman	94	LH	WS	04	01	B								1	1
Lake Holloman	94	LH	WS	04	EB1	B	Eqp Blank							1	1
Lake Holloman	94	LH	WS	05	01	B								1	1
Lake Holloman	94	LH	WS	07	01	B								1	1
Lake Holloman	94	LH	WS	07	21	B	Duplicate							1	1
Lake Holloman	94	LH	WS	07	QA1	B	MRD Dup							1	1
Lake Holloman	94	LH	WS	08	01	B								1	1
Lake Holloman	94	LH	WS	10	01	B								1	1
Lake Holloman	94	LH	WS	12	01	B								1	1
Lake Holloman	94	LH	WS	14	01	B								1	1
Lake Holloman	94	LH	WS	16	01	B								1	1
Lake Holloman	94	LH	WS	17	01	B								1	1
Lake Holloman	94	LH	WS	20	01	B								1	1
Lake Holloman	94	LH	WS	22	01	B								1	1
Lake Holloman	94	LH	WS	22	01	B	MS/MSD							0	2
Lake Holloman	94	LH	WS	23	01	B								1	1
Lake Holloman	94	LH	WS	25	01	B								1	1
										0	0	0	0	17	19

Holloman Lakes and Lagoons
Sample Summary

10/25/94 Rice
Filename: Smplid.wk3

NOTE: Lake Stinky Sampled for Soil Only

IDENTIFICATION										ANALYSES					
Location	Year	Site	Media	Loc	Type Sample	Sample Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Lake Stinky	94	LS	S	01	01					1	1	1			
Lake Stinky	94	LS	S	02	01					1	1	1			
Lake Stinky	94	LS	S	03	01					1	1	1			
Lake Stinky	94	LS	S	04	01					1	1	1			
Lake Stinky	94	LS	S	04	21		Duplicate			1	1	1			
Lake Stinky	94	LS	S	04	QA1		MRD Dup			1	1	1			
Lake Stinky	94	LS	S	05	01					1	1	1			
Lake Stinky	94	LS	S	06	01					1	1	1			
Lake Stinky	94	LS	S	06	01		MS/MSD			2	2	2			
Lake Stinky	94	LS	S	07	01					1	1	1			
Lake Stinky	94	LS	S	08	01					1	1	1			
Lake Stinky	94	LS	S	09	01					1	1	1			
Lake Stinky	94	LS	S	10	01					1	1	1			
Lake Stinky	94	LS	S	11	01					1	1	1			
										15	15	15	0	0	0

IDENTIFICATION										ANALYSES					
Location	Year	Site	Media	Loc	Type Sample	Sample Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Ditch	94	DT	S	01	01	HA				1	1	1			
Ditch	94	DT	S	02	01	HA				1	1	1			
Ditch	94	DT	S	03	01	HA				1	1	1			
Ditch	94	DT	S	04	01	HA				1	1	1			
										4	4	4	0	0	0

IDENTIFICATION										ANALYSES					
Location	Year	Site	Media	Loc	Type Sample	Sample Method	Notes	Northing	Easting	8080	8270	Metals	Kepone	Organolead	Total Lead
Ditch	94	DT	WS	01	01	B								1	1
Ditch	94	DT	WS	03	01	B								1	1
Ditch	94	DT	WS	04	01	B								1	1
										0	0	0	0	3	3
									Grand Totals	**122**	**122**	**122**	**39**	**41**	**45**

Legend
SL - Sludge Sample
S - Soil Sample
WS - Surface Water Sample
PC - Lagoon C
LH - Lake Holloman
DT - Ditch
01-Sample Type - Normal
21-Sample Type - Duplicate
QA1 - Sample Type - MRD Sample
EB1 - Sample Type - Equipment Blank

NOTE: The MS/MSD samples include 1 MS and 1 MSD.
The Grand Totals include the MS/MSD and MRD samples.

Addendum to Field Sampling Plan (FSP)
Holloman Air Force Base
Sewage Lagoons and Lakes Closure Project
Additional Sampling

March 1995

2.4 Additional Sludge Sampling Locations

In order to resolve recent agency concerns, provide data that will enhance the corrective measures study, and to assist in future remediation at the site, additional sludge samples will be collected from Ponds A, B, C, and D. These activities will occur at a later date relative to the sampling activities described in Sections 2.1 and 3.1.

A total of 25 locations will be sampled for sludge in Ponds A, B, C, and D. The total number of samples, including four QA/QC samples and three Missouri River Division (MRD) duplicates, is 32. Prior to sampling, the locations in Ponds A and B will be surveyed by Southwest Engineering Inc. The surveyors will mark each sampling point with a floating buoy positioned by a leader and anchor (all locations are underwater). Previously sampled locations in Ponds C and D will be resampled; therefore, no additional surveying in these impoundments is required.

Table 2-3 shows the numbers and types of samples to be collected in each impoundment. Sample locations are given in Figure 2-3. Appendix C contains a detailed breakdown of all sampling locations and media, with their respective analyses.

Sludge Sample Analyses

All analyses will be performed using SW846 methods. Sludge samples in Ponds A, B, and C will be analyzed for toxicity characteristic leachate procedure (TCLP, SW1311) metals, and total and reactive sulfides. Additionally, Ponds A and B will be analyzed for polychlorinated biphenyls (SW8080). Sludge samples in Pond D will be analyzed for total metals, and organochlorine pesticides (SW8080). Also, samples from Pond D will be collected and extracted for analysis by method SW8270 (semivolatiles), but will only be analyzed to confirm any positive detections of isodrin or heptachlor epoxide in the SW8080 organochlorine pesticides analyses.

All analyses will be performed by Quanterra Inc. The analytical procedures are described in the Sewage Lagoons and Lakes Closure Project *Quality Assurance Project Plan (QAPP)*, October, 1994, and in the addendum to the QAPP, March 1995.

Table 2-3
Sewage Lagoons Closure Project Modification Sample Location and Analyses

Method	Pond A	Pond B	Pond C	Pond D	Duplicates*	Total
Total Metals	--	--	--	6	1	7
TCLP Metals	6	6	6	--	2	20
8270 Extraction				6		6
8270 Analysis	--	--	--	3		3
8080	6	6	--	6	3	20
Sulfides (Total and Reactive)	6	6	6		2	20

* Duplicates do not include MS/MSDs or MRD duplicates.

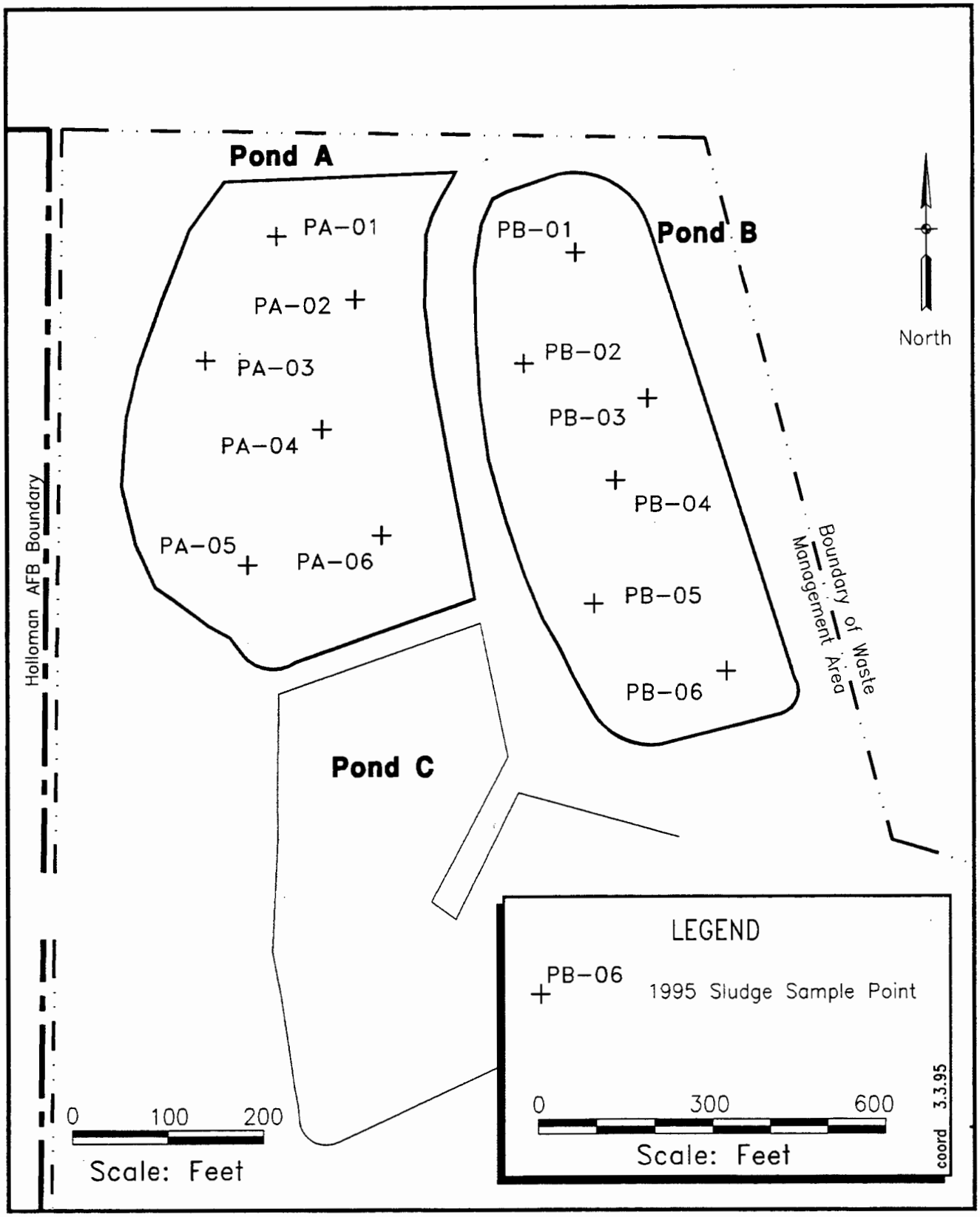

Figure 2-3. Additional Sewage Lagoons Sample Locations for March 1995 Investigation

APPENDIX C

Additional Sampling (March 1995)
Identification Spreadsheet

Holloman Lakes and Lagoons
Sample Summary Modified for 3/95 Sampling Effort

02/28/95 Rice
Filename: Holloman\lagoons\fsp\ModSmpid.wk

IDENTIFICATION

Location	Year	Site	Media	Loc	Type Sample	Sample Method	Notes	Northing	Easting	ANALYSES 8080	8270	Metals	TCLP Metals	Tot. & Reac. Sulfides
Pond A	95	PA	SL	01	01					1			1	1
Pond A	95	PA	SL	02	01					1			1	1
Pond A	95	PA	SL	03	21		Duplicate			1			1	1
Pond A	95	PA	SL	03	QA1		MRD Dup			1			1	1
Pond A	95	PA	SL	03	01					1			1	1
Pond A	95	PA	SL	04	01					1			1	1
Pond A	95	PA	SL	04	01		MS/MSD			2			2	2
Pond A	95	PA	SL	05	01					1			1	1
Pond A	95	PA	SL	06	01					1			1	1
										10	0	0	10	10

Location	Year	Site	Media	Loc	Type Sample	Sample Method	Notes	Northing	Easting	ANALYSES 8080	8270	Metals	TCLP Metals	Tot. & Reac. Sulfides
Pond B	95	PB	SL	01	01					1			1	1
Pond B	95	PB	SL	02	01					1			1	1
Pond B	95	PB	SL	03	01					1			1	1
Pond B	95	PB	SL	03	21		Duplicate			1			*	*
Pond B	95	PB	SL	03	QA1		MRD Dup			1			1	1
Pond B	95	PB	SL	04	01					1			1	1
Pond B	95	PB	SL	05	01					1			1	1
Pond B	95	PB	SL	06	01					1			1	1
										8	0	0	7	7

Location	Year	Site	Media	Loc	Type Sample	Sample Method	Notes	Northing	Easting	ANALYSES 8080	8270	Metals	TCLP Metals	Tot. & Reac. Sulfides
ond C	95	PC	SL	01	01								1	1
ond C	95	PC	SL	03	01								1	1
Pond C	95	PC	SL	03	21		Duplicate						1	1
Pond C	95	PC	SL	03	QA1		MRD Dup						1	1
Pond C	95	PC	SL	05	01								1	
Pond C	95	PC	SL	07	01								1	1
Pond C	95	PC	SL	07	01		MS/MSD						2	2
Pond C	95	PC	SL	08	01								1	1
Pond C	95	PC	SL	10	01								1	1
Pond C	95	PC	SL	11	01									1
										0	0	0	10	10

Location	Year	Site	Media	Loc	Type Sample	Sample Method	Notes	Northing	Easting	ANALYSES 8080	8270	Metals	TCLP Metals	Tot. & Reac. Sulfides
Pond D	95	PD	SL	01	01					1	1	1		
Pond D	95	PD	SL	02	01					1	1	1		
Pond D	95	PD	SL	03	01					1	1	1		
Pond D	95	PD	SL	03	01		MS/MSD			2	2	2		
Pond D	95	PD	SL	04	01					1	1	1		
Pond D	95	PD	SL	04	21		Duplicate			1	1	1		
Pond D	95	PD	SL	04	QA1		MRD Dup			1	1	1		
Pond D	95	PD	SL	05	01					1	1	1		
Pond D	95	PD	SL	06	01					1	1	1		
										10	10	10		

Legend
SL - Sludge Sample
PC - Lagoon C
D - Lagoon D (See Note 3)
01-Sample Type - Normal
-Sample Type - Duplicate
A1 - Sample Type - MRD Sample
EB1 - Sample Type - Equipment Blank
* Duplicate sample on PB-03 will only be duplicated for 8080 analysis.

NOTE:
1) The MS/MSD samples include 1 MS and 1 MSD.
2) The Grand Totals include the MS/MSD and MRD samples.

APPENDIX C

Corrective Measures Study

DCN 96-612-001-24-01

CORRECTIVE MEASURES STUDY

SEWAGE LAGOONS CLOSURE PROJECT
HOLLOMAN AIR FORCE BASE, NM

Prepared for:

49 CES/CEV
Holloman Air Force Base, NM

and

HQ ACC/CEVR
Langley Air Force Base, VA

Prepared by:

Radian International, LLC
8501 North Mopac Boulevard
Austin, Texas 78720-1088
512/454-4797

Under Contract No. DACW45-91-D-0018

U.S. Army Corps of Engineers
Omaha District
Omaha, Nebraska

June 1996
Revised November 1996

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LIST OF ACRONYMS

µg/kg	micrograms/kilograms
ACLs	alternative concentration levels
AFB	Air Force Base
BCP	Base Comprehensive Plan
bgl	below ground level
BHC	hexachlorocyclohexane
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMS	Corrective measures study
DDD	p,p'-Dichlorodiphenyl dichloroethane
DDE	p,p'-Dichlorodiphenyl dichloroethylene
DDT	p,p'-Dichlorodiphenyl trichloroethane
DERA	Defense Environmental Restoration Account
DOC	dissolved organic carbon
DoD	Department of Defense
EPA	Environmental Protection Agency
FFCA	Federal Facilities Compliance Agreement
FS	feasibility study
ft	feet
gal.	gallon(s)
HHSs	Human Health Standards
HWMUs	hazardous waste management units
in.	inch(es)
IRP	Installation Restoration Program
LTM	Long-term Monitoring
MCLs	maximum contaminant levels
mg/L	milligrams per liter
mg/kg	milligrams per kilograms
MSGP	Multi-Sector General Permit
NCP	National Contingency Plan
NM WQCC	New Mexico Water Quality Control Commission
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
PCBs	polychlorinated biphenyls
RCRA	Resource Conservation and Recovery Act
SMCLs	secondary maximum contaminant levels
TC	toxicity characteristic
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TOC	total organic carbon
TSCA	Toxic Substances Control Act
USDA	United States Department of Agriculture

LIST OF ACRONYMS (CONTINUED)

USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTL	upper tolerance limit
WWTP	wastewater treatment plant
yd^3	cubic yard(s)

Section 1
INTRODUCTION

This corrective measures study (CMS) has been prepared as a component of the *Sewage Lagoons Closure Plan* (Radian and Foster Wheeler, 1996c) for Holloman Air Force Base (AFB). It supports the closure plan by providing a more detailed explanation of how the closure alternative was selected and why it was chosen over other alternatives. This CMS describes the current conditions (Section 2), presents the closure objectives (Section 3), describes the screening of technologies and the development of alternatives for closure of the sewage lagoons (Section 4), evaluates the alternatives on the basis of standard evaluation criteria (Section 5), and recommends the most appropriate alternatives for closure (Section 6).

1.1 Regulatory Background

Until July 1996, Holloman AFB operated seven sewage lagoons (Ponds A through G) as part of a system to treat domestic and industrial wastewater. Table 1-1 presents an overview of significant regulatory activities for these sewage lagoons.

The U.S. Environmental Protection Agency (EPA) Region VI informed the Base in 1987 that the facility had lost interim status to operate its surface impoundments on 8 November 1985. Afterwards, EPA Region VI, Holloman AFB, and the New Mexico Environment Department (NMED) signed a Federal Facilities Compliance Agreement (FFCA) in December 1988. Through a series of meetings between EPA Region VI, NMED, and Holloman AFB during January 1991, it was agreed that the Base would pursue clean closure supported by a site-specific demonstration (i.e., a risk assessment).

The sewage lagoons are regulated under the Resource Conservation and Recovery Act (RCRA) as hazardous waste management units (HWMUs). The sewage lagoons are also included in the Installation Restoration Program (IRP), which follows the provisions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Consequently, investigation and remediation activities at the sewage lagoons must comply with CERCLA as well as RCRA. To date, over $10 million have been spent characterizing the sewage lagoons and removing sludge contaminated with polychlorinated biphenyls (PCBs) from Ponds A and B.

1.2 Stakeholders Closure Meeting

A stakeholders closure meeting was held for the sewage lagoons on 3 April 1996. Representatives from EPA Region VI, NMED, Holloman AFB, the U.S. Fish and Wildlife Service (USFWS), and the Audubon Society participated in the meeting, the purpose of which was to discuss issues affecting the closure of the sewage lagoons. The intent was to incorporate the comments and discussions of the meeting into the CMS and the closure plan. The main items discussed at the meeting are summarized below. The incorporation of the input from the meeting is also described.

1.2.1 Items Discussed

The meeting participants generally agreed that the CMS should be streamlined to the extent possible and should focus on reasonable and realistic approaches to closure. It appeared to the participants that closure concentrations could be based on prior sampling at the sewage lagoons and on process knowledge.

Table 1-1
Overview of Significant Project Activities

Date of Activity	Activity Summary
8 November 1985	Interim status units lacking groundwater monitoring program certification lose authorization to operate as HWMUs, triggering closure.
1981-1988	Five nonroutine sampling events conducted. PCBs were contaminant of concern.
20 December 1988	EPA Region VI, NMED, and Holloman AFB sign FFCA to resolve all issues in second Notice of Noncompliance. Major requirements of FFCA were to: 1) develop closure method and have it approved, and 2) develop a groundwater monitoring system and install it.
8 March 1990	Removal of 1316 tons of PCB-contaminated sludge from Pond B completed. Sludge and soil sampled at Pond C.
19 July 1990	Removal of 2588 tons of PCB-contaminated sludge from Pond A completed.
8 May 1991	NMED informed Holloman AFB that closure may be delayed in accordance with new regulations adopted by the state on 13 March 1991.
December 1993	Submitted Draft Risk Assessment for Sewage Lagoons and Lakes, Phase I Groundwater Assessment Monitoring and Phase 2 RFI for Lakes Holloman and Stinky to NMED.
January 1994	Submitted Conceptual Plan for Additional Sampling of Sewage Lagoons and Lakes to NMED.
October 1994	Performed additional sampling of sewage lagoons and lakes.
May 1995	Submitted Closure Plan to NMED.
June 1995	Submitted Site Characterization Report to NMED.
March 1996	Submitted Risk Assessment Addendum to NMED.
June 1996	Submitted CMS and Updated Closure Plan to NMED.
November 1996	Submitted Updated CMS and Closure Plan Revisions to NMED.

FFCA = Federal Facilities Compliance Agreement.
HWMUs = Hazardous waste management units.
NMED = New Mexico Environment Department
PCBs = Polychlorinated biphenyls.

The Base explained that the land use for Ponds A through F is currently industrial, but will be classified as restricted open space after closure because the land is in the runway clear zone. The land use for Pond G is, and will remain, restricted open space. Pond G is an impounded playa lake and, therefore, it is considered Waters of the United States. Also, the lands surrounding Pond G are either jurisdictional wetlands or are in a floodplain.

During the meeting, the participants discussed the possibility that the sewage lagoons could be closed through a risk-based clean closure. Clean closure was defined by NMED as no pathways or unacceptable risks for a residential scenario. The alternative for Ponds A through F discussed at the meeting involves installing a soil cover over the dewatered sludge in the sewage lagoons. There are currently no unacceptable risks associated with the sludge; the addition of a soil cover would further reduce currently acceptable risks and add further protection by controlling disease vectors. It was generally agreed that if sufficient soil cover was placed over the sludge, all exposure pathways would be eliminated, and the alternative would meet residential risk levels. The participants discussed the possibility that long-term groundwater monitoring may not be necessary if clean closure is accomplished.

The group discussed the reasons that Pond G should remain open as a habitat for wildlife. The USFWS and the Audubon Society have requested that Holloman AFB continue to supply water to Pond G to maintain the habitat. The environmental assessment for the construction of the new Holloman AFB wastewater treatment plant (WWTP) documents the importance of keeping Pond G open for wildlife habitat (USAF, 1995). Pond G is an impounded playa lake which is Waters of the United States and is associated with jurisdictional wetlands in the area. It was suggested that Pond G should be addressed separately in the discussion of closure alternatives.

Closure objectives and closure criteria were also discussed during the meeting. The closure objectives and closure criteria for the sewage lagoons are presented in Section 3.

1.2.2 Incorporation of Discussion Items into the CMS

The input and comments from the stakeholders closure meeting have been incorporated into this CMS. The risk-based approach to clean closure is discussed in Section 1.3. As suggested in the 3 April meeting, the CMS process has been streamlined by including only the relevant information. In addition, the closure objectives and closure criteria presented and discussed during the meeting have been incorporated into the CMS without substantive changes. These objectives and criteria follow the RCRA corrective action methodology because the CMS includes an evaluation of closure alternatives.

To focus the CMS, response actions and technologies are screened in Section 4 so that only the practical alternatives for closure are evaluated in Sections 5 and 6. Also, the closure of Pond G is discussed separately from the closure of Ponds A through F in Sections 4 through 6.

1.3 Approach to Closure

The sewage lagoons will be closed in accordance with the closure performance standards for HWMUs listed in 40 CFR Part 265 and the FFCA. Extensive investigations have determined the nature and extent of contamination, and a baseline risk assessment has been performed. These results will be used to demonstrate how the selected closure action will meet the intent of the standards listed in 40 CFR Part 265.

The closure requirements of 40 CFR Sections 265.111 and 265.228 overlap the closure criteria discussed at the stakeholders closure meeting. These are also the waste management standards placed on Holloman AFB by reference in

the FFCA. To meet these requirements for clean closure, the closure action should accomplish the following:

- Minimize the need for further maintenance;
- Control, minimize, or eliminate, to the extent necessary to protect human health and the environment, postclosure releases to the environment; and
- Remove or decontaminate all wastes.

However, as generally agreed in the stakeholders closure meeting, a risk-based approach to closure is appropriate for the sewage lagoons. Therefore, it will not be necessary for the closure action to meet the third criterion if the sludge in the sewage lagoons does not pose an unacceptable risk and/or the exposure pathways to potential risk are eliminated.

1.4 Purpose of CMS

The objective of this CMS report is to identify, develop, and screen alternatives for closure of the sewage lagoons. The closure of the lagoons is funded by the Defense Environmental Restoration Account (DERA), which is the Department of Defense (DoD) implementation for the "Superfund," and is administered by the IRP. As such, the closure process must meet the requirements of CERCLA and the National Contingency Plan (NCP), under which a feasibility study (FS) is normally conducted to examine alternatives. However, because the sewage lagoons are RCRA-regulated facilities, Holloman AFB will use the equivalent RCRA terminology.

Both the RCRA and IRP programs are ultimately intended to ensure the remediation of contaminated sites that pose an actual or potential threat to human health or the environment. Both programs are implemented through phased approaches to identify, investigate, and remediate sites. A comparison of the phases is presented in Figure 1-1.

The purpose of a CMS and an FS is essentially the same: to identify and develop alternatives for closure or remedial action, to evaluate the alternatives against specified criteria, and to justify and recommend specific alternatives on the basis of the accepted criteria. CMS requirements are based on the *RCRA Corrective Action Plan* (EPA, 1988b); FS requirements are based on the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988a). The format for this document will be consistent with the RCRA CMS requirements, and only RCRA terminology will be used in the document. Table 1-2 provides a cross-reference of applicable FS requirements with sections in the CMS report.

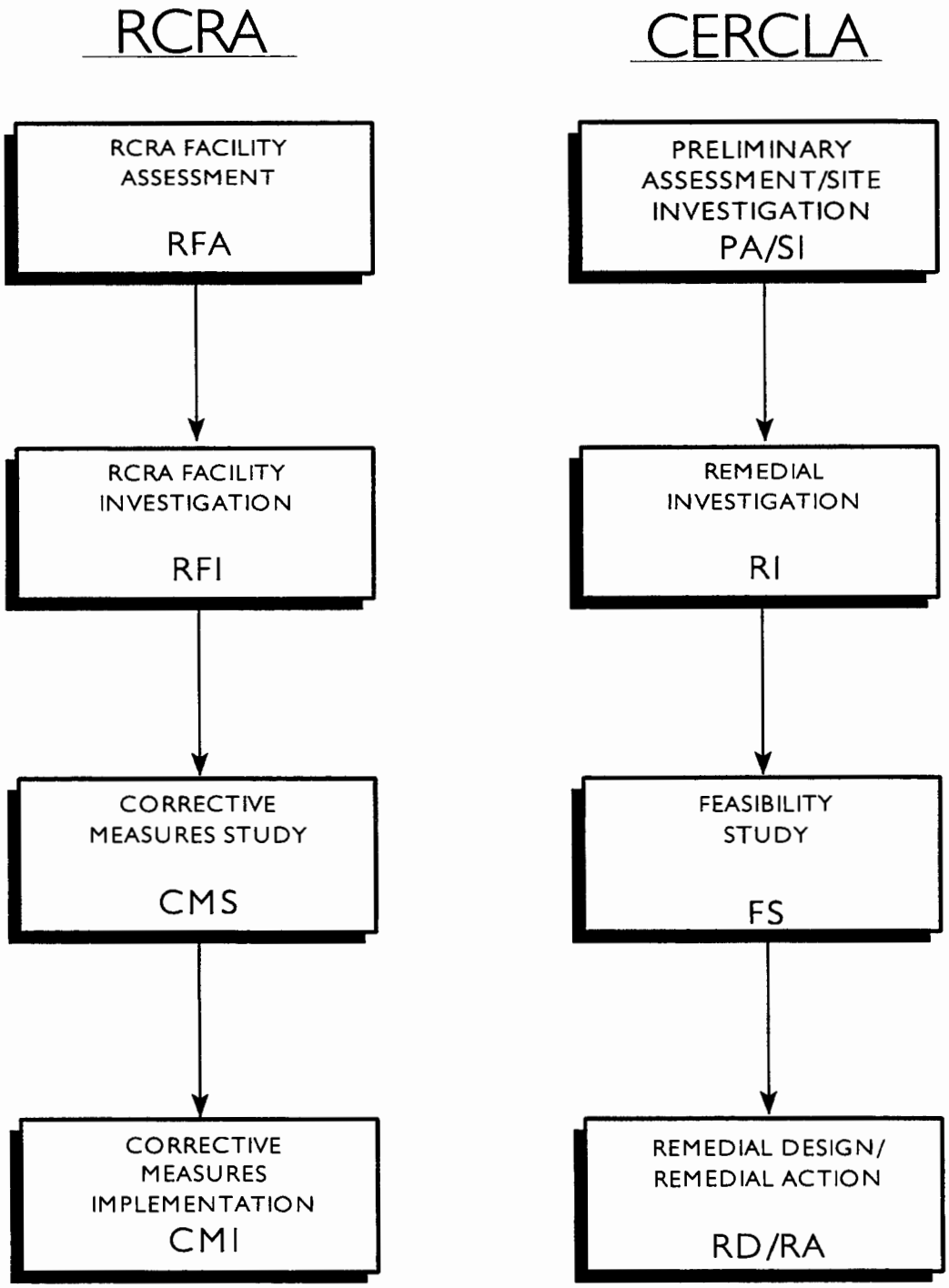


Figure 1-1. Comparison of RCRA Corrective Action and IRP Phases

Table 1-2
Comparison of Key CMS Components with Key CERCLA FS Components

RCRA CMS	CERCLA FS
Description of Current Conditions	Summary of Remedial Investigation
Closure Objectives	Remedial Action Objectives
Screening of Corrective Measures Technologies	Identification and Screening of Technologies
Development of Corrective Measures Alternatives	Development of Remedial Alternatives
Evaluation of Corrective Measures Alternatives • Technical • Environmental • Human Health • Institutional • Cost	Detailed Evaluation of Alternatives • Overall Protection of Human Health and the Environment • Compliance with Applicable or Relevant and Appropriate Requirements (ARARs) • Long-Term Effectiveness/Permanence • Reduction of Toxicity, Mobility, and Volume; Implementability • Short-Term Effectiveness • Cost
Justification and Recommendation of the Corrective Measures	Comparative Analysis and Selection of Preferred Remedial Alternative

Section 2
DESCRIPTION OF CURRENT CONDITIONS

Holloman AFB is situated in south-central New Mexico in the northwest-central portion of Otero County. The Base is located about 75 miles northeast of El Paso, Texas, and about 7 miles west of Alamogordo, New Mexico. The sewage lagoons are located in the southwestern corner of the Base.

The sewage lagoon system consisted of seven aeration/evaporation lagoons. The first three sewage lagoons, Ponds A, B, and C, were aerated. Ponds A and B were generally operated in parallel; occasionally they were operated in sequence to increase residence time. Afterward, the wastewater flowed in series from Pond C through Ponds D, E, and G. Pond F is a sump that recirculated wastewater from Pond E back to the headworks of the system. Discharge from the last sewage lagoon (Pond G) flowed via an open ditch to Lake Holloman.

2.1 Areas and Volumes of the Sewage Lagoons and Sludge Depths

The *Site Characterization Report, Sewage Lagoons Closure Project* (Radian and Foster Wheeler, 1995) summarizes the results of the investigations performed at the Holloman AFB sewage lagoons between 1990 and 1994. Table 2-1 summarizes the estimates of lagoon size and thickness of sludge according to that report. The maximum thickness of the sludge in the sewage lagoons ranges from about 6 in. in Pond F to about 48 in. in Pond E. The total estimated volume of sludge in Ponds A through F is 52,800 yd^3. The sludge, which is primarily the result of domestic wastewater, has a high (55% to 75%) moisture content. When the system was in operation, typical surface water elevations (as compared with mean sea level) ranged from 4037.5 ft in Ponds A and B to 4036.5 ft in Pond E to 4029.9 ft in Pond G.

2.2 Topography

The topography in the region of the southwest portion of Holloman AFB is dominated by the dikes surrounding and dividing the sewage lagoons. In this region, the surface is relatively flat and naturally slopes toward the southwest at less than 0.5% grade. Natural and engineered surface water drainage features circumvent the lagoons and flow directly into Lake Holloman. The main base (developed portion) storm water channel is several feet below grade and runs from northeast to southwest, separating Pond G from Ponds A through F.

The rise of the lagoon dikes over the natural surface features ranges from approximately 1.5 ft on the north end of Ponds A and B to over 10 ft above natural grade on the south end of Pond D.

2.3 Geology and Soils

The soils are either Holloman-Gypsum Land-Yesum, Complex, or Mead silty clay loam soil. The Mead silty clay loam is found in low-lying areas, is less permeable, and sometimes is associated with wetlands, as described in *Soil Survey of Otero County, New Mexico* (USDA Soil Conservation Service, 1981). The surface soils grade into the upper sand unit, which consists of 6 to 40 ft of sand, silt, or silty sand. Clay lenses are common in the upper sand unit. A discontinuous middle clay unit underlies the upper sand. The middle clay is reddish brown with abundant gypsum crystals and ranges from 10 to 40 ft thick where present. A lower sand unit consisting of interbedded sand, clay, and silt lies beneath the middle clay. This unit is lithologically heterogeneous and ranges from 10 to 20 ft thick.

Table 2-1
Summary of Areas and Volumes for the Sewage Lagoons

Sewage Lagoon	Area (acres)	Average Sludge Thickness (ft)	Average Moisture Content of Sludge (%)	Average Water Depth (ft)	Sludge Volume (yd^3)	Total Lagoon Volume (yd^3)
Pond A	10	0.5	70	6.0	8,000	89,000
Pond B	11	0.78	70	6.5	13,800	102,000
Pond C	12	0.88	75	5.4	17,000	88,000
Pond D	18	0.16	70	5.4	4,500	152,000
Pond E	8	0.72	60	4.9	9,200	54,000
Pond F	0.5	0.37	60	5.0	300	3,700
Pond G	39.8	0.38	55	3.4	27,000	219,400

The subsurface conditions at the sewage lagoons were defined by direct sampling and observation of the drilling operations of soil and/or monitor well borings drilled between 1987 and 1993.

The sediments consist of sand, silt, and clay, and are subdivided into six very broadly definable units that appear to be continuous across the site. This interpretation is supported by available data; however, irregularities exist on a smaller scale because of the discontinuous nature of alluvial and lacustrine deposits. Figure 2-1 presents a stratigraphic fence diagram of the sewage lagoons and lakes area.

2.4 Surface Water Hydrology

Holloman AFB is located in the Tularosa Basin, which is a closed basin with no surface water drainage. Lake Lucero, the lowest point in the basin, located approximately 20 miles southwest of Holloman AFB, does not receive surface water from the east side of the Tularosa basin, where Holloman AFB is located.

The Base is crossed by several southwest-trending arroyos that control surface drainage in the undeveloped part of the Base. The arroyos mostly terminate in the gypsum dune fields located in the western portion of the Base.

Most drainage from the main Base (developed portion) runs off through a drainage ditch that bypasses the sewage lagoons and flows to Lake Holloman. The ditch flows most of the year to Lake Holloman. Limited overlap will occur between the wetlands and the ditch.

Lake Holloman and Pond G are impounded playa lakes and are considered Waters of the United States as defined in 40 CFR 122.2. Holloman AFB has submitted a National Pollutant Discharge Elimination System (NPDES) permit application for the new WWTP which will cover the discharge of treated wastewater to Lake Holloman as well as Pond G.

2.5 Regional Groundwater Hydrology

Groundwater occurs in unconfined conditions in the uppermost unconsolidated bolson deposits beneath Holloman AFB. The primary source of recharge for groundwater in the bolson aquifer is percolation of rainfall and stream runoff through the coarse, unconsolidated alluvial fan deposits located near the base of the mountains approximately 10 miles upgradient (east) of

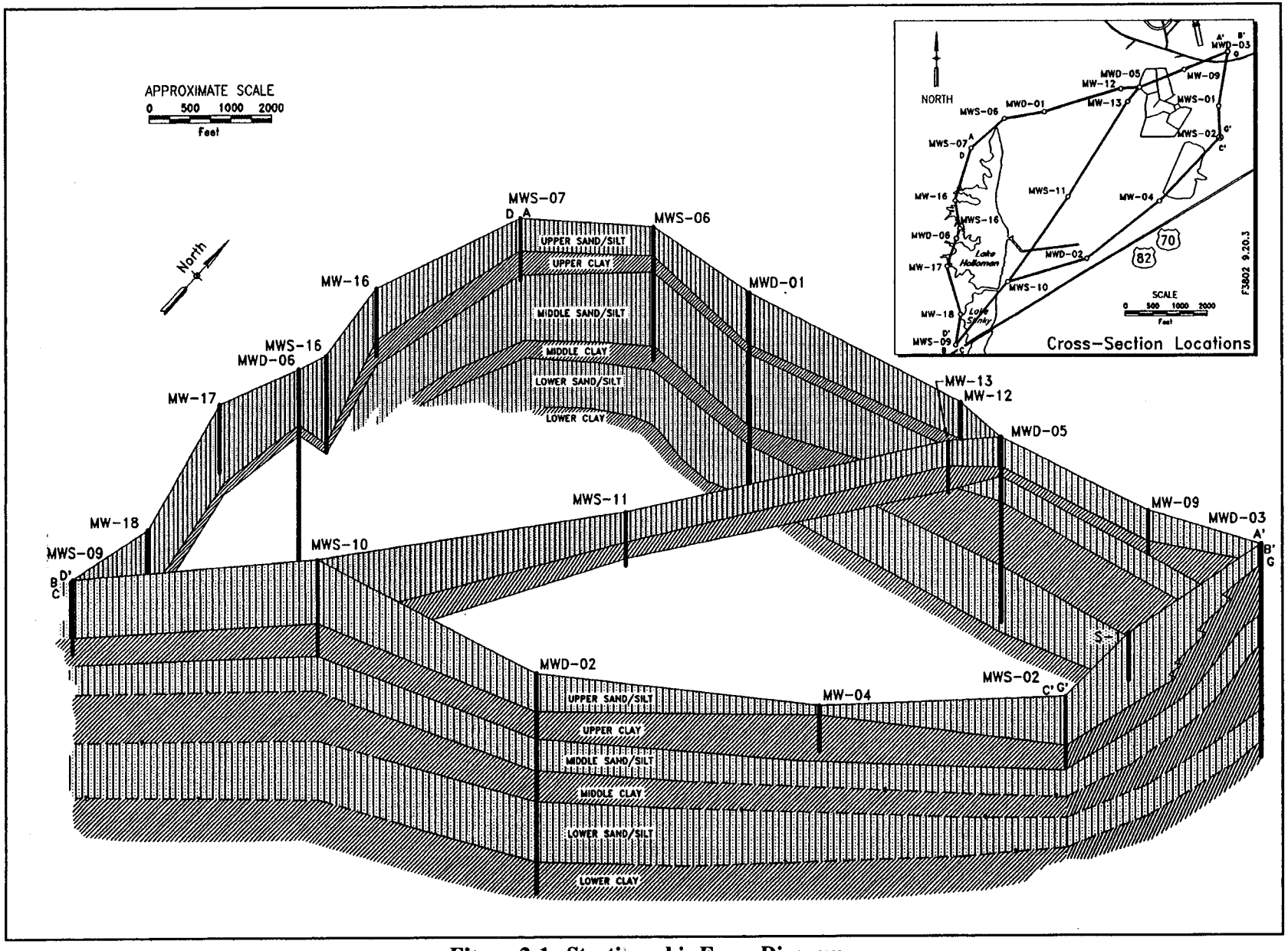


Figure 2-1. Stratigraphic Fence Diagram

Holloman AFB. Groundwater discharge occurs through evapotranspiration or into closed playa lakes such as Lake Lucero, the regional groundwater discharge area.

Regional groundwater flow is to the southwest. Local groundwater flow is seasonally variable and is affected by the relationship between the water table elevation and the elevation of the bottom of the local arroyo channels. In the southeastern portion of the Base, regional groundwater flows to the southwest, following the Dillard Draw surficial drainage system. In the northern portion of the Base, groundwater flows to the west, following the Rita Draw, Malone Draw, and Lost River drainages.

2.6 Local Groundwater Hydrology

The groundwater elevation at the sewage lagoons was surveyed in 1993, 1994, 1995, and 1996 to determine seasonal yearly variation associated with precipitation and evaporation rates at Holloman AFB. As part of that survey, surface water elevations were measured in Ponds A, D, and G and in Lakes Holloman and Stinky to provide data necessary to characterize local relationships between surface water and groundwater. It should be noted that the sewage lagoons created artificial groundwater mounding that is expected to recede after closure. Results of this evaluation are presented in the *Phase I Groundwater Assessment Monitoring Report, Sewage Lagoons and Lakes Investigation* (Radian, 1993). A groundwater contour map is presented in Figure 2-2.

Near the wastewater treatment facility, the depth to groundwater ranges from 2 ft below ground level (bgl) near the sewage lagoons to 13 ft bgl near Lakes Holloman and Stinky. Under an average hydraulic gradient of 0.3, the groundwater flows consistently from the northeast to the southwest. However, surface water in the unlined lakes and lagoons causes groundwater mounding. Immediately to the east of Lakes Holloman and Stinky, groundwater flows to the southeast if the elevation of Lake Holloman surface water is higher than the water table, which occurs most of the time.

According to the *Final Hydrogeologic Investigation Report and Proposed Groundwater Monitoring Plan for the Sewage Treatment Lagoons—Volume 1, Holloman AFB* (Radian, 1989), the geometry of the sediments beneath the sewage lagoons and Lakes Holloman and Stinky is such that no definable lower aquifer boundaries exist.

Several trends in the aquifer in the region at the lagoons were noted from the results of slug tests and pump tests conducted in 1987:

- With increased depth, successive clay and silt units create semiconfining conditions as discussed in the *Long-term Monitoring Plan for the Sewage Lagoons* (Radian, 1995); and
- No evidence of artesian conditions exist in the aquifers below the lagoons.

2.7 Groundwater Quality

Groundwater directly upgradient of the Base (approximately 10 miles) at the recharge zone at the foot of LaLuz canyon is slightly saline, with total dissolved solids (TDS) ranging from 1000 to 3000 mg/L. Groundwater becomes progressively more mineralized as it flows downgradient toward the interior of the basin. This decrease in water quality can be attributed to slow groundwater migration from recharge to discharge areas and the presence of readily soluble minerals in the bolson sediments. TDS exceed 100,000 mg/L in groundwater in some portions of the Tularosa Basin (USGS, 1986).

The groundwater beneath Holloman AFB is designated as unfit for human consumption, based on New Mexico Water Quality Control Commission Regulations (NM WQCC 82-1, as

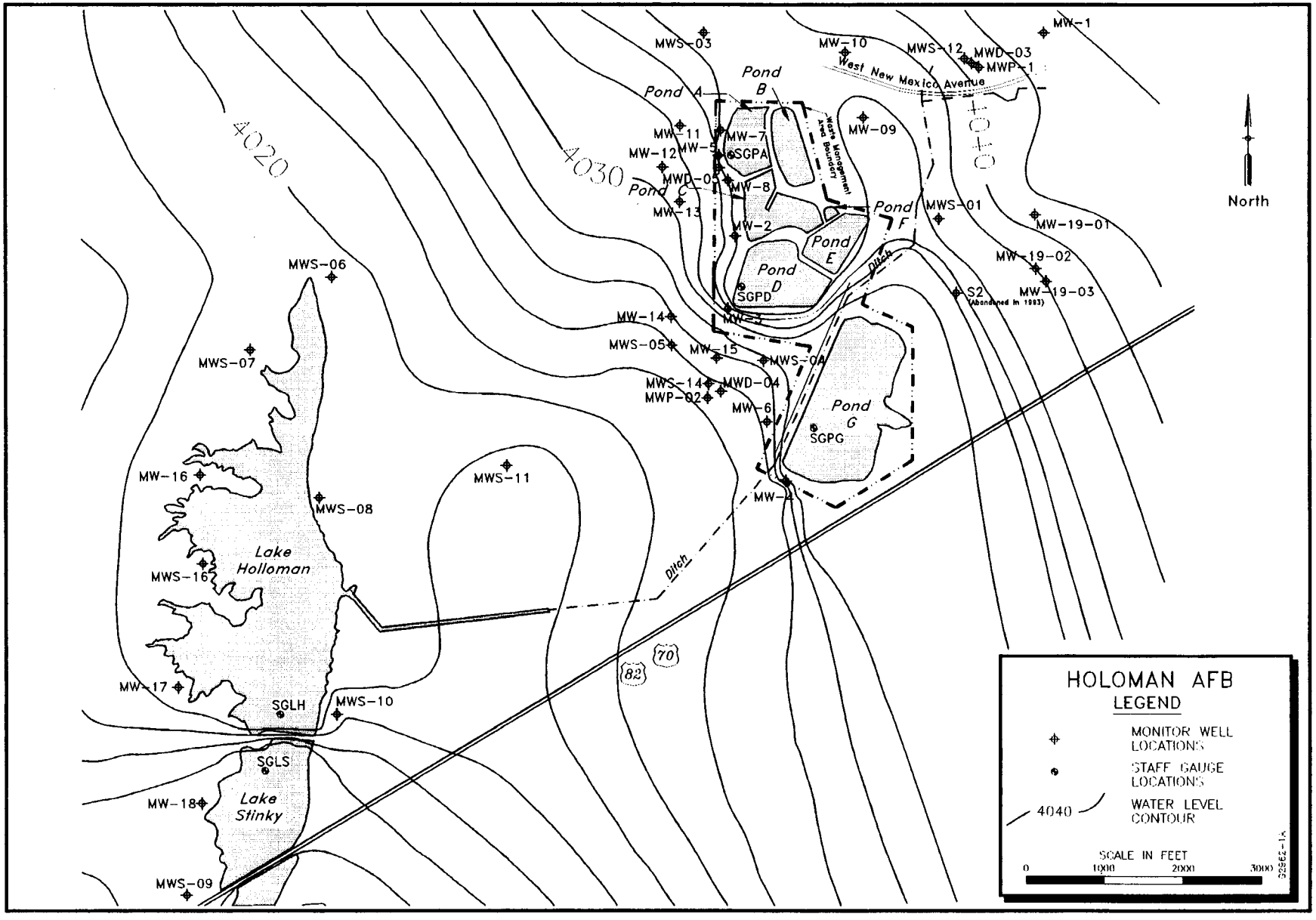


Figure 2-2. Groundwater Contour Map

amended through August 18, 1991 Parts 3-100 through 3-103), because it exceeds New Mexico Human Health Standards (HHSs) for TDS and sulfate. Average values of other groundwater quality parameters measured at Holloman AFB (chloride, fluoride, and nitrate-nitrite) also exceed HHSs and, except for fluoride, also exceed federal primary and secondary drinking water maximum contaminant levels (MCLs; SMCLs). Water quality parameters reflect the fact that the groundwater in this area is not potable under natural conditions.

Although EPA guidelines for groundwater classification (*Guidelines for Groundwater Classification Under the EPA Groundwater Protection Strategy* [EPA, 1986]) are not recognized by the State of New Mexico, the EPA guidelines classify the groundwater beneath Holloman AFB as a Class III B aquifer. Class III groundwater, characterized by having a TDS concentration greater than 10,000 mg/L, is not considered a source or a potential source of drinking water. Class III B groundwater is characterized by a low degree of interconnection to adjacent surface waters or groundwater of a higher class. The average measured TDS value of groundwater at Holloman AFB is greater than 10,000 mg/L, as reported in the *Site Characterization Report, Sewage Lagoons Investigation* (Radian, 1992). Because the Tularosa Basin is a closed basin, its groundwater does not discharge or connect to any adjacent aquifers. Adjacent surface waters include groundwater surfacing in Malone Draw and Lakes Holloman and Stinky. The TDS concentration in Lake Holloman ranges from a winter low of 12,400 mg/L to a summer high of 17,000 mg/L (Cole et al., 1981); therefore, groundwater at Holloman AFB is not interconnected with surface water of a higher class. In the 1993 investigation, TDS concentrations were found to range from 11,000 to 12,000 mg/L in Lake Holloman and were 14,000 mg/L in Lake Stinky.

2.8 Nature and Extent of Release

The historical data summarized in this section are sufficient to demonstrate that the contaminants associated with the sewage lagoons are relatively immobile and are decreasing in concentration. As explained in the *Site Characterization Report, Sewage Lagoons Closure Project* (Radian and Foster Wheeler, 1995), and summarized later in this section, the concentrations of DDT and its derivatives have decreased by approximately one order of magnitude between 1992 and 1994, and are anticipated to continue to decrease. Because the Base has also demonstrated that hazardous constituents have not entered the lagoons since the 1980s, additional sampling is not needed to determine whether or not additional constituents have entered the sewage lagoons since the most recent investigation. Therefore, closure will be based on the results of the previous investigation, and no future investigation or monitoring of the site will be necessary after closure.

2.8.1 Sludge

Sludge samples were collected from the sewage lagoons in 1990 and 1992-1995. Summaries of the analytical results of these investigations are contained in Section 5 of the *Site Characterization Report, Sewage Lagoons Closure Project,* (Radian and Foster Wheeler, 1995). Because of the apparent differences in the character of the sludge contained in Ponds A and B compared with that contained in Ponds C through G, the overall conclusions for these sewage lagoons are discussed separately.

Ponds A and B

Sludge from Ponds A and B has been investigated primarily for PCBs. Sludge found to have PCB concentrations above the Toxic Substances Control Act (TSCA) action level of 25 mg/kg in Ponds A and B during the 1988 investigation was removed in 1990. Subsequent to the sludge removal, confirmation sampling was

performed in 1990 to determine the effectiveness of the removal. The confirmation sampling, along with the 1994 investigation of Ponds A and B, confirmed that sludge PCB concentrations were below the TSCA action level. These investigations also indicated that metal concentrations in the sludge are below the toxicity characteristic (TC) regulatory levels and that the sludge is not characteristically hazardous due to reactivity (i.e., it contains less than 500 mg/kg of reactive sulfides). In addition, metals concentrations are below pollutant concentrations for land-applied sludge in 40 CFR Part 503.13.

Ponds C, D, E, F, and G

Sludge in Ponds C, D, E, F, and G was investigated in 1990 (Pond C only), 1992, and 1994. The sludge was analyzed for Appendix IX constituents in 1990 and 1992. These investigations indicated that organochlorine pesticides and metals were the primary constituents in the sludge. Therefore, the 1994 investigation focused on these constituents.

The only organochlorine pesticides that have been detected above their reporting limits in all of the investigations are 4,4'-DDD and 4,4'-DDE. The concentrations of 4,4'-DDD and 4,4'-DDE, as well as the other constituents that were sporadically detected, have decreased over time.

The investigations also show that 4,4'-DDT, gamma-chlordane, and delta-BHC were detected in the sludge during one or more sampling events. However, these constituents were not detected in all of the investigations, and also appear to have decreased over time. Generally, concentrations of 4,4'-DDT have decreased from concentrations of approximately 100 µg/kg in 1992 to approximately 10 µg/kg in 1994. Concentrations of gamma-chlordane have decreased to either nondetect or to below the reporting limit.

These reductions in 4,4'-DDT, 4,4'-DDD, and 4,4'-DDE can be explained as occurring by both biological and physical phenomena. Biologically, 4,4-DDT can be reduced to 4,4'-DDD and eventually to 4,4'-DDE by anaerobic bacteria as described in *Microbial Ecology* (Atlas and Bartha, 1987). Bacteria use the energy associated with the contaminant's chemical bonds for growth and reproduction. Physically, dechlorination of 4,4'-DDE may result through photolysis as described in *Abiotic Transformations in Water, Sediments, and Soil* (Wolfe, Mingelgrin, and Miller, 1990). Also, the sludge that has been deposited since the 1980s has not contained these constituents, because the Base has taken actions to prevent the discharge of chemicals into the wastewater system.

The 1994 investigation showed that the toxicity characteristic leaching procedure (TCLP) concentrations for all metals were well below the TC regulatory levels. Therefore the sludge is not considered TC hazardous. The 1994 investigation also indicated that the Pond C sludge is not characteristically hazardous due to reactivity. The maximum potential TCLP concentrations for samples from Ponds D, E, and G were calculated by dividing the total concentrations by 20 and comparing the value with TC regulatory levels, as per guidance in Method 1311 TCLP (40 CFR Part 261, Appendix II). Using this approach, referred to as the "20 times rule," it was determined that Ponds D, E, and G do not contain metal constituents in concentrations that could potentially exceed the TC regulatory levels. Therefore, no samples from these sewage lagoons were analyzed for TCLP because the sludge does not have the potential to be TC hazardous. In addition, metals concentrations are below the pollutant concentrations for land-applied sludge, as defined in 40 CFR Part 503.13, which indicate that the metals would not cause an unacceptable risk even if the sludge was spread on the land surface.

Sludge samples collected in 1994 from Ponds C and G were analyzed for kepone because a previous investigation indicated that it may be

present in the sewage lagoons. Eight samples from Pond C and 12 samples from Pond G were analyzed for kepone. Only one sample from each of the two sewage lagoons contained a detectable concentration of kepone. However, the results were below the 70-μg/kg reporting limit.

2.8.2 Soil

Soil samples were collected from Ponds A, B, and C in 1990, and from Ponds C, D, E, F, and G in 1992. Similar to those found in the sludge, the constituents found in the soil were generally limited to organochlorine pesticides and metals. However, the concentrations in soil were significantly lower than those in sludge. 4,4'-DDD and 4,4'-DDE were detected in Ponds C, D, E, F, and G but not in Ponds A and B. Other organochlorine pesticides detected in the soil include 4,4'-DDT, gamma-chlordane, beta-BHC, gamma-BHC, delta-BHC, aldrin, endosulfan sulfate, endosulfan II, and heptachlor epoxide, but many of these constituents were detected below their reporting limits during one or more investigations. The concentrations of these constituents are typically at least one order of magnitude lower in the soil than in the sludge.

A comparison of the results of inorganic analyses for soil samples indicates that several of the metals were detected at concentrations above the 1993 background upper tolerance limit (UTL). However, calculations of the maximum possible TCLP concentrations, according to the "20 times rule," indicate that none of the metals exceed TC regulatory levels.

2.8.3 Surface Water

Surface water samples were collected from the sewage lagoons in 1990, 1993, and 1994 (Pond B in 1990 only). Summaries of the analytical results of these investigations are presented in Section 5 of the *Site Characterization Report, Sewage Lagoons Closure Project* (Radian and Foster Wheeler, 1995). The results of the 1990 and 1993 investigations indicated that metals were the primary constituents of concern in the surface water and organochlorine pesticides existed in parts per trillion range. The 1990 investigation also found unconfirmed concentrations of organic lead; concentrations of organic lead exceeded those for total lead, and similar concentrations were detected in the equipment rinsate samples. In the 1994 investigation, organic lead was not detected even though a methodology with a lower detection limit was used, which indicates that the 1990 results for organic lead were not reliable. All constituents above reporting limits in the surface water are below MCLs.

2.8.4 Groundwater

A groundwater detection monitoring system was installed as part of the FFCA requirement and for the RCRA compliance. Background concentrations were developed on an accelerated schedule and collected during August, September, November, and December 1989. Semiannual monitoring sampling continued in January and July 1990 (a resample was also collected in September 1990), and January 1991. Detection monitoring indicated a potential release of TOC downgradient of Ponds A and B. Therefore, assessment monitoring was required.

As part of assessment monitoring, samples were collected in September 1991 from the monitor well network and analyzed for Appendix IX organic constituents and total organic carbon (TOC). Results of this sampling indicated the presence of primarily organochlorine pesticides. TOC and dissolved organic carbon (DOC) were also detected in several samples. Results showed no strong correlation between the presence of TOC/DOC and waste-specific organic contaminants. TOC can reasonably be present as a result of biological activity (e.g., decomposing organic matter) occurring in the domestic wastewater treatment system.

Subsequent discussion of the Appendix IX sampling results with NMED concluded that

organochlorine pesticides were the only contaminants of concern, and that confirmation sampling should be conducted to confirm the presence of these constituents in the groundwater. The confirmation sampling was conducted in February 1992 for SW-846 Method 8080 compounds. Results of the confirmation sampling indicated that two organochlorine pesticides, alpha-BHC and delta-BHC, are present in the groundwater in monitor wells MW-5 and MW-7 respectively. Therefore, an investigation of the extent was required downgradient of MW-5, MW-7, and MW-03. Analytical results are presented in *Results of Confirmation Sampling and Comparison to Appendix IX Sampling, Assessment Monitoring Program*, (Radian, 1992a).

The extent of contamination was defined in the subsequent investigation and results are documented in the *Groundwater Assessment Monitoring Report* (Radian, 1993). Holloman has subsequently initiated a long-term monitoring program for the lagoons. The *Long-term Monitoring Plan* (Radian, 1995) (LTM Plan) and *Long-term Monitoring Report* (Radian, 1996) document the plan and the results, respectively. All concentrations are below health-based levels presented in the LTM Plan.

2.9 Risk Assessment Results

A risk assessment for each sewage lagoon was prepared in 1993 (Radian, 1993) on the basis of existing data. Biological tissue samples were collected in 1993; however, these samples were not available at the time the 1993 risk assessment was prepared. Because several uncertainties existed in the analytical data that were used to estimate risks in the 1993 risk assessment, an additional investigation was conducted at the sewage lagoons in 1994. The risk assessment was updated in a March 1996 addendum using the results of the 1994 investigation, the biota data, and the supportable data from previous investigations.

The exposure scenarios evaluated in the risk assessment addendum for the sewage lagoons included the following:

1) Current on-site worker (chronic and subchronic) for Ponds A through G;

2) Current/Future recreational—Hunters (chronic and subchronic) for Pond G only; and

3) Current/Future Trespasser—Teenager (subchronic) for Pond G only.

2.9.1 Human Health Site-Specific Risk Assessments

The EPA Superfund site remediation goal set forth in the National Contingency Plan established cancer risks of 10^{-4} to 10^{-6} as acceptable levels for known or suspected carcinogens. This range is designed to protect human health. For noncarcinogens, there may be potential for noncancer effects when the hazard index exceeds 1.

Cancer risk estimates for the lagoons are below or well within the acceptable risk range of 10^{-4} to 10^{-6} established by the EPA. The estimated noncancer hazard index at all sites and for all exposure scenarios is less than 1. It should be noted that arsenic concentrations in the soil beneath the sewage lagoons are within the background range expected, and are below the UTL of 6.88 mg/kg for arsenic in soil at Holloman AFB. However, even the background concentration of arsenic at Holloman AFB has the potential to cause some risk for a residential scenario.

For a residential scenario, exposure pathways could be controlled by covering the sludge in the sewage lagoons with a minimum 12 in. soil cover. Because the land use in that area is restricted by its location in the runway clear zone, and because the sludge would not provide sufficient structural stability, no residences will be constructed in the area.

2.9.2 Ecological Risk Assessment

Ponds A through F were not evaluated in the ecological risk assessment because they will be closed and will not serve as a habitat for aquatic wildlife. Pond G was the only sewage lagoon included in the ecological risk assessment because it is an important wildlife habitat that the stakeholders have suggested should remain open.

DDT and its derivative, DDE, were the only constituents found to have the potential to cause adverse effects in Pond G. These constituents are no longer used at the Base. Furthermore, the concentrations of DDT in the sewage lagoons decreased by an order of magnitude between 1992 and 1994, as is documented in the *Site Characterization Report* (Radian and Foster Wheeler, 1995). It is unlikely that the survivorship and productivity of the aquatic food chains are threatened. For instance, it has been determined that DDT concentrations detected in the tissue of waterfowl from Pond G are unlikely to cause concentrations in eggs that would be detrimental to reproductive success (Foster Wheeler, 1996).

Because only slight ecological risks were indicated in the risk assessment for Pond G, and because Pond G is an important wildlife habitat, there does not appear to be a need to conduct closure activities at this lagoon. Furthermore, the results of the *Biological Resources Report* (Radian and Foster Wheeler, 1996a), which was prepared to assess the effects of closing the sewage lagoons to selected threatened or endangered animal and plant species, indicate that activities such as sludge removal would be disruptive to the wildlife that use Pond G as habitat.

Section 3
CLOSURE OBJECTIVES AND CLOSURE CRITERIA

The closure objectives focus on preventing exposure to the sludge in the sewage lagoons. As discussed in the stakeholders closure meeting, the closure of Ponds A through F will be considered and evaluated separately from Pond G, because Pond G is an important wildlife habitat and the stakeholders are interested in keeping it open. As described in the *Long-term Monitoring Plan* (Radian, 1995) and discussed in Section 2, groundwater contamination is not a problem. Furthermore, the groundwater at Holloman AFB is designated as unfit for human consumption, based on the NM WQCC regulations, because it exceeds New Mexico HHSs for TDS and sulfate. Restoration of groundwater is not considered necessary or a closure objective.

3.1 Closure Objectives

The closure objectives for the sewage lagoons include the following:

- Ensure the protection of human health and the environment at the sewage lagoons after closure;
- Provide an adequate habitat for the wildlife associated with the sewage lagoons; and
- Ensure that closure eliminates disease vectors (e.g., mosquito habitats) and odors that may be associated with the sewage lagoons and that the closure is aesthetically suitable.

3.2 Closure Criteria

The closure criteria for the sewage lagoons include the following:

- Protect human health and the environment;
- Control or eliminate the source of contamination;
- Comply with applicable waste management standards; and
- Prevent human exposure to constituents in soil and/or sludge that would lead to an unacceptable risk for a residential exposure scenario.

These criteria follow the RCRA corrective action methodology. The results of the *Risk Assessment Addendum* (Radian and Foster Wheeler, 1996b), which are discussed in Section 2.9, support the closure of the sewage lagoons under these criteria.

3.3 Discussion of Potentially Relevant Requirements

This section provides a brief overview of the federal and state requirements and guidance documents that may apply to the closure of the Holloman AFB sewage lagoons. Each regulation and guidance document cited below is discussed individually as it may apply to the lagoons. A description of the overall approach to closure incorporating all of these regulations is presented in Section 1.3.

3.3.1 FFCA

Holloman entered into a FFCA with EPA and NMED on 20 December 1988. Violation Number 10 listed on this FFCA is "Failing to submit for approval an adequate closure plan for hazardous waste surface water impoundments," referring to the lagoons. This is the only open violation remaining in the FFCA. To comply with the FFCA, Holloman AFB must certify the completion of closure of the lagoons with NMED.

3.3.2 RCRA

The sewage lagoons are regulated as RCRA HWMUs. The classification as a HWMU is based on the contention by EPA Region VI and NMED that the sewage lagoons allegedly received

listed hazardous wastes after the applicable date of the substantive RCRA rules (19 November 1981). Because of this classification, the closure of the sewage lagoons falls under regulation 40 CFR Part 265. A 6 April 1994 letter from NMED initially indicated that 40 CFR Part 264 should be applied, but NMED clarified during the stakeholders closure meeting in April 1996, that closure is regulated under Part 265.

3.3.3 CERCLA

The CERCLA requirements apply to the sewage lagoons at Holloman AFB because they are identified by the Air Force as an IRP site. The IRP was established to investigate potential former waste sites at DoD installations and to comply with the provisions of CERCLA. Consequently, all of the activities for investigation and remediation of the lagoons must be consistent with the provisions of CERCLA and the NCP.

The lagoons are currently at the RCRA corrective action equivalent of the FS stage of the CERCLA process, having met all recommended milestones up to this point. Holloman AFB is submitting this CMS to satisfy the FS portion of CERCLA guidance which, as stated previously, is compatible with RCRA corrective action guidance.

3.3.4 State of New Mexico Hazardous Waste Regulations

Title 20 Chapter 4 Part 1 of New Mexico's state regulations adopts federal regulations as promulgated in 40 CFR Parts 261 through 281 with few exceptions noted. Therefore, complying with the federal regulations for hazardous waste will meet the requirements of the State of New Mexico.

3.3.5 State and Federal Water Quality Regulations

The discharge to Pond G—the only sewage lagoon that will remain open—will be regulated under the NPDES permit for the new WWTP, which will be in operation by the fall of 1996. Surface water quality for the entire sewage lagoons area will be regulated under the Basewide NPDES storm water permit. In the 29 September 1995 *Federal Register*, the EPA released the final Multi-Sector General Permit (MSGP) for Industrial Activities. The permit lists industry-specific requirements for effluent limitations, storm water pollution prevention plans, and monitoring requirements. Holloman AFB will implement the requirements listed in the MSGP Sector L (Landfills and Land Application Sites) as part of their storm water NPDES compliance activities. (*Federal Register*, September 29, 1995, Volume 60, No. 189, Book 2, Section VIII.L)

3.3.6 Human Health Standards

Any remediation-related activities conducted at the sewage lagoons would require compliance with the requirements in 29 CFR Section 1910.120. These regulations require that personnel receive appropriate training for working at sites where there is the potential for hazardous materials or conditions to be present. These regulations also require the use of personal protective equipment to prevent exposure to hazardous materials.

3.3.7 Wetlands

Ponds A through F are constructed facilities that are not Waters of the United States. Pond G is considered Waters of the United States, but it is currently exempt from Section 404 of the Clean Water Act because it is part of the existing wastewater treatment system. Pond G will be a receiving water for the new WWTP after closure is complete. The discharge from the new WWTP will be required to be an NPDES-permitted outfall for the new WWTP. Any dredging or backfilling would require a Clean Water Act Section 404 permit.

Section 4
TECHNOLOGY SCREENING AND ALTERNATIVES DEVELOPMENT

It is the intent of this document to present a focused discussion of the identification of applicable closure actions and technologies and the development of appropriate alternatives. It is not the intent of this document to review an exhaustive list of technologies that have little or no applicability to this site. As suggested by NMED in the stakeholders closure meeting and generally agreed by the other participants, the CMS will focus on practical alternatives that meet the objectives for closure of the sewage lagoons.

4.1 Development and Screening of Closure Actions

This section of the CMS focuses on the development of appropriate closure actions for the sewage lagoons. The results of the risk assessment indicate no unacceptable risks to human health and the environment, and any currently acceptable risks can be further reduced by eliminating the exposure pathways. On the basis of the risk assessment results, alternatives that involve treatment of the sludge are not required. Alternatives are developed that have the potential to meet the closure objectives by 1) ensuring the protection of human health and the environment, 2) providing an adequate wildlife habitat, and 3) ensuring that closure controls disease vectors and is aesthetically suitable.

4.1.1 Development of Potential Closure Actions

Holloman AFB has decided that Ponds A through F will be removed from service. The alternatives for closing Ponds A through F will center on how to remove them from service in such a way that the closure objectives and criteria can be met.

It has also been decided that Pond G will remain in use because it is a wetland as well as an important ecological habitat. The risk assessment results (Radian and Foster Wheeler, 1996b) indicated that no unacceptable human health or ecological risks are associated with Pond G. There is a slight potential for black-necked stilts to have increased levels of DDE in their tissues; however, the *Site Characterization Report* (Radian and Foster Wheeler, 1995) has shown that concentrations of DDT and its derivatives are decreasing rapidly. On the other hand, the results presented in the *Biological Resource Report* (Radian and Foster Wheeler, 1996a) indicated that adverse effects would likely be associated with removal of sludge from Pond G. On the basis of the stakeholders concerns for keeping Pond G open, the low constituent concentrations, and the absence of unacceptable risk, closure actions involving excavation of sludge are not carried forward for Pond G.

Closure actions that could be considered include the following:

- No action;
- Institutional action;
- Containment;
- In situ treatment;
- Excavation and disposal; and
- Excavation, treatment, and disposal.

4.1.2 Screening of Closure Actions

These closure actions have been screened to represent those that are most appropriate for the given site conditions and closure objectives. The screening criteria include the consideration of the following:

- Site characteristics;
- Waste characteristics;
- Technology limitations; and
- Cost.

No Action

This closure action involves no actions other than removing Ponds A through F from service. It may also involve some type of environmental monitoring. This closure action will not, by itself, meet the third objective: "Ensure that closure eliminates disease vectors (e.g., mosquito habitats) and odors that may be associated with the sewage lagoons and that closure is aesthetically suitable." The no action closure action is retained for further consideration to provide a baseline with which the other closure actions can be compared.

Institutional Action

This closure action provides some type of access restriction such as land use restrictions or deed restrictions. It may also involve some type of environmental monitoring. This closure action will not, by itself, meet the third objective: "Ensure that closure eliminates disease vectors (e.g., mosquito habitats) and odors that may be associated with the sewage lagoons and that closure is aesthetically suitable." Institutional actions are retained, however, to be used in conjunction with other closure actions.

Containment

Containment involves the prevention or minimization of potential risk to human health and the environment by eliminating the exposure pathway. Containment will also prevent or minimize the release of contaminants from the site through surface water or wind erosion. This action is appropriate for consideration because of the low concentrations of constituents and the absence of unacceptable risk at the site. It is also cost effective and effective in controlling disease vectors. The containment action is retained for further consideration for Ponds A through F. It is not retained for Pond G, because of the importance of keeping that lagoon open.

In Situ Treatment

In situ treatment allows treatment of the affected sludge and sediments without excavation of the contaminated media. This could include such technologies as physical treatment, chemical treatment, thermal treatment and biological treatment. In situ treatment would not alone meet the closure objectives and would have to be used in combination with another action such as containment. There is no unacceptable risk at the site, and the levels of constituents are too low to justify treatment, which is an expensive action. Treatment would not provide any added value. Treatment would be used only to address disease vectors, which is not part of RCRA requirements. Since containment alone appears to meet the closure objectives, in situ treatment is eliminated from further consideration because it does not provide added risk reduction or other benefits.

Excavation and Disposal

Excavation and disposal could involve excavating the contaminated sludge and then disposing of the material at an approved facility. The contaminated material could also be excavated from one lagoon and placed in another lagoon to consolidate the material. Off-site disposal would cause significant logistical problems because up to 3000 20-cubic-yard truckloads of sludge from Ponds A through F might potentially require disposal. It would be expensive to excavate and dispose of the material in a permitted facility. Land disposal restrictions would have to be met. Because there is no unacceptable risk at the site, there would be no added value for this action. Therefore, excavation and disposal as a closure action will be retained only to the extent that the sludge could be relocated and consolidated within a lagoon or from one lagoon to another.

Excavation, Treatment, and Disposal

Excavation, treatment, and disposal would involve excavating the contaminated sludge as discussed above and would include an additional step of treating the contaminated material prior to disposal. Treatment could include physical, chemical, thermal, or biological technologies. There is no unacceptable risk at the site, and the

levels of constituents are too low to justify treatment, which is an expensive action. Treatment would be used only to address disease vectors, which is not part of RCRA requirements. This action would not provide any added value. Disposal, which could be either on site or off site, would have to comply with land disposal restrictions. Off-site disposal would cause significant logistical problems because up to 3000 20-cubic-yard truckloads of sludge from Ponds A through F might potentially require disposal. This closure action is eliminated from further consideration since it is very expensive and does not provide any advantage to this site, given the contaminants and site conditions.

4.2 Screening of Technologies

Appropriate technologies that support the remaining closure actions and that will help meet the closure objectives include the following:

Institutional Action

- Land use restrictions.

Containment

- Soil cover.

Excavation and Disposal

- Excavation of sludge; and
- Disposal of sludge in one of the other lagoons or in another area of the same lagoon.

The technologies listed above are considered viable technologies to use in the development of alternatives. These technologies individually may not meet the closure objectives but, when combined with other technologies, will form alternatives that do meet the closure objectives and criteria.

4.3 Development of Closure Alternatives for Ponds A Through F

The following sections describe the closure alternatives that have been developed using the technologies described above and represent the range of alternatives that were developed to meet the closure objectives. The evaluation of these alternatives is presented in Section 5.

4.3.1 Alternative AF1: No Action

This alternative is included to provide a baseline against which other alternatives can be compared as required by the CMS guidance. The no action alternative consists of removing Ponds A through F from service and letting the water infiltrate and evaporate naturally.

4.3.2 Alternative AF2: Containment—Backfill to Top of Berms

This alternative involves draining the water from the lagoons, dewatering the sludge to the extent that it has sufficient structural stability to support the backfill, and then backfilling the lagoons to the top of the existing berms.

The first step involved with implementing this alternative is to shut off the influent to Ponds A and B and to redirect this flow to the new WWTP. This step has already been accomplished. The water in Ponds D, E, and F has been pumped to Ponds A and B, and the water in Ponds A, B, and C is being allowed to infiltrate and evaporate naturally. It is estimated that in November 1996 the lagoons contained approximately 60,000,000 gal. of surface water and that it will take over 6 months for this water to infiltrate and evaporate. A discussion of this calculation is included in Attachment A. Holloman AFB will explore options for removing the water from Ponds A, B, and C more quickly.

Once the surface water has been removed, the sludge will be dewatered. Natural evaporation will play an important part in the sludge dewatering. Current data indicate that the sludge thicknesses in Ponds A through F range from 2 to 48 in. Mixing and turning the sludge with dozers will help with the natural dewatering process. This process can be expedited by mixing soil with the

sludge. If necessary, soil or commercial chemical additives may be mixed with the sludge to reduce odors. Considerations will be given to applying such techniques to all the sludge in Ponds A through F as well as selective use of such techniques depending on the thickness and nature of the sludge (e.g., Ponds A and B only).

Ponds A through F will be backfilled once the sludge is dewatered sufficiently. Clean soil from other locations on the Base will be trucked to the site and placed in the lagoons. This soil will be spread and compacted using standard backfilling techniques and standard earth-moving equipment. The finished surface of the compacted backfill will be graded to provide for adequate drainage. Finally, 6 in. of topsoil will be applied and the area will be vegetated. It is estimated that approximately 1,200,000 yd^3 of backfill and 62,000 yd^3 of topsoil will be required. These calculations are included in Attachment A. Care will be taken to minimize erosion and to control dust during closure activities.

The final contours for Alternative AF2 are shown in Figure 4-1. Typical sections of the backfilled lagoons are shown in Figure 4-2.

Once the closure is completed, the land use for the lagoon area will be restricted open space. The area will be fenced and will remain a restricted area since it is in a designated runway clear zone. This land use cannot be changed unless the potential risks associated with the new land use are reevaluated and the land use designation is changed in the Base Comprehensive Plan (BCP).

Long-term operation and maintenance could involve regrading because of settlement or erosion, and reseeding areas as required. Storm water in this area would be monitored as specified. It may be necessary to provide a system to water the vegetative cover.

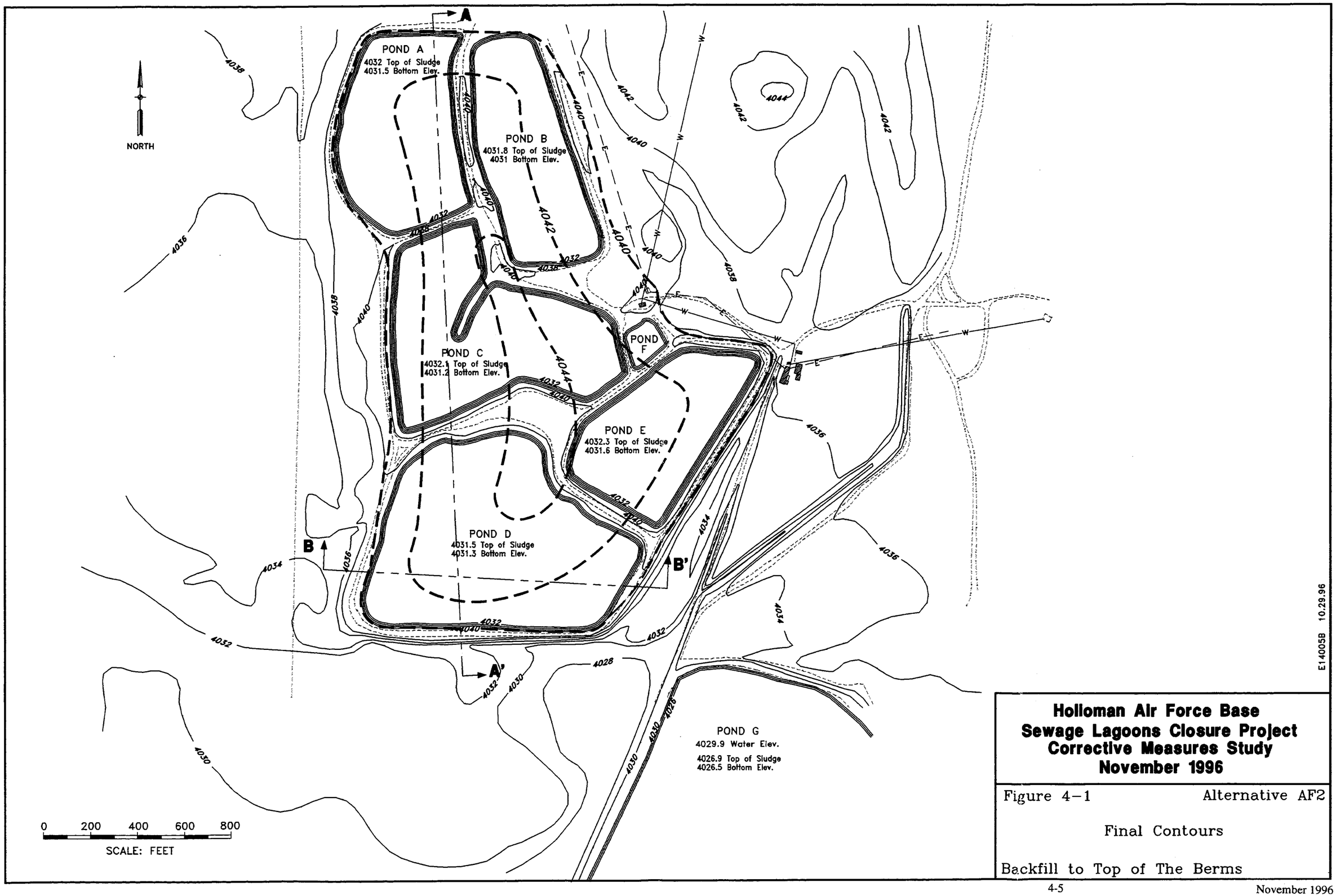
4.3.3 Alternative AF3: Containment—Restore to Natural Contours

Alternative AF3 is similar to Alternative AF2 except that the berms elevated above grade around the lagoons will be removed and placed in the lagoons as a soil cover so that the site can be restored to the approximate natural contours, as shown in Figures 4-3 and 4-4. Although the area will be graded and seeded, topsoil will not be required. It is estimated that approximately 200,000 yd^3 of soil will need to be excavated from the berms and placed in the lagoons. Additional fill material from off site may be needed, especially if the construction for some areas requires a certain type of material (e.g., crushed concrete) that is not available on site. The contours in the final design may differ slightly from those shown in Figures 4-3 and 4-4. The final design may also consider the use of riprap or geotextile products for erosion control.

4.4 Development of the Closure Alternative for Pond G—Alternative G1: No Action

Pond G is an important wildlife habitat that the stakeholders generally agreed should remain open. Because the risk assessment results have indicated no unacceptable human health or ecological risks, only the no action alternative has been developed for Pond G. The evaluation of this alternative is presented in Section 5.

The no action alternative consists of shutting off the influent to Ponds A and B, which effectively shuts off flow to Pond G. A pipeline from the new WWTP will be installed by July 1997 that will pump effluent from the WWTP to Pond G. This will ensure that Pond G continues to receive water and will continue to provide the ecological habitat that it does currently.



Holloman Air Force Base
Sewage Lagoons Closure Project
Corrective Measures Study
November 1996

Figure 4–1 Alternative AF2

Final Contours

Backfill to Top of The Berms

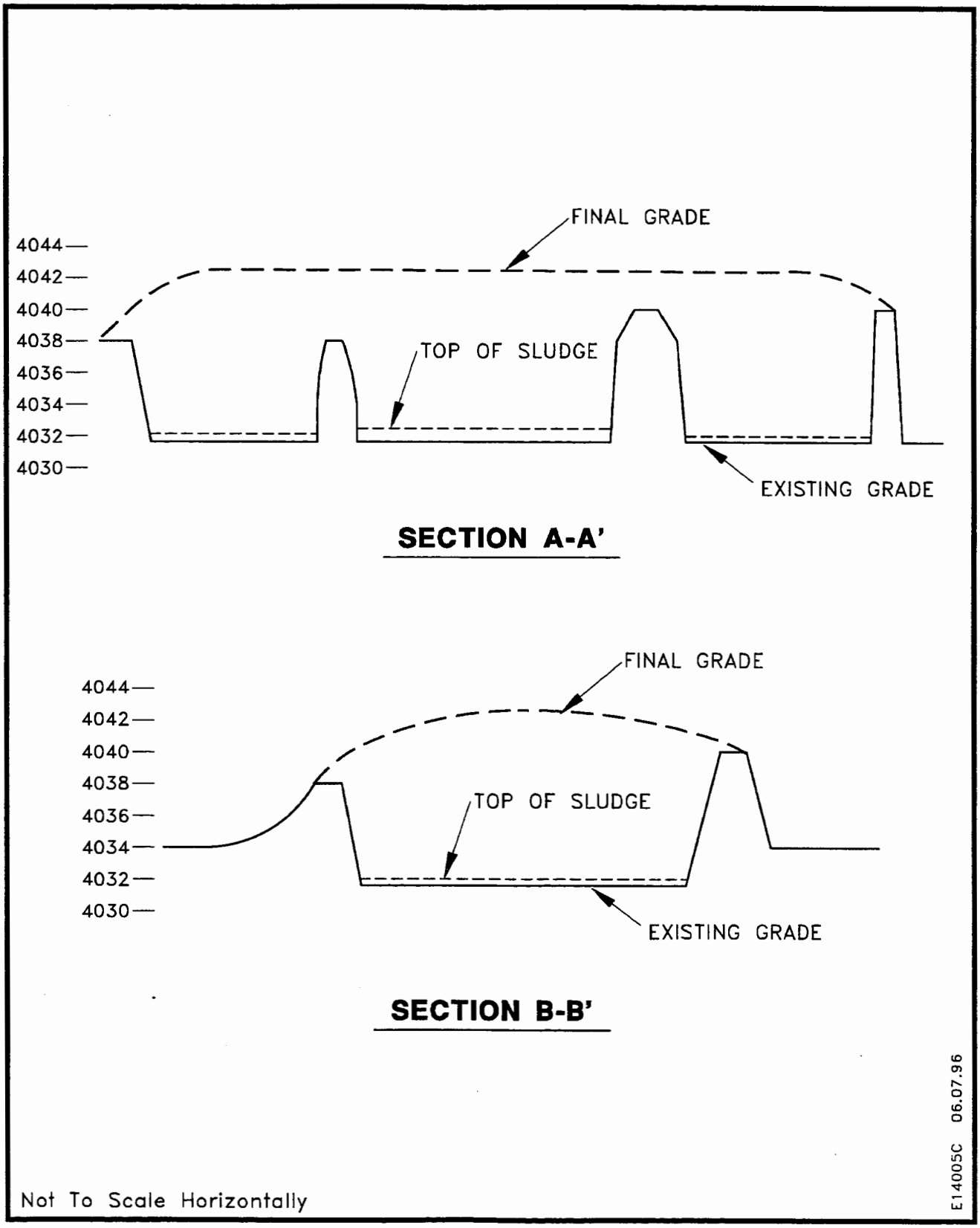
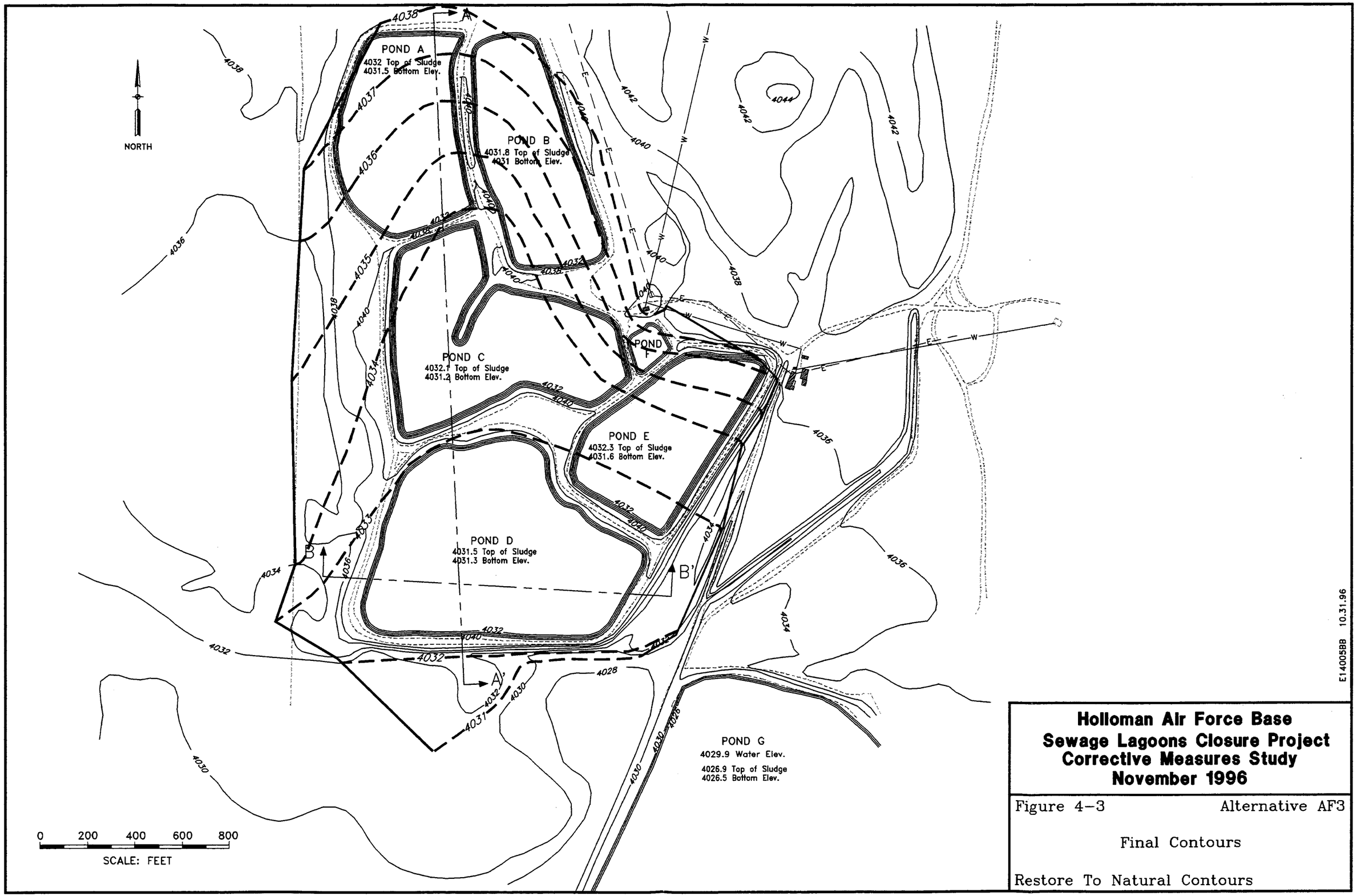


Figure 4-2. Typical Cross Sections—Alternative AF2: Backfill to Top of Berms



Holloman Air Force Base
Sewage Lagoons Closure Project
Corrective Measures Study
November 1996

Figure 4-3 Alternative AF3

Final Contours

Restore To Natural Contours

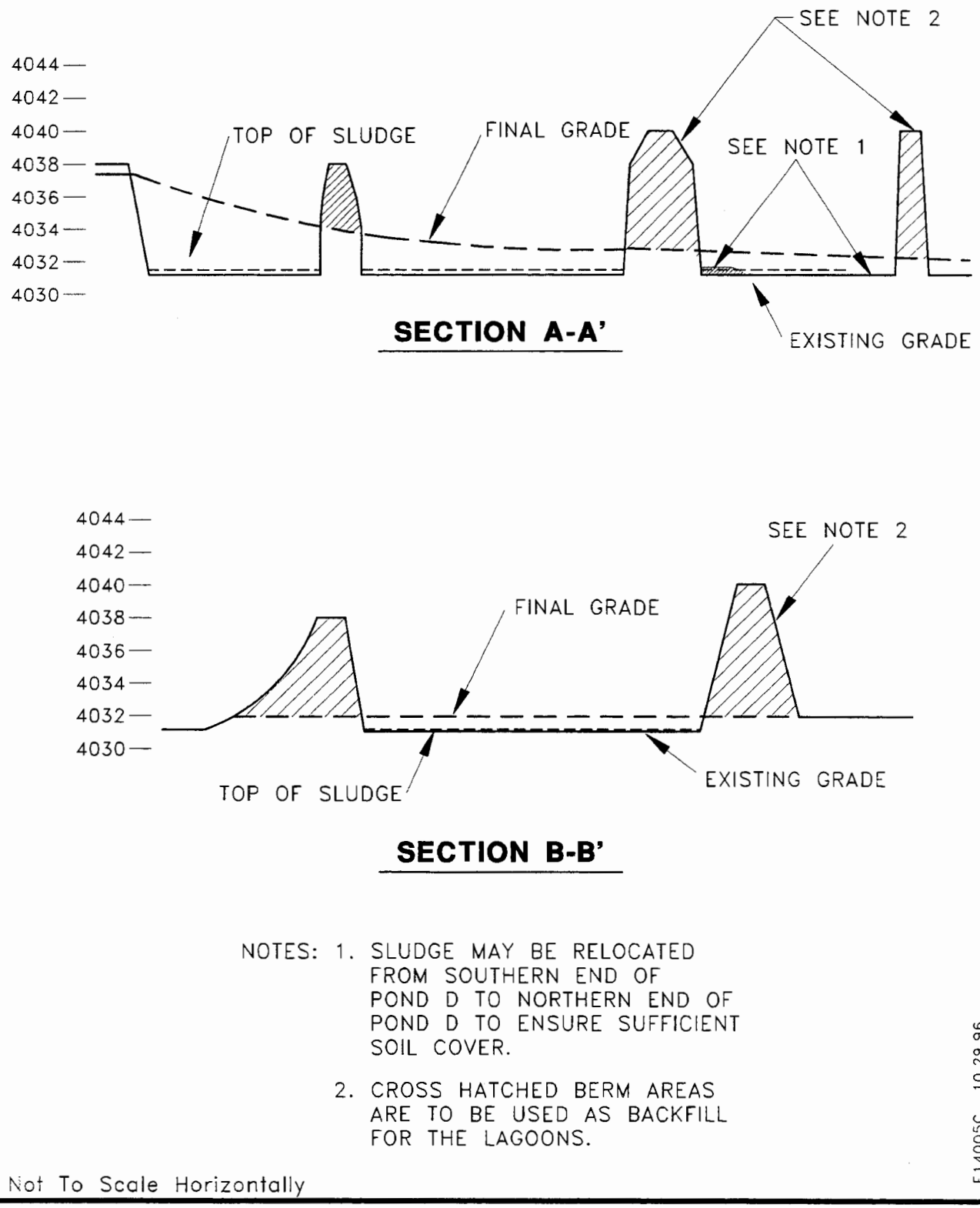


Figure 4-4. Typical Cross Sections—Alternative AF3: Restore to Natural Contours

Section 5
EVALUATION OF CLOSURE ALTERNATIVES

This section provides a focused evaluation of the ability of the closure alternatives developed in Section 4 to meet the closure objectives and closure criteria that were discussed in Section 3 of this report.

5.1 Closure Objectives and Criteria

As stated in Section 3, the closure objectives for the sewage lagoons include the following:

- Ensure the protection of human health and the environment at the sewage lagoons after closure;
- Provide an adequate habitat for the wildlife associated with the sewage lagoons; and
- Ensure that closure eliminates disease vectors (e.g., mosquito habitats) and odors that may be associated with the sewage lagoons and that the closure is aesthetically suitable.

The closure criteria for the sewage lagoons include the following:

1) Protect human health and the environment;

2) Control or eliminate the source of contamination;

3) Comply with applicable waste management standards; and

4) Prevent human exposure to constituents in soil and/or sludge that would lead to an unacceptable risk for a residential exposure scenario.

5.2 Evaluation Criteria

Each of the alternatives is evaluated on the basis of its ability to meet the above closure criteria in accordance with preestablished evaluation criteria. The evaluation is based on technical, environmental, human health, and institutional criteria.

5.2.1 Technical

The technical evaluation involves considering the performance, reliability, implementabilty, and safety of each alternative.

Performance

Performance is a measure of the effectiveness and useful life of the alternative. Effectiveness is evaluated in terms of the ability of the alternative to perform its intended functions, such as containment or isolation of the sludge. Useful life is defined as the length of time that the level of effectiveness can be maintained.

Reliability

Reliability is a measure of the operation and maintenance requirements and the demonstrated and expected reliability of the alternative. Operation and maintenance requirements include the frequency and complexity of necessary operation and maintenance. The availability of labor and materials to meet the requirements also are considered. Demonstrated and expected reliability is a measure of the potential risk and the effect of failure of the alternative to perform as intended to meet the closure criteria. It includes an evaluation of whether the technologies have been used effectively under similar conditions.

Implementability

Implementability is a measure of the constructibility and the total length of time required to achieve a given level of response.

Constructibility includes internal conditions such as depth to groundwater, location of the facility, and availability of fill material. It also includes external factors that affect the implementability such as the need for special permits and the availability of equipment. Time requirements include the time to implement the alternative as well as the time required to actually see any beneficial results from the alternative.

Safety

Safety is a measure of threats to the safety of nearby communities or the environment as well as threats to the safety of workers during the implementation of the alternative.

5.2.2 Environmental

This criterion will include an evaluation of the short- and long-term beneficial and adverse effects of the alternative, any adverse effects on environmentally sensitive areas, and an analysis of measures to mitigate adverse impacts.

5.2.3 Human Health

This criterion will include an evaluation of how well the alternative mitigates short- and long-term potential exposure to any residual contamination and protects human health during and after implementation of the alternative.

5.2.4 Institutional

This criterion will evaluate how well the alternative addresses the relevant institutional needs, including the effects of federal, state, and local environmental and public health standards, regulations, guidance, advisories, ordinances, or community relations on the design, operation, and timing of each alternative.

5.3 Evaluation of Alternatives for Ponds A through F

This section provides an evaluation of each of the alternatives for Ponds A through F using the criteria described above. The performance of each alternative according to the evaluation criteria is presented in Table 5-1.

5.3.1 Alternative AF1: No Action

The no action alternative consists of letting the water in Ponds A through F infiltrate and evaporate naturally.

Technical

The evaluation of this alternative, based on the technical criteria, is as follows:

Performance—The no action alternative would not isolate the sludge. As a result, it would not meet closure objectives, would not control or eliminate the source of contamination, and would not prevent human or ecological exposure to constituents in the sludge and/or soil. Although there is no unacceptable risk for an industrial or restricted open space scenario, the requirements for clean closure include consideration of the residential scenario. Also, it would not control the disease vectors or odor problems associated with leaving the sludge exposed.

Reliability—There would be no operation and maintenance requirements associated with the no action alternative. Since no action would be taken, there are no reliability issues.

Implementability—This alternative is readily implementable since the only action that would be taken would be to allow the water in Ponds A through F to infiltrate and evaporate naturally. The time to implement the alternative would be short.

Safety—This alternative would not fully comply with the evaluation criteria for safety to the environment, because it would not limit potential exposure pathways. It would allow the potential for wildlife and workers to be exposed to the sludge because the water that currently covers the sludge would drain off and the sludge would be

Table 5-1
Summary of Evaluation of Alternatives

Evaluation Criteria	Alternative AF1 No Action	Alternative AF2 Containment: Backfill to top of Berms	Alternative AF3 Containment: Restore to Natural Contours	Alternative G1 No Action
Technical				
Performance	Would not isolate sludges. Would not control disease vectors or odors.	Would contain and isolate sludges. Would control disease vectors and odors.	Would contain and isolate sludges. Would control disease vectors and odors.	Would isolate sludges. Would control disease vectors and odors.
Reliability	No operation and maintenance requirements.	Risk of failure is low. O&M requirements could be relatively high because of potential erosion problems. Labor and materials are readily available.	Risk of failure is low. O&M requirements are significantly lower than for AF2. Labor and materials are readily available.	No operation and maintenance requirements.
Implementability	Readily implementable.	Readily constructable. Equipment readily available. 1.2 million yd^3 of off-site backfill is required. Construction time is reasonable.	Readily constructable. Equipment readily available. Significantly less off-site backfill is required than for AF2. Construction time is reasonable.	Readily implementable.
Safety	Does not limit exposure pathways. Does not control disease vectors or odors.	Potential exposure to sludge during implementation. Eliminates exposure pathways. Controls disease vectors and odors.	Potential exposure to sludge during implementation. Eliminates exposure pathways. Controls disease vectors and odors.	No threats to safety of nearby communities or the environment.
Environmental	Could allow direct or indirect exposure to sludge.	Eliminates exposure pathways.	Eliminates exposure pathways.	Will preserve an important biological resource.
Human Health	Does not limit exposure pathways. No unacceptable risk. Does not control disease vectors or odors.	Eliminates exposure pathways to disease vectors. No unacceptable risk.	Eliminates exposure pathways to disease vectors. No unacceptable risk.	No unacceptable risk.
Institutional	Does not comply with closure requirements. Complies with state and federal water quality regulations.	Complies with 40 CFR Part 265.111. Complies with NM hazardous waste regulations. Complies with state and federal water quality regulations. Complies with worker safety standards.	Complies with 40 CFR Part 265.111. Complies with NM hazardous waste regulations. Complies with state and federal water quality regulations. Complies with worker safety standards.	Complies with 40 CFR Part 265.111. Complies with state and federal water quality regulations. Must continue to meet NPDES permit requirements.

exposed. It would not control disease vectors or odor problems.

Environmental

There would be the potential for direct or indirect exposure to constituents in the sludge, because the water would be drained off and the sludge would be left exposed.

Human Health

The no action alternative would leave contaminated sludge exposed at the site. It would not control disease vectors or odors. This alternative would not meet the clean closure objectives. However, it should be noted that the results of the risk assessment indicate that the constituent concentrations in sludge and soil would not pose an unacceptable risk to human health. The alternative would result in an acceptable risk within the 10^{-4} to 10^{-6} range. Also, the potential for exposure is likely to be relatively low, because the site is fenced and is a restricted area in the runway clear zone.

Institutional

This alternative does not adequately address institutional needs. It does not satisfy the closure criteria. If clean closure is not met, postclosure care is required. However, the no action alternative does not provide for postclosure care. It would comply with state and federal water quality regulations.

5.3.2 Alternative AF2: Containment—Backfill to Top of Berms

This alternative involves draining the water from the lagoons, dewatering the sludge, and then backfilling the lagoons to the top of the existing berms.

Technical

The evaluation, based on the technical criteria, is as follows:

Performance—This alternative would be effective in its ability to perform its intended function of containing and isolating the sludge. It would also control disease vectors and odors. The components of this alternative would have an unlimited useful life.

Reliability—The risk of potential failure for this alternative to perform its intended function would be low. The operation and maintenance requirements would include periodic inspection and maintenance of the vegetative cover to identify and/or address any erosion of the backfill. The relatively steep slopes could cause erosion problems and require substantial maintenance. Monitoring of the storm water runoff would have to be carried out under the storm water regulations in Sector L of the multi-sector general permit (MSGP) (*Federal Register*, 29 Sept., 1995) and under the pollution prevention program. Labor and materials would be readily available to meet these requirements. The use of a soil cover to eliminate exposure pathways has been demonstrated to be reliable under similar conditions. Therefore, this alternative is expected to be reliable.

Implementability — This alternative would be easily implementable. The water should infiltrate and evaporate naturally from the lagoons. The sludge should dry quickly by natural processes in the desert environment. This could be expedited by turning it with standard earth-moving equipment or by adding stabilization agents such as soil, lime, cement, or fly ash. Standard earth moving equipment could be used to backfill the area. This alternative would require a large amount of off-site backfill (approximately 1.2 million yd^3). No special permits would be required. Beneficial results from implementing this alternative would be apparent immediately upon completion of the backfilling and placement of the final cover.

Safety—Potential safety issues during the implementation of this alternative, other than standard construction-related safety issues, would include the potential exposure to the sludge during the dewatering process and the initial backfilling of the lagoons. The potential risk would result largely from disease vectors. These potential safety issues will be addressed by restricting access to the area by maintaining fences around the area; by ensuring that workers are properly trained, wear appropriate personal protective equipment (PPE) in accordance with the regulations in 29 CFR 1910.120 and are vaccinated for the Hepatitis-B virus; and by implementing dust control measures to prevent dust from blowing off site.

Environmental

The long-term beneficial effects would include the containment of and elimination of potential exposure pathways to the sludge by placing a soil cover at least 12 in. thick over the dewatered sludge in the sewage lagoons.

Human Health

Because the installation of a soil cover would eliminate potential exposure pathways, this alternative would be effective in mitigating any long-term potential exposure to the contaminated sludge and would protect human health. The provision of access restrictions (e.g., restricting the land use in the BCP, fencing, etc.) would further ensure that humans could not come into contact with the sludge. The alternative would meet the acceptable risk range for the residential scenario.

Short-term potential health risks during implementation should be minimal and could be addressed by developing a site-specific health and safety plan to address the safety considerations listed in Section 5.3.2.1.

Institutional

This alternative would meet the requirements for closure by ensuring that potential exposure pathways would be eliminated. This alternative meets closure requirements of 40 CFR Parts 265.111 and 265.228, which require that the closure accomplish the following:

- Minimize the need for further maintenance;
- Control, minimize, or eliminate, to the extent necessary to protect human health and the environment, postclosure releases to the environment; and
- Remove or decontaminate all wastes.

By covering the sludge and restricting the use of the land after closure, the alternative meets the first two criteria. Meeting the third criterion will not be necessary because it has been established that the sludge in the sewage lagoons does not pose an unacceptable risk. This alternative will minimize risk, eliminate future releases, and require little future maintenance. It will also comply with state and federal water quality regulations, as well as with the worker safety standards in 29 CFR 1910.120.

5.3.3 Alternative AF3: Containment—Restore to Natural Contours

Alternative AF3 is similar to Alternative AF2, with one exception: the elevated dikes around the south and west sides of lagoons would be removed, and the resulting excavated soil would be placed in the lagoons as a soil cover so that the site could be restored to the approximate natural contours. The major difference would be the amount of backfill and the location of the final contours. Both alternatives would provide a minimum of 12 in. of soil cover over the sludge in the lagoons. Alternative AF3 would perform as well against the evaluation criteria as AF2. In fact, its performance would be superior, because it would require significantly less off-site backfill material and less labor. Alternative AF3 would also be more sustainable. There would be fewer erosion problems because it would include removing the portions of the berms that are above grade and it would restore the area to the

approximate natural drainage. Because the two alternatives are so similar, the evaluation of Alternative AF3 is not repeated here.

5.4 Evaluation of Alternatives for Pond G

Only one alternative—the no action alternative—has been developed for the closure of Pond G. This alternative would meet the closure objectives and the closure criteria by doing the following:

- Ensuring the protection of human health and the environment;
- Providing adequate habitat for the wildlife associated with the sewage lagoons;
- Ensuring that closure eliminates disease vectors and odors and that the closure is aesthetically suitable; and
- Preventing human exposure to constituents in soils and/or sludge that would lead to an unacceptable risk for a residential scenario.

5.4.1 Alternative G1: No Action

The no action alternative consists of shutting off the influent to Ponds A and B, which effectively shuts off flow to Pond G. A pipeline from the new WWTP will be installed by July 1997 that will pump treated wastewater from the new WWTP to Pond G. This will ensure that Pond G receives water (not wastewater as before, but treated effluent via an NPDES permitted outfall) and will continue to provide the ecological habitat that it does currently.

Technical

The technical evaluation criteria are as follows:

Performance—The no action alternative would perform effectively for the foreseeable future. There are no specific activities associated with the no action alternative, so performance should not be a problem.

Reliability—There are no activities associated with the no action alternative, so reliability is not an issue.

Implementability—There are no construction activities associated with this alternative, so implementability is not an issue.

Safety—There will be no threats to the safety of nearby communities or the environment with the continued operation of Pond G under the no action alternative.

Environmental

Pond G is an important wildlife habitat, as discussed in the *Biological Resources Report* (Radian and Foster Wheeler, 1996a). The no action alternative will preserve this valuable resource by allowing Pond G to serve as a wetland and a wildlife habitat. The results of the ecological risk assessment indicated that no unacceptable risks would be associated with leaving Pond G open. As discussed in the *Biological Resources Report*, it would be beneficial to the bird species in the area to leave Pond G open.

Human Health

The risk assessment results indicated that there are no unacceptable human health risks associated with leaving Pond G open. The short- and long-term exposure to any residual constituents is not a concern.

Institutional

The alternative for Pond G will comply with 40 CFR Part 265.111 in that it will minimize the need for further maintenance. Although there are no unacceptable human health or ecological risks associated with Pond G, this alternative will minimize any releases to the environment by keeping the sludge covered with water while further decreases in constituent concentrations occur. The alternative will comply with the state and federal water quality regulations. It will also have to comply with the requirements for the

NPDES permit for the new WWTP. The stakeholders' concerns for keeping Pond G open as an important wildlife habitat are addressed by this alternative.

5.5 Cost Estimates

The estimated capital costs and the estimated operation and maintenance costs (30-year net present worth) for each of the alternatives are shown in Table 5-2. The cost calculations are presented in Attachment B. These cost estimates are intended to provide an accuracy of +50% to -30%. More accurate cost estimates will be developed after the detailed design is completed.

Table 5-2
Summary of Costs for Each Alternative

Alternative	Capital Cost	Operation and Maintenance Cost
AF1	$0	$0
AF2	$16,490,000	$940,000
AF3	$3,280,000	$940,000
G1	$0	$0

The costs for various process options that may be necessary are listed below.

5.5.1 Addition of Erosion Control

The costs for the addition of rubble to control erosion in the area that is currently the southeast corner of Pond D would add only about $14,000 to the cost of Alternative AF3.

5.5.2 Addition of a Sprinkler System

If necessary, the addition of a sprinkler system to provide water for the vegetative cover for Alternative AF3 would add about $360,000 to the total cost.

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Section 6
RECOMMENDATION AND JUSTIFICATION OF THE CLOSURE ALTERNATIVES

On the basis of the evaluation according to the closure criteria, alternatives for Ponds A through F and for Pond G are recommended. Justification for the recommendations is also provided.

6.1 Recommended Alternative for Ponds A through F

Alternative AF3: Containment—Restore to Natural Contours, is the recommended alternative for closing Ponds A through F.

The justification for the recommendation of Alternative AF3, based on the evaluation criteria discussed in Section 5, is presented below. Table 6-1 presents a comparison of the alternatives' performance against the criteria.

6.1.1 Technical

The technical criteria include performance, reliability, implementability, and safety. As discussed in Section 5, Alternative AF1: No Action was rated lower in each of these areas than the other alternatives. In particular, it would not be fully protective of human health and the environment because it would not eliminate exposure pathways. Alternative AF2: Containment—Backfill to Top of Berm, and Alternative AF3: Containment—Restore to Natural Contours were rated higher than was Alternative AF1 in their ability to meet all of these criteria. Both alternatives would protect human health and the environment by eliminating exposure pathways and controlling any potential disease vectors or odor problems. Alternative AF2 would be less reliable than AF3 because the steeper slopes included in the design may cause higher maintenance requirements due to erosion problems. Alternative AF3 would be more easily implementable because it requires significantly less off-site backfill material.

6.1.2 Environmental

Alternatives AF2 and AF3 were rated equal with respect to the environmental criteria. They were rated higher than the no action alternative, AF1, because they eliminate exposure pathways that could lead to ecological risks.

6.1.3 Human Health

Alternatives AF2 and AF3 were rated equal with respect to the human health criteria. They were rated higher than the no action alternative, AF1, because they also eliminate exposure pathways that could lead to other types of risks to human health (e.g., disease vectors).

6.1.4 Institutional

Alternatives AF2 and AF3 were rated equal with respect to the institutional criteria. They were rated higher than the no action alternative, AF1, because they satisfy requirements for closure.

6.1.5 Cost

Alternative AF1, the no action alternative, has no associated cost. The capital and present worth operation and maintenance costs associated with Alternative AF2 were estimated to be $16,490,000 and $940,000, respectively. The capital and present worth operation and maintenance costs for Alternative AF3 were estimated to be $3,280,000 and $940,000, respectively. Alternative AF3 is the least expensive alternative that meets the closure objectives and criteria.

Table 6-1
Comparison of Alternatives Against Evaluation Criteria

Alternative	Technical				Environmental	Human Health	Institutional	Cost
	Performance	Reliability	Implementability	Safety				
AF1	Poor	Excellent	Excellent	Fair	Fair	Fair	Poor	Low
AF2	Excellent	Good	Fair	Good	Excellent	Excellent	Good	High
AF3	Excellent	Excellent	Good	Good	Excellent	Excellent	Good	Moderate
G1	Excellent	Excellent	Good	Good	Good	Good	Good	Low

6.1.6 Recommended Alternatives

A summary of the performance of the alternatives according to the evaluation criteria is presented in Table 5-1. Alternatives AF2 and AF3 were very similar in their performance according to the technical, environmental, human health, and institutional criteria. Alternative AF3 was superior in terms of the technical criteria. It required significantly less material and labor, and the soil cover would be more sustainable because the design does not include as steep of slopes. As seen from the cost estimates, Alternative AF3 is considerably less costly than Alternative AF2. Therefore, since Alternatives AF2 and AF3 perform very similarly in all areas other than cost, Alternative AF3, the least costly of the two, is the recommended alternative.

6.2 Recommended Alternative for Pond G

Alternative G1 was the only alternative evaluated for Pond G. It was found to meet all of the evaluation criteria and to have no cost associated with it. This alternative addresses the stakeholders' concerns for keeping Pond G open as a wetland and as an important wildlife habitat. There are no unacceptable human health or ecological risks associated with leaving the lagoon open. As discussed in the *Biological Resources Report* (Radian and Foster Wheeler, 1996a), the removal of sludge from Pond G is not necessary, and it would result in adverse effects to the wildlife that inhabit the area. Therefore, Alternative G1: No Action, is the recommended alternative for Pond G.

Section 7
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ATTACHMENT A

Conceptual Design Calculations

Calculation of Evaporation and Infiltration Time for Lagoons

An analytical model was used to estimate the time for all of the free standing water to be removed from the lagoons due to natural evaporation and infiltration. The approach used in this modeling is defined in the equation:

$$V(t) = InitialVolumeofLagoons - \sum_t E(t) - \sum_t I(t)$$

Where V(t) is the volume of water contained in the lagoons at time t; E(t) is the amount of water that evaporated during time step t; and I(t) is the amount of water that infiltrated during time step t.

Evaporation was estimated based on the value of 67 inches per year as reported in the *Final Hydrogeologic Investigation Report and Groundwater Monitoring Plan for the Sewage Treatment Lagoons*, Holloman Air Force Base, New Mexico (Radian, 1989). However, this value was reduced by two-thirds to account for the difference in the winter evaproation rate versus the summer rate. The surface area of the lagoons available for evaporation was calculated at every time step based on the dimensions of the lagoons and volume of water. A time step of 1 day was used to calculate the time for the lagoons to dewater. Infiltration was estimated using the Green-Ampt method as described in *The Handbook of Hydrology* (David R. Maidment, 1992). This equation accounts for hydraulic conductivity, wetting front soil suction head, head due to ponded water, porosity, and initial moisture content of the soil. Hydraulic conductivity and porosity were estimated from the *Hydrogeologic Investigation Report* (Radian, 1989). The wetting front soil suction head was estimated based on a table from *The Handbook of Hydrology* (David R. Maidment, 1992). The average head of water in the lagoons was calculated at every time step based on the dimensions of the lagoons and volume of water. Initial soil moisture content was set to 33%, based on the assumption that the porosity was 34% and the soil was over 97% saturated under and around the lagoons.

One simulation was run for Ponds A, B, and C. It was assumed that the lagoons held an average of 6 feet of water. The estimated time to dewater the lagoons from the beginning depth of 6 feet was 179 days. The following page shows the model inputs and output matrix.

Based on historical rainfall data in the *Hydrogeologic Investigation Report* (Radian, 1989), the majority of Holloman AFB's rain falls in the months of July through October. But is is feasible to expect 2-3 inches between December and May. This rainfall will add 3 to 5 days to the numbers estimated by the model. Therefore, with rainfall added into the estimates, the time estimated for the natural removal of the free-standing water in Ponds A, B, and C is approximately 184 days.

In addition to the uncertain rainfall, the hydrogeological parameters of the deeper aquifer were not considered. The hydrogeological parameters used to estimate the infiltration were based on average results of slug tests in the shallow aquifer conducted around the lagoons. Because the deeper aquifer has a lower hydraulic conductivity, the infiltration may be slightly slower than what is estimated by the model. It was determined that the salinity of the water in the lagoons would have very little effect on the evaporation rate based on the book *Hydrology for Engineers* (Linsley, Kohler, and Paulhus, 1986).

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```
**Parameters used in this run are:
**Initial pond volume=8575199 (ft^3)
**Time step(days) =1
**Depth below surface where infiltration starts(feet) = 0
**Pumping rate(gpm)=0
**Pan evaporation rate(inches/year)=67(1/3) to account for winter evap
**Pan evaporation coefficient(unitless)=1
**hydraulic conductivity(feet/day)=2.83    (=1.00e-3 cm/sec)
**wetting front soil suction head(feet)=0.197
**porosity(unitless)=.34
**initial soil moisture content(unitless)=.33
**# of Days before Pumping Begins=0

**Holloman Lagoon #'s 1-3 with 6' of initial h2o

**update inputs

Input.mat[1,]_c(8575199,1,0,0,67*(1/3),1,2.83,0.197,0.34,0.33,0)

hol.6ft_hol.ba2(Input.mat)
hol.6ft_round(hol.6ft,2)
hol.6ft
```

	Day	Pumped	Evap	Infil	Lake.Vol	Inf.depth	surf	Inf.cum	Avg.head
	1	0	7342.47	41573.76	8575199	2.89	1440000	41573.76	6.00
	2	0	7342.19	41173.11	8526283	5.75	1439946	82746.87	5.97
3	3	0	7341.91	41032.93	8477767	8.60	1439892	123779.80	5.93
4	4	0	7341.64	40960.80	8429393	11.44	1439838	164740.59	5.90
5	5	0	7341.37	40916.46	8381090	14.28	1439784	205657.05	5.87
6	6	0	7341.09	40886.19	8332832	17.12	1439731	246543.24	5.83
7	7	0	7340.82	40864.03	8284605	19.96	1439677	287407.27	5.80
8	8	0	7340.55	40846.97	8236400	22.80	1439624	328254.24	5.76
9	9	0	7340.27	40833.33	8188213	25.63	1439570	369087.57	5.73
10	10	0	7340.00	40822.09	8140039	28.47	1439516	409909.66	5.70
						...			
	Day	Pumped	Evap	Infil	Lake.Vol	Inf.depth	surf	Inf.cum	Avg.head
172	172	0	7295.92	40494.06	372807.44	487.05	1430871	6991284	0.29
173	173	0	7295.65	40492.53	325017.45	489.88	1430818	7031777	0.25
174	174	0	7295.38	40490.99	277229.28	492.71	1430765	7072268	0.22
175	175	0	7295.11	40489.45	229442.91	495.54	1430712	7112757	0.19
176	176	0	7294.83	40487.92	181658.35	498.37	1430658	7153245	0.15
177	177	0	7294.56	40486.38	133875.60	501.20	1430605	7193731	0.12
178	178	0	7294.29	40484.84	86094.66	504.03	1430552	7234216	0.09
179	179	0	7294.02	40483.31	38315.53	506.86	1430499	7274699	0.05

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO.

SIGNATURE ROBERT MICHNA DATE 11/1/96 CHECKED DATE

PROJECT HAFB LAGOONS CLOSURE JOB NO.

SUBJECT TOTAL CUT AND FILL SHEET 1 OF 2 SHEETS

TOTALS

RESTORE TO NATURAL CONTOURS

CUT = FILL = 186,233 cy + 10% = 204,856 → 205,000 cy

FILL TO TOP OF BERMS

FILL = 1,163,841 cy + 10% = 1,280,225 → 1,280,000 cy

TOPSOIL = WORKED AREA × 6"

FILL TO TOP OF BERMS

$3,040,000 \frac{6}{12} \div 27 = 56,296$ cy + 10% = 61,926 → 62,000 cy

NOTE: ALL VOLUMES INCREASED BY 10% FOR SCOPE CONTINGENCIES

10-88-30702

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO.

SIGNATURE Robert Michna DATE 11/1/96 CHECKED DATE

PROJECT HAFB Lagoons Closure JOB NO.

SUBJECT TOTAL QUANTITIES SHEET 2 OF 2 SHEETS

FILL TO BERMS

	TOTAL FILL (CY)	OFFSITE FILL (CY)	AREA OF GRADING (SY)
Move on-site cut to fill			
Excavate + move borrow		1,219,000	
Borrow + haul topsoil		61,000	
Common earth backfill	1,280,000		
Grade/seed			372,000

RESTORE TO NATURAL CONTOURS

	TOTAL FILL (CY)	OFFSITE FILL (CY)	AREA OF GRADING (SY)
Move on-site cut to fill	205,000	0	
Common earth backfill	205,000	0	
Grade/seed			540,000

NOTE: ALL QUANTITIES INCREASED BY 10% FOR SCOPE CONTINGENCIES

10-88-30702

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO.

SIGNATURE SgWest DATE 6/6/96 CHECKED DEF DATE 6/7/96

PROJECT HAFB Lagoons Closure JOB NO.

SUBJECT Fill + Mound SHEET 1 OF 6 SHEETS

HAFB Lagoons Closure

OPTION: Fill to Berms + Mound to Drain

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO.

SIGNATURE SWH DATE 6/6/96 CHECKED REF DATE 6/7/96

PROJECT HAFB Lagoons Closure JOB NO.

SUBJECT Fill + mound SHEET 2 OF 6 SHEETS

Alternative AF2 → Backfill to top of berms
Mound interior to drain off area

Fill → Fill all ponds to 4040 el (vol)
Find vol of mound above 4040 el

Procedure – Pond bottoms ~ 4031.5 – 4032.3 (top of sludge)
Side slopes up from bottom

A_1 Measure bottom area
A_2 Measure area at top of sideslopes
A_3 Measure area of 4040 el around pond

$\frac{A_1 + A_2}{2} \cdot \text{depth} = \text{vol}$

$\frac{A_2 + A_3}{2} \cdot \text{depth} = \text{vol}$

A_1, A_2, A_3 for each pond – total to get ∀ to bring site inside berms to 4040 el. $\Sigma = A_{4040}$. Σ vol $= V_{4040}$

A_{4040} – Σ of pond vol
A_{4042} – Measure on map
A_{4044} – Measure on map

$(A_{4040} + A_{4042}) \div 2 \cdot 2'$ Δelev $= V_{4040-4042}$

$(A_{4042} + A_{4044}) \div 2 \cdot 2'$ Δelev $= V_{4042-4044}$

Total fill $= V_{4040} + V_{4040-4042} + V_{4042-4044}$

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO.

SIGNATURE SEWL DATE 6/6/96 CHECKED REF DATE 6/7/96

PROJECT HAFB Lagoons Closure JOB NO.

SUBJECT Fill + mound SHEET 3 OF 6 SHEETS

Pond A

Top of sludge = 4032 → A 4032 contour = 429694 ft^2
Top of sideslopes = 4038 → A 4038 contour = 493117 ft^2
Fill to 4040 → A 4040 contour = 547027 ft^2

$V_{4032-4038} = [(429694 + 493117) \div 2 * (4038 - 4032)] \div 27 = 102535 cy$
$V_{4038-4040} = [(493117 + 547027) \div 2 * (4040 - 4038)] \div 27 = 38524 cy$
$\therefore V_{TO\ 4040} = 141059 cy$

Pond B

T.O.S. = 4031.8 $A_{4032 (\approx 4031.8)} = 404324 ft^2$
Top of banks = 4038 $A_{4038} = 459819 ft^2$
Fill to 4040 $A_{4040} = 612036 ft^2$

$V_{4031.8-4038} = [(404324 + 459819) \div 2 \cdot (4038 - 4031.8)] \div 27 = 99216 cy$
$V_{4038-4040} = [(459819 + 612036) \div 2 \cdot (4040 - 4038)] \div 27 = 39698 cy$
$\therefore V_{TO\ 4040} = 138915 cy$

Pond C

T.O.S. = 4032.1 $A_{4032.1} = 561297 ft^2$
Top of banks = 4040 $A_{4040} = 680216 ft^2$

$V_{4032.1-4040} = (561297 + 680216) \div 2 \cdot (4040 - 4032.1)] \div 27 = 181629 cy$

$V_{TO\ 4040} = 181629 cy$

KADIAN CORPORATION

CALCULATION SHEET

CALC. NO.

SIGNATURE [illegible] DATE 6/6/96 CHECKED REF DATE 6/7/96

PROJECT HAFB Lagoons Closure JOB NO.

SUBJECT Fill + mound SHEET 4 OF 6 SHEETS

Pond D

T.O.S = 4031.5 $A_{(4031.5 (\approx 4032))} = 827676\ ft^2$

Top of banks = 4040 $A_{4040} = 1911712\ ft^2$

$$V_{4031.5-4040} = [(827676 + 911712) \div 2 \cdot (4040 - 4031.5)] \div 27 = 273792\ cy$$

Pond E

T.O.S = 4032.3 $A_{4032.3 (\approx 4032)} = 371027\ ft^2$

Top of banks = 4040 $A_{4040} = 442378\ ft^2$

$$V_{4032.3-4040} = [(371027 + 442378) \div 2 \cdot (4040 - 4032.3)] \div 27 = 115985\ cy$$

Pond F

Bottom elev ~ 4036 $A_{4036} = 28540$

Top of banks = 4038 $A_{4038} = 31712$

Fill to 4040 elev $A_{4040} = 63423$

$$V_{4036-4038} = [(28540 + 31712) \div 2 \cdot (4038 - 4036)] \div 27 = 2232\ cy$$

$$V_{4038-4040} = [(31712 + 63423) \div 2 \cdot (4040 - 4038)] \div 27 = 3523\ cy$$

$$\therefore V_{\text{To } 4040} = 5755\ cy$$

$\therefore$ Total V fill ponds to 4040 = 857134 cy

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO.

SIGNATURE StayWet DATE 6/6/96 CHECKED REF DATE 6/7/96

PROJECT HAFB Lagoons Closure JOB NO.

SUBJECT Fill + mound SHEET 5 OF 6 SHEETS

Fill 4040 → Final contours

$A_{4040} = 3713441\ ft^2$

$A_{4042} = 2032721\ ft^2$

$A_{4044} = 329802\ ft^2$

$V_{4040-4042} = [(3713441 + 2032721) \div 2 \cdot (4042-4040)] \div 27 = 212821\ cy$

$V_{4042-4044} = [(2032721 + 329802) \div 2 \cdot (4044-4042)] \div 27 = 87501\ cy$

Assume ridge at ~ 4045 along peak for drainage

Assume A 4045 = 15000 ft^2

$V_{4044-4045} = [(329802 + 15000) \div 2 \cdot (4045-4044)] \div 27 = 6385$

Total

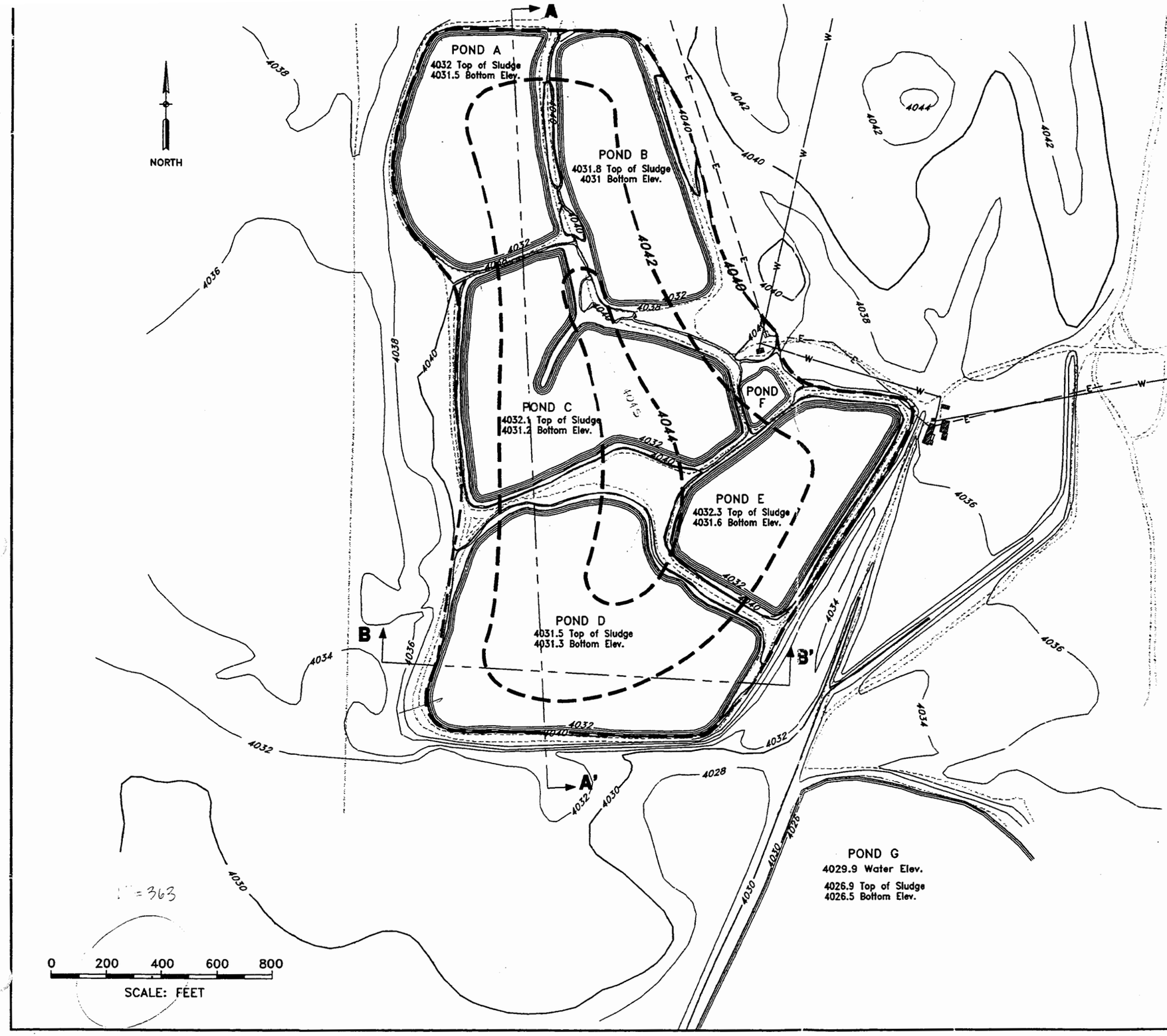
$V_{TO\ 4040} = 857134\ cy$

∴ Total Fill = 857134 + 212821 + 87501 + 6385

= 1,163,841 cy (in place)

10-88-30702

Sheet 5



Total Worked area
= 3,040,000

E14005B 05.13.96

Holloman Air Force Base
Sewage Lagoons Closure Project
Corrective Measures Study
May 1996

Figure 4-1 Alternative AF2

Final Contours

Backfill to Top of The Berms

Sewage Lagoons Closure

Alternative AF3--Containment, Restore to Natural Contours

Volume Calculations Using the Average End Area Method

RADIAN INTERNATIONAL LLC

CALCULATION SHEET

CALC. NO. _____

NATURE [signature] DATE 10/28/96 CHECKED RJM DATE 10/30/96

PROJECT _____ JOB NO. _____

SUBJECT _____ SHEET 1 OF 7 SHEETS

All following cross sections

horizontal scale → 1" = 400'
vertical scale → 1" = 8'

$1 in^2 = 400 \cdot 8 = 3200 sf$

3200 is multiplication factor on x-section measurements to calculate ft^2.

From section	To section	Distance in (ft)
A	B	236
B	B1	69
B1	C	142
C	C1	58
C1	D	255
D	E	69
E	F	65
F	G	182
G	H	138
H	I	156
I	J	73
J	K	102
K	L	109
L	M	385
M	N	80

HJP-3 38776.fm5

RADIAN INTERNATIONAL LLC

CALCULATION SHEET

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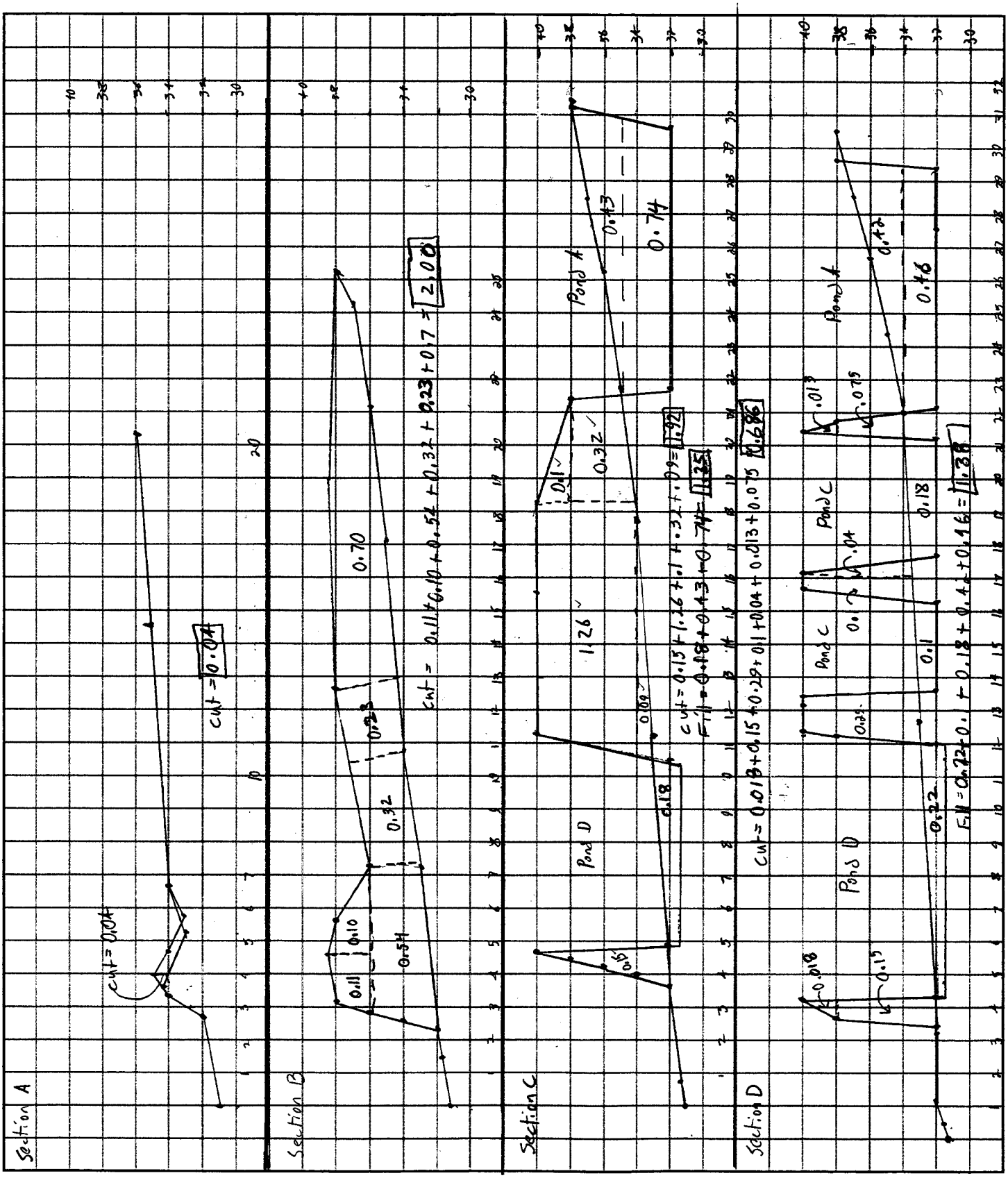
PROJECT _____ JOB NO. _____

SUBJECT _____ SHEET 2 OF 7 SHEETS



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RADIAN INTERNATIONAL LLC

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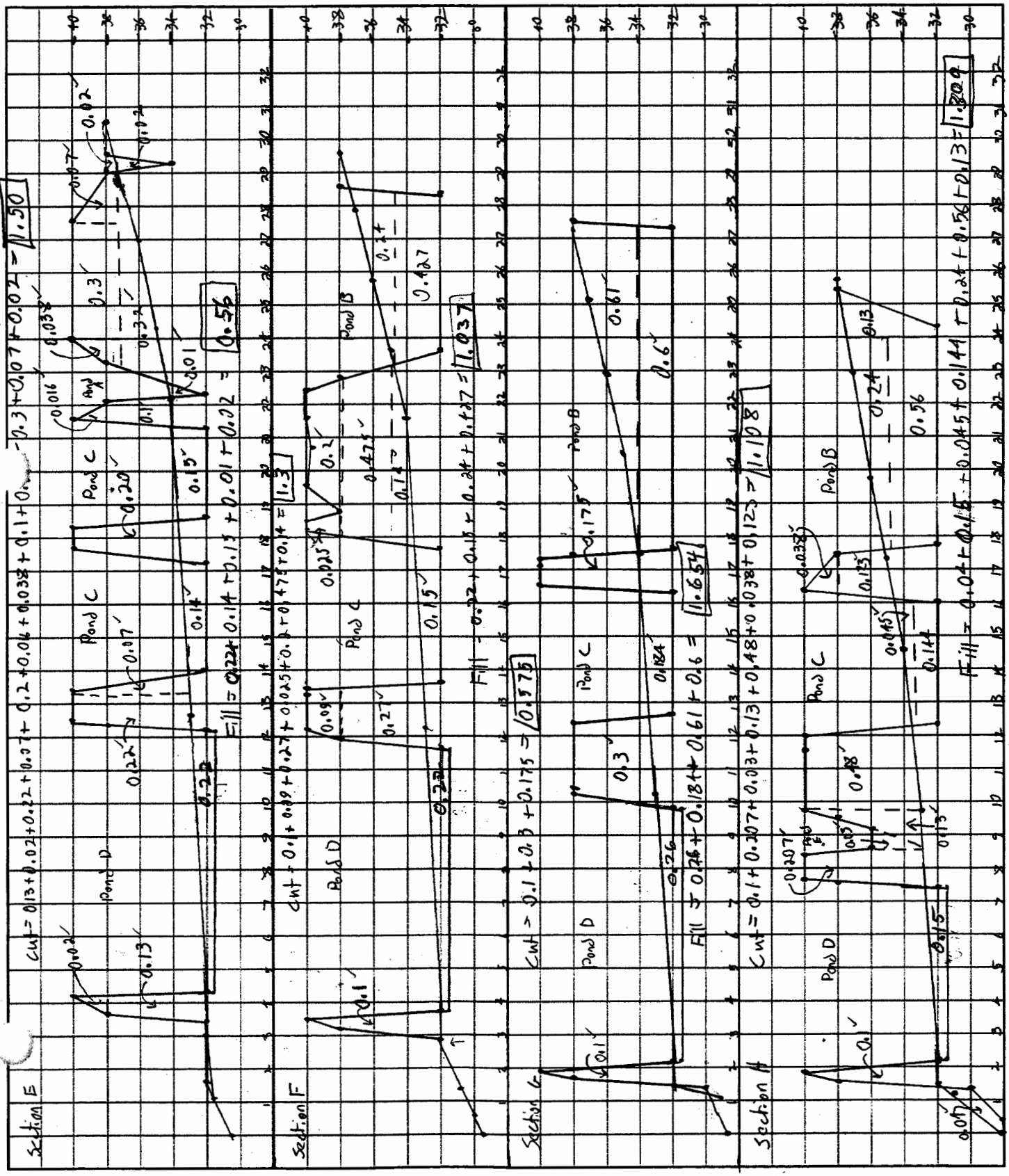
PROJECT _____ JOB NO. _____

SUBJECT _____ SHEET 3 OF 7 SHEETS



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RADIAN INTERNATIONAL LLC

CALCULATION SHEET

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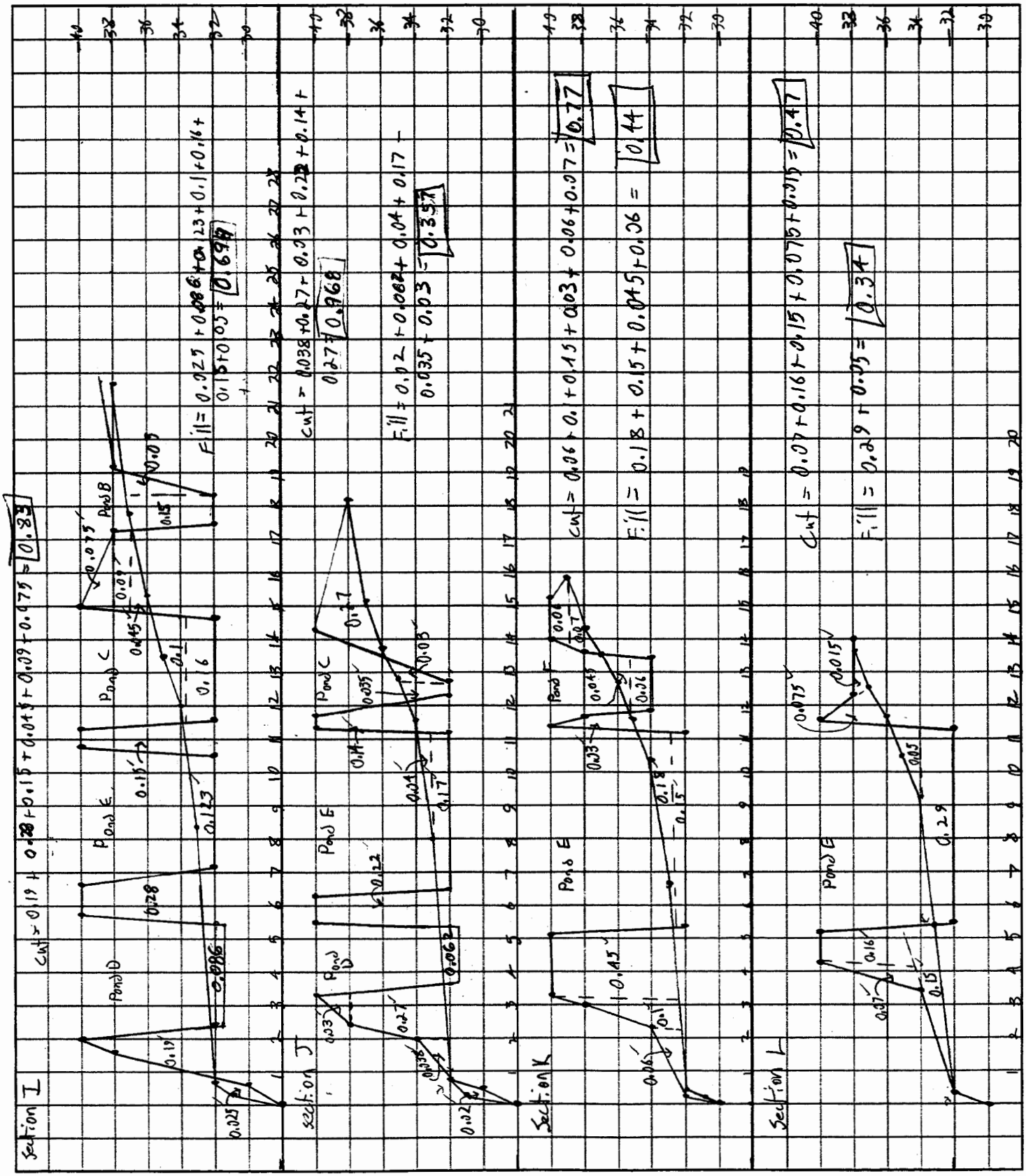
PROJECT _____ JOB NO. _____

SUBJECT _____ SHEET 4 OF 7 SHEETS



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RADIAN INTERNATIONAL LLC

CALCULATION SHEET

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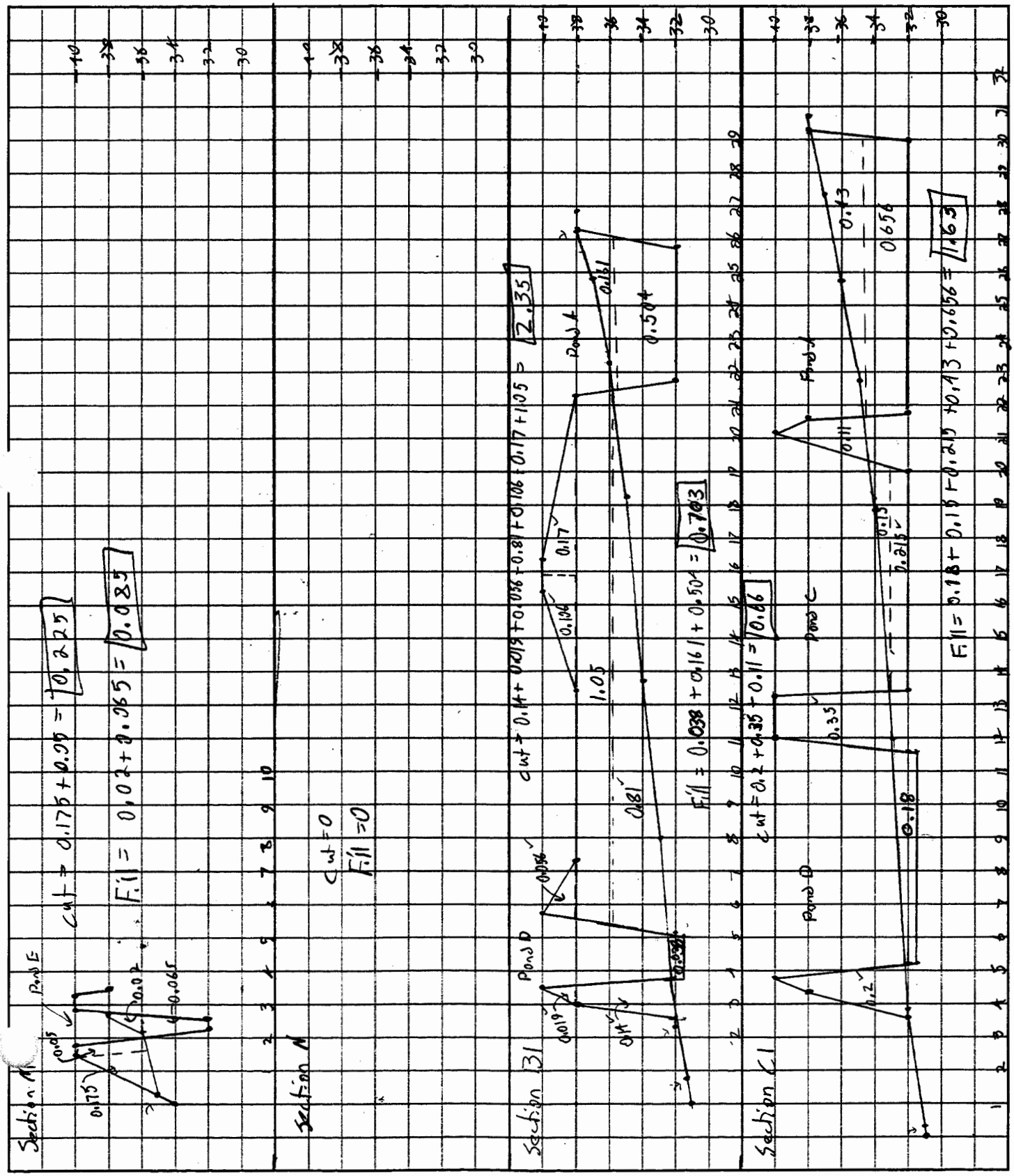
PROJECT _____ JOB NO. _____

SUBJECT _____ SHEET 5 OF 7 SHEETS



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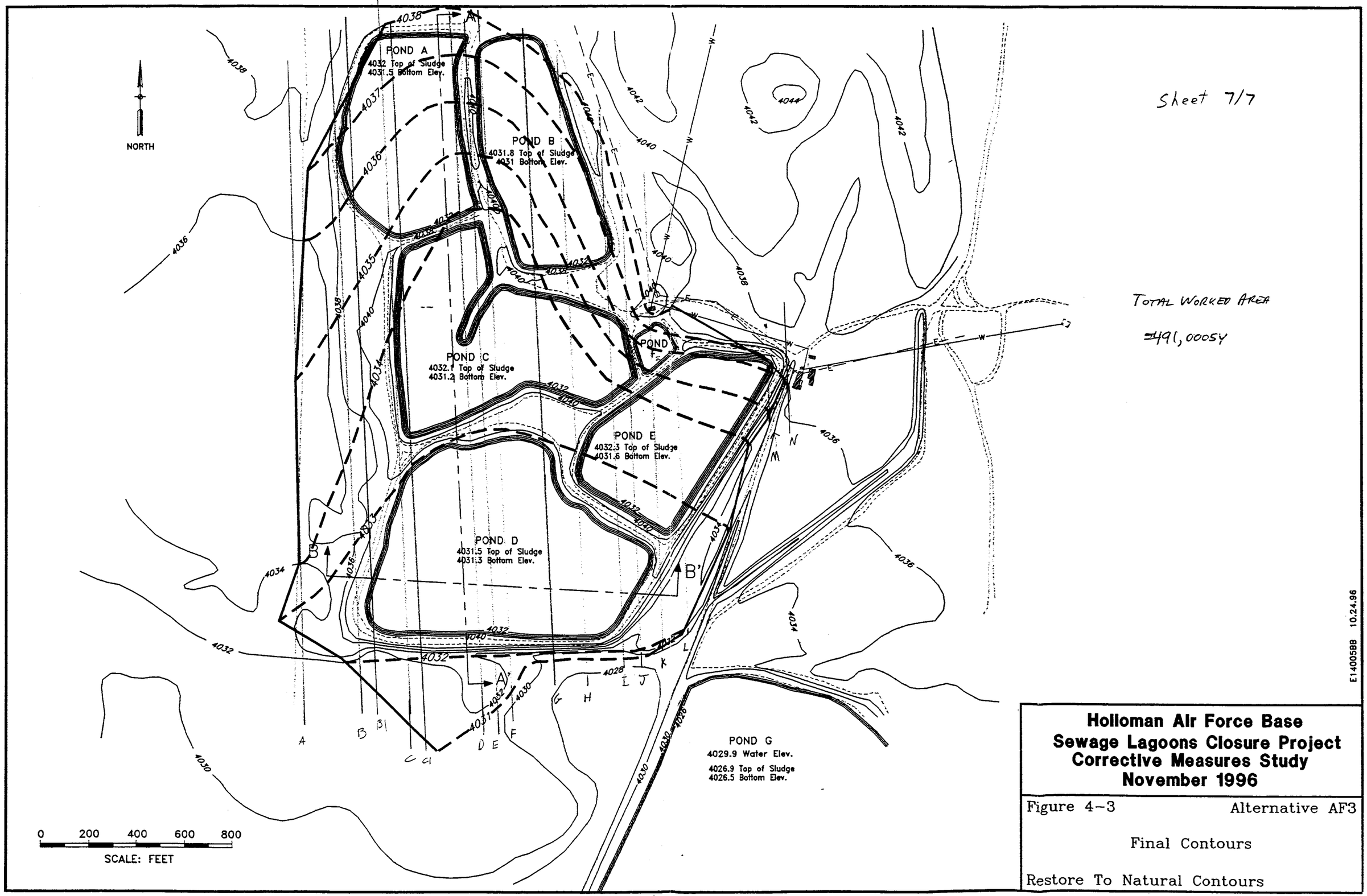
Alternative AF3--Restore to Natural Contours

Section Number	Cut Calculations						Fill Calculations					
	Distance X	(first cut +	second cut /	2) x	Scale Factor =	Total (cf)	Distance X	(first fill +	second fill /	2) x	Scale Factor =	Total (cf)
A-B	236	0.04	2	2	3200	770,304	236	0	0	2	3200	0
B-B1	69	2	2.35	2	3200	480,240	69	0	0.703	2	3200	77,611
B1-C	142	2.35	1.92	2	3200	970,144	142	0.703	1.35	2	3200	466,442
C-C1	58	1.92	0.66	2	3200	239,424	58	1.35	1.63	2	3200	276,544
C1-D	255	0.66	0.686	2	3200	549,168	255	1.63	1.38	2	3200	1,228,080
D-E	69	0.686	1.5	2	3200	241,334	69	1.38	0.56	2	3200	214,176
E-F	65	1.5	1.3	2	3200	291,200	65	0.56	1.037	2	3200	166,088
F-G	182	1.3	0.575	2	3200	546,000	182	1.037	1.654	2	3200	783,619
G-H	138	0.575	1.108	2	3200	371,606	138	1.654	1.309	2	3200	654,230
H-I	156	1.108	0.83	2	3200	483,725	156	1.309	0.694	2	3200	499,949
I-J	73	0.83	0.968	2	3200	210,006	73	0.694	0.357	2	3200	122,757
J-K	102	0.968	0.77	2	3200	283,642	102	0.357	0.44	2	3200	130,070
K-L	109	0.77	0.47	2	3200	216,256	109	0.44	0.34	2	3200	136,032
L-M	385	0.47	0.225	2	3200	428,120	385	0.34	0.085	2	3200	261,800
M-N	80	0.225	0	2	3200	28,800	80	0.085	0	2	3200	10,880
Total Cubic Feet						6,109,970						5,028,278
Total Cubic Yards						226,295						186,233
											+10% Scope Contingency	18,623
												204,856

Difference = 21,439 Cubic Yards Additional Cut Material Available

Sheet 7/7



TOTAL WORKED AREA

=491,000SY

E14005BB 10.24.96

Holloman Air Force Base
Sewage Lagoons Closure Project
Corrective Measures Study
November 1996

Figure 4-3 Alternative AF3

Final Contours

Restore To Natural Contours

ATTACHMENT B

Cost Calculations

Alternative AF2 -- Containment, Backfill to Top of Berms

Reference	Title of Action	Unit Cost				Unit	Quantity	Cost per Category			TOTAL COST
		Material	Equipment	Labor	Total			Material	Equipment	Labor	
c1	Excavate and move borrow material		3.42	1.62	5.04	cy	1,219,000	0	4,168,980	1,974,780	$6,143,760
c2	Borrow and haul topsoil				8.00	cy	62,000	NA'	NA'	NA'	$496,000
d	Common earth backfill		1.51	1.02	2.53	cy	1,280,000	0	1,932,800	1,305,600	$3,238,400
e	Fine grading and seeding	0.21	1.01	0.21	1.43	sy	372,000	78,120	375,720	78,120	$531,960
	TOTAL COST							78,120	6,477,500	3,358,500	$10,410,120

Unit costs are taken from Means 1996 Site Work and Landscape Cost Data

c1 = 5 cy wheel loader, twelve 20 cy dump trailers, 4 mile round trip -- 12.1-614-7600
c2 = Phone estimate from Frank Denton of Tommy Blankenship Construction
Laluz, NM -- 6 June 1996
d = 300-hp dozer and roller compactor, 300' haul, 8" lifts, 2 passes -- 12.1-724-3300
e = Fine grading and seeding -- 022-286-1000
NA' = No cost breakdown was provided by vendor.

ITEM	
Total Earthwork Costs (subcontractor)	$10,410,120
Total Earthwork Cost	$10,410,120
Prime Contractor O&P (20%)	$2,082,024
Bonding and Insurance (3%)	$312,304
Design (10%)	$1,041,012
Small Tools (2%)	$208,202
Prime Contractor	
(4 men @ $35/hr for 360 days)	$403,200
Schedules (0.25%)	$26,025
Submittals (1%)	$104,101
Field and Laboratory Testing (2%)	$208,202
Permitting and Legal (2%)	$208,202
Mobilization/Demobilization (5%)	$520,506
Total Site Construction Costs	$15,523,899
New Mexico Gross Receipt Taxes (6.25%)	$970,244
TOTAL SITE REMEDIATION	**$16,494,143**

Alternative AF3 -- Containment, Restore to Natural Contours

Reference	Title of Action	Unit Cost				Unit	Quantity	Cost per Category			TOTAL COST
		Material	Equipment	Labor	Total			Material	Equipment	Labor	
b	Move on-site cut to fill		2.35	1.26	3.61	cy	205,000	0	481,750	258,300	$740,050
c	Common earth backfill		1.51	1.02	2.53	cy	205,000	0	309,550	209,100	$518,650
d	Fine grading and seeding	0.21	1.01	0.21	1.43	sy	542,000	113,820	547,420	113,820	$775,060
	TOTAL COST							113,820	1,338,720	581,220	$2,033,760

Unit costs are taken from Means 1996 Site Work and Landscape Cost Data

b = 3 cy wheel loader, five 16 cy dump trailers, 1 mile round trip -- 12.1-614-6200
c = 300-hp dozer and roller compactor, 300' haul, 8" lifts, 2 passes -- 12.1-724-3300
d = Fine grading and seeding -- 022-286-1000

ITEM	
Total Earthwork Costs (subcontractor)	$2,033,760
Total Earthwork Cost	$2,033,760
Prime Contractor O&P (20%)	$406,752
Bonding and Insurance (3%)	$61,013
Design (10%)	$203,376
Small Tools (2%)	$40,675
Field Supervision (4 men @ $35/hr for 120 days)	$134,400
Schedules (0.25%)	$5,084
Submittals (1%)	$20,338
Field and Laboratory Testing (2%)	$40,675
Permitting and Legal (2%)	$40,675
Mobilization/Demobilization (5%)	$101,688
Total Site Construction Costs	$3,088,436
New Mexico Gross Receipt Taxes (6.25%)	$193,027
TOTAL SITE REMEDIATION	**$3,281,464**

Addition of 6" Stone Rip-Rap for Channel Erosion Control

Reference	Title of Action	Unit Cost				Unit	Quantity	Cost per Category			TOTAL COST
		Material	Equipment	Labor	Total			Material	Equipment	Labor	
a	Load and Haul 6" Rip-Rap				16.25	cy	370	NA[1]	NA[1]	NA[1]	$6,013
a	Place Rip-Rap in Channel				8.00	cy	370	NA[1]	NA[1]	NA[1]	$2,960
											$0
											$0
											$0
	TOTAL COST										$8,973

a = Phone estimate from Gary Bridges of Danley Construction Laluz, NM -- 6 June 1996
Estimated area of rip-rap is 100' X 200' X 1/2'

NA[1] = No cost breakdown was provided by vendor.

ITEM	
Total Earthwork Costs (subcontractor)	$8,973
Total Earthwork Cost	$8,973
Prime Contractor O&P (20%)	$1,795
Bonding and Insurance (3%)	$269
Design (10%)	$897
Small Tools (2%)	$179
Schedules (0.25%)	$22
Submittals (1%)	$90
Field and Laboratory Testing (2%)	$179
Permitting and Legal (2%)	$179
Mobilization/Demobilization (5%)	$449
Total Site Construction Costs	$13,033
New Mexico Gross Receipt Taxes (6.25%)	$815
TOTAL SITE REMEDIATION	**$13,847**

Addition of Automatic Sprinkler System

Reference	Title of Action	Unit Cost				Unit	Quantity	Cost per Category			TOTAL COST
		Material	Equipment	Labor	Total			Material	Equipment	Labor	
a	Install Automatic Sprinkler System	74,000		42,200	116,200	ea	2	148,000	0	84,400	$232,400
											$0
											$0
											$0
											$0
	TOTAL COST										$232,400

Unit costs are taken from Means 1996 Site Work and Landscape Cost Data

a = Fully automatic system covering 30 acres -- 028-104-0100

ITEM	
Total Earthwork Costs (subcontractor)	$232,400
Total Earthwork Cost	$232,400
Prime Contractor O&P (20%)	$46,480
Bonding and Insurance (3%)	$6,972
Design (10%)	$23,240
Small Tools (2%)	$4,648
Schedules (0.25%)	$581
Submittals (1%)	$2,324
Field and Laboratory Testing (2%)	$4,648
Permitting and Legal (2%)	$4,648
Mobilization/Demobilization (5%)	$11,620
Total Site Construction Costs	$337,561
New Mexico Gross Receipt Taxes (6.25%)	$21,098
TOTAL SITE REMEDIATION	**$358,659**

Annual Operation and Maintenance Costs

Reference	Title of Action	Unit Cost				Unit	Quantity	Cost per Category			TOTAL COST
		Material	Equipment	Labor	Total			Material	Equipment	Labor	
	Maintain Sprinkler System (5% of installation cost)	3,700.00		2,110.00	5,810.00	ea	2	7,400	0	4,220	$11,620
e	Fine grading and seeding (1% of 60 acre area)	0.21	1.01	0.21	1.43	sy	4,940	1,037	4,989	1,037	$7,064
g	Water Charges	6.90				1000 cf	5,663	39,073	0	0	$39,073
											$0
											$0
	TOTAL COST							47,511	4,989	5,257	$57,758

Unit costs are taken from Means 1996 Site Work and Landscape Cost Data

e = Fine grading and seeding -- 022-286-1000
g = City of Alamogordo charges $6.90 per 1,000 cf of water. Assume 1/2 of an inch of water weekly over 60 acre area.

ITEM	
Total Annual Costs	$57,758
New Mexico Gross Receipt Taxes (6.25%)	$3,610
Site Construction Costs	$61,367
TOTAL O&M ANNUAL EXPENSES	**$61,367**

Net Present Value

Assume 5% discount value for 30 years
$61,000 X 15.372 = $940,000

Water for 3-Months to Establish Vegetation

Reference	Title of Action	Unit Cost				Unit	Quantity	Cost per Category			TOTAL COST
		Material	Equipment	Labor	Total			Material	Equipment	Labor	
a	Water Truck Rental		1250		1250	month	3	0	3,750	0	$3,750
g	Water Charges	6.90				1000 cf	1,307	9,017	0	0	$9,017
											$0
											$0
											$0
	TOTAL COST							9,017	3,750	0	$12,767

Unit costs are taken from Means 1996 Site Work and Landscape Cost Data

a = ChemicalSpreader Rental 016-440-1000
g = City of Alamogordo charges $6.90 per 1,000 cf of water. Assume 1/2 of an inch of water weekly over 60 acre area (12 Weeks)

ITEM	
Total System Costs (subcontractor)	$12,767
Total Cost	$12,767
Mobilization/Demobilization (5%)	$638
Total Site Construction Costs	$13,405
New Mexico Gross Receipt Taxes (6.25%)	$838
TOTAL SITE REMEDIATION	**$14,243**

Annual Operation and Maintenance Costs (No Watering)

Reference	Title of Action	Unit Cost				Unit	Quantity	Cost per Category			TOTAL COST
		Material	Equipment	Labor	Total			Material	Equipment	Labor	
e	Fine grading and seeding (1% of 60 acre area)	0.21	1.01	0.21	1.43	sy	2,904	610	2,933	610	$4,153
											$0
											$0
	TOTAL COST										$4,153

Unit costs are taken from Means 1996 Site Work and Landscape Cost Data

e = Fine grading and seeding -- 022-286-1000

ITEM	
Total Annual Costs	$4,153
New Mexico Gross Receipt Taxes (6.25%)	$260
Site Construction Costs	$4,412
TOTAL O&M ANNUAL EXPENSES	**$4,412**

APPENDIX D

List of Reports Prepared Regarding the Sewage Lagoons at Holloman AFB

APPENDIX D
List of Reports Prepared Regarding the Sewage Lagoons at Holloman AFB

REPORT TITLE	DESCRIPTION	DATE
Evaluation for Hazardous Waste at Holloman AFB Sewage Treatment Plant	EP toxicity results of November 1981 water and sludge samples collected from the sewage lagoons and Lake Holloman	January 1982
Report to USEPA Regarding Holloman Air Force Base Lagoons and T-38 Washrack Oil-Water Separator	Analytical results of sludge and wastewater samples collected from Ponds A and B.	December 22, 1983
Sewage Lagoon Test Results	Analytical results of sludge and wastewater samples	UBTL/March 1985
Evaluation for 129 Priority Pollutants, Holloman AFB Sewage Ponds	During December 1984 HAFB collected sludge and wastewater samples from Ponds A, B, and C and analyzed for the 129 priority pollutants, heavy metals and pesticides and EP toxicity. Analytical methods used included EPA methods 624, 625, and 608, cyanides, and total phenols.	Holloman AFB Bioenvironmental Engineering Services/March 1986
Analytical Summary of Holloman Air Force Base Delisting Assessment, Holloman, New Mexico	Analytical results of December 1984 sampling event and a July 1987 sampling event that collected one sludge and one water sample from each sewage lagoon, Lake Holloman, and Lake Stinky. Appendix IX constituents were analyzed during the July 1987 event.	Wadsworth/ALERT Laboratories/August 18, 1987
Draft Quality Control Summary Report (A-E QCSR) for Additional Sampling Hazardous Waste Sewage Sludge Removal	Defines extent of PCB, organic constituents, and metals contamination in Ponds A (45 locations) and B (40 locations) and along the periphery of each lagoon (4 samples each). Analytical results of sewage sludge for metals, Methods 8240, 8270, 8080, cyanide, and EP toxicity. Samples were collected between August 22 and September 8, 1988.	Radian/January 1989
Hydrogeologic Investigation Report and Groundwater Monitoring Plan for the Sewage Treatment Lagoons	Results of hydrogeologic investigation and proposed monitoring system.	Radian/July 1989
Data Quality Control Summary Report for Additional Groundwater Samples from the First Groundwater Sampling Round	Results of groundwater monitoring.	Radian/November 1989
Letter to USACE summarizing sampling activities conducted in March 1990 for Ponds B and C	Analytical results of sludge and soil collected from Pond C.	Radian letter report April 1990

List of Reports Prepared Regarding the Sewage Lagoons at Holloman AFB

(Continued)

REPORT TITLE	DESCRIPTION	DATE
Second, Third, and Fourth Monthly Groundwater Sampling Report	Results of groundwater monitoring from September 25-28; November 5-8; and December 10-14, 1989.	IT Corp./ May 1990
First semiannual groundwater sampling report	Results of groundwater monitoring from January 15-17, 1990	IT Corp./ May 1990
Project Assessment Report of the Sewage Lagoons System, March 1980-July 1990	History of sewage lagoons and lakes project.	Radian/August 1990
Risk Assessment for the Sewage Lagoon System	Table 4-3 of the report contains maximum concentrations of constituents detected in previous investigations of the sewage lagoons.	Radian/February 1991
A-E Sampling and Quality Control Summary Report (A-E SQCSR) for Field Investigation to Support Sewage Lagoon Closure	Focuses on the quality of the soils underlying the sludge in Ponds A and B, and if any contaminants migrated to Pond C. Soil samples were collected from Ponds A, B, and C; sludge samples were collected from Ponds B and C; a groundwater sample was collected from Pond B. Four background soil samples were also collected. Samples were collected in March and November 1990. Samples were analyzed using SW methods 8240 (volatile organics), 8270 semivolatile organics), 8150 (chlorinated herbicides, 8080 (pesticides and PCBs), 9012 (cyanide), and 6010, 7060, 7471, and 7740 (metals).	Radian/June 1991
Quality Control Summary Report for Sewage Lagoon Surface Water Sampling	Results of surface water samples collected October 8-10, 1990 at Headworks, Ponds B, C, D, E, G, and Lake Holloman	Radian/June 1991
Second Semi-annual Groundwater Sampling Report	Results of groundwater sampling performed July 17-20, 1990	IT Corp./June 1991
Background Contamination Indicator Parameters Summary Statistics for Upgradient Wells and Comparison with Data for the Second Semi-annual Groundwater Sampling Episode, Sewage Treatment Lagoons Monitoring Wells	See title for description	IT Corp./June 1991
Third Semi-annual Groundwater Sampling Report	Results of groundwater sampling performed January 14-17, 1991	IT Corp./June 1991

List of Reports Prepared Regarding the Sewage Lagoons at Holloman AFB

(Continued)

REPORT TITLE	DESCRIPTION	DATE
Background Contamination Indicator Parameters Summary Statistics for Upgradient Wells and Comparison with Data for the Third Semi-annual Groundwater Sampling Episode, Sewage Treatment Lagoons Monitoring Wells	See title for description	IT Corp./June 1991
Fourth semiannual groundwater sampling report	Results of groundwater sampling from July 15-19, 1991	IT Corp./ October 1991
Background Contamination Indicator Parameters Summary Statistics for Upgradient Wells and Comparison with Data for the Fourth Semi-annual Groundwater Sampling Episode, Sewage Treatment Lagoons Monitoring Wells	See title for description	IT Corp./October 1991
Groundwater Assessment Monitoring Plan for the Sewage Treatment Lagoons	Describes groundwater monitoring procedures for the Phase I Assessment	Radian/September 1991
Conceptual Plan for Sludge and Soil Sampling	Describes alternate plan for sampling each sewage lagoon to support the PCCP application.	Radian/November 1991
A-E Sampling and Quality Control Summary Report for Appendix IX Groundwater Sampling, Assessment Monitoring Program	Analytical results of assessment monitoring program conducted between September 1991 and April 1992	Radian/April 1992
Results of Confirmation Sampling and Comparison to Appendix IX Sampling, Assessment Monitoring Program, Holloman AFB, NM	Results of confirmation sampling to determine the presence of organochlorine pesticides in the groundwater. Sampling was performed in February 1992.	Radian/April 1992
Hazardous Waste Sewage Sludge Removal Lab Results	Results of sludge sampling on October 9, 1990	WT Environmental Consultants/ May 1992
Sampling and Quality Control Summary Report (A-E SQCSR), Sewage Lagoon Investigation	Appendix IX analytical results of sludge and soil collected in the Ponds C, D, E, G, ditch, and Lakes Holloman and Stinky during the Spring of 1992. Sludge and soil samples were also analyzed for organophosphorus pesticides, chlorinated herbicides, PCBs, dioxins and furans.	Radian/August 1992

List of Reports Prepared Regarding the Sewage Lagoons at Holloman AFB

(Continued)

REPORT TITLE	DESCRIPTION	DATE
Site Characterization Report Sewage Lagoon Investigation	Presents results and conclusions for the spring of 1992 investigation.	Radian/August 1992
Draft Final Chemical Data Acquisition Plan (CDAP)	Presents sampling scheme for 1993 investigation. The appendix presents the results of the 8080 geoprobe analyses.	Radian/January 1993
Draft Final Phase 2 - RCRA Facility Investigation Report for Lakes Holloman and Stinky	Contains data evaluation criteria, conclusions and recommendations for groundwater monitoring results from wells downgradient of the Lakes	Radian/December 1993
Sampling and Quality Control Summary Report (A-E SQCSR) Sewage Lagoons and Lakes Investigation, Draft Final	Analytical results for 8080 geoprobe water samples, and inorganic results for background soils and groundwater samples. Also inorganic analyses for soils, surface water, and groundwater; and organic analyses for soils, surface water and groundwater collected from the sewage lagoons and lakes. In addition results of biota samples collected from sewage lagoons and Lake Holloman.	Radian/October 1993
Holloman Risk Assessments for Sewage Lagoons and Lakes Investigation	Vol. II, Appendix B to this report presents the analytical data collected in previous investigations of the sewage lagoons. Appendix M describes the biota sampling event.	Radian/November 1993
Draft Final Phase 1 - Groundwater Assessment Monitoring Report, Sewage Lagoons and Lakes Investigation	Defines lateral extent of Method 8080 pesticides in uppermost aquifer. Appendix IX constituents were collected in new wells that were installed. Document contains data evaluation criteria, conclusions and recommendations.	Radian/December 1993
Preliminary Survey of Contaminants Present in Biota, Pore-Water, and Sediments at the Holloman Air Force Base Waste Water Treatment Facility	During the summer of 1991, USF&WS collected eleven sediment, 1 pore-water, and 35 biological samples in the sewage lagoons and Lake Holloman. Samples were analyzed for heavy metals and metalloids, organochlorine pesticide and PCBs, polycyclic aromatic hydrocarbons, aliphatic hydrocarbons, and certain dioxin and furan compounds. Results and conclusions are presented in this report.	USF&WS/January 1994
Conceptual Plan for Additional Sampling Sewage Lagoons and Lakes Investigation	Describes proposed sampling procedures to identify extent of contamination in the sewage lagoons and lakes.	Radian/January 1994

List of Reports Prepared Regarding the Sewage Lagoons at Holloman AFB

(Continued)

REPORT TITLE	DESCRIPTION	DATE
Project Assessment Report, Sewage Lagoons and Lakes, Closure Project	Provides historical background of regulatory issues, and investigates from the early 1980s through 1995.	Radian and Foster Wheeler, March 1995
Long-term Monitoring Plan for the Sewage Lagoons	Outlines the current groundwater monitoring program for the sewage lagoons.	Radian, April 1995
Annual Sampling Reports, Sewage Lagoons Long-term Groundwater Monitoring Program	Presents the results of the 1995 groundwater monitoring program for the sewage lagoons.	Radian, February 1996
Risk Assessment Report	Updates risk values for human health using the data collected during 1994 and 1995. Completely redoes the ecological risk assessment using biological sample data collected.	Radian and Foster Wheeler, March 1996
Site Characterization Report	Provides results and conclusions of data collected during 1994 and 1995. Describes trend in data from previous investigations.	Radian and Foster Wheeler, June 1996
Biological Resources Report	Describes effects that different closure alternatives could have on the ecosystem provided by the sewage lagoons and lakes.	Radian and Foster Wheeler, June 1996
Corrective Measures Study	Provides an evaluation of several closure alternatives, defines the closure objective and criteria, and proposes a conceptual design for closure of the sewage lagoons.	Radian, June 1996