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NAS CECIL FIELD
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REMEDIAL ACTION PLAN NORTH FUEL FARM SITE NAS CECIL FIELD FL
1/1/1997
ABB ENVIRONMENTAL SERVICES INC

Rec'd 1-30-97
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REMEDIAL ACTION PLAN
NORTH FUEL FARM SITE

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

UNIT IDENTIFICATION CODE: N60200
CONTRACT NO.: N62467-89-D-0317/124

JANUARY 1997

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORTH CHARLESTON, SOUTH CAROLINA
29419-9010

PRINTED ON RECYCLED PAPER

REMEDIAL ACTION PLAN CHECKLIST

Bureau of Waste Cleanup
Florida Department of Environmental Protection

Facility Name: North Fuel Farm Site, NAS Cecil Field, Jacksonville, Florida **Reimbursement Site:** [ ]

Location: NAS Cecil Field, Jacksonville, Florida **State Contract Site:** [ ]

FAC ID No.: _____

Reviewer: _____ **Date:** January 29, 1997 **Consultant:** ABB Environmental Services

Date of CAR Approval: October 1996

This checklist should not be applied in blanket fashion. Technical judgement may be necessary in determining the applicability of some items. However, all information listed that is relevant to the remedial design should be provided.

PAGE(S) I. GENERAL

PAGE(S)		
14-1	(1)	RAP signed, sealed, and dated by Florida P.E. (per FS 471.025)
no	(2)	indication whether proposed plan is for reimbursement program or state contracted cleanup
2-4	(3)	recap of CAR information and conclusions pertinent to RAP preparation
4-1		a) horizontal and vertical extent of contamination in soil and groundwater
4-1		b) volumes of affected soil and groundwater;
4-1		c) estimated mass of contaminants in soil and groundwater.
2-4		d) depth to water table
2-4		e) groundwater flow direction and gradient
2-4		f) hydraulic conductivity of aquifer and method of determination
2-4		g) transmissivity of aquifer and method of determination
2-4		h) confining layer location
2-4		i) lithology of site
App -A3	(4)	current sampling results (within six (6) months) used for remediation system design
3-2	(5)	latest date underground storage tanks and product lines have tested tight
4-6	(6)	potable water considerations
4-6		a) method of potable water supply to area
Fig 4-5		b) location of private wells in 1/4-mile, and public wells in 1/2-mile radius of site
na		c) indication whether FDEP district office drinking water program was notified if contaminant groundwater could be expected to reach any public or private water well. Method of notification, person notified, and date.
Fig 2-1	(7)	underground utilities which may enhance contaminant transport shown
App-I	(8)	cleanup time
		a) estimated time of cleanup: groundwater; soil
		b) method used to determine cleanup time

_____ (9) fencing treatment area required, unless public access is restricted by institutional controls

13-1 (10) discussion of required maintenance for proposed equipment, including site visit frequency and special O&M considerations

13-1 (11) all local, state, and federal permits obtained and conditions stated

na (12) itemized cost estimate for project: capital, operation, maintenance, sampling, and closure

na (13) feasibility of leasing equipment considered (cost cannot exceed purchase price)

App-B (14) alternative analysis or discussion of other alternatives considered

App-I (15) cost effective analysis provided if design is innovative

13-1 (16) statement that signed and sealed as-built drawings to be provided

na (17) nuisance noise and odor to neighbors avoided by careful location of equipment items and exhaust stacks or other mitigating measures

II. REMOVAL AND/OR REPLACEMENT (R/R) OF PETROLEUM STORAGE SYSTEMS: Technical and Reimbursement Considerations

(1) General

na a) indication whether R/R will be claimed as reimbursable expense

na b) acknowledgement that R/R reimbursement is exclusive of hardware

na c) acknowledgement that any relocation and facility renovation activities during R/R are not reimbursable

na d) if dewatering involved during R/R, then documentation provided regarding proper disposal, or verification that water not contaminated

6-1 e) indication of quantity and location of soil removed, or to be removed, from below the static water table

(2) PRIOR TO JULY 1, 1992: R/R reimbursement justification based on association of contamination with the tank (or tank pit)

na a) verification of petroleum storage system as potential contamination source by either verified leak, apparent leak, or overlapping when soil and/or groundwater contamination plumes superimposed on a site map showing tank bed

na b) indication of whether R/R has already been done, or to be done after RAP approval

na c) proper disposal of water, soil, and sludge from the R/R

na d) scaled site map including:

(1) identification and location of all storage system components to be R/R
(2) boundaries and dimensions of excavation

Yes or No e) FDEP reviewing engineer: Agree that tanks which were subject of R/R were associated with the contamination? If disagree, then include statement in RAP Approval Order, even if tanks already removed

(3) **ON OR AFTER JULY 1, 1992:** R/R reimbursement is based on pertinence of tank removal to the achievement of cleanup criteria set for in 62-770, F.A.C.

na a) R/R justified as meaningful and necessary for achievement of 62-770 FAC cleanup criteria

na b) if R/R is part of a RAP Modification, then show cost-effectiveness in comparison to other alternatives and no action

na c) if R/R was done during IRA, then discussion of necessity of R/R in order to remove contaminated soil and/or free product

na d) if R/R is associated with a MO or NFA, then show that the removal of soil, product, and groundwater contributes or contributed to achieving MO or NFA criteria

Yes or No e) FDEP reviewing engineer: Agree that R/R contributed (or will contribute) in a meaningful way to site cleanup? If disagree, then include statement in RAP Approval Order even if tanks already removed

III. FREE PRODUCT REMOVAL

4-1 (1) free product plume identification

8-1 (2) description of free product recovery system

na (3) oil/water separator sizing calculations and detention time

na (4) free product storage tank of adequate size for reasonable maintenance

na (5) automated product pump shutdown for high level in product tank

na (6) disposition free product after its recovery

IV. SOIL REMEDIATION - GENERAL

6-1 (1) volumes of all contaminated and excessively contaminated soils

3-1 (2) recap of IRA activities and soil volume already excavated

na (3) effect of soil leachate from non-excessively contaminated soils on groundwater contaminant levels evaluated

4-3 (4) indication that excessively contaminated soils (per soil guidance manual) will be remediated, or rationale for "no action" alternative for soil remediation provided

6-1 (5) disposition of excavated, contaminated soils

na (6) indication that hazardous soils (e.g., ignitable, corrosive, reactive, toxic, or petroleum refining waste) will be disposed of properly

V. LAND FARMING OF SOIL

_____ (1) adequate surface area available (_____ sq ft) to spread soils 6 to 12 inches thick

_____ (2) location of landfarming operation

_____ (3) landfarming area is flat (less than 5% slope)

_____ (4) impermeable base provided. Type:

_____ (5) surface water runoff controls provided

_____ (6) groundwater monitoring plan proposed if landfarm is outside of immediate contamination area

_____ (7) frequency of tilling provided

_____ (8) frequency and details of nutrient application or other enhancements provided (if proposed)

_____ (9) soil sampling frequency and sampling methods provided

_____ (10) potential for land farm causing nuisance conditions evaluated

_____ (11) underlying soil and groundwater monitoring procedures provided and acceptable

_____ (12) landfarming will be continued until the TRPH concentration is 10 ppm or less (by EPA Method 9073) and the BTEX concentration is less than 100 ppb (by EPA method 5030/8020); or TRPH concentration is 50 ppm or less, and PAH concentration is 1 ppm or less, and VOH concentration is 50 ppb or less. Alternate TRPH standard may be considered if appropriate and acceptable means of soil disposal is identified.

_____ (13) cost-effectiveness evaluated

_____ (14) ultimate disposition of soils discussed

_____ (15) need to fence landfarm area considered

VI. LANDFILLING OF SOILS

_____ (1) landfill lined permitted by FDEP

_____ (2) name and location of landfill provided along with conditions of acceptance

_____ (3) cost-effectiveness considerations

VII. SOIL THERMAL TREATMENT

App-D (1) name and location of thermal treatment facility provided

_____ (2) facility is permitted for thermal treatment of petroleum contaminated soils

_____ (3) indication of whether pretreatment soil samples will be collected at site or at thermal treatment facility

_____ (4) cost-effectiveness evaluation

VIII. COMMERCIAL BIOREMEDIATION OF SOIL

_____ (1) name and location of bioremediation facility provided

_____ (2) facility is permitted for bioremediation of petroleum contaminated soils

_____ (3) indication of whether pretreatment soil samples will be collected at site or at bioremediation facility

_____ (4) cost-effectiveness evaluation

IX. IN SITU BIOVENTING OF SOIL

_____ (1) soil cleanup criteria identification

_____ (2) estimated mass of contaminants in the vadose

_____ (3) pilot test determination of: a) soil temperature, permeability, pH, moisture, b) nutrient requirements; c) presence of suitable indigenous microbes; and d) oxygen requirement (usually as pounds of air to pound of hydrocarbon degraded)

_____ (4) layout: a) location of air injection and air extraction and wells with respect to contaminated soil plume location and depth; b) location and depth of soil gas monitoring probes with respect to contaminated soil plume and the air injection and extraction wells.

_____ (5) mechanical details, equipment sizing calculations, and operating parameters: a) well type - vertical or horizontal; b) well construction details; c) indication whether soil vacuum pump will be used alone (with induced influx of air from unsealed surface acting as oxygen source) or accompanied by air injection pump as oxygen source; d) vacuum pump/blower specifications and horsepower; e) method and design details of moisture addition if site soils are dry; [illegible] method and design details of nutrient delivery system, if necessary

_____ (6) estimated cleanup time

_____ (7) instruments, controls, gauges, and valves: a) subsurface soil gas monitoring probes; b) pressure gauges; c) shutoff/throttling valves; d) nutrient and moisture addition control devices and meters

_____ (8) monitoring plan: CO_2; pertinent bioremediation parameters; contaminants of concern.

_____ (9) air emissions: a) generally, no air emissions treatment necessary because vapor flow rates are so low and biodegradation of petroleum results in production of CO_2 and water; b) evaluation of need for offgas treatment if pilot test indicated that a significant amount of coincidental hydrocarbon volatization occurs.

X. SOIL VACUUM EXTRACTION

7-1 (1) Prerequisites

7-1 a) relatively permeable soil

7-1 b) depth to groundwater > 3 ft

7-1 c) relatively volatile contaminants

(2) Pilot study (results of onsite testing, unless pilot study approaches size of full-scale system)

_____ a) pilot test components designed and located for cost-effective subsequent integration into full-scale design

_____ b) diagram of pilot layout indicating location of vapor extraction well, and radial distance of monitoring wells from the vapor extraction well

_____ c) air flow, cfm

_____ d) radius of influence, ft; vacuum (inches of water) at limit of radius of influence

_____ e) water elevations at monitoring wells to assess groundwater mounding; observed mound, inches

_____ f) vacuum readings at monitoring wells and at various radial distances from extraction well to aid in full-scale design

_____ g) measurement of offgas contaminant concentrations for the purpose of selecting and sizing cost-effective offgas treatment for full-scale system

_____ h) determination of soil's permeability (Rule of thumb): permeability should be greater than 10^{-9} sq cm)

(3) Full-scale design

7-1 a) location(s) and radius of influence, ft; overlapping radii for adequate coverage of excessively contaminated soil plume

Fig 7-3 b) vapor extraction well(s) construction details

7-1 1) no. of wells; cfm ea well; total cfm; well type (vertical or horizontal); well diameter; well depth; water table (ft bls); screen slot size; screened interval (ft bls); well sealed w/bentonite or non-shrinking grout at screen design depth to prevent short-circuiting.

7-1 2) screen location close to water table to optimize collection of vapors across vadose depth but not so close as to collect excessive water

App-E c) operating vacuum @ wellhead(s), inches water

1) calculation of piping system friction losses

2) calculation of vacuum pump motor hp based on system losses plus required vacuum at wellhead

App-E d) vacuum source type; regenerative blower; positive displacement vacuum pump; other

_____ 1) design: cfm @ inches water; operating cfm @ inches water

_____ 2) mfgr; model; motor hp; rpm; performance curves; hp calculations or curves

_____ 3) nonferrous materials of construction and/or assembly to minimize potential for sparking and friction

_____ 4) explosion proof motor specified

_____ e) moisture separator/condensation trap ("knock out pot") prior to inlet of vacuum pump

_____ f) surface sealing provided for vacuum extraction, or existing concrete or asphalt adequate

_____ g) safety:

_____ 1) system operation at approximately 25% of Lower Explosive Limit (LEL)

_____ 2) bleed valve to control flammable vapor concentrations

_____ h) instrumentation, gauges, and appurtenances:

_____ 1) vacuum gauges at each well; temperature gauges (@ vacuum pump and/or exhaust gas stack)

_____ 2) sample ports for influent from each well, and for the offgas from the treatment unit

_____ 3) air flow control: shout/throttling valve at each well; other air flow control device or method

_____ d) screening interval appropriate

_____ (3) predicted horizontal and vertical area of influence with hydraulic gradient provided

_____ (4) expected drawdown in recovery well or trench (_____ft)

_____ (5) consideration of multiple well configurations to minimize drawdown

_____ (6) groundwater pump(s) description , pump characteristic curve, design flowrate (____gpm at ____ft TDH provided) mfgr; model; motor hp

_____ a) hydraulic design (including friction losses and suction lift considerations acceptable

_____ (7) automated well level controls provided for stopping/starting groundwater pump(s)

_____ (8) totalizing flowmeter installed on influent line from each groundwater recovery pump

_____ (9) check valve provided on pump discharge piping if not integral to pump

_____ (10) shutoff/throttling valve provided on pump discharge piping

XIV. GROUNDWATER TREATMENT SYSTEM - GENERAL

_____ (1) expected or calculated influent concentrations acceptable (based upon pumping test dynamic sample, weighted averaging procedure, or other reasonable assumptions)

_____ a) summary of the expected influent concentrations: benzene_____; toluene_____; ethylbenzene_____

xylene_____; MTBE_____; total naphthalenes_____

PAHs _____; EDB_____; 1-2 dichloroethane_____

others_____

_____ (2) feasibility of discharge to sewage treatment plant evaluated

_____ a) consideration given to less time and/or level of treatment required to meet sewage system pretreatment standards

_____ (3) site piping plan, and schematics of all treatment components, piping valves, controls and appurtenances provided

_____ a) influent and effluent sampling ports provided

_____ b) piping type and size provided

_____ (4) Iron fouling: a) groundwater analyses: total ____ppm; dissolved____ppm; and b) consideration whether iron fouling should be controlled by filtration of influent to remove particulately-bound iron, and/or by removal or sequestering of dissolved iron to prevent precipitation in process equipment items.

(Generally, "normal" concentration of dissolved iron in water is approx. 0.1 to 0.3 ppm, and unless the pH of the water falls below 5, it rarely exceeds 1 ppm.)

_____ (5) Calcium carbonate: Consideration whether pretreatment or other measures necessary to prevent fouling by calcium carbonate (Langalier Index calculation based on groundwater samples may aid in this consideration)

_____ (6) need for pretreatment or O&M for biofouling considered

XV. AIR STRIPPING TREATMENT PROCESS

_____ (1) Packed Tower:

_____ a) type, size, and surface area of packing

_____ b) calculations, criteria, design parameters

tower height ; tower diameter
packing height ; water flow rate

air flow rate ; blower hp

air/water ratio ; pressure drop across packing

_____ c) pressure gauge to indicate effects of fouling over time

_____ d) mist eliminator

_____ e) observation port

_____ f) O&M considerations (fouling potential)

_____ (2) Diffused Aerator (tank type):

a) calculations, parameters (tank volume; contact time, air flowrate, pressure drop, contaminant removal efficiency) and design assumptions

_____ (3) Low Profile Air Stripper

_____ a) Number of trays; water flow rate; air flow rate; air/water ratio; pressure drop; blower horsepower; mist eliminator;

_____ (4) General:

_____ a) maximum ambient air impact calculations; emissions stack height

_____ b) equipment description if emissions treatment necessary

_____ c) automated recovery well shutdown when blower failure occurs

_____ d) daily analysis screening with portable GC, or other appropriate measures, during system startup until system consistently meets discharge criteria

XVI. LIQUID-PHASED CARBON ADSORPTION

_____ (1) indication whether adsorption is for primary treatment of groundwater or polishing of effluent

_____ (2) carbon specifications

_____ (3) carbon unit(s) sizing calculations (carbon usage rate, contact time, pressure losses) /design assumptions

_____ (4) isotherm data from pilot study needed if carbon adsorption used as primary treatment and total VOA concentrations are appreciable (VOA > 100 ppb typically) in order to estimate carbon capacity required and sampling frequency

_____ (5) TOC in groundwater determined and effect on carbon usage considerations

_____ (6) need for sand filter or cartridge unit considered prior to carbon unit

_____ (7) pressure gauge and pressure relief valve provided on carbon (and sand) filter

_____ (8) carbon disposal and replacement method

_____ (9) series configuration of carbon units considered to allow for maximum carbon utilization and prevention of contaminant breakthrough to system effluent

_____ (10) automated recovery well shutdown if primary carbon unit pressure too high

_____ (11) schedule for sampling between and after carbon adsorption units

XVII. IN SITU AIR SPARGING OF GROUNDWATER

_____ (1) Prerequisites:

_____ a) No or little free product which could spread via sparge turbulence, or prolong sparging

_____ b) Volatile (C3-C10) petroleum fractions with Henry's Constant > = .00001 atm.m^3/mole (approx. rule of thumb, unless biosparging is proposed)

_____ c) no high concentrations of metals (iron, magnesium) to form oxides which plug aquifer or well screens, or high concentrations of dissolved calcium, which could react with CO_2 in air to clog aquifer w/calcium carbonate

(Notes: Langelier index calculation regarding equilibrium between calcium carbonate and dissolved CO_2 may be helpful. Generally, precipitation of dissolved iron is less likely when water is acidic, approx. of pH less than 6.)

(2) Pilot study results

_____ (3 stage pilot study recommended prior to RAP design): vapor extraction only; sparging only; combined extraction and sparging

A pilot study is generally necessary, unless plume size is relatively small and aquifer characteristics favorable

_____ a) pilot test components designed and located for cost-effective subsequent integration into full-scale design

_____ b) diagram of pilot layout indicating locations of air injection well, vapor extraction well, and radial distance of monitoring wells from the air injection well

_____ c) air flow rates for each stage: vapor extract, cfm; sparging, cfm; combined cfm

_____ d) radius of influence for each stage: vapor extract, ft; sparging, ft; combined ft

_____ e) groundwater mounding observed during each stage: vap extract, inches; sparging, inches; combined, inches

_____ f) measurement of parameters which are pertinent to full-scale design at various radial distances from the air injection well (for example: vacuum readings, pressure readings, water elevations, dissolved oxygen, pH, and conductivity)

_____ g) measurement of vapor extraction system offgas contaminant concentrations for the purpose of selecting and sizing cost-effective offgas treatment for full-scale system

_____ h) determination of soil's permeability. (should be greater than 10^{-9} sq cm for sparging to be feasible)

_____ i) need for groundwater recovery for plume control evaluated.

(3) Full-scale design

_____ a) groundwater contamination plume coverage:

_____ 1) location(s) and radius of influence for full-scale air injection well(s); Adequate coverage by overlapping radii of influence if multiple well system

_____ b) air injection well(s): no. of wells; well design; operating air press at wellheads; cfm each well; total cfm _____

_____ c) avoidance of long screen allowing air to diffuse at top portion only, where air flow resistance is least (typ screen is 1 to 3 ft lg)

_____ d) well depth and screened interval (or depth of sparge tip) appropriate w/ respect to depth of contamination _____

_____ e) vapor extraction well(s) in conjunction w/sparging situated properly to recover volatiles and prevent their release to atmosphere:

_____ 1) injection cfm of air typically 20 to 80 % of vapor extraction cfm. (0.2 to 0.8)

_____ 2) automatic shutdown of air injection upon loss or low vapor extraction system vacuum, or failure of vacuum pump motor, in order to prevent air emissions

_____ 3) adequate and cost-effective treatment of vapor extraction system offgas proposed to prevent air emissions

_____ f) compressor:

design: cfm @ psig; operating cfm @ psig
compressor: type; mfgr; model; motor hp; rpm; performance curves;
air filter at compressor inlet; oil trap or oil-free compressor to avoid introducing more contamination to aquifer

_____ g) safety: pressure relief valve at discharge of compressor and/or high pressure switch for automatic shutdown

_____ h) instrumentation and gauges: pressure indicating gauges at each sparging well

_____ i) air flow control: shutoff/throttling valve at each well; other flow control device or method

_____ j) cost-effectiveness evaluation of proposed full-scale design includes cost of pilot study

XVIII. IN SITU/ENHANCED BIORECLAMATION

App-I (1) groundwater parameters evaluation (pH, DO, TDS, N, P, Temp, TOC, and Alk, etc.)

11-1 (2) monitoring program discussion. TOC to be monitored

_____ (3) additional oxygen source provision

_____ (4) oxygen and nutrients method of application and application rate to contaminated area evaluated

_____ (5) suitable soils present (non-clayey, good transport, low adsorption properties)

_____ (6) bench scale and/or in situ pilot study proposal

XIX. LEAD REMOVAL

_____ (1) discussion of area(s) where groundwater lead concentrations exceeds 15 ppb

_____ (2) lead concentrations; unfiltered (___ppb); filtered (___ppb); background (___ppb);

_____ (3) proposal for lead removal by filtration if unfiltered sample is greater than 15 ppb and filtered sample is less than 15 ppb

_____ (4) method of lead removal, including pertinent design calculations

XX. INFILTRATION GALLERY

_____ (1) field percolation test (preferably with double ring infiltrometer) provided if gallery base is located in the vadose zone

_____ (2) infiltration gallery construction details and location (upgradient location if site layout allows)

_____ (3) gallery calculations/assumptions with mounding analysis

_____ (4) piezometer and cleanout pipe in gallery

_____ (5) geotextile filter fabric to be installed around the above gallery

_____ (6) discussion or modeling of gallery's effect on plume migration

XXI. INJECTION WELL

_____ (1) discussion of injection zone and relevant lithology information

_____ (2) injection well location and proposed construction details

_____ (3) screening interval appropriate

_____ (4) effluent discharge pump description, pump characteristic curve, and design flow rate (____gpm at ____ft TDH)

_____ (5) carbon polishing unit (or equivalent)

_____ (6) air release valve at highest point of effluent discharge piping

_____ (7) injection rate (well hydraulics) calculations

_____ (8) Underground Injection Control (UIC) permit conditions met

_____ (9) evaluation of injection well's effect on potable wells and plume migration

XXII. ALTERNATE DISPOSAL METHODS

_____ (1) cost-effectiveness comparison of alternatives (including general permit fee of $2,500 per year in the cost estimate for NPDES disposal, if it is one of the alternatives being compared)

_____ (2) for surface water discharge:

_____ a) conditions for NPDES general permit met

_____ b) indication that notice of intent for NPDES permit will be submitted after RAP approval

_____ (3) if applicable, consumptive use permit obtained from water management district

_____ (4) approval from municipality for sewer discharge, and conditions and effluent standards to be met

_____ (5) applicable permits for stormwater discharge

XXIII. SAMPLING REQUIREMENTS

App-K (1) designated monitoring wells and their sampling frequency:

upgradient_____; downgradient_____; highest concentration_____

_____ (2) weekly sampling of influent from recovery well(s) and effluent at treatment system for first month, monthly sampling for first year

_____ (3) filing of annual status reports acknowledgement

_____ (4) water table contours and depth and extent of free product to be determined at monthly or quarterly sampling event

_____ (5) sampling program includes appropriate contaminants/procedures as specified in 62-770.600

_____ (6) periodic maintenance and site inspection limited to twice a month for first quarter, monthly thereafter, or justification for alternative frequency provided

REMEDIAL ACTION PLAN
NORTH FUEL FARM SITE

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Unit Identification Code: N60200

Contract No.: N62467-89-D-0317/124

Prepared by:

ABB Environmental Services, Inc.
2590 Executive Center Circle, East
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Prepared for:

Department of the Navy, Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29418

Bryan Kizer, Code 1842, Engineer-in-Charge

January 1997

CERTIFICATION OF TECHNICAL
DATA CONFORMITY (MAY 1987)

The Contractor, ABB Environmental Services, Inc., hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0317/124 are complete and accurate and comply with all requirements of this contract.

DATE: January 28, 1997

NAME AND TITLE OF CERTIFYING OFFICIAL: Rao Angara
Task Order Manager

NAME AND TITLE OF CERTIFYING OFFICIAL: Gopi Kanchibhatla, P.E.
Project Technical Lead

(DFAR 252.227-7036)

FOREWORD

Subtitle I of the Hazardous and Solid Waste Amendments of 1984 to the Solid Waste Disposal Act of 1965 established a national regulatory program for managing underground storage tanks (USTs) containing hazardous materials, especially petroleum products. Hazardous wastes stored in USTs were already regulated under the Resource Conservation and Recovery Act of 1976. Subtitle I requires that the U.S. Environmental Protection Agency (USEPA) promulgate UST regulations. The program was designed to be administered by individual States, who were allowed to develop more stringent, but not less stringent, standards. Local governments were permitted to establish regulatory programs and standards that are more stringent, but not less stringent, than either State or Federal regulations. The USEPA UST regulations are found in the Code of Federal Regulations (CFR), Title 40, Part 280 (40 CFR 280) (*Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks*) and 40 CFR 281 (*Approval of State Underground Storage Tank Programs*). 40 CFR 280 was revised and published on September 23, 1988, and became effective December 22, 1988.

The Navy's UST program policy is to comply with all Federal, State, and local regulations pertaining to USTs. This report was prepared to satisfy the requirements of Chapter 62-770, Florida Administrative Code (FAC) (*State Underground Petroleum Environmental Response*) regulations on petroleum contamination in Florida's environment as a result of spills or leaking tanks or piping.

Questions regarding this report should be addressed to the Commanding Officer, Naval Air Station Cecil Field, Jacksonville, Florida, or to Southern Division, Naval Facilities Engineering Command, Code 1842, at 803-820-5596 (AUTOVON 563-0307).

EXECUTIVE SUMMARY

A Contamination Assessment Report Addendum (CARA) for North Fuel Farm Site at Naval Air Station Cecil Field, Florida, was submitted by ABB Environmental Services, Inc. (ABB-ES), in April 1996 to Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM).

The CARA has concluded that

- jet fuel-contaminated soil at the site will require remediation to meet soil standards as outlined in Chapter 62-770, Florida Administrative Code (FAC);
- groundwater contamination at the site appears to be related to releases from the aboveground storage tanks (AST) and associated pipelines; and
- free product at the site is likely associated with one or more previous releases from the AST system. Very little of the product released at the site has been recovered by the bioslurping system and the infiltration/oil recovery trenches, currently part of an Initial Remedial Action for the site.

After review of the CARA by the Florida Department of Environmental Protection in October 1996, ABB-ES was authorized by SOUTHNAVFACENGCOM to develop a Remedial Action Plan (RAP), under Contract Task Order No. 124 of the Comprehensive Long-term Environmental Action, Navy (CLEAN) contract. This RAP has been developed to describe site cleanup. Components of this remedial action plan are as follows:

- excavation of excessively contaminated soil outside of the mound area containing active ASTs;
- installation of a soil vapor extraction system to treat excessively contaminated soil within the mound area;
- free product recovery and monitoring program implemented via installing temporary well points on the mound and connecting the points to the existing bioslurping system;
- installation of a biosparging system to treat contamination in the shallow groundwater zone (0 to 55 feet below land surface [bls]);
- installation of recirculation wells to enhance *in situ* bioremediation and implement *in situ* stripping of groundwater in the intermediate zone (55 to 100 feet bls);
- remediation by natural attenuation for the intermediate and deep zones (55 to 110 feet bls); and
- groundwater and system performance monitoring and reporting.

These systems will be operated until the "kerosene and mixed products analytical group" constituents (Chapter 62.770 FAC) in both the groundwater and the soil reach the required target concentrations or until remedial activities are no longer effective. It is estimated that the operation period will be about 5 to 10 years.

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Naval Air Station Cecil Field
Jacksonville, Florida

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GLOSSARY

AAS	Aquifer Air Sparging
ABB-ES	ABB Environmental Services, Inc.
acfm	actual cubic feet per minute
ASTM	American Society for Testing and Materials
BDL	below detection limits
BCT	Base Realignment and Closure (BRAC) cleanup team
BTEX	benzene, toluene, ethylbenzene, and xylenes
bls	below land surface
°C	degrees Celsius
CA	Contamination Assessment
CARA	Contamination Assessment Report Addendum
CAR	Contamination Assessment Report
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cm^2	square centimeters
COC	chemical of concern
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
ft/day	feet per day
ft/ft	feet per foot
Hg	mercury
IRA	Initial Remedial Action
JP-5	jet propellant 5
LTM	Long-Term Monitoring
mg/ℓ	milligrams per liter
MO	monitoring only
MTBE	methyl tert-butyl ether
μg/ℓ	micrograms per liter
NAS	Naval Air Station
NFA	no further action
NFF	North Fuel Farm
NPDES	National Pollution Discharge Elimination System
O&M	operation and maintenance
OVA	organic vapor analyzer
PAH	polynuclear aromatic hydrocarbons
POC	point-of-compliance
ppb	parts per billion
ppm	parts per million
ppmv	parts per million by volume
psi	pounds per square inch

GLOSSARY (Continued)

psig	pounds per square inch gauge
PVC	polyvinyl chloride
RAP	Remedial Action Plan
scfm	standard cubic feet per minute
SOUTHNAV-FACENGCOM	Southern Division Naval Facilities Engineering Command
SVE	soil vapor extraction
TRPH	total recoverable petroleum hydrocarbons
UV	ultraviolet
USEPA	United States Environmental Protection Agency
VOA	volatile organic aromatic
VOC	volatile organic compound
WWTP	Waste Water Treatment Plan
yd^3	cubic yard

1.0 INTRODUCTION

A Contamination Assessment Report Addendum (CARA) for the North Fuel Farm (NFF) Site at Naval Air Station (NAS) Cecil Field, Florida, was submitted by ABB Environmental Services, Inc. (ABB-ES) in April 1996 to Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM). After review of the CARA by the Florida Department of Environmental Protection (FDEP), ABB-ES was authorized by SOUTHNAVFACENGCOM to develop a Remedial Action Plan (RAP). This work is being performed under Contract Task Order No. 124 of the Comprehensive Long-term Environmental Action, Navy contract.

The NFF Site is located at the northeast corner of "A" Avenue and Loop Road (Figure 1-1). The fuel farm consists of six 595,000-gallon, interior-lined, asphalt-coated, steel, earth-mounded tanks that contain jet propellant 5 (JP-5 or Navy jet fuel). The tanks are numbered Tank 76 and 76-A through 76-E.

1.1 PURPOSE. The purpose of the RAP is to present a plan for remediation of petroleum contamination at the NFF Site consistent with the requirements of Chapters 62-770 and 62-775, Florida Administrative Code (FAC) (FDEP, 1994).

1.2 SCOPE. This RAP presents the rationale and details of the remedial actions to be implemented at the NFF Site and includes the following components:

- excavation of excessively contaminated soil outside of the mound area;
- installation of a soil vapor extraction (SVE) system to treat excessively contaminated soil within the mound area;
- free product recovery and monitoring program implemented via installing temporary well points on the mound and connecting the well points to the existing bioslurping system;
- installation of a biosparging system to treat contamination in the shallow groundwater zone (0 to 55 feet below land surface [bls]);
- installation of recirculation wells to enhance *in situ* bioremediation and implement *in situ* stripping of groundwater in the intermediate zone (55 to 100 feet bls);
- remediation by natural attenuation for the intermediate and deep zones (55 to 110 feet bls); and
- groundwater and system performance monitoring and reporting.

1.3 REPORT ORGANIZATION. The remainder of this report is organized as follows:

- Chapter 2.0 presents the history of investigations and a brief summary of contamination assessment and conclusions.

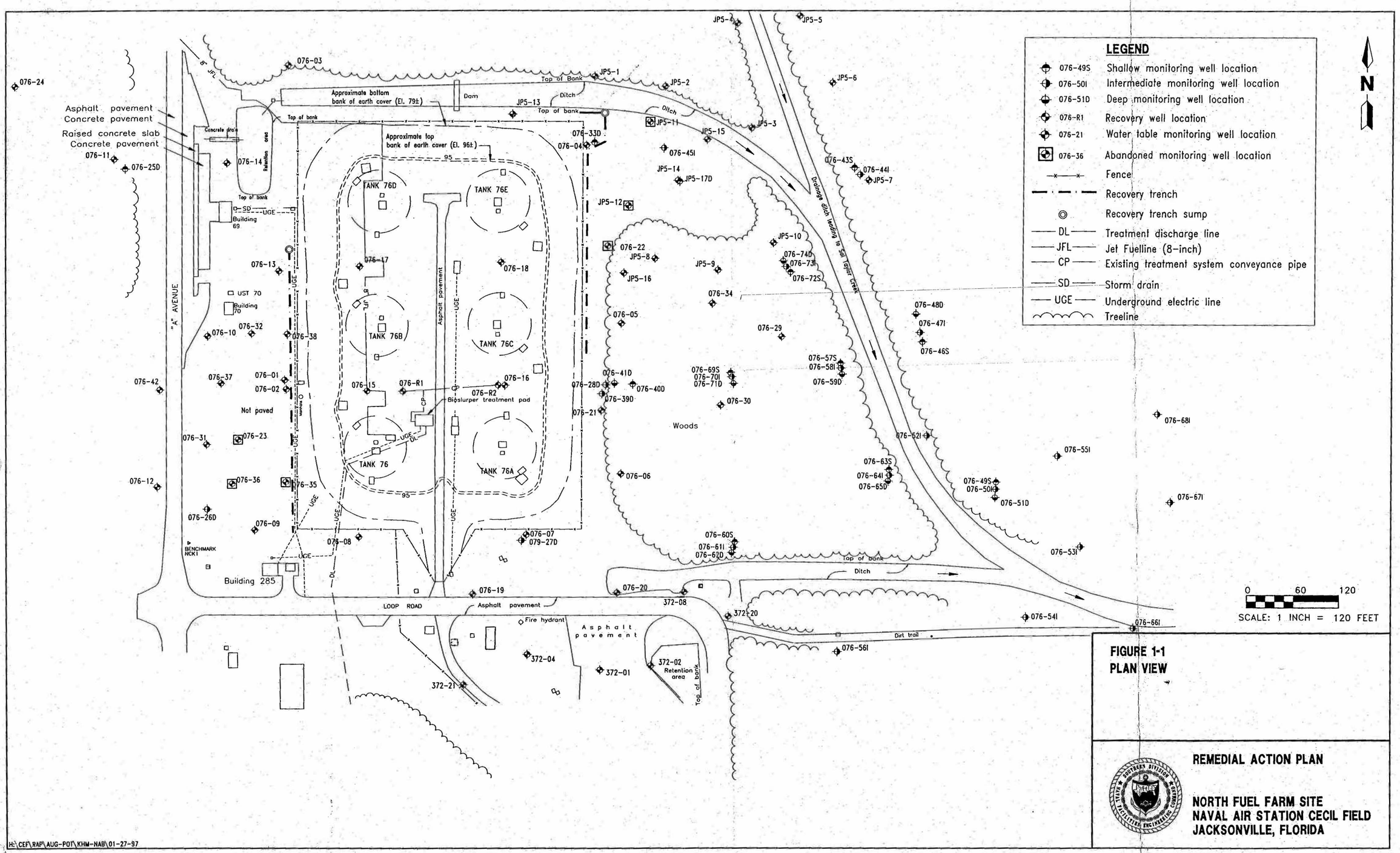


FIGURE 1-1
PLAN VIEW

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

- Chapter 3.0 presents a list of initial remedial actions conducted at the NFF Site.

- Chapter 4.0 includes a list of areas of concern, plus quantity and quality estimates of media to be addressed. It also includes a brief overview of exposure pathways and establishes a basis for the remedial strategy. The rest of Chapter 4.0 presents a review of technologies appropriate for implementing the remedial strategy and provides the rationale for the selection of technologies.

- Chapter 5.0 summarizes the components of the RAP outlined for the NFF Site.

- Chapters 6.0 through 11.0 present details of the technology description, system design, startup, and long-term monitoring plans for each of the components listed in Chapter 5.0.

- Chapter 12.0 presents the details of cost estimates for implementation of each of the components of the RAP.

- Chapter 13.0 outlines the reporting and documentation requirements during the implementation stage of the RAP.

- Chapter 14.0 includes the professional certification.

2.0 BACKGROUND

2.1 SITE DESCRIPTION. The NFF Site is located at the northeast corner of "A" Avenue and Loop Road (Figure 1-1). The fuel farm consists of six 595,000-gallon, interior-lined, asphalt-coated, steel, earth-mounded tanks that contain JP-5 (jet fuel). The tanks are numbered Tank 76 and 76-A through 76-E.

Tanks 76 and 76-A were installed in 1952; the remainder of the tanks were installed in 1954. The associated pipes are corrosion-resistant, coated steel. In 1987, each tank was relined and overfill protection (high-level alarms) was installed. In addition, Tank 76 is equipped with an automatic shut-off system. The volume of each tank is measured by a float indicator on a graduated gauge and recorded daily. Tank 76-E was taken out of service in July 1991 when it was determined to be leaking.

Figure 2-1 presents the details of fuel lines, underground utility lines, and associated substructures at the NFF Site.

2.2 SITE HISTORY.

2.2.1 Spill and Release History Review of records at NAS Cecil Field indicates the spill and release history at NFF Site as follows:

- The records showed that several holes had been discovered and repaired in the NFF Tanks 76, 76-A, and 76-B approximately 1 to 2 years after the tanks were put into service in 1954 and 1955.

- Major spills occurred on August 3, 1987, (22,772 gallons) on the west side of NFF, February 10, 1991, (913,000 gallons) on the northeast side of NFF, and November 28, 1993, (1,800 gallons) on the west side of NFF. The area associated with the 913,000-gallon spill is defined as the JP-5 Spill Site.

2.2.2 History of Investigations ABB-ES was contracted by SOUTHNAVFACENGCOM in 1991 to conduct a contamination assessment (CA) to characterize and assess the vertical and horizontal extent of contamination at the NFF Site and submit a Contamination Assessment Report (CAR) to the FDEP. Activity at the site included the following:

- Thirty-seven soil borings, 26 shallow monitoring wells, and 4 deep monitoring wells were installed at the site. Soil and groundwater samples were collected and analyzed for petroleum constituents of the kerosene analytical group (which includes JP-5) as defined in Chapter 62-770, FAC. In June 1992, ABB-ES submitted a CAR for the NFF Site to the FDEP (ABB-ES, 1992).

- The FDEP reviewed the NFF Site CAR and recommended that additional soil borings and monitoring wells be installed and sampled to better delineate the extent of soil contamination and free product at the site.

- In October 1993, ABB-ES advanced 92 soil borings at the NFF Site. In addition, three water table monitoring wells and one double-cased vertical extent monitoring well were installed in January 1994. Groundwater samples from all monitoring wells at the NFF Site that did not contain free product were collected in February 1994. The groundwater samples were analyzed for the kerosene analytical group parameters

- In April 1994, ABB-ES advanced 43 soil borings on the west side of the NFF Site to assess the extent of soil contamination from a 1,800-gallon JP-5 fuel spill that occurred in November 1993. Four water table monitoring wells were installed west of the tank farm and east of A Avenue and sampled in May 1994 to assess the extent of free petroleum product detected in three of the site monitoring wells. No free petroleum product was detected in any of the four product delineation wells. After discussing the soil boring results with FDEP representatives, ABB-ES advanced 12 additional soil borings on the west side of A Avenue on June 20, 1994, to further assess soil contamination from the 1,800-gallon fuel release. No soil contamination was detected west of A Avenue.

- One vertical extent monitoring well on the east side of the NFF Site was resampled on May 5, 1994, to verify benzene concentrations detected in February 1994 that exceeded Chapter 62-770, FAC, target levels. The resampling results indicated that groundwater was contaminated in the intermediate and deep zones (approximately 45 feet to 110 feet bls) of the surficial aquifer on the east side of the site. Consequently, two intermediate double-cased wells and one deep double-cased well were installed and sampled to assess the vertical extent of groundwater contamination.

- Groundwater analytical results of samples from the intermediate monitoring wells indicated that the horizontal extent of petroleum contamination detected in the intermediate zone of the surficial aquifer had not been adequately assessed. Installation of additional monitoring wells to assess the extent of contamination in the deep and intermediate zones was needed before the CAR addendum could be submitted to the FDEP for approval.

- Based on groundwater analytical data obtained from the deep and intermediate monitoring wells, it was apparent that a considerable quantity of fuel had leaked from Tanks 76, 76-A, and 76-B, approximately 40 years ago. After discussing the circumstances at the NFF Site with the FDEP, it was agreed that the addendum to the 1992 NFF Site CAR and RAP for the NFF Site should be submitted separately from the other NFF area sites.

- A supplemental assessment was initiated in October and November 1994 to assess the extent of the contamination from Tanks 76, 76-A, and 76-B. Based on hydraulic conductivity measurements obtained from aquifer slug tests at the site, ABB-ES estimated the fuel released in the 1950s had migrated approximately 500 to 800 feet from the source area. Groundwater samples were collected using a Hydropunch™ direct push sampler to estimate the horizontal and vertical extent of groundwater contamina-

tion, to determine locations of proposed monitoring wells, and to optimize screen interval depths. A technical memorandum summarizing the results of the Hydropunch™ direct push sampling investigation and outlining recommendations to complete the NFF Site CA was prepared and submitted to SOUTHNAVFACENGCOM and the FDEP in January 1995 (ABB-ES, 1995).

- Based on results from the Hydropunch™ direct push sampler investigation, installation and sampling of monitoring wells in the shallow, intermediate, and deep zones of the surficial aquifer on the east side of the NFF Site were completed from April through September 1995. Results and conclusions based on this assessment for the NFF Site are presented in the CAR Addendum (ABB-ES, 1996).

- Upon review of the CAR Addendum, the FDEP recommended that the horizontal extent of groundwater contamination had not been adequately assessed in the deep zone of the surficial aquifer; therefore, one additional deep monitoring well should be installed approximately 120 feet downgradient (southeast) of monitoring well 076-51D adjacent to monitoring well 076-53I.

- In October 1996, supplemental investigations were initiated to complete the delineation of the horizontal extent of contamination in shallow, intermediate, and deep zones. A cluster of three monitoring wells was installed on the mound and screened in the shallow, intermediate, and deep zones. An additional deep monitoring well was installed adjacent to monitoring well 0-76-53I and downgradient of the leading edge of the deep plume. Two intermediate monitoring wells were installed to confirm the lateral extent of intermediate zone contamination on the northeast side of the plume. Results of this supplemental investigation are proposed to be submitted to SOUTHNAVFACENGCOM, NAS Cecil Field and the FDEP in early 1997. The NAS Cecil Field Base Realignment and Closure Cleanup Team (BCT) consisting of remedial project managers from the FDEP, U.S. Environmental Protection Agency (USEPA), and SOUTHNAVFACENGCOM has recommended the submittal of an RAP.

2.3 SUMMARY OF THE CARA. Based on the site history, findings of the CA field investigations, and laboratory analytical results, the following is a summary of existing conditions at the NFF Site:

Aquifer Characteristics and Hydrogeologic Parameters.

- Site soil consists predominantly of silty sand from the surface to approximately 50 feet bls. Below 50 feet bls, sediments increase in clay content to a depth of about 80 feet bls. From 80 feet to 100 feet bls, phosphate pebbles, shark teeth, quartz pebbles, shell fragments, barnacles, and other carbonate sediments are abundant. Below 100 feet bls, sandy clay separates the base of the surficial aquifer from the top of the upper zone of the Hawthorn Group.

- Depth to water ranges from approximately 3 feet to 5 feet bls at the site. There is a net downward vertical hydraulic gradient in the

general vicinity of the fuel farm, and a net upward vertical gradient in the eastern part of the site. The upward gradient is associated with the drainage ditch east of the site that feeds into Sal Taylor Creek.

- The groundwater flow direction at the water table is radially outward from the fuel farm. Groundwater flow is east-southeast in the shallow, intermediate, and deep zones of the surficial aquifer. Near the drainage ditch to Sal Taylor Creek, however, the deep zone groundwater flow direction changes to south-southeast.

- The average hydraulic gradient across the site ranges from 0.001 to 0.0007 feet per foot (ft/ft) in the upper (shallow and intermediate, respectively) zones and 0.00076 ft/ft in the deep zone. The average hydraulic conductivities for the shallow, intermediate, and deep zones are 5.67 feet per day (ft/day), 6.24 ft/day, and 0.29 ft/day, respectively. The average pore water velocity is 0.0177 ft/day in the shallow zone, 0.0227 ft/day in the intermediate zone, and 0.0002 ft/day in the deep zone.

Summary of Soil and Groundwater Contamination.

- Approximately 11,000 cubic yards (yd^3) of excessively contaminated soil with organic vapor analyzer (OVA) readings exceeding 1,000 parts per million by volume (ppmv) based on OVA headspace readings were excavated from the JP-5 Spill Site and the area on the west side of the NFF Site between A Avenue and Tanks 76 and 76-B during an Initial Remedial Action (IRA) described in Chapter 3.0. Clean backfill material was returned to the excavated areas.

- Excessively contaminated soil (OVA headspace readings exceeding 50 ppmv) was detected in four areas at the site.

- Benzene, total volatile organic aromatics (VOAs), and total naphthalenes concentrations in groundwater samples from site monitoring wells exceeded Chapter 62-770, FAC, No Further Action (NFA) and Monitoring Only (MO) target levels for Class G-II groundwater.

- The vertical extent of petroleum-contaminated groundwater exceeding the Chapter 62-770, FAC, NFA and MO target levels for Class G-II groundwater is less than 109 feet bls.

2.4 CONCLUSIONS

- The horizontal and vertical extents of excessively contaminated soil and petroleum-contaminated groundwater have been assessed at the NFF Site in accordance with Chapter 62-770, FAC.

- Spills and leaks from the fuel storage and overfill containment tanks at the site were the sources of soil and groundwater contamination.

- Petroleum-contaminated groundwater exceeding the Chapter 62-770, FAC, NFA and MO target levels for Class G-II groundwater has migrated verti-

cally downward into the surficial aquifer and downgradient from the source areas.

2.5 CARA RECOMMENDATIONS. Develop an RAP to address the requirements of Chapter 62-770, FAC.

3.0 SUMMARY OF INITIAL REMEDIAL ACTIONS

An IRA was initiated in July 1995, at the NFF Site in accordance with the objectives of the NAS Cecil Field BCT tank management strategy and Chapter 62-770, FAC. Details of the IRA are presented in the Interim Remediation Work Plan (Bechtel, 1995). Design drawings of the IRA are included in Appendix C. The following sections present a brief summary of the IRA activities performed to date at the NFF Site, NAS Cecil Field.

3.1 PURPOSE. The purpose of initial remedial action is to reduce the volume of excessively contaminated soil and recover free product.

3.2 SCOPE. The scope of the IRA was as follows:

- to remove free product in the areas east and west of the mounded fuel farm area, to the extent practicable, in accordance with FAC 62-770.300(3);
- to remove and treat the excessively contaminated soils located in the same area, and to provide a subsurface barrier to prevent free product from recontaminating the excavated area after backfilling;
- to excavate, stockpile, and thermally treat excessively contaminated soils located east and west of the mounded fuel farm area and to recover any free product encountered during the excavation activity; and
- to begin *in situ* free product recovery operations in the mounded fuel farm area using a bioslurping system and an infiltration trench system.

3.3 SOIL REMOVAL. The IRA involved the removal of excessively contaminated soils from the area east and west of the mounded fuel farm. The BCT has set the excavation criterion to 1,000 parts per million (ppm) OVA concentrations. The volume estimate of soil that was removed and treated was approximately 11,000 cubic yards. Prior to excavation, a vertical isolation barrier was placed between the existing mounded fuel farm area and the excavation area to intercept free product migration during and after excavation activities. Additionally, all existing utilities were located, removed, protected in-place and/or rerouted as was required.

Thermal treatment of the excavated contaminated soils was used to reduce contamination levels consistent with FAC 62-775 (Soil Thermal Treatment Facilities). The treated soil that has been verified to be clean from thermal treatment was stockpiled and used as backfill for the excavation. Excavation of the area of the existing retention area did not occur.

3.4 FREE PRODUCT RECOVERY. A free product monitoring and recovery program is being implemented in three stages as follows:

Stage 1. Install a bioslurper system consisting of two recovery wells on the mound, one liquid ring pump, one fluids separation tank, one oil-water separator, one air treatment unit, and piping to the sewage treatment plant.

Stage 2. Install two infiltration trenches at the boundaries of the mound, each consisting of a sump with a submersible pump and a scavenger pump to recover free product.

Stage 3. Install several temporary well points on the mound for product delineation and recovery and connect piping to the existing bioslurping system.

Stage 1 and Stage 2 were implemented during 1995 and 1996. Free product recovery from the bioslurping system and the infiltration trench system has been in progress since 1996. Stage 3 is proposed to be implemented in early 1997. Implementation of Stage 3 is explained in Chapter 8.0 of this plan.

A brief summary of Stages 1 and 2 implemented to date is presented below.

Two recovery wells and two infiltration trenches were installed in March 1996. Recovery wells were installed on the top of the mounded fuel farm area. These recovery wells were constructed of 4-inch-diameter polyvinyl chloride (PVC) and installed to a depth of 27 feet, with 20 feet of 0.020-inch slotted PVC well screen. The screened interval is 5 to 25 feet bls. The bioslurper unit began operating in May 1996.

Infiltration trenches were installed on the east and west toes of the slope for the mounded area. Each trench was installed to a total depth of 5 feet below the water table, with a minimum width of 2.5 feet. A 4-inch slotted high density polyethylene perforated pipe was laid in each trench and was backfilled with a material that is more permeable than the surrounding soil. Each trench is directed into a 36-inch-diameter sump. Groundwater flows by gravity into the pipe and to the sump where it is collected and pumped to the treatment system. Groundwater is pumped to create the necessary hydraulic gradient for the free product. Free product flows by gravity into the sump and is recovered using a scavenger pump floating at the oil-water interface.

As of October 30, 1996, the volume of contaminated groundwater recovered from the bioslurping system and the infiltration trench system was 356,387 gallons (see Appendix C). The total mass of benzene, toluene, ethylbenzene, and xylenes (BTEX) removed through dissolved-phase groundwater is about 7 pounds. The volume of free product recovered was about 135 gallons (900 pounds). The bioslurping unit is operating at an estimated air flow rate of 100 cubic feet per minute (cfm), and the mass BTEX recovered in the vapor phase was about 7,800 pounds.

3.5 MISCELLANEOUS MEASURES. In August 1996, the JP-5 fuel tanks and the associated piping had a tightness test to check for leaks and other integrity flaws. To date, no evidence of leaks or integrity flaws has been established (Enterprises Engineering, Inc., 1996).

4.0 REMEDIAL ALTERNATIVES

4.1 CONTAMINANTS OF CONCERN. Contamination at the NFF Site is the result of release of JP-5 into the environment. Therefore, the Chapter 62-770, FAC, kerosene analytical group of contaminants is the basis for the remedial design. These parameters are

- volatile organic compounds (VOCs) (USEPA Methods 601 and 602), including methyl tert-butyl ether;
- polynuclear aromatic hydrocarbons (PAHs) (USEPA Method 610);
- total recoverable petroleum hydrocarbons (TRPH) (USEPA Method 418.1);
- ethylene dibromide (USEPA Method 504.1); and
- dissolved lead (USEPA Method 239.2).

4.2 APPLICABLE CLEANUP STANDARDS. Standards and regulations regarding required remedial goals for soil and groundwater are contained in Chapter 62-770, FAC, and should be applied following treatment by any method. The following table presents the applicable guidance concentrations for soil and groundwater at the NFF Site.

Parameter	Target Concentration	
	Soil (ppmv)	Groundwater ($\mu g/\ell$)
OVA reading for excessively contaminated soil	50	
TRPH health-based criteria[1] for contaminated soil	300 - 25,000[2]	
Total VOCs		50
Benzene		1
1,2-Dibromomethane		0.02
PAHs excluding naphthalenes		10
Total naphthalenes		100
Lead		50
Methyl tert-butyl ether (MTBE)		50
Total recoverable petroleum hydrocarbons		5

[1] TRPH draft guidance yet to be promulgated by FDEP, but adopted by the NAS Cecil Field BCT.
[2] $\mu g/kg$ by weight.

4.3 EXTENT OF CONTAMINATION. Areas of contamination at the NFF Site include the free product consisting of degraded JP-5, soil contaminated with kerosene analytical group petroleum hydrocarbons, and groundwater contaminated with BTEX, PAHs including total naphthalenes, and TRPH. The following paragraphs present a description of the extent of contamination in each of the areas.

4.3.1 Free Product Assessment Free product was encountered in monitoring wells 076-15, -16, -17, and -18. Free product monitoring data are included in Table A-1 of Appendix A. Figure 4-1 presents the distribution of free product based

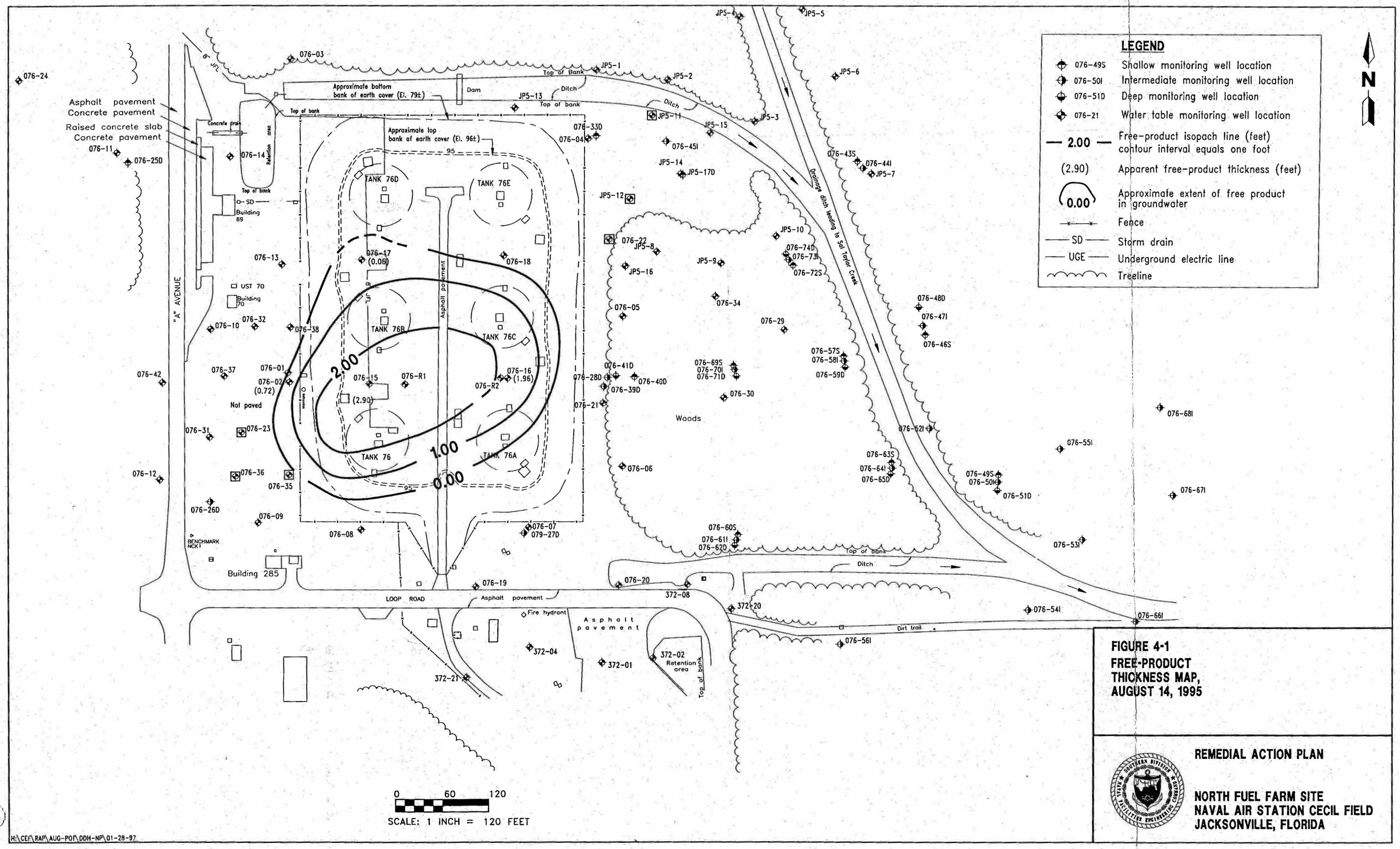


FIGURE 4-1
FREE-PRODUCT THICKNESS MAP, AUGUST 14, 1995

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

on the thickness measurements made on August 14, 1995, and Figure 4-2 presents data pertaining to November 4, 1996. Volume estimation of the free product based on the observed apparent thickness of free product in the monitoring wells varies from a few hundreds to several thousands of gallons. Calculations are included in Appendix A.

4.3.2 Soil Contamination Assessment A summary of the soil OVA analyses is presented in Table A-2 in Appendix A. Contaminated soil was detected in the vicinity of the spill areas listed in Section 2.2. The perimeter of the excessively contaminated soil is outlined by the 50 ppm isoconcentration line and is included in Figure 4-3. OVA readings from most of the borings generally increased with depth. In most of the borings, the highest OVA reading occurred immediately above the water table. Much of the excessively contaminated soil is associated with the mound area, the JP-5 spill area on the north east side of the mound, and the 8,000-gallon spill area on the west of the mound.

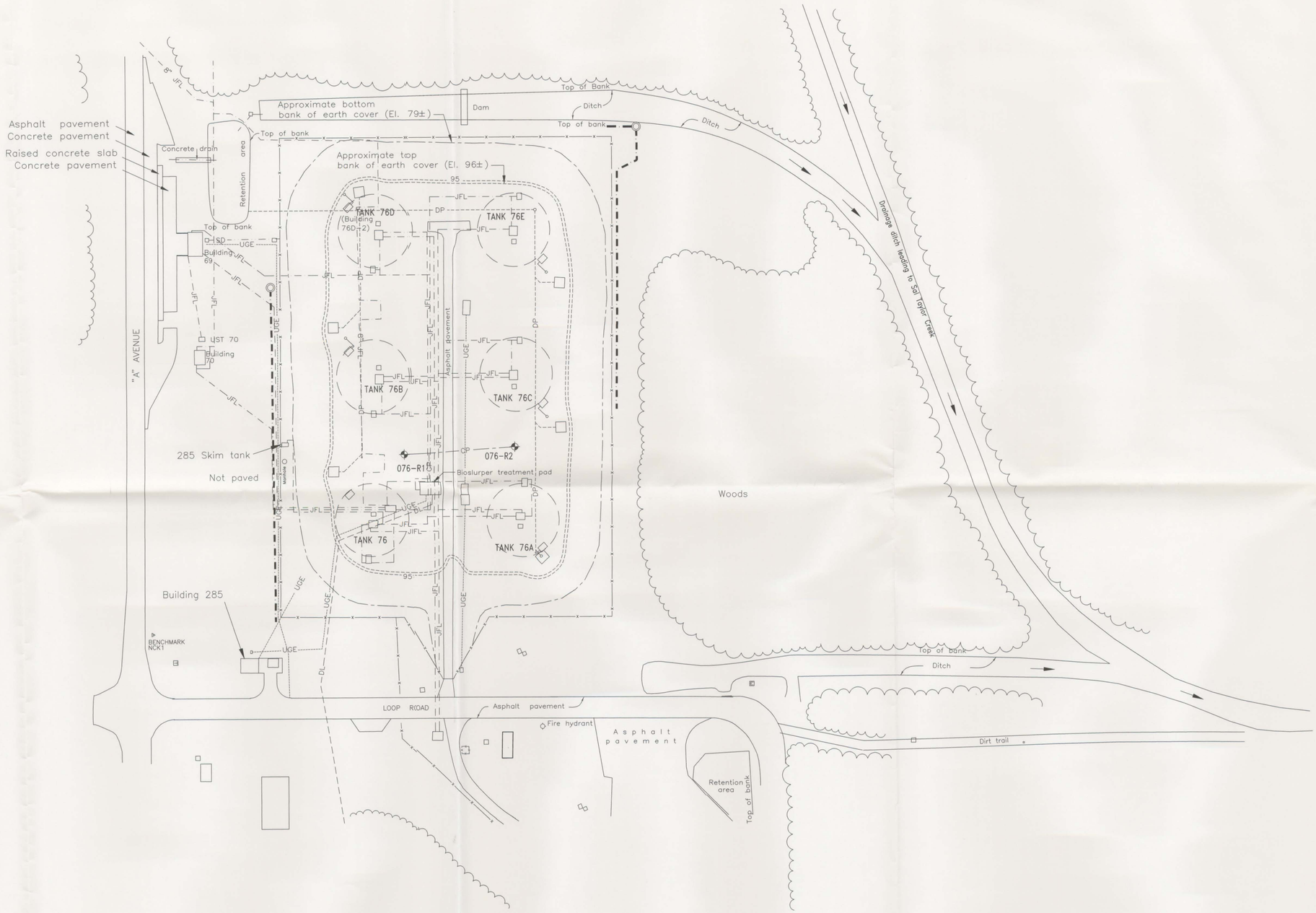
Contaminated soil associated with areas east and west of the mound, with OVA headspace readings greater than 1,000 ppmv, was excavated during the IRA. Figure 4-3 depicts locations of the remaining contaminated soil requiring remedial action.

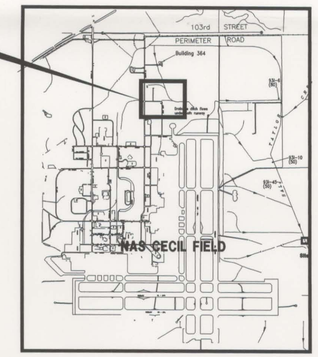
4.3.3 Groundwater Contamination Assessment Analytical laboratory results for the groundwater samples collected in October 1992, March 1993, October 1995, and November 1996 are presented in Table A-3 of Appendix A. VOA, (MTBE), PAHs (including naphthalenes), TRPH, lead, and several chlorinated compounds were detected in groundwater samples. Free product was detected in monitoring wells 076-15, -16, -17, and -18 at the site. For petroleum compounds regulated under Chapter 62-770, FAC, Class G-II groundwater target levels are used, where applicable. Florida NFA or MO target levels for G-II groundwater and for no potable wells within 0.25 mile of the site have been established for benzene (50 parts per billion [ppb]), total VOA (50 ppb), MTBE (50 ppm), total naphthalenes (100 ppb), TRPH (5 ppm), and lead (50 ppb) (Florida Department of Environmental Regulation, October 1990). Chlorinated compounds are compared to Chapter 62-770, FAC, recommended guidance concentrations of 700 ppb for 1,1-dichloroethane and 75 ppb for 1,4-dichlorobenzene (FDEP, June 1994). For groundwater concentrations encountered in this study, 1 ppm is comparable to 1 milligram per liter (mg/ℓ) and ppb is comparable to 1 microgram per liter (μg/ℓ).

Petroleum contaminant concentrations exceeding State regulatory levels are presented in Table A-3 of Appendix A. Figures A-1 through A-4 in Appendix A present isoconcentration contours of total VOA in the water table, shallow, intermediate, and deep zones, respectively.

4.3.4 Retention Pond and Drainage Ditch There are two structural features: the retention pond located on the northeast corner of the mound (see Figure 1-1) and the drainage ditch leading to the Sal Taylor Creek at the NFF Site. The retention pond was built in the late 70s to contain the run-on and runoff from the NFF Site. The drainage ditch leading from the retention pond area to Sal Taylor Creek receives run-on and runoff from the retention pond.

In November 1996, three sets of surface water and sediment samples from the drainage ditch and one set of groundwater seepage samples from an area potentially receiving groundwater within the ditch were collected and analyzed





LEGEND

—x—x—x—	Fence
— — SD — —	Existing storm drain (4-inch)
— — SS — —	Existing sanitary sewer (4-inch)
— — JFL — —	Existing jet fuel line
UGE	Existing underground electric
— — CP — —	New treatment conveyance pipe
— — DL — —	New treatment discharge line
— — DP — —	Polyvinyl chloride drain pipe
	Recovery trench and sump
	Indicates flow direction in ditch
076-R1	Recovery well designation

N

0 30 60
SCALE: 1 INCH = 60 FEET

FIGURE 2-1
SITE UTILITY MAP

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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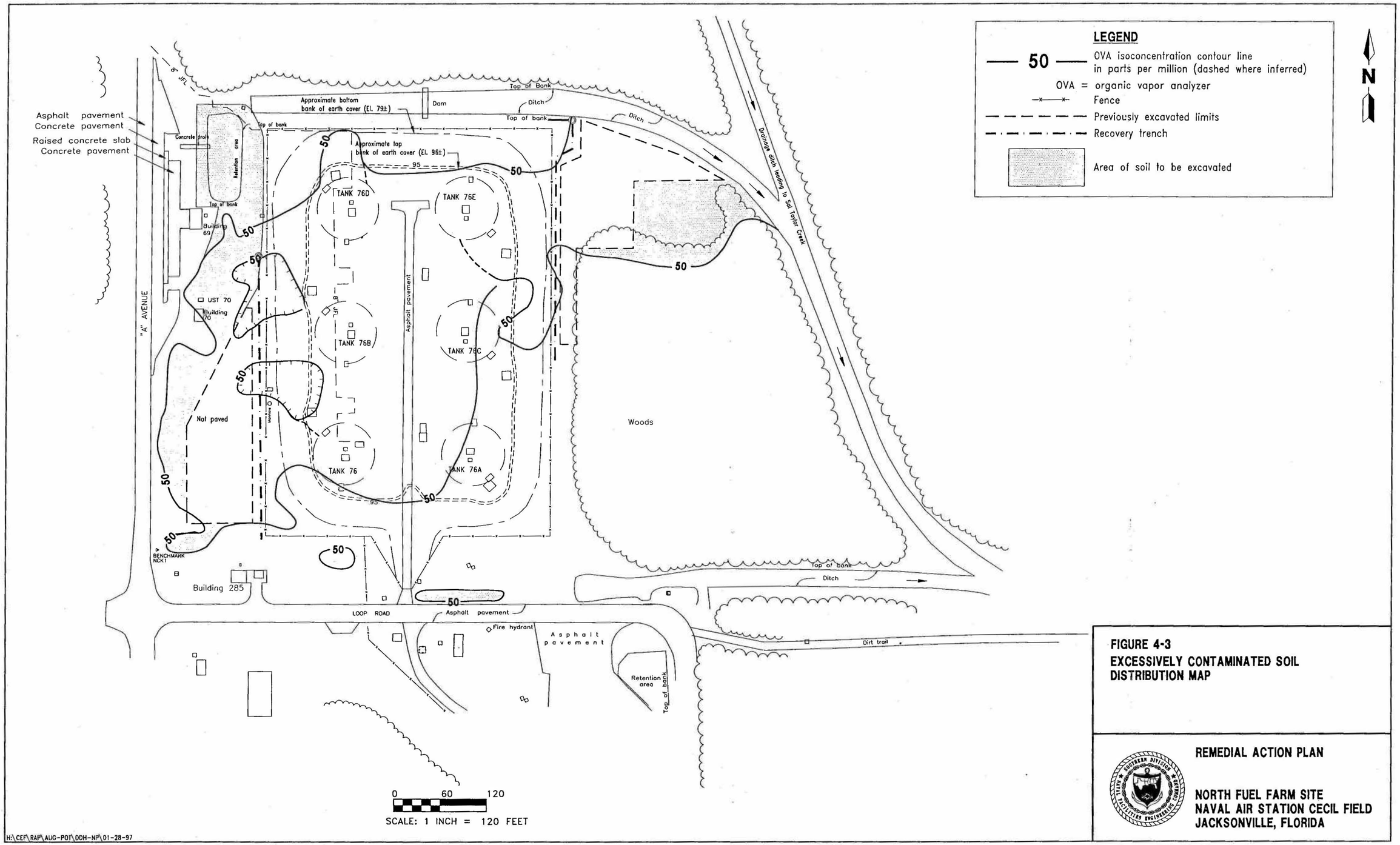

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FIGURE 4-3
EXCESSIVELY CONTAMINATED SOIL DISTRIBUTION MAP

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

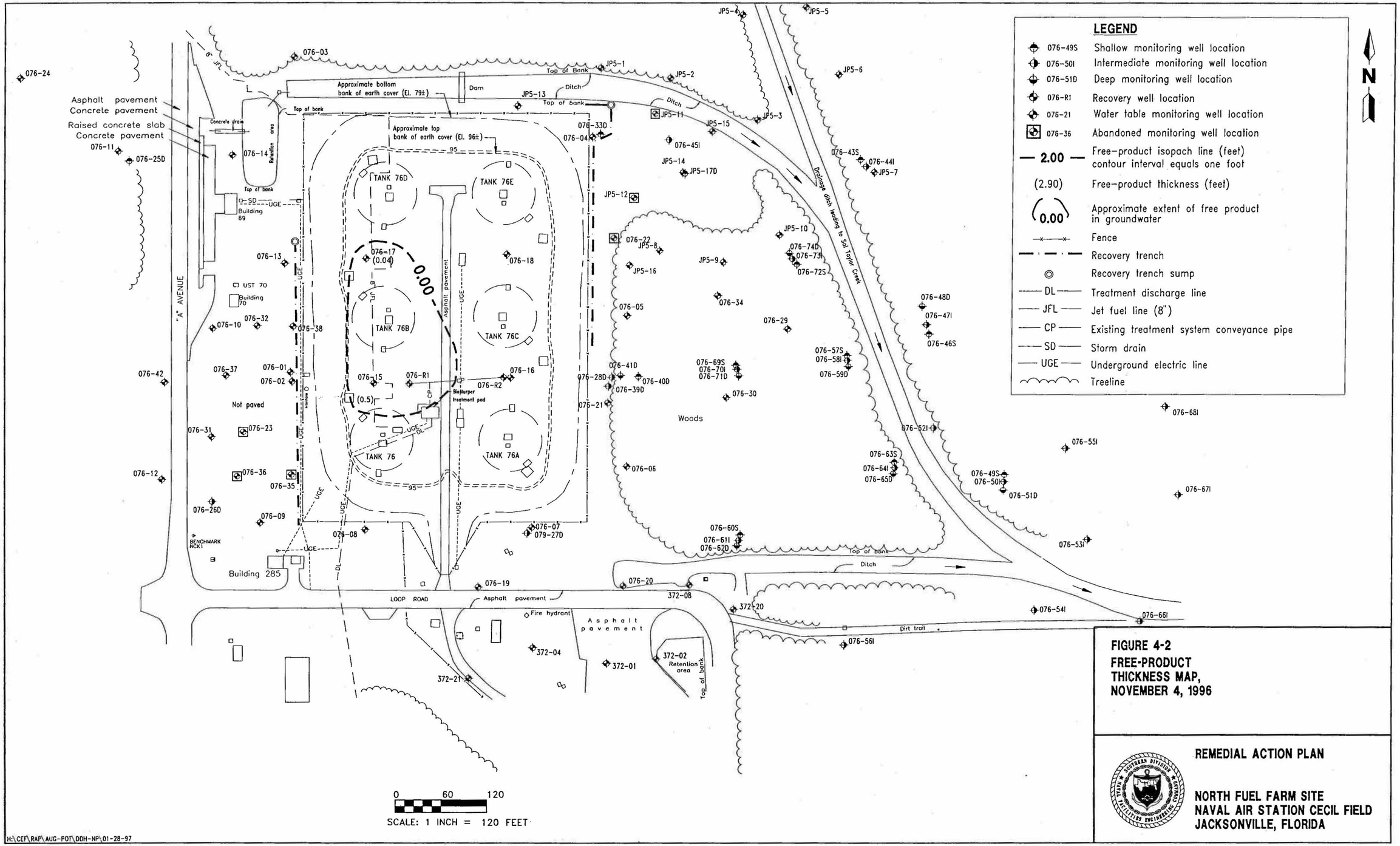

FIGURE 4-2
FREE-PRODUCT THICKNESS MAP, NOVEMBER 4, 1996

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

for kerosene analytical group constituents (see Figure A-5, Appendix A). Results of analyses are included in Table 4-1. In December 1996, five soil borings were advanced in the retention pond area,and soil samples were collected for OVA headspace analyses. Results of OVA headspace analyses are included in Table A-2 of Appendix A.

Upon review of the results,it has been concluded as follows:

- Since concentrations of BTEX for the surface water and sediment samples were below detection limits (BDL), concentrations of the remaining constituents of the kerosene analytical group were above detection limits and below MO limits of Chapter 62-770, FAC.

- The retention pond area soils are excessively contaminated and require remedial action in accordance with Chapter 62-770, FAC.

4.4 EXPOSURE PATHWAYS. Figure 4-4 presents a conceptual model of the NFF Site. The potential exposure pathways for the existing contaminants in groundwater are either via direct ingestion through an existing potable water supply well within the zone of contamination or migration of contaminated groundwater into the adjacent ditch and further exposure to the environment.

4.4.1 Pathway Assessment

- There are no active potable wells within the zone (0.25-mile radius) of contamination. All the potable water wells were screened at more than 700 feet bls in the Floridian aquifer. Figure 4-5 presents the locations of potable wells on base.

- A basewide groundwater model evaluated for NAS Cecil Field indicated that groundwater is migrating into the drainage ditch (USGS, 1996).

- Concentrations of BTEX in the surface water and sediment samples collected from the drainage ditch were BDL. Concentrations of BTEX in the water table monitoring wells located near the ditch are BDL.

- Concentrations of BTEX for the groundwater seepage sample collected from the ditch were BDL.

- Based on the information presented in Subsection 4.3.4, evidence of direct migration of contaminants to the adjacent ditch is not established at this time.

4.5 SITE-SPECIFIC LIMITATIONS TO ALTERNATIVES. The NFF Site is presently active. Problems due to excessive traffic or military security and operational activity do not exist at this time. Remedial construction or operation and maintenance activities would be acceptable in the area defined; however, subsurface features including fuel tanks, fuel supply lines, stormwater drainage lines, sewage lines, potable water lines, and underground electric lines will restrict construction activities to some extent as these utilities need to be maintained in an operational condition. Figure 2-1 depicts locations of utility

Table 4-1
Laboratory Analytical Results for Surface Water and Sediment Samples, September 19, 1996

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Sample ID	VOCs Method USEPA 601/602	PAHs Method USEPA 610
Surface Water Sample Results $\mu g/\ell$		
CEF-76-SW-A01	xylenes (total) = 2.1	ND
CEF-76-SW-A01 (DUP)	ND	ND
CEF-76-SW-B01	ND	ND
CEF-76-SW-C01	ND	ND
Seepage Sample Results $\mu g/\ell$		
CEF-76-SW-D01	ND	ND
CEF-76-SW-D02	ND	ND
CEF-76-SW-D03	ND	ND
Sediment Sample Results $\mu g/kg$		
	SW846 8020A	SW846 8310
CEF-76-SD-A01	ND	Benzo(b)fluoranthene = 40 Benzo(k)fluoranthene = 14 Benzo(ghi)perylene = 26 Chrysene = 68 Ideno(1,2,3-cd)pyrene = 12 Pyrene = 24
CEF-76-SD-A01 (DUP)	ND	Benzo(b)fluoranthene = 34 Benzo(k)fluoranthene = 12 Benzo(ghi)perylene = 21 Chrysene = 65 Ideno(1,2,3-cd)pyrene = 8.6 Pyrene = 23
CEF-76-SD-B01	ND	Benzo(b)fluoranthene = 12 Benzo(ghi)perylene = 10
CEF-76-SD-C01	ND	ND

Notes: See Figure A-5, Appendix A, for locations of surface water and sediment samples.

ID = identification.
VOC = volatile organic compound.
PAH = polynuclear aromatic hydrocarbons.
USEPA = U.S. Environmental Protection Agency.
$\mu g/\ell$ = micrograms per liter.
ND = not detected.
DUP = duplicate.
$\mu g/kg$ = micrograms per kilogram.

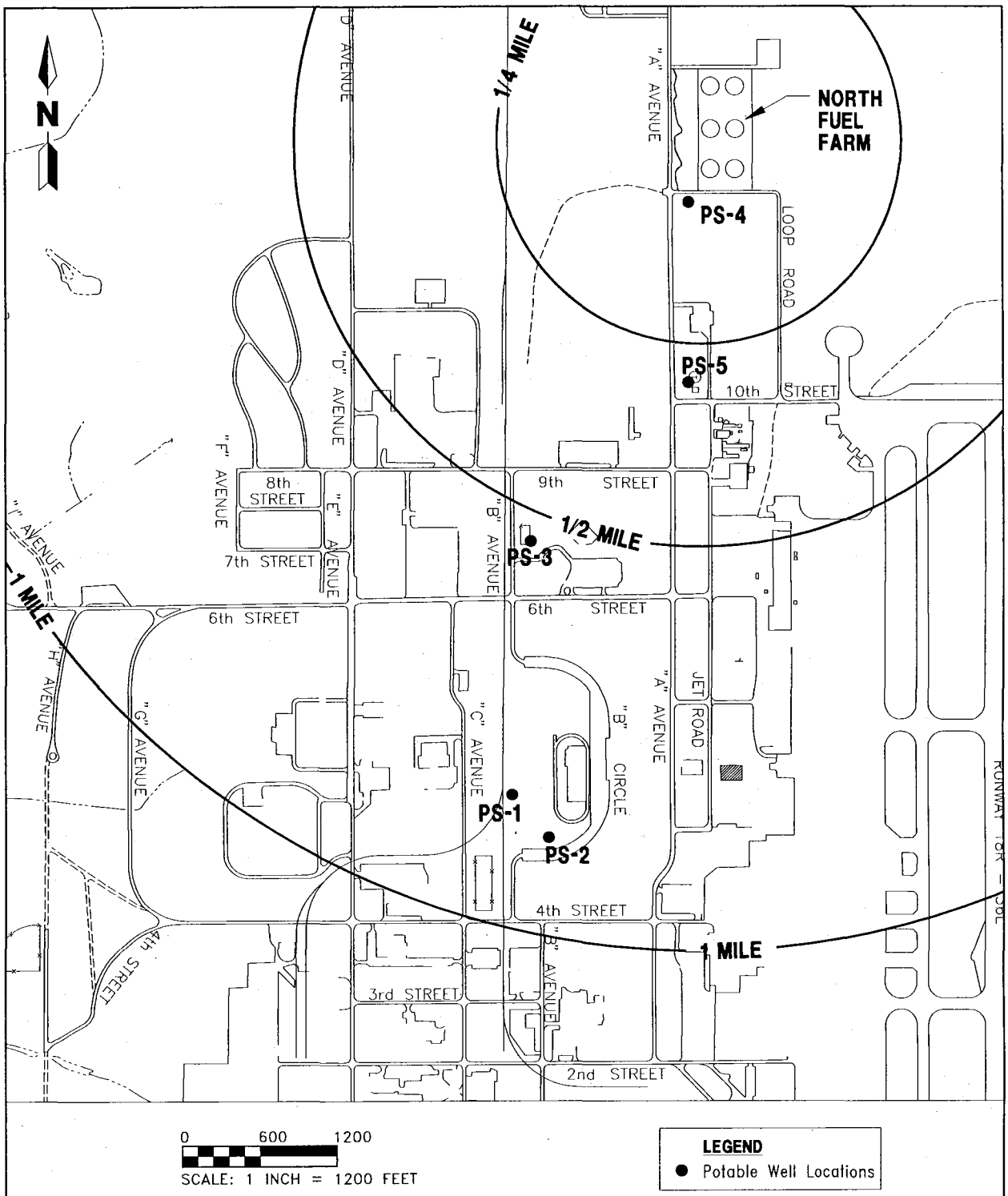

FIGURE 4-5
LOCATION OF POTABLE WELLS

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REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

lines and other subsurface features that may interfere with the remedial construction activities.

4.6 BASIS FOR REMEDIAL STRATEGY. The remedial system chosen for the NFF Site should be designed to address the area of free product, the associated soil, and groundwater contamination. Presented below is the basis for the development of a remedial strategy for the NFF Site.

- Source abatement via free product recovery is currently in progress as part of the IRA.

- Due to the potential nature of existence of free product as several small pockets confined within the vadose zone, the current monitoring well network has not completely delineated the extent of the free product. Hence, the BCT has decided to install several temporary well points on the mound to better delineate the free product and connect bioslurper piping to the temporary points to recover free product.

- Excessively contaminated soil remaining at the NFF Site is generally classified into two geographic locations: the area associated with the mound, and the areas outside the mound.

  - the area of soil associated with the mound has contamination from 5 to 20 feet bls, and has an estimated total volume of 87,000 yd^3 (calculated). Technologies selected for treatment of mound area soil should allow simultaneous implementation of the free product monitoring and recovery program.

  - Areas of soil associated with the east, west, and south sides of the mound are confined between the land surface and the water table interface (5 feet bls) and have an estimated volume of 8,000 yd^3.

- Groundwater contamination is confined within a water column 100 feet thick below the groundwater table and extends downgradient approximately 900 feet. Chemicals of concern (COCs) including total VOA, total naphthalenes, and TRPH are anticipated to be naturally attenuated. However, a cost-effective approach for source reduction in the shallow (0 to 55 feet bls) and intermediate (55 to 95 feet bls) zones should be evaluated in conjunction with natural attenuation.

Table 4-2 presents the summary of the remedial strategy for the NFF Site.

4.7 DISCUSSION OF ALTERNATIVES. After defining the COCs, the applicable cleanup standards, extent of contamination, and exposure pathways, and developing a remedial strategy, it is necessary to identify and screen technologies that may be applicable to mitigating the contamination at the site. Because each site is unique and cleanup technologies applicable to sites contaminated with petroleum substances are continually being improved and developed, it is important to develop remedial action alternatives using the most effective technologies available.

Table 4-2
Remedial Strategy

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Area of Concern	Remedial Strategy
Source	Reduce concentrations of detected VOCs and SVOCs in the unsaturated soil in accordance with Chapter 62-770, FAC. Recover free product, and reduce the residual soil contamination in the capillary fringe.
Groundwater (0-55 feet bls)	Reduce the water table and shallow zone groundwater concentrations for total VOAs, benzene, and total naphthalenes to Chapter 62-770, FAC, guidelines for G-II groundwater.
Groundwater (55 - 100 feet bls)	Reduce groundwater concentrations for total VOAs, benzene, and total naphthalens to Chapter 62-770, FAC, for G-II groundwater guidance levels. Compare cost, time, and contaminant removal efficiency for an aggressive approach vs. natural attenuation. Use an aggressive approach for contaminant reduction in the hotspots and natural attenuation for the rest of the plume.
Groundwater (100 - 110 feet bls)	Remediate through natural attenuation.

Notes: VOCs = volatile organic compounds.
SVOCs = semivolatile organic compounds.
bls = below land surface.
VOAs = volatile organic aromatics.
FAC = Florida Administrative Code.

4.7.1 Free Product Removal A free product recovery system may include either a passive, active, or combination of passive and active means of removal based on the amount of recoverable free product in the unsaturated and saturated zones of the aquifer.

Passive Mode of Free Product Removal: The passive mode involves technologies that rely on the existing hydraulic gradients of the free product and groundwater. Two technologies are considered for evaluation: (1) free product removal by periodic manual bailing and (2) the use of oil-absorbing hydrophobic socks inside the monitoring wells and periodic extraction of free product from the absorbent socks.

Efficiency of passive technologies is dependent on the natural gradient of free product near the well and availability of recoverable free product within the zone of the screen interval of the monitoring well.

Active Mode of Free Product Removal: Active mode involves technologies that would actively enhance the fluid recovery process by inducing low pressures within the extraction well at the oil-water interface, and accelerate accumulation of free product within the extraction well during recovery. Two technologies are considered for the active mode of free product removal. The technologies evaluated include product recovery using submersible pumps in recovery trenches and vacuum-enhanced extraction using a bioslurper.

Submersible Skimmer Pumps. Submersible skimmer pumps create pressure differences by lowering the free product levels within the infiltration trench. However, skimmer pumps cannot enhance the natural hydraulic gradient of free product. Hence the efficiency of a skimmer pump is greatly dependent on the potential for continued migration of recoverable free product into the infiltration trench.

Bioslurper System. The bioslurper system involves removal of free product, soil vapor, and groundwater by applying a high vacuum (6 to 12 inches of mercury [Hg]) to the recovery well. An application of high vacuum to the well head increases the hydraulic gradient of free product and groundwater. When the vacuum is applied in the well, liquids in the well and pore gases in the soil will migrate toward the extraction well due to groundwater removal and reduced pressure above the fluid interfaces. Removal of soil pore gases draws oxygen from the atmosphere, enhancing biological activity within the vadose zone.

4.7.2 Soil Remediation Soil remediation may be accomplished via *ex situ* and *in situ* alternatives.

***Ex Situ* Treatment.** *Ex situ* treatment alternatives involve soil excavation followed by a selected treatment alternative. Five types of *ex situ* treatment technologies applicable to the NFF Site are onsite incineration, thermal desorption, thermal aeration, offsite incineration, and offsite landfilling. Each of these technologies is briefly described in Appendix B.

Ex situ treatment technologies are best applicable in situations where the site is free of any existing structures, facilities, underground utilities, and the volume to be treated is relatively low. *Ex situ* treatment is appropriate for

areas having a shallow vadose zone that does not allow economic installation of intrusive treatment technologies such as SVE.

Area Within the Mound: For areas within the mound, where the water table is at 18 feet bls and the mound is currently serving the purpose of protecting what would have been aboveground fuel tanks, application of *ex situ* treatment technology is not economical. If a future land-use scenario dictates demolition of the mound and dismantling of the tanks, an *ex situ* treatment will be appropriate and presents an aggressive cleanup option. Appropriate technology may be selected based on the cleanup schedule and associated operational costs.

Areas Outside the Mound: Depth to water table in areas outside the mound is between 4 to 6 feet bls. There are no substructures affecting the excavation of soils. However, excavation of excessively contaminated soils at the retention pond area will require replacement of the existing structure with a similar structure including an impervious liner to maintain the runoff and run-on control functions. Hence application of *ex situ* treatment technologies is appropriate for areas outside the mound.

***In Situ* Treatment**. Two types of *in situ* treatments that may be applicable to this site are (1) SVE and (2) biological degradation or intrinsic biodegradation.

SVE systems may be used to remediate soil in the vadose zone or dewatered saturated zones. This technology generally consists of "vacuuming" gases from unsaturated soil through SVE wells with vacuum pumps. Negative pressure induced by the vacuum draws gases through the soil pore spaces and into extraction wells. Air inlet wells combined with a surface cover may be used to facilitate the flow of atmospheric air into targeted zones of the soil to replace the extracted gases. Soil permeability and contaminant volatility are critical factors in the success of these systems. The extracted gases can be treated as necessary before discharge to the atmosphere. Implementation of an SVE system at the NFF Site is feasible because of the following factors:

- the NFF Site has fine- to very fine-grained sand in the vadose zone. Intrinsic permeability is anticipated to range from 10^{-8} to 10^{-6} square centimeters (cm^2). Intrinsic permeability estimates based on the hydraulic conductivity reported in the CAR range from 10^{-8} to 10^{-7} cm^2.

- COCs are constituents of JP-5. A substantial portion of the constituents are relatively volatile and amenable to SVE (vapor pressure range: 10 - 200 Hg at 20 degrees Celsius [°C]; boiling point range: 180 - 300 °C; and Henry's Law Constant range: 20 - 300 atmosphere [atm]).

Intrinsic biodegradation or biological degradation can be accomplished if sufficient oxygen and moisture levels occur below land surface. The greatest microbial activity reportedly occurs for soil oxygen content greater than 2 percent and groundwater dissolved oxygen greater than 2 mg/ℓ (USEPA, 1995). Maintaining proper levels of oxygen requires that the soils are relatively permeable (with an intrinsic permeability greater than or equal to 10^{-8} cm^2). Also, the moisture available for the transport of microorganisms to sustain biodegradation should be in the range of 40 to 85 percent of field capacity (field capacity is a moisture condition in vadose zone soils where the introduction of additional water will result in an equivalent drainage by

gravity) for the biodegradation to be sustained (USEPA, 1995). If petroleum degrading bacteria are present (microbes capable of degrading petroleum products are present in almost all subsurface environments) in the vadose zone and proper conditions are met, aerobic or anaerobic degradation of contaminants can occur. Oxygen levels in the vadose zone are sometimes controlled to maximize the degrading capacity of the microbes.

4.7.3 Groundwater Remediation As described in Section 4.4, groundwater at the NFF Site does not pose a current threat to human health or the environment. However, methods to accelerate the cleanup of aquifer materials (saturated soils and groundwater) are evaluated in conjunction with natural attenuation. Accelerated aquifer remediation may be accomplished via *ex situ* treatment or *in situ* treatment.

***Ex Situ* Treatment** This alternative would consist of withdrawing (extracting) contaminated groundwater until the aquifer material meets groundwater criteria; treating the extracted groundwater to reduce contaminant mobility, toxicity, and volume; and disposing of the treated effluent. Treatment technologies considered include use of NAS Cecil Field's wastewater collection and treatment system and those that require installing and operating treatment systems onsite.

Groundwater Extraction: Alternatives considered include extraction wells, vacuum enhanced extraction systems, and recovery trenches.

- Extraction wells consist of one or more wells from which groundwater can be pumped to a treatment system. Wells are designed based on the location of the contamination, the aquifer hydraulic conductivity, the hydraulic gradient of the water table, and the depth to the water table. The depth, diameter, screen length, pumping rate, and drawdown for each well, as well as the number and location of wells, are designed to produce the appropriate capture zone. This is a widely used and accepted groundwater recovery method.

- Combined vapor-fluid vacuum enhanced extraction systems consist of vacuum pumps that remove soil vapors and dewater the selected zone simultaneously. The systems are similar to well point dewatering systems with draw tubes within the vapor recovery well and are also defined as bioslurping systems. If a saturated part of the aquifer is dewatered, air flows through the pores allowing the volatilization and biodegradation of contaminants present in residual moisture or aquifer soils. Because the depth of dewatering is controlled by the magnitude of the vacuum, the extraction and treatment zone is automatically maintained during variation of the water table. This method has a physical limitation on the depth from which water can be removed. Theoretically, a perfect vacuum can support a water column of about 34 feet. In application, this method can typically lift water from 18 to 20 feet below the elevation of the vacuum pump. With the bioslurper system option of free product removal, groundwater is typically extracted in batch flow rather than continuous extraction.

- A recovery trench typically consists of perforated pipes laid in a trench, which is backfilled with material that is more permeable than the surrounding soil. Groundwater flows by gravity into the pipe and to a sump where it is collected and pumped to the treatment system.

Recovery trenches can be placed at the water table to intercept free product. Trenches can also be located downgradient and perpendicular to the groundwater flow direction to intercept the targeted contaminated flow paths.

Groundwater Treatment: Extracted groundwater from the NFF Site may be treated with an oil-water separator and discharged to the base Waste Water Treatment Plan (WWTP). The process flow consists of a collection tank, an oil water separator, and the base WWTP.

An alternative treatment train involving the following technologies may also be considered in place of the base WWTP for either polishing or primary treatment of groundwater prior to effluent disposal.

- ultraviolet (UV)/oxidation
- air stripping
- granular activated carbon adsorption
- biological treatment

These technologies are capital intensive and require substantial operation and maintenance (O&M). One of the above four technologies will be evaluated in the event the WWTP requires pretreatment of the groundwater, leases operation, or is otherwise not available.

Effluent Disposal: If *ex situ* treatment of groundwater is selected, disposal of the treated effluent must be considered. The options considered include discharge to the NAS Cecil Field WWTP, reinjection to the groundwater, and discharge to a surface water body.

- The NAS Cecil Field WWTP has sufficient hydraulic and treatment capacity to accept the effluent from the oil-water separator. There would be minimum additional disposal costs associated with this option, since the nearest portion of the collection system capable of receiving the effluent is 1,000 feet from the NFF Site.

- Installation of recharge galleries is not feasible at the NFF Site. The existing structures at the site would make it difficult to excavate trenches and discharge treated effluent through a recharge gallery.

- Discharge to a surface water body would be easy to implement, but would require a National Pollution Discharge Elimination System permit. The permit monitoring requirements, which might include more frequent sampling and bioassays, would increase the O&M cost of this option.

***In Situ* Treatment** The alternative would consist of treating aquifer material to reduce the mobility, toxicity, and/or volume of the contamination without removing the groundwater. *In situ* treatment technologies considered included natural attenuation, enhanced bioremediation, and aquifer air sparging.

Natural Attenuation: Natural attenuation consists of destructive and nondestructive attenuation of contaminants in the aquifer material. Components of nondestructive attenuation include volatilization, dispersion, dilution, and adsorption. Components of destructive attenuation include aerobic and anaerobic

biological degradation and hydrolysis. Natural attenuation is appropriate if the following conditions are satisfied:

- documented loss of contaminants of concern at the field scale
- evidence of biodegradation by means of geochemical indicators including nutrient concentrations such as oxygen, sulfur, phosphorous, and nitrogen
- evidence of laboratory microcosm studies for the specific contaminants of concern, and existence of petroleum-degrading microorganisms in groundwater

Sufficient historical data are not currently available to establish a decreasing trend in the concentrations of contaminants at the NFF Site. However, microbial, geochemical, and nutrient data collected through November 1996 at the NFF Site indicate that natural attenuation is occurring in, and may be appropriate for, the intermediate and deep zones of groundwater contamination (see Appendix I).

Biosparging: Enhanced bioremediation or biosparging typically involves the delivery of nutrients and or oxygen to bacteria that degrade petroleum products, breaking them down to carbon dioxide and water. Some type of initial testing is typically required to assess the existing level of biological activity and the appropriate nutrient supplements needed to affect biodegradation. This technology has been used successfully to reduce VOC contamination levels. Implementation would require a system for injection of nutrients and oxygen.

Microbial sampling for soil and aquifer matrix conducted at the NFF Site indicates the presence of petroleum-degrading bacteria at concentrations of 1×10^3 to 1×10^4 Colony Forming Units per gram or milliliter. A biosparging pilot test conducted at the NFF Site in the shallow groundwater zone has indicated that the oxygen concentrations could be supplemented in order to enhance the biological activity.

Aquifer Air Sparging: Aquifer Air Sparging (AAS) is an *in situ* remedial technology that reduces concentrations of volatile constituents in petroleum products that are adsorbed to soils and dissolved in groundwater. This technology, which is also known as "*in situ* air sparging," involves the injection of contaminant-free air into the subsurface saturated zone, enabling a phase transfer of hydrocarbons from a dissolved state to a vapor phase. The air is then vented through the unsaturated zone. Aquifer Air Sparging is most often used together with SVE, but it can also be used with other remedial technologies. When air sparging is combined with SVE, the SVE system creates a negative pressure in the unsaturated zone through a series of extraction wells to control the vapor plume migration. This combined system is called AAS/SVE. The introduction of air can also be expected to enhance aerobic biodegradation processes.

AAS effectiveness is reduced if free-phase petroleum product is present at the site. Application of AAS results in potential mounding of groundwater around the sparge well, thus resulting in smearing of the free product in the unsaturated zone. The CA has reported the presence of free product at a portion of the NFF Site (see Figures 4-1 and 4-2).

In Situ Bioremediation using Recirculation Wells: This remediation system involves mobilization and transportation of VOCs via groundwater circulation to a recirculation well and volatilization with *in situ* stripping. Simultaneously, *in situ* aerobic bioremediation is enhanced due to the continuous enrichment of the groundwater within the circulation cell with dissolved oxygen. Inorganic nutrients (nitrogen and phosphorous) may be added as necessary to optimize biodegradation efficiency. A groundwater recirculation cell may be created by installing two screens at two different depth zones. Low pressure conditions created at the bottom screen will initiate flow of groundwater into the lower screen and release through the upper screen, thus, establishing a recirculation cell. Low pressure conditions at the bottom screen may be introduced via one of two methods: by use of a mechanical pump, or by use of an air lift pump.

Appendix B presents a list of all the technologies evaluated for the NFF Site, and describes the rationale for screening and selection of technologies for further consideration.

4.8 ALTERNATIVE SELECTION. Based on the site conditions and current and planned use of the base, the following characteristics are identified for the remedial system:

- The primary COCs within the source area are the free product and the associated soil contamination. Hence, the remedial system should recover both the vapor phase and the liquid phase contaminants. If the soil contamination is of limited volume and the vadose zone is less than 5 feet thick and easily accessible, an *ex situ* treatment option will be appropriate.

- Since the contaminated groundwater is not, or planned to be, used as a potable water supply and does not discharge to any nearby surface water, exposure pathways for total VOCs, total naphthalenes, and TRPH in groundwater are not complete. Hence, an aggressive approach for bioremediation in conjunction with natural attenuation for dissolved plume cleanup may be considered viable for groundwater remediation proposed for groundwater at the NFF Site.

Considering these characteristics and site conditions, Table 4-3 presents the summary of technologies included in the preferred alternative for the RAP at the NFF Site.

Table 4-3
Summary of Technologies Included in the Preferred Remedial Alternative

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Area of Concern	Remedial Technology	Rationale
Source	Tightness testing	To control future releases.
	SVE for the mound area Soil excavation for outside area	To reduce volume of excessively contaminated soil.
	Bioslurper expansion	To recover free product.
Groundwater (0-55 feet bls)	Biosparging	To actively remove volatile organics from the aquifer material and enhance biodegradation.
Groundwater (55 - 100 feet bls)	Source reduction through enhanced *in situ* bioremediation and *in situ* stripping using recirculation wells	To actively remove volatile organics from the aquifer material and enhance the biodegradation near the tank area.
	Natural attenuation	To reduce concentrations of organic contaminants prior to release of groundwater to the environment.
Groundwater (100 - 110 feet bls)	Natural attenuation	To reduce concentrations of organic contaminants prior to release to the environment.

Notes: SVE = soil vapor extraction.
bls = below land surface.

5.0 RECOMMENDED REMEDIAL ACTION

The components of the remedial action at the NFF Site are as follows:

- excavation and treatment of jet fuel-contaminated soil outside of the mound area;
- installation of an SVE system to treat excessively contaminated soil within the mound area;
- free product recovery and monitoring program implemented via installing temporary well points on the mound and connecting to the well points to the existing bioslurping system;
- installation of a biosparging system to treat contamination in the shallow groundwater zone (0 to 55 feet bls) at the tank farm;
- installation of recirculation wells to enhance *in situ* bioremediation and implement *in situ* stripping of groundwater beneath the tank farm and immediately downgradient of the tank farm in the intermediate zone (55 to 100 feet bls);
- remediation by natural attenuation downgradient of the tankfarm for the intermediate and deep zones (55 to 110 feet bls); and
- groundwater-system monitoring and reporting.

6.0 SOIL EXCAVATION AND OFFSITE TREATMENT

This section presents the details of source removal via excavation of excessively contaminated soil from the ground surface to the water table depth, from the areas outside the NFF mound.

The purpose of source removal is to eliminate the primary source of petroleum hydrocarbon contamination to the groundwater.

6.1 TECHNOLOGY DESCRIPTION AND SYSTEM DESIGN. Major components of soil excavation and treatment include the following:

- site preparation
- excavation and transportation to offsite location
- excavation backfill and compaction
- site restoration and/or grading

Figure 4-3 presents the boundaries of the excavation area. Soil will be excavated to the 50 ppmv (OVA head space reading) isoconcentration contour as required by Chapter 62-770, FAC. Based on a 50 ppmv boundary and an average depth of excavation of 5 feet bls, the estimated volume of soil to be excavated is 8,000 yd^3 (see Appendix D).

6.1.1 Site Preparation Prior to commencement of the work, the designated areas will be flagged and boundaries will be established by fluorescent yellow caution tape to define the exclusion zone. Prior to beginning any excavation activities or any intrusive work, the designated areas will be checked for any substructures, utility lines, and other potential interferences. A professional survey to verify locations of site utilities was not conducted for this report; however, active or inactive subsurface obstructions may include electric lines, piping for sanitary sewage, JP-5 distribution, gas distribution, storm drainage, and/or fresh water distribution.

6.1.2 Excavation and Offsite Transportation Soil excavation will be within an area bounded by the 50 ppmv (OVA head space reading) contour as depicted in Figure 4-2. Excavation will be conducted using standard earthmoving equipment. All operators will be certified to be in compliance with 29 Code of Federal Regulations 1910.120 health and safety requirements. OVA headspace analyses will be used to monitor soil contamination levels at set intervals during the excavation. Excavation in the vertical direction would extend to the groundwater table unless free product is encountered. Excavation to a depth approximately 1 foot below the groundwater table may be necessary to implement free product removal where free product is encountered. Free product that is exposed in the open excavation will be recovered to the extent practicable by using high vacuum suction, product absorbing socks, or over excavation.

Temporary controls for stormwater run-on and runoff will be implemented before excavation of contaminated soil in the retention pond area. The retention pond area will be replaced with a similar lined construction during site restoration activities in order to control the long-term stormwater run-on and runoff.

Excavated soil that is contaminated (greater than 50 ppmv) should be loaded directly into trucks to facilitate immediate site removal and delivery to a FDEP-permitted soil thermal treatment facility and to prevent spreading of contaminated soil at the site. A listing of permitted thermal treatment facilities is provided in Appendix D.

The excavation should have sides sloped or shored in accordance with applicable standards to prevent unstable conditions during excavation that could pose hazards to personnel or surrounding structures and pavements. Stormwater run-on and runoff controls should be implemented to prevent offsite migration of sediment or contaminated stormwater during site activities. Fugitive emissions should be prevented through applicable dust control actions during excavation and soil handling. Monitoring wells, benchmarks, existing structures, fences, curbs, sidewalks, and other structural features shall be protected from excavation equipment.

6.1.3 Site Restoration Backfill to excavated areas may be performed simultaneous to excavation. All water from the excavation during soil replacement should be removed as necessary to accommodate compaction. To minimize recontamination of the backfill soil by groundwater, a low (i.e., less than 0.5 percent) organic content soil will be used as backfill material. Backfill material shall be well-graded granular soil, consisting of silica sand or other approved materials. Backfill shall contain less than 0.5 percent organic carbon as measured in accordance with American Society for Testing and Materials (ASTM) D2074-87. Moisture-density testing shall be in accordance with ASTM D698-91. Certification that the borrow source is free of petroleum hydrocarbon contamination is required from the borrow source prior to delivery. Backfill will be field compacted in place to achieve 85 percent Proctor (ASTM D1557) or approved equal. Backfill material will be compacted in lifts of approximately 1 foot. Compactive effort will be no less than four passes of the earth-moving equipment. Approximately 8,000 yd^3 of backfill material will be required. If excavation and backfill operations are performed simultaneously, a separation distance will be maintained between the toe of the slope for excavation and the toe of the slope for backfill to prevent or minimize cross-contamination by direct contact with free product or excessively contaminated soil. After all disturbed areas of excavation have been successfully backfilled, the sites will be graded to drain. The excavation will be graded to above surrounding elevations, and the grade will be sloped from the center outward to a minimum slope of 50 horizontal to 1 vertical so that runoff will flow away from the backfilled area. The slope will be blended into level areas, and the grade changes will be gradual. If necessary, prior to backfilling, an appropriate amount of 1-1/2- to 2-inch diameter crushed stone may be provided as a bottom layer in order to stabilize saturated material resulting from groundwater encroachment within the open excavation.

An acceptable borrow source will be identified and subsequent samples will be sent to a geotechnical testing laboratory for moisture content, organic carbon, and moisture-density relationships.

During backfill operations, utility services will be disconnected in coordination with base personnel. After completion, benchmarks, existing structures, fences, sidewalks, utilities, and other cultural features to remain that were damaged during remedial activities will be repaired. All lines and grades will be verified after all equipment and materials have been removed from the site and work is complete. Final review of project documentation as well as walkover of the site will be conducted to assure satisfactory completion of the project prior to leaving the site.

7.0 SOIL VAPOR EXTRACTION SYSTEM

This section presents the details of implementing source removal via SVE for soil within the mound area at the NFF Site.

The SVE system at the NFF Site will be used to remediate excessively contaminated (soil OVA head space reading exceeding 50 ppmv) soil within the mound.

Components of the SVE system at the NFF Site include

- SVE wells,
- piping network,
- vacuum blower, and
- vapor treatment.

Figure 7-1 presents the schematic for the SVE system.

7.1 TECHNOLOGY DESCRIPTION. Vacuum applied to the well casing creates an air flow through the contaminated soil toward the extraction well. As the contaminated vapor is extracted from the subsurface, a concentration gradient is created between the soil vapor and the sorbed contaminants. As the imbalanced contaminant concentration attempts to reach equilibrium, fresh air continues to enter the contaminated soils. The continual recharge of air sustains the on-going concentration gradient, until the soils become clean.

The areal extent of soil contamination based on a 50 ppmv OVA head space reading isoconcentration contour is approximately 180,000 square feet (see Appendix E for calculations).

7.2 SYSTEM DESIGN. Subsurface soil at the NFF Site consists of fine- to medium-grained silty sand with less than 10 percent of clay. Based on the hydraulic conductivity values estimated through slug tests conducted during the CA, the intrinsic permeability at this site is estimated to range between 10^{-7} cm^2 (10 Darcys) to 10^{-8} cm^2 (1 Darcy). Based on information gathered during implementation of bioslurping pilot scale studies at the site within the mound area, the vacuum radius of influence has been estimated to range from 50 feet to 70 feet (Appendix E).

An estimate of vacuum drawdown, vapor flow rate, and the number of SVE wells required was calculated based on the site-specific data presented above. Based on calculations presented in Appendix E, it is estimated that the NFF Site requires 22 SVE wells, with an average flow rate of 25 cfm each, and a total flow rate of 550 cfm at a vacuum of 60 inches of water column. An EG&G model EN14DX72WL ROTRON™, explosion proof regenerative blower or approved equivalent is selected for supply of vacuum.

This blower has a 30-horsepower motor and operates on 460 volt, 3-phase, 60 hertz alternating current, electric power. The blower will generate a maximum flow rate of 920 standard cubic feet per minute (scfm) at a maximum vacuum of 115 inches of water column.

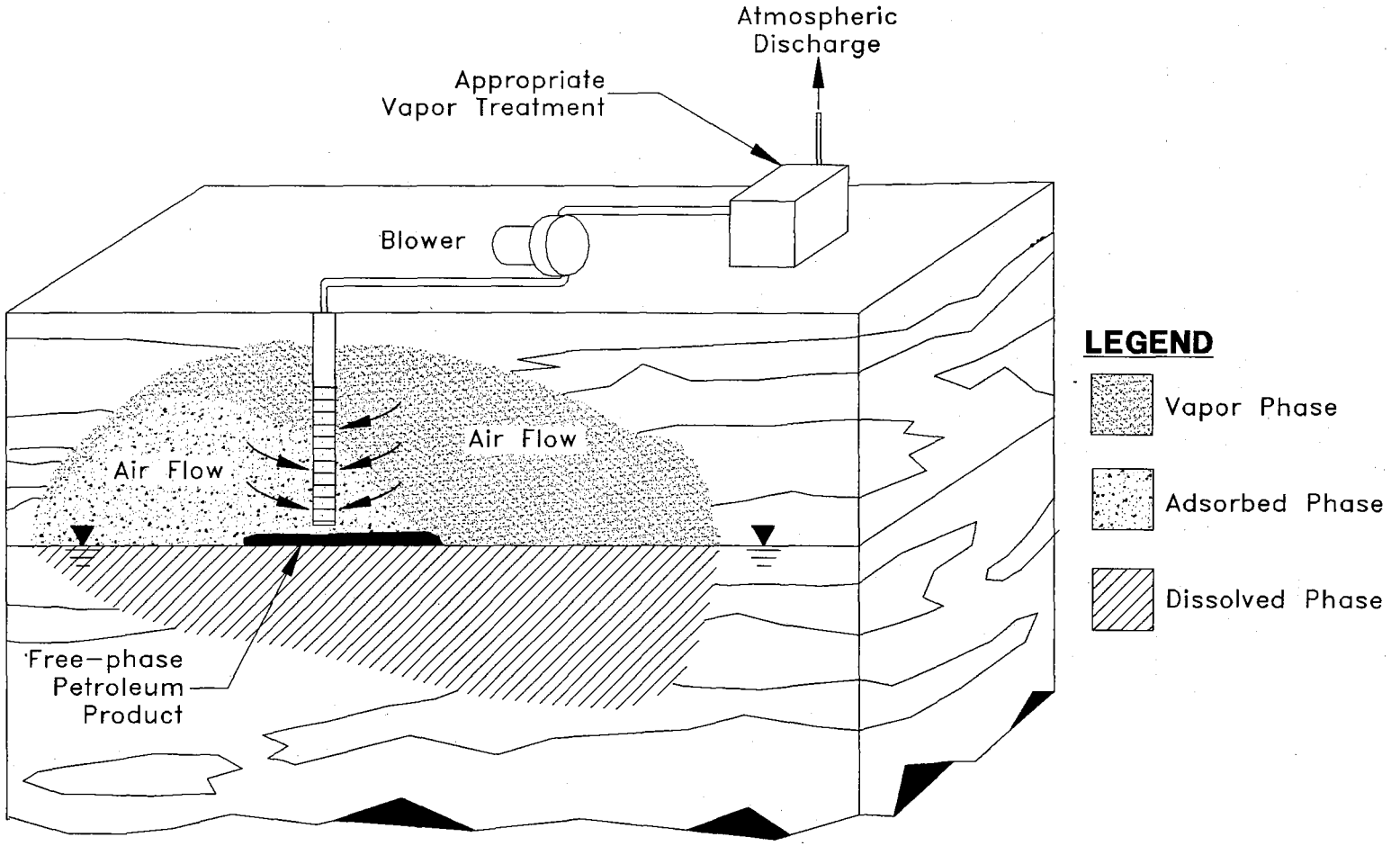

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FIGURE 7-1
SOIL VAPOR EXTRACTION SYSTEM SCHEMATIC

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

The blower will be skid mounted and equipped with pressure and vacuum gauges, adjustable pressure relief valve, a flow meter, and a thermometer. The vacuum pump will be explosion proof, and it will be operated by a control panel located on the skid. The panel will actuate a shutdown of the blower if the thermometer on the blower reads temperatures above a set point. In case of a shutoff, the system will be serviced and the blower will be manually restarted.

SVE wells VW-1 through VW-25 will be installed at the locations shown on Figure 7-2. All the SVE wells will be constructed of 4-inch, schedule 80 PVC riser, and 0.020-inch slotted screen. The SVE wells will be screened between 5 feet bls to 25 feet bls. Figure 7-3 presents the construction details for the SVE wells.

Figure 7-4 includes the process and instrumentation diagram for the SVE system. Each SVE well will be manifolded to the header pipe leading to the compound. Appropriate sampling ports, flow control valves, and flow meters will be installed on each vacuum supply line at the SVE manhole to facilitate selective operation of the SVE wells. A totalizer flow meter and totalizer sampling port will be installed on the header pipe in the compound to monitor the performance of the SVE process. Piping from the SVE wells to the header pipe will be 1-inch-diameter, Schedule 80 PVC. The header pipe (main supply line) connecting the manifold to the blower will be 2-inch-diameter Schedule 80 PVC.

Based on calculations presented in Appendix E the estimated total flow rate contributed by the SVE system is about 600 scfm. This off-gas will be combined with the off-gas generated from the other sources and treated via catalytic oxidation. The catalytic oxidizer will meet the combined requirements of all the VOC sources at the NFF Site during implementation of the RAP.

7.3 SYSTEM STARTUP. Upon approval of the construction workplan, it is estimated that approximately 2 weeks will be required to release the bids for procurement of the equipment. Equipment will be delivered within 2 to 3 weeks. Trenching and installation is anticipated to take 5 to 6 weeks. Thus the total time for the installation of the equipment is estimated as 11 weeks.

A vapor extraction pilot study was not conducted prior to the preparation of this RAP; therefore, it will be necessary to conduct startup testing of the vapor extraction system to fine tune and adjust the vacuum and flow rate and monitor VOA continuous concentrations at the effluent port. The startup testing program will consist of a vacuum pumping test of up to 8 hours in which vacuum pressures and flow rates will be measured. Based on the results of this testing program, the extraction rates necessary to achieve remedial goals will be determined.

7.4 SYSTEM MONITORING. The overall performance of the SVE system will be evaluated based on the data obtained for the monitoring parameters listed below.

- vapor flow rates from the recovery wells
- vapor concentrations during application of the SVE
- vacuum readings at the well heads from source area and perimeter area wells during operation of the SVE

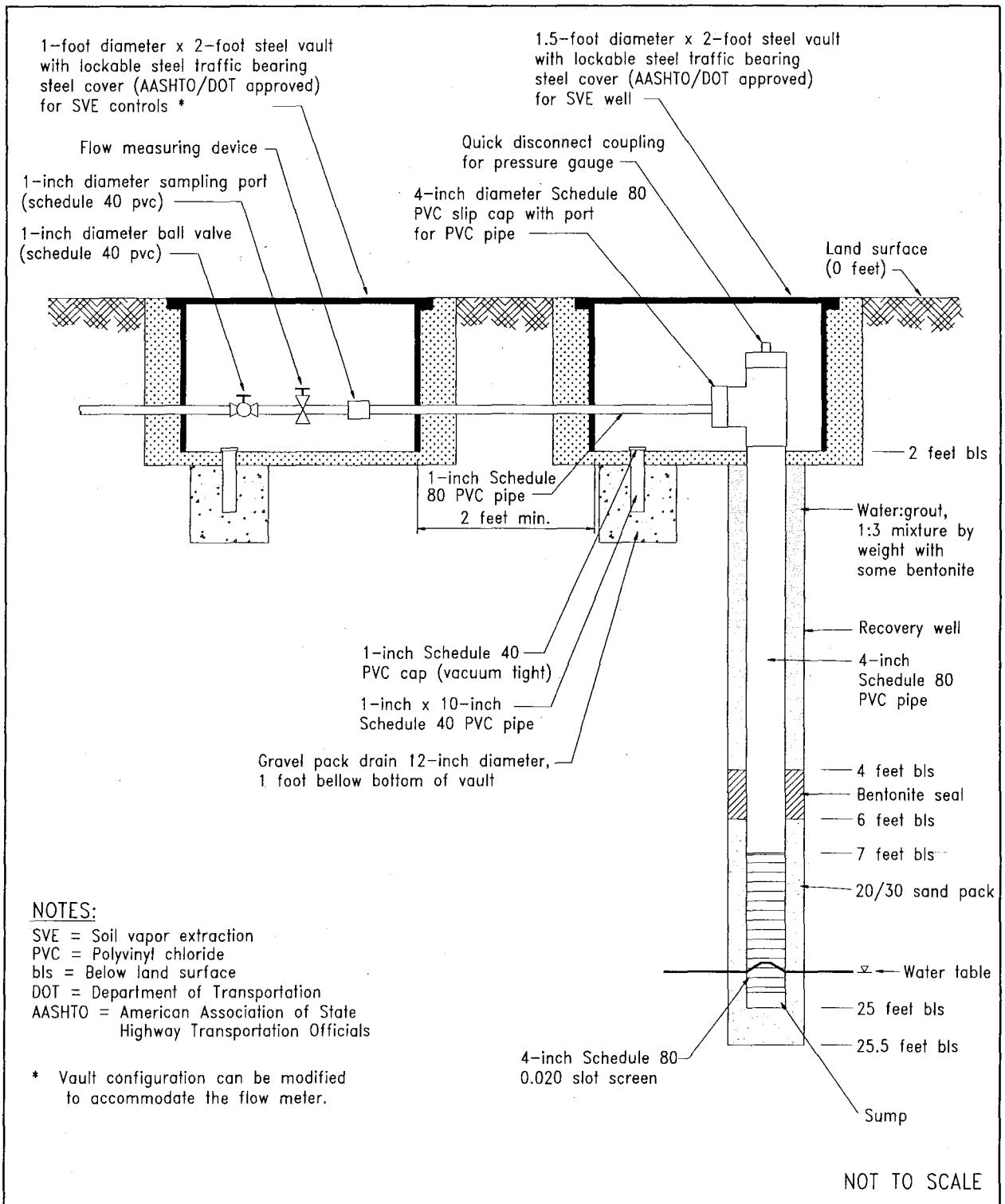

FIGURE 7-3
CONSTRUCTION DETAILS OF SVE WELLS VE-1 THROUGH VE-22

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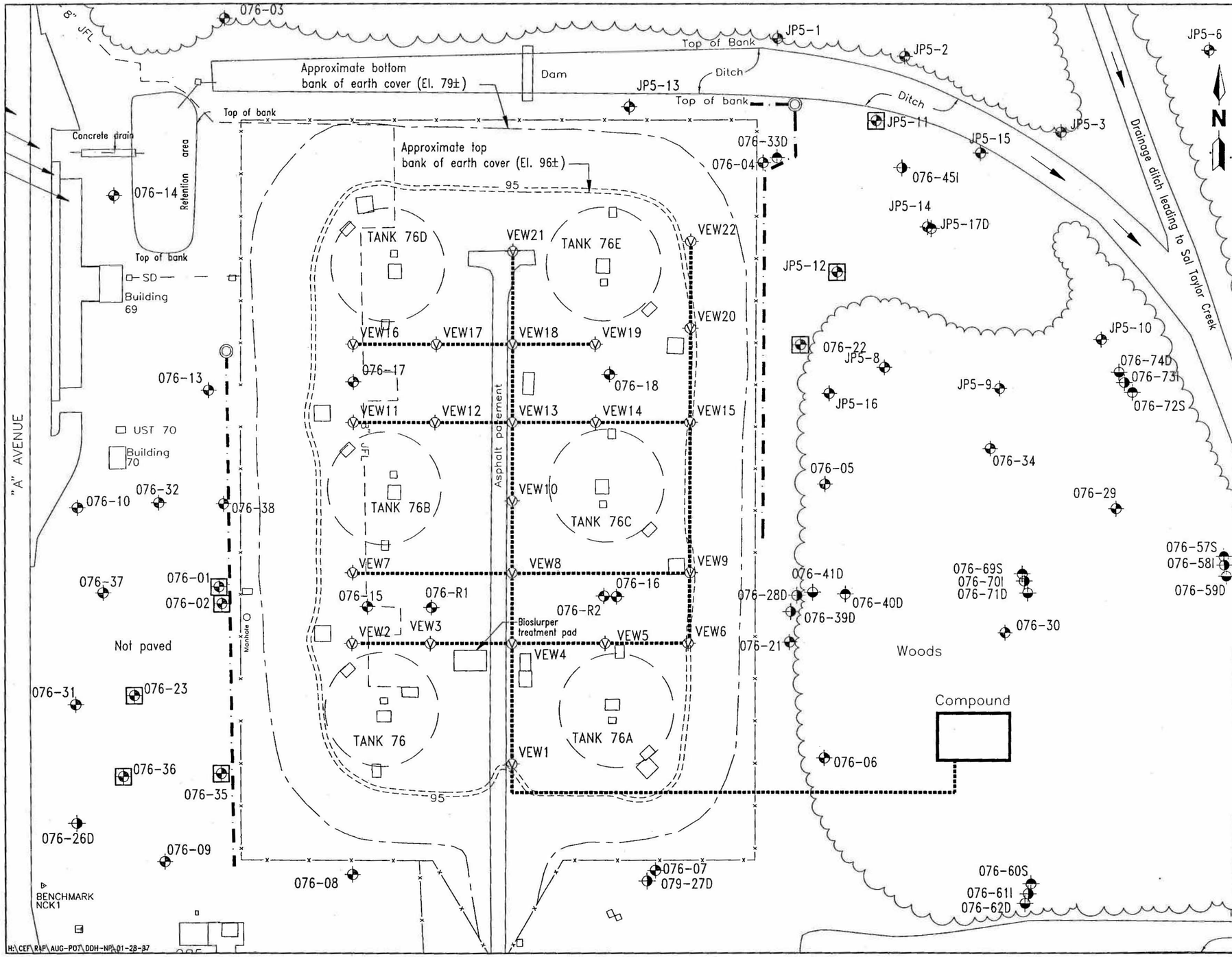
REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA



LEGEND

076-49S	Shallow monitoring well location
076-50I	Intermediate monitoring well location
076-51D	Deep monitoring well location
076-21	Water table monitoring well location
076-36	Abandoned monitoring well location
VEW6	Vapor extraction well location
	Fence
	Recovery trench
	Recovery trench sump
	Vapor extraction conveyance piping
	Treeline

Notes:

1. Maintain a minimum of 5 feet between the underground electric lines and the edge of the soil vapor extraction system trench.
2. Refer to Figure 2-1 for a more complete drawing of the site utility map.

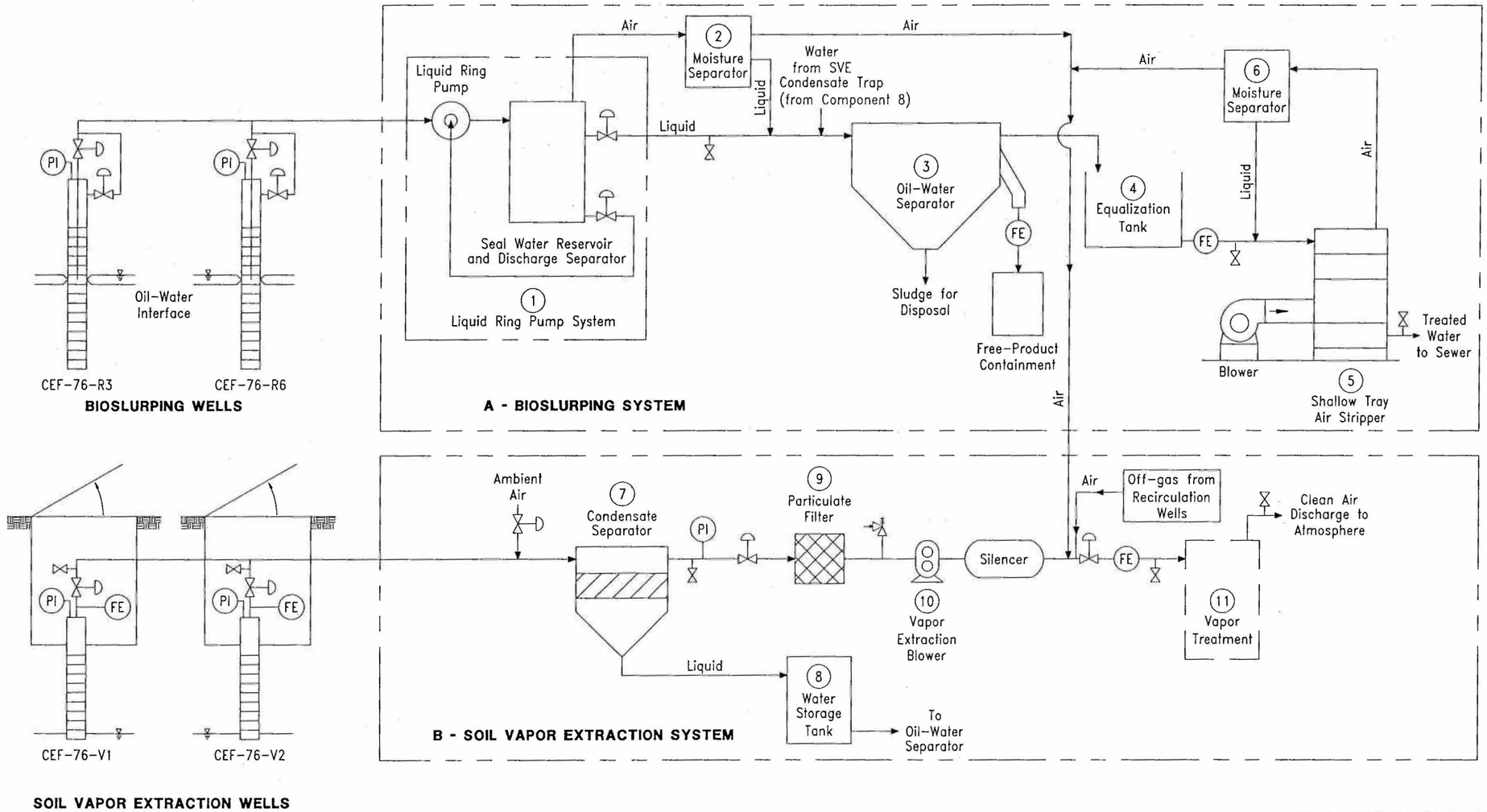
0 37.5 75

SCALE: 1 INCH = 75 FEET

FIGURE 7-2
SOIL VAPOR EXTRACTION SYSTEM LAYOUT

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA



LEGEND

- Flow control valve
- PI — Pressure gauge
- FE — Flow meter
- Vacuum relief valve
- Sample port

NOT TO SCALE

FIGURE 7-4
PROCESS AND INSTRUMENTATION DIAGRAM FOR BIOSLURPING AND SVE SYSTEMS

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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On a weekly basis for the first 3 months and monthly for the remainder of the first year of operation, SVE emissions will be monitored for volatile organic hydrocarbons using an OVA or portable gas chromatograph. Additionally, vapor samples will be collected monthly and analyzed in accordance with USEPA Method T-14 in an offsite laboratory, and the concentrations will be expressed as milligrams per cubic centimeter. These concentrations coupled with the total flow rates will be used to estimate the BTEX mass removal rates. Vapor monitoring will be performed on the SVE airstream before and after entering the vapor treatment system. The monitoring schedule for the remaining period of remediation will be based on an evaluation of the first 3 months of data collected on the operation of the system.

Table 7-1 presents an example of the data log to be used during the monitoring phase of the SVE system. Collection and reporting of the data as presented in Table 7-1 will facilitate timely evaluation of system efficiency and an opportunity to adjust system parameters for optimum operation.

Table 7-1
Example of a Recommended List of Parameters for Monthly Monitoring SVE System

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Date: Logged By: Verified By:	VEW-1	VEW-2	VEW-3	VEW-4	VEW-5	VEW-6	VEW-7	VEW-8	VEW-9	VEW-10	Influent to Vapor Treatment	Effluent from Vapor Treatment
Airflow rates, cfm												
Vacuum, inches of H_2O												
OVA reading, ppmv												
Laboratory analyses T-14, BTEX mg/m^3												
Time system was in operation, days												
Mass of BTEX, pounds												
Remarks												

Notes: SVE = soil vapor extraction.
cfm = cubic feet per minute.
OVA = organic vapor analyzer.
ppmv = parts per million by volume.
mg/m^3 = milligrams per cubic meter.
BTEX = benzene, toluene, ethylbenzene, and xylenes.
H_2O = water.

8.0 BIOSLURPING SYSTEM

This section presents the details for implementing the bioslurping system expansion for free product recovery from within the mound area at the NFF Site.

Components of the bioslurping system at the NFF Site include the following:

- bioslurping wells,
- piping network,
- liquid ring pump,
- fluids-air separation tank,
- vapor treatment,
- oil-water separator, and
- groundwater treatment system.

Figure 8-1 presents the schematic for the bioslurping system.

8.1 TECHNOLOGY DESCRIPTION. Bioslurping combines vacuum-enhanced free product recovery and soil vapor extraction with bioventing to simultaneously bioremediate the vadose zone.

8.1.1 Free Product Recovery Free-phase liquid and groundwater are extracted, using a draw-tube with its tip located at the oil-water interface. Location of the tip of the draw-tube is adjusted based on the depth to the oil-water interface. The draw-tube and the well casing are manifolded to the same vacuum source. A vacuum is initially applied to the draw-tube to begin removal of groundwater and free product. High vacuum is applied to the draw-tube in order to lift the water and/or free product, thus lowering the water table within the formation in the vicinity of the recovery well.

The vacuum influence of the well increases the hydraulic gradient for flow of groundwater and product to the well, improving the ability of the recovery well to extract the free product.

Implementation of the free product recovery using bioslurping technology incidentally will result in two additional actions:

- extraction of contaminated groundwater from the hot spot areas

- increasing dissolved oxygen levels in the groundwater within the influence area of the bioslurper well

Pilot-scale tests conducted elsewhere using bioslurping have reported an increase of 1 to 2 mg/ℓ of dissolved oxygen at the recovery well at the end of an 8-hour bioslurping event. Oxygen is one of the main nutrients required for sustaining biodegradation of petroleum hydrocarbon components dissolved in groundwater.

8.1.2 Soil Vapor Extraction Vacuum applied to the well casing creates an air flow through the contaminated soil in the unsaturated zone, toward the extraction well. As the contaminated vapor is extracted from the subsurface, a concentration gradient is created between the soil vapor and the sorbed contaminants. As the imbalanced contaminant concentration attempts to reach equilibrium, fresh air

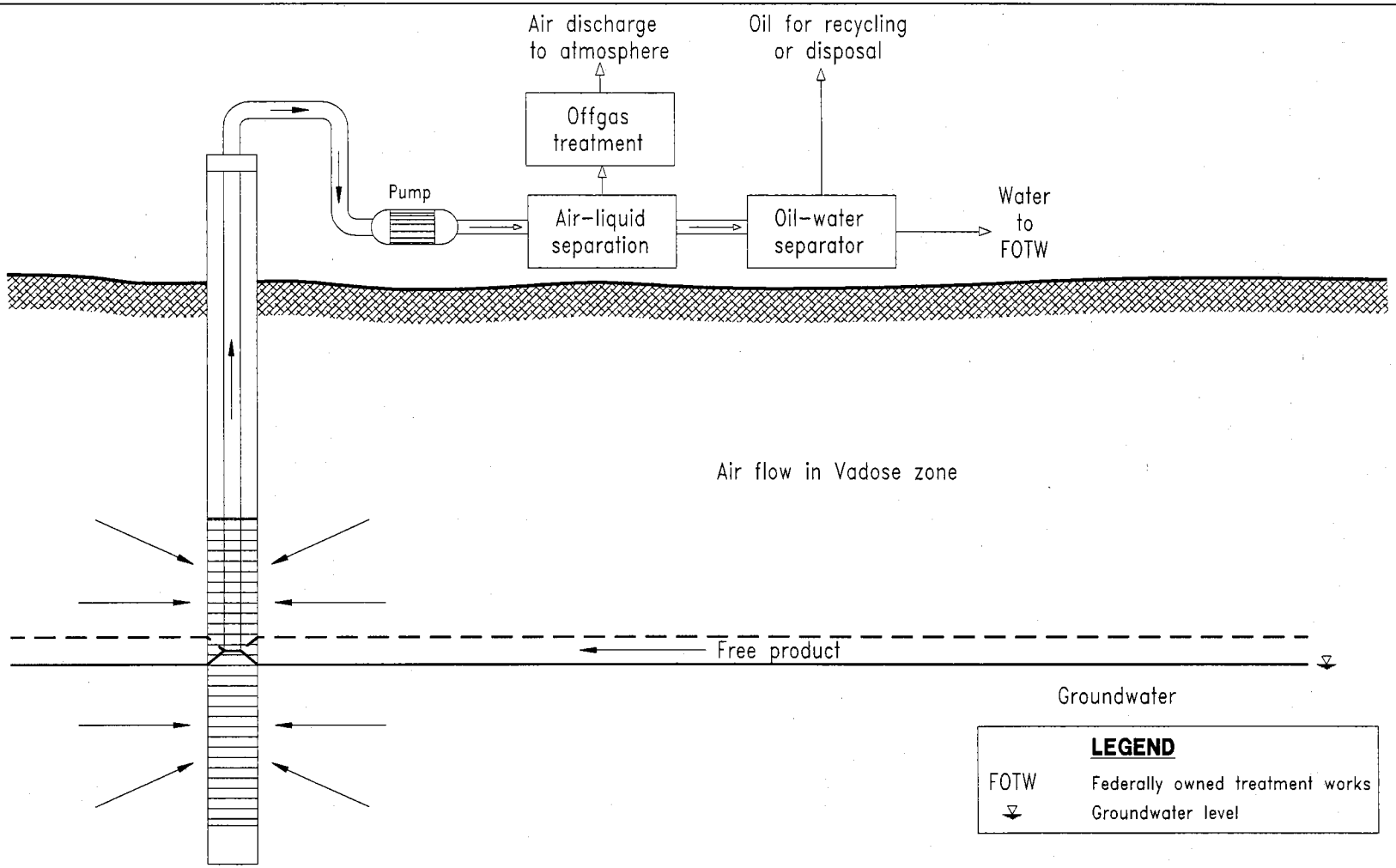

FIGURE 8-1
BIOSLURPER SYSTEM SCHEMATIC

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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continues to enter the contaminated soils. The continual recharge of air sustains the ongoing concentration gradient, until the soils become clean.

8.1.3 Bioventing of Unsaturated Zone Contaminants Bioventing is the process of aerating subsurface soils, which stimulates soil-indigenous microorganisms to aerobically metabolize fuel hydrocarbons in unsaturated soils. During bioslurping, a significant volume of air is drawn through the ground surface, into the vadose zone, thus providing oxygen for microbial growth. Respiratory studies conducted during the operation of the pilot system have confirmed increases in oxygen levels up to 20 percent by volume (Appendix C). The soil gas data collected over time (after shutdown of the bioslurper, i.e., during system dormancy) can be used to establish the rates of oxygen utilization or carbon-dioxide evolution. High oxygen utilization rates (e.g., greater than 1 percent/day) are a good indication that bioslurper-induced aeration would effectively improve microbial activity (NFEC, 1996). If oxygen utilization rates are low, yet significant contamination is present, other factors such as high clay content, low moisture content, nutrient limitation, and/or contaminant levels toxic to microorganisms may result in limiting biodegradation.

8.2 SYSTEM DESIGN. Currently the NFF Site has a bioslurping system with the following components:

- liquid ring pump,
- fluid-air separation tank,
- oil-water separation tank,
- piping to sewage treatment plant headworks, and
- off-gas treatment.

Appendix F presents details of the process and instrumentation diagram for the existing bioslurping system.

The current capacity of the liquid ring pump is limited to 10 recovery points. Hence, piping from a maximum of 10 slurping points will be connected to the liquid ring pump at any given time. However, once the product thickness within a recovery well reaches a value less than 0.01 foot, the piping will be switched to new slurper points, which may be located elsewhere within the product plume.

Additional bioslurping wells will be located to maximize the recovery of free product and ensure supply of oxygen-rich air to the saturated and unsaturated zones. Hence, the areal distribution of bioslurping wells at the NFF Site is based on the horizontal and vertical extent of contamination in the following forms: (1) free product, and (2) residual soil contamination within the capillary fringe. As described in Section 3.0, free product delineation is one of the objectives during implementation of the bioslurper expansion on the NFF mound.

Due to the nature of existence of free product at the NFF mound, a flexible approach was chosen toward the expansion of the bioslurping system.

The concept of this approach is to

- maximize the benefits of the existing bioslurping system and

- maximize the total number of points that may be installed on the mound by keeping the construction details of the bioslurping well simple.

Thus bioslurping wells will be installed as temporary piezometers to reduce the cost per well. A well construction detail will be adopted, to facilitate simultaneous monitoring and recovery of free product. The temporary bioslurping wells will be installed to a depth of 25 feet. The screen intervals will be placed between 15 feet and 25 feet. The well material will be 2-inch-diameter Schedule 40 PVC pipe. Actual locations of the additional temporary wells will be determined in the field based on the product monitoring and delineation.

An average air flow rate of 50 scfm is anticipated at each bioslurper well. Thus the total flow rate from the bioslurping system is 500 scfm at vacuum of 5 to 25 inches of Hg column. Off-gas from bioslurping system will be combined with that of SVE system and treated via catalytic oxidation.

Figure 7-4 includes the process and instrumentation diagram for the bioslurping system expansion. The vacuum supply line from each bioslurper well will be manifolded to a connection piping, and the connection piping from each row of bioslurpers will be manifolded to a header piping. Header piping will be further connected to the liquid ring pump at the compound. The header piping will be of Schedule 80, 4-inch PVC, the connection piping will be of Schedule 80 2-inch PVC, and the individual supply lines within the bioslurper well manhole will be of Schedule 40, 1-inch PVC.

Appropriate sampling ports, flow control valves, and flow meters as detailed in Figure 7-4 will be installed on each vacuum source at the bioslurper well for optimum control during the recovery of free product, soil vapor, and groundwater.

8.3 SYSTEM STARTUP. Several components of the bioslurping system are already in place at the NFF Site. In order to complete the construction as per the Process and Instrumentation Diagram presented in Figure 7-4, the following are the critical tasks to be completed as part of the overall workplan:

- install temporary piezometers,
- connect piping to piezometers
- connect piping to vapor treatment system, and
- install water treatment system.

It is anticipated that the bidding for purchase of additional equipment and procurement of subcontractor services will be initiated within 2 to 3 weeks after approval of the workplan. Procurement of equipment and any additional services is estimated to take 4 to 5 weeks. Installation of temporary piezometers is anticipated to take 2 to 3 weeks. Thus, the total time for system installation is 10 weeks.

System startup will include two phases.

- In the initial phase, a system shakedown will test proper operation of all the system components. Components to be checked include the liquid ring pump; aqueous effluent transfer pump; vapor, free-product, and water flow meter; oil-water interface probes; soil gas analyses instrumentation; emergency shut-off float switches in the oil-water

separator and the effluent equalization tank, and any vapor and groundwater treatment components.

- In the second phase of the system startup, the bioslurper design parameters will be monitored and tuned for optimum recovery of free product. Design parameters to be monitored include vacuum, air flow rate, vapor concentrations, and total fluids flow rate. Additionally, design parameters associated with the oil-water separator, vapor treatment, and water treatment will be monitored and utilized to tune up the system. Startup monitoring is anticipated to occur daily for the first week of operation, then weekly for the remainder of the first month.

8.4 SYSTEM MONITORING. The overall performance of the bioslurper system will be evaluated based on the data obtained from the monitoring and reporting of the parameters listed below.

Free Product Recovery:

- thicknesses of free product in source area monitoring wells
- volume of free product and water collected during extraction
- total volume of free product recovered

SVE:

- vapor flow rates from the recovery wells
- vapor concentrations during bioslurping
- vacuum readings at the bioslurper well head

Table 8-1 presents the data log for bioslurping system monitoring.

Based on the soil vacuum data generated during the bioslurping system operation at the NFF Site and full-scale studies completed elsewhere, and review of literature for sites with similar characteristics it is estimated that the total cleanup time will be of the order of 5 to 10 years.

Table 8-1
Example of a Bioslurping System Data Log

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Site:	Bioslurper Well ID:
Date:	System Operator:
Logged By:	Checked By:

Time[1]	Applied Vacuum[2] (H_2O in.)			Vapor Flow Rate[3] (scfm) at the Recovery Well	Vapor Concentration[4]	Well Head Vacuum[5] (H_2O in.) at Observation Wells					Volume of Fluids[6] (gallons)		
	Total	Drop Tube	Well Casing	Total	Total	Well-1	Well-2	Well-3	Well-3	Well-4	Total	Water	FP

[1] Time: Time at which the measurements are made.
[2] Applied Vacuum: Vacuum measured at bioslurper well head. Use vacuum gauges.
[3] Vapor Flow Rate: Measured at bioslurper well head. Use anemometer.
[4] Vapor Concentration: Measured at bioslurper well head. Use tedlar bags to collect vapor sample and measure with a VOCs analyzer.
[5] Well Head Vacuum: Vacuum measured at monitoring wells. Use vacuum gauges.
[6] Volume of Fluids: Measured from the equivalization tank. Use oil-water interface probe.

Notes: H_2O = water.
scfm = standard cubic feet per minute.
FP = free product.
VOCs = volatile organic compounds.

9.0 BIOSPARGING SYSTEM

This section presents details of reducing concentrations of groundwater contaminants including benzene, total VOAs, and total naphthalenes in the shallow zone (0 to 55 feet bls).

Biosparging will be employed to reduce concentrations of contaminants in the shallow and consequently water table groundwater to regulatory limits. This biosparge system is anticipated to complement the other groundwater remedial measures proposed in this plan, including remediation by natural attenuation.

9.1 TECHNOLOGY DESCRIPTION. Biosparging is the process of injecting air at controlled pressures and volumes into the groundwater below the deepest point of contamination. There are three mass transfer phenomena that take place during air injection into an aquifer matrix: volatilization of dissolved-phase organic compounds, increased mobility of the contaminants adsorbed to the aquifer material, and increased biological activity due to increased levels of oxygen available for the microorganisms. Biosparging differs from air sparging in one important respect, the goal of air sparging is to volatilize organic compounds and remove them via stripping, while the goal of biosparging is to create an optimum environment for microorganism growth. Biodegradability varies with the contaminant present in the plume. Since most petroleum compounds have been proven to be amenable to bioremediation, increasing the dissolved oxygen should stimulate the microbes to consume the contaminant plume.

Potential problems with *in situ* biosparging usually occur as a result of either a too loose or too tight aquifer formation. If the sediments are too loose (i.e., gravel), the oxygen tends to bubble through the aquifer vertically, with little horizontal movement occurring. On the other hand, if the sediments are too tight (i.e., clays), then the system may resist the movement of oxygen through the aquifer and create pockets of untreated contamination.

Since biodegradation is the goal of this remedial action, and the primary factor limiting biodegradation rates is the lack of available oxygen, biosparging has the potential to increase biological activity.

Components of a biosparging system include the following:

- biosparging wells
- manifold piping
- compressed air equipment
- monitoring controls

Figure 9-1 presents a schematic of a biosparging system.

9.2 SYSTEM DESIGN. The design of the biosparging system is geared toward introducing a sufficient amount of oxygen into the aquifer matrix using a series of injection wells. Figure 9-2 shows the estimated extent of groundwater contamination (greater than 50 ppb total VOA) as determined in the CARA.

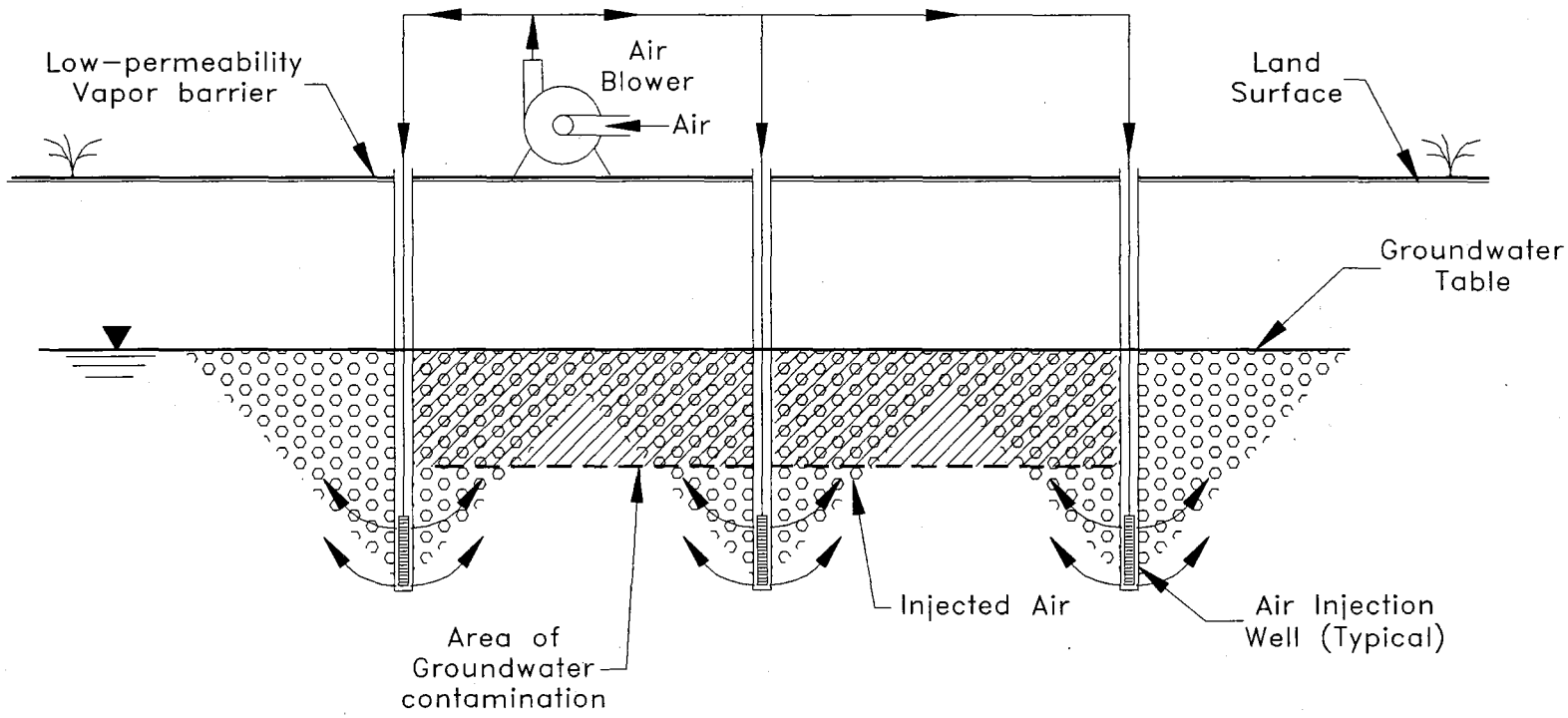

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FIGURE 9-1
BIOSPARGING SYSTEM SCHEMATIC

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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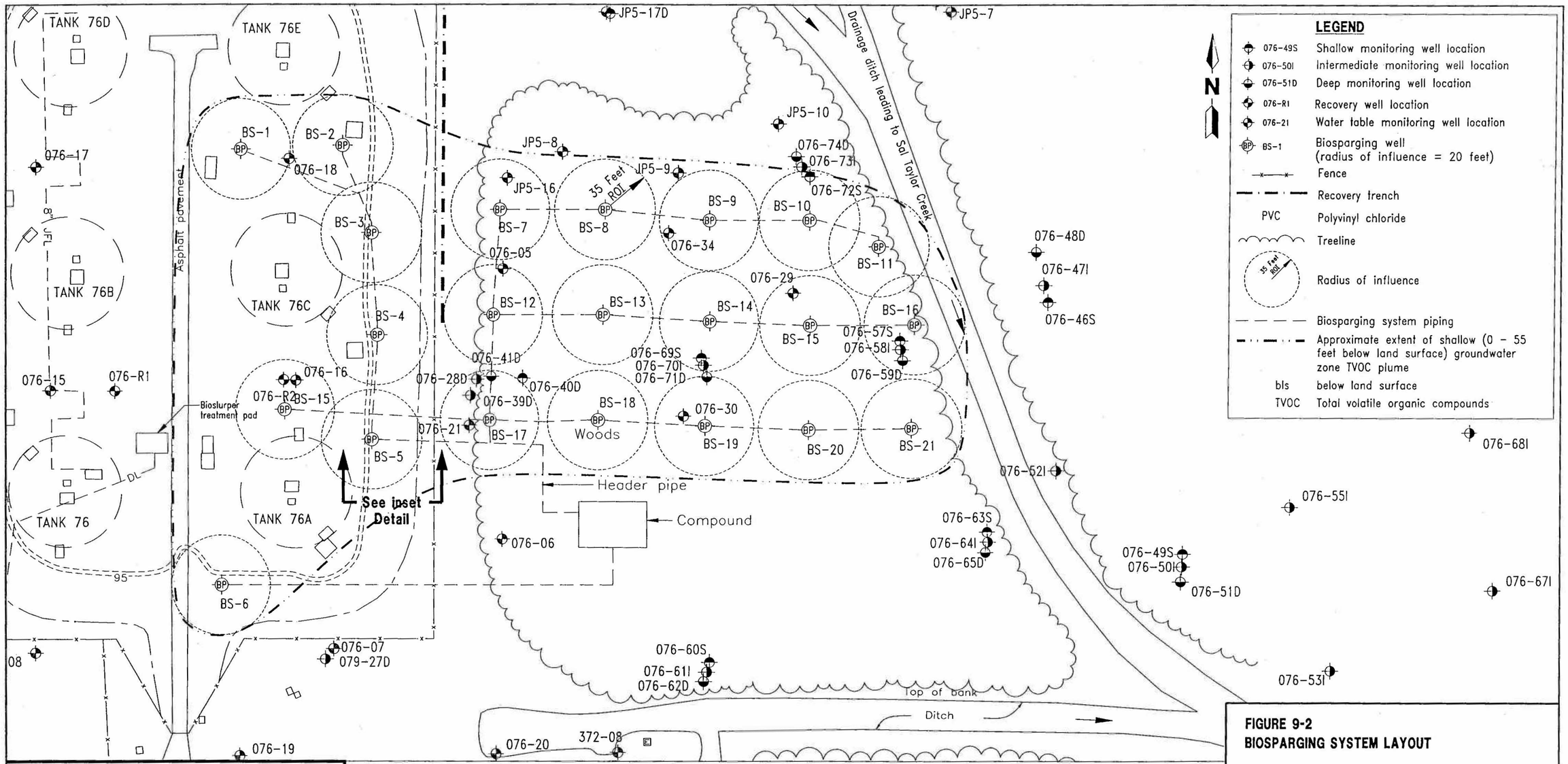
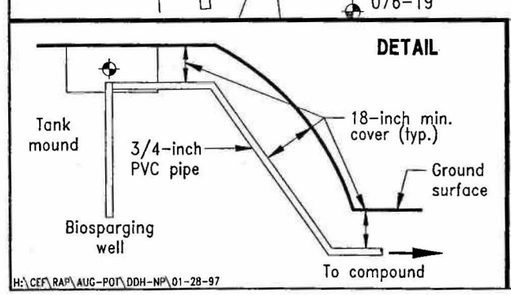


LEGEND

076-49S	Shallow monitoring well location
076-50I	Intermediate monitoring well location
076-51D	Deep monitoring well location
076-R1	Recovery well location
076-21	Water table monitoring well location
BS-1	Biosparging well (radius of influence = 20 feet)
	Fence
	Recovery trench
PVC	Polyvinyl chloride
	Treeline
35 Feet ROI	Radius of influence
	Biosparging system piping
	Approximate extent of shallow (0 – 55 feet below land surface) groundwater zone TVOC plume
bls	below land surface
TVOC	Total volatile organic compounds



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SCALE: 1 INCH = 75 FEET

NOTES:
1. All piping is 3/4-inch schedule 80 polyvinyl chloride.
2. Use 18-inch minimum cover.
3. See Figure 8-3 for well vault details.
4. See Figure 8-4 for compound details.
5. Use existing monitoring wells as reference points to locate header.

FIGURE 9-2
BIOSPARGING SYSTEM LAYOUT

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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A design radius of influence of 35 feet per well was selected based on the pilot test results included in Appendix H. Based on calculations presented in Appendix H, a total of 21 biosparging wells are required to cover the shallow groundwater contamination at the NFF Site. Locations of biosparge wells are presented on Figure 9-2. Construction details for biosparge wells BS-1 through BS-6 are included on Figure 9-3. Construction details for biosparge wells BS-7 through BS-22 are included on Figure 9-4.

To size the compressor, the actual pressure and flow rate for the system were calculated taking into account pressure and dynamic losses and employing a safety factor of 1.5. The estimated design pressure and total flow rate is 120 actual cubic feet per minute (acfm) and 25 pounds-force per square inch, respectively. These calculations can be found in Appendix H. Based on these requirements, the recommended compressor for the site is a Kaeser Model Number SM-11 Screw-type Air Compressor or an approved equivalent. The compressor is capable of delivering air at a pressure of 25 pounds per square inch (psi) at a maximum flow rate of 180 scfm. A Kaeser Model Number KRD-250 compressed air dryer will be used to eliminate moisture from the air stream. Existing power poles will be used to deliver 3-phase power to the compressor. To help increase the life of the compressor, a Dayton Model 5Z361 stationary 350-gallon air tank will be used as a receiver to store the compressed air, allowing the compressor to operate intermittently and the air to cool.

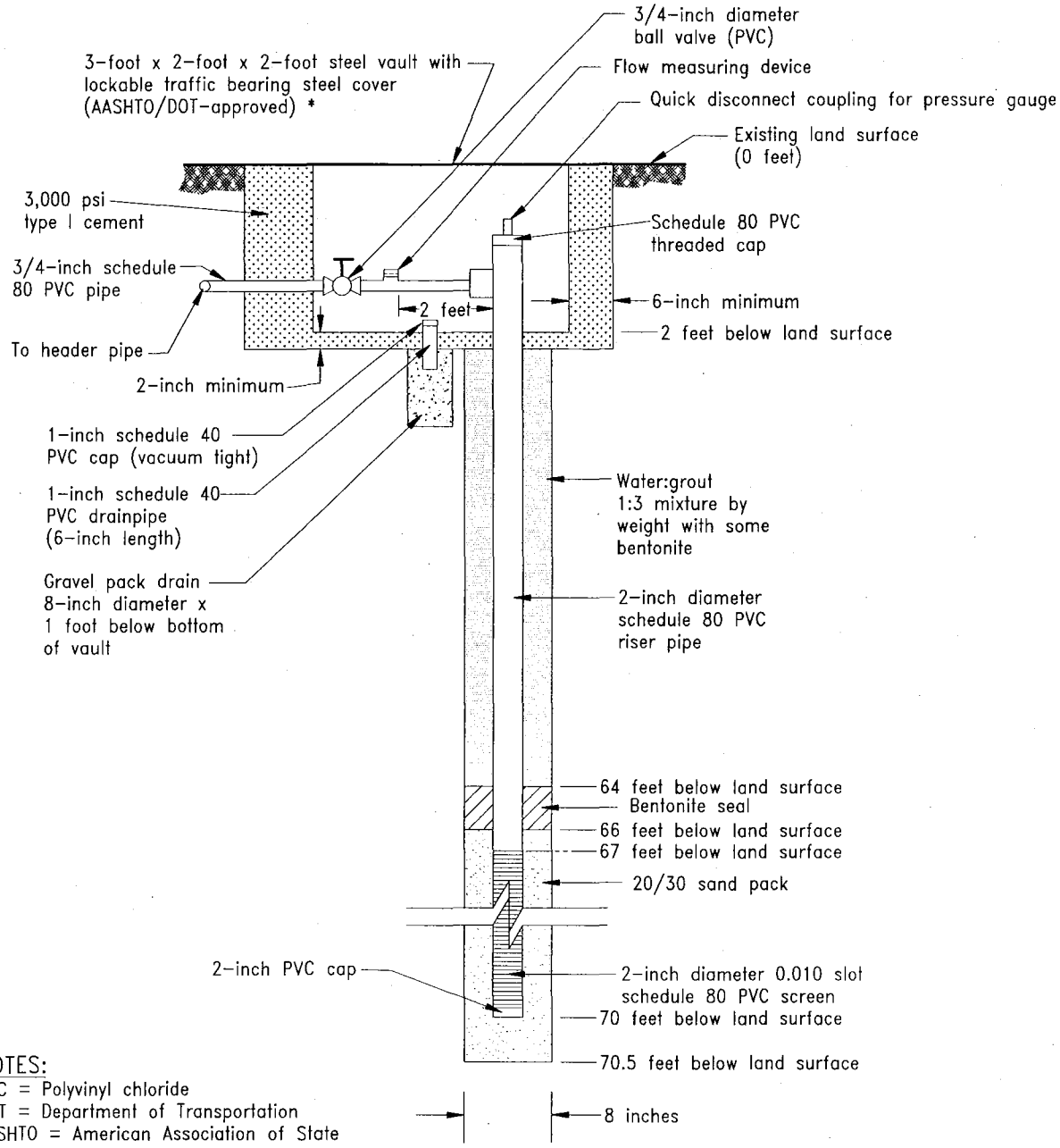
The compressor, dryer, and air tank will be housed in the same building as the SVE system blower, and wired to the same control panel. The compressor outlet line will be equipped with a pressure switch that is designed to control the cycle time of the system. A pressure gauge (rated at 0 to 250 psi) and check valve will be installed in-line prior to the air tank to ensure the proper operation of the pressure switch and to only allow air to flow one-way from the compressor to the air tank. When the compressor stops, the check valve closes, thus preventing loss of air from the tank or damage to the compressor. A refrigerated air dryer will be mounted next to the compressor and will be used to remove moisture from the atmospheric air and help to cool the air stream.

The air tank discharge line will be fitted with a ball valve, a Kaeser filtered centrifugal separating filter, and a coalescing oil removal filter to reduce moisture and remove any oil that may be present. This line will also include a pressure regulator to help the operator deliver the correct pressure to the system and a flow measuring device. System piping will be 3/4-inch Schedule 80 PVC pipe. The system will deliver air to each well at a flow rate of 5 to 7 acfm at an in-line pressure of 21 pounds-force per square inch. Piping inside the compound will be galvanized steel.

Figure 9-5 presents the process and instrumentation diagram of the biosparging system at the NFF Site.

9.3 SYSTEM STARTUP. Upon approval by the regulatory agencies of this RAP, the startup of the system will commence. It is anticipated to take a month to obtain competitive bids for contractors for this project. It should require no more than 3 weeks to build the biosparging portion as described in this chapter.

A preconstruction meeting will be held after the selection of the remedial contractor and will include the design engineers, the activity, the Resident



NOTES:

PVC = Polyvinyl chloride
DOT = Department of Transportation
AASHTO = American Association of State Highway Transportation Officials
psi = Pounds per square inch
Well operating parameters: 1 cfm at 15 psi
cfm = Cubic feet per minute

* Vault configuration can be modified to accommodate the flow measuring device.

NOT TO SCALE

FIGURE 9-3
BIOSPARGE WELL CONSTRUCTION DETAIL FOR THE MOUND AREA BS-1 THROUGH BS-6

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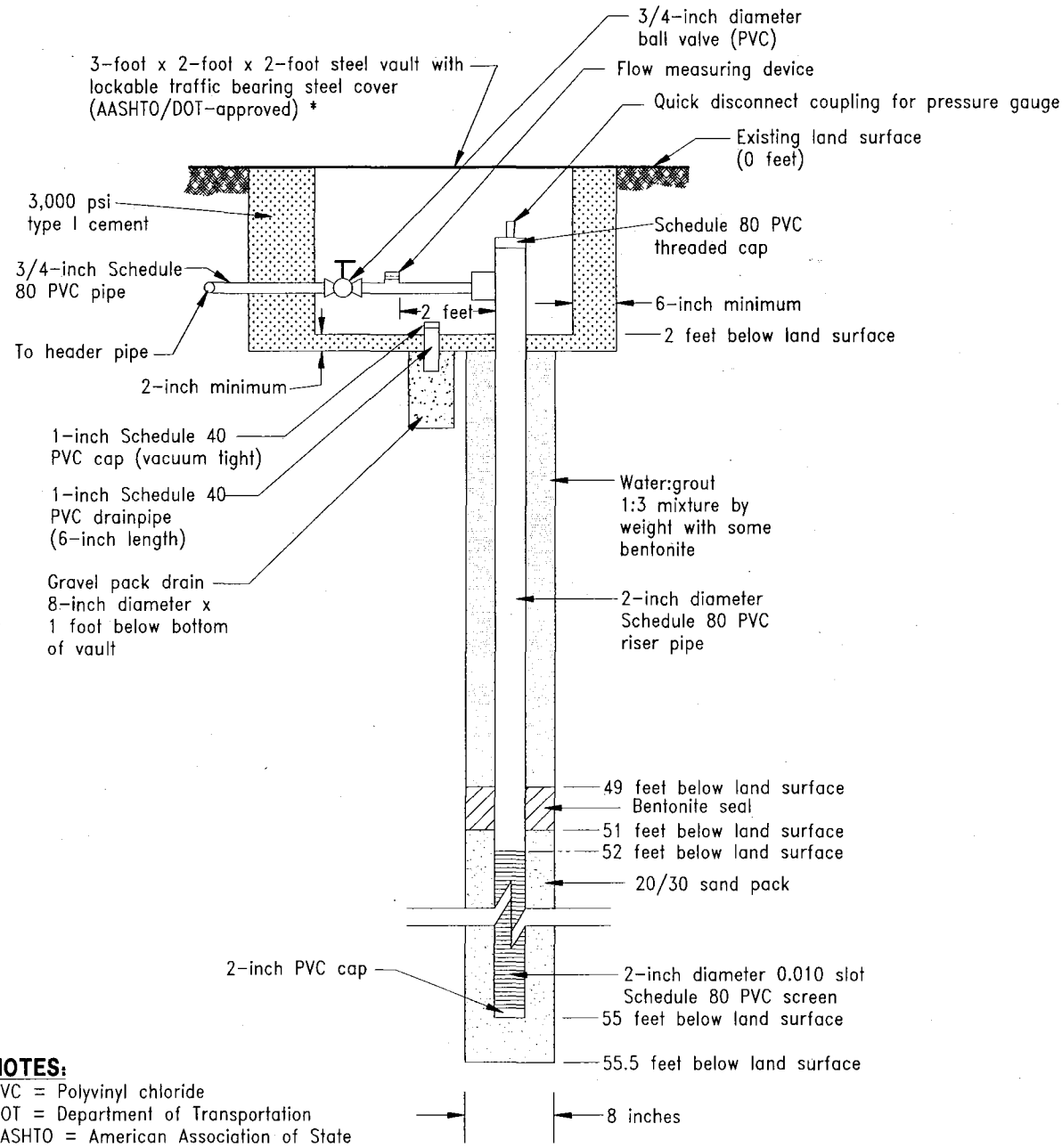
REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA



NOTES:

PVC = Polyvinyl chloride
DOT = Department of Transportation
AASHTO = American Association of State Highway Transportation Officials

psi = Pounds per square inch
Well operating parameters: 1 cfm at 15 psi
cfm = Cubic feet per minute

* Vault configuration can be modified to accommodate the flow measuring device.

NOT TO SCALE

FIGURE 9-4
BIOSPARGE WELL CONSTRUCTION DETAIL FOR AREA OUTSIDE OF THE MOUND BS-7 THROUGH BS-22

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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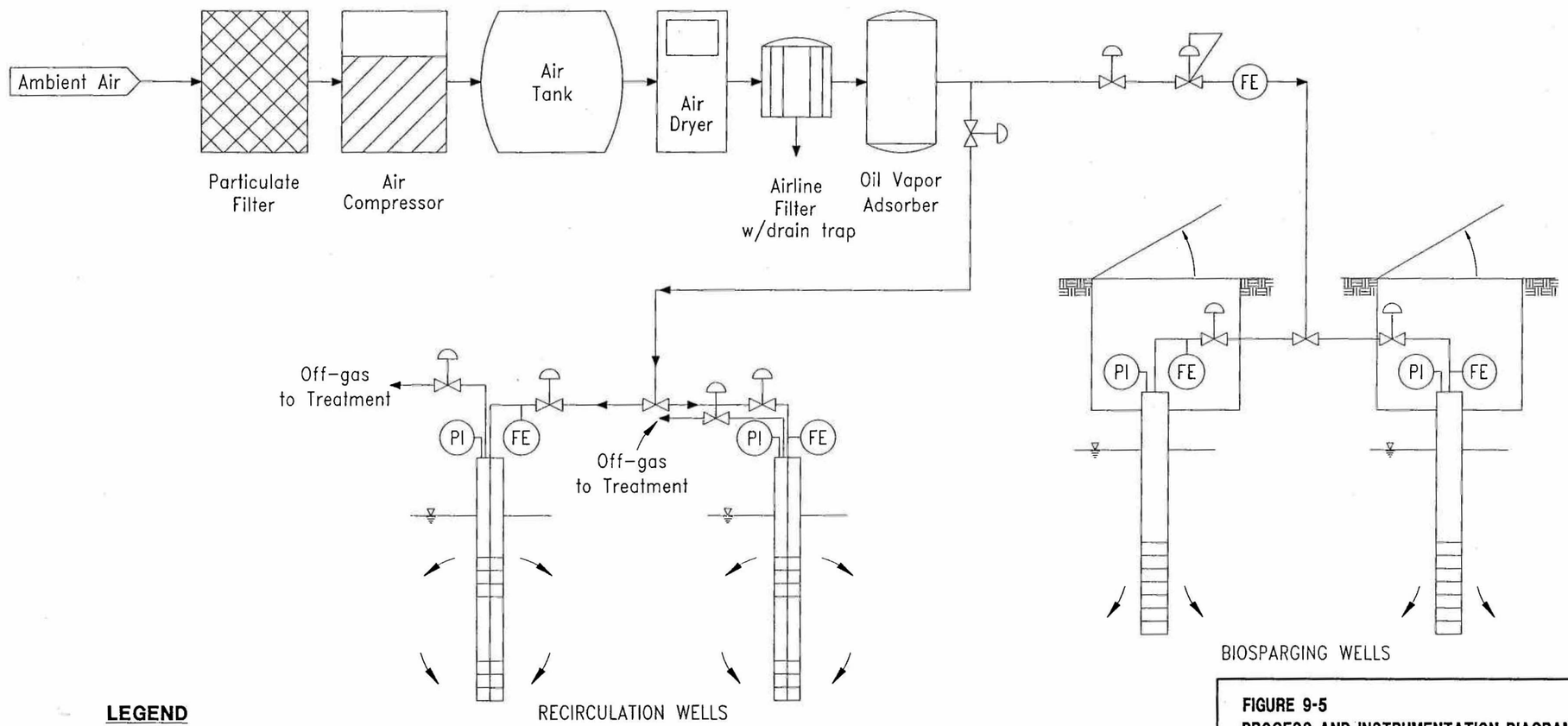

LEGEND

- Pressure Regulator – Reducing
- Flow control valve
- (PI) Pressure gauge
- (FE) Flow meter

NOT TO SCALE

FIGURE 9-5
PROCESS AND INSTRUMENTATION DIAGRAM OF BIOSPARGING AND RECIRCULATION WELL SYSTEMS

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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Officer in Charge, and the contractor. To ensure that the contractor has constructed the system appropriately, construction oversight will be required by the design engineers. Additionally, an initial optimization test should be completed no more than 1 month after the construction of the biosparging system. The components of the optimization will be at the discretion of the design engineers and will be completed and submitted to the Navy separately.

Twenty-one biosparging wells will be installed. The compressor will run intermittently and deliver compressed air to the air tank. The cycle time for the air compressor will be determined in the field prior to operation startup. The air tank will deliver compressed air to the biosparging wells continuously 24 hours a day 7 days a week. The manufacturer's specifications for the biosparging equipment are found in Appendix H.

9.4 SYSTEM OPERATION, MONITORING, AND REPORTING. Existing monitoring wells 076-5, -6, -21, -28D, -46S, -47I, -57S, -58I, -69S, -70I, -72S, and -73I will be used for monitoring the progress of the biosparging system. These 12 monitoring wells will be sampled quarterly the first year and annually thereafter until the site is remediated. Table 9-1 shows the compliance monitoring schedule for biosparging.

Based on the biosparging pilot test conducted at the NFF Site and full-scale studies elsewhere, as well as a review of literature for sites with similar characteristics, it is estimated that the total cleanup time will be of the order of 5 to 10 years.

Table 9-1
Biosparging System Monitoring Schedule

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Media	Frequency							
	[1]Q1	Q2	Q3	Q4	[2]Y2	Y3	Y4	Y5
Groundwater[3]								
Volatile Organic Aromatics and Polynuclear Aromatic Hydrocarbons	15	15	15	15	15	15	15	15
Soil[4]								
Total BTEX[5] and Total Recoverable Petroleum Hydrocarbons	0	0	0	15	15	15	15	15

[1] Q = Quarterly.
[2] Y = Yearly.
[3] USEPA Method 601/602/610. For each groundwater event, collect the following samples:

076-5	076-57S
076-6	076-58I
076-21	076-69S
076-28D	076-70I
076-46S	076-72S
076-47I	076-73I

QA duplicate
QA MS/MSD
QA trip blank.

[4] USEPA Method 8020/9073.
[5] Benzene, toluene, ethylbenzene, and xylenes.

10.0 RECIRCULATION WELL SYSTEM IN THE INTERMEDIATE PLUME

This section presents the details of removal of aquifer contaminants through enhanced bioremediation and *in situ* stripping using recirculation wells in the intermediate plume (55-100 feet bls).

Recirculation wells are installed within the 5,000 $\mu g/\ell$ TVOA isoconcentration contour to reduce the secondary source of contamination within the intermediate plume. The remaining portion of intermediate zone groundwater contamination is anticipated to be naturally attenuated.

10.1 TECHNOLOGY DESCRIPTION. A recirculation well is constructed with standard monitoring well construction materials, but includes two screens separated by an annular seal. Screens are installed at the top and bottom boundaries of the contaminant plume to be remediated. Air is injected through a small-diameter PVC pipe at the base of the well, near the bottom screen, and allowed to bubble upward in the wellbore. Bubbling air within the well casing creates a hydrostatic head gradient along the wellbore, which drives aerated water out of the upper well screen while simultaneously drawing formation groundwater in through the lower screen.

Figure 10-1 presents a schematic of a recirculation well system. Groundwater is essentially remediated through two mechanisms: (1) physical stripping of highly volatile components in the groundwater entering the wellbore and (2) biodegradation of less volatile components through oxygen enrichment of groundwater leaving the wellbore.

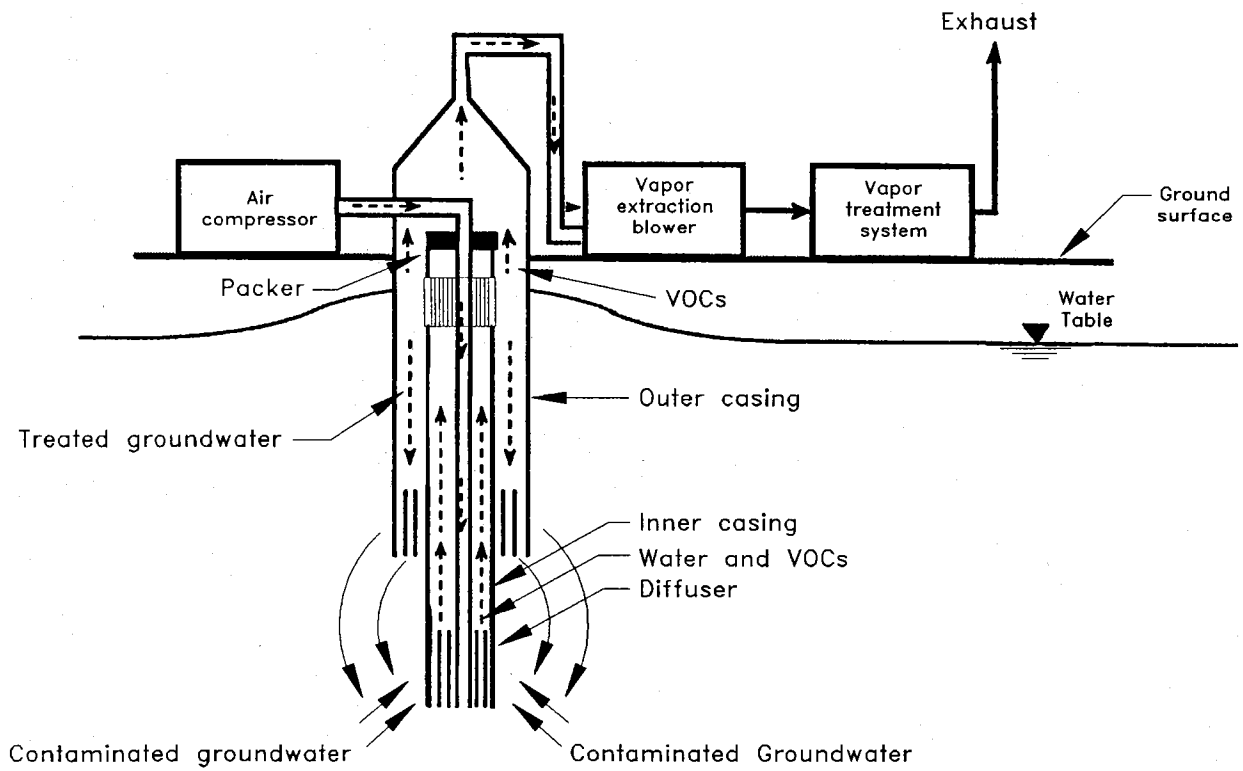
Stream lines entering the wellbore at the bottom screen will travel through the wellbore and leave at the top screen, resulting in a three-dimensional array of flownet surrounding the wellbore. The area surrounding the wellbore affected by the hydraulic head gradient is defined as the "sphere of influence." The radius of the sphere of influence is typically equal to the separation distance between the two screens multiplied by a factor greater than one. Actual values of the radius of influence are estimated based on aquifer properties at the well location.

The recirculation well system will combine groundwater sparging with vapor collection and treatment.

10.2 SYSTEM DESIGN. The recirculation well system consists of the following primary components:

- recirculation wells
- a positive pressure blower or air compressor
- a vacuum blower
- an off-gas treatment system

Recirculation Wells. Recirculation wells will be located to maximize the recovery of dissolved hydrocarbons via *in situ* stripping within the wellbore. Areal distribution of recirculation wells will be based on the estimated radius of influence of 50 feet. Based on calculations presented in Appendix G, it is



In-well aeration well

Note:
VOC = Volatile organic compound

FIGURE 10-1
SCHEMATIC OF RECIRCULATION WELL

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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estimated that the NFF Site intermediate plume will require five wells to cover the contaminant plume with total BTEX concentrations greater than 5,000 ppb.

Figure 10-2 presents the location of the recirculation wells. Each recirculation well will be constructed to a total depth of 100 feet bls, and the screens will be located at 55 feet bls and 100 feet bls. Screens will be located at 4-foot intervals and will consist of 0.01-inch slots.

Bubbling air at the bottom screen in a recirculation well results in formation of a temporary rise in hydrostatic water level within the well casing. Maximum possible rise will be equivalent to the hydrostatic head created at the bottom of the wellbore. Since the natural piezometric surface is only a few feet below the ground surface, the recirculation well has to be extended several feet above the ground surface in order to sustain the ensuing hydrostatic head. Based on calculations presented in Appendix G, a maximum stack height of 15 feet will be required for each recirculation well. Figure 10-3 presents the construction details of recirculation wells.

Positive Pressure Blower. Air for groundwater sparging will be generated using a positive pressure blower. Air would be delivered from a 3/4-inch-diameter tube to the bottom of the recirculation wells.

Based on calculations presented in Appendix G, the sparge flow rate at each well will be less than 10 acfm, at a maximum pressure of 10 pounds per square inch gauge (psig). Sparge air will be delivered by a compressor that could generate 50 scfm air flow rate at 10 psig. The compressed air for the recirculation wells will be drawn from the compressor system designed for the biosparging system (see Section 9-2). Air flow to each of the recirculation wells will be gauged and regulated from controls housed in the compound within a central location.

Vacuum Blower. Volatile contaminants stripped and trapped within the well casing will be collected under vacuum using a vacuum blower. Piping from the vacuum blower will be connected to the top of the well head, and the off-gas stream will be delivered to a central vapor treatment system housed in the compound (See Figure 9-5).

Based on calculations presented in Appendix G, the vacuum flow rate from each well will be less than 10 acfm, at a maximum vacuum of 50 inches of water. The blower system will be designed to supply vacuum for the SVE system as well as the recirculation well system. Hence, the blower selected for the SVE system (see Section 7.2) will be used for supply of vacuum to the recirculation well system. Off-gas flow from each of the recirculation wells will be collected and delivered to a central off-gas treatment system housed in the compound.

Off-Gas Treatment System. Volatile organic contaminants delivered by the vacuum blower will be transferred to a centrally located vapor treatment system. A catalytic oxidizer vapor treatment unit will be used. This unit will have a maximum capacity of 1,000 cfm to treat combined vapors from SVE, bioslurping, and recirculation well systems.

Figure 9-5 includes the process and instrumentation diagram for the recirculation well system at the NFF Site.

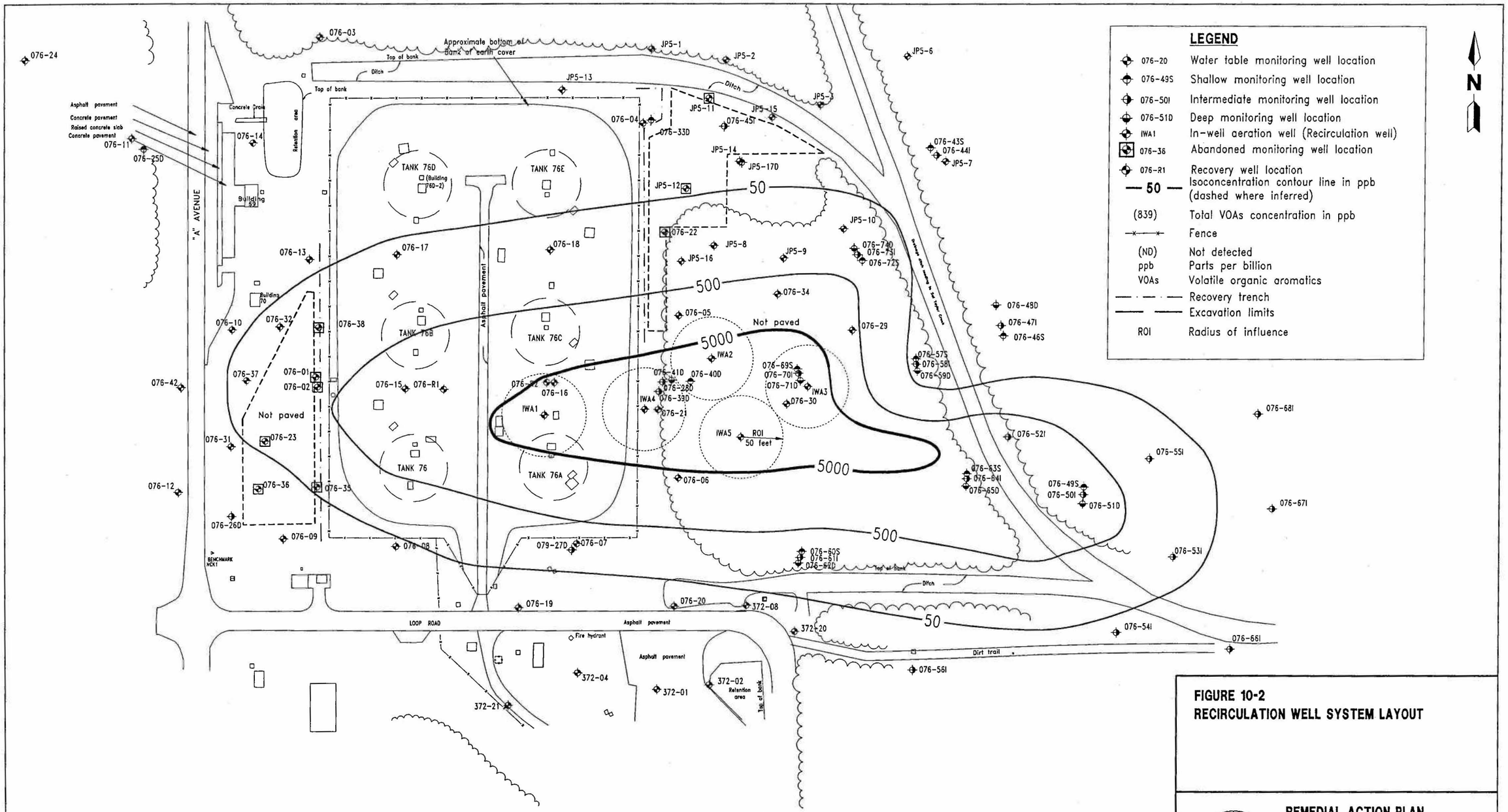

FIGURE 10-2
RECIRCULATION WELL SYSTEM LAYOUT

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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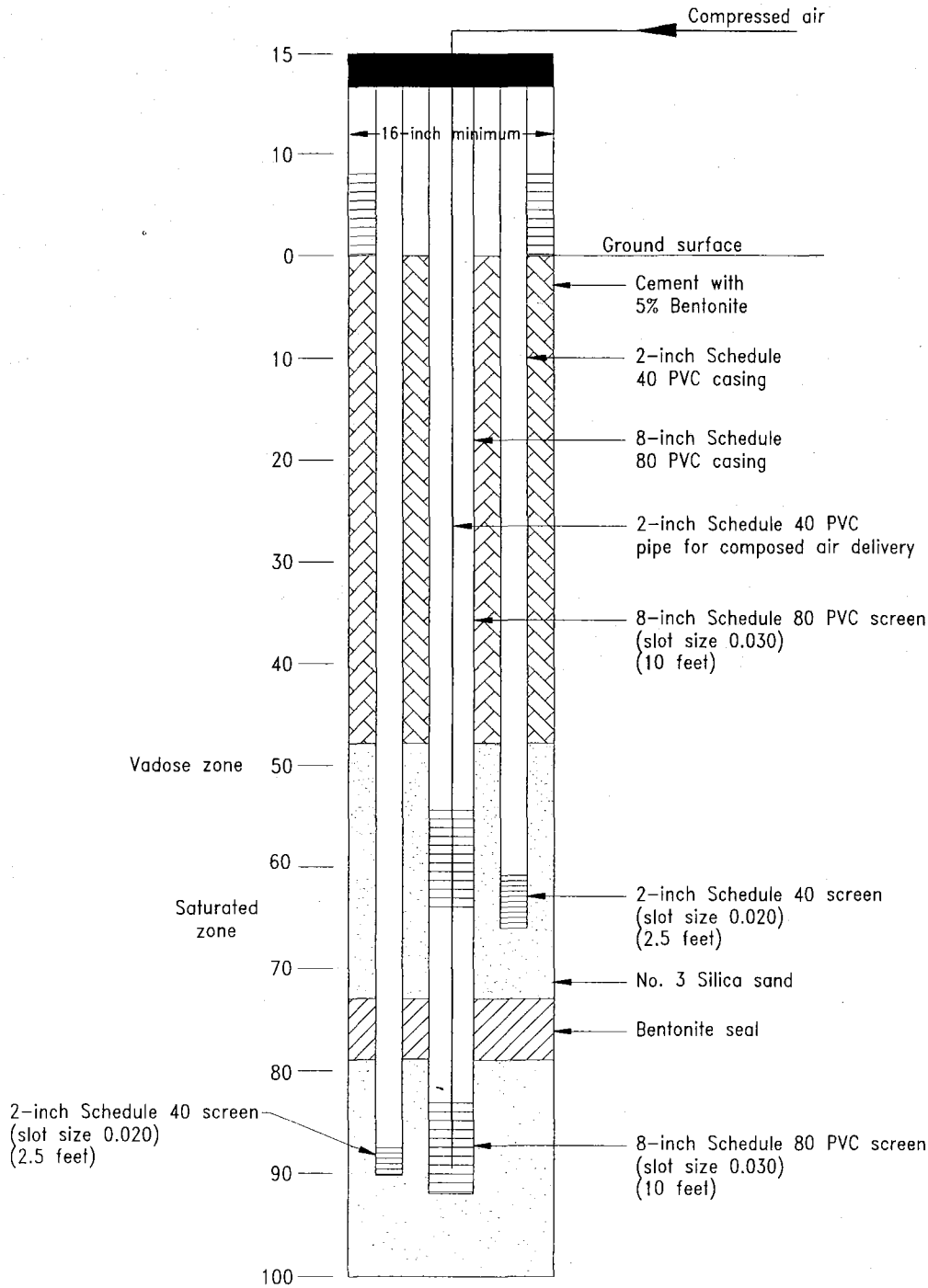

NOTES:
PVC = Polyvinyl chloride
1. Vault configuration can be modified to accommodate the flow measuring device.

NOT TO SCALE

FIGURE 10-3
RECOMMENDED RECIRCULATION WELL CONSTRUCTION

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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10.3 SYSTEM STARTUP. The recirculation well system installation will begin within 4 weeks after approval of the workplan. Equipment procurement will take 4 to 6 weeks. Installation of recirculation wells will take 3 to 5 weeks. Installation of trenching and piping will take an additional 2 weeks. Since installation of the off-gas treatment unit will be included as part of the SVE system, the time for installation is not included under this system. Thus, the total time for *in situ* stripping system installation will be 17 weeks.

Prior to system startup monitoring wells will be installed within the recirculation zone at the NFF Site as presented in Figure 10-2. These monitoring wells are strategically located to monitor the performance of the recirculation system. During the system startup, operational data including air flow rates, sparging pressure, vacuum flow rates, well head vacuum, and vapor concentrations will be monitored daily for the first week and weekly for 2 months in order to optimize the air flow rate and VOCs stripping efficiencies. Also, trends regarding potential for clogging of the screen due to excessive biological activity, and biomass buildup, vapor emission rates, groundwater recirculation flow rates, and oxygen concentrations within the wellbore will be monitored and recorded as baseline for future comparison.

10.4 SYSTEM OPERATION, MONITORING, AND REPORTING. Required maintenance will be performed during weekly visits. Typical weekly maintenance of the system includes adjusting of sparging air flow rates and vapor collection vacuum rates.

Table 11-1
Groundwater Monitoring Plan Sampling Schedule
Remediation by Natural Attenuation

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Task	Quarterly Monitoring				Semi-Annual Monitoring			
	Q1	Q2	Q3	Q4	Q6	Q8	Q10	Q12
Measure water levels	X	X	X	X	X	X	X	X
Long-Term Monitoring (LTM) Wells[2]	0	X	0	X	X	X	X	X
Point of Compliance Wells[3]	0	X	0	X	X	X	X	X

[1] Estimated maximum time to cleanup.
[2] Includes monitoring wells 076-75S, -76I, -77D, -21, -39D, -40D, -69S, -70I, -71D, -30, -58I, -63S, -64I, and -65D.
[3] Includes monitoring wells 076-47I, -53I, -67I, -54I, -51D, and -78D.

Notes: Groundwater samples will be analyzed for all the required parameters in accordance with the "Technical Protocol for Implementing Intrinsic Remediation, Vols. I and II," by Todd Wiedemeier et al. (see Appendix I).

0 = indicates task is not scheduled.
X = indicates task is scheduled to be performed once in the given month.

according to the analytical protocol presented in Table 11-1. Water-level measurements are to be made during each sampling event.

All POC monitoring wells will be sampled and analyzed to monitor trends in groundwater chemistry, to verify the effectiveness of natural attenuation at the site, and to demonstrate protection of human health and the environment and compliance with site-specific numerical remediation goals. Water-level measurements are to be made in POC wells during each sampling event. All groundwater samples from the POC wells will be analyzed according to the analytical protocol presented in Table 11-1.

Each of the LTM and POC sampling points will be sampled twice each year for 15 years. If the data collected during this time period support the anticipated effectiveness of the natural attenuation at this site, the sampling frequency can be reduced to once every year for all the wells.

12.0 COST ESTIMATE

The cost estimate has been inserted following Appendix K in those report copies that require it and has been omitted in others. This was done to facilitate Navy procurement requirements.

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APPENDIX A

SUMMARY OF CONTAMINATION ASSESSMENT

APPENDIX A-1

Free Product Monitoring

Appendix A-1

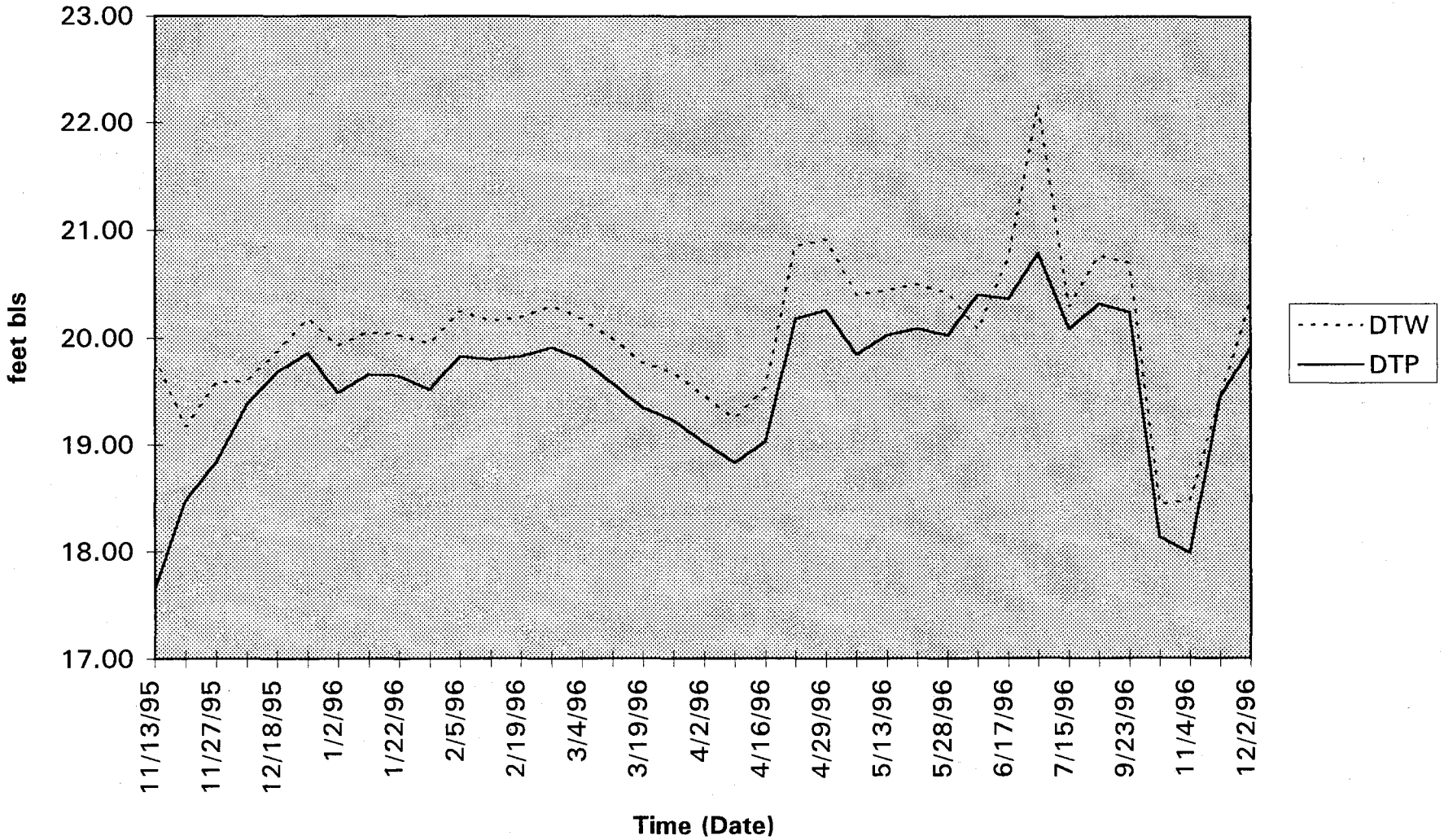
N.A.S. Cecil Field
North Fuel Farm Site
Product Thickness Monitoring
November 1995 - December 1996

Engineer: Tim Kelly Reviewed by: KGK Date: 1/27/97

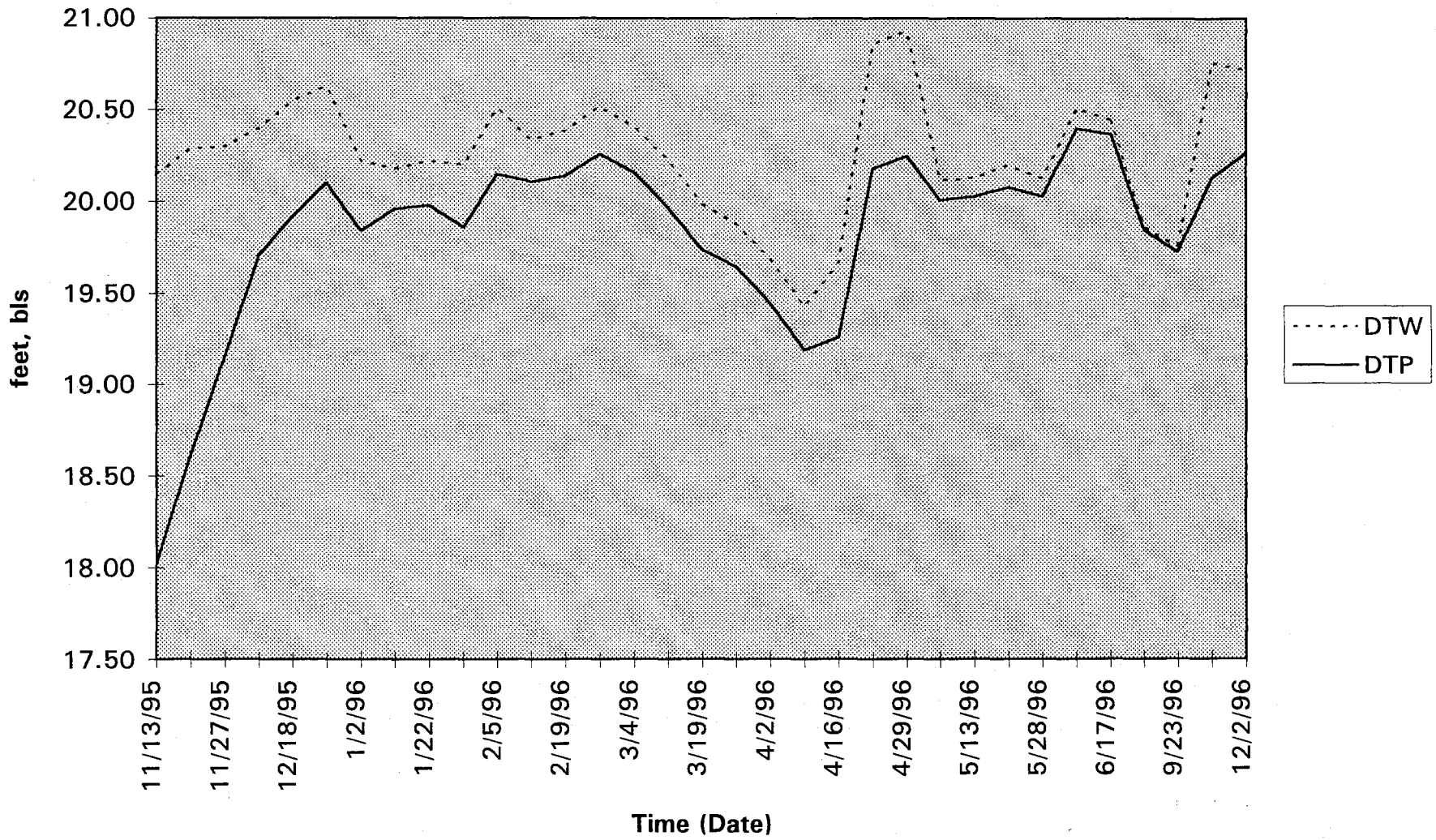
Date	CEF-076-15			CEF-076-16			CEF-076-17		
	DTW (ft, btoc)	DTP (ft, btoc)	Thickness (ft)	DTW (ft, btoc)	DTP (ft, btoc)	Thickness (ft)	DTW (ft, btoc)	DTP (ft, btoc)	Thickness (ft)
11/13/95	19.83	17.65	2.18	20.15	18.02	2.13	0.00	0.00	0.00
11/22/95	19.17	18.48	0.69	20.29	18.61	1.68	0.00	0.00	0.00
11/27/95	19.59	18.84	0.75	20.30	19.16	1.14	0.00	0.00	0.00
12/11/95	19.60	19.38	0.22	20.40	19.71	0.69	0.00	0.00	0.00
12/18/95	19.88	19.68	0.20	20.55	19.92	0.63	0.00	0.00	0.00
12/18/95	20.18	19.86	0.32	20.63	20.10	0.53	0.00	0.00	0.00
1/2/96	19.93	19.49	0.44	20.22	19.84	0.38	0.00	0.00	0.00
1/15/96	20.06	19.66	0.40	20.18	19.96	0.22	0.00	0.00	0.00
1/22/96	20.03	19.65	0.38	20.22	19.98	0.24	0.00	0.00	0.00
1/19/96	19.95	19.52	0.43	20.20	19.86	0.34	0.00	0.00	0.00
2/5/96	20.25	19.83	0.42	20.51	20.15	0.36	0.00	0.00	0.00
2/13/96	20.16	19.80	0.36	20.34	20.11	0.23	0.00	0.00	0.00
2/19/96	20.19	19.83	0.36	20.39	20.14	0.25	0.00	0.00	0.00
2/26/96	20.30	19.91	0.39	20.52	20.26	0.26	0.00	0.00	0.00
3/4/96	20.18	19.80	0.38	20.41	20.16	0.25	0.00	0.00	0.00
3/11/96	20.00	19.58	0.44	20.23	19.97	0.26	0.00	0.00	0.00
3/19/96	19.77	19.35	0.42	19.99	19.74	0.25	0.00	0.00	0.00
3/25/96	19.68	19.23	0.45	19.88	19.65	0.23	0.00	0.00	0.00
4/2/96	19.47	19.02	0.45	19.69	19.45	0.24	0.00	0.00	0.00
4/8/96	19.25	18.83	0.42	19.43	19.19	0.24	0.00	0.00	0.00
4/16/96	19.54	19.03	0.51	19.67	19.26	0.41	0.00	0.00	0.00
4/22/96	20.85	20.18	0.67	20.86	20.18	0.68	19.82	19.74	0.08
4/29/96	20.92	20.26	0.66	20.93	20.25	0.68	19.90	19.82	0.08
5/6/96	20.40	19.85	0.55	20.12	20.01	0.11	19.72	19.66	0.06
5/13/96	20.44	20.03	0.41	20.13	20.03	0.10	19.76	19.69	0.07
5/21/96	20.50	20.09	0.41	20.20	20.08	0.12	19.85	19.77	0.08
5/28/96	20.42	20.03	0.39	20.13	20.03	0.10	19.76	19.69	0.07
6/3/96	20.08	20.40	0.40	20.51	20.40	0.11	20.05	19.97	0.08
6/17/96	20.74	20.36	0.38	20.45	20.37	0.08	19.99	19.92	0.07
7/2/96	22.17	20.79	1.38	0.00	0.00	0.00	20.05	20.03	0.02
7/15/96	20.29	20.09	0.20	0.00	0.00	0.00	19.46	19.39	0.07
9/6/96	20.77	20.32	0.45	19.87	19.85	0.02	21.56	20.04	1.52
9/23/96	20.70	20.24	0.46	19.76	19.73	0.03	21.45	20.00	1.45
10/8/96	18.44	18.13	0.31	0.00	0.00	0.00	18.42	18.41	0.01
10/21/96	0.00	0.00	0.00	0.00	0.00	0.00	17.62	17.58	0.04
11/4/96	18.48	17.98	0.50	0.00	0.00	0.00	18.19	18.15	0.04
11/18/96	19.46	19.45	0.01	20.76	20.13	0.63	0.00	0.00	0.00
12/2/96	20.35	19.91	0.44	20.72	20.27	0.45	19.97	19.96	0.01

Note: DTW = depth to water. DTP = depth to product.

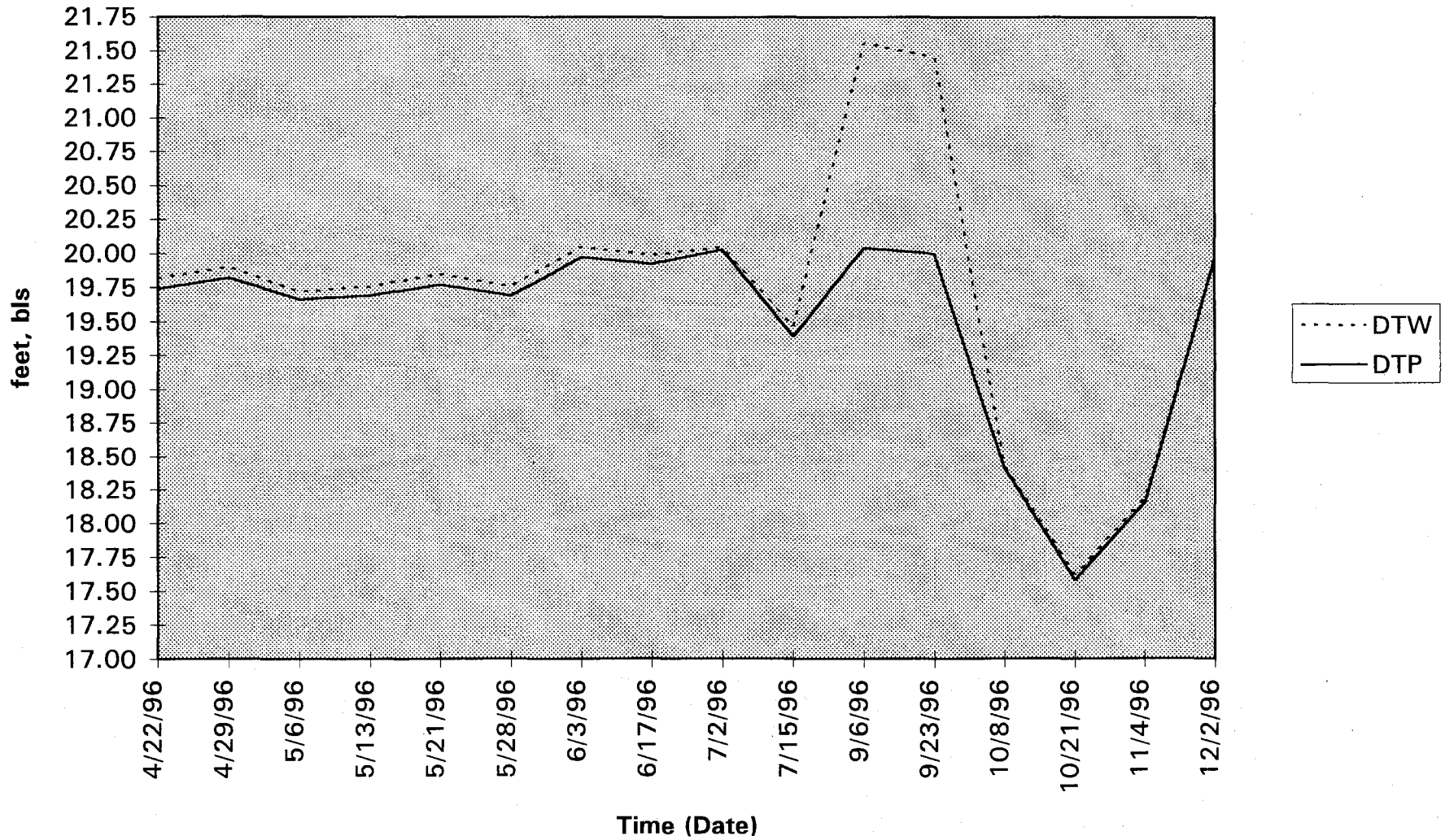
Thickness of Product - Well 15



Thickness of Product - Well 16



Thickness of Product - Well 17



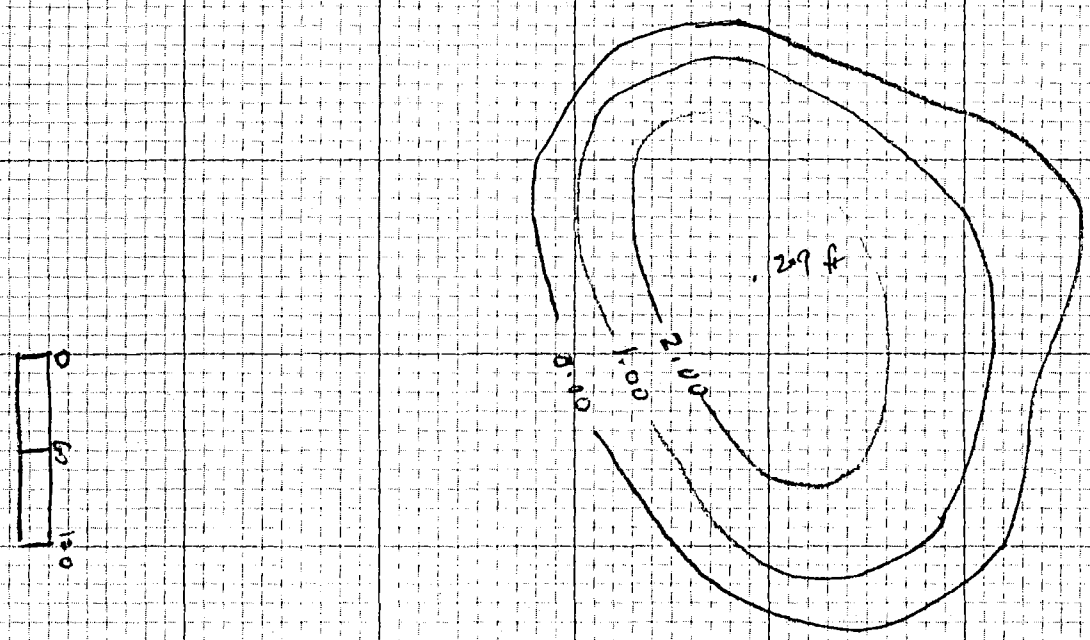
APPENDIX A

PROJECT	COMP. BY	JOB NO.
NFF SITE NAS Cecil Field.	KGK	8563-03
	CHK. BY TMK	DATE 1-26-97

FREE PRODUCT VOLUME ESTIMATE

AUGUST 14, 1995.

See Fig 4-1



Apparent thickness (ft)	Areal Extent (ft^2)	
0.00	6 X 120 X 120	= 86,400 ft^2
1.00	4 X 120 X 120	= 57,600 ft^2
2.00	1.5 X 120 X 120	= 21,600 ft^2

Cumulative Volume occupied.

$\left(\frac{1}{4}\right) \times \left(\frac{2.9+2}{2}\right) ft \times (21,600\ ft^2) = 13230\ ft^3 = 98,960$ gal.

$\left(\frac{1}{4}\right) \times \left(\frac{2+1}{2}\right) ft \times (57,600 - 21,600)\ ft^2 = 13,500\ ft^3 = 100,980$ gal.

$\left(\frac{1}{4}\right) \times \left(\frac{1+0}{2}\right) ft \times (86400 - 57,600)\ ft^2 = 3600\ ft^3 = 26,928$ gal.

Total Volume of Pore space $= 0.25\,(98960 + 100980 + 26928) = \underline{\underline{56,717}}$ gal

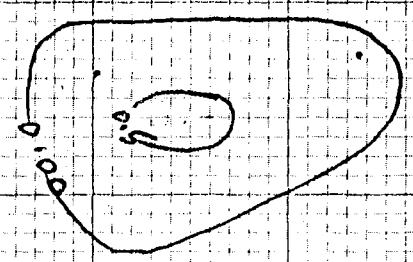
ABB Environmental Services, Inc.

APPENDIX A

PROJECT	COMP. BY	JOB NO.
NFF SITE NAS CECIL FIELD FREE PRODUCT VOLUME ESTIMATE	KGK	8563-03
	CHK. BY JMK	DATE 1-26-97

NOVEMBER 4, 1996

See Fig A-2



0 60 120 ft

Apparent Thickness (ft)	Areal Extent (ft^2)
0.00	1.7 X 120X120 = 10,080 ft²
0.50	0.1 X 120 X120 = 1440 ft².

Cumulative Volume Occupied

$\left(\frac{1}{4}\right)(0.5)(1440) = 180\ ft^3 = 1346.4$ gal

$\left(\frac{1}{4}\right)\left(\frac{0+0.5}{2}\right)(10080-1440) = 540\ ft^3 = 4039.2$ gal.

Net Volume occupied by product = 0.25 (1346.4 + 4039.2) gal

= 1346.4 gal

APPENDIX A-2

Soil - Organic Vapor Analyzer (OVA) Results

Table A-2
Organic Vapor Analyzer (OVA) Results, 1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
1	5.5	1991	>1,000	34	>1000
2	2.5	1991	60	0	60
3	2.5	1991	63	1	62
4	6.5	1991	0	NM	0
5	6.5	1991	0	NM	0
6	2.0	1991	100	3	97
7	1.5	1991	170	6	164
8	1.5	1991	100	4	96
9	3.0	1991	0	NM	0
10	2.5	1991	0	NM	0
11	2.0	1991	>1,000	12	>1000
12	2.5	1991	13	0	13
13	9.0	1991	1	NM	1
14	6.8	1991	4	NM	3
15	1.0	1991	100	0	100
16	5.5	1991	>1,000	5	>1,000
17	6.0	1991	0	NM	0
18	5.5	1991	1	NM	1
19	2.5	1991	40	0	40
20	0.6	1991	35	0	35
21	1.5	1991	>1,000	5	>1,000
22	1.0	1991	18	0	18
23	6.0	1991	0	NM	0
24	1.5	1991	47	3	44
25	4.0	1991	390	4	386
26	6.5	1991	0	NM	0
27	6.5	1991	0	NM	0
28	5.5	1991	>10	0	>10
29	5.5	1991	0	NM	0
30	6.0	1991	0	NM	0
31	6.6	1991	0	NM	0
32	6.0	1991	0	NM	0
33	6.0	1991	0	NM	0
34	6.0	1991	0	NM	0
35	6.0	1991	0	NM	0
36	6.0	1991	0	NM	0
37	6.0	1991	0	NM	0

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results,
1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
38	0-1	1993	0	NM	0
	2-3 (wet)	1993	0	NM	0
39	0-1	1993	0	NM	0
	1-2 (wet)	1993	0	NM	0
40	0-1	1993	0	NM	0
	1-2 (wet)	1993	0	NM	0
41	0-1 (wet)	1993	0	NM	0
	1.5 (wet)	1993	0	NM	0
42	0.5	1993	0	NM	0
	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3 (wet)	1993	0	NM	0
43	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3 (wet)	1993	0	NM	0
44	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3 (wet)	1993	0	NM	0
45	0 (surface)	1993	12	0	12
	0-1	1993	1	NM	1
	1-2	1993	0	NM	0
46	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
47	0-1	1993	1	NM	1
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
48	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
49	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
50	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results,
1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
51	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
52	0-1	1993	0	NM	0
	1-2	1993	160	0	160
	2-3	1993	3,300	18	3,282
53	0-1	1993	0	NM	0
	1-2	1993	2	NM	0
	2-3	1993	0	NM	0
54	0-1	1993	0	NM	0
	1-2	1993	300	0	300
	2-3	1993	75	0	75
55	0-1	1993	265	0	265
	1-2	1993	160	7	153
	2-3	1993	700	0	700
56	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
57	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
58	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
59	0-1	1993	0	NM	0
	1-2	1993	365	0	365
	2-3	1993	160	0	160
60	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
61	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4 (wet)	1993	0	NM	0

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results, 1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
62	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
63	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	260	0	260
	4-5 (wet)	1993	290	0	290
64	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	2	NM	2
	4-5 (wet)	1993	11	0	11
65	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
66	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	1,000	4	996
	3-4	1993	1,300	0	1,300
67	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
68	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
69	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
70	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results,
1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
71	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
72	0-1	1993	0	NM	0
	1-2	1993	25	1	24
	2-3	1993	2	NM	2
	3-4	1993	18	1	17
	4-5 (wet)	1993	100	0	100
73	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
	4-5	1993	0	NM	0
74	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
	4-5	1993	0	NM	0
75	0-1	1993	0	NM	0
	1-2	1993	260	0	260
	2-3	1993	1,900	0	1,900
	3-4 (wet)	1993	1,600	0	1,600
76	0-1	1993	3	NM	3
	1-2	1993	900	0	900
	2-3	1993	1,450	0	1,450
	3-4	1993	2,100	0	2,100
	4-5 (wet)	1993	1,500	0	1,500
77	0-1	1993	3	NM	3
	1-2 (wet)	1993	50	0	50
	2-3 (wet)	1993	2,000	0	2,000
78	0-1	1993	0	NM	0
	1-2 (wet)	1993	45	0	45
	2-3 (wet)	1993	2,700	0	2,700
79	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4 (wet)	1993	1,300	18	1,282

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results,
1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
80	0-1	1993	7	NM	7
	1-2	1993	350	0	350
	2-3 (wet)	1993	1,800	0	1,800
81	0-1	1993	0	NM	0
	1-2 (wet)	1993	30	0	30
82	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3 (wet)	1993	0	NM	0
83	0-1	1993	600	0	600
	1-2	1993	>5,000	0	>5,000
	2-3	1993	>5,000	0	>5,000
	3-4 (wet)	1993	>5,000	0	>5,000
84	0-1	1993	9	NM	9
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4 (wet)	1993	0	NM	0
85	0-1	1993	5	NM	5
	1-2	1993	19	0	19
	2-3 (wet)	1993	2	NM	2
86	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	1	NM	1
	3-4	1993	0	NM	0
87	0-1	1993	2	NM	2
	1-2	1993	11	0	11
	2-3	1993	2,400	0	2,400
	3-4	1993	4,700	0	4,700
	4-5 (wet)	1993	>5,000	0	>5,000
88	0-1	1993	1	NM	1
	1-2	1993	2	NM	2
	2-3	1993	2	NM	2
	3-4 (wet)	1993	1	NM	1
89	0-1	1993	5	NM	5
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results,
1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
90	0-1	1993	4	NM	4
	1-2	1993	10	0	10
	2-3	1993	1	NM	1
	3-4 (wet)	1993	2	NM	2
91	0-1	1993	4	NM	4
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4 (wet)	1993	0	NM	0
92	0-1	1993	1	NM	1
	1-2	1993	3	NM	3
	2-3	1993	0	NM	0
	3-4 (wet)	1993	0	NM	0
93	0-1	1993	0	NM	0
	1-2	1993	6	NM	6
	2-3	1993	0	NM	0
	3-4 (wet)	1993	>500	0	>500
94	0-1	1993	0	NM	0
	1-2	1993	1,400	0	1,400
	2-3	1993	1,700	0	1,700
	3-4 2 (wet)	1993	2,000	0	2,000
95	0-1	1993	0	NM	0
	1-2	1993	8	NM	8
	2-3 (wet)	1993	55	0	55
96	0-1	1993	265	0	265
	1-2	1993	1,200	0	1,200
	2-3	1993	1,500	0	1,500
	3-4 (wet)	1993	1,500	0	1,500
97	0-1	1993	2,000	0	2,000
	1-2	1993	2,400	0	2,400
	2-3	1993	3,800	0	3,800
	3-4 (wet)	1993	>5,000	0	>5,000
98	0-1	1993	1,400	0	1,400
	1-2	1993	4,000	0	4,000
	2-3	1993	>5,000	0	>5,000
	3-4 (wet)	1993	2,600	0	2,600

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results,
1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
99	0-1	1993	1,000	0	1,000
	1-2	1993	1,400	0	1,400
	2-3	1993	2,100	0	2,100
	3-4	1993	2,400	0	2,400
100	0-1	1993	220	0	220
	1-2	1993	1,400	0	1,400
	2-3	1993	3,200	0	3,200
	3-4 (wet)	1993	2,500	0	2,500
101	0-1	1993	1,000	0	1,000
	1-2	1993	1,200	0	1,200
	2-3	1993	1,400	0	1,400
	3-4	1993	2,200	0	2,200
102	0-1	1993	450	0	450
	1-2	1993	1,500	0	1,500
	2-3	1993	1,500	0	1,500
	3-4 (wet)	1993	2,000	0	2,000
103	0-1	1993	2	NM	2
	1-2	1993	0	NM	0
	2-3	1993	30	0	30
	3-4	1993	28	0	28
104	0-1	1993	1	NM	1
	1-2	1993	1	NM	1
	2-3	1993	2,400	0	2,400
105	3-4 (wet)	1993	4,900	0	4,900
106	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4 (wet)	1993	0	NM	0
107	0-1	1993	480	0	480
	1-2	1993	800	0	800
	2-3	1993	4,000	0	4,000
	3-4	1993	>5,000	0	>5,000
108	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results,
1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
109	0-1	1993	3	NM	3
	1-2	1993	0	NM	0
	2-3	1993	50	0	50
	3-4 (wet)	1993	20	0	20
110	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
111	0-1	1993	2	NM	2
	1-2	1993	1	NM	1
	2-3	1993	0	NM	0
	3-4 (wet)	1993	0	NM	0
112	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4 (wet)	1993	0	NM	0
113	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
114	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4 (wet)	1993	120	0	120
115	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
116	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
117	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results, 1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
118	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	21	0	21
119	0-1	1993	0	NM	0
	1-2	1993	270	0	270
120	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
121	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
122	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
123	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
124	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
125	0-1	1993	60	0	60
	1-2	1993	200	0	200
	2-3	1993	300	0	300
126	0-1	1993	0	NM	0
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4	1993	0	NM	0
127	0-1	1993	2	NM	2
	1-2	1993	0	NM	0
	2-3	1993	0	NM	0
	3-4 (wet)	1993	0	NM	0
128	0-1	1993	0	NM	0
	1-2	1993	90	0	90
	2-3	1993	20	0	20
	3-4 (wet)	1994	12	0	12
129	0-1	1994	0	NM	0
	1-1.5	1994	22	0	22
	1.5-2	1994	120	0	120
	2-2.5 (wet)	1994	230	0	230

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results,
1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
130	0-1	1994	0	NM	0
	1-1.5	1994	2	NM	2
	1.5-2	1994	12	0	12
	2-2.5 (wet)	1994	39	0	39
131	0-1	1994	0	NM	0
	1-2	1994	98	0	98
132	0-.5	1994	0	NM	0
	.5-1	1994	6	NM	6
	1.5-2	1994	29	0	29
	2-2.5	1994	5	NM	5
	2.5-3 (wet)	1994	36	0	36
133	0-.5	1994	22	0	22
	1-1.5	1994	0	NM	0
	1.5-2	1994	0	NM	0
	2.5-3 (wet)	1994	1	NM	1
134	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	1.5-2	1994	0	NM	0
	2.5-3 (wet)	1994	0	NM	0
135	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	1.5-2	1994	0	NM	0
	2-2.5	1994	0	NM	0
	3-3.5 (wet)	1994	0	NM	0
136	0-.5	1994	125	0	125
	1-1.5	1994	220	10	210
	2-2.5	1994	260	0	260
	3-3.5 (wet)	1994	180	0	180
137	0-1	1994	220	0	220
	1-2	1994	360	0	360
138	0-.5	1994	190	0	190
	1-1.5	1994	440	0	440
	1.5-2	1994	440	0	440
	2-2.5	1994	1,200	0	1,200
	2.5-3 (wet)	1994	1,300	0	1,300

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results, 1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
139	0-.5	1994	52	0	52
	1-1.5	1994	180	0	180
	1.5-2	1994	220	0	220
	2-2.5	1994	280	0	280
	2.5-3	1994	420	0	420
140	0-.5	1994	0	NM	0
	1-1.5	1994	4	NM	4
	1.5-2	1994	10	0	10
	2-2.5	1994	8	NM	8
	3-3.5	1994	38	0	38
141	0-.5	1994	150	0	150
	1-1.5	1994	1,300	0	1,300
	2.5-3	1994	1,500	0	1,500
142	0-.5	1994	11	0	11
	1-1.5	1994	900	0	900
	2-2.5	1994	1,500	0	1,500
	3-3.5	1994	1,400	0	1,400
143	0-.5	1994	90	0	90
	1-1.5	1994	330	0	330
	2-2.5	1994	390	3	387
	3-3.5	1994	1,300	0	1,300
144	0-.5	1994	280	0	280
	1-1.5	1994	1,100	0	1,100
	2-2.5	1994	1,700	0	1,700
	3-3.5	1994	1,500	0	1,500
145	0-.5	1994	1	NM	1
	1-1.5	1994	0	NM	0
	2-2.5	1994	80	0	80
	3-3.5	1994	300	0	300
146	0-.5	1994	80	0	80
	1-1.5	1994	1,700	0	1,700
	2-2.5	1994	4,600	0	4,600
	3-3.5	1994	>5,000	0	>5,000
147	0-.5	1994	>5,000	0	>5,000
	1-1.5	1994	>5,000	0	>5,000
	2-2.5	1994	>5,000	0	>5,000
	3-3.5 (wet)	1994	>5,000	0	>5,000

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results, 1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
148	0-.5	1994	1,300	0	1,300
	1-1.5	1994	1,400	0	1,400
	2-2.5	1994	2,000	0	2,000
	3-3.5	1994	1,500	- -	1,500
149	0-.5	1994	1,300	0	1,300
	1-1.5	1994	1,000	0	1,000
	2-2.5	1994	1,200	0	1,200
	3-3.5	1994	1,700	0	1,700
150	0-.5	1994	2,000	0	2,000
	1-1.5	1994	900	0	900
	2-2.5	1994	900	0	900
	3-3.5	1994	280	0	280
151	0-.5	1994	0	NM	0
	1-1.5	1994	2	NM	2
	2-2.5	1994	0	NM	0
152	0-.5	1994	0	NM	0
	1-1.5	1994	>5,000	0	>5,000
	2-2.5	1994	>5,000	0	>5,000
	3-3.5	1994	>5,000	0	>5,000
153	0-.5	1994	1	NM	1
	1-1.5	1994	1	NM	1
	2-2.5	1994	4	NM	4
154	0-.5	1994	2	NM	2
	1-1.5	1994	0	NM	0
	2-2.5	1994	0	NM	0
	3-3.5	1994	0	NM	0
155	0-.5	1994	5	NM	5
	1-1.5	1994	0	NM	0
	2-2.5	1994	2	NM	2
	3-3.5	1994	7	NM	7
156	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	2-2.5	1994	0	NM	0
	3-3.5	1994	0	NM	0
157	0-.5	1994	130	0	130
	1-1.5	1994	220	0	220
	2-2.5	1994	5	NM	5
	3-3.5 (wet)	1994	5	NM	5

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results, 1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
158	0-.5	1994	38	0	38
	1-1.5	1994	1	NM	1
	2-2.5	1994	1	NM	1
	3-3.5	1994	0	NM	0
159	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	2-2.5	1994	0	NM	0
160	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	2-2.5	1994	6	NM	6
161	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	2-2.5	1994	0	NM	0
162	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	2-2.5	1994	0	NM	0
163	0-.5	1994	50	0	50
	1-1.5	1994	0	NM	0
	2-2.5	1994	0	NM	0
164	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	2-2.5	1994	800	0	800
165	0-.5	1994	0	NM	0
	1-1.5	1994	340	0	340
	2-2.5	1994	1,200	0	1,200
166	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	2-2.5	1994	0	NM	0
167	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	2-2.5	1994	0	NM	0
168	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	2-2.5	1994	0	NM	0
169	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	2-2.5 (wet)	1994	0	NM	0

See notes at end of table.

Table A-2 (Continued)
Organic Vapor Analyzer (OVA) Results, 1991 to 1995

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Boring No.	Depth (feet)	Year Sampled	Unfiltered Concentration	OVA Filtered Concentration	OVA Actual Concentration
170	0-.5	1994	1	NM	1
	1-1.5	1994	0	NM	0
	2-2.5	1994	0	NM	0
171	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	2-2.5	1994	0	NM	0
172	0-.5	1994	0	NM	0
	1-1.5	1994	0	NM	0
	2-2.5	1994	0	NM	0
173	0-1 (wet)	1994	0	NM	0
	2-3	1994	0	NM	0
174	0-1	1994	0	NM	0
	1-2 (wet)	1994	80	0	80
175	0-1	1994	0	NM	0
	1-2 (wet)	1994	110	0	0
176	0-1	1994	>5,000	0	>5,000
	1-2 (wet)	1994	1,800	0	1,800
177	0-1	1994	3	NM	3
	1-2	1994	15	0	15
	2-3 (wet)	1994	0	NM	0
178	0-1	1994	0	NM	0
	1-2 (wet)	1994	0	NM	0
179	0-1	1994	13	0	13
	1-2 (wet)	1994	0	NM	0
180	0-1	1994	3	NM	3
	1-2 (wet)	1994	0	NM	0
181	0-1	1994	3	NM	3
	1-2 (wet)	1994	0	NM	0
182	0-1	1994	35	0	35
	1-2 (wet)	1994	0	NM	0
183	0-1	1994	9	NM	9
	1-2 (wet)	1994	0	NM	0
184	0-1	1994	0	NM	0
	1-2 (wet)	1994	0	NM	0

Notes: Concentrations are reported in parts per million.

NM = not measured.
> = greater than.

APPENDIX A-3

Groundwater Results Exceeding State of Florida Criteria

Table A-3
Groundwater Results Exceeding State of Florida Criteria

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Monitoring Well Designation	Contaminant	Contaminant Concentration[1]
076-01[3]	Benzene	110
	Total VOAs	1,090
	Total naphthalenes	1,260
	TRPH	6.5
076-04[3]	Benzene	1.2
	Total naphthalenes	158
	TRPH	9.2
076-05[2,3]	Benzene	4.1/1.2
	Total VOAs	150.1
	Total naphthalenes	157/202
076-13[2,3]	Benzene	1.4
	Total VOAs	928
076-18	Benzene	1.7
	Total VOAs	62.3
076-22[2,3]	Benzene	2.0/4.5
	TRPH	6.3
076-28D	Benzene	750/1,500
	Total VOAs	880/1,700
076-32[3]	Total VOAs	89
076-35[3]	TRPH	6.7
076-36[3]	Benzene	6.8
	Total VOAs	175.8
076-37[3]	Benzene	6.7
	Total VOAs	267.7
	TRPH	5.4
076-38[3]	Benzene	250
	Total VOAs	6,850
	TRPH	15.2
076-39D[2]	Benzene	7,400/13,000
	Total VOAs	12,900/21,720
	Total naphthalenes	155
076-40D	Benzene	6,800/7,300
	Total VOAs	12,600/14,710
	Total naphthalenes	195/161
076-41D[3]	Benzene	2.3
076-50I	Benzene	690
	Total VOAs	839
076-51D	Benzene	70
	Total VOAs	70
076-52I	Benzene	3,600
	Total VOAs	4,080
076-53I	Total VOAs	88

See notes at end of table.

Table A-3 (Continued)
Groundwater Results Exceeding State of Florida Criteria

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Monitoring Well Designation	Contaminant	Contaminant Concentration[1]
076-55I	Benzene	120
	Total VOAs	129
076-57S	Benzene	140
	Total VOAs	400
076-58I	Benzene	6
076-59D	Benzene	7.7
076-61I	Total VOAs	191
076-64I	Benzene	750
	Total VOAs	960
076-65D	Benzene	330
	Total VOAs	330
076-69S	Benzene	120
	Total VOAs	646
076-70I	Benzene	11,000
	Total VOAs	16,440
076-71D	Benzene	5.3
076-72S	Benzene	17
076-73I	Benzene	370
	Total VOAs	373.1
076-75S	Benzene	560
	Total VOAs	9050
	Total naphthalenes	212
076-76I	Benzene	2,000
	Total VOAs	2,182
076-80D	Benzene	13
JP5-12[3]	Benzene	1.8/19
	Total VOAs	56/354
	Total naphthalenes	244
JP5-14	Benzene	200/160
	Total VOAs	220/368
JP5-15[3]	Benzene	1.2
	Total VOAs	119/266
	Total naphthalenes	121 (1995)
	TRPH	5.1

See notes at end of table.

Table A-3 (Continued)
Groundwater Results Exceeding State of Florida Criteria

Remedial Action Plan
North Fuel Farm Site
Naval Air Station Cecil Field
Jacksonville, Florida

Monitoring Well Designation	Contaminant	Contaminant Concentration[1]
DPT-2 48'-50' bls	Benzene	4.1
DPT-3 23'-25' bls	Benzene	1.1

[1] All concentrations are reported in parts per billion (ppb), except TRPH, which is reported in parts per million (ppm).
[2] The contaminant concentration shown in this table is the higher of the two concentrations detected in a groundwater sample or its duplicate.
[3] 1994 groundwater sample result.

Notes: *Chapter 62-770, Florida Administrative Code No Further Action and Monitoring Only target levels: Benzene (50 ppb), total VOAs (50 ppb), total naphthalenes (100 ppb), TRPH (5 ppm).
157/202 = 1994/1995 groundwater sample results.
Total VOAs = The sum concentration of benzene, toluene, ethylbenzene, and xylenes.
Total naphthalenes = The sum concentration of naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene.
TRPH = Total recoverable petroleum hydrocarbons. Monitoring wells 076-01 and 076-04 were sampled below the free-product groundwater interface in 1994.
VOAs = volatile organic aromatics.

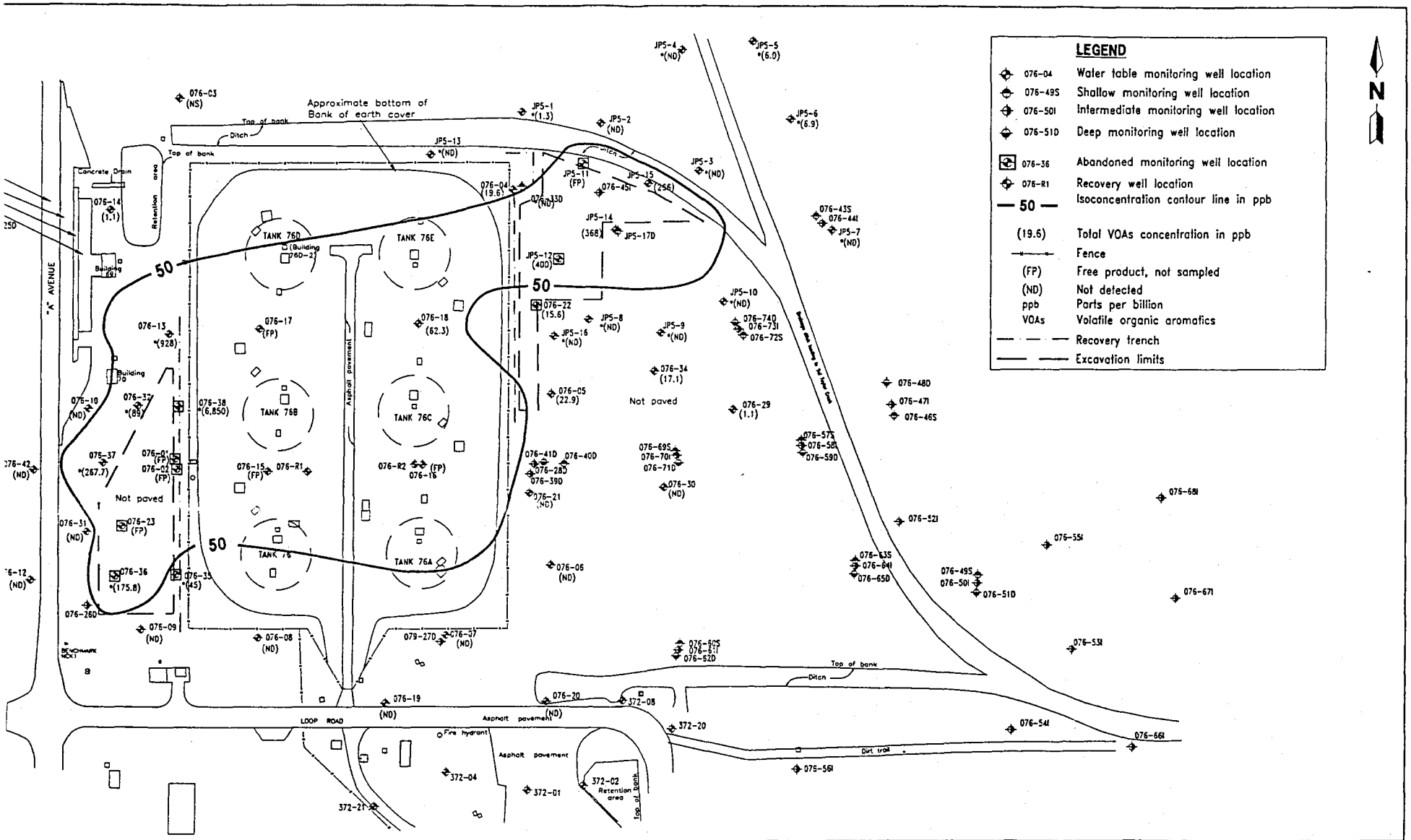


FIGURE ~~4-8~~ A-1
TOTAL VOAs ISOCONCENTRATION MAP
(WATER TABLE), FEBRUARY AND MARCH 1994
AND MAY TO AUGUST 1995

CONTAMINATION ASSESSMENT
REPORT ADDENDUM

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

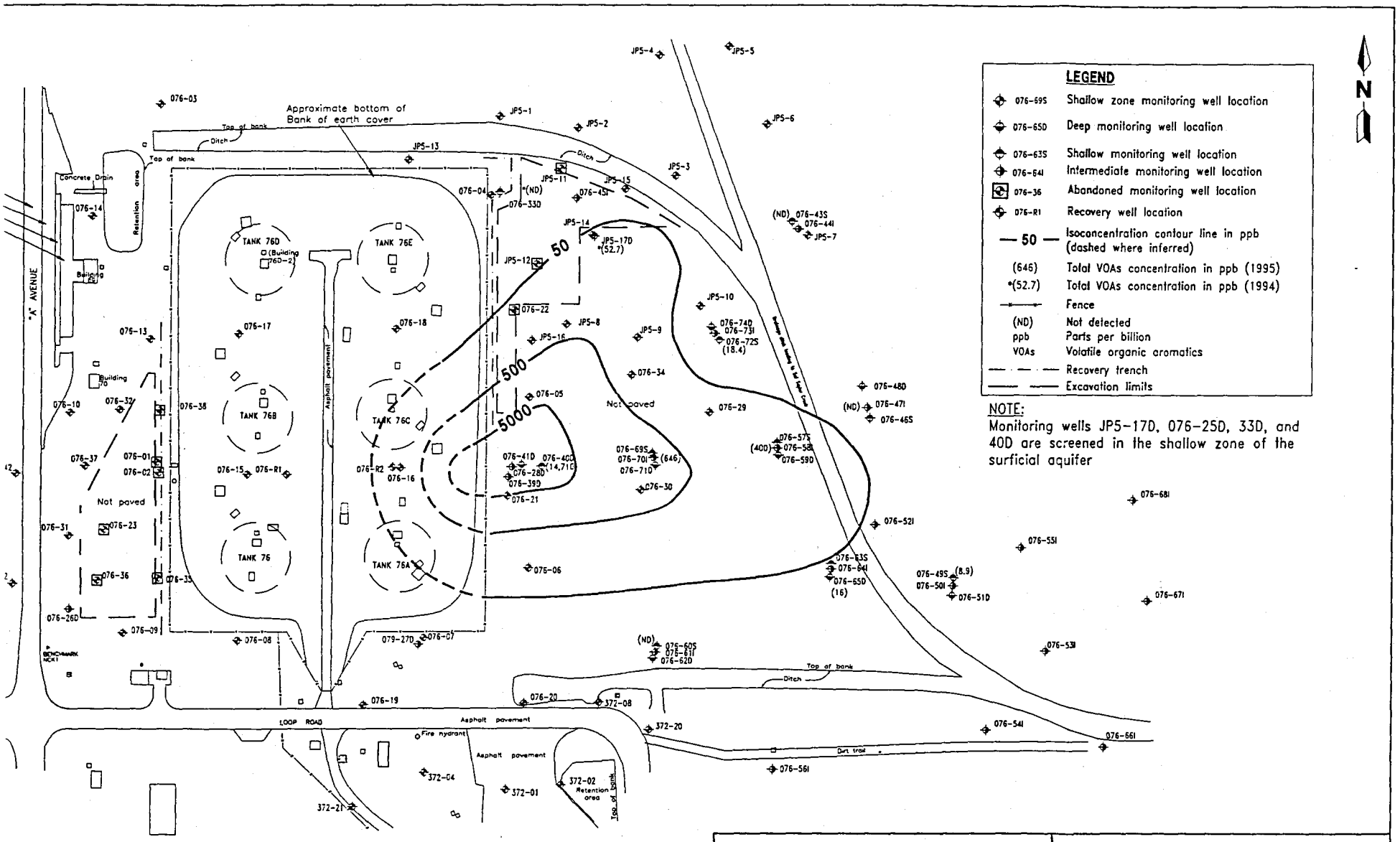


FIGURE ~~4-7~~ A-2
TOTAL VOAs ISOCONCENTRATION MAP (SHALLOW ZONE), FEBRUARY TO MAY 1994 AND MAY TO AUGUST 1995

CONTAMINATION ASSESSMENT REPORT ADDENDUM

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

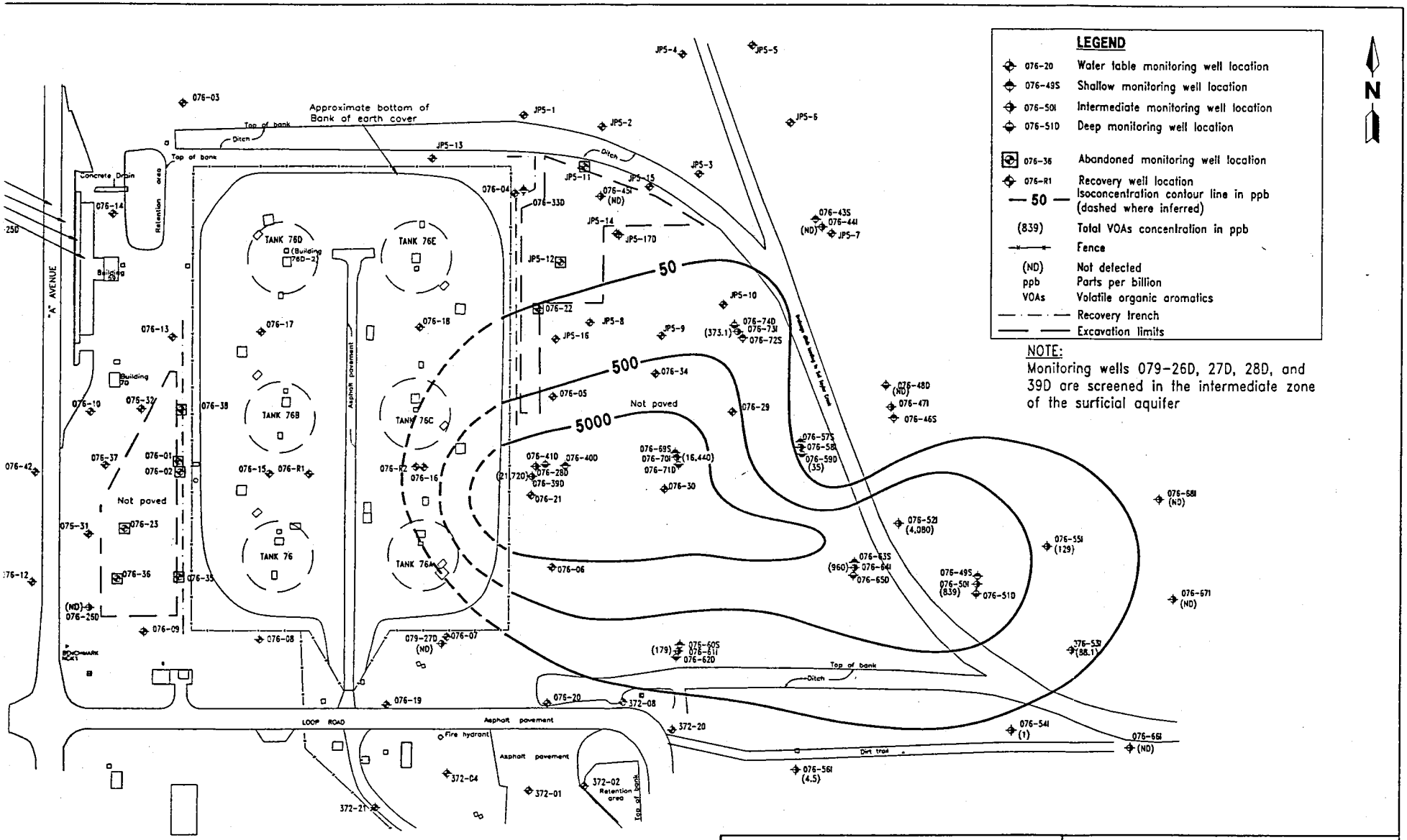


FIGURE ~~4-8~~ A-3
TOTAL VOAs ISOCONCENTRATION MAP (INTERMEDIATE ZONE) FEBRUARY TO MAY 1994 AND MAY TO AUGUST 1995

CONTAMINATION ASSESSMENT REPORT ADDENDUM

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

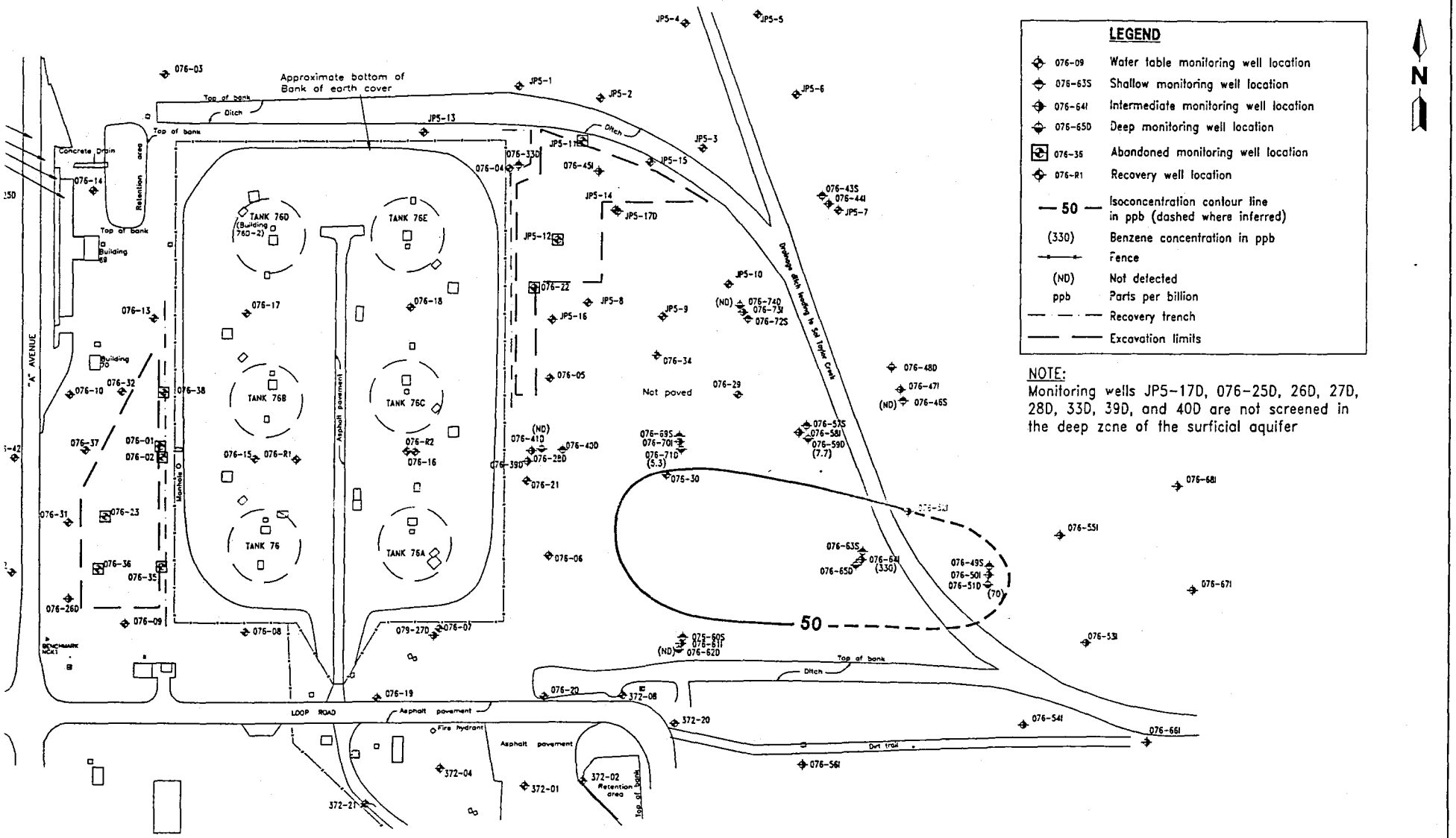


FIGURE ~~4-5~~ A-4
BENZENE ISOCONCENTRATION MAP (DEEP ZONE), FEBRUARY TO MAY 1994 AND MAY TO AUGUST, 1995

CONTAMINATION ASSESSMENT REPORT ADDENDUM

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

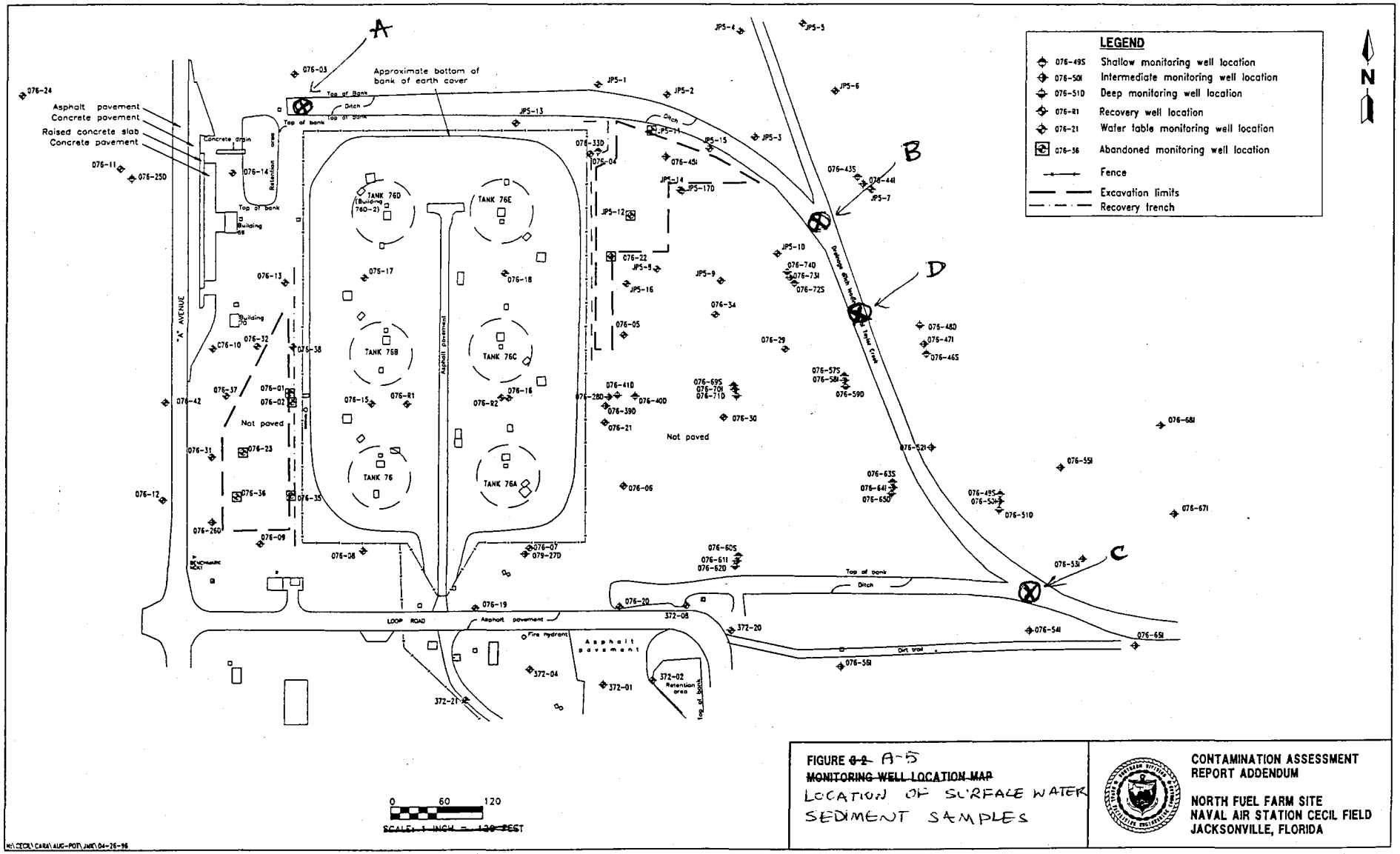


FIGURE ~~G-2~~ A-5
~~MONITORING WELL LOCATION MAP~~
LOCATION OF SURFACE WATER SEDIMENT SAMPLES

CONTAMINATION ASSESSMENT REPORT ADDENDUM

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

APPENDIX B

DETAILED ANALYSES OF TECHNOLOGIES

APPENDIX B-1
Free Product Recovery

Table B-1-1. Identification of Free Product Removal Technologies (continued)

Remedial Alternatives Evaluation
North Fuel Farm
NAS Cecil Field, Jacksonville, Florida

General Response Action	Recovery Technology	Description
Passive Recovery	Bailing	Efficiency of this technology depends on the natural gradient of free product near the extraction well and continued migration of recoverable product into the extraction well.
	Absorbent Socks	SAA
	Skimmer Pumps	SAA
	Interceptor Trenches	SAA
Active Recovery	Dual Phase vacuum enhanced Extraction	Vacuum enhanced extraction involves removal of free product, soil vapor and groundwater by applying a high vacuum (6 to 12 inches of Hg) to the recovery well. Application of high vacuum results in increase of hydraulic gradient of free product and accelerated accumulation near the recovery well.

Table B-1-2. Preliminary Screening of Free Product Removal Technologies

Remedial Alternatives Evaluation
North Fuel Farm
NAS Cecil Field, Jacksonville, Florida

General Response Action	Advantages	Disadvantages	Status	Comments
Passive Recovery . Bailing . Absorbent Socks	Does not involve installation of expensive systems.	Efficiency of this technology depends on the natural gradient of free product near the extraction well and continued migration of recoverable product into the extraction well. Removal process takes longer time frames. Can not remove all the recoverable volume of free product.	Retained	
Active Recovery . Bioslurping	Vacuum enhances the hydraulic gradient of the free product. Free product removal process takes relatively shorter time frames. Free product, groundwater, and soil vapors can be extracted simultaneously.	Requires installation of high vacuum pumps. Free product, soil vapor, and groundwater are mixed in the process of extraction.	Retained	

APPENDIX B-2

Soil Remediation

Table B-2-1. Identification of Soil Remedial Technologies

Remedial Alternatives Evaluation
North Fuel Farm
NAS Cecil Field, Jacksonville, Florida

General Response Action	Soil Technology	Description
Containment	Soil cover	A layer of native soil is placed over the site that is sufficiently thick to prevent direct contact and ingestion hazards associated with contaminated surface soil.
	Capping	Low-permeability cover (e.g., clay and soil, asphalt, or clay and synthetic membrane covered with soil) is constructed over the site to provide a barrier to water infiltration and prevent direct contact and ingestion hazards associated with contaminated soil.
	Cap and slurry wall	Emplacement of a low permeability barrier to restrict contaminant migration in the vadose zone.
Excavation and disposal	Offsite landfill	Soil is excavated, transported, and disposed in a permitted Subtitle D landfill as a special waste.
Ex-situ treatment	Onsite thermal desorption	Soil is excavated and treated by a onsite mobile low temperature thermal desorption unit that thermally destroys organics (volatile and semivolatile) in a direct fired unit.
	Offsite incineration	Soil is excavated and transported to a licensed incinerator that thermally destroys organics in a direct fired unit.
	Supercritical extraction	Extract organics using gases (e.g., carbon dioxide or propane) at a certain temperature and pressure (critical point) such that their solvent properties are greatly altered. These properties make extraction of organics more rapid and efficient than processes using distillation or conventional solvent extraction methods.
	Stabilization and solidification.	Soil is excavated and mixed with a setting agent (e.g., cement, fly ash, and lime) to form a product (either a cement-like or soil-like product) in which contaminants are entrapped by the solidified mass.
	Thermal soil aeration	Soil is excavated and treated by a mobile unit that volatilizes and desorbs organics from the soil through contact with a heated surface within a reaction vessel. Contaminants are transferred to the gaseous state.
	Soil washing	Soil is excavated and mixed with an aqueous based washing solution in a series of high-energy mobile washing units. Organics and metals can be separated from soil with this system. Washing solution is recycled.
	Composting	Soil is excavated and mixed with amendment (cow manure, straw, and vegetable wastes) to prepare for composting. The mixture is placed in windrows and composted for several weeks. Final compost is backfilled into the excavated area.

Table B-2-1. Identification of Soil Remedial Technologies (continued)

Remedial Alternatives Evaluation
North Fuel Farm
NAS Cecil Field, Jacksonville, Florida

General Response Action	Soil Technology	Description
In-situ treatment	Soil vapor extraction	A vacuum is applied to wells to extract vapor from voids in the subsurface soil. The vapor is collected and either treated or released to the atmosphere.
	Stabilization and solidification.	A setting agent is mixed in place with contaminated soil to form a monolithic product in which contaminants are entrapped by the solidified mass.
	Soil flushing	Aqueous-based washing solution is applied at the ground surface. Contaminants are removed through extraction wells after reaching the water table.
	Bioventing	Air, nutrients, and moisture (as needed) are injected into a contaminated soil zone to enhance the indigenous microbe environment and increase the biodegradation rate of organics.

Table B-2-2. Preliminary Soil Remedial Technology Review

Remedial Alternatives Evaluation
North Fuel Farm
NAS Cecil Field, Jacksonville, Florida

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Soil cover	• Reduces exposure potential for human receptors. • Easily implemented. • Not subject to RCRA land disposal restrictions.	• Would not reduce toxicity or volume of contaminants. • Would not reduce mobility of contaminants resulting from infiltration of precipitation. • Uncertain design life. • Long-term monitoring and maintenance would be required. • Long-term liability associated with waste.	Eliminated	Site area will remain active during site remedial activity. A large land area would require coverage.
Capping	• Reduces exposure potential for human receptors. • Not subject to RCRA land disposal restrictions. • Commonly used method for remediation.	• Would not reduce toxicity or volume of contaminants. • Uncertain design life. • Long-term monitoring and maintenance would be required. • Long-term liability associated with waste.	Eliminated	Groundwater contamination is already present at the site and the site has remained uncovered for years since the initial release.
Slurry wall	• Reduces migration of contaminated groundwater. • Reduces lateral migration of infiltration precipitation in the vadose zone. • Technology has been demonstrated for controlling ground-water at dam projects. • Slurry walls can be constructed up to a 200-foot depth.	• Would not reduce toxicity or volume of contaminants. • Long-term integrity of a slurry wall in the presence of common groundwater con-taminants is not proven. • Compatibility tests with slurry wall material and contaminants are necessary.	Eliminated	Retardation of site contaminants is occurring naturally due to the hydrogeology.

See notes at end of table.

Table B-2-2. Preliminary Screening of Soil Remedial Technologies

Remedial Alternatives Evaluation
North Fuel Farm
NAS Cecil Field, Jacksonville, Florida

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Offsite landfill	• Widely used and easily implemented technology. • No wastes or treatment residuals remaining onsite. • Contaminants may be relocated to a more stable, contained, lower exposure potential environment. • Relatively little mobilization effort and cost. • Experienced excavation contractors available.	• Subsurface utilities make excavation difficult. • Would not reduce toxicity or volume of contaminants. • RCRA land disposal restrictions may limit wastes eligible for disposal. • Limited landfill capacity nationwide. • Transportation and landfilling costs may be expensive. • Long-term liability associated with landfilled waste.	Eliminated	
Onsite incin-eration	• Destruction and removal efficiencies are greater than 99.99 percent, thus reducing volume of contaminants. • Technology is reliable and has been demonstrated for treating organics at full scale. • Widely used for treatment of organics wastes. • Mobile units are available.	• Subsurface utilities make excavation difficult. • Treatment of volatile metals (e.g., lead) collected by air pollution control equipment potentially required. • Treatment of inorganics remaining in soil potentially required.	Eliminated	Excavation would occur while tanks are in operation and there is contaminated soil beneath buildings.
Offsite incin-eration/Low Temperature Thermal Desorption	• Destruction and removal efficiencies are greater than 99.99 percent, thus reducing volume of contaminants. • Technology is reliable and has been demonstrated for treating organics at full scale. • Widely used for treatment of organics wastes. • Experienced vendors are available.	• Subsurface utilities make excavation difficult. • Treatment of inorganics remaining in soil potentially required. • Limited capacity at RCRA-permitted incinerators. • High costs associated with transportation and incineration of wastes.	Retained	Excavation is applicable only in areas out-side the mound.

Table B-2-2. Preliminary Screening of Soil Remedial Technologies

Remedial Alternatives Evaluation
North Fuel Farm
NAS Cecil Field, Jacksonville, Florida

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Supercritical extraction	• Capable of treating soil contaminated with organic contaminants. • Contaminants are transferred to a manageable gaseous waste stream.	• Would not reduce mobility, toxicity, or volume of contaminants. • Concentrated contaminant waste stream requires further treatment. • Limited operating experience with site-specific contaminated soil. • Treatability studies required to determine potential for treating site soil.	Eliminated	Not a proven technology for site contaminants. Would not offer any advantage over other proven technologies.

See notes at end of table.

Table B-2-2. Preliminary Screening of Soil Remedial Technologies

Remedial Alternatives Evaluation
North Fuel Farm
NAS Cecil Field, Jacksonville, Florida

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Stabilization and solidification	• Reduces mobility of metals. • Technology is reliable and has been demonstrated at full scale for treating inorganics. • Technology is relatively simple and easily implemented. • Experienced vendors are available.	• Would not reduce toxicity or volume of contaminants. • Volume of contaminated media increased by 20 to 30 percent. • Long-term performance for treating organic wastes not demonstrated. • Pre-treatment of organics potentially required.	Eliminated	Excavation of soil is not desired as the tank area is to remain operational during remedial actions.
Thermal soil aeration	• Technology has been demonstrated full scale for treating organics. • May not require an incinerator permit to operate. • Mobile units are available.	• Would not reduce toxicity, mobility, and volume of contaminants.	Eliminated	Majority of contaminated soil is within the tank area which will be operational during remedial actions.
Soil washing	• Demonstrated at full scale for removal of metals from soil. • Wide application to varied waste groups. • Mobile units are available.	• Difficulty in treating complex waste mixtures. • Potentially hazardous chemicals may be brought onsite to be used in process. • Potential difficulty in removing washing solution from treated soil. • Limited effectiveness for treating soil with high humic content and high fine-grained clay fraction.	Eliminated	Preferred for metals contamination not volatiles.

Table B-2-2. Preliminary Screening of Soil Remedial Technologies

Remedial Alternatives Evaluation
North Fuel Farm
NAS Cecil Field, Jacksonville, Florida

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Composting/ Tilling	• Widely used technology for organic wastes and does not require specialized operating personnel. • Minimal operating cost. • No secondary waste stream generated. • Operating equipment readily available. • Treated soil can be used for backfilling. • Very cost-effective method of treatment.	• Subsurface utilities make excavation difficult. • Treatability studies may be necessary for site-specific wastes.	Retained.	Will be applicable to areas out-side the mound.

Table B-2-2. Preliminary Screening of Soil Remedial Technologies

Remedial Alternatives Evaluation
North Fuel Farm
NAS Cecil Field, Jacksonville, Florida

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Soil vapor extraction	• Reduces mobility, toxicity, and volume of contaminants if vapors are collected and treated. • Effective for extraction of VOCs from unsaturated zone. • Demonstrated capability for extracting up to 2,000 pounds of VOCs per day. • Not subject to RCRA land disposal restrictions. • Extraction equipment is off-the-shelf and experienced vendors are readily available.	• Dispersion of vapors could result in localized concentrations of contaminants near well heads. • Contaminants with low vapor pressure cannot be effectively removed. • Extensive soil, air, and groundwater monitoring required, including soil borings. • Treatment of metals remaining in soil potentially required. • Not effective for treating soil with a high moisture content.	Retained	Capable of treating organic compounds. May be used with air sparging or bioventing.
In-situ stabilization and solidification	• Technology has been demonstrated at pilot scale for metals. • Reduces mobility of metals. • Not subject to RCRA land disposal restrictions.	• High concentrations of organics may interfere with the setting agent. • Reagent and waste ratios are difficult to control. • Volume of contaminated media increased. • Not demonstrated at full scale. • Verification of treatment can be difficult.	Eliminated	Not effective for subsurface soil.
Soil flushing	• Can be used in conjunction with groundwater treatment. • Effective for removal of organics from permeable soil. • Not subject to RCRA land disposal restrictions. • Full-scale units are available.	• Difficulty in treating complex waste mixtures. • Potential for uncontrolled migration of contaminants to groundwater. • Limited effectiveness for treating soil with high humic content and high fine-grained clay fraction.	Eliminated	The number of pore volumes necessary would be exessive, and some contaminated soil is in the vadose zone.

Table B-2-2. Preliminary Screening of Soil Remedial Technologies

Remedial Alternatives Evaluation
North Fuel Farm
NAS Cecil Field, Jacksonville, Florida

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Bioventing	• Demonstrated at pilot-scale for treating hydrocarbons in soil. • Reduces toxicity and volume of organics. • No secondary waste streams. • Not subject to RCRA land disposal restrictions.	• Significant time and expense for laboratory degradation studies and field demonstrations. • Injected air may mobilize VOCs in the vadose zone. • Strict operating controls are required to maintain optimal biodegradation environment.	Retained	Capable of treating organics. May be used with soil vapor extraction.

Notes: Shading indicates technology was eliminated.
RCRA = Resource Conservation and Recovery Act.
VOCs = volatile organic compounds.
SVOCs = semivolatile organic compounds.

APPENDIX B-3

Groundwater Remediation

Table B-3-1. Identification of Groundwater Remedial Technologies

Remedial Alternatives Evaluation
North Fuel Farm site
NAS Cecil Field, Jacksonville, Florida

General Response Action	Groundwater Technology	Description
No Action	No Action	No Action
Natural Attenuation	Groundwater monitoring	Perform water quality analyses to monitor contaminant migration and assess future environmental impacts.
Institutional Controls	Deed restrictions, educational programs, and groundwater monitoring.	Restrictions on use of contaminated groundwater. Educate public concerning site hazards.
Containment	Slurry wall	Emplacement of a low-permeability barrier to restrict groundwater migration. Should include a cover system to reduce infiltration.
Collection	Groundwater extraction wells.	Installation of several strategically located pumping wells to collect contaminated groundwater for treatment.
Ex-situ treatment	Oil Water Separation	Non dissolved product is separated from recovered groundwater and stored for recycling. Groundwater treatment is finalized at the federally owned treatment works (FOTW).
In-situ treatment	Biological	Introduce nutrients and oxygen or methane into the groundwater using a matrix of extraction wells and recirculation techniques.
	Air Sparging	Air is injected into the saturated zone. As air bubbles travel upward, contaminants are volatilized from soil or groundwater and carried to the vadose zone where they are recovered via vacuum extraction.
	Biosparging	Air is injected into the saturated zone and indigenous microorganisms biodegrade petroleum constituents and other contaminants in the saturated zone. When volatile organic compounds are present, biosparging is often combined with SVE or bioventing.
	Bioslurping	Combines SVE, Bioventing, for soil remediation, VEE for free product removal and limited groundwater extraction from the contaminated area.
	Recirculation Wells	This remediation system involves mobilization and transportation of VOCs via groundwater circulation to a recirculation well and volatilization with in-situ stripping. Simultaneously, in-situ aerobic bioremediation is enhanced due to the continuous enrichment of the groundwater within the circulation cell with dissolved oxygen. Inorganic nutrients (nitrogen and phosphorous) may be added as necessary to optimize biodegradation efficiency.
Disposal	Wastewater treatment facility.	Disposal of extracted groundwater to the base treatment facility. Groundwater would require transport by means of a force main and/or gravity sewer or by truck to the facility.
	Groundwater Reinjection	Treated groundwater is reinjected for further treatment
	Discharge to Surface Water	Treated water is discharged to surface water.

Table B-3-2. Preliminary Screening of Groundwater Remedial Technologies

Remedial Alternatives Evaluation
North Fuel Farm Site
NAS Cecil Field, Jacksonville, Florida

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Natural Attenuation	• Disturbance to existing site operations is minimal. • The technology can be used in locations that cannot be excavated or where groundwater pumping rates would not be sufficient for reasonable cleanup times.	• The technology is not suitable at sites where free product is impacting groundwater. • Natural attenuation may not be suitable if receptors could be affected by migration of contaminants. • Treatment times are longer than for active remedial measures.	Retained	Extended cleanup times are acceptable for the sites at NAS Cecil Field.
Groundwater monitoring	• Monitors short- and long-term effectiveness of remedial technologies when used during and after remediation.	• Would not reduce mobility, toxicity, or volume of contaminants when used alone.	Retained	Required component of any groundwater remediation.
Slurry wall	• May reduce the mobility of contaminants present in groundwater. • Current construction methods are capable of going to a depth of 200 feet below ground surface.	• Containment would not reduce the toxicity or volume of contaminants in groundwater. • Would not reduce mobility of contaminants without capping the site. • Contaminants may well degrade slurry wall material.	Eliminated	Contaminant migration is sufficiently retarded naturally.
Groundwater extraction wells	• Some existing wells and sumps from interim measures may be used.	• Wells must be strategically located so that cones of depression intersect and capture all contaminated groundwater.	Retained	Groundwater extraction wells required for pump and treat or groundwater depression.

See notes at end of table.

Table B-3-2. Preliminary Screening of Groundwater Remedial Technologies

Remedial Alternatives Evaluation
North Fuel Farm Site
NAS Cecil Field, Jacksonville, Florida

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Air sparging	• Injected air may volatilize contaminants from the saturated zone to the vadose zone. • Effective for VOCs when used in conjunction with soil vapor extraction. • Groundwater is treated in-situ with no need for groundwater treatment or disposal.	• Soil vapor extraction system may be required to recover vapors. • Treatability studies may be required to determine proper dispersion rates. • Extensive soil, air, structural stability and groundwater monitoring are required. • High groundwater table may and mounding make vapor extraction and application difficult. • Perimeter containment may be necessary to avoid contaminant migration outside the plume area. • Groundwater depression may be necessary if excessive mounding is experienced. • Depth of airsparge wells is typically limited to 30-40 feet bls.	Retained	Has proven itself to be effective in treating volatile organics when combined with soil vapor extraction.
Bioslurping	• Extraction of groundwater, free product and soil vapor sumulteneously under high vacuum and air flow rates. Results in biological degradation of contaminants in-situ.	• Phase separation and treatment for each of the phases is required. • Free product recovery is enhanced by simultenous extraction.	Retained	Pilot tests are currently being implemented.

Table B-3-2. Preliminary Screening of Groundwater Remedial Technologies

Remedial Alternatives Evaluation
North Fuel Farm Site
NAS Cecil Field, Jacksonville, Florida

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Biosparging	• Injected air stimulates biological degradation of contaminants in-situ.	• Soil vapor extraction system may be required to recover vapors. • Treatability studies may be required to determine proper dispersion rates. • Extensive soil, air, structural stability and groundwater monitoring required. • High groundwater table may and mounding make vapor extraction and application difficult. • Perimeter containment may be necessary to avoid contaminant migration outside the plume area. • Groundwater depression may be necessary if excessive mounding is experienced.	Retained	Low air flow rates may caused less structural instability in the subsurface soils than flow rates associated with air sparging
Recirculation Wells	• Treatment would reduce volume, toxicity , and mobility of chemicals present in groundwater. • Contaminants are degraded to non-toxic compounds. • No air emissions or secondary waste streams are produced. • In-situ in-well stripping may be imoplemented in addition to the biodegradtion.	• Significant time and expense for laboratory degradation studies and field demonstrations. • Parameters (e.g., temperature, pH, nutrients, and oxygen) for optimal microorganism growth can be difficult to maintain. • Uniform distribution of nutrients and oxygen may be difficult to obtain.	Retained	To achieve uniform distribution, a recirculation of groundwater would be necessary. Other problems may be encountered in the development of a distribution system.
In-situ biological	• Treatment would reduce volume, toxicity , and mobility of chemicals present in groundwater. • Contaminants are degraded to non-toxic compounds. • No air emissions or secondary waste streams are produced.	• Significant time and expense for laboratory degradation studies and field demonstrations. • Parameters (e.g., temperature, pH, nutrients, and oxygen) for optimal microorganism growth can be difficult to maintain. • Uniform distribution of nutrients and oxygen may be difficult to obtain.	Retained	To achieve uniform distribution, a recirculation of groundwater would be necessary. Other problems may be encountered in the development of a distribution system.

Table B-3-2. Preliminary Screening of Groundwater Remedial Technologies

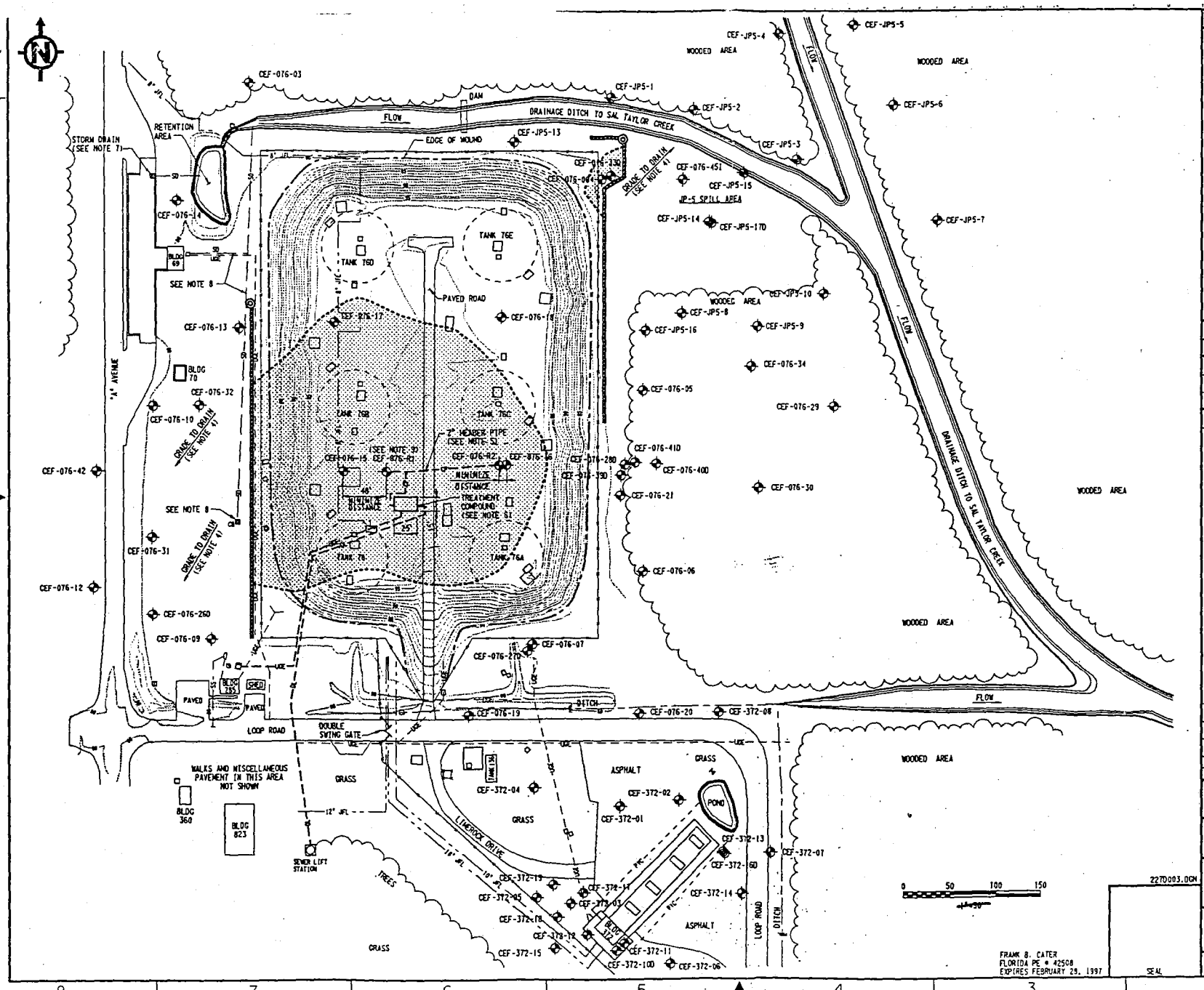
Remedial Alternatives Evaluation
North Fuel Farm Site
NAS Cecil Field, Jacksonville, Florida

Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Wastewater treatment facility disposal	• May only require the use of an oil-water separator prior to wastewater treatment.	• Treatability studies would be required to determine effect on treatment. • Approval required by operating agency.	Retained	Operating agency (FOTW) has approved direct discharge.
Groundwater reinjection disposal	• Treated groundwater is reinjected for further treatment. • Accelerates groundwater cleanup.	• Infiltration of treated groundwater could affect the migration of contaminants. • Reinjection of water into the plume's path may have an adverse effect on the collection system. • Requires permitting.	Eliminated	Reinjection may be complicated by low soil permeability. Direct discharge to the sanitary sewer is acceptable.
Discharge to surface water	• Existing NPDES permit for the FOTW.	• Effluent must meet discharge permit requirements.	Eliminated	Not practical, pumping would be required and direct discharge to sanitary sewer is acceptable.

Notes: Shading indicates technology was eliminated.
VOCs = volatile organic compounds.
RCRA = Resource Conservation and Recovery Act.
IM = Interim Measure.
FOTW = Federally Owned Treatment Works.
ppm = parts per million.
NPDES = National Pollution Discharge Elimination System.

APPENDIX C

SUMMARY OF IRA RESULTS



FRANK B. CATER
FLORIDA PE # 42508
EXPIRES FEBRUARY 28, 1997

SEAL

2270003.DGN

NOTES

1. BACKFILL SHALL BE PERFORMED IN ACCORDANCE TECHNICAL SPECIFICATION 22567-001-SP000-006, UNLESS NOTED OTHE
2. SITE INFORMATION WAS PROVIDED TO BECHTEL BY THE NAVY.
3. BACKFILL SHALL BE COMPACTED TO 85% MAXIMUM DENSITY U OTHERWISE DIRECTED BY THE NAVY.
4. MATCH EXISTING GRADE IN BACKFILLED AREA. SLOPE TO DR INDICATED.
5. TREATMENT SYSTEM PIPING WILL BE PLACED 18" BELOW GRAD ABOVE GROUND PIPING IS APPROVED BY NAS CECIL FIELD PE
6. FINAL TREATMENT COMPOUND LOCATION IS TO BE COORDINATE FIELD (SEE DRAWING 227-00000-005 FOR COMPOUND LAYOUT) PROVIDE 6" 3000psi 6x6 6/6 WWF REINFORCED PAD WITH THI EDGE FOOTER.
7. AT COMPLETION OF DECONTAMINATION ACTIVITIES, RESTORE DRAIN.
8. PROVIDE NEW CATCH BASIN AND STORM DRAIN TO MATCH EXIST BASIN AND DRAIN REMOVED DURING EXCAVATION, IF DIRECTE THE NAVY.
9. NEW RECOVERY WELL LOCATIONS ARE DEPENDENT UPON FIELD CONDITIONS. LOCATE NEW WELLS AS CLOSE TO EXISTING WEL AND 16 AS POSSIBLE.
10. PROVIDE 480v/60Hz/3 PHASE POWER TO COMPOUND AREA. POW UP, CABLES, AND TRENCHING WILL BE IN ACCORDANCE WITH L CODES AND PROVIDED BY A LICENSED ELECTRICIAN.

TECHNICAL SPECIFICATIONS

UNCONTAMINATED EARTHWORK	22567-001-S

REFERENCE DRAWINGS

DEMOLITION PLAN	227-00000-0
EXCAVATION PLAN	227-00000-0

LEGEND

- EXISTING MONITORING WELL
- NEW RECOVERY WELL
- NEW 3'-0" DIAMETER SUMP
- NEW RECOVERY TRENCH
- APPROXIMATE AREA OF FREE PRODUCT PLU
- EXISTING FENCE
- SD — EXISTING STORM DRAIN (4")
- SS — EXISTING SANITARY SEWER (4")
- JFL — EXISTING JET FUEL LINE
- UGE — EXISTING UNDERGROUND ELECTRIC
- UGE — NEW UNDERGROUND ELECTRIC
- CP — NEW TREATMENT SYSTEM CONVEYANCE PIPE
- DL — NEW TREATMENT SYSTEM DISCHARGE LINE
- CB — EXISTING CATCH BASIN
- JP-5 STORAGE TANK (UNDERGROUND)
- ABOVE GROUND ELECTRIC TRANSFORMER

NO.	DATE	REVISIONS	BY	CHK'D	REVIEW	CHK'D
1	11/2/95	REVISED SCOPE PER NAVY DIRECTION	JCD	RDH	JRM	FBC
0	7/31/95	ISSUED FOR CONSTRUCTION	DLL	RTJ	FBC	FBC

SCALE 1"=50'

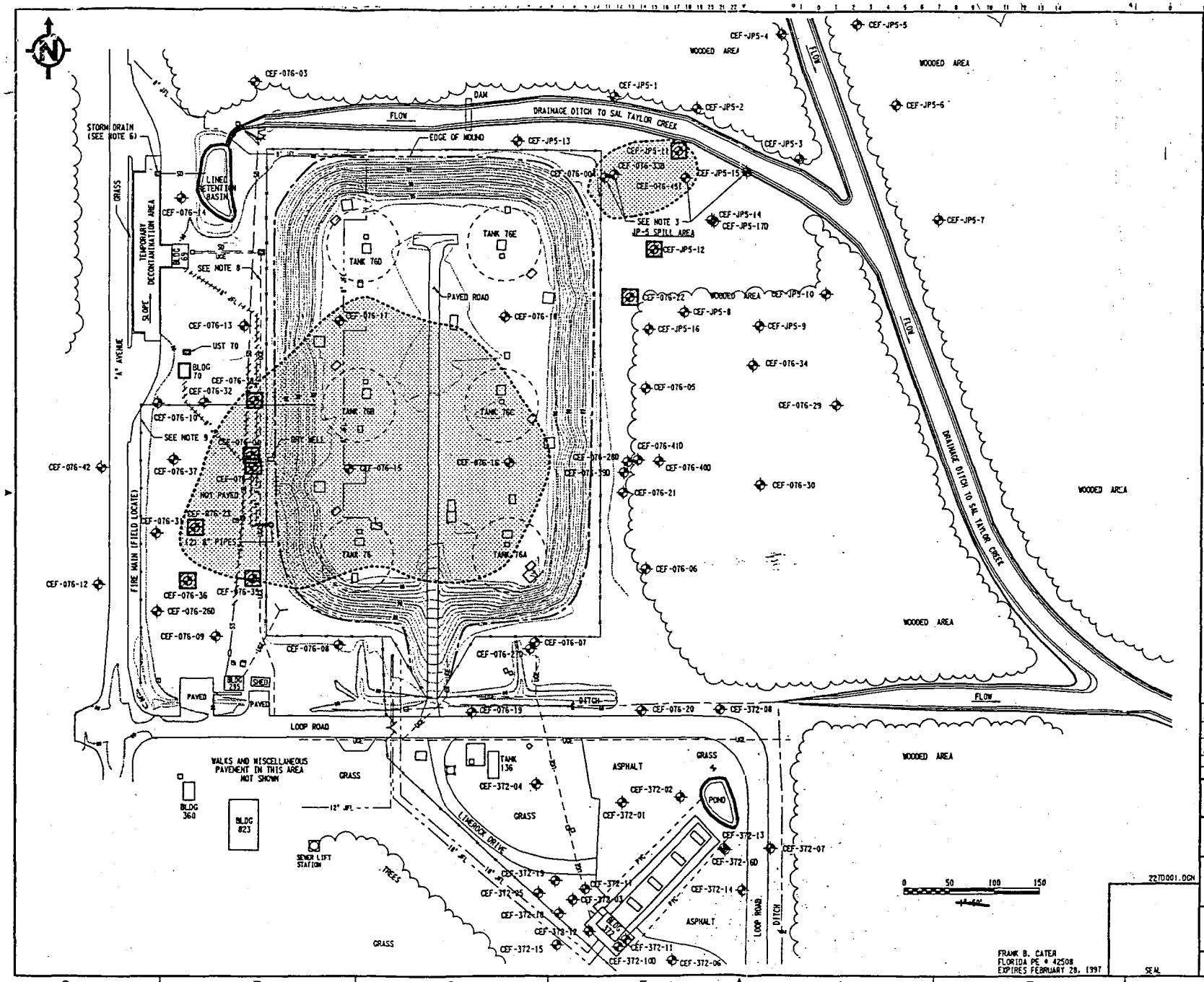
BECHTEL ENVIRONMENTAL I
OAK RIDGE, TENNESSEE

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING CO
CHARLESTON, SOUTH CAROLINA

NAS CECIL FIELD
NORTH FUEL FARM - SITE RESTORATION PL
AND BIO SLURPING REMEDIATION LAYOUT

JOB NO.	DRAWING NO.
22567	227-00000-003

C-1



NOTES

1. DEMOLITION SHALL BE PERFORMED IN ACCORDANCE WITH TECHNICAL SPECIFICATION 22567-001-SP000-017, AND TECHNICAL SPECIFICATION 22567-001-SP000-005, UNLESS NOTED OTHERWISE.
2. MONITORING WELL ABANDONMENT SHALL BE PERFORMED IN ACCORDANCE WITH TECHNICAL SPECIFICATION 22567-001-SP000-022, UNLESS NOTED OTHERWISE. (SEE WORK PLAN)
3. MONITORING WELLS THAT ARE INDICATED TO REMAIN, BUT FALL WITHIN LIMITS OF EXCAVATION WILL BE PROTECTED FROM DAMAGE. DO NOT EXCAVATE WITHIN 5 FEET IN ANY DIRECTION OF NOTED MONITORING WELLS.
4. SITE INFORMATION WAS PROVIDED TO BECHTEL BY THE NAVY.
5. SEE "INTERIM REMEDIATION WORK PLAN, SOIL AND FREE PRODUCT REMOVAL, NORTH FUEL FARM, NAS CECIL FIELD, JACKSONVILLE, FL FOR ADDITIONAL INFORMATION. SEE ALSO MEETING MINUTES AND SCOPE REVISION DOCUMENT BASED ON AUGUST MEETING.
6. IF EXISTING TRUCK STAND AREA IS USED AS DECONTAMINATION PAD STORM DRAIN WILL BE RENDERED INOPERABLE DURING DECONTAMINATION ACTIVITIES.
7. COORDINATE ALL DEMOLITION WITH THE NAVY IN THE FIELD.
8. COORDINATE REMOVAL/REROUTE OF UGE WITH THE NAVY IF REQUIRED FOR THIS LINE.
9. COORDINATE ANY RE-ROUTE OR SERVICE INTERRUPTION WITH RDICC AND FIRE DEPARTMENT.

TECHNICAL SPECIFICATIONS

DEMOLITION OF STRUCTURES	22567-001-SP000-
EXCAVATION OF CONTAMINATED SOIL AND MISCELLANEOUS DEMOLITION	22567-001-SP000-
MONITORING WELL INSTALLATION AND ABANDONMENT	22567-001-SP000-

REFERENCE DRAWINGS

EXCAVATION PLAN	227-00000-002

LEGEND

- MONITORING WELL TO BE ABANDONED
- EXISTING MONITORING WELL
- STRUCTURE TO BE DEMOLISHED
- APPROXIMATE AREA OF FREE PRODUCT PLUME
- EXISTING FENCE
- EXISTING STORM DRAIN (4")
- EXISTING STORM DRAIN (4") TO BE REMOVED
- EXISTING SANITARY SEWER (4") TO BE REMOVED
- EXISTING UNDERGROUND ELECTRIC
- EXISTING UNDERGROUND FIRE MAIN (WATER)
- EXISTING JET FUEL LINE
- EXISTING JET FUEL LINE TO BE REMOVED
- EXISTING TELEPHONE
- EXISTING CATCH BASIN
- JP-5 STORAGE TANK (UNDERGROUND)
- POWER POLE
- ABOVE GROUND ELECTRIC TRANSFORMER

NO.	DATE	REVISIONS	BY	CHKD	APPR	ENGR	PROJ ENGR
2	10/ /95	REVISED SCOPE PER NAVY DIRECTION	JED	REH	JRH	FBC	FBC
1	7/31/95	ISSUED FOR CONSTRUCTION	JED	RTJ	FBC	FBC	JRH

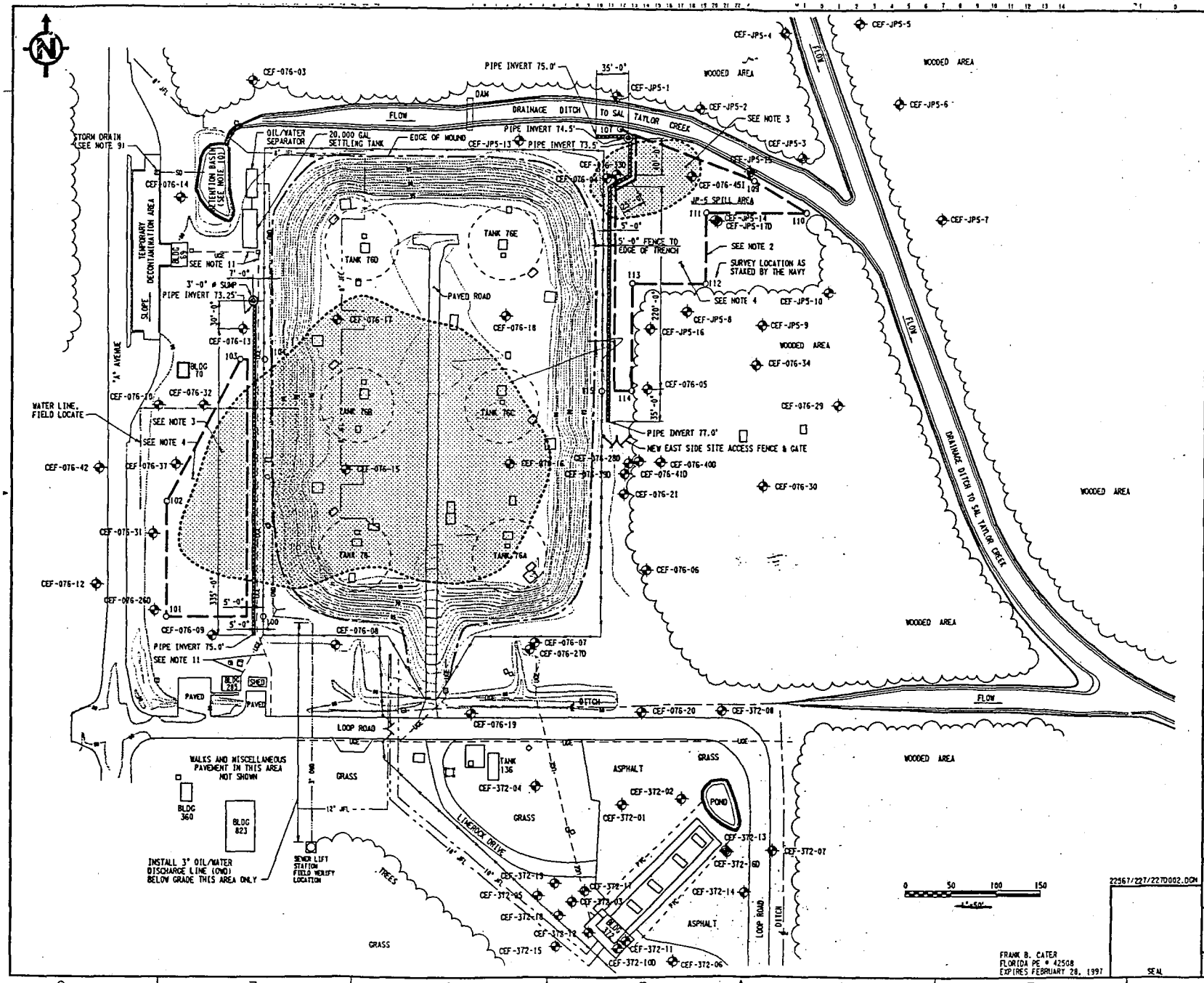
SCALE 1"=50'

BECHTEL ENVIRONMENTAL INC
OAK RIDGE, TENNESSEE

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAN
CHARLESTON, SOUTH CAROLINA

NAS CECIL FIELD
NORTH FUEL FARM
DEMOLITION PLAN

JOB NO.	DRAWING NO.	RE
22567	227-DD000-001	



NOTES

1. EXCAVATION SHALL BE PERFORMED IN ACCORDANCE WITH TECHNIC SPECIFICATION 22567-001-SP000-005, UNLESS NOTED OTHERWI
2. EXCAVATION LIMITS BASE ON NAVY DIRECTION AND FIELD MARKE AREA. LIMITS BASED UPON ASSUMED 1000 ppm TRPH LINE NO NO EXCAVATION IS TO BE PERFORMED BEYOND LIMITS NOTED WITHOUT EXPRESS WRITTEN PERMISSION FROM THE NAVY.
3. EXCAVATION WITHIN THE FREE PRODUCT PLUME AS INDICATED ON DRAWING SHALL BE TO 5' DEPTH (WEST SIDE) AND 3' DEPTH (E SIDE). USE SKIMMER PUMP OR ADSORBENT PADS TO RECOVER FRE PRODUCT.
4. EXCAVATION OUTSIDE THE FREE PRODUCT PLUME SHALL BE TO 3' GROUND ELEVATION, TYPICAL.
5. EXCAVATED MATERIAL WILL BE LOADED AND TRANSPORTED TO SIT
6. MAINTAIN MINIMUM 2v:1h SLOPE ON EXCAVATION SIDEWALL.
7. COORDINATE ANY SECURITY FENCE REQUIREMENTS WITH THE NAVY OPEN EXCAVATIIONS SHALL BE MARKED WITH A MINIMUM OF ORAN CONSTRUCTION FENCING.
8. SITE INFORMATION WAS PROVIDED TO BECHTEL BY THE NAVY.
9. IF EXISTING TRUCK STAND AREA IS USED AS DECONTAMINATION STORM DRAIN WILL BE RENDERED INOPERABLE DURING DECONTAMINATION ACTIVITIES.
10. SEE "INTERIM REMEDIATION WORK PLAN SOIL AND FREE PRODUCT REMOVAL, NORTH FUEL FARM, NAS CECIL FIELD, JACKSONVILLE, FOR ADDITIONAL INFORMATION. SEE ALSO MEETING MINUTES AND SCOPE REVISION DOCUMENT BASED ON AUGUST MEETING.
11. COORDINATE REMOVAL/REROUTE OF ALL UTILITIES WITH THE NAV

TECHNICAL SPECIFICATIONS

EXCAVATION OF CONTAMINATED SOIL AND MISCELLANEOUS DEMOLITION	22567-001-SP00

REFERENCE DRAWINGS

DEMOLITION PLAN	227-00000-001

LEGEND

- EXISTING MONITORING WELL
- NEW 3'-0" DIAMETER SUMP (SEE DRAWING 227-00000-
- NEW RECOVERY TRENCH (SEE DRAWING 227-00000-006)
- APPROXIMATE AREA OF FREE PRODUCT PLUME
- 101 EXCAVATION LIMIT STAKED LOCATION (SURVEYED)
- EXCAVATION LIMITS
- EXISTING FENCE
- SD — EXISTING STORM DRAIN (4")
- SS — EXISTING SANITARY SEWER (4")
- JFL — EXISTING JET FUEL LINE
- UGE — EXISTING UNDERGROUND ELECTRIC
- OWD — NEW OIL/WATER DISCHARGE LINE
- CB — EXISTING CATCH BASIN
- JP-5 STORAGE TANK (UNDERGROUND)
- ABOVE GROUND ELECTRIC TRANSFORMER

NO.	DATE	REVISIONS	BY	CHKD			
2	11/2/95	REVISED SCOPE PER NAVY DIRECTION	JED	RCH	JRM	FBC	FBC
0	7/31/95	ISSUED FOR CONSTRUCTION	JED	RTJ	FBC	FBC	JRM

SCALE 1"=50'

BECHTEL ENVIRONMENTAL IN

OAK RIDGE, TENNESSEE

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMM
CHARLESTON, SOUTH CAROLINA

NAS CECIL FIELD
NORTH FUEL FARM
EXCAVATION PLAN - SOIL REMOVAL

JOB NO.	DRAWING NO.
22567	227-DD000-002

8 7 6 5 4 3 2 1

Appendix C

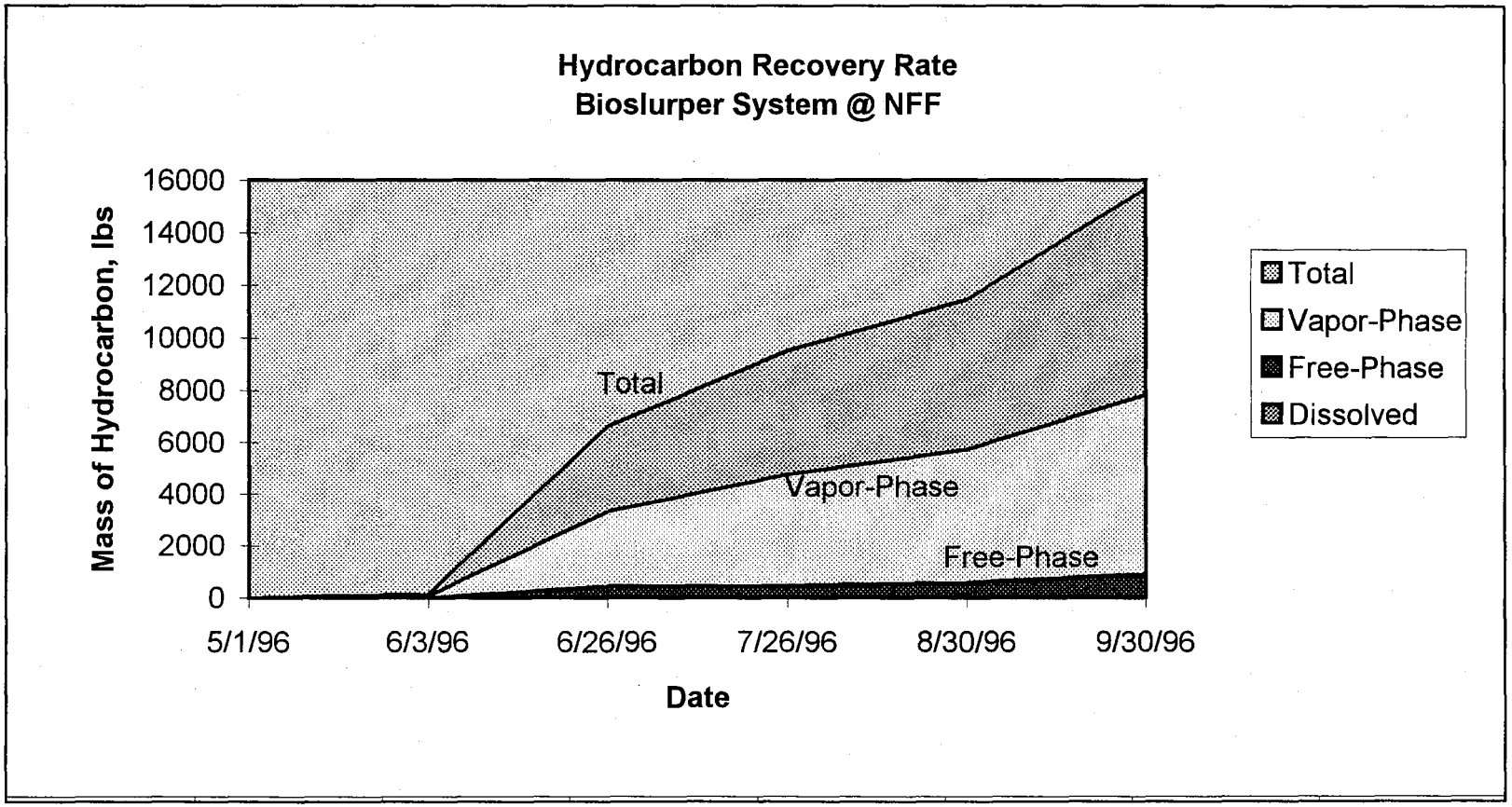
Bioslurper Performance Data

Remedial Action Plan

NFF Site, NAS Cecil Field

Jacksonville, Florida

Time Data			Water Flow Data , cummulative volume,						Product Flow Data				Vapor Flow Data			Grand
Date	Operation	Total	West	East	bsp	total	Avg. BTE	Mass BTEX	West Sump	East Sump	Bioslurper	total	CFM	Concn.	Mass	Total Mass
Units	days	days	gals.	gals.	gals.	gals.	gals.	lbs.	gals.	gals.	gallons	lbs.		ppmv	lbs.	lbs.
5/1/96		0	0	0	0	0	9100	0	0	0	0	0		8	0	0
6/3/96	10	30	700	539	1848	3087	9712	0	0	0	0	0	100	179	63	63
6/26/96	21	31	21923	18971	22192	63086	1235	1	0	25	40	434	100	3800	2872	3306
7/26/96	22	30	110104	63565	60234	233903	2900	4	0	25	42	447	100	1850	4304	4756
8/30/96	13	31	141457	82880	74472	298809	2640	1	0	30	55	568	100	1850	5151	5720
9/30/96	22	30	177482	85341	93564	356387	2049	1	0	35	100	901	100	2300	6932	7834
10/30/96		31				0										


Hydrocarbon Recovery Rate
Bioslurper System @ NFF
Mass of Hydrocarbon, lbs
16000
14000
12000
10000
8000
6000
4000
2000
0
5/1/96
6/3/96
6/26/96
7/26/96
8/30/96
9/30/96
Date
Total
Vapor-Phase
Free-Phase
Total
Vapor-Phase
Free-Phase
Dissolved

STAFF CIVIL ENGINEER

DEPARTMENT

DATE 1-15-97 PAGES 3 (PLUS COVER)

FINANCIAL DIVISION _____ FIRST LIEUTENANT _____

FACILITIES MANAGEMENT DIVISION _____ SEABEES _____

PLANNING DIVISION _____ RECYCLING _____

ENVIRONMENTAL DIVISION ✓

FROM: Dave Kruzicki
PWD / Environmental

PHONE: (904) 778-5620

DSN: _____

FAX: (904) 778-6567/[redacted]

DSN: 860-6567/[redacted]

TO: Kolu

AGENCY: ABB

CODE: _____

PHONE: _____

FAX: (904) 877-0742

REMARKS: _____

C-6

API 653 TANK INSPECTION
and
SUITABILITY FOR SERVICE EVALUATION

NAS CECIL FIELD, FLORIDA

Under Contract to
Southern Division
Naval Facilities Engineering Command
Charleston, South Carolina

Contract N62472-94-D-0845
Amendment Nos. 7 and 14
EEI Project No. 95-1872

August, 1996

PREPARED BY:
Michael P. St. Amour
Stephen J. DiGregorio, P.E.

SUBMITTED BY:
Stephen J. DiGregorio, P.E.
Jeremiah L. Ferguson, P.E.

ENTERPRISE ENGINEERING, INC.

C-7

01-15-1997 12:02PM FROM STAFF CIVIL ENGINEER DEPT TO 919048770742 P.02

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	PWO - NAS Cecil Field	2

Issue No.	Description	Distribution	Issue Date	Approved By
1	Draft Submission	R. Mims	04/09/96	
2	Final Submission	See Document Distribution Above	8/30/96	SJD

ABSTRACT

Enterprise Engineering, Inc. (EEI) has completed a comprehensive, Out-of Service Inspection and Suitability for Service Evaluation of Tanks 1, 2, 3, 4, 5 and 6 at NAS Cecil Field, Florida, following the applicable criteria of API Standard 653. The inspections were performed during 1995 and 1996.

Tanks 2, 3, 4, and 5 are in serviceable condition. Minor repairs were performed to Tanks 2, 3, 4, and 5, and the tanks have been returned to service. Minor repairs have been recommended for Tank 1 before it is returned to service. Additional repairs and upgrades will be required to Tanks 1 to 5 for long-term service and to comply with Florida Administrative Code (FAC) 62-761, Underground Storage Tank Systems.

Inspection did not find any indication of the reported leak in Tank 6. Tank 6 remains out-of-service and no decision has been made to return the tank to service. Should Tank 6 be selected for return-to-service, minor repairs are recommended before returning the tank to service.

This report documents the inspection and suitability for service evaluation of the tanks inspected, including return-to-service repairs. Recommendations for continued long-term service and tank closure requirements are also provided.

In accordance with EPA Regulation 40 CFR 112 and API Standard 653, this report satisfies the requirement for a tank integrity inspection and evaluation and, as such, should remain available as a historical record for future reference.

We hereby acknowledge that being familiar with the provisions of API Standard 653, the inspection and evaluation was performed in accordance with the provisions of API Standard 653 and good engineering practices, and with the exercise of usual and customary care.

Michael P. St. Amour
ANSI/API 653 Aboveground Storage Tank Inspector
Certificate No. 1834

Date 9/3/96

STATE OF MAINE
STEPHEN J. DI GREGORIO
6224
REGISTERED PROFESSIONAL ENGINEER

Stephen J. DiGregorio, P.E.
ANSI/API 653 Aboveground Storage Tank Inspector
Certificate No. 1113

Date 9/3/96

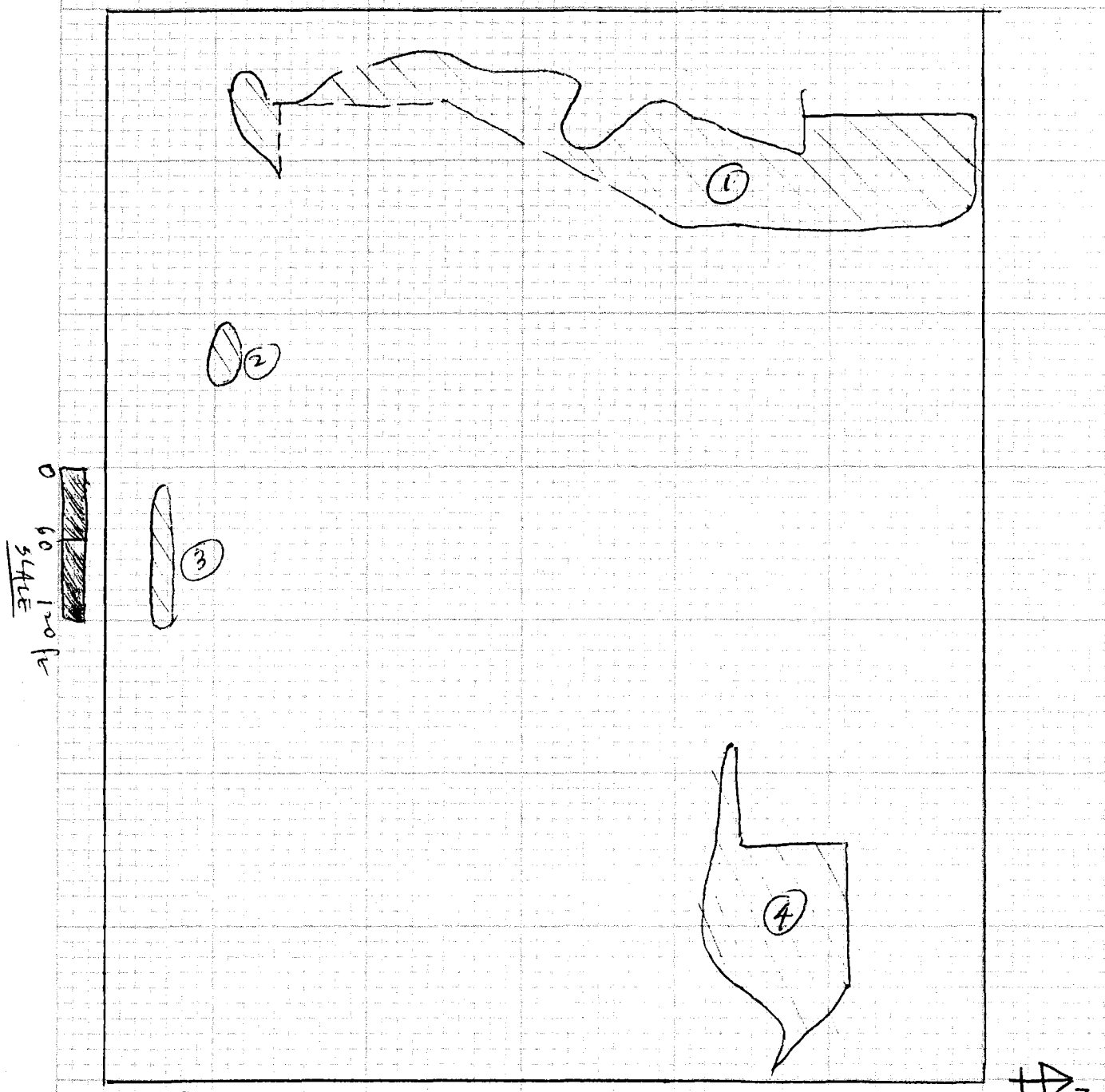
APPENDIX D

FDEP-APPROVED SOIL THERMAL TREATMENT FACILITIES

APPENDIX - D

PROJECT	COMP. BY	JOB NO.
NFF SITE NAS Cecil Field — Remedial Action Plan	KGK.	8563-03
	CHK. BY TMA	DATE 1/26/97

Estimation of Excessively Contaminated Soil Volume:
Refer to Figure 4-3.



① $(200 \times \frac{1}{10} \times \frac{1}{10}) \times (120\,ft)(120\,ft) = 28800\ ft^2$

② $(7 \times \frac{1}{10} \times \frac{1}{10}) \times (120\,ft)(120\,ft) = 1008\ ft^2$

③ $(10 \times \frac{1}{10} \times \frac{1}{10}) \times (120\,ft)(120\,ft) = 1440\ ft^2$.

④ $(100 \times \frac{1}{10} \times \frac{1}{10}) \times (120\,ft)(120\,ft) = 14400\ ft^2$.

ABB Environmental Services, Inc.

APPENDIX D.

PROJECT	COMP. BY	JOB NO.
NFF RAP NAS Cecil Field	KGK.	8563-03
	CHK. BY TMW	DATE 1-26-97

Net Volume

① 28800 ft^2 x 5 ft = 144,000 ft^3 = 5333 yd^3.

② 1008 ft^2 x 5 ft = 5040 ft^3 = 187 yd^3.

③ 1440 ft^2 x 5 ft = 7200 ft^3 = 267 yd^3.

④ 14400 ft^2 x 5 ft = 72,000 ft^3 = 2667 yd^3.

Total Volume of Excessively Contaminated Soil outside the modeled area. } 8454 yd^3.

ABB Environmental Services, Inc.

PERMITTED HEAT TREATMENT FACILITIES ACCEPTING PETROLEUM CONTAMINATED SOILS IN FLORIDA
AS OF AUGUST 30, 1990

I. Southeast District Stationary Units (305) 964-9668
SC 221-5005

1. Brewer Company of Florida - Medley Facility
   Contact Person: Walter Brewer
   Phone: (305) 885-2463
   9501 NW 106th Street
   Miami, FL 33178

DRAFT

2. Hardrives Asphalt
   Contact Person: Gary Gregg
   Phone: (305) 428-6144
   5700 Powerline Road
   Delray Beach, FL 33445

3. Rinker
   Contact Person: Bill Voshell
   Phone: (407) 833-5555
   P.O. Box 24635
   West Palm Beach, FL 33416

4. South Florida Materials
   Contact Person: J. Chellgrene
   Phone: (305) 421-6248
   2501 NW 48th Street
   Pompano Beach, FL 33060

5. Tarmac Florida
   Contact Person: Scott Quaas
   Phone: (305) 823-8800
   P.O. Box 122035
   Hialeah, FL 33012

II. Central District Stationary Units (407) 894-7555
SC 325-1011

1. Southern Soil Services, Inc.
   Contact Person: Christopher Hill
   Phone: (407) 933-8414
   3505 Pugmill Road
   Kissimmee, FL 34741-6462

2. A.A. Meyer Construction Company

DRAFT

III. South Florida District Stationary Units (813) 332-2667
SC 721-7900

1. Gulf Paving Company
Contact Person: Tim Lause, P.E.
Phone: (813) 334-3652
3540 Hardee Street
Fort Myers, FL 33901

Operating under temporary construction permit; status is under review by District Office.

IV. Southwest District Stationary Units (813) 623-5561
SC 552-7612

1. Resource Recovery of America
Contact Person: David S. Dye or Janice J. Stewart
Phone: (813) 425-1084 or 1-800-752-3242
2300 Highway 60 West
Mulberry, FL 33860

2. Asphalt Pavers, Inc.
Contact Person: Tony Tripi
Phone: (904) 471-8628
4101 N.E. 35th Street
Ocala, FL 32650

Issued construction permit for facility located at 15100 Brittle Road, Brooksville.

V. Northeast District Stationary Units (904) 798-4200
SC 821-5295

1. Columbia-Anderson Asphalt Plant £7, Clay County
Contact Person: Mike McRae
Phone: (904) 752-7585
P.O. Box 1386
Lake City, FL 32056-1386

VI. Northwest District Stationary Units (904) 436-8300
SC 695-8300

1. Capital Asphalt
   Contact Person: George Atkins
   Phone: (904) 575-8102
   Blounstown Hwy.
   Tallahassee, FL

DRAFT

VII. Mobile Units

1. Environmental Technology Southeast
   Contact Person: Carlton J. Dixon
   Phone: (904) 355-2157
   1819 Albert Street
   Jacksonville, FL 32202

2. Denard & Moore Construction Company
   Contact Person: Dan Moxley
   Phone: (813) 646-0366
   P.O. Box 5170
   Lakeland, FL 33807

3. Industrial Waste, Inc.
   Contact Person: Richard A. Singer
   Phone: (904) 479-1788
   Ellyson Industrial Park, Box 34
   Pensacola, FL 32514

   IWI is permitted to operate in the sixteen counties of FDER's Northwest District.

4. O.H. Materials Company
   Contact Person: Al Tobin or David Urann
   Phone: (904) 394-8601 or 1-800-552-2038
   Route 2
   P.O. Box 60-A
   Clermont, FL 32711

5. Site Reclamation Systems
   Contact Person: Larry Wood
   Phone: (904) 324-3651
   P.O. Box 11
   Howey-in-the-Hills, FL 32737

   SRS has applied for a Statewide Construction Permit to operate two mobile incineration units. Status is pending; Department awaiting public notice.

DRAFT

6. Thermal Process Systems Technologies, Inc.
   Contact Person: Ken Wood
   Phone: (407) 886-2000
   2070 South Orange Blossom Trail
   Apopka, FL 32703

7. Clean Soils, Inc.
   Contact Person: Robert Wills, Mgr. Process Engineering
   Phone: (612) 557-7106
   14120 23rd Avenue North
   Minneapolis, MN 55447

Unit may operate in the following counties: Alachua, Baker, Bay, Bradford, Brevard, Calhoun, Citrus, Clay, Columbia, De Soto, Dixie, Duval, Escambia, Franklin, Gadsden, Gulf, Hamilton, Hardee, Hernando, Highlands, Hillsborough, Jackson, Jefferson, Lafayette, Lake, Leon, Levy, Liberty, Madison, Manatee, Marion, Nassau, Orange, Osceola, Pasco, Pinellas, Polk, Putnam, Santa Rosa, Sarasota, St. Johns, Seminole, Sumter, Suwannee, Taylor, Union, Volusia, Wakulla, and Walton. Other counties may be added after public notice requirements are satisfied.

APPENDIX E

SVE DESIGN CALCULATIONS AND VENDOR INFORMATION

Appendix E

Soil Vapor Extraction - Vacuum Pump Sizing

Remedial Action Plan
North Fuel Farm Site
Naval Air Station, Cecil Field
Jacksonville, Florida

Engineer: KGK | Date: 1/5/97 | Checked By: CDJ

		Value		Units	Remarks
Number of SVE points					
L	Length of the mound	510		ft	Figure 7-3
W	Width of the mound	360		ft	Figure 7-3
H	Thickness of vadose zone with OVA reading >10 ppm.	15		ft	Figure 7-3
R	Radius of JP-5 tanks	37.5		ft	Figure 7-3
Anet	Net areal extent contaminated soil	179182.135		ft^2	Calculated (see Ref. 1)
Vnet	Net volume of contaminated soil	2687732.03		ft^3	Calculated
ROI	Design radius of influence for each SVE well	50		ft	Pilot Test
N	Number of SVE wells required	23		dimensionless	Calculated
Flow Rate					
Minimum Flow Rate (based on 1 pore volume per day)					
n	Porosity	0.25			Assumed
v	Pore volume	671933.007		ft^3	Calculated
Q	Air flow rate required to maintain 1 pore volume per day	466.620144		cfm	Calculated
q_min	Air flow rate required to maintain 1 pore volume per day per SVE well	20		cfm	Calculated
Maximum Flow Rate (based on intrinsic permeability)		k1	k2		
k	intrinsic permeability of soil	1.00E-08	1.00E-07	cm^2	slug tests
u	viscosity of air	1.80E-04	1.80E-04	g/cm-s	constant
P w	absolute pressure at extraction well	8.00E+05	8.00E+05	g/cm-s^2	assumed
P Atm	absolute ambient pressure	1.01E+06	1.01E+06	g/cm-s^2	constant
R w	radius of vapor extraction well	2.00	2.00	in	constant
ROI	radius of influence	50.00	50.00	ft	Pilot test
q/H	flow rate per unit thickness per SVE well	14.54	145.44	cm^3/s	calculated (see Ref. 2)
q _max	flow rate per SVE well	14	142	cfm	calculated
Flow Rate Required Based on Biosparging Within the Mound Area					
q_bm	maximum biosparging flow rate anticipated	9		cfm	Pilot test
N_bm	number of biosparging wells located within the mound area	7			Calculated
Q_bm	total flow rate anticipated due to biosparging within the mound area	63		cfm	Calculated
N_sve	number of SVE points located within the biosparging area	14			Figure 7-3
q_sve	minimum flow rate required per SVE well to capture sparged vapors	4.5		cfm	Calculated
q	Design flow rate per SVE well (q_min & q_sve < q < q_max)	25		cfm	selected
Q	total flow rate for the SVE system	570		cfm	Calculated
Q_rcw	Additional flow rate from recirculation wells @ 10 cfm per well	50		cfm	

Q_Design	Design flow rate							620		cfm	calculated
Use one "EG&G ROTRON" model no. EN 14DX72WL (Part# 038188) Explosion-Proof Regenerative Blower or equivalant											
with the following specifications:											
Max Flow @ Max. Suction					920 SCFM @ -115" WG						
Horse Power					30	HP					
Phase-Frequency					Three - 60	Hz					
Voltage					460	V					
Notes:											
	Ref. 1=	Net areal extent of soil contmaination = cross sectional area of mound - cross sectional area of 6 tanks									
	Ref. 2=	"A Practical Approach to the Design, Operation, and Monitoring of In situ Soil-Venting Systems,									
		by P.C. Johnson, C.C. Stanley, M.S. Kemblowski, F.L. Byers, and J.D. Colthart" Spring 1990, Groundwater.									

EG&G

FAX TRANSMITTAL

EG&G ROTRON
INDUSTRIAL DIVISION

NORTH STREET
SAUGERTIES, NY 12477
PHONE: (914) 246-3401
FAX: (914) 246-3802

DATE:	January 21, 1997	TIME:	
TO:	Gopi K.	NUMBER OF PAGES:	3
COMPANY:	ABB Inc.	REP:	
FAX NUMBER:	904 877 0742 PH: 904 656 1293 x 294		
FROM:	Neil Lynch		
SUBJECT:	EN14BK72MWL		

Please find catalog cut sheets on this unit. This should show you the updated dimensions, weights, and performance.

I'm trying to remember if that was what you needed. If you require further information, please feel free to call or fax me at the above numbers.

Sincerely,

Neil Lynch

E-3

EN/CP 14
Explosion-Proof Regenerative Blower

EN FEATURES

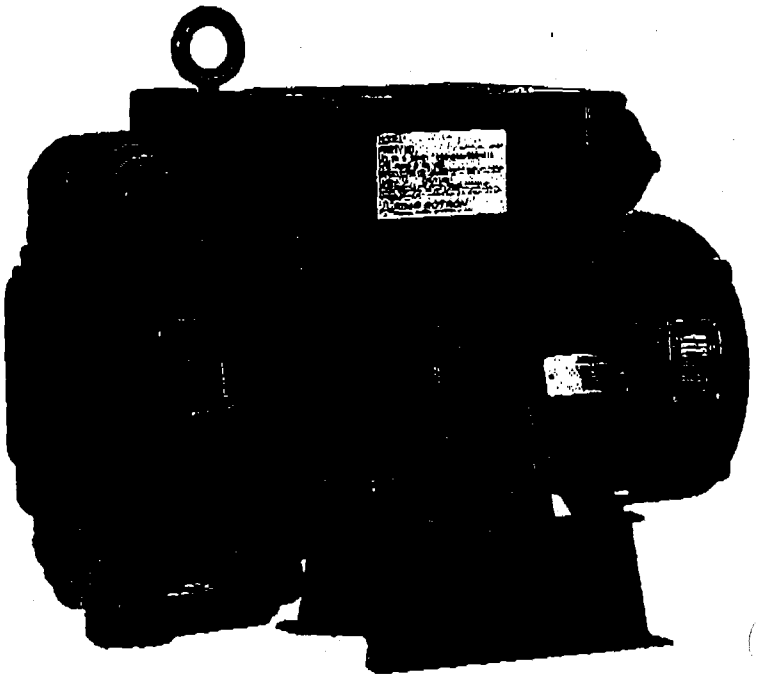
- Manufactured in the USA
- Maximum flow: 920 SCFM
- Maximum pressure: 144" WG
- Maximum vacuum: 115" WG
- Standard motor: 30 HP
- Blower construction – cast aluminum housing, cover, impeller & manifold; cast iron flanges
- UL & CSA approved motors for Class I, Group D atmospheres
- Sealed blower assembly
- Quiet operation within OSHA standards

OPTIONS

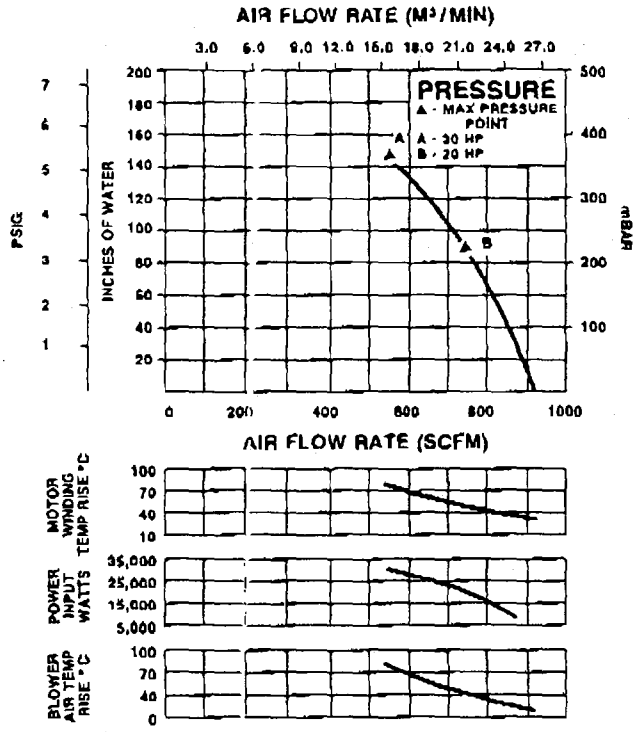
- TEFC motors
- 50 Hz motors
- International voltages
- Other HP motors
- Corrosion resistant surface treatments
- Remote drive (motorless) models

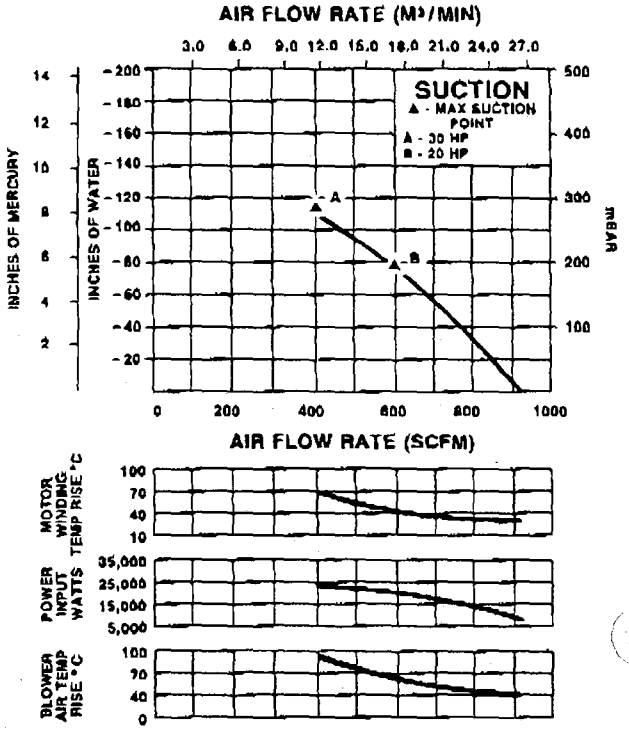
ACCESSORIES

- Moisture separators
- Explosion-proof motor starters
- Inline & inlet filters
- Vacuum & pressure gauges
- Relief valves
- External mufflers



BLOWER PERFORMANCE AT STANDARD CONDITIONS

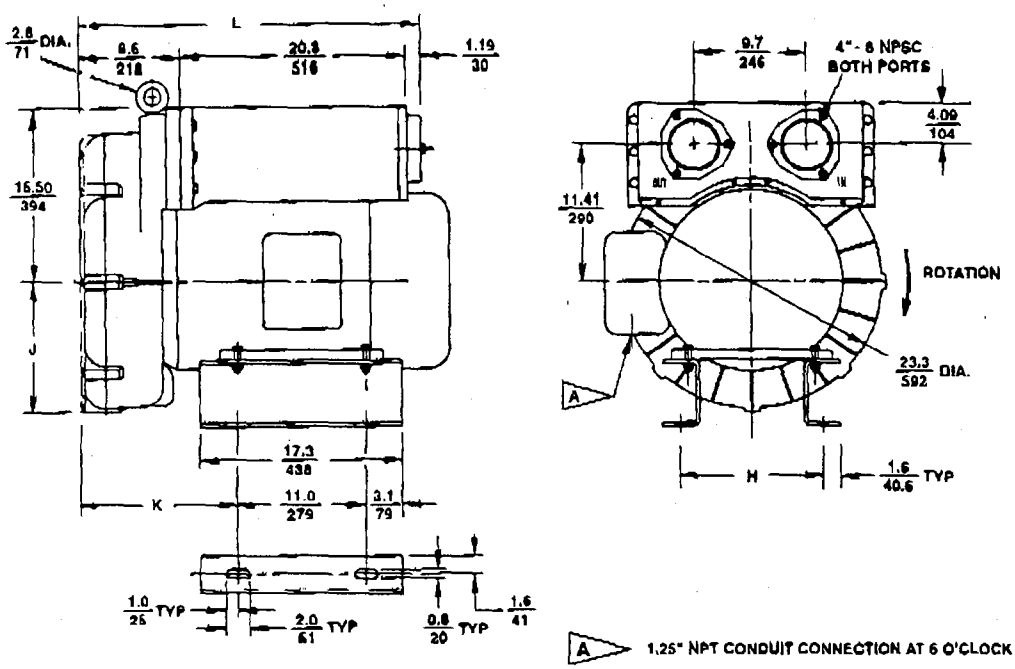




EG&G ROTRON, SAUGERTIES, N.Y. 12477 • 914/246-3401 • FAX 914/246-3802

01/21/97 TUE 16:09 FAX 914 246 3802 EG&G ROTRON SAUG 002

EN/CP 14
Explosion-Proof Regenerative Blower



DIMENSIONS: IN/MM
TOLERANCES: .XX ± .1/2.5
(UNLESS OTHERWISE NOTED)

MODEL	L (IN/MM)	K (IN/MM)	J (IN/MM)	H (IN/MM)
EN/CP14DX72WL	31.9/810	12.3/338	12.9/328	12.38/314
EN/CP14BK72WL	30.2/767	12.3/312	12.1/307	8.62/219

SPECIFICATIONS

MODEL	EN14BK72MWL		EN14DX72MWL		EN14DX86MWL	CP14GB72MWLR	CP14GC72MWLR
Part No.	038760		038761		038762	–	038984
Motor Enclosure – Shaft Material	Explosion-proof – CS		Explosion-proof – CS		Explosion-proof – CS	Chem XP – SS	Chem XP – SS
Horsepower	20		30		30	Same as EN14BK72MWL – 038760 except add Chemical Processing (CP) features from catalog inside front cover	Same as EN14DX72MWL – 038761 except add Chemical Processing (CP) features from catalog inside front cover
Phase – Frequency	Three - 60 Hz		Three - 60 Hz		Three - 60 Hz		
Voltage [1]	230	460	200-230	460	575		
Motor Nameplate Amps	50	25	80-70	35	28		
Maximum Blower Amps [3]	60	30	82	41	33		
Inrush Amps	317	159	495-430	215	226		
Starter Size	3	2	3	3	3		
Service Factor	1.0		1.0		1.0		
Thermal Protection [2]	Pilot Duty		Pilot Duty		Pilot Duty		
Bearing Type	Sealed, Ball		Sealed, Ball		Sealed, Ball		
Shipping Weight	680 lb (309 kg)		816 lb (370 kg)		816 lb (370 kg)		

BLOWER LIMITATIONS FOR 60 Hz

Min. Flow @ Max. Suction	600 SCFM @ –80" WG	400 SCFM @ –115" WG	400 SCFM @ –115" WG	600 SCFM @ –80" WG	400 SCFM @ –115" WG
Min. Flow @ Max. Pressure	750 SCFM @ 90" WG	550 SCFM @ 144" WG	550 SCFM @ 144" WG	750 SCFM @ 90" WG	550 SCFM @ 144" WG

1 All dual voltage 3 phase motors are factory tested and certified to operate on 200-230/400-460 VAC-3 ph-60 Hz and 220-240/380-415 VAC-3 ph-50 Hz. All dual voltage 1 phase motors are factory tested and certified to operate on 110-120/200-230 VAC-1 ph-60 Hz and 220-240 VAC-1 ph-50 Hz.
2 Maximum operating temperatures: Motor winding temperature (winding rise plus ambient) should not exceed 140° for Class F insulation or 120° for Class B insulation. Blower outlet air temperature should not exceed 140° (air temperature rise plus ambient).
3 Corresponds to the performance point at which the blower and / or motor temperature rise reaches the limit of the thermal protection in the motor.

Specifications subject to change without notice. Please contact factory for specification updates.

01/21/97 TUE 16:09 FAX 914 246 3802 EG&G ROTRON SAUG 003

Vendor Information for Thermal Oxidation Unit for Off-Gas Treament

INDEX OF CONTENTS

****

1. Introduction to VAPOR CHECK

2. Quality control measures

3. Specification Sheets

4. Receiving / set up / hook up

   A. Heat Exchanger
   B. Turnkey "VES" System

5. Start-up Operations

   A. CAT VAC
   B. Turnkey "VES" System
   C. Burner Adjustment

6. Preventative maintenance

7. Gas Train

8. Burner

9. Controls

10. Refractory

11. Spare Parts

12. Trouble shooting

THERMTECH, INC. (713) 359-7555 FAX (713) 359-7550
1-(800)-659-8271

ver. 5.5 (10-07-92)

The **VAPOR CHECK/CAT VAC** is oxidation/incineration equipment that was specifically designed with the soil remediation market in mind; however, this equipment is very well suited for the destruction of most VOC fumes, smoke, and odors.

The **CAT VAC** is available in six (6) standard pre-designed/pre-engineered models ranging in size from 100 SCFM to 1500 SCFM. Plus custom designed systems to 30,000 SCFM. Heat exchangers, analytical monitors, strip chart recorders and more are available for each model as well as double axle utility trailers.

The basic **CAT VAC** system operates catalytically, raising the temperature of the process stream from ambient to 600° F before it passes through the catalyst bed and into the atmosphere.

The basic model is test fired before being shipped complete with refractory lined combustion chamber, burner package, control panel, FM gas train, and refractory lined interconnected snub stack where the catalyst bed is located.

The process blower, interconnecting duct work, erection, field wiring, and plumbing is the responsibility of others.

The **VAPOR CHECK/CAT VAC** oxidation system has been designed to be as energy efficient as possible while still offering the destructive efficiency necessary to meet and/or exceed EPA and your local air quality control standards.

While catalytic operation has the distinct advantage of using less fuel than it's thermal sister it does have some inherent disadvantages. Catalyst of all types, can be deactivated by lead, sulfur, chlorinated hydrocarbons, silicon and phosphorus containing compounds. The result of this deactivation is reduction of destructive efficiency. In addition to those compounds mentioned, all particulates may also cover catalyst surfaces, thereby reducing activity by this masking effect. While trace amounts of the above agents may not lower the catalyst activity or shorten it's life, appreciable quantities must not be present in the gas stream. Check with Factory for written recommendations specifically addressing your process stream.

Our catalyst is an extremely active precious metal catalyst having a lower temperature limit of 500° F and an upper temperature limit of 1350° F. Generally, in a field catalytic oxidizer such as the **VAPOR CHECK** system, you will find a 25° F increase in the catalyst bed temperature for each 1.0% of the LEL of hydrocarbon passing through the bed. For specific application information, please supply us with the exact chemical analysis.

The destructive efficiency of your catalytic system is directly related to the catalytic bed temperature, the quantity of catalyst in the bed, and the actual condition of the catalyst. Typically, the destructive efficiency of this catalytic system can be improved by increasing either/or both the amount of catalyst and /or the bed's inlet temperature while observing the exit temperature to be sure you do not exceed the catalyst's upper temperature limit of operation. This is an important fact about the operation of a catalytic oxidizer. If the catalyst is in good condition (has not been deactivated), the difference between 50% destructive efficiency and 99% destructive efficiency is directly related to the amount of catalyst in the bed and the temperature of that bed.

June 30, 1992

VAPOR CHECK

MODEL: **CATVAC 100**

GENERAL DATA

* SCFM rating	1000 SCFM
* burners maximum output capability	1,000,000 BTU/Hr
* burner turndown ratio	20 to 1
* combustion blower motor size	1.5 HP
* preheat chamber I D	18" x 18" x 68"
* stack I D	22" x 23"
* skid size	64" x 103"
* velocity through 6" process inlet	
@ 500 SCFM from process stream	42.4 ft./sec.
@ 1000 SCFM from process stream	84.9 ft./sec.

CATALYTIC DATA

* SCFM added by combustion blower when fired on ratio	117 SCFM
* total ACFM @ 600 deg. F.	2242 ACFM
* catalyst volume for 90% plus destructive efficiency	2.0 cu. ft.
* inlet temperature	600 deg. F.
* maximum concentrations	25 % of the LEL
* stack velocity	
@ 500 SCFM from process stream	5.3 ft./sec. +
@ 1000 SCFM from process stream	10.6 ft./sec. +
* estimated weight	2170 lbs.

* The above data is intended to be used as general, guide line type information. For specific application proposal, please contact the manufacturer.

June 30, 1992

VAPOR CHECK

MODEL: **CATVAC 50**

GENERAL DATA

* SCFM rating	500 SCFM
* burners maximum output capability	500,000 BTU/Hr
* burner turndown ratio	20 to 1
* combustion blower motor size	.75 HP
* preheat chamber I D	12" x 12" x 60"
* stack I D	12" x 12"
* skid size	48" x 95"
* velocity through 4" process inlet	
@ 250 SCFM from process stream	47.5 ft./sec.
@ 500 SCFM from process stream	95.0 ft./sec.

CATALYTIC DATA

* SCFM added by combustion blower when fired on ratio	58 SCFM
* total ACFM @ 600 deg. F.	1120 ACFM
* catalyst volume for 90% plus destructive efficiency	1 cu. ft.
* inlet temperature	600 deg. F.
* maximum concentrations	25 % of the LEL
* stack velocity	
@ 250 SCFM from process stream	9.3 ft./sec. +
@ 500 SCFM from process stream	18.6 ft./sec. +
* estimated weight	1850 lbs.

* The above data is intended to be used as general, guide line type information. For specific application proposal, please contact the manufacturer.

June 30, 1992

VAPOR CHECK

MODEL: **CATVAC 75**

GENERAL DATA

* SCFM rating	750 SCFM
* burners maximum output capability	1,000,000 BTU/Hr
* burner turndown ratio	20 to 1
* combustion blower motor size	1 HP
* preheat chamber I D	16" x 16" x 60"
* stack I D	12" x 24"
* skid size	64" x 95"
* velocity through 6" process inlet	
@ 375 SCFM from process stream	31.9 ft./sec.
@ .750 SCFM from process stream	63.7 ft./sec.

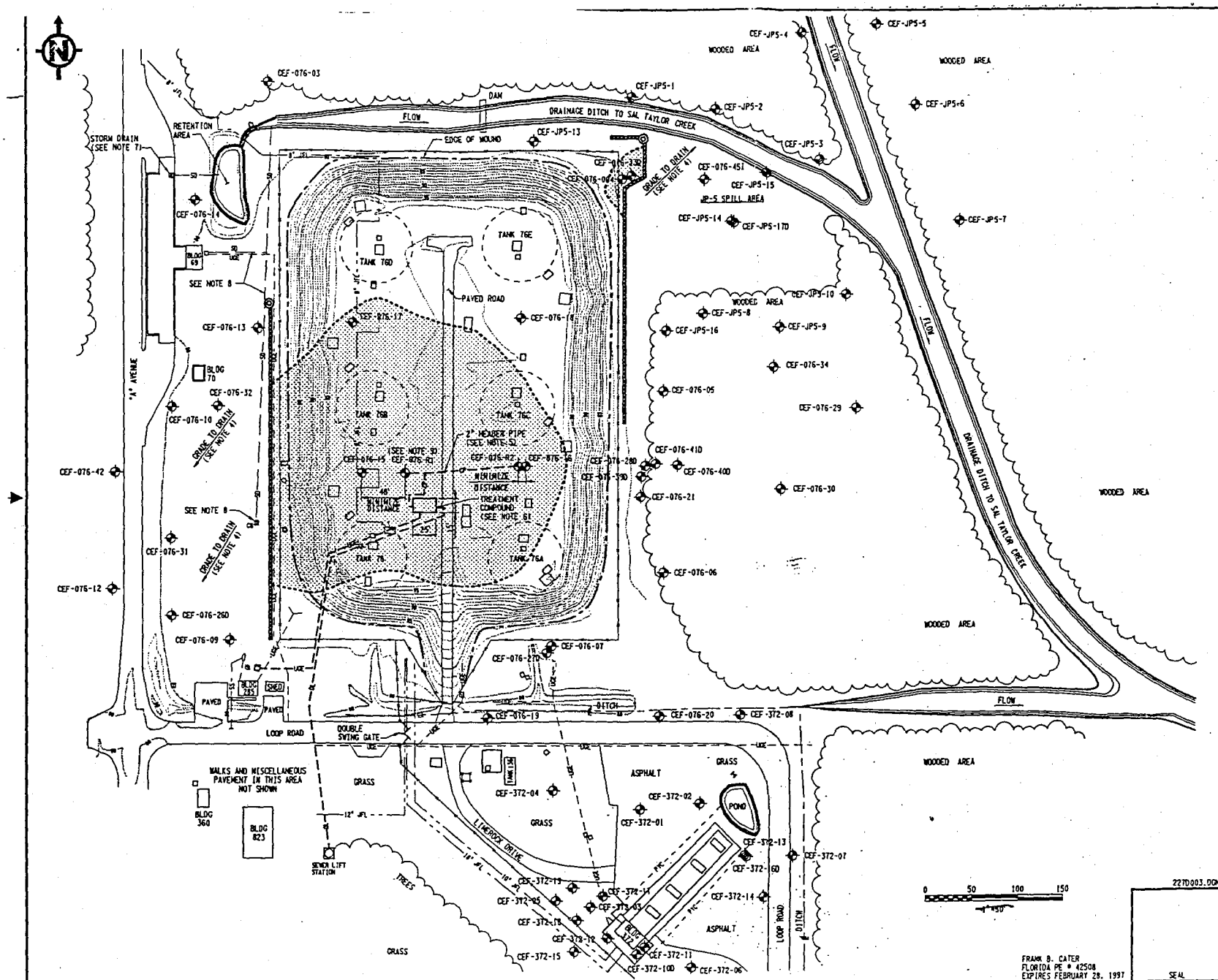
CATALYTIC DATA

* SCFM added by combustion blower when fired on ratio	88 SCFM
* total ACFM @ 600 deg. F.	1682 ACFM
* catalyst volume for 90% plus destructive efficiency	1.5 cu. ft.
* inlet temperature	600 deg. F.
* maximum concentrations	25 % of the LEL
* stack velocity	
@ 375 SCFM from process stream	7.0 ft./sec. +
@ 750 SCFM from process stream	14.0 ft./sec. +
* estimated weight	1970 lbs.

* The above data is intended to be used as general, guide line type information. For specific application proposal, please contact the manufacturer.

APPENDIX F

DETAILS OF EXISTING BIOSLURPING SYSTEM



NOTES

1. BACKFILL SHALL BE PERFORMED IN ACCORDANCE TECHNICAL SPECIFICATION 22567-001-SP000-006, UNLESS NOTED OTHE
2. SITE INFORMATION WAS PROVIDED TO BECHTEL BY THE NAVY.
3. BACKFILL SHALL BE COMPACTED TO 85% MAXIMUM DENSITY U OTHERWISE DIRECTED BY THE NAVY.
4. MATCH EXISTING GRADE IN BACKFILLED AREA. SLOPE TO DR INDICATED.
5. TREATMENT SYSTEM PIPING WILL BE PLACED 18" BELOW GRAD ABOVE GROUND PIPING IS APPROVED BY NAS CECIL FIELD PE
6. FINAL TREATMENT COMPOUND LOCATION IS TO BE COORDINATE FIELD (SEE DRAWING 227-00000-005 FOR COMPOUND LAYOUT) PROVIDE 6" 3000psi 6x6 6/6 WWF REINFORCED PAD WITH THI EDGE FOOTER.
7. AT COMPLETION OF DECONTAMINATION ACTIVITIES, RESTORE DRAIN.
8. PROVIDE NEW CATCH BASIN AND STORM DRAIN TO MATCH EXIST BASIN AND DRAIN REMOVED DURING EXCAVATION, IF DIRECTED THE NAVY.
9. NEW RECOVERY WELL LOCATIONS ARE DEPENDENT UPON FIELD CONDITIONS. LOCATE NEW WELLS AS CLOSE TO EXISTING WEL AND 16 AS POSSIBLE.
10. PROVIDE 480v/60Hz/3 PHASE POWER TO COMPOUND AREA. POW UP, CABLES, AND TRENCHING WILL BE IN ACCORDANCE WITH L CODES AND PROVIDED BY A LICENSED ELECTRICIAN.

TECHNICAL SPECIFICATIONS

UNCONTAMINATED EARTHWORK	22567-001-SP

REFERENCE DRAWINGS

DEMOLITION PLAN	227-00000-00
EXCAVATION PLAN	227-00000-00

LEGEND

- EXISTING MONITORING WELL
- NEW RECOVERY WELL
- NEW 3'-0" DIAMETER SUMP
- NEW RECOVERY TRENCH
- APPROXIMATE AREA OF FREE PRODUCT PLU
- EXISTING FENCE
- SD — EXISTING STORM DRAIN (4")
- SS — EXISTING SANITARY SEWER (4")
- JFL — EXISTING JET FUEL LINE
- UGE — EXISTING UNDERGROUND ELECTRIC
- UGE — NEW UNDERGROUND ELECTRIC
- CP — NEW TREATMENT SYSTEM CONVEYANCE PIPE
- DL — NEW TREATMENT SYSTEM DISCHARGE LINE
- CB — EXISTING CATCH BASIN
- JP-5 STORAGE TANK (UNDERGROUND)
- ABOVE GROUND ELECTRIC TRANSFORMER

NO.	DATE	REVISIONS	BY	CHKD	APPD	CHKD
1	11/2/95	REVISED SCOPE PER NAVY DIRECTION	JED	REH	JRM	FBC
3	12/31/95	ISSUED FOR CONSTRUCTION	DLL	RTJ	FBC	FBC

SCALE 1"=50'

BECHTEL ENVIRONMENTAL I

OAK RIDGE, TENNESSEE

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING CO
CHARLESTON, SOUTH CAROLINA

NAS CECIL FIELD
NORTH FUEL FARM - SITE RESTORATION PLA
AND BIO SLURPING REMEDIATION LAYOUT

JOB NO.	DRAWING NO.
22567	227-DD000-003

F-1

B01 - LIQUID RING PUMP
TYPE: LIQUID RING PUMP
POWER: 10 HP, 460/3/60
CAPACITY: 125 CFM
@ 22" Hg VACUUM

P05 - GROUNDWATER EXTRACTION PUMP
TYPE: GRUNDFOS REDI-FLO4 SE5
POWER: 1/3 HP, 230/1/60
CAPACITY: 1-7 GPM @ 50 FT HEAD

T10 - DISCHARGE SEPARATOR
CAPACITY: 300 GAL (MIN)

B02 - FAN
TYPE: CENTRIFUGAL
POWER: 0.5 HP, 460/3/60
CAPACITY: 50 CFM

P01 - OIL TRANSFER PUMP
TYPE: DIAPHRAGM, ELECTRIC
POWER: HP DETERMINED BY MFG.
460/3/60
CAPACITY: 20 GPM

P02 - LIQUID SEAL PUMP
TYPE: CENTRIFUGAL
POWER: HP DETERMINED BY MFG.
460/3/60
CAPACITY: DETERMINED BY MFG.

P06 - GROUNDWATER EXTRACTION PUMP
TYPE: GRUNDFOS REDI-FLO4 SE5
POWER: 1/3 HP, 230/1/60
CAPACITY: 1-7 GPM @ 50 FT HEAD

T30 - MOISTURE SEPARATOR
CAPACITY: 40 GAL

GAC1 - GRANNULAR ACTIVATED CARBON
CAPACITY: 1800 lbs. (MIN)
TYPE: VAPOR PHASE

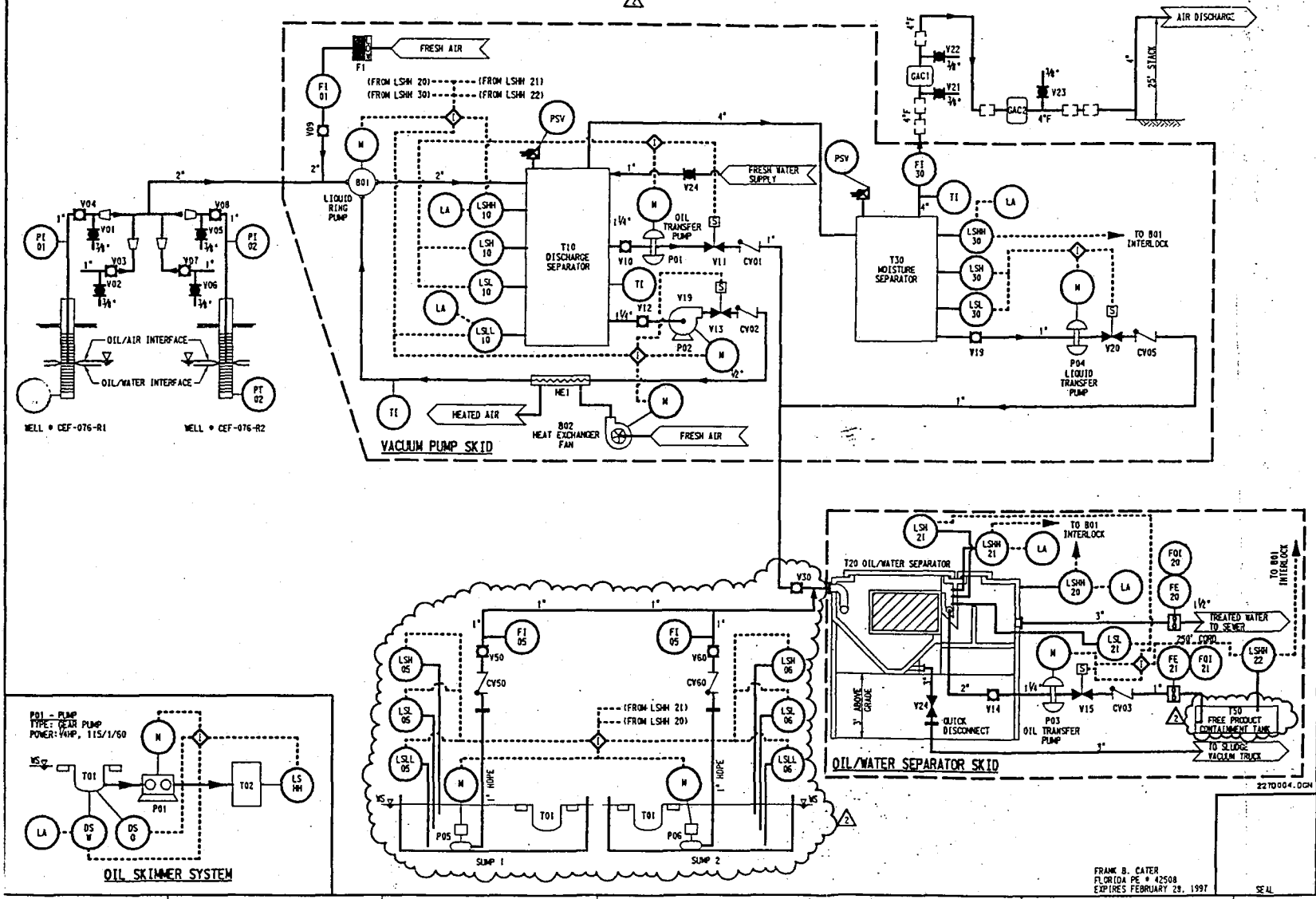
T20 - OIL/WATER SEPARATOR
CAPACITY: 1-25 GPM
INLET TEMP=140 °F (MAX)
COALESCING SURFACE AREA= 1088 FT2 (MIN)
SLUDGE CHAMBER CAPACITY=28 GAL (MIN)
OIL CAPACITY=39 GAL (MIN)
OIL DROPLET REMOVAL RATE=10mg/l OF OIL DROPLETS
> 20 MICRONS

P03 - OIL TRANSFER PUMP
TYPE: DIAPHRAGM, ELECTRIC
CAPACITY: 20 GPM
POWER: 1 HP, 460/3/60

P04 - LIQUID TRANSFER PUMP
TYPE: DIAPHRAGM, ELECTRIC
CAPACITY: 20 GPM
POWER: 1 HP, 460/3/60

GAC2 - GRANNULAR ACTIVATED CARBON
CAPACITY: 1800 lbs. (MIN)
TYPE: VAPOR PHASE

T50 - FREE PRODUCT TANK
CAPACITY: DETERMINED IN FIELD



LEGEND

- HEAT EXCHANGER
- GEAR PUMP
- LIQUID RING PUMP
- CENTRIFUGAL PUMP
- DIAPHRAGM PUMP
- SUBMERSIBLE PUMP
- FLOW ELEMENT
- GATE VALVE (STATUS - NORMALLY CLOSED)
- CHECK VALVE
- BALL VALVE (STATUS - NORMALLY OPEN)
- BALL VALVE (STATUS - NORMALLY CLOSED)
- PRESSURE RELIEF VALVE
- BLOWER
- PARTICULATE FILTER
- SOLENOID
- INSTRUMENT FOR SINGLE MEASURED VARIABLE (LOCALLY MOUNTED)
- HOSE QUICK CONNECT
- REDUCER
- PRESSURE CONTROL VALVE

PT - PRESSURE TRANSMITTER
CV - CHECK VALVE
FX - PARTICULATE FILTER/SILENCER
F - FLEXIBLE HOSE
PSV - PRESSURE SAFETY VALVE
GAC - GRANULAR ACTIVATED CARBON
FI - FLOW INDICATOR
FQI - TOTALIZING FLOW METER
TI - TEMPERATURE INDICATOR
PI - PRESSURE INDICATOR
TXX - TANK
BXX - BLOWER
HS - HAND CONTROL SWITCH
V - VALVE
PCV - PRESSURE CONTROL VALVE
HE - HEAT EXCHANGER
LA - LOCAL ALARM
M - MOTOR
DSO - DENSITY SWITCH, OIL
DSW - DENSITY SWITCH, WATER

NOTES:
1. ALL LINES AND FITTINGS ARE 4" SCH 40 PVC EXCEPT WHERE NOTED.
2. ALL VALVES ARE 4" PVC EXCEPT WHERE NOTED.

NO.	DATE	REVISIONS	BY	CHKD	PROJ ENGR	ENGR	ENGR CHKD
3	11/6/95	ADDED SUMP PUMPS	KCL	WRZ	JRM	FBC	FBC
1	11/2/95	ADDED FREE PRODUCT TANK CONTROLS AND CHANGED LINE SIZES	DLL	WRZ	JRM	FBC	FBC
0	8/1/95	ISSUE FOR CONSTRUCTION	RGB	ABJ	FBC	WRZ	JRM

SCALE

BECHTEL ENVIRONMENTAL INC
OAK RIDGE, TENNESSEE

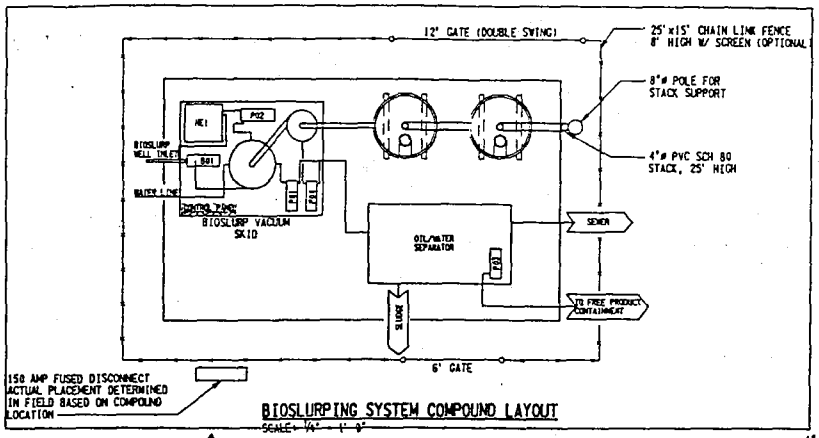
DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA

PROCESS AND INSTRUMENTATION DIAGRAM FOR BIOSLURPER SYSTEM AND OIL SKIMMER SYSTEM

JOB NO.	DRAWING NO.	REV
22567	227-DD000-004	2

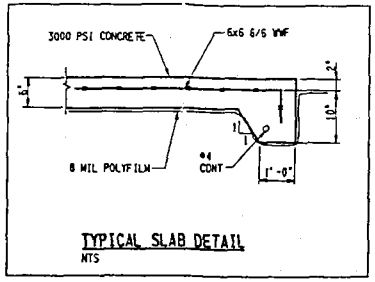
FRANK B. CATER
FLORIDA PE # 42508
EXPIRES FEBRUARY 28, 1997

SEAL



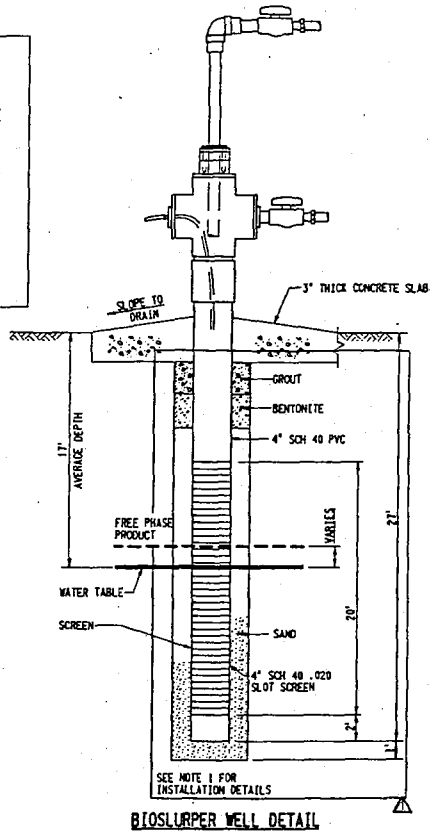
BIOSLURPING SYSTEM COMPOUND LAYOUT

SCALE: 1/4" = 1'-0"

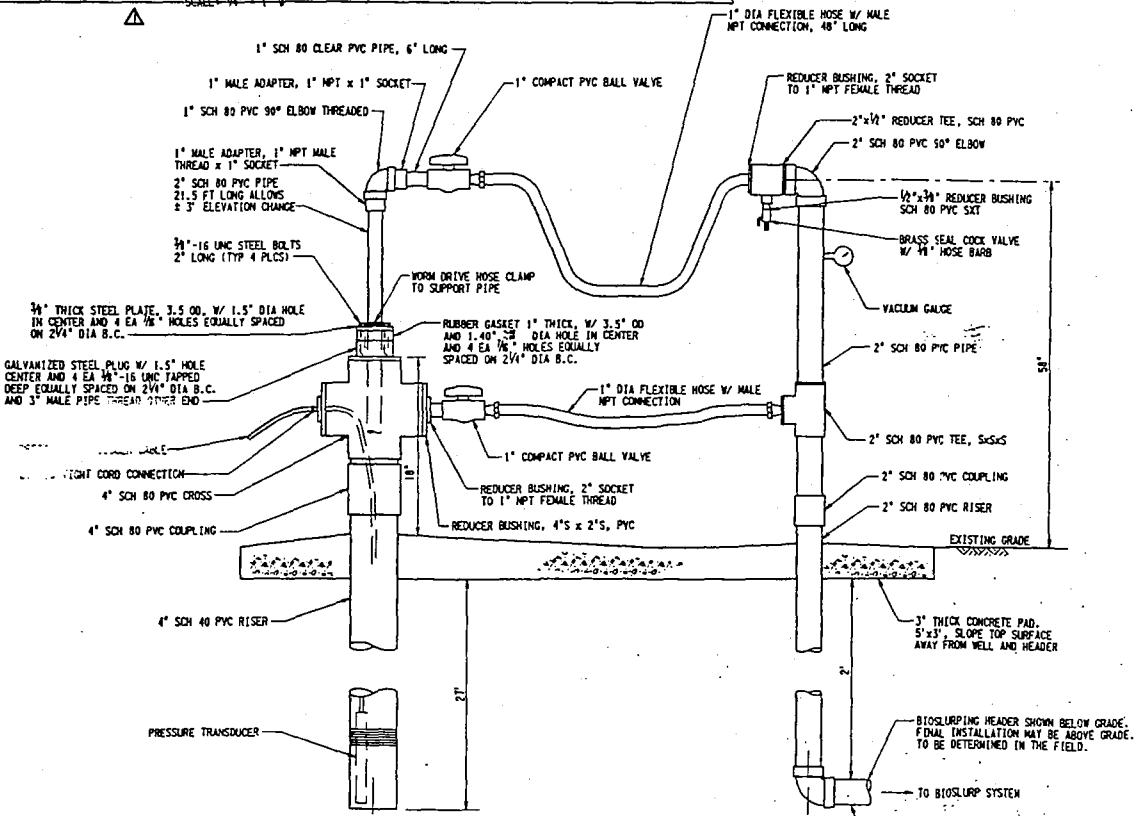


TYPICAL SLAB DETAIL

NTS



BIOSLURPER WELL DETAIL



BIOSLURPING WELL HEAD DETAIL

NTS

NOTES

1. TYPICAL BIOSLURPER WELL INSTALLATION:
   - FILTER PACK (10/20 SAND) PLACED TO APPROXIMATELY 2' A TOP OF WELL SCREEN.
   - 2' THICK BENTONITE SEAL (3/8"-1/4" PELLET) PLACED ABO FILTER PACK.
   - PORTLAND CEMENT (TYPE I TYPICAL) GROUT PLACED IN REMA ANNULAR SPACE TO GRADE.

NO.	DATE	REVISIONS	BY	CHK'D	PROJ ENGR	ENGR	PROJ ENGR
1	11/2/95	REVISE BIOSLURP WELL AND TREATMENT COMPOUND	DLL	VRZ	FBC	FBC	FB
0	11/31/95	ISSUED FOR CONSTRUCTION	RGB	ABJ	FBC	VRZ	JR

SCALE NOTED

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CHARLESTON, SOUTH CAROLINA

BIOSLURPER SYSTEM DETAILS

JOB NO.	DRAWING NO.
22567	227-DD000-005

227D005.DGN

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EXPIRES FEBRUARY 28, 1997

SEAL

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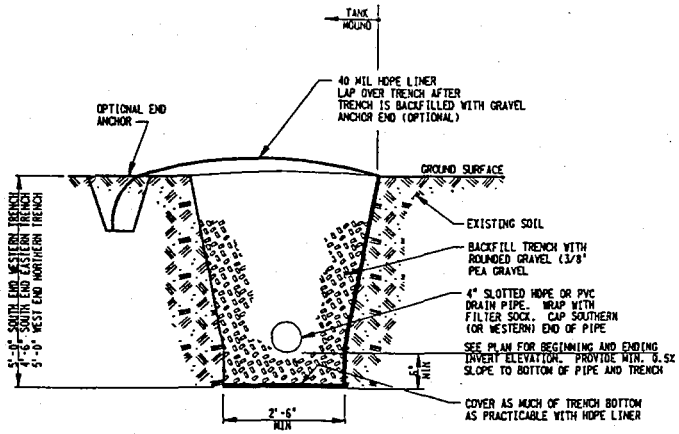
F - 3

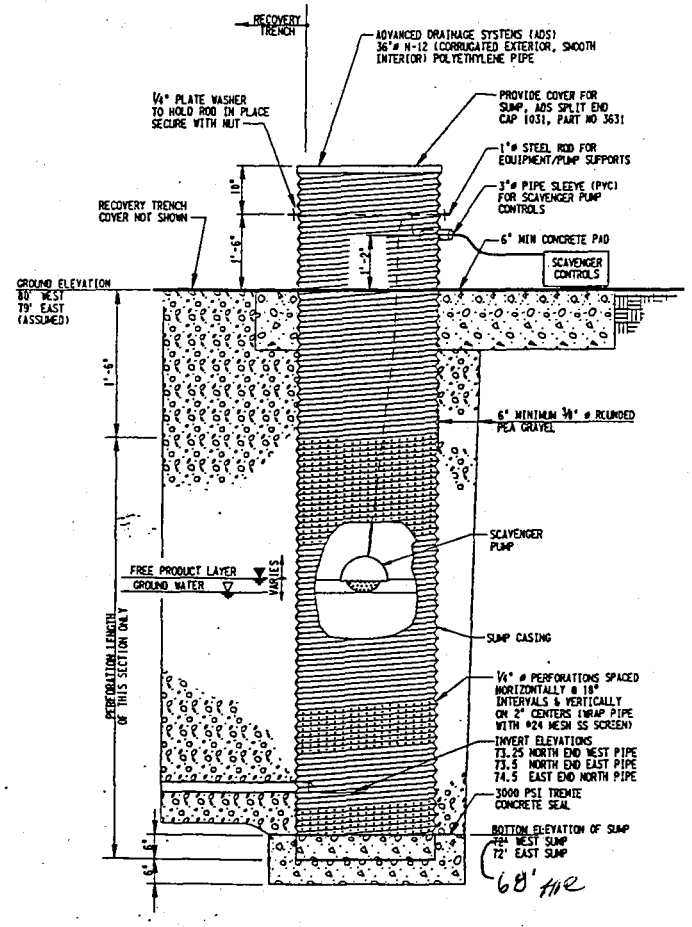


NOTE:

1. CUT SIDE SLOPE OF TRENCH AS NECESSARY TO KEEP TRENCH OPEN DURING EXCAVATION.
2. UNDER NO CIRCUMSTANCES IS ANY WORKMAN TO ENTER THE TRENCH EXCAVATION UNLESS ALL CONDITIONS SET FORTH BY 29 CFR PART 1926 SUBPART P ARE MET.

TYPICAL TRENCH CROSS-SECTION

NTS



TYPICAL SUMP DETAIL

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22567 227 227D006.DGN

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NOTES

NO.	DATE	REVISIONS	BY	CHKD	REVIEW	CHIEF	PROJ CHIEF
0	11/2/95	ORIGINAL ISSUE	DLL	REH	JRM	FBC	

SCALE NONE

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SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMM
CHARLESTON, SOUTH CAROLINA

OIL RECOVERY TRENCH AND OIL RECOVERY SUMP DETAILS

JOB NO.	DRAWING NO.
22567	227-DD000-006

F-4

APPENDIX G

RECIRCULATION WELL SYSTEM DESIGN CALCULATIONS AND VENDOR INFORMATION

Table G1: Time to Cleanup for 5 In-well Aeration Wells

In-Situ Stripping Design Calculations

Date: 1-28-97	Project: NFF RAP	Engineer: KGK	Reviewed by: SG	
Reference: Paper by Todd and Less Parrington, Batelle Publications				
Hydrostatic Head, H				
rw	well radius	4.00	inches	assumed
Qair	air flow rate	10.00	cfm	assumed
Vs	superficial air velocity	0.15	m/s	calculated
L	saturated thickness of the aquifer	50.00	ft	given
H/L	vertical hydraulic gradient	0.27	m/m	Graph 1
H	hydrostatic head generated due to air flow	***13.65***	ft	calculated
Flow Rate, Qc				
Kr	radial hydraulic conductivity	5.00	ft/day	Slug Tests
Kz	vertical hydraulic conductivity	0.40	ft/day	Assumed
rwD	dimensionless well radius	0.0019		Calculated
QD	dimensionless flow rate	0.15		Graph 2
Qc	flow rate	***2.74***	GPM	Calculated
Time for ROI development				
ROI/L	ratio of ROI to saturated thickness	1.00		typical
ROI	radius of influence	50.00	ft	calculated
V	volume of sphere of influence	523598.78	ft^3	calculated
n	porosity	0.25		assumed
Vw	volume of water in the sphere of influence	979129.71	gal.	calculated
S.F.	Factor of Safety	2.00		
t	time for ROI development (i.e., one pore volume)	***496.84***	days	calculated
Hydrodynamic Retardation Factor				
Koc	partitioning coefficient of benzene	100.00		literature
foc	fraction of organics	0.50	%	analyses
Kd	distribution coefficient of benzene	0.50		calculated
B	bulk density	170.00	lb/ft^3	estimated
Rh	hydrodynamic retardation factor	5.09		calculated
Ci	initial concentration	21000.00	ug/L	analyses
Co	target concentration	5000.00	ug/L	given
Co/Ci	fraction remainig	0.24		calculated
N	number of pore volumes	7.30		calculated
T	total time to flush N porevolumes	***9.94***	yrs.	calculated

WASATCH ENVIRONMENTAL, INC.

STATEMENT OF QUALIFICATIONS

2240 West California Avenue
Salt Lake City, Utah 84104-4109
(801) 972-8400 Fax (801) 972-8459

In Situ Aeration: Air Sparging, Bioventing, and Related Remediation Processes

Edited by

Robert E. Hinchee
Battelle Memorial Institute

Ross N. Miller
U.S. Air Force Center for Environmental Excellence

Paul C. Johnson
Arizona State University

BATTELLE PRESS
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G-3

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3(5) *Monitoring and Verification of Bioremediation*

3(6) *Applied Bioremediation of Petroleum Hydrocarbons*

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Design and Application of an Alternative Groundwater Sparging Technology

Todd W. Schrauf and Leslie H. Pennington

ABSTRACT

Density-driven convection, an alternative method of in situ groundwater sparging, is being used to remediate 27 underground storage tank releases involving a wide distillation range of petroleum hydrocarbons (gasoline to waste oil) in a variety of site soils (silty clay to sandy gravel). The described method overcomes many of the inherent disadvantages of air sparging methods currently in use (such as pressurized injection) without additional complexity in design, installation, or operation. The principles of operation and design for density-driven convection are discussed in detail and supported by field and laboratory studies. Primary factors affecting the hydraulic driving force, groundwater circulation patterns around the sparging well, and air stripping performance are identified and related to system design. The effectiveness of the system is demonstrated with results from full-scale system installations.

INTRODUCTION

Groundwater sparging is a term applied to the injection of air below the water table to induce contaminant removal by volatilization and enhancement of natural aerobic biodegradation. Two separate methods have been used to introduce air to the saturated subsurface: (1) pressurized injection of air into the pore space surrounding the sparge well; and (2) aeration of water within the sparge well by bubbling air through the wellbore water column. The latter method, which the authors have termed density-driven convection (Notice of Allowance for patent received), also is referred to as in-well aeration.

A diagram of a density-driven convection well is presented in Figure 1. Air is injected through a small-diameter line at the base of the well and allowed to bubble upward in the wellbore. The well is constructed with standard monitoring well construction materials, but includes upper and lower screen intervals separated by an annular seal. The upper screen straddles the water table surface

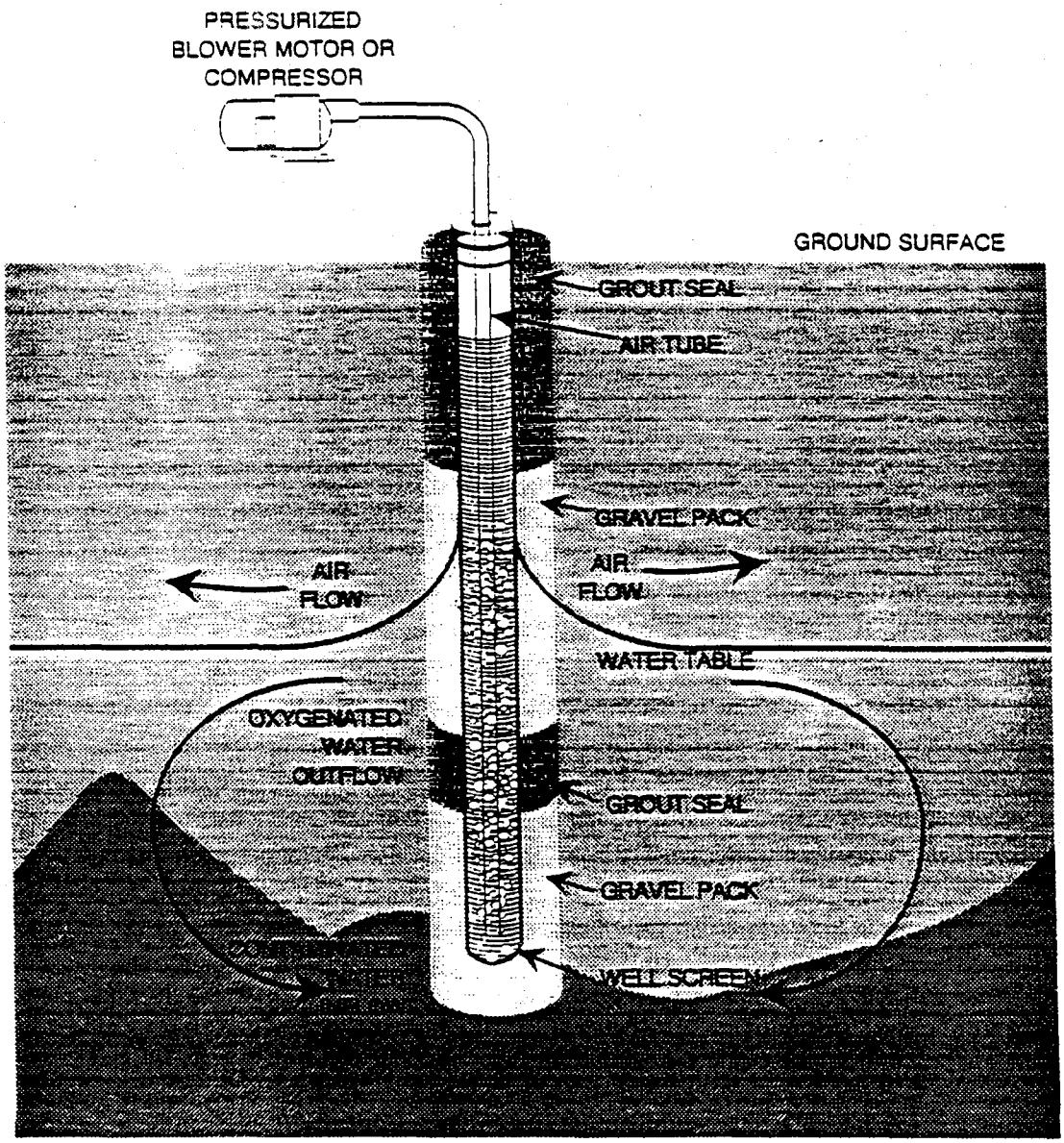

FIGURE 1. Schematic of density-driven convection system.

and exhaust air from the well is discharged to the vadose zone soils via the unwetted portion of the upper screen. Bubbling air within the well creates a hydrostatic head gradient along the wellbore which drives aerated water out of the upper well screen while simultaneously drawing resident groundwater in through the lower screen. Because only water circulates through the formation, the method is suitable for fine-grained soils and high air pressures are not required. The system may also be used to distribute alternative electron acceptors and biological nutrients.

The principles of wellbore hydraulics, groundwater hydraulics, and air-water mass transfer are presented. Evaluation of vadose zone aeration and vapor degradation, associated with exhausting of air through the upper well screen, follows

.e same principles used in the design of soil vapor extraction and bioventing systems and is not presented herein.

WELLBORE HYDRAULICS

Four distinct flow patterns, shown in Figure 2, have been observed in laboratory experiments (Govier et al. 1957) of the flow of gas-liquid mixtures in vertical pipes. The stable flow pattern observed is strongly dependent upon the superficial gas velocity (volumetric gas flowrate/cross-sectional area) and weakly dependent upon the superficial liquid velocity. The slug flow pattern has been observed in laboratory studies conducted by the authors using a 5 cm diameter clear plastic pipe at air flowrates of 0.3 to 2.3 m^3/h (0.2 to 1.3 cfm). Field measurements of wellbore fluid conductivity and pressure at a fixed measurement point over time also suggest a slug flow pattern in both 5-cm and 10-cm-diameter wells at air flowrates of 1.7 to 6.8 m^3/h (1 to 4 cfm). The identical slug flow pattern was observed using both open tube and air diffuser tips at the point of air injection. Slug flow is characterized by alternating bullet-shaped bubbles (termed Taylor bubbles), which are surrounded by a thin annulus of water, and water slugs containing small air bubbles.

The hydrostatic pressure gradient created along the wellbore during air injection is directly related to the density of the air-water mixture as illustrated in Figure 3. Prior to the introduction of air, the hydraulic head along the wellbore is equal to the static hydraulic head (H_i) in the surrounding formation (Figure 3a). Introduction of air into the wellbore (Figure 3b) results in a change in the average density of the wellbore fluid column and the creation of a vertical hydraulic head gradient (dH/dz) along the wellbore given by:

$$dH/dz = E_g/(1-2T_f/D)^2 - h_l \approx E_g \qquad (1)$$

where E_g is the volume of air per unit volume of mixture, T_f is the water film thickness around the Taylor bubble, D is the wellbore diameter, and h_l is the frictional head loss per unit length associated with water flow through the wellbore. Due to the high density contrast of air and water, the density of the air is ignored in Equation 1. T_f and h_l can be calculated using formulas presented by Govier and Aziz (1972), provided the air and water flowrates through the wellbore are known. For most cases of practical interest, the values of T_f and h_l are sufficiently small that dH/dz can be assumed to approximately equal E_g. Due to the compressibility of air, the value of E_g at a given air flowrate decreases with increasing depth below the water table.

As water flows out of the upper portion of the well into the formation, the height of the air-water column (i.e., the average hydraulic head) in the wellbore decreases so that the average hydraulic head in the wellbore matches that in the adjacent formation (Figure 3c). Because the density contrast of the wellbore fluid with the formation water creates the driving force for groundwater circulation, the term density-driven convection has been used to describe the process.

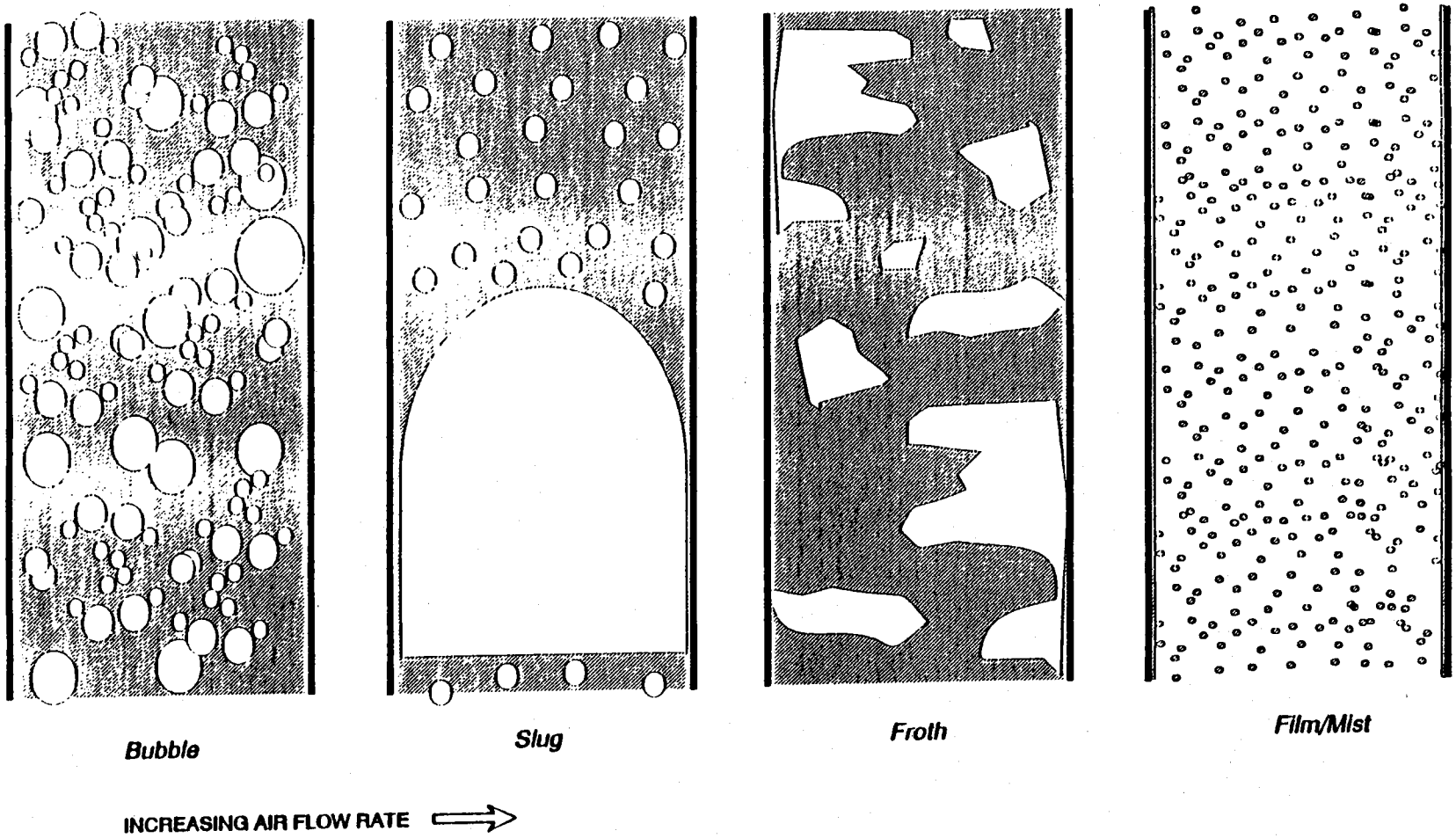

FIGURE 2. Observed flow patterns for air-water mixtures.

8-4

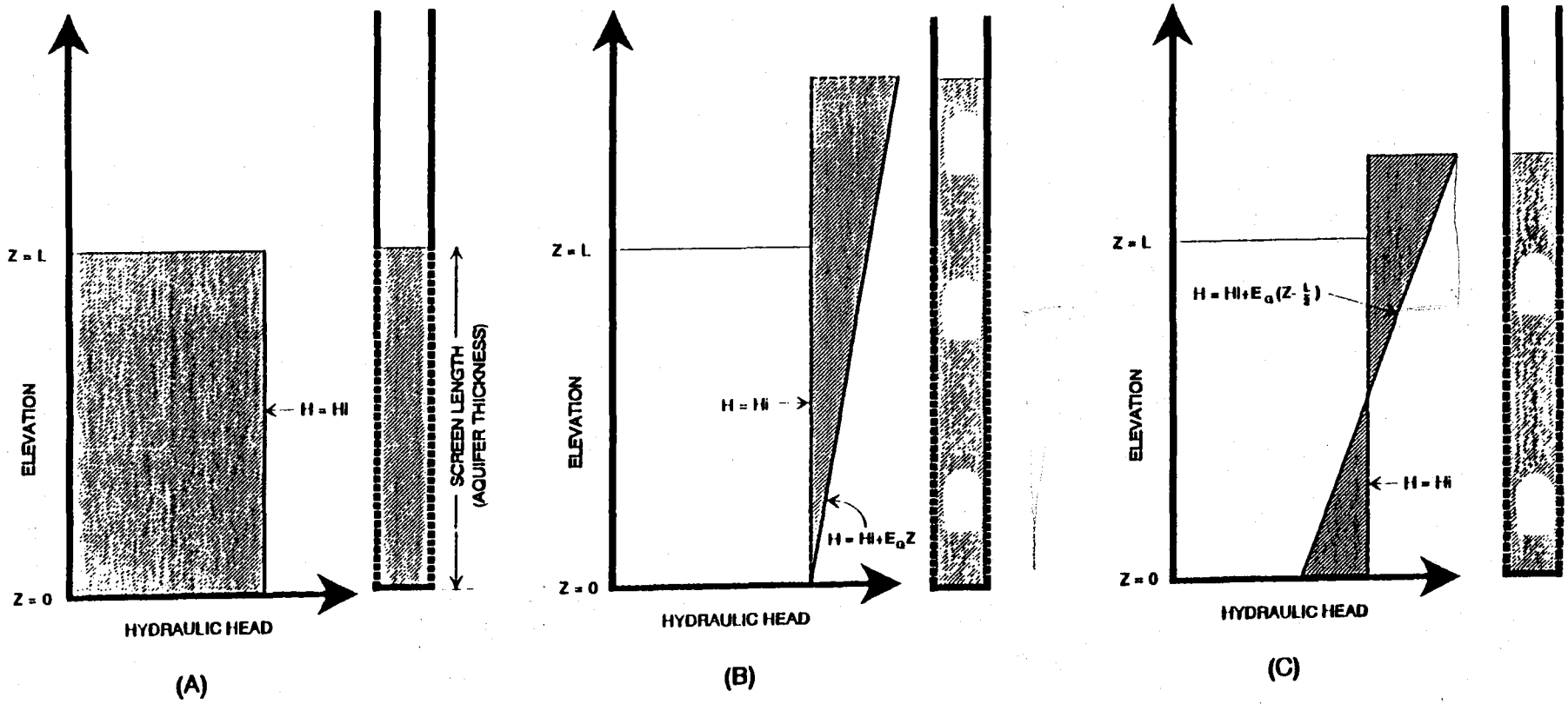

FIGURE 3. Evaluation of driving force for bubble/slug flow.

Laboratory experiments by Akagawa (1964) and Akagawa and Sakaguchi (1966) indicate the hydraulic gradient along the wellbore is strongly dependent upon the superficial air velocity and weakly dependent upon the superficial water velocity. Although the hydraulic gradient initially increases rapidly with increasing superficial air velocity, the hydraulic gradient asymptotically approaches a maximum of about 0.7 m/m at superficial air velocities of about 1.5 m/s. At a given superficial air velocity, the hydraulic gradient decreases slightly in direct proportion to the increase in superficial water velocity. Laboratory and field measurements of hydraulic gradient versus superficial air velocity conducted by the authors have agreed with these previously reported experimental results (Figure 4).

With the relationships presented in this section, the achievable hydraulic gradient and required air flowrate necessary to maintain that gradient can be determined. For shallow groundwater conditions the maximum achievable hydraulic gradient is limited by the depth to groundwater, unless the well casing can be extended above ground surface. Although the relationship between hydraulic gradient and air flowrate can be measured directly in the field, sufficiently accurate estimates for engineering design can normally be obtained from laboratory data.

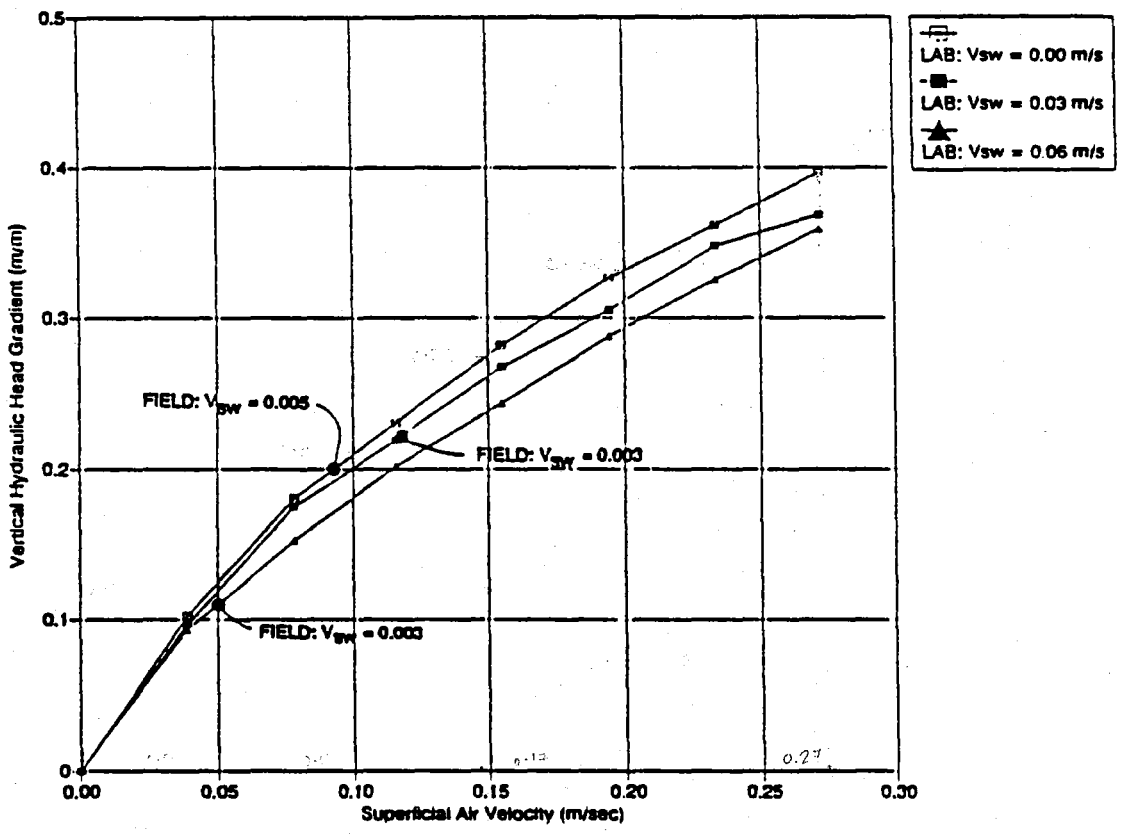

FIGURE 4. Measurements of hydraulic gradient versus superficial air velocity.

GROUNDWATER HYDRAULICS

The hydrostatic head gradient within the wellbore provides the driving force for groundwater circulation in the formation surrounding the sparge well. To evaluate the pattern of groundwater circulation around the sparge well, an analytical solution to Laplace's equation for steady-state groundwater flow in a two-dimensional (radial and vertical) flow field around a sparge well was obtained using separation of variables. The solution for the hydraulic head distribution, based on the flow geometry and boundary conditions presented in Figure 5, is given by:

$$h_D(r,z) = -4/\Pi^2 \sum_{n_{odd}} K_o(nk^*r)\cos(nkz)/K_o(nk^*r_w)n^2$$
$$k = \Pi/L; \quad k^* = k(K_z/K_r)^{0.5} \tag{2}$$

where:
- h_D = the dimensionless head change (head change divided by the total head differential at the sparge well)
- K_o = the modified zero-order Bessel function of the second kind
- L = the aquifer thickness
- r = the radial coordinate (r=0 at centerline of well)
- z = the vertical coordinate (z=0 at base of aquifer)
- r_w = the well radius
- K_r = the radial (horizontal) hydraulic conductivity
- K_z = the vertical hydraulic conductivity

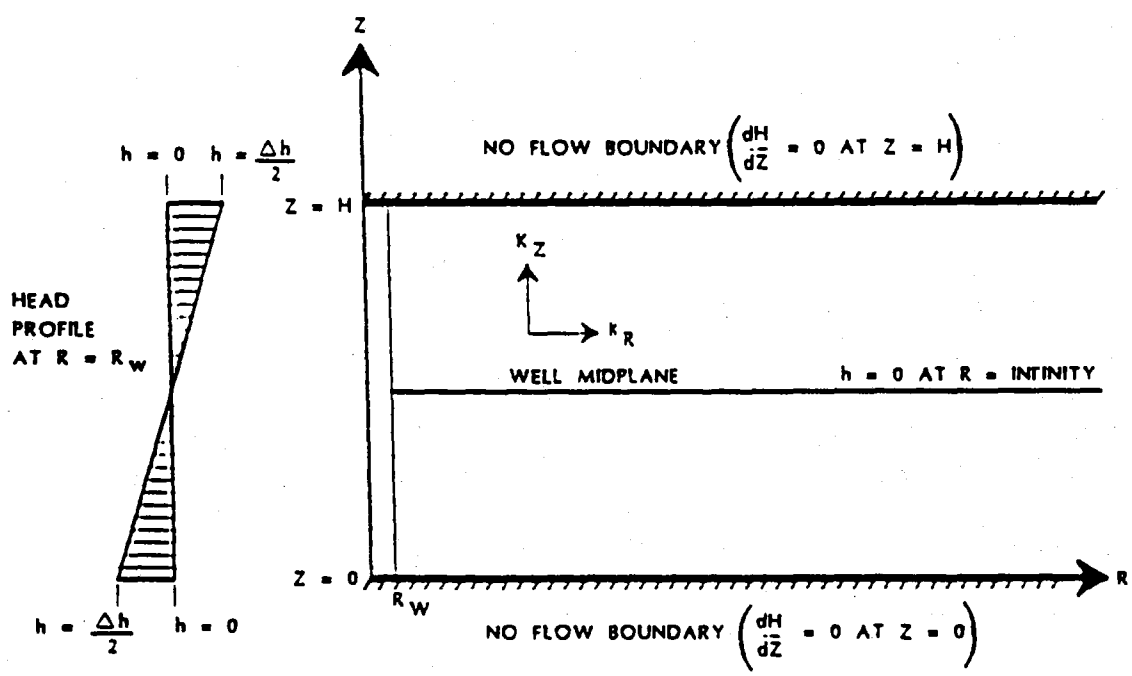

FIGURE 5. Boundary conditions for analytical solution.

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Equation 2 is a function of three dimensionless spatial variables: $r_D = (r/L)(K_z/K_r)^{0.5}$; $r_{wD} = (r_w/L)(K_z/K_r)^{0.5}$; and $z_D = (z/L)$. By virtue of the definition of these dimensionless variables, the effects of aquifer thickness and horizontal to vertical conductivity ratios are accounted for by scaling the problem to an equivalent dimensionless space. This is analogous to the use of type curve fitting techniques for pumping test analysis.

Of greater interest in defining the flow field around a sparge well is the pattern of groundwater flow, or streamlines around the well. Using Equation 2 to determine derivatives of hydraulic head with respect to r and z, a stream function may be defined as the cumulative flowrate Q_c over a line integral between $(r_w,0)$ and any arbitrary (r,z). This stream function is given by:

$$Q_c(r,z) = -8\Delta h(K_zK_r)^{0.5}r/\Pi \sum_{n_{odd}} \sin(nkz)K_1(nk^*r)/n^2K_0(nk^*r_w) \qquad (3)$$

where K_1 is the modified first-order Bessel function of the second kind. Equation 3 is also a function of the three dimensionless variables: r_D, r_{wD}, and z_D. For $r_{wD} < 0.03$, Equation 3 is a function of r_D and z_D only. The streamlines defined by Equation 3 are presented in Figure 6 for $r_{wD} = 0.01$, where each streamtube represents 10% of the total flow through the sparge well. As seen from Figure 6, outflow from the upper well screen is concentrated towards the top of the well, with 50% of the outflow occurring within the upper 15% of the total aquifer

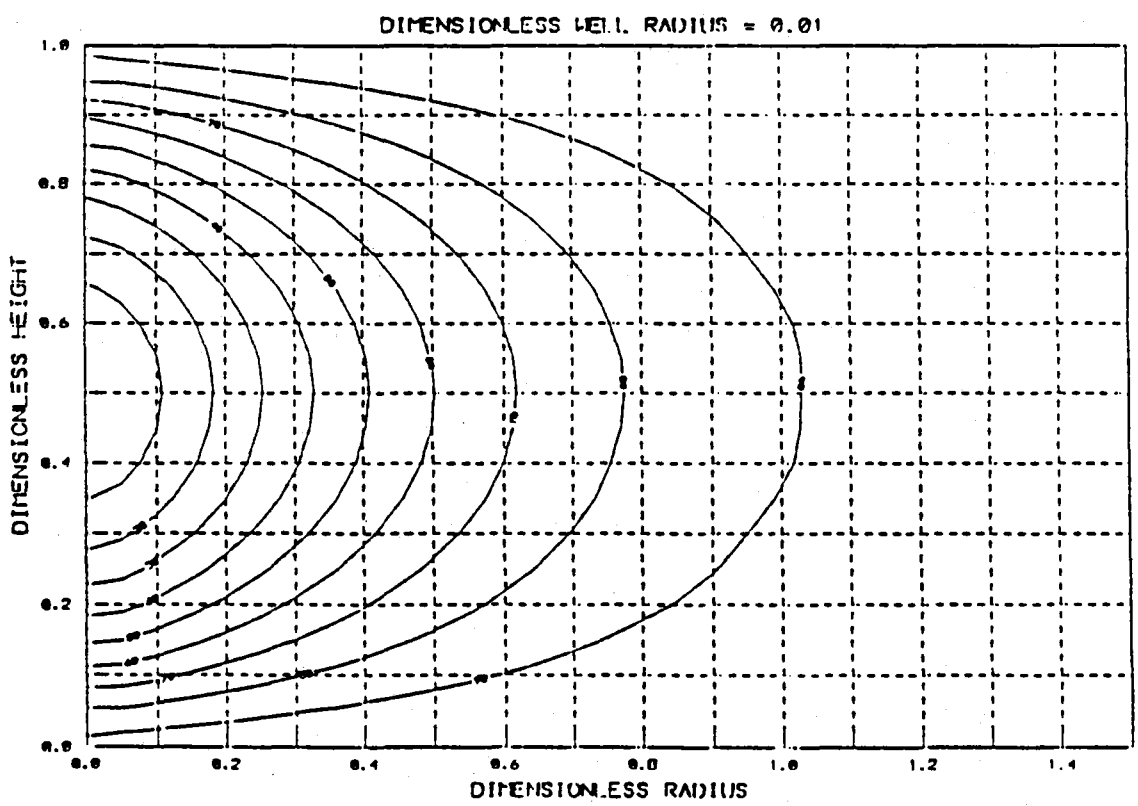

FIGURE 6. Sparge well streamlines as a percent of total flow.

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thickness. As petroleum hydrocarbon contamination is normally concentrated near the top of the aquifer (or water table surface for unconfined aquifers), the system delivers most of the aerated water outflow to the most contaminated portion of the aquifer. The inflow to the well is similarly concentrated towards the base of the aquifer. As denser types of contamination, such as volatile chlorinated solvents, often accumulate near the base of the aquifer, the system may be particularly effective in removing such contamination. In comparison, pressurized injection systems treat a zone which cones outwards from the base of the aquifer and thus may not be effective in removing contamination concentrated at the aquifer base.

The radius of influence of a sparge well is theoretically infinite, but has been previously defined as the radial distance where the cumulative flow across the centerline $z_D = 0.5$ equals a certain percentage of the total groundwater circulation through the sparge well. For $r_{wD} < 0.03$, approximately 90% of the total flow occurs within a radius of $r_D = 1$. This effective radius of influence has been confirmed in laboratory bench-scale simulations of sparge well operation in a coarse sand using a rhodamine dye tracer. This radius of influence should be considered a maximum hydraulic radius of influence for system design, and spacing between sparge wells placed in a regular grid over the area of contamination should not exceed $r_D = 2$.

The total groundwater circulation rate (water flowrate) through the sparge well equals $Q_c(r_w, L/2)$. It is convenient to express the total circulation rate in dimensionless form as:

$$Q_D(r_{wD}) = Q_c(r_w, L/2)/\Delta hLK_r \tag{4}$$

The dimensionless total flowrate is a function of r_{wD} only, as shown in Figure 7. Equation 4 is used to determine the achievable groundwater circulation rate, given measurements or estimates of the horizontal hydraulic conductivity.

In tight formations where groundwater circulation rates are reduced, a smaller well spacing may be desirable to reduce the operational life of the system. The simplest method of evaluating the relationship between well spacing and time to complete remediation is to use the estimated groundwater circulation rate (Equation 4) to determine the rate of hydrocarbon removal by biodegradation (assuming oxygen limited degradation) and volatilization. The estimated total mass of hydrocarbon to be removed within the aquifer volume Lr_D^2 is then divided by the removal rate.

Equation 4 was derived assuming that the well was fully screened across the aquifer. In actual field installations, the well is screened across only the upper and lower portions of the aquifer. Comparison of the analytical solution results to numerical (finite difference) model results, indicate that the effect of partial screening is relatively minor both in terms of the pattern of groundwater circulation and the total rate of circulation. Reducing the combined length of the upper and lower screen lengths to 40 and 20% of the total aquifer thickness reduced the total flow rate by 11 and 47%, respectively. In comparison, the total screen length is at least 60% of the total aquifer thickness in actual field installations.

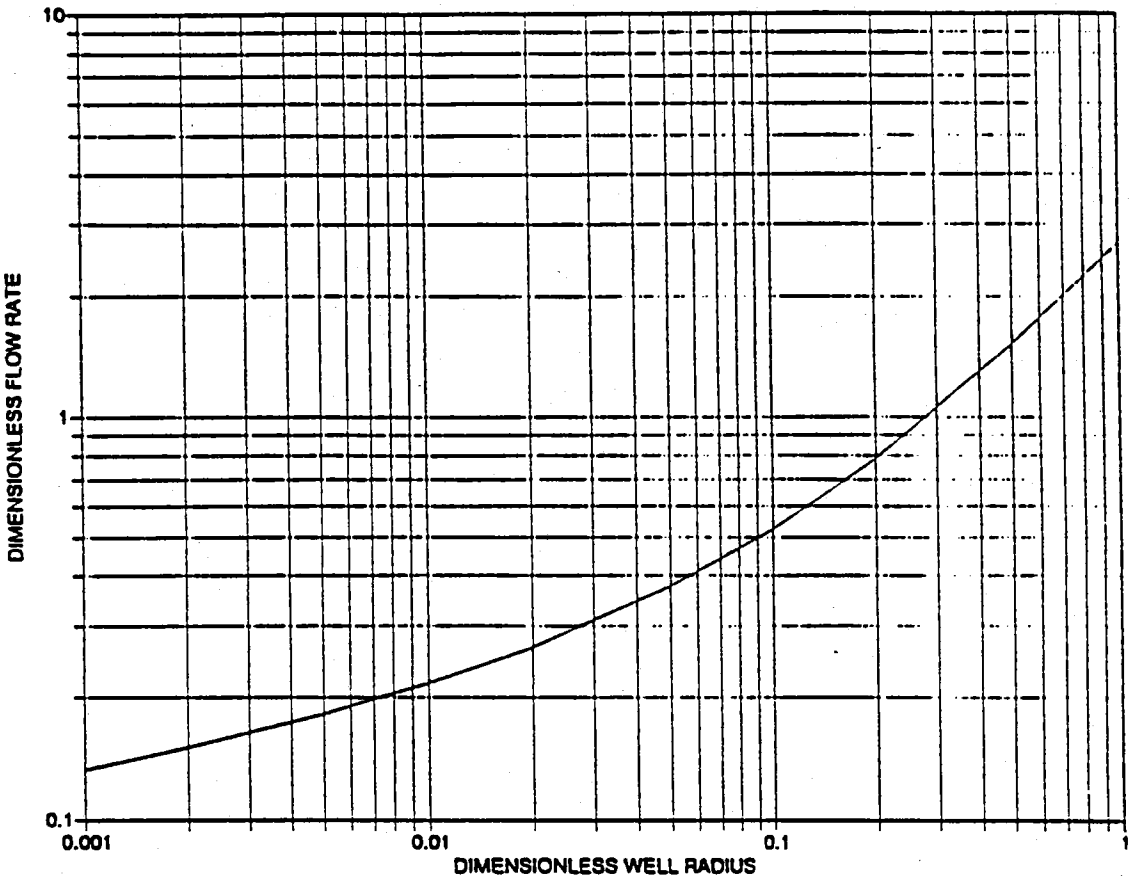

FIGURE 7. Dimensionless flowrate versus dimensionless well radius.

The analytical solution presented here assumes that the aquifer is confined, whereas many field applications are in unconfined aquifers. Hence, the solution may not be valid in unconfined aquifers where the water table rise at the well is large compared to the total aquifer thickness. Although the analytical solution was derived for a single well in an aquifer of infinite aerial extent, the effect of adjacent sparge wells can be accounted for using the principle of superposition.

CONTAMINANT REMOVAL MECHANISMS

Contaminant removal is effected during sparge well operation by two mechanisms: (1) supply of oxygen to promote aerobic biological degradation; and (2) removal (air stripping) of volatile organic compounds from the circulating groundwater. The rate of contaminant removal from the vadose zone by both mechanisms is dependent upon the rate of groundwater circulation through the sparge well and the rate of mass transfer between the air and water phases. The rate of groundwater circulation can be estimated using Equation 4.

The rate of mass transfer can be evaluated for volatile compounds (Henry's law constant > 0.04) using a first-order approximation to Fick's law of diffusion.

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Gvirtzman and Gorelick (1992) presented engineering estimates of mass transfer efficiency for TCE for slug flow and concluded the air bubbles in the sparge well would reach equilibrium partitioning between the air and water phases over a well length of 10 meters. The authors have conducted a more exact evaluation of mass transfer efficiency with similar results and found the percent decrease in groundwater solute concentration during one pass through the sparge well is strongly dependent upon the holdup ratio (ratio of average air velocity to average water velocity). The holdup ratio increases dramatically (up to a maximum of about 100) with increased air injection rates and can be controlled for a given water flow rate by selecting a suitable well diameter and air injection rate. Field measurements indicate that water exiting the sparge well is saturated with oxygen even over well lengths as small as 2 m. A single measurement of the removal efficiency of trichloroethylene over a well length of 6 meters indicated a removal efficiency of 98.5% (reduction from 250 to 3.7 μg/L), which compared favorably to a calculated removal efficiency of 96% assuming equilibrium portioning between the air and water phases.

Air stripping often results in the formation of calcium carbonate and iron oxide precipitates or scaling. Scaling tends to clog the well screen and reduce the rate of groundwater circulation. Scale has been readily removed from PVC well casing in field installations using a high-pressure water spray. Measurements of hydraulic conductivity in sparge wells, at the time of installation and following scale removal, showed no apparent reduction in well performance.

CASE HISTORY SUMMARY

The density-driven convection (DDC) system has been implemented at a total of 27 sites to date. Of these 27 sites, 8 cleanups have been completed and 11 systems have been operating for periods of greater than 6 months. These 19 sites are summarized in Table 1. A detailed case history for a single site has been previously presented by Schrauf et al. (1994). To evaluate the effectiveness of the DDC system, first-order decay constants were calculated from the change in maximum soil and/or groundwater concentrations over the operational life of the system. First-order decay is described by the equation $C/C_o = e^{-kt}$, where C/C_o is the ratio of the current to initial concentration, k is the decay constant, and t is elapsed time since start of remediation. Results of periodic monitoring at DDC sites generally indicate a first-order rate of decline in dissolved groundwater concentrations. Exceptions to this include sites where free product is present, because free product at the source area continues to dissolve into the groundwater until all residual free product is removed. For this reason, meaningful decay constants cannot be calculated at these sites based on maximum concentrations.

Comparison of the calculated decay constants for total petroleum hydrocarbons at sites remediated using DDC sparging with those undergoing natural attenuation (no active remediation) over periods of 26 to 41 months within the same geographical areas are presented in Figure 8. As calculated decay constants

TABLE 1. Case history summary (all concentrations in mg/L or mg/kg; S = soil; G = groundwater).

Release Type (FP = Free Product)	USCS Soil Type	Plume Area (m^2)	Operating Period (mos)	Maximum Initial Concentration			Maximum Final Concentration		
				TPH	Benzene	Naphthalene	TPH	Benzene	Naphthalene
Completed Remediations									
Diesel	SW,GW	900	18	11,200 (S); 15 (G)		1.7 (S); 0.18 (G)	13 (S); 0.11 (G)		<0.1 (S); <0.004 (G)
Waste Oil (FP)	SM,CL	1,000	12	190 (G)			3.7 (G)		
Gasoline	SW	50	6	67 (S); 15 (G)	0.1 (S); 0.78 (G)	0.5 (S); 0.09 (G)	<2.0 (S); <0.02 (G)	<0.1 (S); <0.002 (G)	<0.1 (S); <0.004 (G)
Gasoline, Diesel	SP,SM	200	12	18 (G)	0.19 (G)	0.14 (G)	0.13 (G)	0.021 (G)	<0.004 (G)
Gasoline, Diesel	SW,GW	3,000	18	1,600 (S); 190 (G)	4.7 (S); 7.8 (G)	0.63 (G)	19 (S); 1.3 (G)	<0.1 (S); <0.002 (G)	<0.1 (S); 0.01 (G)
Gasoline	SM,ML	240	12	0.65 (G)	0.34 (G)	0.01 (G)	0.06 (G)	0.008 (G)	<0.004 (G)
Gasoline	SM,ML	100	15	7,000 (S); 8.5 (G)	15 (S); 0.43 (G)	1.7 (S); 0.1 (G)	<2.0 (S); <0.02 (G)	<0.1 (S); <0.002 (G)	<0.1 (S); <0.004 (G)
Waste Oil	CL	100	5	1,300 (S); 66 (G)			<20 (S); <1 (G)		
Ongoing Remediations									
Diesel	CL,SM	100	42	51,000 (S); 110 (G)	0.16 (S); 0.12 (G)	0.16 (G)	170 (S); <0.02 (G)	<0.1 (S); <0.002 (G)	0.7 (S); <0.004 (G)
Hydraulic Oil (FP)	CL	1,100	36	1,100 (G)			<1 (G)		
Gasoline (FP)	SC,SM	3,500	36	88 (G)	14 (G)		79 (G)	5.6 (G)	0.69 (G)
Gasoline (FP)	ML,SM	3,000	16	7.1 (G)	4.3 (G)	0.14 (G)	26 (G)	8.2 (G)	0.36 (G)
Gasoline (FP)	ML,SM	1,000	16	8.9 (G)	0.45 (G)	0.17 (G)	6.3 (G)	0.21 (G)	0.17 (G)
Gasoline	CL	1,700	15	8,800 (S)	9.8 (S)		720 (S)	1.9 (S)	
Diesel				43 (G)	5.7 (G)	0.71 (G)	9.8 (G)	1.5 (G)	0.41 (G)
Gasoline	SP,SM	2,500	14	52 (G)	2.7 (G)	0.48 (G)	2.0 (G)	0.15 (G)	0.031 (G)
Gasoline	SP,ML	2,000	14	330 (G)	0.79 (G)	0.71 (G)	0.41 (G)	0.31 (G)	0.18 (G)
Gasoline	SM,ML	600	12	89 (G)	6.9 (G)	0.78 (G)	14 (G)	1.9 (G)	0.21 (G)
Gasoline	SP,ML	1,700	10	15 (G)	2.2 (G)	0.1 (G)	3.0 (G)	0.21 (G)	0.041 (G)
Gasoline (FP)	SM,ML	5,400	8	58 (G)	15 (G)	0.61 (G)	51 (G)	12 (G)	0.47 (G)

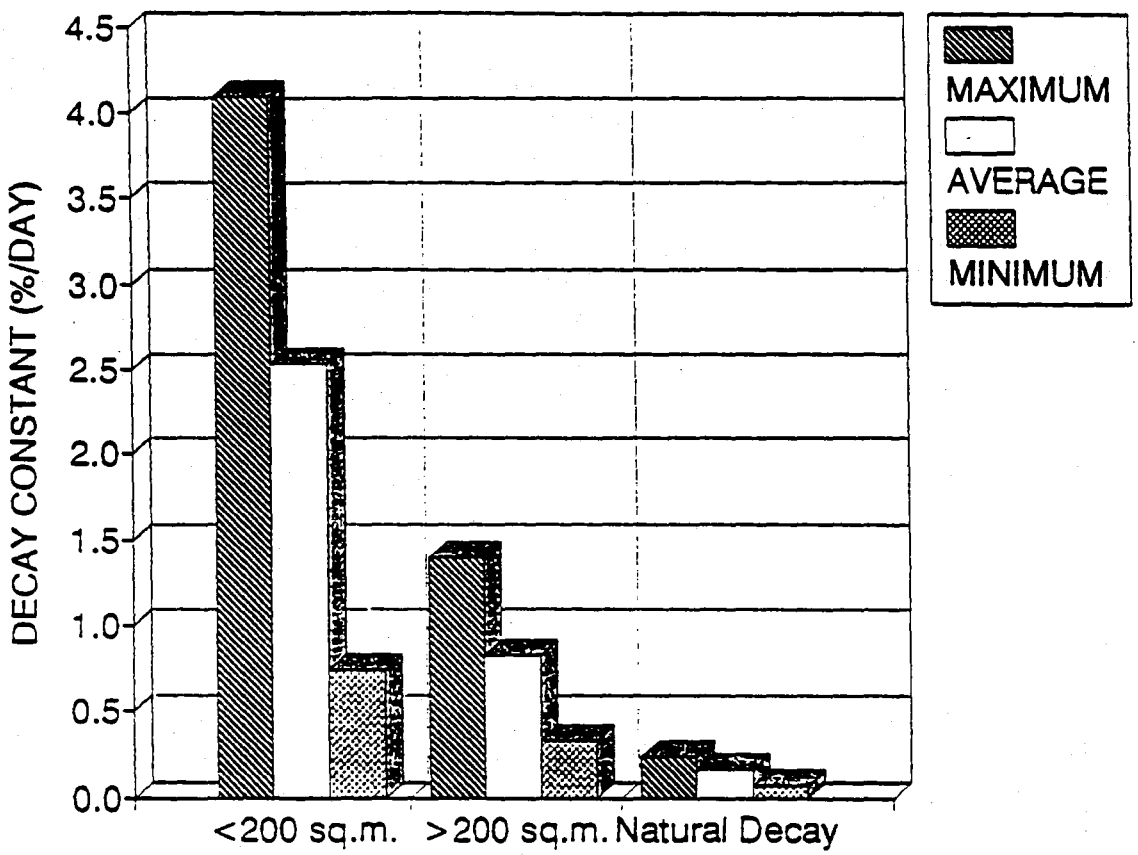

FIGURE 8. TPH decay constants for DDC sparging and natural attenuation.

for smaller sites (plume area <200 m^2) are generally higher and more variable than larger sites, the calculated decay constants for these two groups are presented separately. For larger sites, these data indicate sparging accelerates the rate of contaminant removal by an average of five times that observed for natural attenuation. DDC sparging has been employed in conjunction with complementary technologies, including vapor extraction systems and groundwater recirculation systems. Groundwater recirculation involves extraction of contaminated groundwater at the downgradient edge of the plume and reinjection along the upgradient edge of the plume. The average decay constants for sites utilizing DDC sparging alone and those employing DDC sparging with either vapor extraction or groundwater recirculation are virtually identical. No significant difference was found when comparing average decay constants for sites with different soil types.

SUMMARY AND CONCLUSIONS

Slug flow is the characteristic flow pattern observed during in-well aeration. The driving force for groundwater circulation is the density difference of the

air water mixture in the wellbore and the surrounding groundwater which creates a hydraulic head gradient along the well. The rate of groundwater circulation through the sparge well can be evaluated from the horizontal hydraulic conductivity and hydraulic head gradient along the well. Water circulation rates are necessary to determine the rate of contaminant removal by both biodegradation and volatilization. The effective radius of influence is a function of the saturated aquifer thickness and the ratio of horizontal to vertical hydraulic conductivity. Mass transfer of volatile substances between the air and water phases is relatively efficient, with oxygen saturation of the water phase occurring within a well length of 2 meters. Observed performance of systems operating for over 6 months indicates that the average rate of hydrocarbon degradation is increased 5 times over natural degradation rates.

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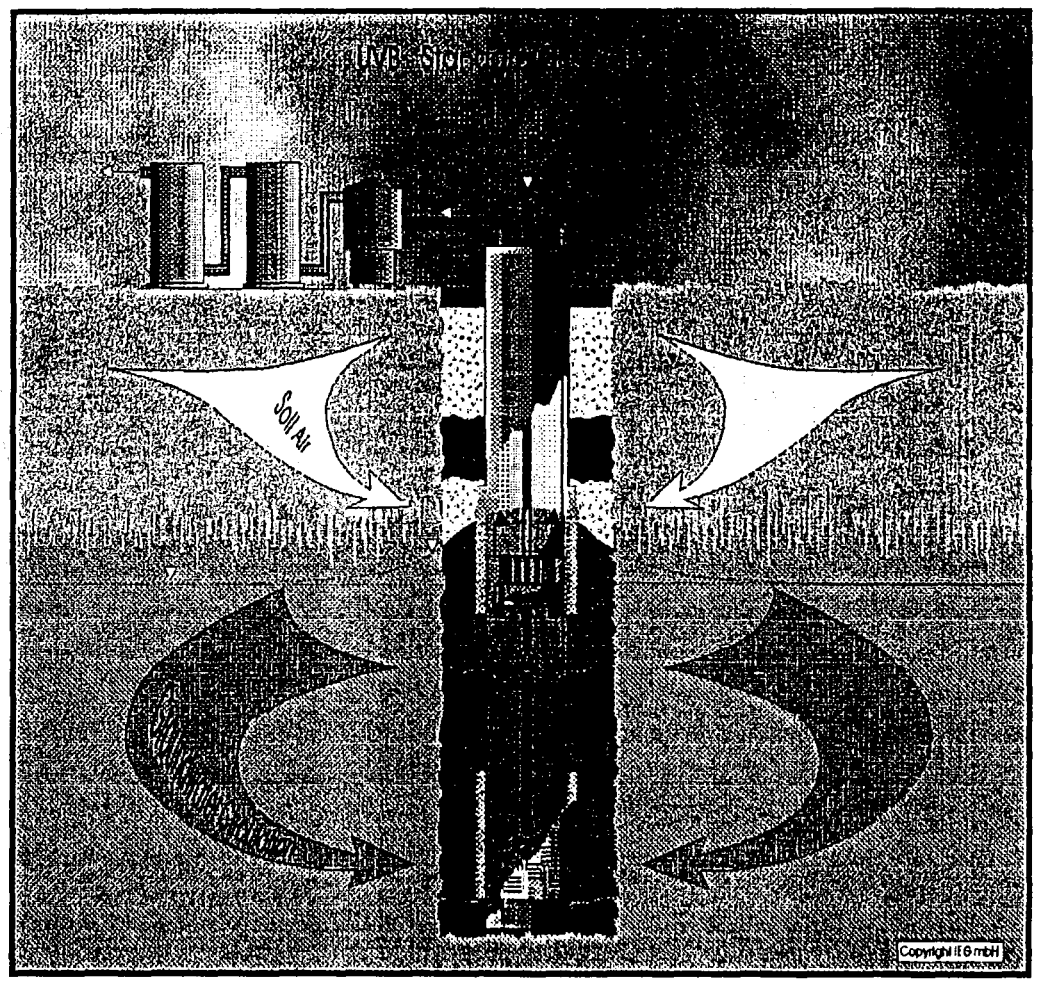
INNOVATIVE BIOREMEDIATION UTILIZING VERTICAL GROUNDWATER CIRCULATION CELL TECHNOLOGY



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Environmental Engineers and Bioremediation Specialists

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Environmental Engineers and Bioremediation Specialists

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SENT TO: Gopi Kanchibhara

FIRM: ABB Environmental Services, Inc. - Tallahassee

FAX NO.: (904) 877-0742 SENT FROM: Susanne Borchert

COMMENTS:

I apologize for the delay, but hope you find the following calculations useful in your evaluation of technology alternatives for this site. Feel free to call me with any questions you may have! Also, if you would like for me to calculate constituent of interest (COI) removal rates and stripping efficiencies, please provide me with addition data regarding COI concentrations found at the site!

Happy holidays - sincerely

Susanne B.

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Susan Borchert → Ph: 904 934 9343

SBP Technologies, Inc.
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REMEDIATION CONCEPT AND PRELIMINARY COST ANALYSIS FOR UVB INSTALLATION AND OPERATION

Prepared for
NAS Cecil Field, North Fuel Farm Site in Jacksonville, FL
ABB Environmental Services, Inc., Tallahassee, FL
SBP Project Number: T7037.00

Date: December 18, 1996

1.0 INTRODUCTION

Gopi Kanchibhara of ABB Environmental Services, Inc. (ABB), Tallahassee, asked SBP Technologies, Inc. (SBP) to assess and describe the feasibility of implementing SBP's *in situ* bioremediation systems (UVBs or CGC/CGAs) at the NAS Cecil Field area for the treatment of groundwater impacted by volatile organic compounds (VOCs). The proposal addresses *in situ* bioremediation and source management (or "hot spot remediation") of the impacted groundwater in the intermediate zone (approximately 50 to 90 ft bls), downgradient of six tanks. In addition, an overview of costs associated with remediation design, remediation system(s) installation, operation and maintenance, and performance monitoring are presented.

2.0 BACKGROUND INFORMATION

The data provided to SBP on November 27, 1996 supplied the background for this bioremediation concept and cost assessment:

1) Groundwater in the unconfined aquifer flows towards the SE to ESE.

2) The average horizontal hydraulic conductivity (Kh) calculated for the intermediate zone (65 to 80 ft bls) is 4.08 ft/day, or 1.4 $x10^{-3}$ cm/s. The lithologies above and below this zone reflect hydraulic conductivities of 5.67 ft/day or 2 $x10^{-3}$ cm/s and 0.29 ft/day or 1.05 x10 cm/s, respectively.

3) Vertical hydraulic conductivity (Kv) is estimated to be 1.4 $x10^{-4}$ cm/s, based on horizontal stratification (Kh to Kv ratio of 10:1).

4) The hydraulic gradient was determined to be 0.001 ft/ft from Figure 3-12 (Potentiometric Map of Intermediate Zone).

5) The average Darcy (linear) velocity using a 0.001 ft/ft gradient and a 4.08 ft/day horizontal hydraulic conductivity is 0.0041 ft/day (1.4 $x10^{-6}$ cm/s), or 1.5 ft/year (0.44 m/year). The average seepage velocity taking into account a porosity of 20 % (n=0.2) is 7.5 ft/year (2.2 m/year).

6) The groundwater table is encountered about 5 ft below land surface (bls). Seasonal fluctuations of the water table have been measured to be no more than 2 feet.

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7) The thickness of the groundwater saturated zone impacted by VOCs is up to 100 ft, however, the thickness of the impacted zone to be treated with a circulation well is about 40 ft (50 to 90 ft bls).

8) The lithology of the impacted saturated zone at the site consists of a clayey fine- to coarse-grained sand.

9) The subsurface constituents of interest are VOCs (individual constituents not known).

10) Geochemistry of the groundwater or inorganics such as iron (5 ppm) are not anticipated to hinder the operation of an *in situ* system. Bicarbonate alkalinity needs to be evaluated for the intermediate saturated zone.

3.0 INITIAL REMEDIATION CONCEPT

Site characterization data suggests that *in situ* bioremediation using vertical circulation cell technologies represents a viable, cost-efficient remedial option. The groundwater remedial system will mobilize and transport the VOCs via groundwater circulation to the UVB well and volatize them with *in situ* stripping. Simultaneously, *in situ* aerobic bioremediation is enhanced by continuously enriching the groundwater within the circulation cell with a high dissolved oxygen concentration (from in-well aeration). Inorganic nutrients (nitrogen and phosphorus) may need to be added (injection of nutrients into a monitoring well adjacent to the lower screen section) to optimize biodegradation efficiency. Again, the circulation cell around the UVB well is used to distribute the nutrients throughout the biodegradation zone.

Depending on compounds present in the groundwater, establishing environmental conditions more conducive to aerobic biodegradation processes is more advantageous and desirable due to the production of hazardous intermediates during the course of anaerobic biotransformation of certain constituents (i.e., TCE yielding VC). The UVB system proposed herein is most effective in establishing such conditions *in situ*. Recognizing, of course, that no technology is capable of generating entirely aerobic or anaerobic conditions for an aquifer (niches will always exist), the combined effects of in-well aeration, *in situ* air stripping using negative pressure, and 3-dimensional circulation of oxygenated groundwater make the proposed technologies a preferred remedial approach.

3.1 Source Reduction and Remediation in the vicinity downgradient of the tanks

SBP recommends implementing one *in situ* UVB-400 (400 stands for a 400 mm or 16" diameter well casing) standard or reverse flow groundwater circulation system. The standard flow circulation is recommended in the case of completely dissolved or DNAPL constituents in the groundwater, whereas a reverse flow circulation is more desirable if the constituents include LNAPL. The dissolved concentrations are immediately drawn into the *in situ* stripping reactor through the lower or upper screen section. Groundwater is stripped and simultaneously oxygenated before it is thrust out radially through the second screen section, creating the circulation cell.

We propose to place the system east of the tanks (where the concentrations exceed 5000 ppb - see copy of figure). The partially penetrating well should be placed to a depth of approximately 90 ft below land surface. The lower screen will be implemented at this depth,

whereas the upper screen will be located at about 50 ft bls. The circulation cell induced by the well will develop in the approximately 40 ft thick saturated zone between the two screens, mobilizing and transporting the VOCs to the treatment well. If a circulation flow rate of 4 m^3/hr (ca. 17 gpm) is assumed, and a hydraulic conductivity of 1.4 $x10^{-3}$ cm/sec is used, the effective radius of influence in the groundwater saturated zone will be about 165 ft (50.2 m). This is taking into account that 80% of the circulation cell that develops will be effective from a remediation time standpoint. The treatment zone around the UVB well that can contain and remediate the dissolved phase VOCs in the groundwater will have a diameter of about 330 ft.

The effective radius of influence is partially dependent on the anisotropy of the lithology. Should, for example, this value be half of what was assumed for our calculations, or 5 instead of 10, then the radius of influence decreases to 37.8 m, or 124 feet. Therefore, two wells may be required to transect the plume.

The UVB system design for creating a circulation cell in an intermediate area within the saturated zone is somewhat more complex since sufficient effluent pressure is needed to ensure the groundwater exits through a screen back into the aquifer to circulate.

To monitor the performance of the UVB system, additional monitoring wells or piezometers may be needed up and/or downgradient of the treatment, each cluster with separate shallow and deep screened sections.

Due to the borehole size and especially depth of the remediation wells needed for the UVB systems, the costs associated with various drilling techniques (each having distinct advantages and disadvantages) cover a broad range. These should be critically analyzed.

We recommend the UVB system (well head and vacuum blower) at this site to be placed in padded, fenced in areas. Should the total CHC concentrations in the off-air exceed Florida emission standards, addition of vapor phase bioreactors and/or GAC could be implemented on the surface.

NOTE: Should high amounts of TCE be analyzed in the off-gas, specially SBP-designed vapor phase bioreactors degrading TCE can be placed in series prior to the activated carbon drums. This allows more of the adsorptive capacity of the carbon to be used for other hazardous constituents, saving overall carbon costs.

The advantages of the *in situ* UVB Systems at this site include:

- vertical and horizontal component to groundwater circulation accelerates cleanup
- no groundwater removal from the subsurface
- very low energy requirements (5 HP vacuum blower and 0.5 HP submersible pump) accelerated remediation time
- minimal permitting requirements
- system adjusts automatically to changing groundwater levels
- ability to control air and groundwater flows rates allows for more effective system management/control as compared to conventional *in situ* treatment strategies (e.g., air sparging).

4.0 REMEDIATION COST ESTIMATE

Source Reduction and Hot Spot Bioremediation

Design:

4.1	Preparation of Final Remedial Design (incl. detailed review of all existing reports):	$ 12,000.00

Equipment:

4.2	One UVB-400 system consisting of the following:	$ 64,400.00
	One 400 mm diam. IEG double-cased screen; 0.5 HP pump; one Johnson wire wrapped screen and attached sump; 5 HP, three phase 208 volt blowers; HDPE blower enclosure with moisture knockout and mini-air stripper; Connections for installation within 5 ft. of well head.	
4.3	Installation of UVB-400 System (Requires 24" diameter borehole)	
4.3.1	Geologic supervision, installation and start-up (Incl. Travel time and costs)	$ 5,340.00
4.3.2	Technical Supervision and Project Management of UVB installation and start-up (field prep.)	$ 3,600.00
4.3.3	Additional costs associated with more complex Installation of circulation in intermediate zone	$ 5,000.00
	SUBTOTAL - GW REMEDIATION DESIGN/CONSTRUCTION COST:	$ 90,340.00

Annual Operation and Maintenance:

4.4	Operation and Maintenance (exclusive of sampling and analyses)	
4.4.1	Four Quarterly Op. & Maintenance visits (incl. Travel costs)	$ 7,680.00
4.4.2	PM including quarterly review of Data and Report with Recommendations for system adjustments	$ 5,040.00
	SUBTOTAL - GW REMEDIATION PM and O.& M. COST (one year):	$ 12,720.00
	Source reduction using *in situ* Bioremediation, YEAR 1 TOTAL:	$103,060.00

6.0 SUMMARY OF SERVICES AND PROVIDERS:

Services provided by SBP:

- Supervising drilling of the borehole
- Installing the remediation system according to the results obtained from the borehole log
- Introduction to on-site staff or consultant of different modes of operation of IEG soil and groundwater remediation systems
- Adjustment of system at time of installation
- Maintenance and adjustment of systems, as needed
- Remediation performance evaluation and data management
- Quarterly technical reporting assistance, as needed

Services provided by ABB (SBP can provide all of the services listed below upon request):

- Client interactions and overall project management
- Drilling of boreholes and providing well installation equipment (solid casings, well completion material, etc.), as needed (compare barber rig with mud rotary techniques)
- Installing any additional monitoring wells or piezometers
- Disposal of drill cuttings, well development, and water disposal
- Surveying new wells
- Hook-up for adequate electricity, plus wiring
- Obtaining of permits for drilling, remediation, and off-gas treatment
- Equipment for off-gas treatment (e.g. bioreactors, activated carbon), if required
- Blower/compressor enclosure (concrete pad and fencing) and trenching, if required
- Analytical monitoring
- Health and Safety Plans

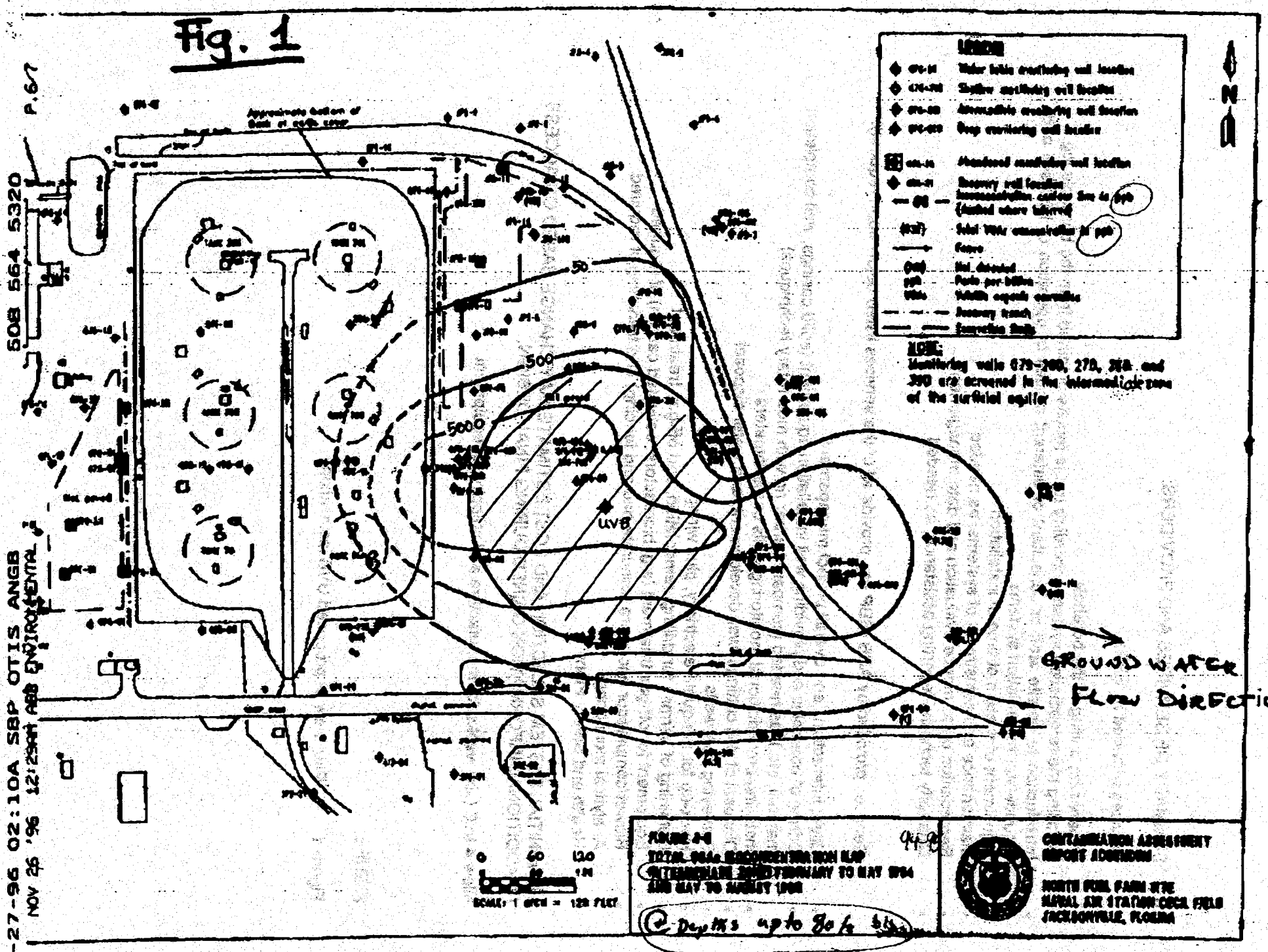
SBP's INITIAL SYSTEM SELECTION AND COST ESTIMATE MAY CHANGE BASED ON ACCESS TO ADDITIONAL INFORMATION GAINED DURING FINAL DESIGN.

Allow 4 to 6 (six) weeks for manufacture and shipping of equipment

FIGURE:

Figure 1 Plan view of proposed UVB installation.

Fig. 1


LEGEND
Water table monitoring well location
Shallow monitoring well location
Intermediate monitoring well location
Deep monitoring well location
Abandoned monitoring well location
Recovery well location
Contamination contour line in ppb (dashed where inferred)
Total VOCs concentration in ppb
Fence
Not detected
ppb Parts per billion
VOCs Volatile organic compounds
Recovery trench
Excavation limits
NOTE:
Monitoring wells 079-200, 270, 358 and 390 are screened in the intermediate zone of the surficial aquifer
Approximate bottom of bank of north ditch
50
500
5000
UV8
GROUND WATER FLOW DIRECTION
0 60 120
SCALE: 1 INCH = 120 FEET
FIGURE 2-6
TOTAL VOCs CONCENTRATION MAP
SEMI-ANNUAL MONITORING FEBRUARY TO MAY 1994
AND MAY TO AUGUST 1995
Depths up to 80 ft
CONTAMINATION ASSESSMENT REPORT ADDENDUM
NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

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EG&G ENVIRONMENTAL

A TECHNOLOGY AND SYSTEMS INTEGRATION COMPANY

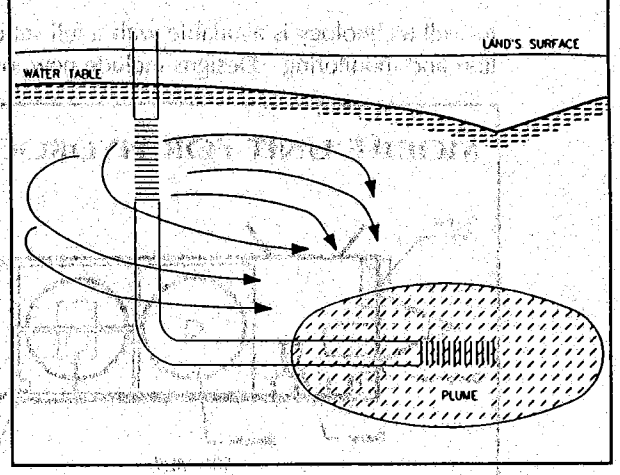
NoVOCs SYSTEM: IN-WELL STRIPPING OF VOCs FROM GROUNDWATER

THE CONCEPT

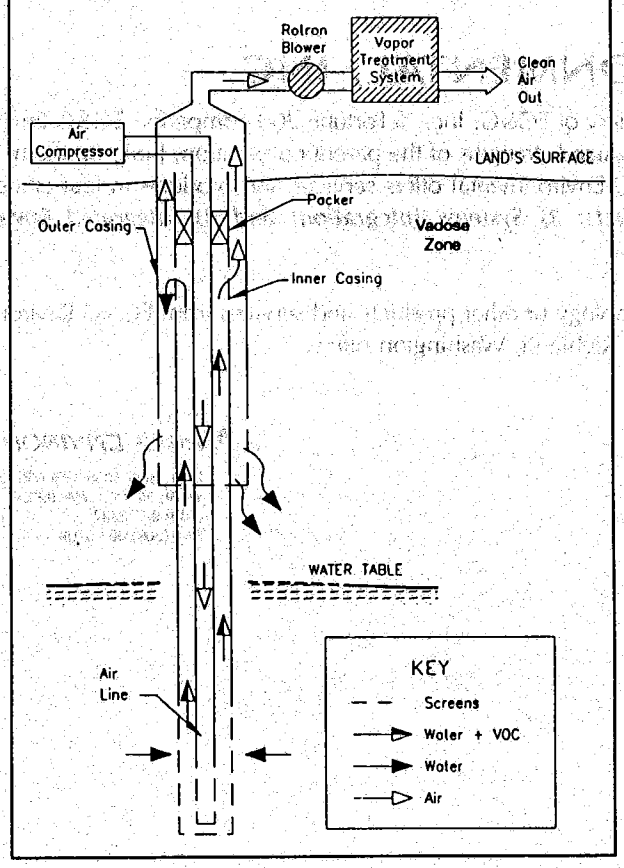
EG&G Environmental, Inc., through its NoVOCs division, offers a cost-effective new technology for removing volatile organic compounds (VOCs) from contaminated groundwater (US Patent No. 5,180,503). Traditional remedies for removing petroleum hydrocarbons and chlorinated solvents in the groundwater have relied upon extraction wells to bring contaminated water to the surface, followed by one of several treatment alternatives to remove contaminants from the aqueous phase. These options include: air stripping, activated carbon, and UV-peroxide oxidation.

In-well stripping, however, simplifies the process and results in significant savings by eliminating separate above-ground aqueous phase treatment.

HORIZONTAL NoVOCs WELL



OPERATION OF A NoVOCs WELL



In-well stripping operates on the same principle as the aerator in an aquarium. A compressor is used to deliver air or an inert gas such as nitrogen to the water column within an extraction well. The resulting bubbles in the water constitute an air lift pump. Because the water with bubbles has a lower density than water outside the well, a pressure gradient is established which causes water outside the well to flow into it through the lower screened section. The bubble-water mixture rises in the well. At the same time, VOCs in the water volatilize into the bubbles. The bubble-water mixture is allowed to rise to a point where optimum volatilization has occurred. The casing is screened at that point and sealed with a deflector plate.

When the mixture encounters the deflector plate, the bubbles break and combine. Water then flows through the upper screen and is allowed to reinfiltrate into the vadose (above water table) zone. A larger casing placed over the top of the well is maintained under vacuum; it allows coalesced bubbles to be drawn off for treatment above ground. Reinfiltrating water creates a torroidal circulation pattern around the well so that waters can be treated through multiple cycles to achieve the desired level of removal.

EG&G ENVIRONMENTAL

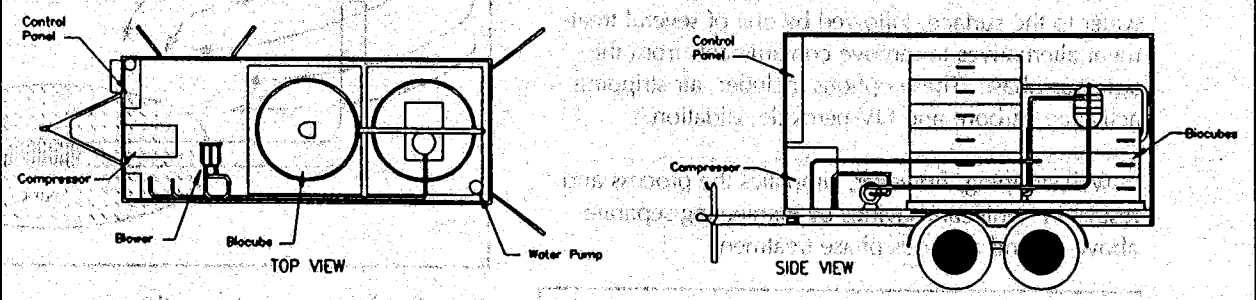
ADVANTAGES

In-well stripping offers a number of advantages over traditional pump and treat technologies:

- ***Reduces Capital Costs***
- ***Reduces Operating Costs Associated With Pumping Vapor, Not Water, to the Surface***
- ***Accelerates Restoration Due to Disruption of Free Phase Product in the Capillary Fringe***
- ***Enhances Bioremediation of Hydrocarbons as a Result of Aeration/Recirculation of Treated Water***
- ***Eliminates Need for Reinjection Wells, Discharge Lines and Discharge Fees***
- ***Facilitates Coupling with Soil Vapor Extraction Systems***
- ***Minimizes Installation Time/Cost Through Use of Integrated System Mobile Unit***

In-well technology is available with a full set of related services, including consultation, design, installation, operation and monitoring. Designs include new installation and retrofits for existing extraction wells.

MOBILE UNIT FOR HYDROCARBON RECOVERY WITH NoVOCs SYSTEM



ABOUT EG&G ENVIRONMENTAL, INC.

EG&G Environmental is a wholly-owned subsidiary of EG&G, Inc., a Fortune 200 company. EG&G Environmental was formed in January 1994 to harness the recognized strengths of the parent corporation, build on them, and apply them in environmental problem solving. EG&G Environmental offers services and products in four strategic areas: ***1) Consulting Services; 2) Technology Products; 3) Systems Integration; and 4) Integrated Environmental Management.***

For further information on in-well stripping technology or other products and services from EG&G Environmental, contact the Pittsburgh headquarters office or the Richland, Washington office.

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IN-WELL TREATMENT FOR REMEDIATION OF VOCS IN GROUND WATER

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Presented at the I&EC Special Symposium (Preprinted Extended Abstract)
American Chemical Society
Atlanta, GA, September 17-20, 1995

INTRODUCTION

With over a decade of experience under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), it has become clear to both the regulated and regulator communities that pump and treat remedies are not likely to restore ground water contaminated with volatile organic compounds (VOCs) to drinking water quality in less than decades, if not hundreds of years. The lengthy periods of time required for restoration result from the extremely low target concentrations for cleanup, and the heterogeneous nature of alluvial aquifers. Chemical residues lodged in fine-grained materials and dead-end pores, and pockets of free phase chemicals are not directly accessible to the predominantly convective flow channels swept by traditional pump and treat designs. As a consequence, movement of contaminants out of these sites becomes diffusion limited and very long time periods are required for diffusion to move significant quantities of chemical over any meaningful distance.

As a result of mass transfer limitations on the performance of pump and treat remedies, there are significant incentives to develop lower cost alternatives. Ideally, one would derive remedies that do not rely on mass transfer mechanisms. For example, contaminants could be destroyed in place by directing an appropriate form of energy to the plume. Unfortunately, energetic destruction is often associated with elevated temperatures that are expensive to achieve in a saturated zone because of water's intrinsic thermal properties. Use of chemical energy suffers mass transfer limitations because of the need to deliver the reactive chemical to the contaminant. Even bioremediation must surmount mass transfer limitations in order to provide nutrients to organisms at the contaminated site.

Recognizing these difficulties, technology innovators have focused on creative ways to minimize effects of mass transfer and reduce unit costs so that total cost to restoration can be held down. One promising approach to cost reduction is the use of in-well treatment technologies with recirculating wells. The first commercially available embodiment of in-well treatment is in-well vapor stripping for VOCs.

IN-WELL VAPOR STRIPPING - THE NoVOCs™ PROCESS

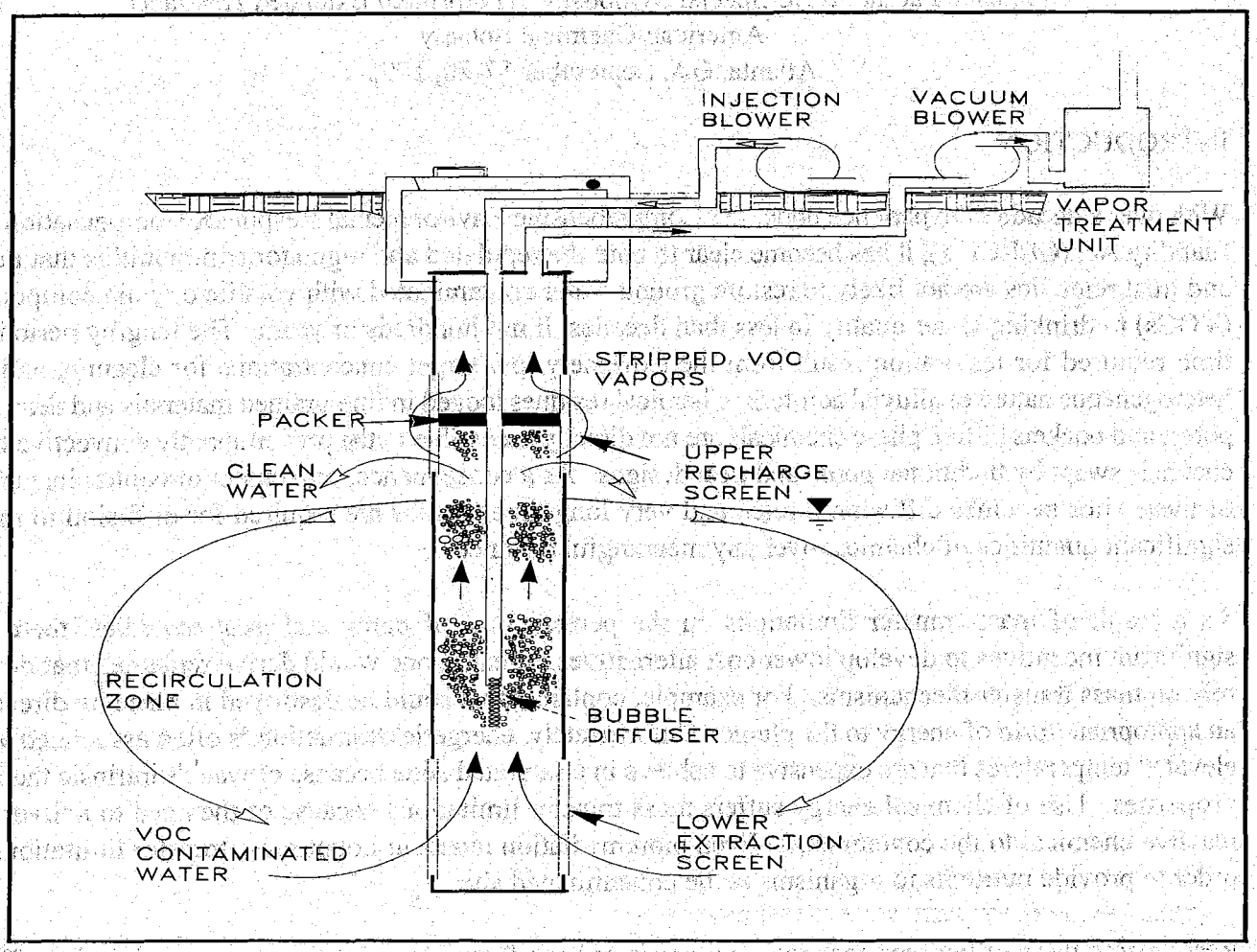
Of these emerging designs for in-well vapor stripping, the NoVOCs™ process offered by EG&G Environmental, Inc. is one of the most efficient and advanced in concept. It relies on an over-pressure principle applied to a recirculating well wherein water is continuously routed through a well structure and VOC mass transfer from dissolved to vapor phase occurs in situ within the well.

Configuration of a typical NoVOCs™ well is depicted in Figure 1. The well is installed to a point near the ground water plume base such that the full depth of plume is within the capture zone when the well is pumped. The well casing is screened at two depths: 1) Within the saturated zone where the casing is in contact with the contaminant plume, and 2) Within the vadose zone at a selected height above the water table. Air is injected by means of a regenerative blower and interior pipe so that a continuous stream of bubbles is formed in the casing starting at some point above the lower screen. The air may be

G-29

replaced/augmented by nitrogen, carbon dioxide or other gas depending upon geochemical considerations.

Figure 1. Diagram of NoVOCs™ System



Nitrogen or carbon dioxide is used to prevent oxidation-related fouling. Regardless of the air stream selected, its introduction constitutes an air lift pump (i.e., the presence of bubbles in the casing causes the column of water in the casing to have a lower density than water outside the casing and hence, water flows into the well in response to the pressure differential). The ground water flowing into the well carries dissolved VOC contamination with it.

A deflector plate (packer) is installed in the casing within the upper screen. This plate prevents the combined flow of water and vapor from rising any higher in the casing, thereby forcing it to pass out through the screen into the vadose zone. The vapors are then drawn, under vacuum, back into the well through the screened section above the plate by means of a blower whose exhaust is directed to an off-gas treatment module and water flows through the vadose zone back into the aquifer.

When operated, the air lift pump draws contaminated water into the well where volatile contaminants vaporize as they are transferred into the bubbles in the water column. This transfer continues until equilibrium is reached as defined by Henry's Law. At the plate, the bubbles break and coalesce. The water percolates downward through the vadose zone, while the contaminant vapors are drawn off by the vacuum in the upper portion of the well. The equilibrium phase partitioning for most contaminants is insufficient

to produce drinking water quality on a single pass. Therefore, the pumping rates and well placement are selected to accommodate multiple cycles for each unit of water. The optimum number of cycles is dependant on the starting concentration and the flow rate of the ground water. Some additional removal occurs in the vadose zone where soil particles act like packing in an air stripper. The degree of additional removal achieved will depend on the size of the soil particles, amount of flow induced by the vacuum, and degree of saturation produced by the infiltrating water. Off-gas treatment for in-well stripping units is selected on a contaminant-specific basis.

If unusual stratigraphic considerations indicate a high probability of vertical short circuiting down the outside of the casing, lateral pipes can be installed to carry recirculated water out away from the casing prior to discharge. In most aquifers, the anisotropic hydraulic conductivity will cause reinfiltrating water to flow outward the desired distance. Under either configuration, a torroidal pattern of flow results and defines the zone of capture and recirculation for the well (Figure 1). For elongated plumes, a horizontal well can be highly effective. The lower screen is positioned at the far end of the lateral member. As a consequence, the radius of recirculation is selected during design as the horizontal distance separating the end of the casing and the point of entry in the ground. Another modification that has been developed provides for treatment of dissolved metals by using an infiltration gallery combined with chemical reagents to absorb and/or precipitate the metals as water is recharged to the vadose zone.

PERFORMANCE DATA

The first two NoVOCs™ wells have been installed at a site in France, while the first U.S. installation was installed at Edwards Air Force Base this past spring. The radial influence data presented in Figure 2 were collected from one of the French wells. This well operates at 125 gallons per minute and based upon this data has a circulation diameter zone of 70 to 80 meters (230 to 260 feet). Similar data were obtained from the other well operating in France. This circulation zone data is based on measured dissolved oxygen (DO) levels in ground water. Background DO was measured at 1 to 2 mg/l, DO levels in the circulation zone were measured at 5 to 8 mg/l (60 to 100% of saturated DO levels). The match between the predicted and measured circulation zone is quite good.

Figure 2. Measured NoVOCs™ Circulation Zone

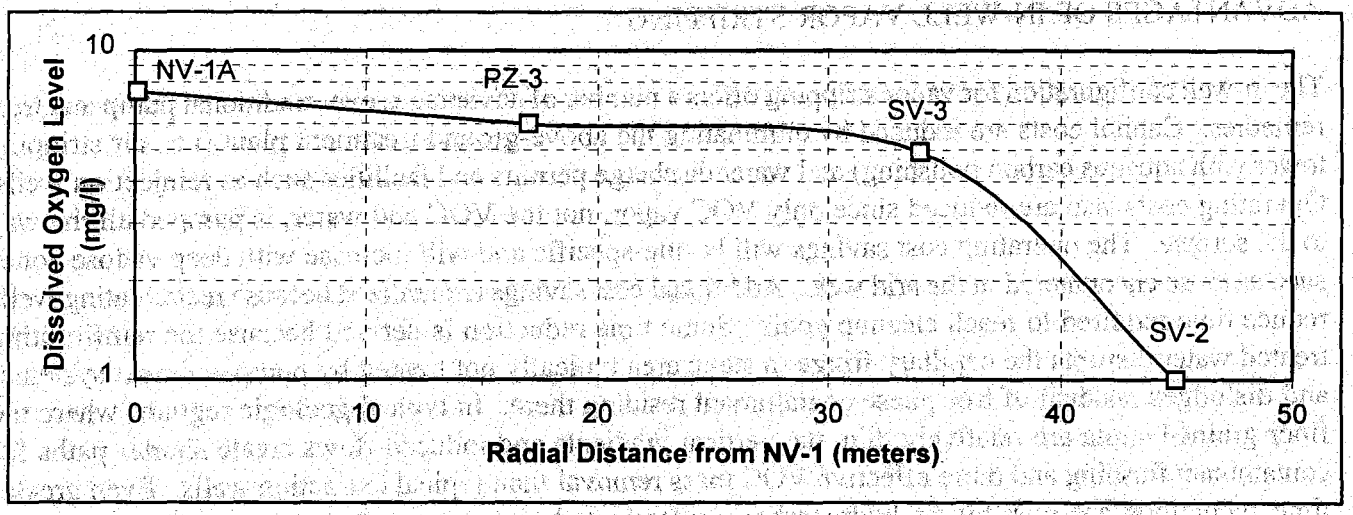
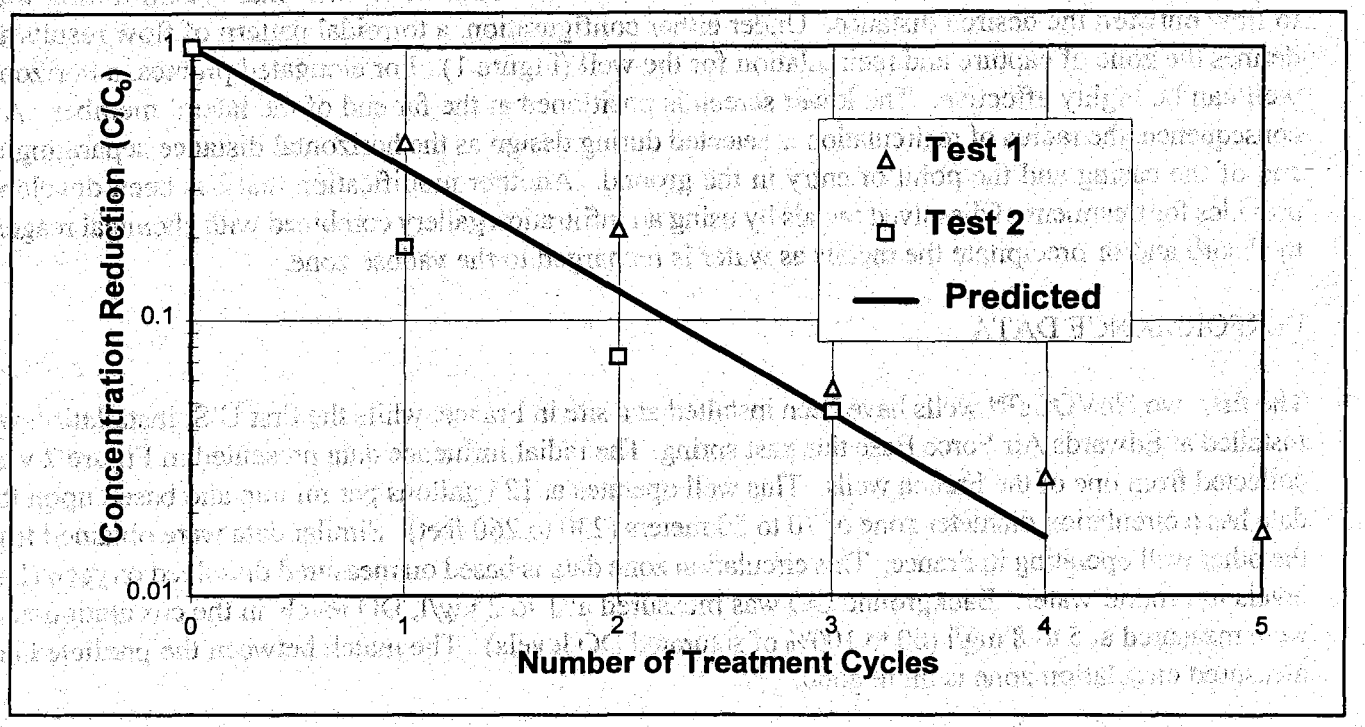


Figure 3 presents mass removal data that were collected from a large scale pilot test of a NoVOCs™ installation in Washington State. The well was operated at a flow rate of 20 gallons per minute with an air-to-water ratio of 6. Flow through the NoVOCs™ system was recirculated through a storage tank and back into the stripping well for multiple cycles. The VOC treated was 1,1,1-TCA. Concentrations were reduced several orders of magnitude during the pilot test and final treatment levels obtained were below 5 ppb, demonstrating that this treatment process can achieve typical MCLs in the low ppb range. The mass removal data from this pilot test correspond well to design mass removal rates based on equilibrium mass transfer calculations.

Figure 3. Pilot Testing Results of NoVOCs™ TCA Mass Removal



ADVANTAGES OF IN-WELL VAPOR STRIPPING

The in-well configuration for vapor stripping offers a number of advantages over traditional pump and treat remedies. Capital costs are reduced by eliminating the above-ground treatment plant (i.e., air stripping tower with aqueous carbon polishing) and water discharge permits and facilities such as reinjection wells. Operating costs also are reduced since only VOC vapor, not the VOC and water, is pumped all the way to the surface. The operating cost savings will be site-specific and will increase with deep vadose zones such as those encountered in the arid west. Additional cost savings are realized because recirculating wells reduce time required to reach cleanup goals. Some time reduction is derived because the reinfiltrating treated water disrupts the capillary fringe (a static area typically not treated by pump and treat systems) and dislodges residual of free phase contaminant residing there. In typical geologic regimes where the finer grained strata are relatively thin, the vertical gradients and induced flows create shorter paths for contaminant flushing and more effective VOC mass removal than typical extraction wells. Even greater time reductions are possible at hydrocarbon-contaminated sites where the oxygenated return flows stimulate in situ biodegradation concomitant to removal action.

Elimination of the need for discharge lines or a reinjection well can be much more significant than the obvious cost reduction. In some urban areas (e.g. downtown gas stations), there may be no feasible location for a discharge, or permitting may be problematic. If an untreatable co-contaminant is present (e.g. tritium), it may be politically difficult to release the untreated residuals. Similarly, in traditionally water short areas such as Arizona, there are incentives for not having to remove ground water from the aquifer and deal with water rights issues.

APPENDIX H

BIOSPARGING DESIGN CALCULATIONS AND VENDOR INFORMATION

APPENDIX H

BIOSPARGING PILOT TEST

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1.0 INTRODUCTION

Biosparging is an in-situ remediation technology that uses indigenous microorganisms to biodegrade organic constituents in the saturated zone. In biosparging, air is injected into the saturated zone to increase the concentration of dissolved oxygen in groundwater and enhance the biological activity of indigenous microorganisms. Biosparging can be used to reduce concentrations of petroleum constituents dissolved in groundwater, adsorbed to soil below the water table, and within the capillary fringe.

Initial Screening of Biosparging Effectiveness:

- Determine if site-specific factors that could hinder the effectiveness of biosparging are present.
- Determine if key parameters contributing to the effectiveness and performance are within appropriate ranges for biosparging.

Tables H-1-1 and H-1-2 present the details of the initial screening of biosparging technology.

1.1 PURPOSE

The purpose of the biosparging pilot test was to evaluate the applicability of this technology as an in-situ groundwater treatment at the NFF site. Additionally, the radius of influence for the sparge well was estimated and operation parameters optimized.

D = depth of the sparge well
ROI = radius of influence

If ROI > D
technology is applicable and economical.

If D > ROI > 0.5 D
technology is applicable and needs further evaluation.

If ROI < 0.5 D
technology may not be economical.

1.2 OBJECTIVES

The objective of the biosparging pilot test was to provide site-specific data that supporting the design and engineered remediation thus meeting remediation goals for the site. Specific design parameters evaluated during the pilot test are as follows:

1. breakthrough pressure (pressure at which water column will be displaced and air begins to get injected into the aquifer = [45/2.3] X 1.15 = 22.5 psi);

2. maximum allowable biosparging pressure (pressure at which volatile organic contaminants are stripped from groundwater, and concentration of total volatile organics exceeding air emission standards);

3. equilibrium pressure and the optimum air flow rate (air flow rate at which channelization is minimized and pressure maintained over an extended period of time);

4. radius of influence of the sparge well based on the distribution of the dissolved oxygen, pressure fields around the sparging well, dissolved concentrations of BTEX in groundwater, water level fluctuations, and

5. degradation rates of groundwater contaminants based on the observed decrease in concentrations and the rate of oxygen supply.

2.0 PILOT-TEST SET-UP

The biosparging system location is shown in Figure H-2-1. The system is located within the plume of groundwater contamination.

One air injection well (BSP-1), 11 pressure monitoring points (PMPs), and 11 groundwater monitoring points (GMPs) were installed for the pilot test. All the wells were installed using hollow stem auger techniques. BSP-1 was constructed with 2 inch diameter stainless steel casing. PMPs and GMPs were constructed with 2 inch ID, schedule 40, PVC casing.

The biosparging pilot test system configuration included:

- Groundwater monitoring points
- Pressure monitoring points
- Biosparge well point
- Compressor
- Piping from compressor to the biosparge well point
- Monitoring gauges

Figure H-2-2 presents the process and instrumentation diagram for the biosparging pilot test system. Table H-2-1 includes well construction details for the monitoring points and the sparge well.

A pilot scale study of biosparging was conducted for 72 hours based on procedures described below.

A. Increase the applied pressure 2 psi every 5 minutes from 15 psi through 40 psi (until air flow is observed to take place into the system). Record the compressor pressure, well head pressure, and air flow rate at 2 min. intervals at the sparge well. Verify the breakthrough pressure, the equilibrium pressure, and optimum flow rate.

B. Beginning with the equilibrium pressure, run a continuous 48 hour biosparging test. Monitor and record the following parameters on the average of every 2 hours.

- compressor pressure
- well head pressure, temperature, and flow rate at sparge well
- well head pressure at PMPs
- dissolved oxygen in groundwater at GMPs using HACH test kits
- water levels at GMPs
- GA-90 gas analyzer and FID readings at PMPs

C. At the end of 48 hours, increase the compressor pressure at a rate of 2 psi. every 2 min. until air flow rate at the well head is twice the initial air flow rate. Record the compressor pressure, well head pressure, well head flow rate, and temperature.

D. Continue the biosparging test for another 24 hours at the new air flow rates. Monitor and record all the parameters mentioned in step B.

3.0 METHODOLOGY AND RESULTS

3.1 **Step-Test** The purpose of the step-test was to verify the minimum breakthrough pressure (Pmin) required to force the air into the aquifer matrix. Pmin was initially calculated by multiplying the total column of water in feet by 0.43 psi per foot. This calculation yielded an estimated value of 19.56 psi and adding 15 percent for the pressure losses resulted in a theoretical Pmin of 22.5 psi.

An initial compressor pressure was chosen at 70% of the calculated Pmin (i.e. 16 psi). Compressor pressure was gradually increased in steps of 2 psi. every 2 min. from the initial pressure of 16 psi. to a final pressure of 30 psi. During each step the system was allowed to reach equilibrium at the well head before the recording was made.

The following parameters were monitored for and recorded during each step of the pressure change:

- Compressor pressure
- well-head pressure at the sparge well
- well-head flow rate at the sparge well
- well-head temperature at the sparge well

Table H-3-1 presents the system results for the step-test. The pilot study step-test indicated that the initial breakthrough pressure at the sparge well was between 18 and 21 psi.

3.2 **72-Hour Biosparging Test** The primary objective of this phase of the test was to observe changes in DO, water level elevations at each of the GMPs, and changes in pressure at each of the PMPs during the 72-hour period. Based on the step-test an air injection pressure of 20 psi was chosen to obtain an air flow rate of 9 acfm. During the first 48 hours of the biosparge test, these initial injection pressures and air flow rates were used. During the last 24 hours of the test, the injection pressure was increased to 60 psi with an air flow rate of 14 acfm. The initial operating pressure and air flow rate conditions were modified after 48 hours of the biosparging test in order to evaluate the effect on the radius of influence.

3.2.1 Physical Observations As the test progressed, several visual observations regarding the behavior of the water at the GMP wells was recorded. Table H-3-2 summarizes the chronology of the observations at various wells. The physical observations were prioritized based on indications of high or low influence on the aquifer. Observations indicating high influence include: 1) the springing up of water from the top of the monitoring well, and 2) the bubbling of water around the surface casing of the monitoring wells. Observations indicating low influence include: 1) frothing of water in the monitoring well, 2) bubbling of water in the monitoring well, and 3) acoustical observations in the well monitoring. Figure H-3-1 presents the pictorial representation of various events observed.

3.2.2 Water Levels Depth to water measurements were recorded throughout the test at each of the GMP points. Table H-3-3 summarizes the water level measurements for each monitoring point over time. Figures H-3-2A through 3-2D present plots of water level measurements versus elapsed time from the sparge point at 7, 15, 25, and 40 feet from the sparge point. Significant changes in depth to water were observed to occur within 7 to 25 feet from the sparge point. Less than 0.5 feet water level changes were observed to occur between 25 to 40 feet from the sparge point. Note that water levels were difficult to obtain from GMP-2, GMP-3, GMP-5, and GMP-6 due to either violent frothing or water springing conditions. GMP-2 and GMP-6 began springing water after 4 hours of sparging. GMP-5 was initially dry and began frothing after 14 hours of sparging. GMP-3 began frothing after 57 hours of sparging. Mounding began within the first 10 hours of sparging and stabilized after 24 hours. Based on water level observations, it appears that the influence has extended to an area between 25 to 35 feet from the sparge well.

3.2.3 Pressure Data Pressure measurements were recorded at the PMPs throughout the test. Table H-3-4 summarizes the pressure measurements for each monitoring point over time. Figures H-3-3A through 3-3L present plots of pressure versus elapsed time for various PMPs. Significant pressure changes were observed up to 15 feet from the sparge well at PMP-1, PMP-2, PMP-3, PMP-5, and PMP-6. Pressure changes between 0.1 inch to 1 inch of water was observed up to 40 feet from the sparge well at PMP-4, PMP-7, PMP-8, and PMP-11. Maximum pressure readings were sustained throughout the test at PMP-1, and PMP-2. Maximum pressures recorded at PMP-1, PMP-2, PMP-6, and PMP-9 are 138 in., 346 in., 304 in., and 207 in. respectively. The pressure readings of the entrapped air expressed as inches of water at each of these observation points correspond to the total height of water column above the screen intervals. This suggests observed formation of air channels up to a distance of 25 ft. and pressure influence to a total distance of 40 feet from the sparge point. Even though pressure influence was observed at PMPs as far as 40 feet from the sparge well, variability of pressure with respect to depth suggests formation of preferential pathways. Hence the average radius of influence based on pressure data is 35 feet.

3.2.4 Dissolved Oxygen Data DO was monitored throughout the test at all the GMPs. Table H-3-5 summarizes the DO measurements for each monitoring point over time. Figures H-3-4A through 3-4D present plots of DO versus elapsed time at various distances from the sparge well. DO increases were observed up to 40 feet distance from the sparge well at various depths. Sustained influence was observed at GMP-1, GMP-2, GMP-3, GMP-5, and GMP-8, however, DO influence was cyclical at GMP-4, and GMP-9. Note that after only a few hours of sparging, it was not possible to measure DO from some of the GMPs due to frothing, springing, or dry conditions. It is assumed that all of these wells were influenced because the intermittent readings and the final readings of DO were significantly higher than the baseline readings. DO increases were observed at several depths (10, 25, and 35 ft bls. at 7 ft; 10, 20, 30 ft bls. at 15 ft; and 7, 15, 25 ft. bls. at 25 ft from the sparge well) within 15 hours of sparging. The radius of influence based on DO observations is between 25 ft and 40 ft.

3.2.5 FID and GA-90 Gas Analyzer Readings Sparging of air into the aquifer matrix results in stripping of volatile organic compounds from the soil and water particles. PMP well screens are located at various depths below the land surface ranging from 7 feet to 40 feet. All the PMP wells were sealed with a quick connect, in order to sample the entrapped sparge air. The GA-90 gas analyzer was used to measure percent O_2, CO_2, and CH_4 in the entrapped air. The FID was used to measure TVOA concentration in the entrapped air.

Table H-3-6 summarizes the FID and GA-90 data for each monitoring point over time. Figure H-3-5 presents the percentage of O_2, CO_2, and CH_4 readings at each of the PMPs throughout the 72-hour biosparging test. Figure H-3-6 presents the concentrations of TVOA at each of the PMPs versus time. Sustained elevations in TVOC concentrations were observed at PMP-5, PMP-6, and PMP-11 at sparge flow rate of 9 acfm. TVOC concentrations were observed to increase at PMP-11 after the 48 hour sparging and increase of the sparge flow rate. Thus this data indicates that potential for stripping increases when the sparge flow rates were increased from 9 acfm to 12 acfm. Also, the design sparge flow rate should be maintained below 9 acfm in order to reduce the potential for stripping of TVOCs from the aquifer matrix.

4.0 SUMMARY AND CONCLUSIONS

1. The breakthrough pressure (pressure at which water column will be displaced and air begins to get injected into the aquifer) is observed as between 18 psig and 20 psig.

2. The biosparging pressure remained constant in spite of an increase in the influent air pressure. However, a corresponding increase in the air flow rate was observed at the sparge well. When the compressor air pressure was doubled from 30 psig to 60 psig, the air flow rate increased from 9 acfm to 12 acfm at the sparge well.

3. The equilibrium pressure and the optimum air flow rate (air flow rate at which the channelization is minimal and pressure can be maintained over a long period of observation) is 19 psig and < 9 acfm, respectively.

4. The radius of influence of the sparge well based on the influence on the dissolved oxygen, pressure field around the sparging well, dissolved concentrations of BTEX in groundwater, and water level fluctuations is observed as 25 to 35 feet.

5. The degradation rates of groundwater contaminants based on the observed decrease in the concentrations and the rate of supply of oxygen were not evaluated at this time.

Table H-1-1 Initial Screening of Biosparging		
Factor	Description	Situation at NFF
Free Product	Biosparging can create groundwater mounding which could cause free product to migrate and contamination to spread.	Free product is identified within the mound area. Free product is not identified on the east-side of the mound area.
Basements, sewers, or other subsurface confined spaces	Potentially dangerous constituent concentrations could accumulate in basements and other subsurface confined spaces.	Within the mound area there are several structural features and utility lines. Further evaluation is necessary during implementation. Area east of the mound is either unpaved or wooded. There are no subsurface confined spaces.
Aquifer System	If groundwater is present in a confined aquifer system, air sparged into the aquifer would be trapped by saturated confining layer and could not escape to unsaturated zone.	Groundwater at NFF is surficial aquifer system and is unconfined.

Table H-1-2 Key Parameters Used to Evaluate the Suitability of Biosparging		
Site Characteristics	Effective Range	NFF Site
Intrinsic Permeability (k cm^2)	$k > 10^{-10}$	$10^{-8} > k > 10^{-10}$
Soil structure and stratification	affects the applied pressure, resulting flow rate, efficiency of oxygen distribution. Silty sands to sands.	Fine sands to silty sands. D_{60} = 0.19 mm D_{30} = 0.14 mm D_{10} = 0.09 mm $C_u > 2$
Temperature	between 10^0 C and 40^0 C microbial activity doubles every 10^0 C rise in temperature.	15^0 C to 25^0 C
pH	6 to 8	5.5 to 7
Microbial population density	soil range 10^4 - 10^7 CFU/gram	10^4 to 10^6 CFU/gram
Nutrient concentrations	C:N:P = 100:10:1 to 100:1:0.5	unknown
Dissolved iron concentration	$FE^{2+} < 10$ mg/L	< 5 mg/l

Table H-2-1. Monitoring Well Construction Detail		
Well Id	Distance from Sparge Well, ft.	Screen Interval (FT BLS)
BSPW-1	0	43-45
GMP-1 & PMP-1	7	7-10
GMP-2 & PMP-2	7	22-25
GMP-3 & PMP-3	7	32-35
GMP-4 & PMP-4	15	7-10
GMP-5 & PMP-5	15	17-20
GMP-6 & PMP-6	15	27-30
GMP-7 & PMP-7	25	4-7
GMP-8 & PMP-8	25	12-15
GMP-9 & PMP-9	25	22-25
GMP-10 & PMP-10	40	2-5
GMP-11 & PMP-11	40	12-15

Table H-3-1

Results for Step-Test

Date	Time	Compres. Pressure psig	Well hd. Pressure psig	Temp. degree F	Rotometer Flow Rate acfm	scfm
9/23/96	20:35	16	15	75	0	0
	20:51	17	17	75	0	0
	20:53	20	19.5	75	0	0
	20:55	22	19.5	75	0	0
	20:56	24	20	78	0	0
	20:57	26	20	78	0	0
	20:58	28	21	78	4.5	7
	20:59	30	21	79	5	8
	21:14	30	21	79	5.5	9
	21:24	30	20	79	5.8	9
	21:27	25	19	78	4	6
	21:34	25	18	78	4	6
	21:37	20	18	75	2	3
	21:40	20	17	75	1.8	3
	21:50	20	16.5	75	1.8	3
	22:01	20	16.5	75	1	1
	22:35	18	16.5	75	0.5	1
	22:45	16	16.5	75	0	0
	22:55	15	13	75	0	0
9/26/96	9:15	32	18	80	9.3	14
	9:25	36	18	80	9.4	14
	9:30	38	18	80	10.4	15
	9:32	40	18.2	80	10.75	16
	9:34	42	18.3	80	11.1	17
	9:36	44	18.4	80	11.8	18
	9:37	46	18.5	80	12.1	18
	9:38	48	19	80	12.8	19
	9:40	52	19	80	13.2	20
	9:41	54	20	80	13.7	21
	9:42	56	20	80	13.8	21
	9:43	58	20	80	14.2	22
	9:45	60	20	80	14.8	23
	10:49	59	19	80	14.8	22

Table H-3-2

Physical Observations at Various Monitoring Points

Initial Time	Elapsed time hrs.	GMP-1 10 ft. bls	GMP-2 25 ft. bls	GMP-3 35 ft. bls.	GMP-4 10 ft. bls.	GMP-5 20 ft. bls	GMP-6 30 ft. bls.	GMP-7 7 ft. bls.	GMP-8 15 ft. bls.	GMP-9 25 ft. bls.	GMP-10 5 ft. bls.	GMP-11 15 ft. bls.
9/23/96 21:11					Highly Turbid	Dry	Highly Turbid			Turbid	Dry	
9/24/96 9:30	0:00		PMP-2 bubbling									
9/24/96 9:50	0:20			Seal broken/add pellets			Water Flow/closed					
9/24/96 10:50	1:20		Water Flow/closed									
9/25/96 0:15	14:45	bubbling ac	CAP opened/sealed			bubbling						
9/25/96 0:15	14:45				do not recharge	Turbid	water flow/closed					
9/25/96 2:10	16:40	turbid	closed			Turbid	closed		turbid	turbid		
9/25/96 10:22	24:52					very turbid		dry				
9/26/96 4:45	43:15		closed				opened					
9/26/96 11:20	49:50			water flow(1-2 ft)								
9/26/96 12:17	50:47			frothing		highly turbid	water flow/closed					
9/26/96 22:00	60:30			closed								
9/27/96 0:30	63:00			closed			closed					

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Table H-3-3. Water Level measurements at various GMPs

	Initial Time	Elapsed time hrs.	GMP-1 10 ft. bls	GMP-2 25 ft. bls	GMP-3 35 ft. bls.	GMP-4 10 ft. bls.	GMP-5 20 ft. bls	GMP-6 30 ft. bls.	GMP-7 7 ft. bls.	GMP-8 15 ft. bls.	GMP-9 25 ft. bls.	GMP-10 5 ft. bls.	GMP-11 15 ft. bls.
TOC ALS	9/24/95 10:00		3.21	2.46	2.88	3.48	3.02	2.92	0.96	3.31	2.67	3.35	3.00
	9/19/96 16:00	0:00	3.03	3.07	3.18	2.70	3.35	4.02	2.75	2.80	3.31	3.34	3.37
9/24/96	9/24/96 10:00	0:30	3.10	3.54	3.64	3.20	3.43	3.81	3.12	3.21	3.71	3.81	3.75
	9/24/96 14:15	4:45	1.76	AW	2.40	2.09	-1.66	AW	2.27	1.36	2.18	3.36	2.87
	9/24/96 18:50	9:20	2.24	AW	3.52	2.46	-0.47	AW	2.49	1.86	3.59	3.39	3.08
	9/24/96 22:10	12:40	3.68	AW	3.74	2.54	RC	AW	2.48	1.80	3.72	3.38	3.12
	9/25/96 0:45	15:15	2.68	AW	4.22	2.70	2.13	AW	2.75	2.56	4.89	3.69	3.49
	9/25/96 4:17	18:47	2.50	AW	3.65	6.32	5.98	AW	2.54	3.23	4.00	3.50	3.33
	9/25/96 7:25	21:55	2.33	AW	3.73	2.55	0.09	AW	2.56	2.20	3.85	3.49	3.25
	9/25/96 9:00	23:30	2.47	AW	3.81	2.67	FR	AW	2.63	2.41	4.17	3.72	3.33
SUSPECT	9/25/96 11:50	26:20	2.66	AW	4.07	2.81	DR	AW	2.76	2.80	4.30	3.73	3.52
	9/25/96 17:45	32:15	2.72	AW	3.87	2.90	0.90	AW	2.90	2.98	4.34	3.75	3.68
	9/25/96 22:25	36:55	2.73	AW	3.81	2.96	1.50	AW	2.91	2.90	3.84	3.72	3.65
	9/26/96 2:00	40:30	2.81	AW	3.82	3.00	1.56	AW	2.96	2.97	4.05	4.01	3.67
	9/26/96 9:20	47:50	2.87	AW	3.87	3.04	FR	3.79	3.03	3.09	3.94	4.04	3.73
	9/26/96 9:40	48:10	2.39	AW	0.55	2.79	FR	2.03	2.96	2.87	3.19	3.30	4.34
	9/26/96 10:30	49:00	1.78	AW	0.12	2.33	FR	-0.76	2.71	2.27	1.97	3.80	3.36
	9/26/96 12:17	50:47	3.04	AW	FR	3.21	FR	2.88	3.00	3.00	4.49	4.13	3.69
	9/26/96 14:17	52:47	2.96	AW	FR	3.14	FR	5.47	3.03	3.09	4.92	3.83	3.77
	9/26/96 16:33	55:03	2.93	AW	FR	3.14	FR	5.36	3.06	3.14	4.90	4.16	3.87
	9/26/96 18:11	56:41	2.81	AW	FR	3.06	FR	5.26	3.01	3.11	4.75	3.93	3.80
	9/26/96 22:00	60:30	2.10	AW	AW	2.53	FR	-2.03	2.61	2.06	2.68	3.58	3.23
	9/27/96 0:30	63:00	2.26	AW	AW	2.61	FR	AW	2.66	2.18	3.43	4.09	3.29
	9/27/96 2:00	64:30	2.24	AW	AW	2.57	FR	AW	2.62	2.14	3.28	3.56	3.23
	9/27/96 3:05	65:35	2.25	AW	AW	2.57	FR	AW	2.61	2.14	3.40	3.48	3.20
	9/27/96 4:27	66:57	3.38	AW	AW	2.66	FR	AW	2.66	3.22	3.67	4.02	3.27
	9/27/96 6:36	69:06	2.37	AW	AW	2.63	FR	AW	2.62	2.23	3.63	3.47	3.24

Note: FR = frothing, DR = Dry, AW = springing water, RC = well rim capped

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Table H-3-4. Pressure Measurement at various PMPs

Initial Time	Elapsed time hrs.	PMP-1 10 ft. bls	PMP-2 25 ft. bls	PMP-3 35 ft. bls.	PMP-4 10 ft. bls.	PMP-5 20 ft. bls	PMP-6 30 ft. bls.	PMP-7 7 ft. bls.	PMP-8 15 ft. bls.	PMP-9 25 ft. bls.	PMP-10 5 ft. bls.	PMP-11 15 ft. bls.
9/24/96 9:00	0:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9/24/96 9:30	0:30	138.50	221.60	23.00	0.00	1.25	1.50	0.08	0.50	0.80	0.00	1.00
9/24/96 12:00	3:00	110.80	304.70	28.00	0.25	0.25	8.00	0.25	0.02	0.00	0.05	0.10
9/24/96 12:30	3:30	110.80	304.70	30.00	0.10	0.10	20.00	0.10	0.10	0.02	0.05	0.15
9/24/96 14:24	5:24	110.80	332.40	27.70	0.00	0.00	110.80	0.50	0.50	45.00	0.05	0.15
9/24/96 17:30	8:30	108.03	326.86	13.85	0.02	0.00	110.80	0.03	0.00	83.10	0.04	0.00
9/24/96 20:25	11:25	96.95	326.86	13.85	0.00	0.00	0.00	0.00	0.00	138.50	0.00	0.00
9/24/96 23:05	14:05	96.95	318.55	8.10	0.00	0.04	0.00	0.00	0.00	110.80	0.00	0.00
9/25/96 0:44	15:44	83.10	304.70	12.00	0.60	1.20	1.40	0.00	0.60	55.40	0.00	0.00
9/25/96 1:02	16:02	60.00	NR	2.80	0.30	0.50	0.30	0.05	0.30	NR	0.00	0.25
9/25/96 3:51	18:51	110.80	318.55	3.70	0.05	0.10	0.00	0.00	0.00	52.00	0.00	0.00
9/25/96 6:15	21:15	110.80	318.55	4.30	0.00	0.05	0.05	0.00	0.00	50.00	0.00	0.00
9/25/96 8:10	23:10	96.95	311.63	3.00	0.00	0.00	0.02	0.00	0.00	42.00	0.00	0.00
9/25/96 11:50	26:50	96.95	304.70	3.00	0.00	0.00	0.80	0.05	0.00	28.00	0.00	0.50
9/25/96 15:27	30:27	83.10	304.70	6.00	0.10	0.50	0.10	0.06	0.05	5.00	0.04	0.08
9/25/96 17:55	32:55	83.10	304.70	6.00	0.10	0.24	0.06	0.02	0.05	0.15	0.02	0.04
9/25/96 22:30	37:30	83.10	304.70	4.50	0.01	0.00	0.00	0.00	0.01	0.12	0.00	0.01
9/26/96 0:48	39:48	83.10	332.40	6.10	0.03	0.09	0.00	0.00	0.06	0.15	0.06	0.06
9/26/96 2:00	41:00	96.95	304.70	2.00	0.02	0.02	0.05	0.00	0.02	0.15	0.00	0.04
9/26/96 6:08	45:08	83.10	304.70	5.80	0.03	0.02	0.00	0.00	0.00	0.10	0.00	0.07
9/26/96 8:15	47:15	83.10	304.7	2	0.00	0	0.00	0.00	0.00	0.05	0.00	0.00
9/26/96 9:15	48:15	83.10	304.7	4	0.05	0	0.07	0.01	0.07	0.15	0.00	0.05
9/26/96 9:48	48:48	83.10	332.4	30	0.92	9.2	0.40	0.04	0.50	1.00	0.00	0.45
9/26/96 10:38	49:38	110.80	346.25	69.25	0.00	15	0	0.00	0.20	0.00	0.05	0.25
9/26/96 11:00	50:00	96.95	360.1	138.5	0.00	14	0	0.04	0.00	0.00	0.03	0.05
9/26/96 11:35	50:35	96.95	304.7	138.5	0.00	0	0	0.04	0.00	0.00	0.03	0.00
9/26/96 12:00	51:00	96.95	304.7	135.73	0.00	0	0	0.00	0.00	0.00	0.03	0.00
9/26/96 14:00	53:00	83.10	277	27.7	0.00	0	0.05	0.07	0.10	0.30	0.10	0.10
9/26/96 16:35	55:35	83.10	277.00	13.85	0.06	0.10	0.05	0.04	0.17	0.20	0.03	0.10
9/26/96 18:04	57:04	83.1	304.7	22	0	4	0.02	0	0	0.14	0	0
9/26/96 22:00	61:00	96.95	332.4	83.1	0	12	59	0	0.1	20	0	0
9/27/96 0:30	63:30	110.8	332.4	55.4	0	5	221.6	0	0	96.95	0.02	0.01
9/27/96 1:57	64:57	110.8	332.4	48	0	1.7	277	0	0	138.5	0	0
9/27/96 3:09	66:09	96.95	318.55	48	0.01	0.25	304.7	0	0	193.9	0	0.14
9/27/96 4:31	67:31	96.95	318.55	44	0	0.18	263.15	0	0.05	193.9	0.05	0.1
9/27/96 6:21	69:21	83.1	290.85	48	0	0.38	207.75	0.04	0	207.75	0	0.14

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Table H-3-5. Dissolved Oxygen Measurements at varios GMPs

Initial Time	Final Time	Elapsed time hrs.	GMP-1 10 ft. bls GMP-1	GMP-2 25 ft. bls	GMP-3 35 ft. bls.	GMP-4 10 ft. bls.	GMP-5 20 ft. bls	GMP-6 30 ft. bls.	GMP-7 7 ft. bls.	GMP-8 15 ft. bls.	GMP-9 25 ft. bls.	GMP-10 5 ft. bls.	GMP-11 15 ft. bls.
9/23/96 21:11	9/23/96 23:15	0:00	3	6	3			1	0	0	5		4
9/24/96 9:30		0:00											
9/24/96 11:12	9/24/96 12:33	2:22	4		3	1.6	7	4	2.2	5	6	0.8	0.8
9/24/96 15:50	9/24/96 16:50	6:50	9			1.6			1.8	4	8	2.4	0.8
9/24/96 18:50	9/24/96 19:47	9:48	3		6		12		4	3	5	6	2.8
9/24/96 22:15	9/25/96 0:30	13:52	5.5	11	3.8	2.4	12		3	4	4.8	6.5	2.4
9/25/96 2:10	9/25/96 3:30	17:20	4		5	2.6	9		4.4	4.2	6	6	2
9/25/96 5:00	9/25/96 6:10	20:05	4.2		4.5	3	9		4	4	2.2	5	1.2
9/25/96 7:40	9/25/96 8:45	22:42	4		1.6	2.2	11		4.2	4	6.2	6	3.2
9/25/96 10:15	9/25/96 11:38	25:26	4		2.4	4.2	12			6	3.6	7	3.4
9/25/96 13:20	9/25/96 14:10	28:15	4		5	1.2	7			7	7		4
9/25/96 16:18	9/25/96 17:21	31:19	4		4	1.6	9		4	7	7	4	1
9/25/96 18:56	9/25/96 19:42	33:49	4		5	1.4	7		4	6	5	3	1.4
9/25/96 23:25	9/26/96 0:55	38:40	3.8		2.4	0.9	9		3.4	7.5	5	7	1
9/26/96 3:15	9/26/96 5:30	42:52	4.2	6.5	1.2	3.8	10	3.2	3	8	6	7	1.4
9/26/96 7:15	9/26/96 8:15	46:15	5		5	2.4	8.5	1.4	2.4	8	6	7	1.4
9/26/96 10:55	9/26/96 12:12	50:03	6		6	3	8	6	2.8	6	4	6	0.8
9/26/96 14:58	9/26/96 16:04	54:01	4		6	2.6	6	5	2.4	5	6	2.4	
9/26/96 23:00	9/27/96 0:05	62:02	6			0.6	6.5	5	3	5	9	7	1
9/27/96 3:30	9/27/96 4:15	66:22	6.5			1.2	7		2.6	6	4	7	0.8
9/27/96 8:11	9/27/96 8:43	70:57	5			1.6	8		3.4	5	3		1.2

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Table H-3-6. FID and GA-90 Data at various PMPs

	Initial Time	Elapsed	PMP-1	PMP-2	PMP-3	PMP-4	PMP-5	PMP-6	PMP-7	PMP-8	PMP-9	PMP-10	PMP-11
		time	10 ft. bls	25 ft. bls	35 ft. bls.	10 ft. bls.	20 ft. bls	30 ft. bls.	7 ft. bls.	15 ft. bls.	25 ft. bls.	5 ft. bls.	15 ft. bls.
		hrs.	PMP-1										
9/24/96	9/24/96 9:30	0:00											
CH4	9/24/96 9:50	0:20	0.2	0.3	37	0	0	2.1	3.9	5.9	12.7	0.2	0.2
CH4	9/24/96 14:24	4:54	0.1	0.1	0.6	0.2	1	0.7	0.1	0.1	21.7	0.1	0.2
CH4	9/24/96 17:30	8:00	0.1	0.1	0.3	0.2	0.6	0.5	0.1	0.1	4.4	0.2	0.3
CH4	9/24/96 21:10	11:40	0.1	0.1	0.1	0.1	0.2	0.3	0.1	0.1	0.7	0	0
CH4	9/25/96 1:15	15:45	0.1	0	0.1	0	0.4	0.3	0	0	0.4	0	0.1
CH4	9/25/96 4:30	19:00	0	0	0.1	0	0.1	0.2	0	0	0.2	0	0
CH4	9/25/96 7:00	21:30	0	0	0.1	0	0.1	0.2	0	0	0.1	0	0
CH4	9/25/96 9:32	24:02	0	0	0.1	0	0.1	0.2	0	0	0.1	0	0
CH4	9/25/96 12:13	26:43	0.1	0.1	0.3	0.1	0.1	0.3	0.1	0.1	0.3	0.1	0.2
CH4	9/25/96 15:47	30:17	0.2	0.1	0.3	0.2	0.3	0.4	0.2	0.2	0.3	0.1	0.4
CH4	9/25/96 18:30	33:00	0.1	0	0.2	0.1	0.1	0.3	0	0.1	0.2	0.1	0.3
CH4	9/26/96 1:00	39:30	0	0	0.2	0	0.1	0.2	0	0	0.2	0	0.3
CH4	9/26/96 6:45	45:15	0	0	0.2	0	0	0.1	0	0	0.2	0.1	0.4
CH4	9/26/96 10:17	48:47	0.1	0.1	0.4	0.1	0.3	0.2	0.1	0.1	0.2	0.1	0.4
CH4	9/26/96 14:37	53:07	0.1	0.2	0.4	0.1	0.5	0.2	0.2	0.1	0.4	0.2	0.5
CH4	9/26/96 19:00	57:30	0.1	0	0.1	0	0.6	0.1	0.1	0.1	0.5	0.1	0.4
CH4	9/26/96 22:25	60:55	0	0	0.1	0.1	NR	0.9	0.1	0.1	0.6	0.1	0.4
CH4	9/27/96 2:05	64:35	0	0	0.1	0	0.2	0.2	0	0	0.7	0	0.4
CH4	9/27/96 4:35	67:05	0.1	0.1	0	0	0.1	0.1	0.1	0	0.3	0.1	0.4
CH4	9/27/96 7:00	69:30	0.1	0	0.1	0	0.1	0.1	0.1	0.1	0.2	0.1	0.5
CH4	9/27/96 10:39	73:09	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.3	0.6
	Initial Time	Elapsed	PMP-1	PMP-2	PMP-3	PMP-4	PMP-5	PMP-6	PMP-7	PMP-8	PMP-9	PMP-10	PMP-11
		time, hrs	10 ft. bls	25 ft. bls	35 ft. bls.	10 ft. bls.	20 ft. bls	30 ft. bls.	7 ft. bls.	15 ft. bls.	25 ft. bls.	5 ft. bls.	15 ft. bls.
CO2	9/24/96 9:50	0:20	1.1	0.6	15	0	0	0	0	0.2	0	1.1	0.4
CO2	9/24/96 14:24	4:54	0.3	0.2	4.2	0	2.2	2.6	0	0.2	6.9	0.9	0.4
CO2	9/24/96 17:30	8:00	0.2	0.1	3.4	0.1	1.7	1.2	0	0.2	5.6	0.9	0.3
CO2	9/24/96 21:10	11:40	0.1	0	2	0	0.5	0.5	0	0	4.2	0.9	0.2
CO2	9/25/96 1:15	15:45	0.3	0	1.7	0	0.9	0.4	0	0.1	3.9	1	0.3
CO2	9/25/96 4:30	19:00	0.1	0	0.4	0	0.8	0.4	0	2.2	2.7	0.9	0.3
CO2	9/25/96 7:00	21:30	0.1	0	1.1	0	0.9	0.3	0	0.2	2.3	0.9	0.3
CO2	9/25/96 9:32	24:02	0	0	1.1	0.1	0.8	0.3	0	0.2	2.2	0.8	0.3
CO2	9/25/96 12:13	26:43	0	0	1.3	0.1	1	0.3	0	0.2	2.5	0.8	0.4
CO2	9/25/96 15:47	30:17	0	0	1.4	0.1	2.6	0.2	0.2	0.2	1.9	0.7	0.7
CO2	9/25/96 18:30	33:00	0	0	1.6	0	1.9	0.1	0	0.1	1	0.7	0.7
CO2	9/26/96 1:00	39:30	0	0	1.9	0	1.9	0.1	0	0.1	0.7	0.8	1
CO2	9/26/96 6:45	45:15	0	0	2	0	1.3	0	0	0.1	0.4	0.9	1.4
CO2	9/26/96 10:17	48:47	0	0	0.5	0	3	0.1	0.1	0.1	0.4	0.9	1.2
CO2	9/26/96 14:37	53:07	0	0	1.3	0	1	0	0.2	0.1	0.2	0.9	1.1
CO2	9/26/96 19:00	57:30	0	0	0.6	0	1.4	0	0.2	0.1	0.1	0.8	0.8
CO2	9/26/96 22:25	60:55	0	0	0.3	0		1.8	0.3	0.2	2.6	1	0.5
CO2	9/27/96 2:05	64:35	0	0	0.2	0.1	1.2	0.5	0.2	0.1	2.2	1.1	0.5
CO2	9/27/96 4:35	67:05	0	0	0	0	0.8	0.4	0.2	0.1	1.8	1.1	0.7
CO2	9/27/96 7:00	69:30	0	0	0	0	0.9	0.4	0.1	0.1	1.2	1.1	0.9
CO2	9/27/96 10:39	73:09	0	0	0	0	0	0.4	0.2	0	1.1	2	1.2

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GA-90, FID

	Initial Time	Elapsed	PMP-1	PMP-2	PMP-3	PMP-4	PMP-5	PMP-6	PMP-7	PMP-8	PMP-9	PMP-10	PMP-11
		time, hrs	10 ft. bls	25 ft. bls	35 ft. bls.	10 ft. bls.	20 ft. bls	30 ft. bls.	7 ft. bls.	15 ft. bls.	25 ft. bls.	5 ft. bls.	15 ft. bls.
FID	9/24/96 9:50	0:20	20	50	2000	10	10	500	8	8	400	4	0
FID	9/24/96 14:24	4:54	0	25	25	7	5	40	3	18	2000	9	18
FID	9/24/96 17:30	8:00	15	0	5	6	1700	20	5	18	70	5	50
FID	9/24/96 21:10	11:40	48	25	20	15	20	1000	9	9	500	10	100
FID	9/25/96 1:15	15:45	150	13	55	15	1000	1100	13	38	250	11	120
FID	9/25/96 4:30	19:00	11	5	250	16	950	1000	10	50	150	10	130
FID	9/25/96 7:00	21:30	20	0	90	12	650	900	10	50	40	10	130
FID	9/25/96 9:32	24:02	0	0	90	3	45	50	18	5	19	2	28
FID	9/25/96 12:13	26:43	0	3	45	2	40	150	35	10	90	5	180
FID	9/25/96 15:47	30:17	9	3	55	2	70	50	0	0	100	10	230
FID	9/25/96 18:30	33:00	0	1	45	0	40	60	45	6	100	5	140
FID	9/26/96 1:00	39:30	16	3	300	20	350	350	90	45	130	F	2100
FID	9/26/96 6:45	45:15	15	11	600	15	260	220	60	43	50	50	2000
FID	9/26/96 10:17	48:47	3	0	200	3	210	10	38	8	35	45	900
FID	9/26/96 14:37	53:07	3	1	150	7	300	40	80	18	150	40	600
FID	9/26/96 19:00	57:30	3	1	50	9	600	50	50	30	350	90	1500
FID	9/26/96 22:25	60:55	23	6	390	17		2500	350	45	50	50	1900
FID	9/27/96 2:05	64:35	28	4	32	25	800	250	400	48	350	50	2300
FID	9/27/96 4:35	67:05	25	8	20	16	330	400	420	35	200	50	2400
FID	9/27/96 7:00	69:30	32	3	14	13	280	340	240	20	5000	140	1300
FID	9/27/96 10:39	73:09	4	6	15	16	14	220	180	32	F	F	1000
	Initial Time	Elapsed	PMP-1	PMP-2	PMP-3	PMP-4	PMP-5	PMP-6	PMP-7	PMP-8	PMP-9	PMP-10	PMP-11
		time, hrs	10 ft. bls	25 ft. bls	35 ft. bls.	10 ft. bls.	20 ft. bls	30 ft. bls.	7 ft. bls.	15 ft. bls.	25 ft. bls.	5 ft. bls.	15 ft. bls.
O2	9/24/96 9:50	0:20	24.6	24.9	15	20.6	20.6	25.5	20.5	20.5	20.6	16.9	20.2
O2	9/24/96 14:24	4:54	19.9	20.2	18.8	20.4	17.8	18.7	20.4	20.4	10.9	17.5	20.4
O2	9/24/96 17:30	8:00	20.3	20.5	19.3	20.3	18.5	19.3	20.4	20.2	15.3	17.6	20.3
O2	9/24/96 21:10	11:40	20.2	20	19.6	20.4	19.9	19.7	20.3	20.3	16.7	17.4	20
O2	9/25/96 1:15	15:45	19.9	20.3	19.2	19.9	19.2	19.5	20.1	20.1	16.4	17.2	20.2
O2	9/25/96 4:30	19:00	19.8	20	19.4	19.7	19.1	19.2	19.7	19.7	17.4	17	19.8
O2	9/25/96 7:00	21:30	19.8	20	19.4	19.6	19.1	19.2	19.7	19.7	17.5	17	19.7
O2	9/25/96 9:32	24:02	20.3	20.5	19.4	20.6	20.2	20.2	20.5	20.5	17.7	17.6	20.4
O2	9/25/96 12:13	26:43	20.6	20.7	19.2	20.6	19.9	20.2	20.4	20.6	16.8	17.6	20.3
O2	9/25/96 15:47	30:17	20.4	20.5	18.9	20.5	18.9	20.2	20.5	20.5	17	17.9	19.6
O2	9/25/96 18:30	33:00	20.7	20.8	18.9	20.8	19.5	20.6	20.7	20.7	18.4	18.1	19.6
O2	9/26/96 1:00	39:30	20.6	20.7	18.4	20.4	19.2	20.2	20.4	20.4	18.4	17.9	19.3
O2	9/26/96 6:45	45:15	20.5	20.6	18.3	20.2	19.4	20.3	20.3	20.4	18.6	17.5	18.5
O2	9/26/96 10:17	48:47	20.5	20.5	16.6	20.5	17.5	20.5	20.5	20.5	18.1	17.6	18.7
O2	9/26/96 14:37	53:07	20.5	20.6	19.7	20.4	17.6	20.6	20.1	20.4	18.8	17.6	18.4
O2	9/26/96 19:00	57:30	20.7	20.7	19.8	20.6	17.6	20.6	20.2	20.6	18.1	17.6	18.6
O2	9/26/96 22:25	60:55	20.8	21	20.5	20.9		18.8	20.4	20.8	12	17.8	19
O2	9/27/96 2:05	64:35	20.6	21	20.7	20.6	19	20.2	20.3	20.7	18	17.4	19
O2	9/27/96 4:35	67:05	20.7	21	20.8	20.6	19.6	20.3	20.3	20.7	18.7	17.4	18.5
O2	9/27/96 7:00	69:30	20.7	20.9	20.2	20.7	19.5	20.1	20.4	20.7	19	17.2	18
O2	9/27/96 10:39	73:09	20.3	20.5	20.5	20.7	20.6	20	20.3	20.5	17.1	17.6	17.6

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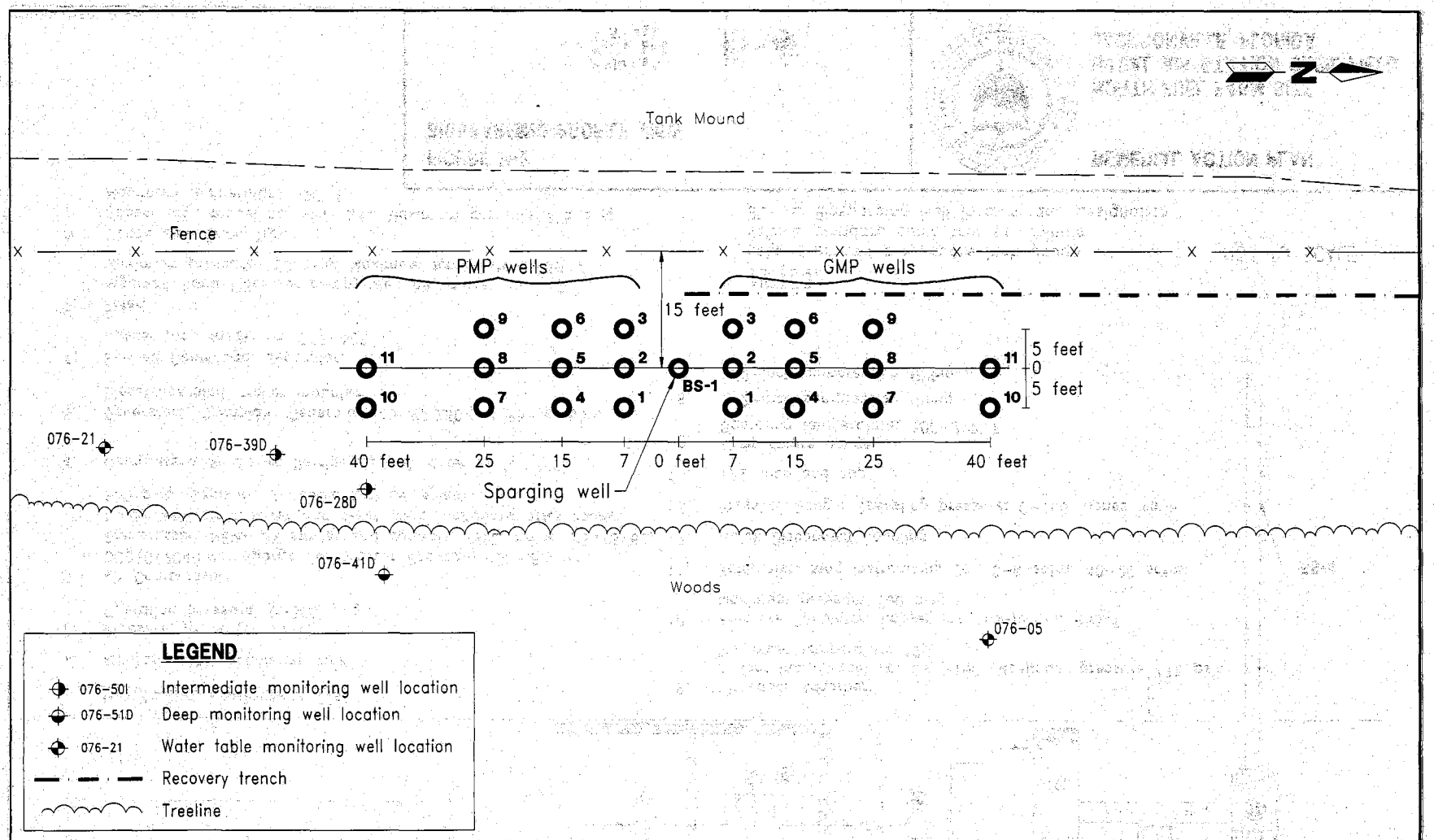

Notes:
PMP = Pressure monitoring point
GMP = Groundwater monitoring point

0 10 20
SCALE: 1 INCH = 20 FEET

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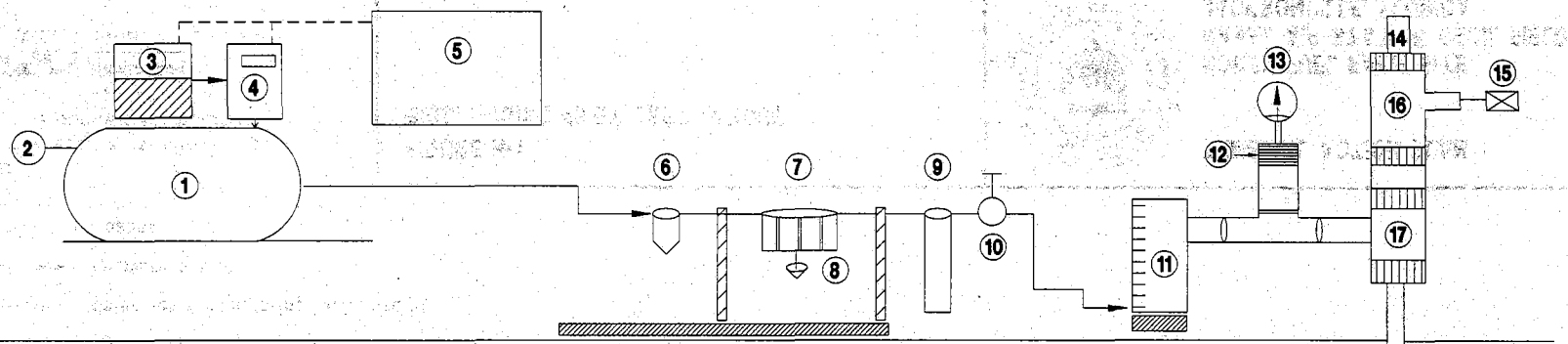
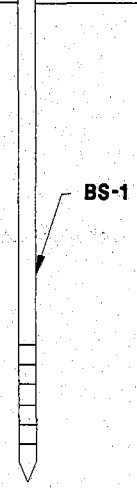
FIGURE H-1
BIOSPARGING PILOT TEST LAYOUT

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA





Monitoring Equipment List

1. Air Tank: 150-gallon air tank
2. Pressure gauge (on tank):
   Operating pressure: 0-300 psig
3. Air Compressor:
   QCS1012040 Air Sparge Compressor Package, 10 H.P., Air Compressor, NEMA 3R starter and controls, TEFC motor, 230/3/60, ASME Code air receiver and relief valve, boltguard after cooler: 120 psig. Capacity: 40 cubic feet per minute
4. Compressed Air Dryer: Refrigerated air dryer (115/1/60)
5. Generator: "Olympian" Generator, 40KW, 230V, 3 Phase, 60Hz, Diesel operated, trailer mounted
6. Filtered Centrifugal Separator:
   Kaeser Inc., model no. FCS-100
7. Filter:
   Ingersoll-Rand Filter for compressed air, model no. 150. Maximum pressure 150 psig. Maximum temperature 150° F
8. Condensate Drain Trap:
   Kaeser Inc., model no. ADT-20M. Maximum pressure 175 psig. Maximum temperature 120° F
9. Oil Vapor Adsorber:
   Kaeser Inc., model no. OVA-100. Maximum pressure 175 psig Maximum temperature 120° F
10. Pressure Regulator: Kaeser Inc., model no. R354T. Maximum pressure 300 psig
11. Rotameter: King Instruments Co., 0-6 scfm, 40-20 scfm
12. Quick Disconnect Coupling
13. Pressure Gauge: Operating pressure: 0-100 inches water
14. 1/2-inch end cap
15. Temperature gauge:
    Operating temperature: 100-212° F
16. 1/2-inch compression fitting
17. 1/2-inch compression fitting

NOTES:

psig = pounds per square inch gauge
scfm = standard cubic foot per minute
BS-1 = Biosparging well location and designation

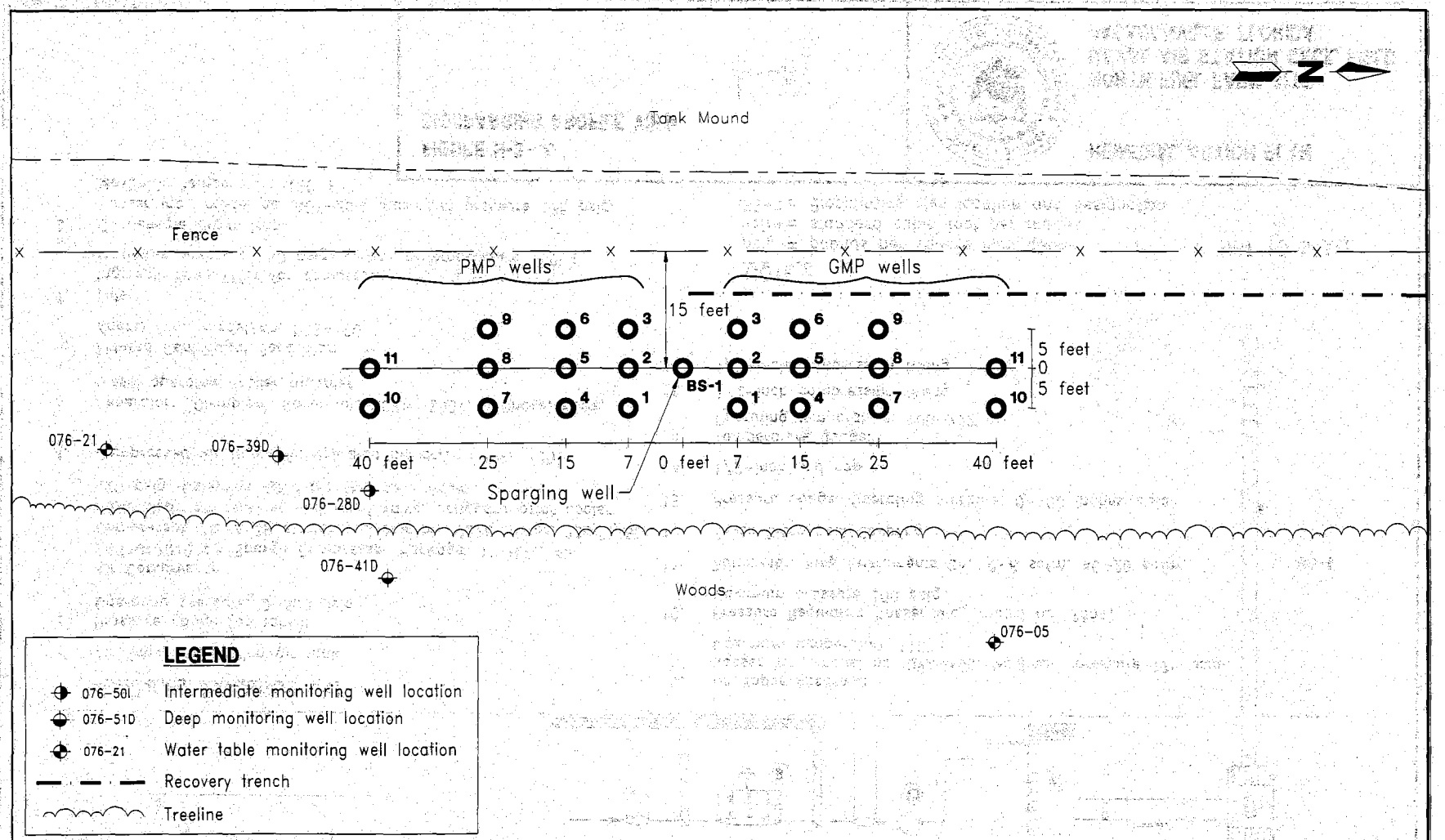
NOT TO SCALE

FIGURE H-2
BIOSPARGING PROFILE VIEW

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

T:\8560-03\BIOSPAR\PWF\1-24-97



Notes:
PMP = Pressure monitoring point
GMP = Groundwater monitoring point

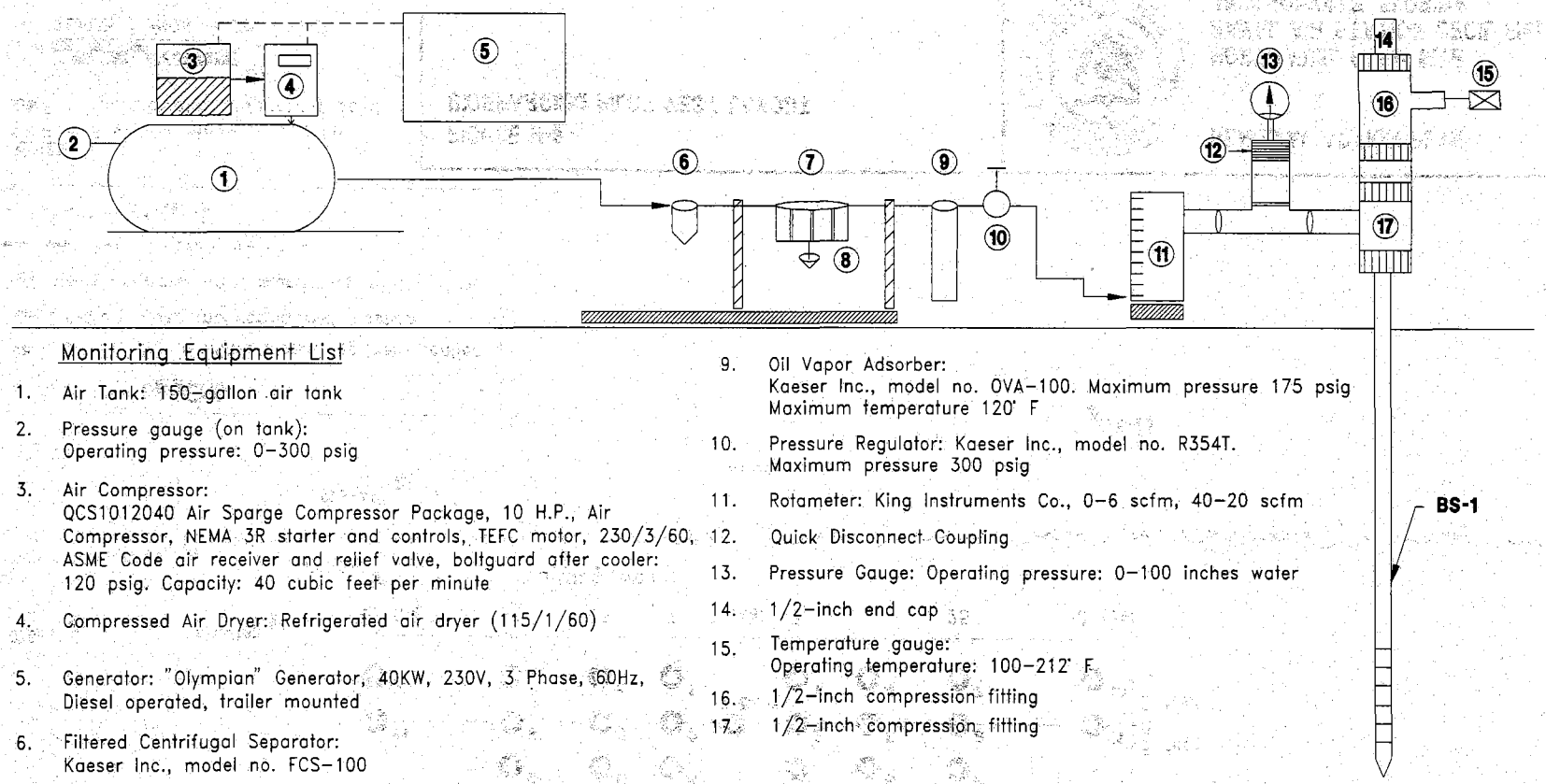
0 10 20
SCALE: 1 INCH = 20 FEET

T:\8560-03\8560F003\PWF\1-24-97

FIGURE H-2-1
BIOSPARGING PILOT TEST LAYOUT

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA



Monitoring Equipment List

1. Air Tank: 150-gallon air tank
2. Pressure gauge (on tank):
   Operating pressure: 0-300 psig
3. Air Compressor:
   QCS1012040 Air Sparge Compressor Package, 10 H.P., Air Compressor, NEMA 3R starter and controls, TEFC motor, 230/3/60, ASME Code air receiver and relief valve, boltguard after cooler: 120 psig. Capacity: 40 cubic feet per minute
4. Compressed Air Dryer: Refrigerated air dryer (115/1/60)
5. Generator: "Olympian" Generator, 40KW, 230V, 3 Phase, 60Hz, Diesel operated, trailer mounted
6. Filtered Centrifugal Separator:
   Kaeser Inc., model no. FCS-100
7. Filter:
   Ingersoll-Rand Filter for compressed air, model no. 150. Maximum pressure 150 psig. Maximum temperature 150° F
8. Condensate Drain Trap:
   Kaeser Inc., model no. ADT-20M. Maximum pressure 175 psig. Maximum temperature 120° F
9. Oil Vapor Adsorber:
   Kaeser Inc., model no. OVA-100. Maximum pressure 175 psig Maximum temperature 120° F
10. Pressure Regulator: Kaeser Inc., model no. R354T. Maximum pressure 300 psig
11. Rotameter: King Instruments Co., 0-6 scfm, 40-20 scfm
12. Quick Disconnect Coupling
13. Pressure Gauge: Operating pressure: 0-100 inches water
14. 1/2-inch end cap
15. Temperature gauge:
    Operating temperature: 100-212° F
16. 1/2-inch compression fitting
17. 1/2-inch compression fitting

NOTES:

psig = pounds per square inch gauge
scfm = standard cubic foot per minute
BS-1 = Biosparging well location and designation

NOT TO SCALE

FIGURE H-2-2
BIOSPARGING PROFILE VIEW

REMEDIAL ACTION PLAN

NORTH FUEL FARM SITE
NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

T:\8560-03\BIOSPAR\PWF\1-24-97

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FIG H-3-1 Pictorial Representation

PROJECT	COMP. BY	JOB NO.
NFF RAP – BIOSPARGING PILOT TEST SCHEMATIC OF OBSERVATIONS	KGK	8520-92
	CHK. BY	DATE 10/2/96

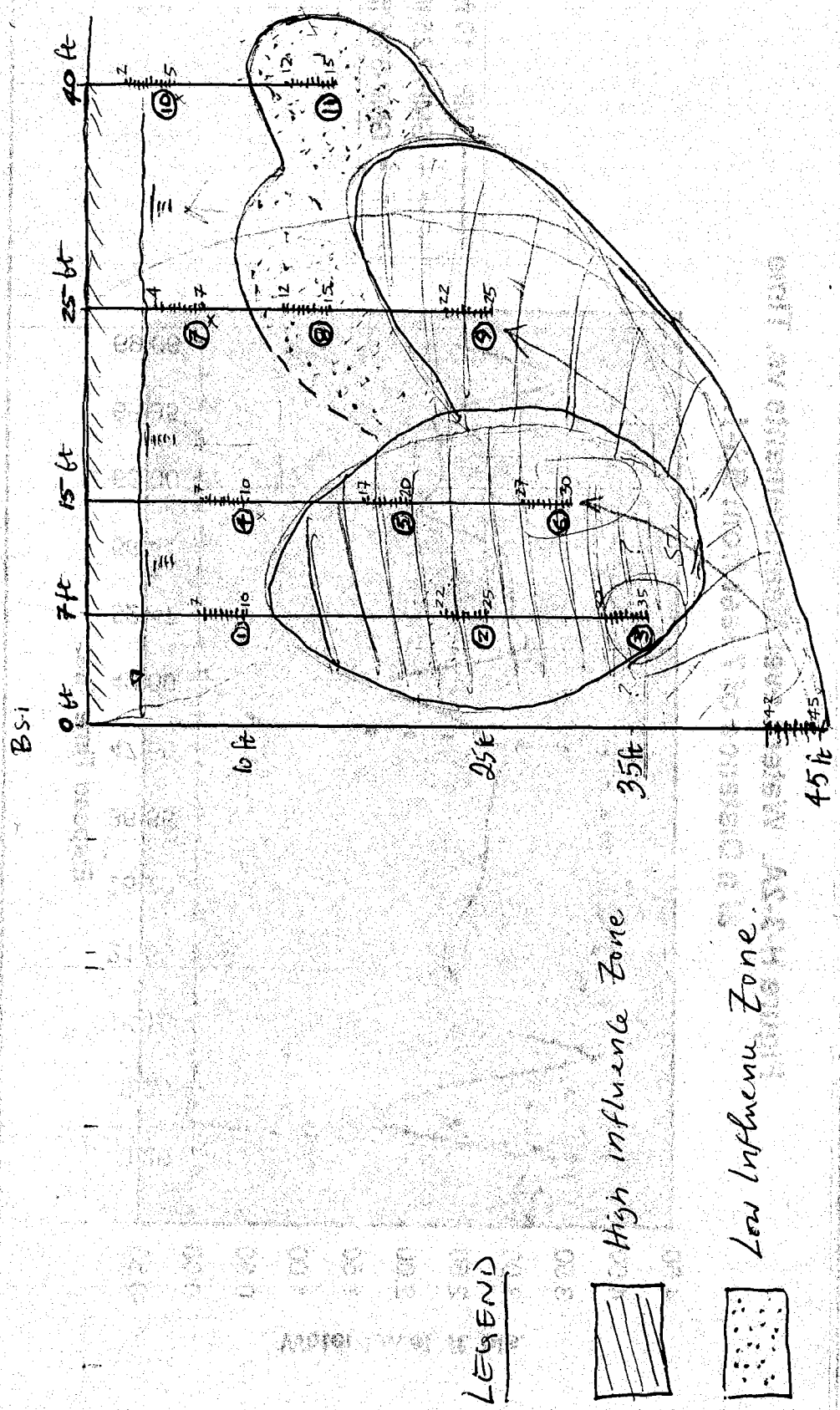
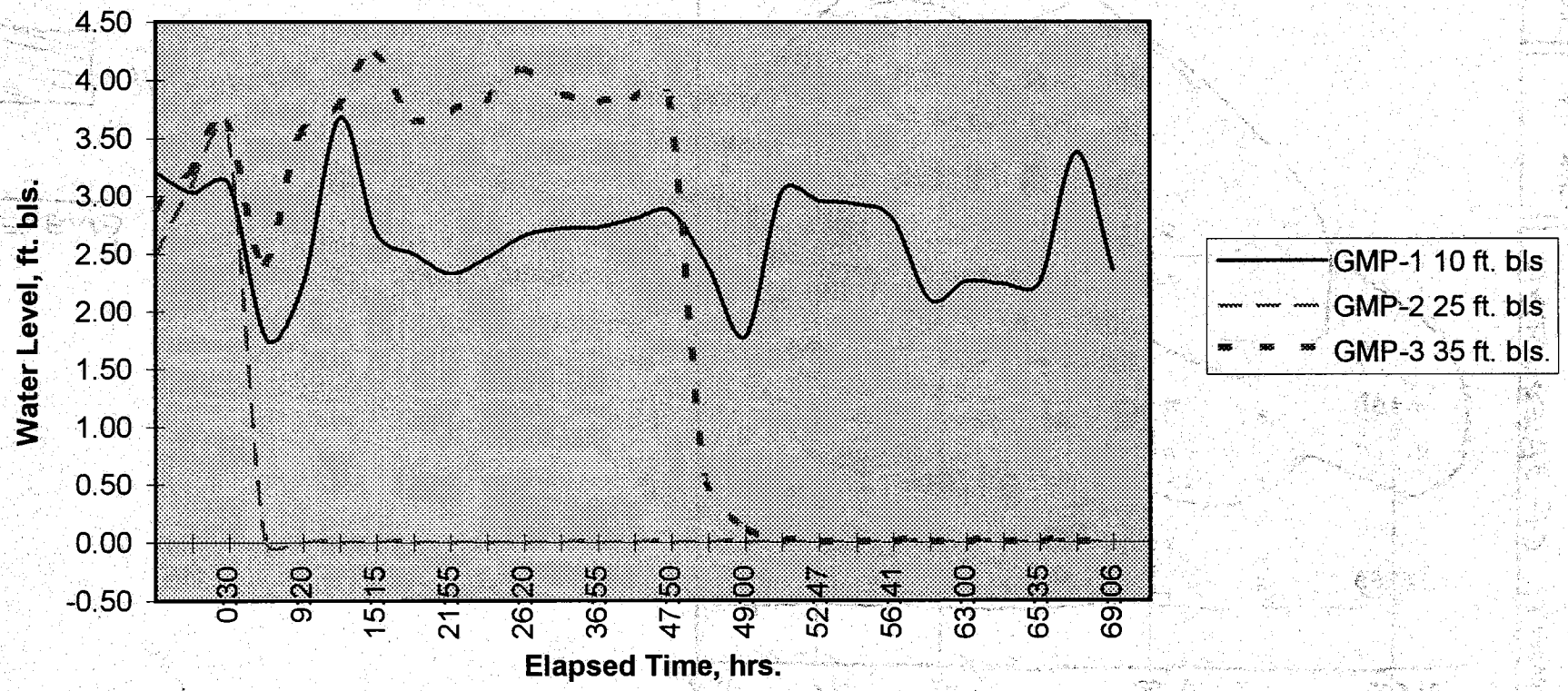


Figure H-3-2A. Water Level Measurements vs. Time at a Distance of 7 feet from BS-1.



H-2-2

Figure H-3-2B. Water Level Measurements vs. Time at a Distance of 15 feet from BS-1

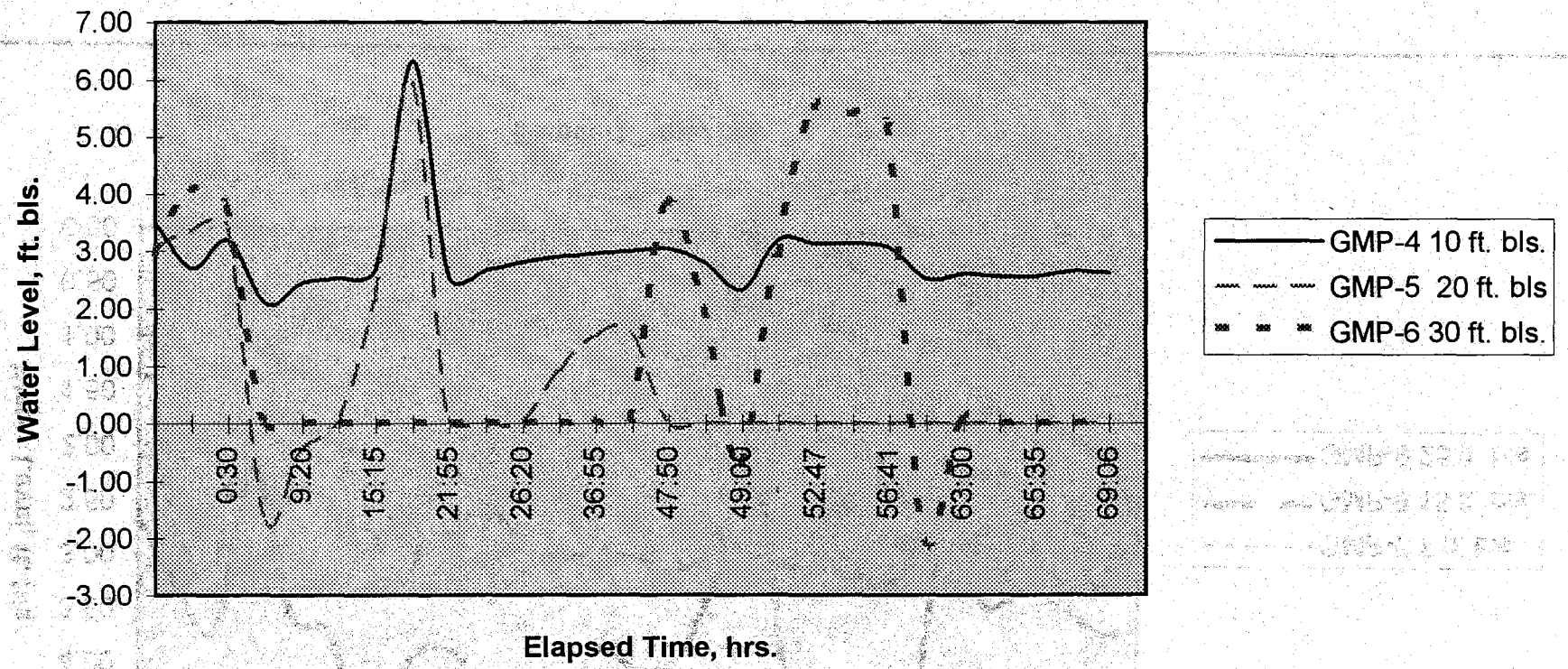


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Figure H-3-2C. Water Level Measurements vs. Time at a Distance of 25 feet from BS-1.

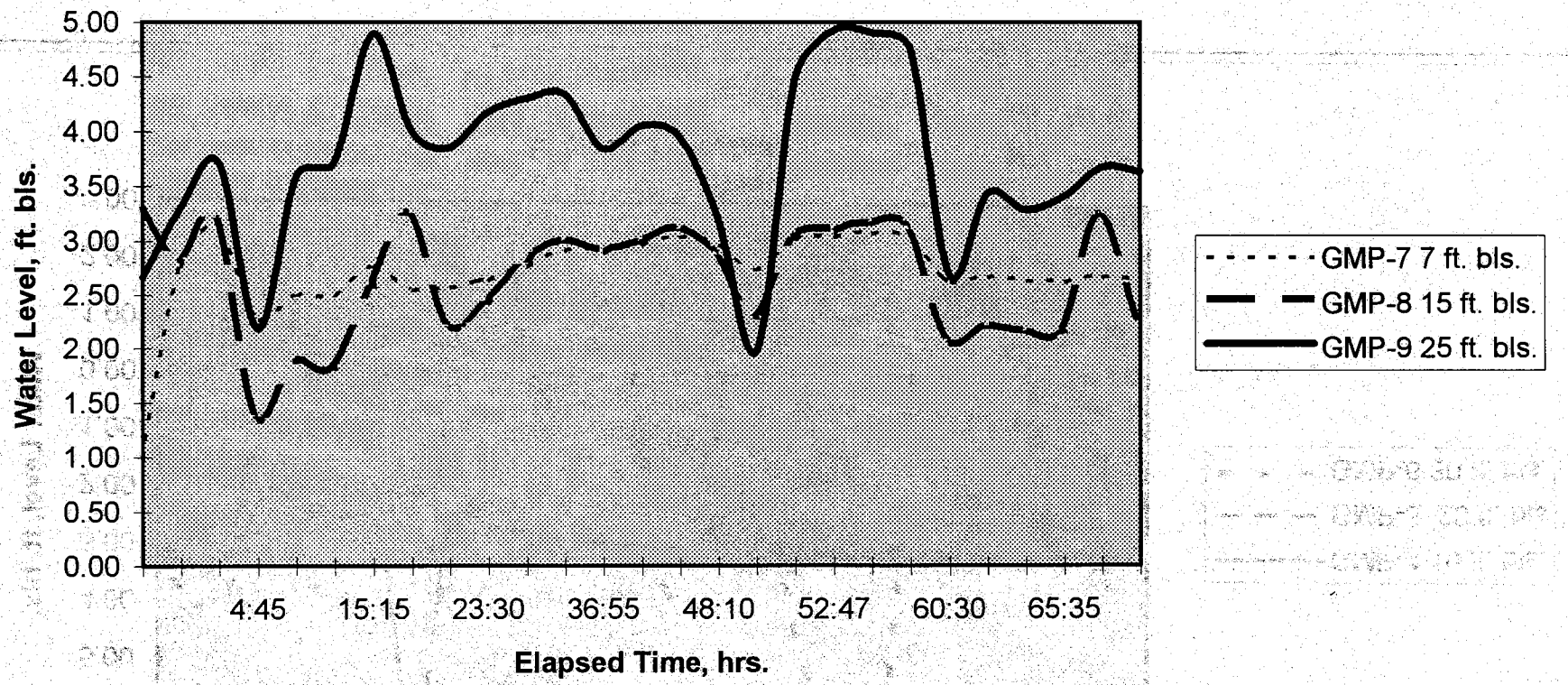

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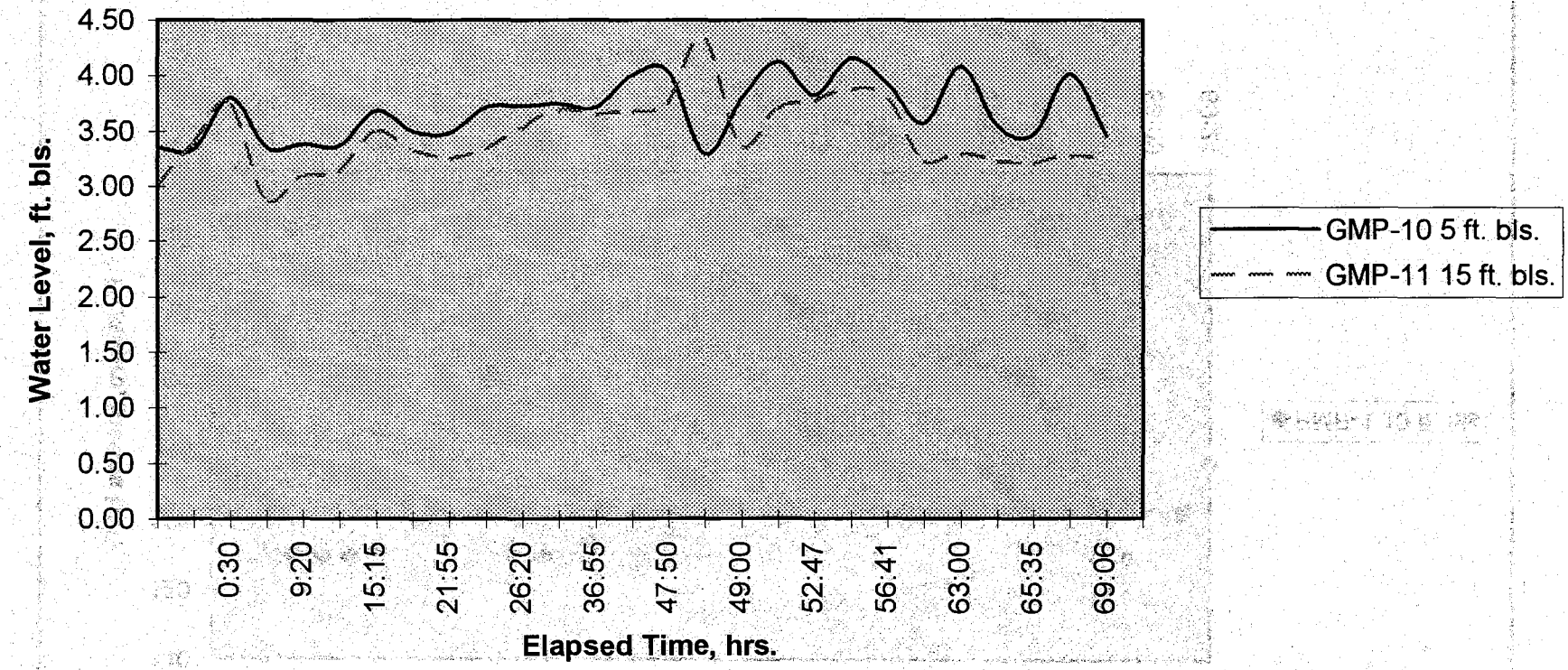
Figure H-3-2D. Water Level Measurements vs. Time at a Distance of 40 feet from BS-1



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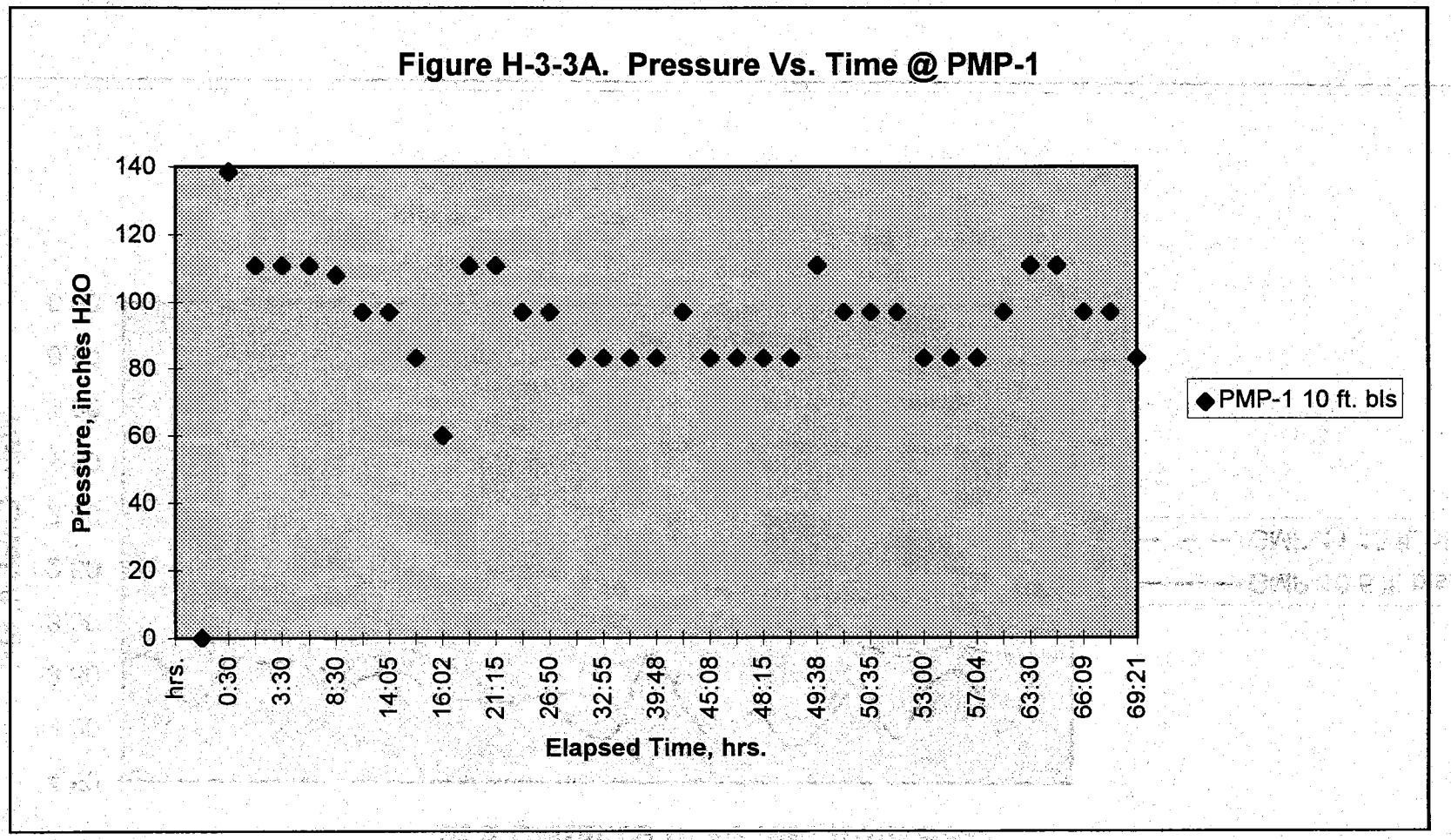
Figure H-3-3A. Pressure Vs. Time @ PMP-1
Pressure, inches H2O
140
120
100
80
60
40
20
0
hrs.
0:30
3:30
8:30
14:05
16:02
21:15
26:50
32:55
39:48
45:08
48:15
49:38
50:35
53:00
57:04
63:30
66:09
69:21
Elapsed Time, hrs.
PMP-1 10 ft. bls

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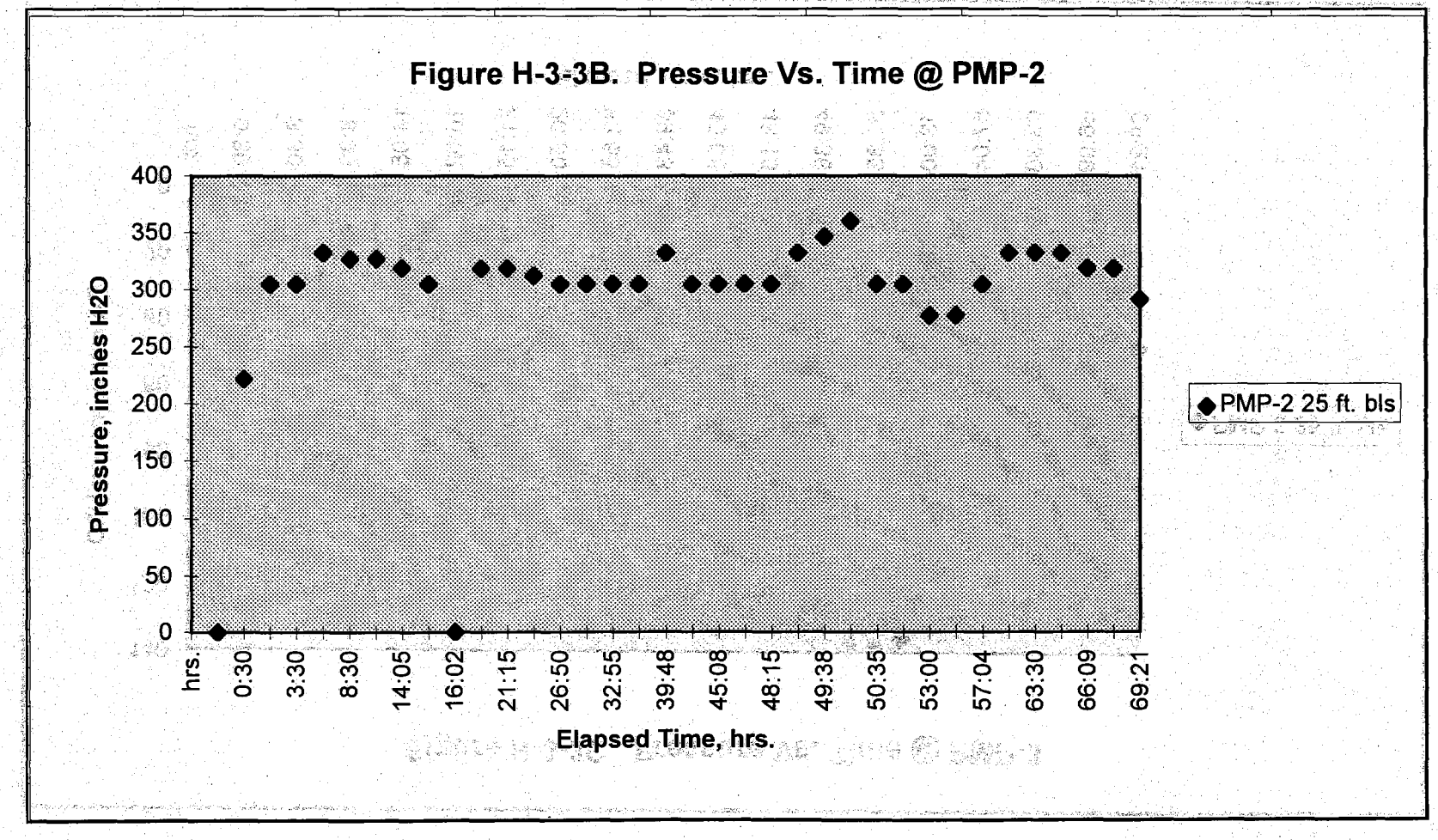
Figure H-3-3B. Pressure Vs. Time @ PMP-2
Pressure, inches H2O
400
350
300
250
200
150
100
50
0
hrs.
0:30
3:30
8:30
14:05
16:02
21:15
26:50
32:55
39:48
45:08
48:15
49:38
50:35
53:00
57:04
63:30
66:09
69:21
Elapsed Time, hrs.
PMP-2 25 ft. bls

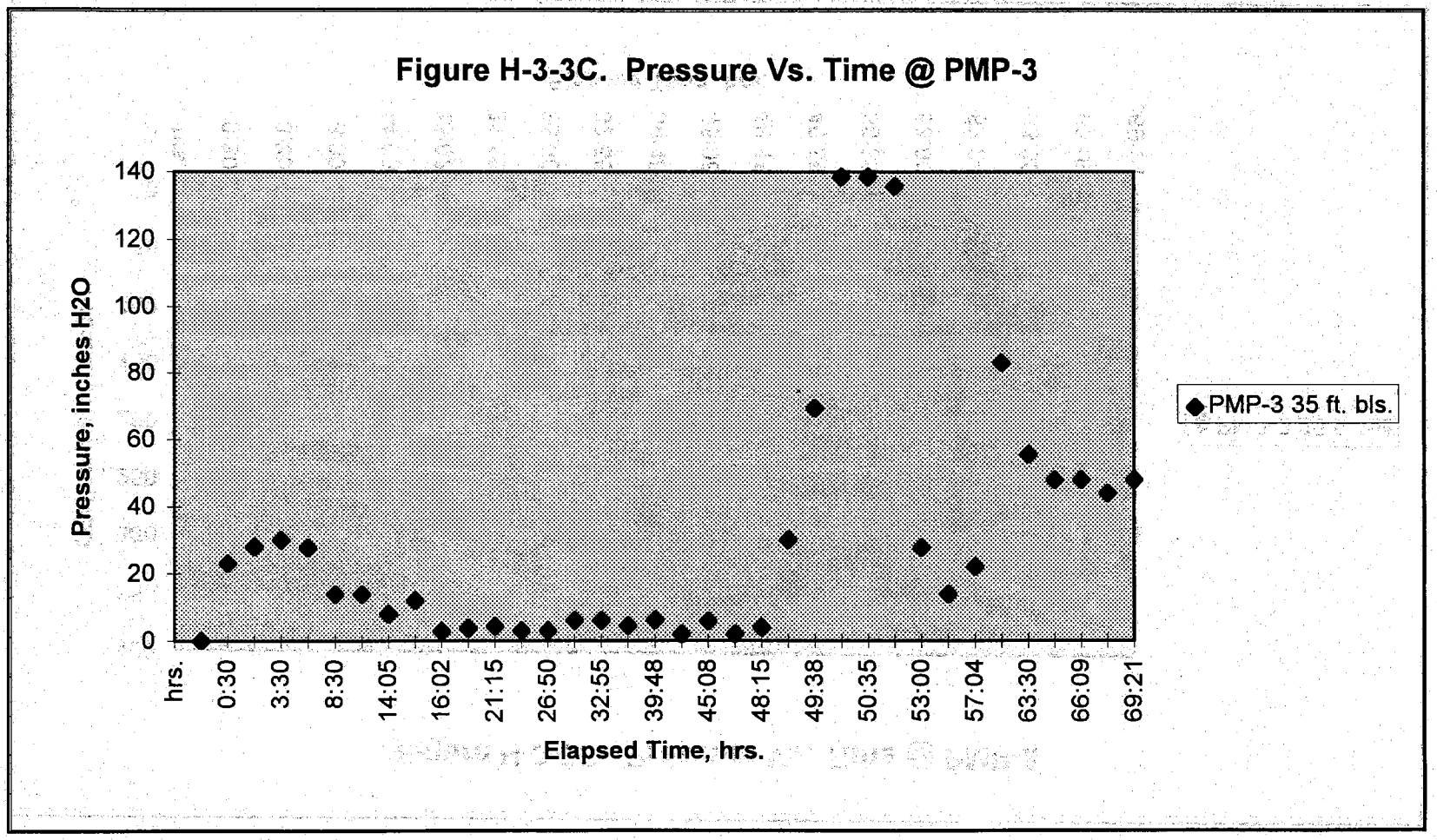
Figure H-3-3C. Pressure Vs. Time @ PMP-3
Pressure, inches H2O
140
120
100
80
60
40
20
0
hrs.
0:30
3:30
8:30
14:05
16:02
21:15
26:50
32:55
39:48
45:08
48:15
49:38
50:35
53:00
57:04
63:30
66:09
69:21
Elapsed Time, hrs.
PMP-3 35 ft. bls.

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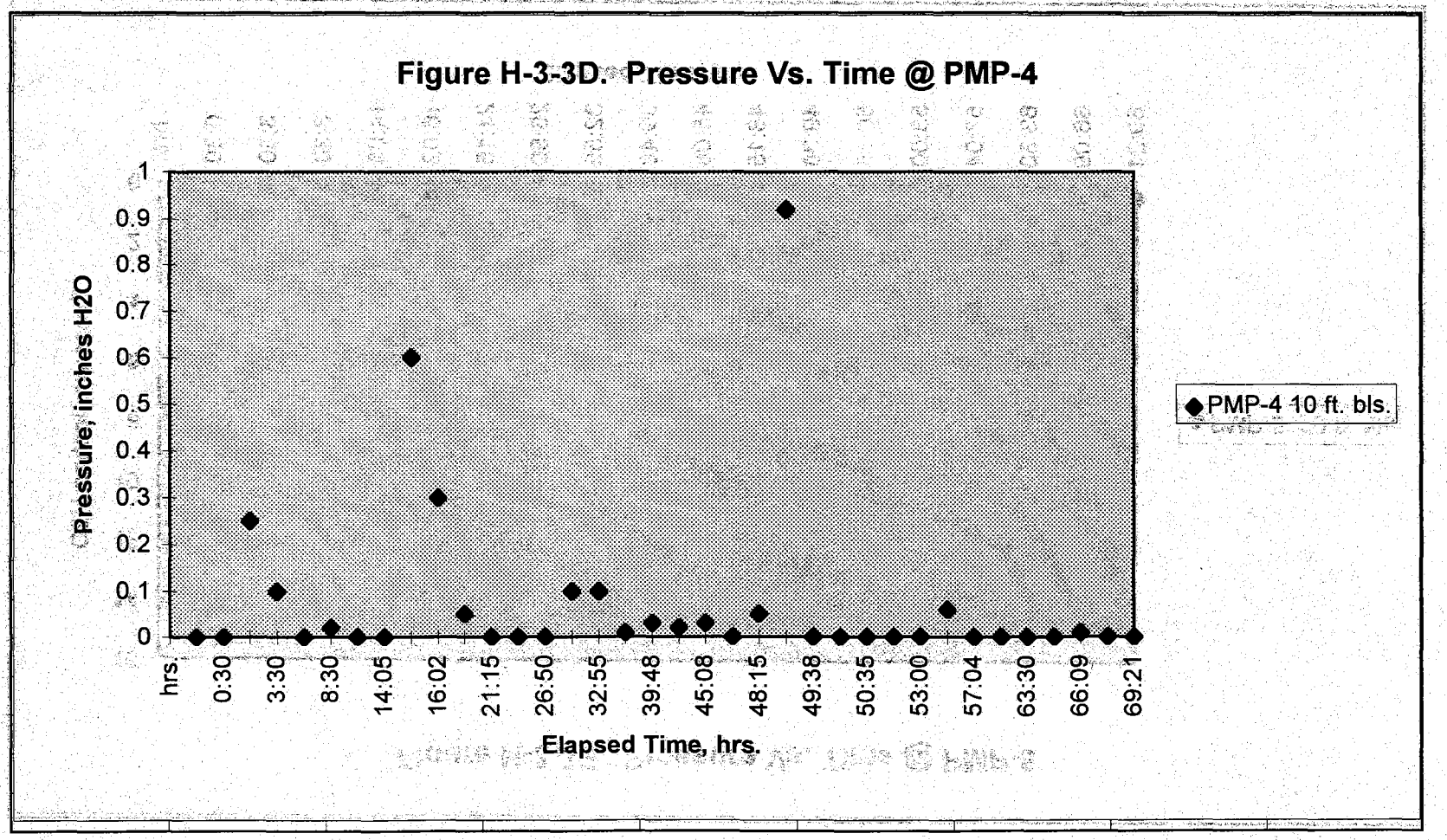
Figure H-3-3D. Pressure Vs. Time @ PMP-4
Pressure, inches H2O
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
hrs.
0:30
3:30
8:30
14:05
16:02
21:15
26:50
32:55
39:48
45:08
48:15
49:38
50:35
53:00
57:04
63:30
66:09
69:21
Elapsed Time, hrs.
PMP-4 10 ft. bls.

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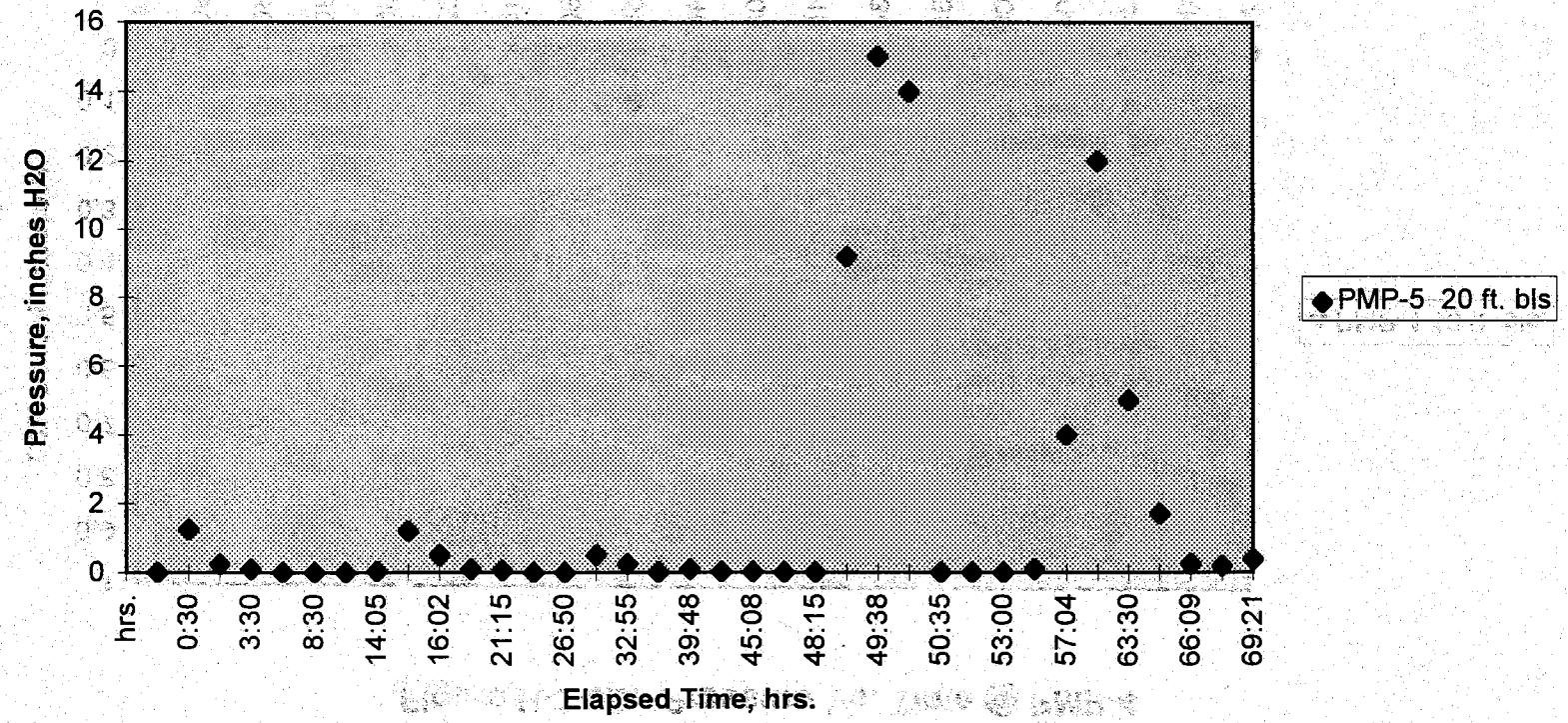
Figure H-3-3E. Pressure Vs. Time @ PMP-5



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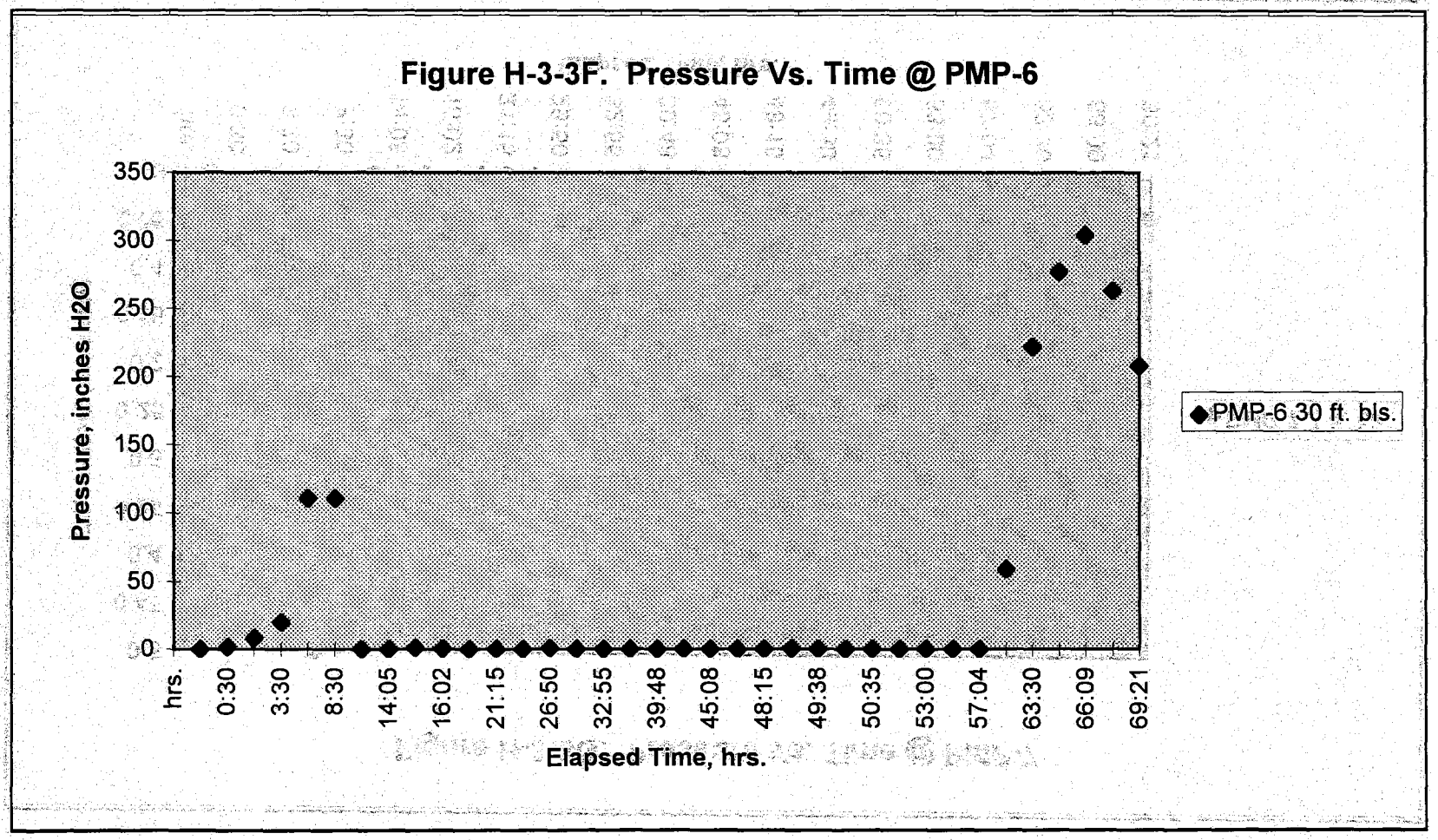
Figure H-3-3F. Pressure Vs. Time @ PMP-6
Pressure, inches H2O
350
300
250
200
150
100
50
0
hrs.
0:30
3:30
8:30
14:05
16:02
21:15
26:50
32:55
39:48
45:08
48:15
49:38
50:35
53:00
57:04
63:30
66:09
69:21
Elapsed Time, hrs.
PMP-6 30 ft. bls.

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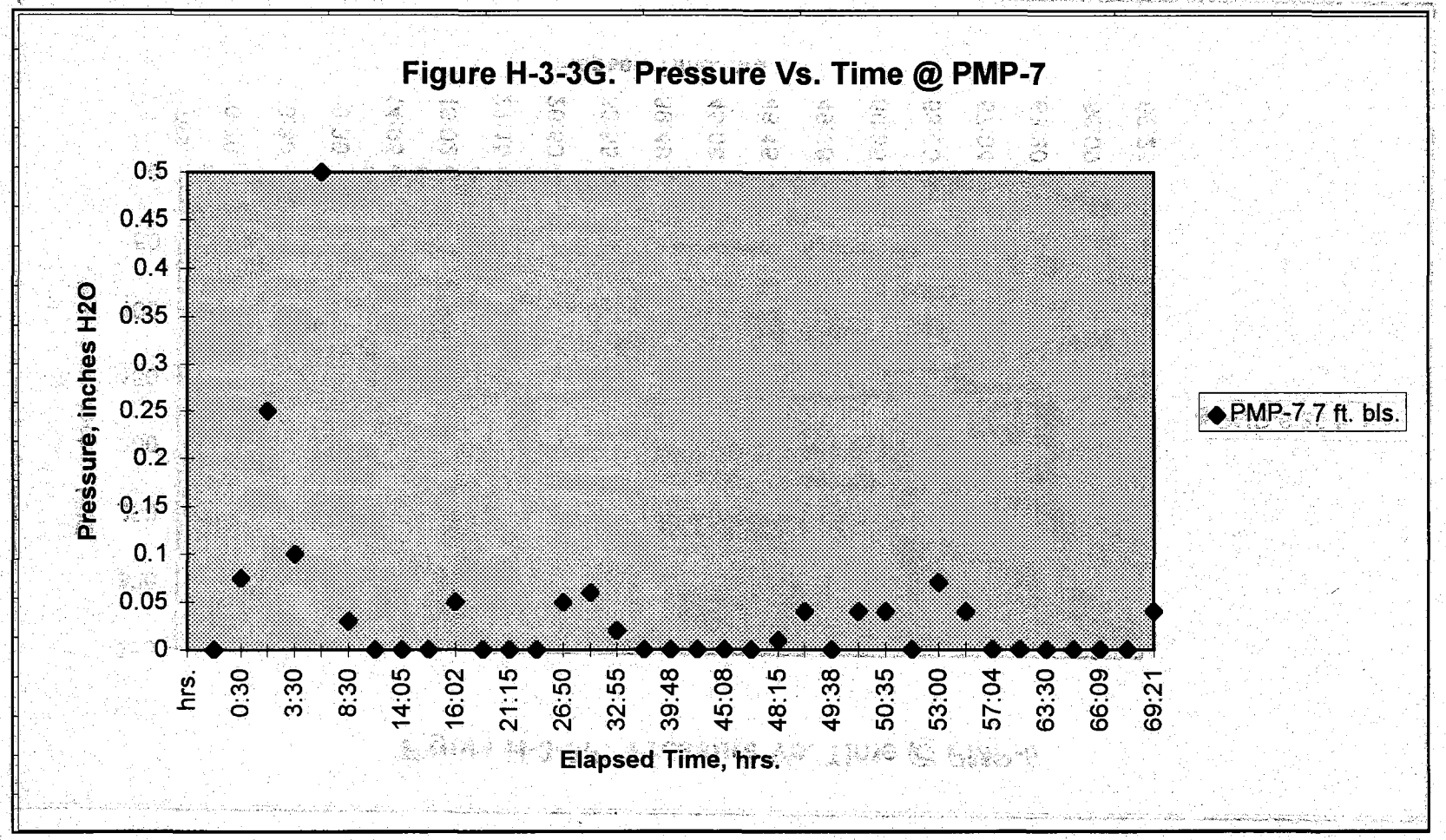
Figure H-3-3G. Pressure Vs. Time @ PMP-7
Pressure, inches H2O
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
hrs.
0:30
3:30
8:30
14:05
16:02
21:15
26:50
32:55
39:48
45:08
48:15
49:38
50:35
53:00
57:04
63:30
66:09
69:21
Elapsed Time, hrs.
PMP-7 7 ft. bls.

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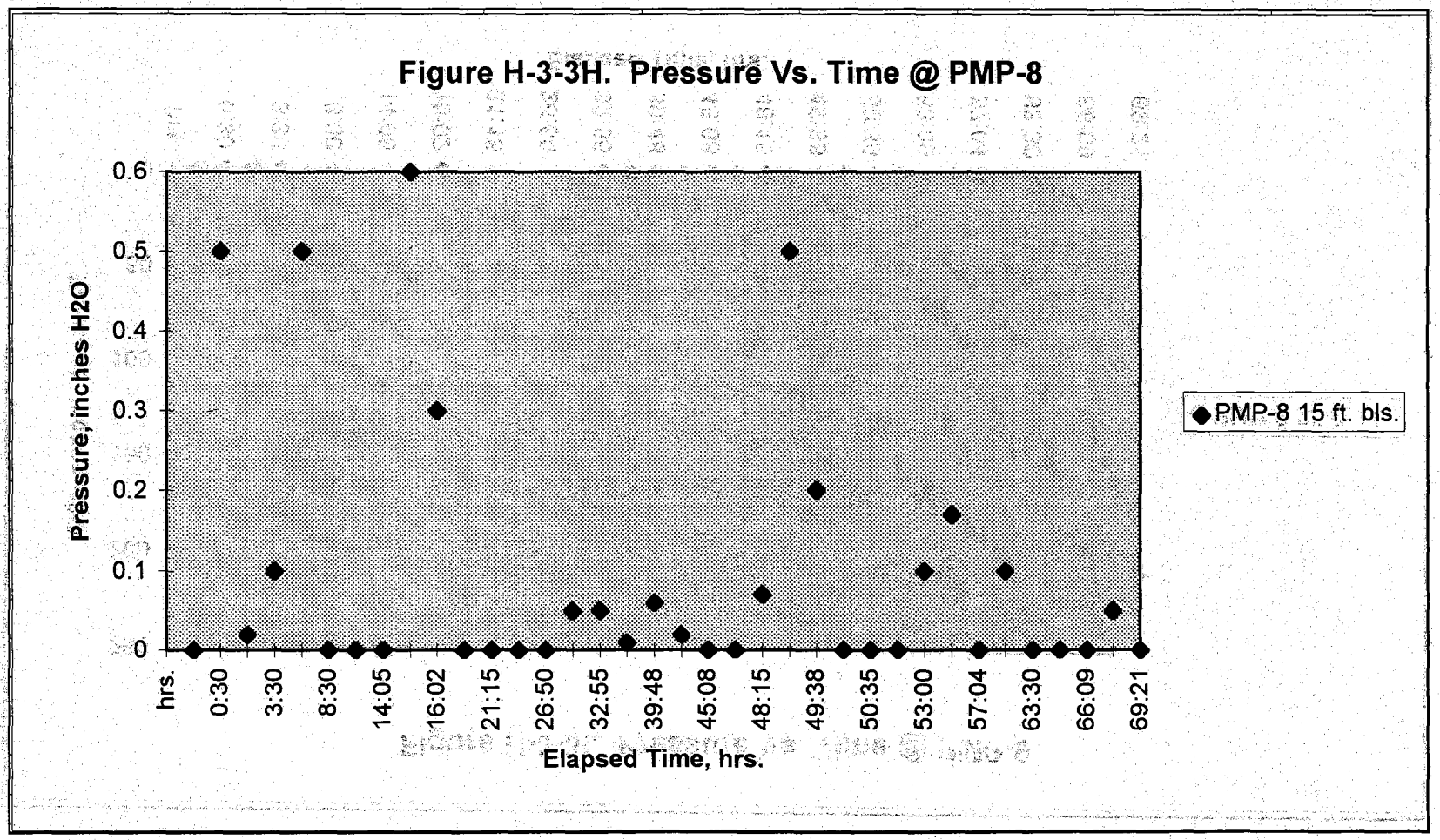


Figure H-3-3H. Pressure Vs. Time @ PMP-8
Pressure, inches H2O
0.6
0.5
0.4
0.3
0.2
0.1
0
hrs.
0:30
3:30
8:30
14:05
16:02
21:15
26:50
32:55
39:48
45:08
48:15
49:38
50:35
53:00
57:04
63:30
66:09
69:21
Elapsed Time, hrs.
PMP-8 15 ft. bls.

H-3-3

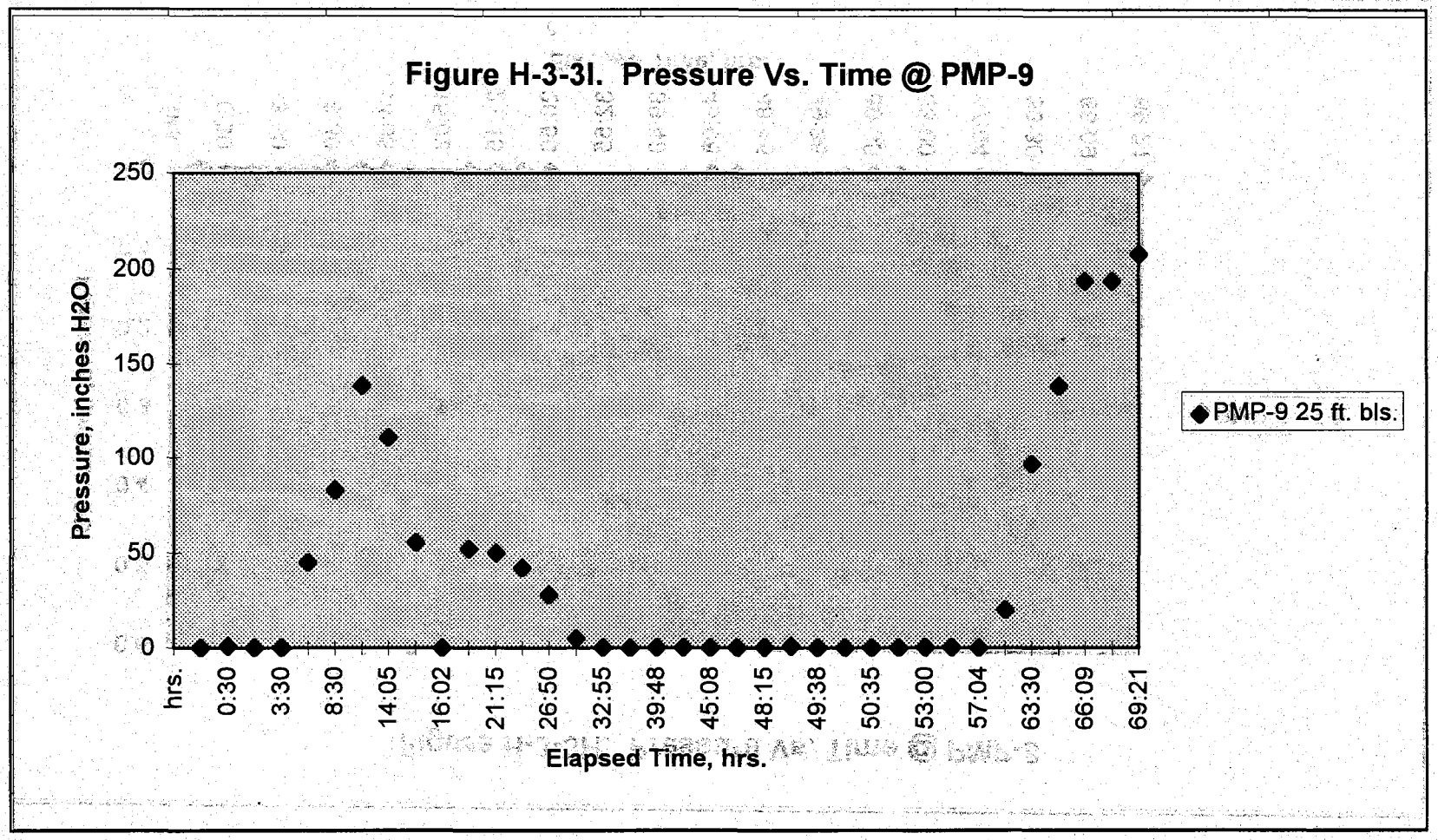


Figure H-3-3I. Pressure Vs. Time @ PMP-9
Pressure, inches H2O
250
200
150
100
50
0
hrs.
0:30
3:30
8:30
14:05
16:02
21:15
26:50
32:55
39:48
45:08
48:15
49:38
50:35
53:00
57:04
63:30
66:09
69:21
Elapsed Time, hrs.
PMP-9 25 ft. bls.

H-34

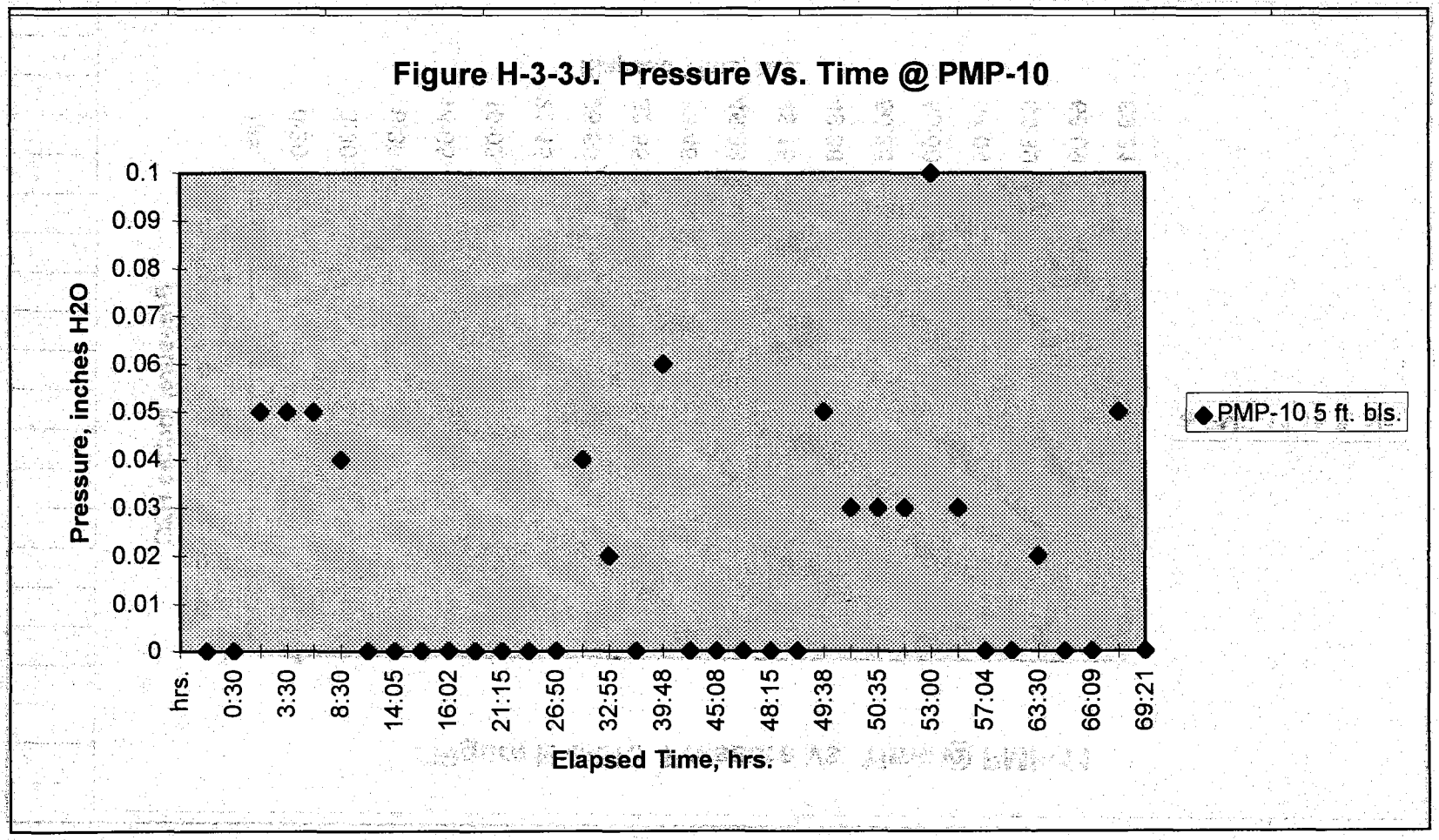


Figure H-3-3J. Pressure Vs. Time @ PMP-10
Pressure, inches H2O
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
hrs.
0:30
3:30
8:30
14:05
16:02
21:15
26:50
32:55
39:48
45:08
48:15
49:38
50:35
53:00
57:04
63:30
66:09
69:21
Elapsed Time, hrs.
PMP-10 5 ft. bls.

H-35

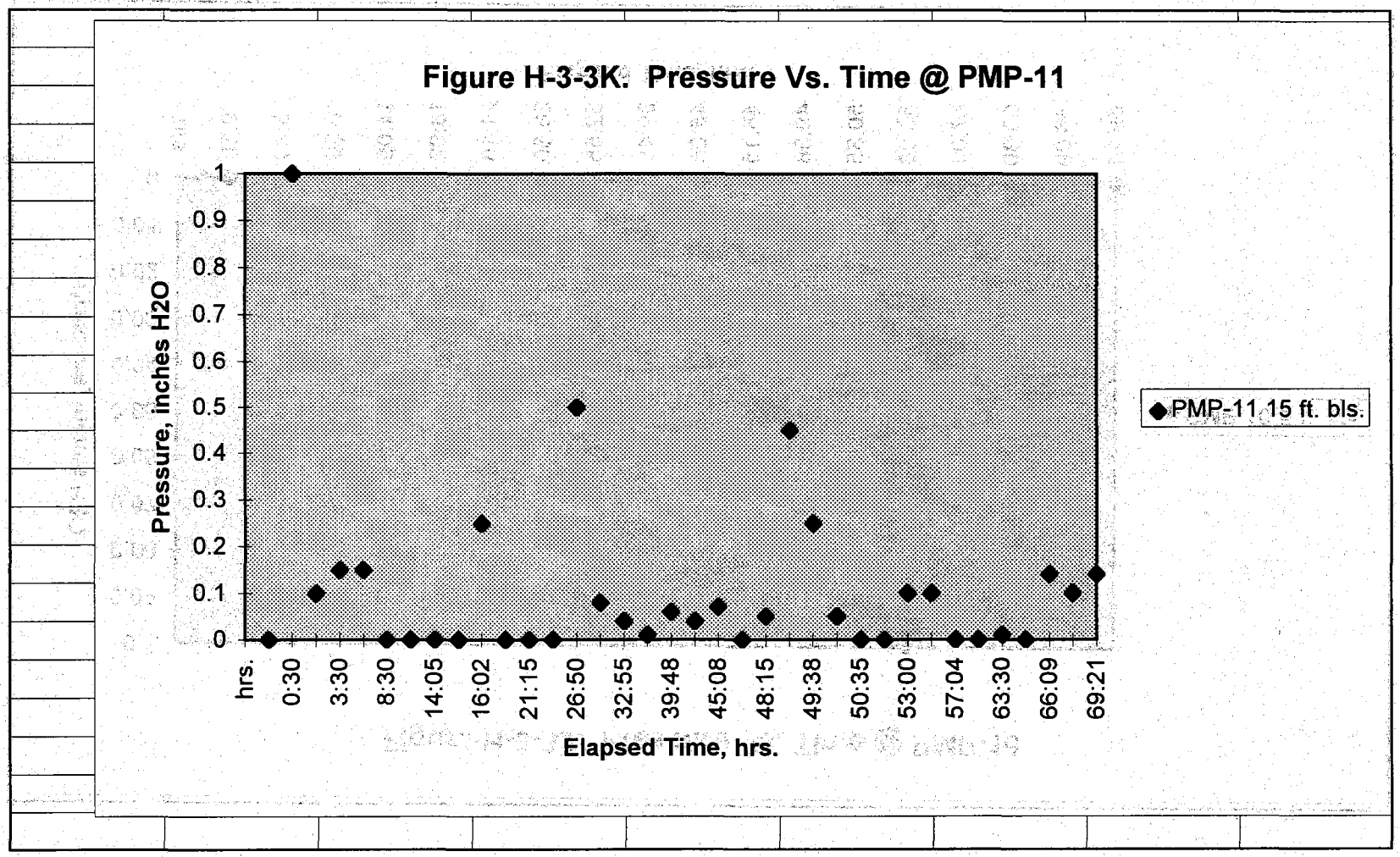


Figure H-3-3K. Pressure Vs. Time @ PMP-11
Pressure, inches H2O
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
hrs.
0:30
3:30
8:30
14:05
16:02
21:15
26:50
32:55
39:48
45:08
48:15
49:38
50:35
53:00
57:04
63:30
66:09
69:21
Elapsed Time, hrs.
PMP-11 15 ft. bls.

H-36

Figure H-3-4A. DO measurement vs. Time at a Distance of 7 feet from BS-1

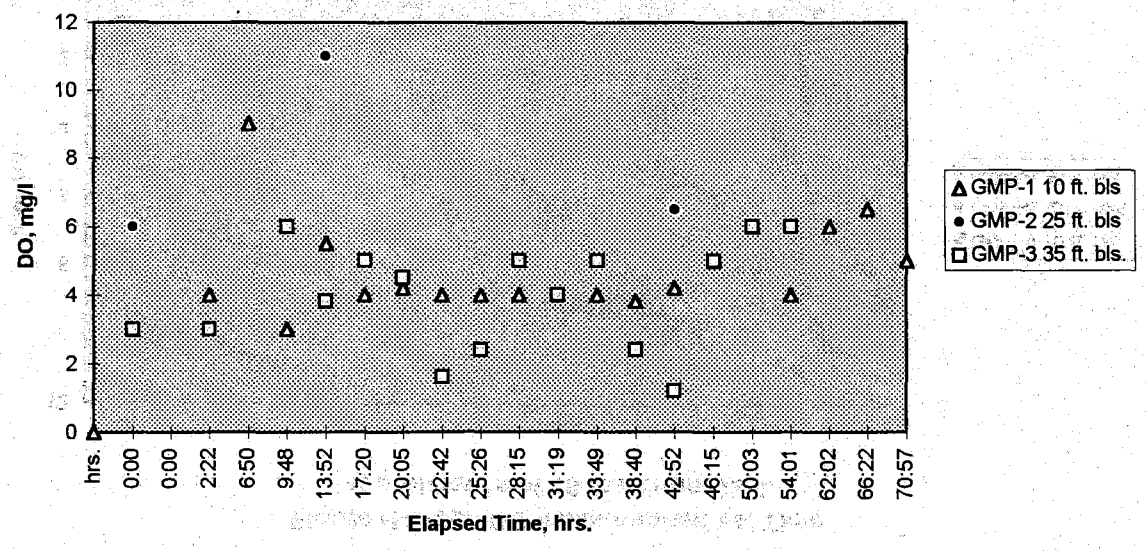


Figure H-3-4B. DO measurement vs. Time at a Distance of 15 feet from BS-1

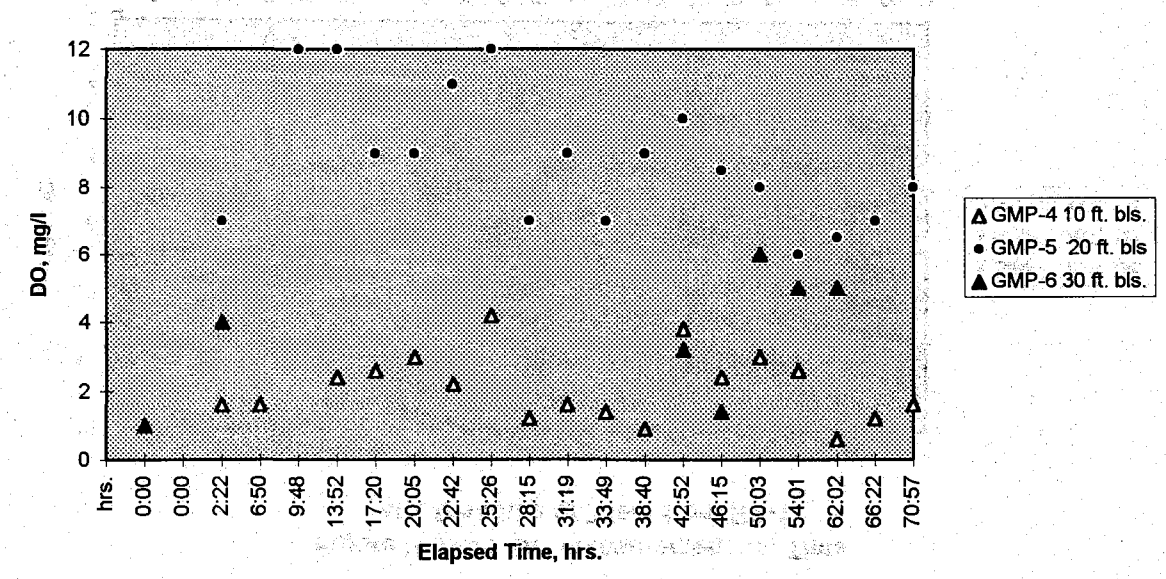


Figure H-3-4C. DO measurement vs. Time at a Distance of 25 feet from BS-1

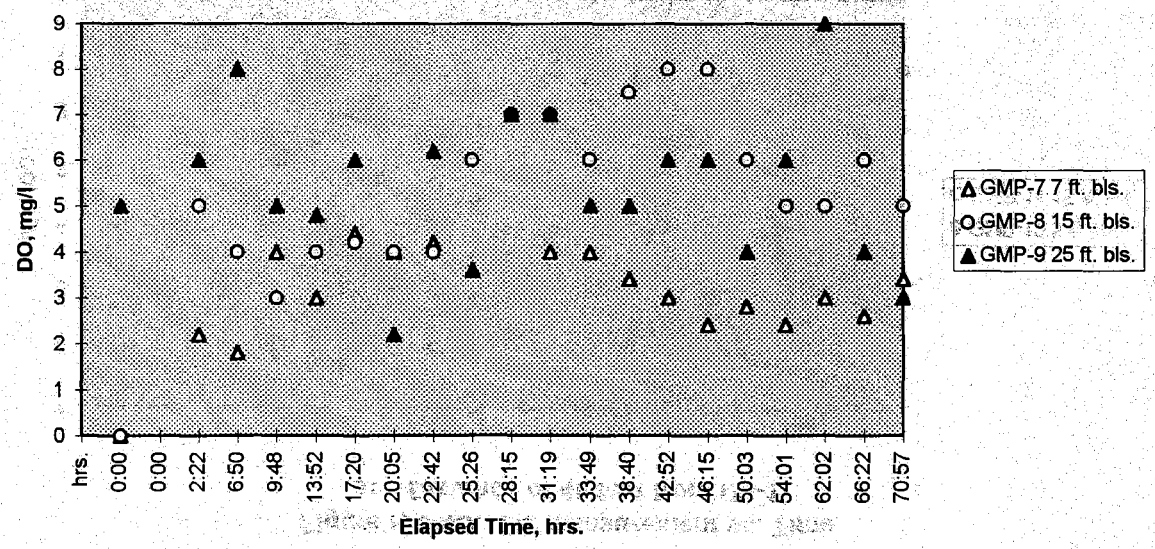
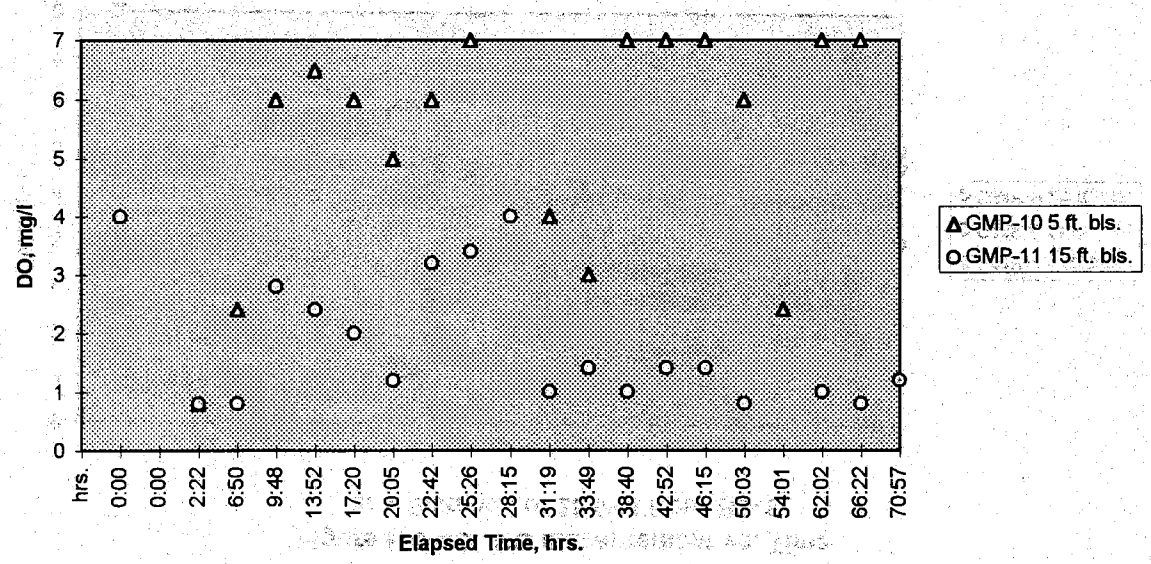


Figure H-3-4D. DO measurement vs. Time at a Distance of 40 feet from BS-1



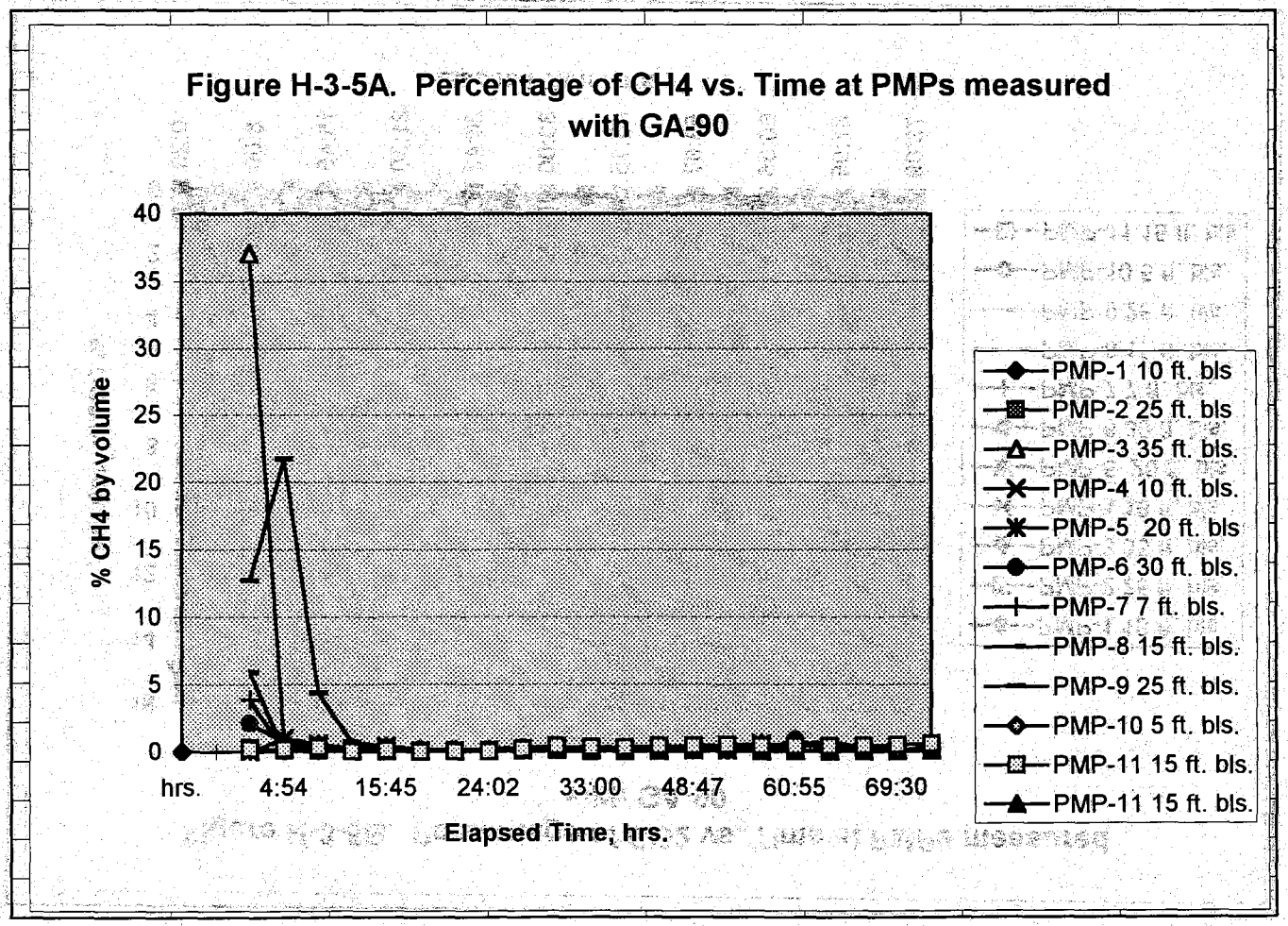


Figure H-3-5A. Percentage of CH4 vs. Time at PMPs measured with GA-90
% CH4 by volume
40
35
30
25
20
15
10
5
0
hrs.
4:54
15:45
24:02
33:00
48:47
60:55
69:30
Elapsed Time, hrs.
PMP-1 10 ft. bls
PMP-2 25 ft. bls
PMP-3 35 ft. bls.
PMP-4 10 ft. bls.
PMP-5 20 ft. bls
PMP-6 30 ft. bls.
PMP-7 7 ft. bls.
PMP-8 15 ft. bls.
PMP-9 25 ft. bls.
PMP-10 5 ft. bls.
PMP-11 15 ft. bls.
PMP-11 15 ft. bls.

Figure H-3-5B. Percentage of CO2 vs. Time at PMPs measured with GA-90

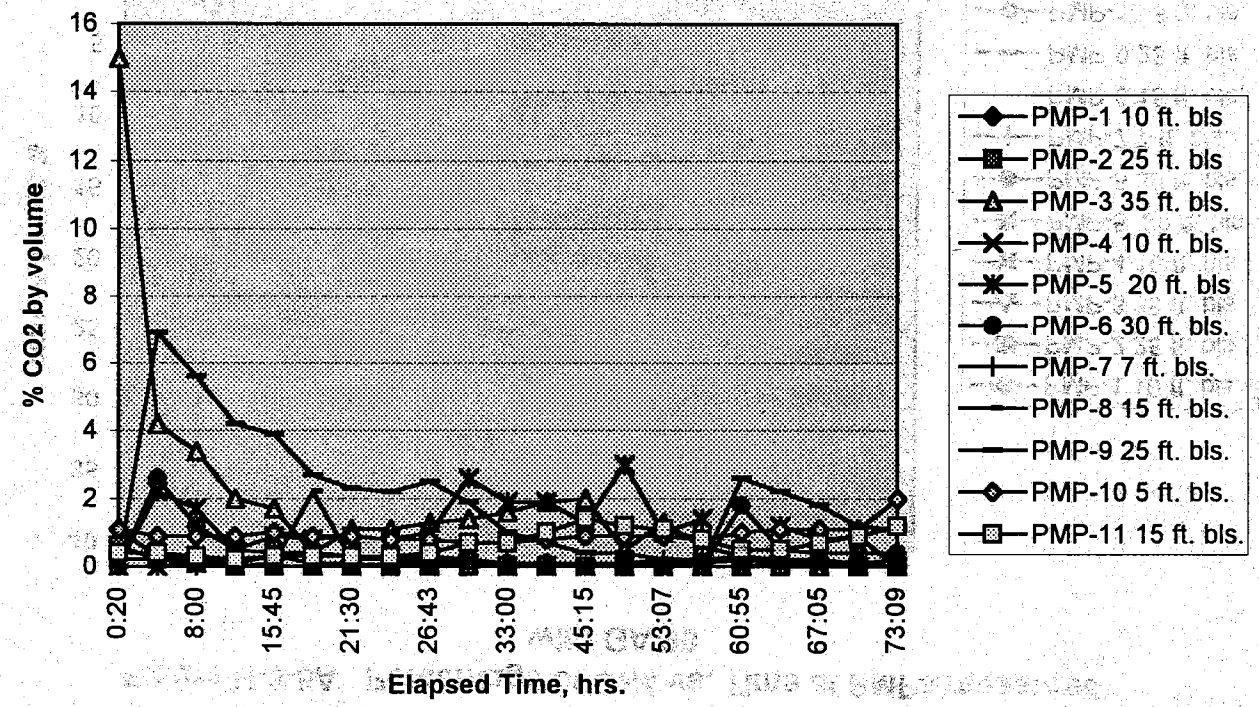
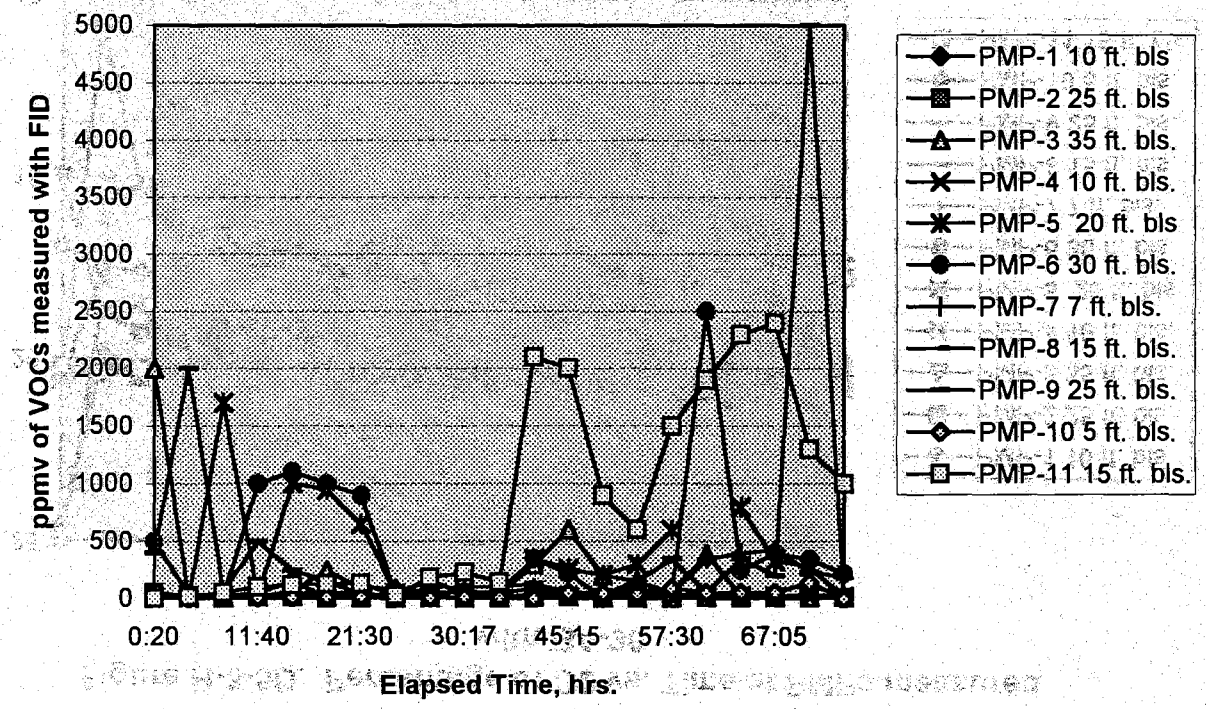


Figure H-3-5C. ppmv of VOCs measured with FID vs. Time



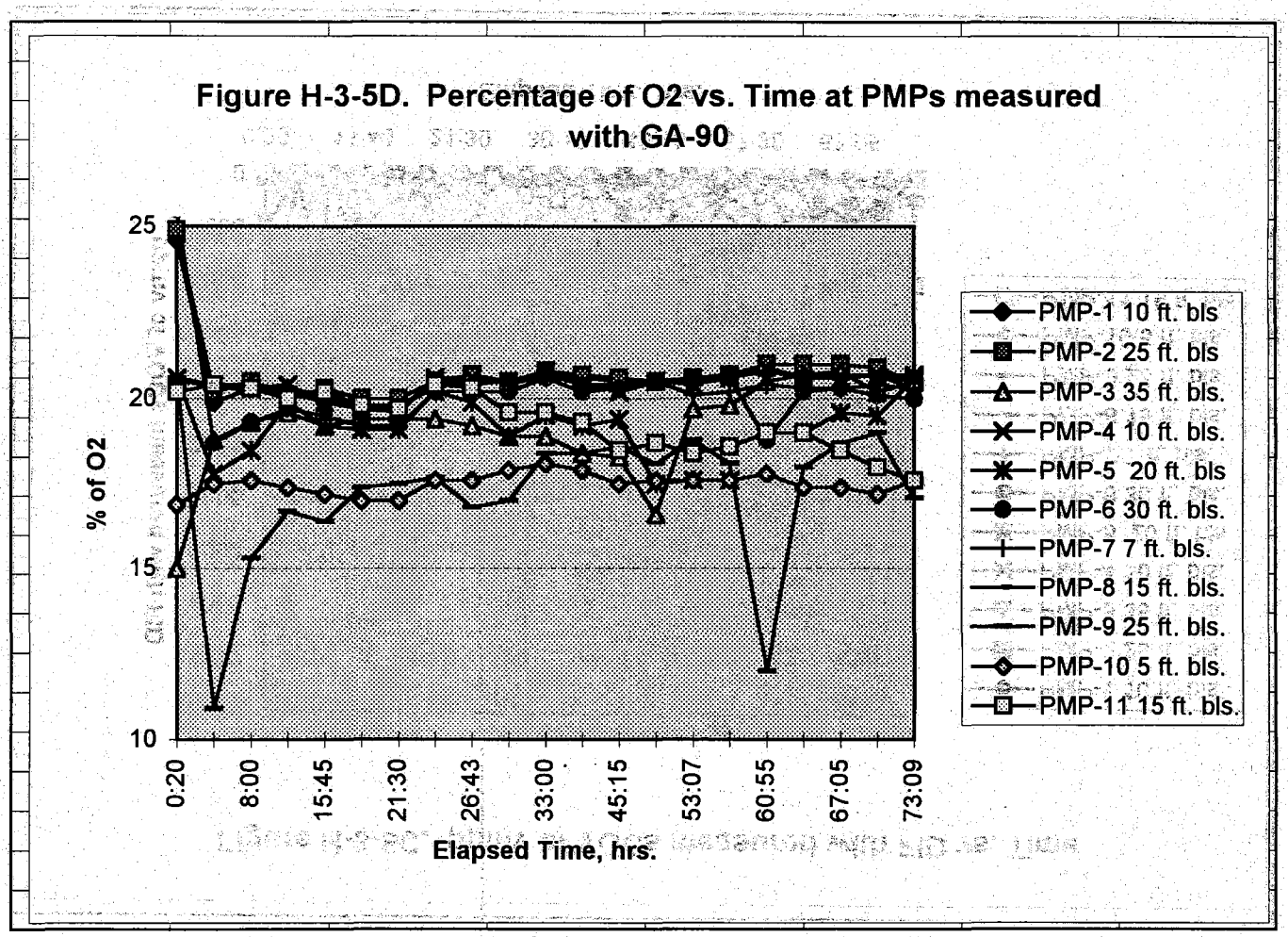


Figure H-3-5D. Percentage of O2 vs. Time at PMPs measured with GA-90
% of O2
25
20
15
10
0:20
8:00
15:45
21:30
26:43
33:00
45:15
53:07
60:55
67:05
73:09
Elapsed Time, hrs.
PMP-1 10 ft. bls
PMP-2 25 ft. bls
PMP-3 35 ft. bls.
PMP-4 10 ft. bls.
PMP-5 20 ft. bls
PMP-6 30 ft. bls.
PMP-7 7 ft. bls.
PMP-8 15 ft. bls.
PMP-9 25 ft. bls.
PMP-10 5 ft. bls.
PMP-11 15 ft. bls.

APPENDIX H - Biosparging Compressor Sizing

PROJECT NAME:	NAS Cecil Field, NFF Site		
Biosparging of Shallow Groundwater			
DATE: 12/24/96	ENGINEER: KGK	Reviewed by: JWL	

Compressor Sizing

Determination of Air Injection Pressure, ref: Evan K. Nyer and S. Suthersan, Fall 1990 GWWR p. 90

The injection pressure necessary to initiate in-situ biosparging should be able to overcome the following:

1. The depth of water column at the point of injection.
2. The frictional losses in the system.
3. The capillary entry resistance to displace the pore water.

These values were calculated in the biosparging pilot test and the total pressure (adding a factor of safety of 2) is 50 psi, and the total air flow rate is approximately 300 cfm.

W.E.S., Inc.

January 24, 1997

ABB Environmental Services
2590 Executive Center Circle East
Berkely Building
Tallahassee, FL 32301

Attn: Mr. Tim Kelly

Re: Proposal # 990

Dear Mr. Kelly:

Thank you for allowing us the opportunity to submit the following quotation for an air sparging system capable of 300 cfm at 50 psi.

The explosion proof air sparging system will consist of the following components:

- One (1) rotary screw air compressor unit
  - capable of 364 cfm @ 100 psi.
  - X-P motor (1.15 service factor)
  - bearing coolant dams (eliminates dry start-ups)
  - duplex tapered roller bearing airend (minimizes thrust loads, increases bearing life)
  - factory fill of SSR 8000 hr. ultracoolant
  - sheet metal sound enclosure (75 dBA max.)
  - efficient coolant separation system (< 2 ppm carryover)
  - dedicated fan motor
  - SAE O-ring fittings (eliminates leaks)
  - 115 degree ambient operation (no high temp. shutdowns)
  - 460/ 3/ 60 electrics

- One (1) heatless regenerative air dryer including:
  - solid core desiccant
  - pneumatic control to meet NEMA 7
  - twin tower design
  - 385 scfm capacity @ 33 - 39 degree dewpoint

• Corporate Headquarters •
6389 Tower Lane • Sarasota, Florida 34240 • (941) 371-7617 • Fax (941) 378-5218
• Web Site: http://www.wesinc.com/water

- One (1) particulate filter
  - after-filter for desiccant dryer
  - 99.9999% efficiency @ 1 micron and above
  - internal float drain
  - cast aluminum alloy housing
  - 400 cfm capacity

- One (1) coalescing filter assembly
  - pre-filter
  - cast aluminum alloy housing
  - 99.9999% efficient @ .01 micron
  - initial pressure drop < 1 psi

- One (1) explosion proof control panel

TOTAL COST.....$52,750.00

The price quoted above is FOB Sarasota, Florida. The price is valid for a period of sixty (60) days from the date quoted. Taxes have NOT been included. Delivery can be made within 8 - 12 weeks after receipt of your purchase order. All shipments are subject to WES Standard Terms & Conditions of Sale which are incorporated herein by reference.

Should you have any additional questions or require further information, please do not hesitate to call.

Sincerely,

W.E.S., Inc.

Nathan J. Yoder
Marketing Representative

John R. Gengler
Director of Operations

W.E.S., Inc.
ENVIRONMENTAL DIVISION

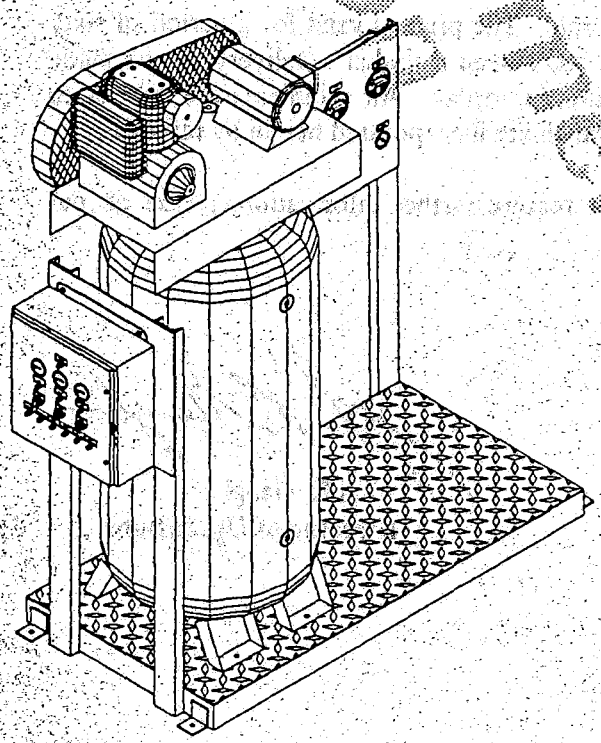
SILVER SERIES

AIR SPARGING SYSTEM

W.E.S., Inc. Environmental Division (WES) manufactures a complete line of air sparging systems suitable for use in hazardous and non-hazardous locations. The systems can be equipped with either a regenerative or positive displacement blower or an air compressor, depending on airflow and pressure requirements. For systems larger than 60 CFM, consult W.E.S., Inc. for design.

STANDARD FEATURES:

* Steel Reinforced Mounting Skid
* Blower or Compressor w/ motor
* On/Off Starter Box
* Inlet Muffler/Filter



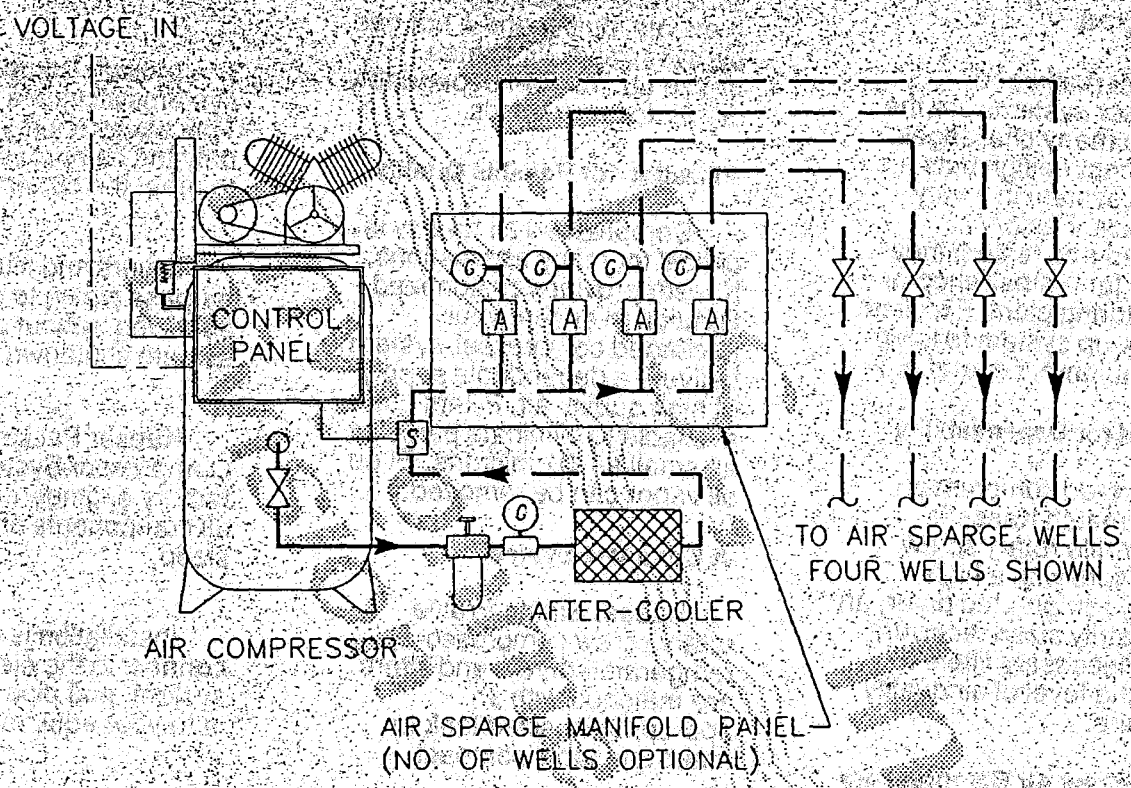
OPTIONS:

1. Electrical Control Panel
2. High Pressure Shut-off
3. High Temperature Shut-off
4. Temperature Gauge
5. Pressure Gauge
6. Flow Meter
7. Motor HP Upgrade
8. Blower Upgrade
9. Pressure Relief Valve
10. System Manifold
11. Pressure Regulator

MODEL SHOWN:
SS-5010

OPTIONS SHOWN:
1. Electrical Control Panel
5. Pressure Gauge
6. Flow Meter
9. System Manifold

PROCESS & INSTRUMENTATION DIAGRAM



AIR SPARGING SYSTEMS

** NOTE: PROCESS SHOWN WITH OPTIONS

LEGEND	
PRESSURE REGULATOR/ MOISTER SEPARATOR	PRESSURE GAUGE
	SOLENOID VALVE
SHUTOFF/THROTTLING VALVE	AIR FLOW INDICATOR

W.E.S., Inc.
Environmental Division
6389 TOWER LANE
SARASOTA, FLORIDA 34240
PH (813) 371-7617
FAX (813) 378-5218

KAESER COMPRESSORS

PACKAGED COMPRESSOR SYSTEMS

Complete Compressed Air Systems

Packaged Systems are perfect for many applications.

Kaeser packaged compressor systems are the answer to many challenges. The compact design puts a complete system in a very small space. Factory assembled and tested, they are great for a small shop or manufacturing plant. Excellent as a back-up system to keep critical equipment operating.

Designed for Dependability

Packaged compressor systems match Kaeser's Sigma Profile rotary screw compressors with a high efficiency refrigerated dryer, an appropriately sized receiver, and the necessary filters to provide the level of air quality you require.

Rotary Screw Air Compressors

The rotary screw compressor is designed without compression valves or piston rings. Maintenance is easy. Kaeser's efficient sigma profile design produces up to 20% more air per horsepower.

Each compressor is contained in a sound absorbing enclosure. This filtered enclosure keeps the components clean and reduces noise levels to as low as 66 dB(A).

Refrigerated Air Dryers

Kaeser refrigerated dryers cool the compressed air to condense and remove moisture. They produce pressure dew points as low as 35°F. The tube in tube smooth surface heat exchanger prevents fouling and a hot gas by-pass valve eliminates freeze up. You get dependably dry air for your needs.

Filtration for Reliable Quality

Compressed air quality is critical for many applications. Kaeser provides customized filtration to ensure your packaged compressor system delivers a dependable supply of high quality air. Filters are available to eliminate particles as small as .01 microns. Even oil vapor can be removed.

A Complete System

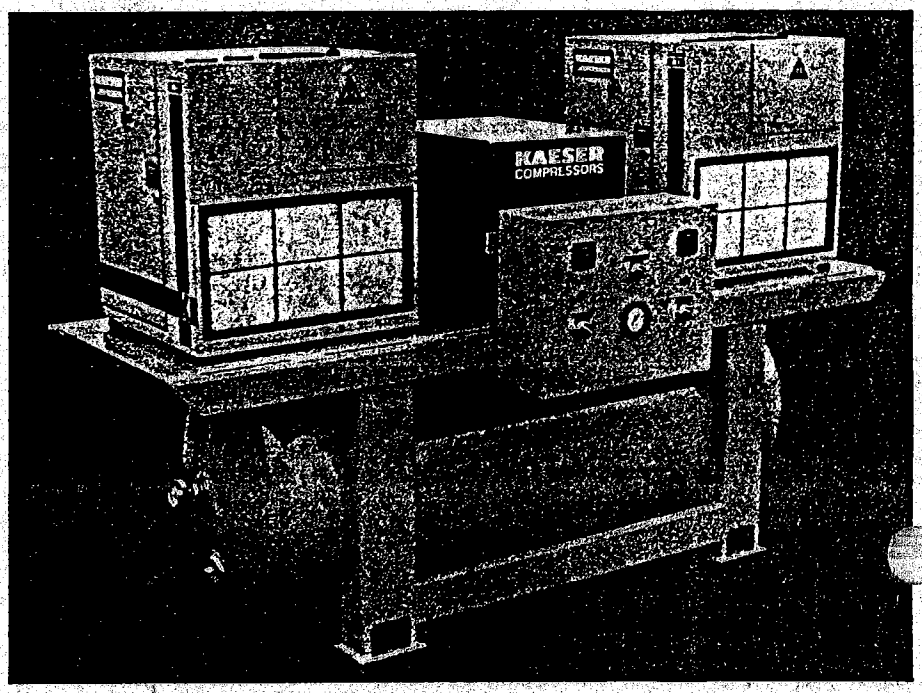
Kaeser Sigma Profile rotary screw compressors, refrigerated dryers and filters are matched with an appropriately sized tank to make a reliable compact system. All inter-connecting piping and wiring is completed at the factory.

Multiple compressor systems include a sequencer. This saves energy by running only the compressor(s) needed to meet the current demand.

Dryers and filters include by-pass piping to allow servicing without complete system shutdown.

Kaeser Packaged Compressor Systems are factory engineered to ensure all components are properly sized.

Installation is easy. Simply connect to the electrical system and pipe the package in to your equipment.



Single Compressor Packaged Systems

Compressor Model	Comp. H.P.	Max Operating Pressure (psig)	Capacity (cfm free air)	Compressor Model	Comp. H.P.	Max Operating Pressure (psig)	Capacity (cfm free air)
SX-3	3	110	11.5	SM-8	7.5	110	30
		145	8.5			145	25
		190	5.5			190	20
SX-4	4	110	15.5	SM-11	10	110	42
		145	12.5			145	36
		190	9			190	29
SX-6	5	110	21				
		145	17				
		190	13				

Dual Compressor Packaged Systems

Compressor Model	Comp. H.P.	Max Operating Pressure (psig)	Capacity (cfm free air)	Compressor Model	Comp. H.P.	Max Operating Pressure (psig)	Capacity (cfm free air)
SX-3	2 x 3	110	23	SM-8	2 x 7.5	110	60
		145	17			145	50
		190	11			190	40
SX-4	2 x 4	110	31	SM-11	2 x 10	110	84
		145	24			145	72
		190	18			190	58
SX-6	2 x 5	110	42				
		145	34				
		190	26				

STANDARD FEATURES:

- SX or SM Sigma Screw Compressors
- Refrigerated Dryer with by-pass piping
- ASME coded receiver tank including
  - Air pressure safety relief valve
  - Liquid filled pressure gauge
  - Manual drain valve
- Heavy Duty Steel Frame
- Compressors in sound absorbing enclosures
- Sequencer or multiple compressor models

OPTIONAL FEATURES:

- Filters
- Automatic Tank Condensate Drain
- Single Point Electrical Connection
- Non- standard Operating Pressures from 80 psig to 205 psig
- Single Phase Electrics on SX models
- 208/230V and 460V

KAESER COMPRESSORS

P.O. Box 946 • 4950 Quality Drive • Fredericksburg, VA 22404 • Tel: 703/898-5500 • FAX 703/898-5520

APPENDIX I

LIFETIME COST ANALYSIS OF RECIRCULATION WELL SYSTEM AND NATURAL ATTENUATION

GROUNDWATER GEOCHEMISTRY
NAS Cecil Field, North Fuel Farm Site

The most important assumption when modeling natural attenuation is that biodegradation is occurring at the site. A strong indication of biodegradation is the presence of electron acceptors relative to the contamination at each sample location. At the North Fuel Farm site, electron acceptor concentrations and other physical parameters such as pH, temperature, and turbidity were measured to evaluate if natural degradation is occurring. These data were collected in November 1996, and are provided in Table I-1. A total of 6 intermediate wells were sampled from outside the plume area while 9 wells were sampled in the plume area. Although some wells in Table I-1 have the D (i.e., deep) modifier, all wells are screened in the intermediate zone of the surficial aquifer.

Evidence exists for biodegradation when concentrations of electron acceptors, such as dissolved oxygen, nitrate, and sulfate, are depleted in the area of contamination. Other indicators of biodegradation are increased by-product concentrations, such as carbon dioxide (CO_2) and iron (II), in known areas of groundwater contamination.

The last row in Table I-1 is the values that were entered into the BIOSCREEN model. The value listed is either the change in concentration from the upgradient and plume areas or the average concentration. The change in concentration is used for dissolved oxygen, sulfate and nitrate. Iron and methane are direct inputs based on average concentrations.

Table I-1: Natural Attenuation Monitoring

Project Name: NAS Cecil Field, North Fuel Farm Site

Date: 1/27/97 12/24/96 ENGINEER: Tim Kelly Checked By: KGK

Results from entire plume area and upgradient areas.

MW ID	Iron	Chloride	Alkalinity	DO	CO2	Redox Po	H2S	Nitrate	Sulfate	Methane	pH	Conducti	Screen Interval		TVOA
	mg/L	mg/L	mg/L CaCO3	mg/L	mg/L	mV	mg/L	mg/L	mg/L	mg/L		umhos	ft. bls.		ppb
CEF-76-26D	5.00	55.00	13.60	0.00	65.00	-138.00	0.50	<0.1	37.60	0.28	4.58	15.00	50	60	4
CEF-76-27D	1.40	15.00	20.40	0.00	65.00	-181.00	1.10	<0.1	6.00	0.18	5.24	61.00	66	76	4
CEF-76-47I	1.00	25.00	20.40	0.10	75.00	-22.80	<0.05	<0.1	<1.0	0.72	5.18	82.00	65	70	4
CEF-76-66I	2.00	15.00	20.40	0.80	50.00	-71.80	0.40	<0.1	2.70	16.00	5.40	46.00	80	85	4
CEF-76-67I	1.60	30.00	20.40	0.00	60.00	1.60	0.70	<0.1	<1.0	0.18	5.18	119.00	80	85	4
CEF-76-56I	1.60	10.00	27.20	0.00	80.00	-153.00	0.80	<0.1	3.40	0.16	5.16	41.00	70	75	4.5
CEF-76-53I	1.40	25.00	20.40	0.00	75.00	-45.80	0.10	<0.1	<1.0	0.10	5.22	77.00	75	80	88
CEF-76-61I	1.00	10.00	20.40	0.00	60.00	-164.50	3.75	<0.1	4.10	0.71	5.01	N/A	65	70	191
CEF-76-73I	5.60	20.00	170.00	0.00	125.00	-75.80	0.10	<0.1	<1	22.00	5.63	179.00	60	65	373.1
CEF-76-50I	2.20	20.00	27.20	0.00	135.00	-55.80	0.00	<0.1	<1.0	27.00	4.90	120.00	75	80	839
CEF-76-64I	1.40	20.00	20.40	0.00	105.00	-88.90	0.45	<0.1	<1.0	17.00	5.49	60.00	70	75	960
CEF-76-76I	1.20	15.00	40.80	<0.1	65.00	-192.90	0.10	<0.1	10.50	9.00	5.05	58.00	85	95	2182
CEF-76-52I	3.20	15.00	40.80	0.00	65.00	-30.00	<0.05	<0.1	<1.0	31.00	5.33	101.70	75	80	4080
CEF-76-70I	1.40	15.00	27.20	0.30	130.00	-129.00	0.20	<0.1	<1.0	25.00	5.15	47.00	65	70	16440
CEF-76-39D	2.20	20.00	20.40	0.20	80.00	-32.00	0.00	<0.1	<1.0	37.00	4.80	72.00	55	65	21720
average	2.15	20.67	34.00	0.09	82.33	-91.98	0.55	0.00	4.29	12.42	5.15	71.91	69.07	75.40	3126.51

Results from Outside the plume area.

MW ID	Iron	Chloride	Alkalinity	DO	CO2	Redox Po	H2S	Nitrate	Sulfate	Methane	pH	Conducti	Screen Interval		TVOA
	mg/L	mg/L	mg/L CaCO3	mg/L	mg/L	mV	mg/L	mg/L	mg/L	mg/L		umhos	ft. bls.		ppb
CEF-76-26D	5.00	55.00	13.60	0.00	65.00	-138.00	0.50	<0.1	37.60	0.28	4.58	15.00	50	60	4
CEF-76-27D	1.40	15.00	20.40	0.00	65.00	-181.00	1.10	<0.1	6.00	0.18	5.24	61.00	66	76	4
CEF-76-47I	1.00	25.00	20.40	0.10	75.00	-22.80	<0.05	<0.1	<1.0	0.72	5.18	82.00	65	70	4
CEF-76-66I	2.00	15.00	20.40	0.80	50.00	-71.80	0.40	<0.1	2.70	16.00	5.40	46.00	80	85	4
CEF-76-67I	1.60	30.00	20.40	0.00	60.00	1.60	0.70	<0.1	<1.0	0.18	5.18	119.00	80	85	4
CEF-76-56I	1.60	10.00	27.20	0.00	80.00	-153.00	0.80	<0.1	3.40	0.16	5.16	41.00	70	75	4.5
average	2.10	25.00	20.40	0.15	65.83	-94.17	0.58	0.00	8.28	2.92	5.12	60.67	68.50	75.17	4.08

Results from inside the plume area.

MW ID	Iron	Chloride	Alkalinity	DO	CO2	Redox Po	H2S	Nitrate	Sulfate	Methane	pH	Conducti	Screen Interval		TVOA
	mg/L	mg/L	mg/L CaCO3	mg/L	mg/L	mV	mg/L	mg/L	mg/L	mg/L		umhos	ft. bls.		ppb
CEF-76-53I	1.40	25.00	20.40	0.00	75.00	-45.80	0.10	<0.1	<1.0	0.10	5.22	77.00	75	80	88
CEF-76-61I	1.00	10.00	20.40	0.00	60.00	-164.50	3.75	<0.1	4.10	0.71	5.01	N/A	65	70	191
CEF-76-73I	5.60	20.00	170.00	0.00	125.00	-75.80	0.10	<0.1	<1	22.00	5.63	179.00	60	65	373.1
CEF-76-50I	2.20	20.00	27.20	0.00	135.00	-55.80	0.00	<0.1	<1.0	27.00	4.90	120.00	75	80	839
CEF-76-64I	1.40	20.00	20.40	0.00	105.00	-88.90	0.45	<0.1	<1.0	17.00	5.49	60.00	70	75	960
CEF-76-76I	1.20	15.00	40.80	<0.1	65.00	-192.90	0.10	<0.1	10.50	9.00	5.05	58.00	85	95	2182
CEF-76-52I	3.20	15.00	40.80	0.00	65.00	-30.00	<0.05	<0.1	<1.0	31.00	5.33	101.70	75	80	4080
CEF-76-70I	1.40	15.00	27.20	0.30	130.00	-129.00	0.20	<0.1	<1.0	25.00	5.15	47.00	65	70	16440
CEF-76-39D	2.20	20.00	20.40	0.20	80.00	-32.00	0.00	<0.1	<1.0	37.00	4.80	72.00	55	65	21720
average	2.18	17.78	43.07	0.06	93.33	-90.52	0.52	0.00	1.62	18.76	5.18	79.41	69.44	75.56	5208.12
Delta or value used	2.18			0.09				0	6.66	18.76					

The BIOSCREEN computer model was used to model transport and degradation of hydrocarbons at the North Fuel Farm site. The BIOSCREEN model was developed by the U.S. Air Force in August 1996 as a user friendly model set in a Microsoft Excel spreadsheet environment (BIOSCREEN - Natural Attenuation Decision Support System, August 1996). It is based on the Domenico analytical solute transport model. The BIOSCREEN model used in this demonstration assumes that the limiting factors of biodegradation are the presence of indigenous hydrocarbon degrading bacteria and the presence of sufficient background electron acceptor concentrations. Evidence exists that anaerobic degradation is occurring at the North Fuel Farm site.

BIOSCREEN simulates advection, adsorption, dispersion, aerobic, and dominant anaerobic reactions through three model types. These three model types are

- solute transport without decay,
- solute transport with first-order decay, and
- solute transport with biodegradation assuming an instantaneous biodegradation reaction.

For the North Fuel Farm site, benzene and total VOA contamination was modeled using the instantaneous reaction type.

GROUNDWATER MODEL DESIGN AND ASSUMPTIONS. In order to use the BIOSCREEN model to predict future contaminant transport and degradation, the model was calibrated to present site conditions.

After an active remediation is used to cleanup the source area and the shallow zone of the surficial aquifer, groundwater contamination will be restricted to the intermediate zone of the surficial aquifer. The lithology of the upper zone consists of silty, fine-grained sand, with clay lenses occurring locally. A conservative effective porosity of 0.25 is estimated. The use of BIOSCREEN, which is a two-dimensional model, is appropriate as the saturated interval is relatively homogeneous, and evidence of significant vertical migration of the groundwater contamination is not present.

The extent of petroleum contaminated soil, which appears to be acting as a continuing source to groundwater contamination, is shown on Figure A-3-3. This area was used in calculating the soluble contaminant mass contributing to the groundwater plume in the model calibration. Contributions from soils outside this region are assumed to be relatively minor and the main process of interest is the length of the plume from the high concentration source zone.

This appendix will consider three cases:

1) Remediation by natural attenuation assuming the source has not been removed and the contaminated groundwater will not be remediated.

2) Source has been removed and shallow groundwater has been remediated to below 50 ppb TVOA.

3) Source has been removed, shallow groundwater has been remediated and five in-well aeration wells have been installed in the hot areas (greater than 10,000 ppb).

Reference: BIOSCREEN - Natural Attenuation Decision Support System, User's Manual, August 1996.

Table I-2
BIOSCREEN Model Input Parameters

Remedial Action Plan, North Fuel Farm
Naval Air Station Cecil Field
Jacksonville, Florida

Data Type	Parameter	Source, Intermediate, and Shallow Model Value	Intermediate Zone Model Value	In-Well Aeration (10,000) ppb Model Value	Source of Data
Hydrogeology	Hydraulic Conductivity: Hydraulic Gradient: Porosity:	6.6×10^{-3} (cm/sec) 0.00071 (ft/ft) 0.25	6.6×10^{-3} (cm/sec) 0.00071 (ft/ft) 0.25	6.6×10^{-3} (cm/sec) 0.00071 (ft/ft) 0.25	CARA Calculated Estimated
Dispersion	Longitudinal Dispersivity: Transverse Dispersivity: Vertical Dispersivity:	23.6 (ft) 2.36 (ft) 0 (ft)	23.6 (ft) 2.36 (ft) 0 (ft)	23.6 (ft) 2.36 (ft) 0 (ft)	Based on estimated plume length of 920 feet and Xu's dispersivity formula
Adsorption	Retardation Factor: Soil Bulk Density, ρ_b: K_{oc}: f_{oc}:	2.3 1.7 (kg/l) 38 5×10^{-3}	2.3 1.7 (kg/l) 38 5×10^{-3}	2.3 1.7 (kg/l) 38 5×10^{-3}	Calculated Estimated Literature Lab analysis from North Fuel Farm area
Biodegradation	Electron Acceptor: Background Conc. (mg/l): Minimum Conc. (mg/l): Change in Conc. (mg/l): Electron Acceptor: Avg. Conc. (mg/l):	O_2 NO_3 SO_4 0.15 0.00 8.28 0.06 0.00 1.62 **0.09 0.00 6.66** Fe CH_4 **2.18 18.78** Note: Bold faced values are BIOSCREEN input values.	O_2 NO_3 SO_4 0.15 0.00 8.28 0.06 0.00 1.62 **0.09 0.00 6.66** Fe CH_4 **2.18 18.78** Note: Bold faced values are BIOSCREEN input values.	O_2 NO_3 SO_4 0.15 0.00 8.28 0.06 0.00 1.62 **0.09 0.00 6.66** Fe CH_4 **2.18 18.78** Note: Bold faced values are BIOSCREEN input values.	O_2: Based on field data collected November 1996 NO_3: Not considered SO_4: Based on background data from NFF. Fe: Based on field data collected November 1996 CH_4: Based on site average.
General	Modeled Area Length: Modeled Area Width: Simulation Time:	920 (ft) 420 (ft) 632 (years)	920 (ft) 420 (ft) 38.5 (years)	920 (ft) 420 (ft) 33 (years)	Selected Selected Selected

See notes at end of table.

Table I-2 (Continued)
BIOSCREEN Model Input Parameters

Remedial Action Plan, North Fuel Farm
Naval Air Station Cecil Field
Jacksonville, Florida

Data Type	Parameter	Source, Intermediate, and Shallow Model Value	Intermediate Zone Model Value	In-Well Aeration (10,000) ppb Model Value	Source of Data
Source Data	· Source Thickness: · Source Concentration:	35 (ft) See Figure A-3-3	35 (ft) See Figure A-3-3	35 (ft) See Figure A-3-3	

Notes: Use of data displayed above is shown in Appendix C-2.
Units selected in the table above were based on units input into the BIOSCREEN model.

cm/sec = centimeters per second.
ft = feet.
BTEX = benzene, toluene, ethylbenzene,and xylenes.
ft/ft = feet per foot.
USGS = U.S. Geological Survey.
kg/l = kilograms per liter.
O_2 = oxygen.
NO_3 = nitrate.
SO_4 = sulfate.
Fe = iron.
CH_4 = methane.

MASS OF CONTAMINANT
NAS Cecil Field, North Fuel Farm Site

Given the total amount of contaminated material in the intermediate zone of the surficial aquifer, soil porosity, moisture content, volume of contaminated aquifer material and associated groundwater can be determined. Using the total volume averaged concentration and the estimated Henry's law constant, the contaminant concentration in the vadose zone water can be determined using the following equation:

$$Cw = Ca/Hc$$

Where:

Hc = Henry's Law Constant
Ca = Contaminant Concentration in Air
Cw = Contaminant Concentration in Water

With the water concentration and the total water volume in the soil, the total mass of contaminant in the soil zone moisture can be determined. Using the estimated Koc and the fraction of organic carbon (foc), the distribution coefficient Kd can then be determined using the following equation:

$$Kd = Koc \times foc/100$$

The sorbed to dissolved ratio can then be determined by the following equation:

$$Ka = Kd \times Ws \times (1-n)/yW \times n$$

Where

Ka = Sorbed to dissolved ratio
Kd = Distribution coefficient
Ws = Unit weight of water (lbs/ft^3)
yW = Unit weight of water (lbs/ft^3)
n = Porosity

The mass of contaminant sorbed to the soil is then determined by the product of the mass of contaminant in the water and the sorbed to dissolved ratio. The mass of contaminated soil is then calculated using the estimated unit weight of soil and the volume of contaminated soil.

TOTAL MASS OF HYDROCARBON IN THE INTERMEDIATE ZONE

Table I-3 shows the derived mass of contaminant in the intermediate zone that was entered into the BIOSCREEN model. Approximately 2,781 kgs of hydrocarbon is acting as the soluble mass of contaminant.

Table I-4 shows only the mass of hydrocarbon in the intermediate zone after 5 in-well aeration wells have been installed. These wells are anticipated to operate for 10 years and after such time the mass of contaminant remaining in the intermediate zone is 2,781-695 = 2,086 kgs. This value was also used in the BIOSCREEN model.

Table I-5 and I-6 show the remaining mass of hydrocarbon in both the shallow groundwater and mound areas. These values are only used in the BIOSCREEN model for the no action scenario (i.e., no source removal or groundwater remediation) and is used for illustrative purposes only.

TABLE I-3 :TOTAL MASS OF HYDROCARBON
IN THE INTERMEDIATE SATURATED ZONE

PROJECT NAME: NAS Cecil Field, NFF Site

MASS OF CONTAMINANT

DATE: 12/24/96 ENGINEER: KGK Reviewed by: MR

Symbol	Description	Quantity	Units	Remarks
Vol Total	TOTAL VOLUME OF CONTAMINATED MATERIAL	11012400	ft^3	Calculated
Ca	AVERAGE AIR OVA CONCENTRATION	0	ppm	No Air
Vol Air	VOLUME OF CONTAMINATED AIR	0	ft^3	No Air
Mass Air	MASS OF CONTAMINATED AIR	0.0	kg	No Air
Hc	ESTIMATED JP-5 HENRY'S LAW CONSTANT	48.18	atm*m^3/mole	Estimated
Cw	WATER CONTAMINATION CONCENTRATION	10.00	mg/l	Estimated
Vol Soil	VOLUME OF CONTAMINATED SOIL	8259300	ft^3	Calculated
Mc	SOIL MOISTURE CONTENT	1	unitless	Saturated
Vol	VOLUME OF CONTAMINATED WATER IN SOIL	21584304	gal	Calculated
Cw	MASS OF CONTAMINANT IN WATER	816.9659064	kg	Calculated
Koc	ESTIMATED JP-5 PARTITIONING COEFFICIENT	100	l/kg	Estimated
foc	FRACTION OF ORGANICS	0.5	%	Lab Anaysis
n	POROSITY	0.25	dimensionless	Assumed
Kd	DISTRIBUTION COEFFICIENT	0.5	l/kg	Calculated
W	UNIT WEIGHT OF SOIL	100	lb/ft3	Assumed
Ka	SORBED TO DISSOLVED RATIO	2.404	dimensionless	Calculated
Cs	MASS OF CONTAMINANT IN SOIL	1963.860352	kg	Calculated
Ct	TOTAL MASS OF CONTAMINANT	2780.826258	kg	Calculated

V	Total Volume of Contaminated Material in the Intermediate Zone	11012400	ft^3
L	920		
W	342		
H	35		

TABLE I-4: MASS REMOVED BY IWA
IN THE INTERMEDIATE SATURATED ZONE

PROJECT NAME: NAS Cecil Field, NFF Site

MASS OF CONTAMINANT

DATE: 12/24/96 ENGINEER: KGK Reviewed by: Jm

Symbol	Description	Quantity	Units	Remarks
Vol Total	TOTAL VOLUME OF CONTAMINATED MATERIAL	5506200	ft^3	Calculated
Ca	AVERAGE AIR OVA CONCENTRATION	0	ppm	No Air
Vol Air	VOLUME OF CONTAMINATED AIR	0	ft^3	No Air
Mass Air	MASS OF CONTAMINATED AIR	0.0	kg	No Air
Hc	ESTIMATED JP-5 HENRY'S LAW CONSTANT	48.18	atm*m^3/mole	Estimated
Cw	WATER CONTAMINATION CONCENTRATION	5.00	mg/l	Estimated
Vol Soil	VOLUME OF CONTAMINATED SOIL	4129650	ft^3	Calculated
Mc	SOIL MOISTURE CONTENT	1	unitless	Saturated
Vol	VOLUME OF CONTAMINATED WATER IN SOIL	10792152	gal	Calculated
Cw	MASS OF CONTAMINANT IN WATER	204.2414766	kg	Calculated
Koc	ESTIMATED JP-5 PARTITIONING COEFFICIENT	100	l/kg	Estimated
foc	FRACTION OF ORGANICS	0.5	%	Lab Anaysis
n	POROSITY	0.25	dimensionless	Assumed
Kd	DISTRIBUTION COEFFICIENT	0.5	l/kg	Calculated
W	UNIT WEIGHT OF SOIL	100	lb/ft3	Assumed
Ka	SORBED TO DISSOLVED RATIO	2.404	dimensionless	Calculated
Cs	MASS OF CONTAMINANT IN SOIL	490.965088	kg	Calculated
Ct	TOTAL MASS OF CONTAMINANT	695.2065646	kg	Calculated

V	Total Volume of Contaminated Material	11012400	ft^3
L	920		
W	342		
H	35		

TABLE I-5: TOTAL MASS OF HYDROCARBON
IN THE SHALLOW SATURATED ZONE

PROJECT NAME: NAS Cecil Field, NFF Site

MASS OF CONTAMINANT

DATE: 12/24/96 ENGINEER: KGK Reviewed by: JM

Symbol	Description	Quantity	Units	Remarks
Vol Total	TOTAL VOLUME OF CONTAMINATED MATERIAL	8835750	ft^3	Calculated
Ca	AVERAGE AIR OVA CONCENTRATION	0	ppm	No Air
Vol Air	VOLUME OF CONTAMINATED AIR	0	ft^3	No Air
Mass Air	MASS OF CONTAMINATED AIR	0.0	kg	No Air
Hc	ESTIMATED JP-5 HENRY'S LAW CONSTANT	0.19	atm*m^3/mole	Estimated
Cw	WATER CONTAMINATION CONCENTRATION	5.00	mg/l	Estimated
Vol Soil	VOLUME OF CONTAMINATED SOIL	6626812.5	ft^3	Calculated
Mc	SOIL MOISTURE CONTENT	1	unitless	Saturated
Vol	VOLUME OF CONTAMINATED WATER IN SOIL	17318070	gal	Calculated
Cw	MASS OF CONTAMINANT IN WATER	327.7444748	kg	Calculated
Koc	ESTIMATED JP-5 PARTITIONING COEFFICIENT	100	l/kg	Estimated
foc	FRACTION OF ORGANICS	0.5	%	Lab Anaysis
n	POROSITY	0.25	dimensionless	Assumed
Kd	DISTRIBUTION COEFFICIENT	0.5	l/kg	Calculated
W	UNIT WEIGHT OF SOIL	100	lb/ft3	Assumed
Ka	SORBED TO DISSOLVED RATIO	2.404	dimensionless	Calculated
Cs	MASS OF CONTAMINANT IN SOIL	787.8472951	kg	Calculated
Ct	TOTAL MASS OF CONTAMINANT	1115.59177	kg	Calculated

V	Total Volume of the Contaminated Material	8835750
L1	300	
L2	960	
H	55	
W	255	

TABLE I-6: TOTAL MASS OF HYDROCARBON
IN THE MOUND AREA SOIL IN THE VADOSE ZONE

PROJECT NAME: NAS Cecil Field, NFF Site

MASS OF CONTAMINANT

DATE: 12/24/96 ENGINEER: KGK Reviewed by: JMC

Symbol	Description	Quantity	Units	Remarks
Vol Total	TOTAL VOLUME OF CONTAMINATED MATERIAL	2356300	ft^3	Calculated
Ca	AVERAGE AIR OVA CONCENTRATION	1000	ppm	No Air
Vol Air	VOLUME OF CONTAMINATED AIR	471260	ft^3	No Air
Mass Air	MASS OF CONTAMINATED AIR	13.3	kg	No Air
Hc	ESTIMATED JP-5 HENRY'S LAW CONSTANT	0.41	atm*m^3/mole	Assumed
Cw	WATER CONTAMINATION CONCENTRATION	2460.59	mg/l	Estimated
Vol Soil	VOLUME OF CONTAMINATED SOIL	1767225	ft^3	Calculated
Mc	SOIL MOISTURE CONTENT	0.2	unitless	Saturated
Vol	VOLUME OF CONTAMINATED WATER IN SOIL	923669.6	gal	Calculated
Cw	MASS OF CONTAMINANT IN WATER	8602.455839	kg	Calculated
Koc	ESTIMATED JP-5 PARTITIONING COEFFICIENT	100	l/g	Estimated
foc	FRACTION OF ORGANICS	1.1	%	Lab Anaysis
n	POROSITY	0.25	unitless	Assumed
Kd	DISTRIBUTION COEFFICIENT	1.1	l/g	Calculated
W	UNIT WEIGHT OF SOIL	100	lb/ft3	Assumed
Ka	SORBED TO DISSOLVED RATIO	5.288	unitless	Calculated
Cs	MASS OF CONTAMINANT IN SOIL	45493.75684	kg	Calculated
Ct	TOTAL MASS OF CONTAMINANT	54109.55876	kg	Calculated

Total Volume of Contaminated Material In the Vadose Zone

Vm	Total Volume of the Mound	2754000	ft^3
L	510 ft		
W	360 ft		
H	15 ft		
Vt	Total Volume of Tanks	397767.8571	ft^3
r	37.5 ft		
V	Total Volume of Contaminated Material	2356232.143	ft^3

BIOSCREEN Modeling Summary: North Fuel Farm Site, NAS Cecil Field, Jacksonville, Florida:

A synopsis of each modeling scenario is provided in this appendix followed by the model results each describes.

Natural Attenuation of Entire Intermediate Plume with No Removal of Source or Shallow Groundwater Plume:

Assumptions:

1) The source (i.e., vadose zone contaminated soils) has a mass of approximately 54,000 kgs.

2) The shallow zone of the surficial aquifer has a soluble contaminant mass of approximately 1,100 kgs.

3) The intermediate zone of the surficial aquifer has a soluble contaminant mass of approximately 2,800 kg.

4) The total mass is approximately 58,000 kgs.

5) The soluble mass is modeled as the sum of total volatile organic aromatics.

Results:

Based on these assumptions and using an instantaneous reaction scenario, the time to reduce the TVOA plume to below 50 ppb is approximately 632 years.

BIOSCREEN Natural Attenuation Decision Support Sy

Air Force Center for Environmental Excellence — *Version 1.3*

NAS Cecil Field
North Fuel Farm
Run Name

Data Input Instructions:
115 ▷ 1. Enter value directly....or
or 2. Calculate by filling in grey
0.02 ◁ cells below. (To restore formulas, hit button below).
Variable* ▷ Data used directly in model.
20 ▷ Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	19.4	(ft/yr)
or		or	
Hydraulic Conductivity	K	6.6E-03	(cm/sec)
Hydraulic Gradient	i	7.1E-4	(ft/ft)
Porosity	n	0.25	(-)

2. DISPERSION

Longitudinal Dispersivi	alpha x	23.6	(ft)
Transverse Dispersivit	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		or	
Estimated Plume Leng	Lp	920	(ft)

3. ADSORPTION

Retardation Factor*	R	4.4	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	100	(L/kg)
FractionOrganicCarbo	foc	5.0E-3	(-)

4. BIODEGRADATION

1st Order Decay Coeff	ambda	6.9E+0	(per yr)
or		or	
Solute Half-Life	t-half	0.10	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0.09	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron	e2+	2.18	(mg/L)
Delta Sulfate*	SO4	6.66	(mg/L)
Observed Methane*	CH4	18.76	(mg/L)

5. GENERAL

Modeled Area Lengt	920	(ft)
Modeled Area Width*	420	(ft)
Simulation Time*	632	(yr)

6. SOURCE DATA

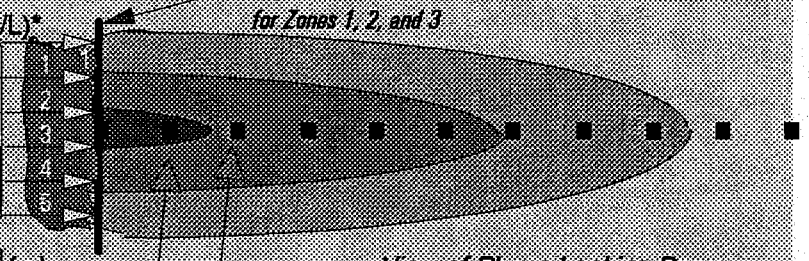
Source Thickness in Sat.Zone* 35 (ft)

Source Zones:

	Width* (ft)	Conc. (mg/L)*
1	84	1
2	84	8
3	84	21
4	84	8
5	84	1

Source Decay (see Help):
ourceHalflife* 00 - >100 (yr)
Soluble Mass or
In NAPL, Soil 58000 (Kg)

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	0		0			0		0		0	0
Dist. from Source (ft)	0	92	184	276	368	460	552	644	736	828	920

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE — View Output
RUN ARRAY — View Output
Help
Recalculate This Sheet
Paste Example Dataset
Restore Formulas for Vs, Dispersivities, R, lambda, other

I-13

Figure I-2 BIOSCREEN Input: RNA with no Source Removal, or Groundwater Remediation.

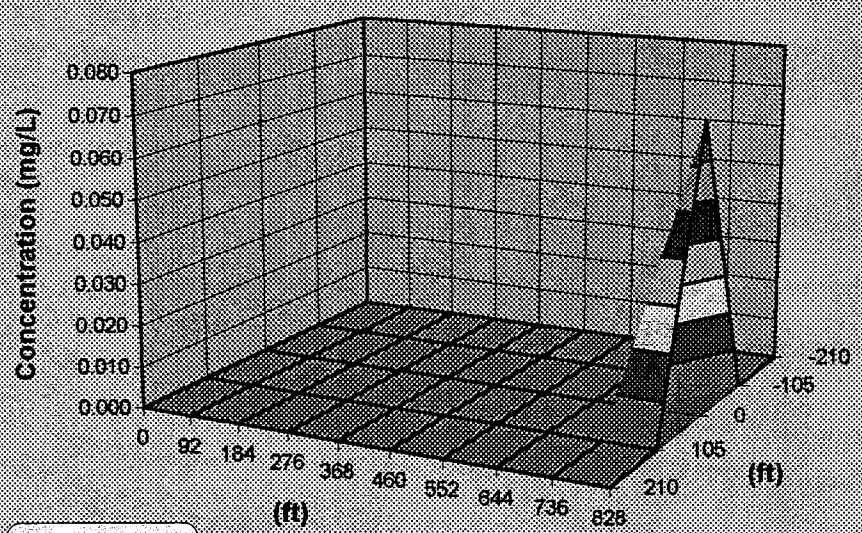
DISSOLVED HYDROCARBON CONCENTRATIONS IN PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft) →	0	92	184	276	368	460	552	644	736	828	920
210	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
105	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.070	0.326
-105	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-210	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Model to Display:

- No Degradation Model
- 1st Order Decay Model
- Instantaneous Reaction Model

Time: 632 Years Target Level: 0.005 mg/L Displayed Model: Inst. Reaction



Plot All Data

Plot Data > Target

Plume and Source Masses (Order of Magnitude Accuracy)

Plume Mass if No Biodegradation: an't Calc (Kg)

Actual Plume Mass: an't Calc (Kg)

= Plume Mass Removed by Biodeg: - (Kg)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	Nitrate	Iron II	Sulfate	Methane
-	-	-	-	-

(Kg)

Original Mass in Source (Time = 0 Years): 58000.0 (Kg)

Mass in Source Now (Time = 632Years): 27839.2 (Kg)

Current Volume of Groundwater in Plume: an't Calc (ac-ft)

Flowrate of Water Through Source Zone: an't Calc (ac-ft/yr)

Mass HELP

Recalculate

Figure [illegible] (cont.) Centerline Output: RNA with no Source Removal or Groundwater Remediation.

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BIOSCREEN Modeling Summary: North Fuel Farm Site, NAS Cecil Field, Jacksonville, Florida:

A synopsis of each modeling scenario is provided in this appendix followed by the model results each describes.

Natural Attenuation of Entire Intermediate Plume with Removal of Source and Shallow Groundwater Plume:

Assumptions:

1) The source (i.e., vadose zone contaminated soils) has a mass of approximately 54,000 kg and was removed to 0 kg.

2) The shallow zone of the surficial aquifer has a soluble contaminant mass of approximately 1,100 kg and was cleaned up to 0 kgs.

3) The intermediate zone of the surficial aquifer has a soluble contaminant mass of approximately 2,800 kg.

4) The total mass is approximately 2,800 kgs.

5) The soluble mass is modeled as the sum of total volatile organic aromatics.

Results:

Based on these assumptions and using an instantaneous reaction scenario, the time to reduce the TVOA plume to below 50 ppb is approximately 38.5 years.

BIOSCREEN Natural Attenuation Decision Support Sy

Air Force Center for Environmental Excellence — *Version 1.3*

NAS Cecil Field
North Fuel Farm
Run Name

Data Input Instructions:
115 — 1. Enter value directly....or
or
0.02 — 2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
Variable* — Data used directly in model.
20 — Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	19.4	(ft/yr)
or		or	
Hydraulic Conductivity	K	6.6E-03	(cm/sec)
Hydraulic Gradient	i	7.1E-4	(ft/ft)
Porosity	n	0.25	(-)

2. DISPERSION

Longitudinal Dispersivi	alpha x	23.6	(ft)
Transverse Dispersivit	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		or	
Estimated Plume Leng	Lp	920	(ft)

3. ADSORPTION

Retardation Factor*	R	4.4	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	100	(L/kg)
FractionOrganicCarbo	foc	5.0E-3	(-)

4. BIODEGRADATION

1st Order Decay Coeff	ambda	6.9E+0	(per yr)
or		or	
Solute Half-Life	t-half	0.10	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	0.09	(mg/L)
Delta Nitrate*	NO3	0	(mg/L)
Observed Ferrous Iron	e2+	2.18	(mg/L)
Delta Sulfate*	SO4	6.66	(mg/L)
Observed Methane*	CH4	18.76	(mg/L)

5. GENERAL

Modeled Area Lengt	920	(ft)
Modeled Area Width*	420	(ft)
Simulation Time*	38.5	(yr)

6. SOURCE DATA

Source Thickness in Sat.Zone* 35 (ft)

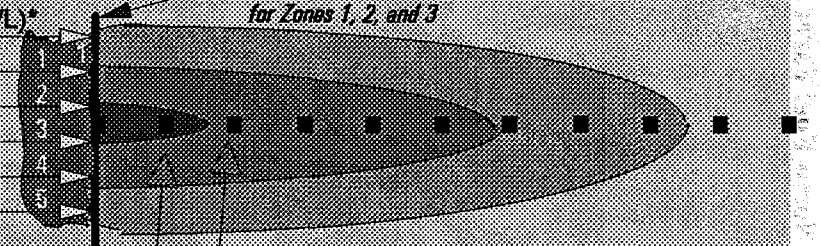
Source Zones:

Width* (ft)	Conc. (mg/L)*
84	1
84	8
84	21
84	8
84	1

Source Decay (see Help):

ourceHalflife*	30 - 100	(yr)
Soluble Mass	or	
In NAPL, Soil	2781	(Kg)

Vertical Plane Source: Look at Plume Cross Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	.0		.0			.0		.0		.0	.0
Dist. from Source (ft)	0	92	184	276	368	460	552	644	736	828	920

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE — View Output
RUN ARRAY — View Output
Help
Recalculate This Sheet
Paste Example Dataset
Restore Formulas for Vs, Dispersivities, R, lambda, other

Figur BIOSCREEN Input: RNA of Intermediate Plume with Source and Shallow Groundwat ediated.

I-16

DISSOLVED HYDROCARBON CONCENTRATIONS IN PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft) →	0	92	184	276	368	460	552	644	736	828	920
210	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
105	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	0.000	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-105	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-210	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

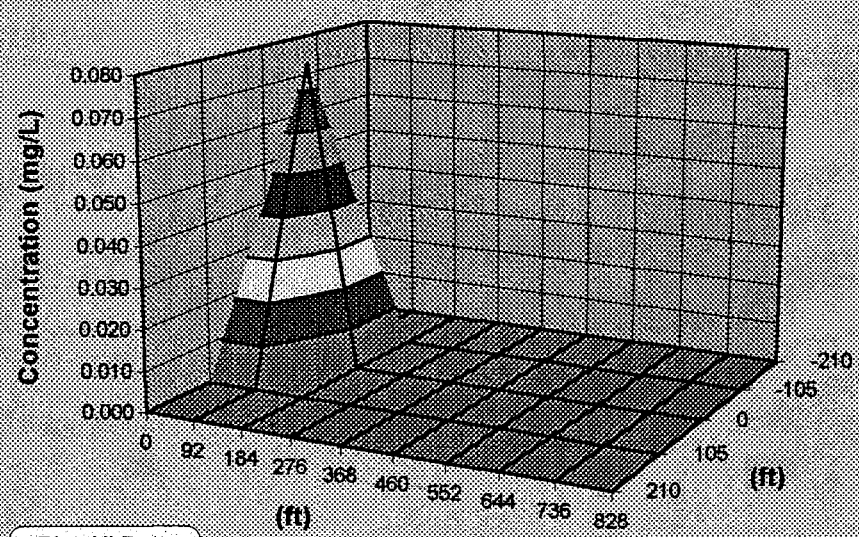
Model to Display:

- No Degradation Model
- 1st Order Decay Model
- Instantaneous Reaction Model

Time: 38.5 Years

Target Level: 0.005 mg/L

Displayed Model: Inst. Reaction



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	1686.5	(Kg)
- Actual Plume Mass	0.7	(Kg)
= Plume Mass Removed by Biodeg	1685.8	(Kg) (100 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	Nitrate	Iron II	Sulfate	Methane	
5.9	+0.0	+143.6	-438.6	+1235.6	(Kg)

Original Mass In Source (Time = 0 Years)	2781.0	(Kg)
Mass in Source Now (Time = 38.5Years)	1094.5	(Kg)
Current Volume of Groundwater in Plume	1.9	(ac-ft)
Flowrate of Water Through Source Zone	1.636	(ac-ft/yr)

Mass HELP

Recalculate

Figure I-3(cont.) Centerline Output: RNA of Intermediate Plume with Source and Shallow Groundwater Remediated.

BIOSCREEN Modeling Summary: North Fuel Farm Site, NAS Cecil Field, Jacksonville, Florida:

A synopsis of each modeling scenario is provided in this appendix followed by the model results each describes.

Natural Attenuation of Intermediate Plume After Source Removal, Remediation of Shallow Contaminated Groundwater and Installation of 5 In-Well Aeration Wells.

Assumptions:

1) The intermediate zone of the surficial aquifer has a soluble contaminant mass of approximately 2,800 kg.

2) Five in-well aeration wells will be installed in the plume area covering the 10,000 ppb TVOA contour.

3) The in-well aeration wells will be operating until the contaminated groundwater in the greater than 10,000 ppb TVOA contour is remediated to 10,000 ppb.

4) When the "hot spot" (greater than 5,000 ppb TVOA) has been removed, natural attenuation will clean up the remainder of the plume to 50 ppb TVOA.

5) The total mass contained in the "hot spot" is approximately 695 kg.

6) The soluble mass is modeled as the sum of total volatile organic aromatics.

7) The total mass remaining to remediate via natural attenuation is 2,086 kgs.

Results:

Based on these assumptions and using an instantaneous reaction scenario, the time to reduce the TVOA plume to below 50 ppb is approximately 22 years.

BIOSCREEN Natural Attenuation Decision Support Sy

Air Force Center for Environmental Excellence — *Version 1.3*

NAS Cecil Field
North Fuel Farm
Run Name

Data Input Instructions:

115 → *1. Enter value directly...or*
↑ or
0.02 → *2. Calculate by filling in grey cells below. (To restore formulas, hit button below).*

Variable* → *Data used directly in model.*
20 → *Value calculated by model. (Don't enter any data).*

1. HYDROGEOLOGY

Seepage Velocity*	*Vs*	19.4	*(ft/yr)*
or		↑ or	
Hydraulic Conductivity	*K*	6.6E-03	*(cm/sec)*
Hydraulic Gradient	*i*	7.1E-4	*(ft/ft)*
Porosity	*n*	0.25	*(-)*

2. DISPERSION

Longitudinal Dispersivi	*alpha x*	23.6	*(ft)*
Transverse Dispersivit	*alpha y*	2.4	*(ft)*
Vertical Dispersivity*	*alpha z*	0.0	*(ft)*
or		↑ or	
Estimated Plume Leng	*Lp*	920	*(ft)*

3. ADSORPTION

Retardation Factor*	*R*	4.4	*(-)*
or		↑ or	
Soil Bulk Density	*rho*	1.7	*(kg/l)*
Partition Coefficient	*Koc*	100	*(L/kg)*
FractionOrganicCarbo	*foc*	5.0E-3	*(-)*

4. BIODEGRADATION

1st Order Decay Coeff	*ambda*	6.9E+0	*(per yr)*
or		↑ or	
Solute Half-Life	*t-half*	0.10	*(year)*

or Instantaneous Reaction Model

Delta Oxygen*	*DO*	0.09	*(mg/L)*
Delta Nitrate*	*NO3*	0	*(mg/L)*
Observed Ferrous Iron	*e2+*	2.18	*(mg/L)*
Delta Sulfate*	*SO4*	6.66	*(mg/L)*
Observed Methane*	*CH4*	18.76	*(mg/L)*

5. GENERAL

Modeled Area Lengt	920	*(ft)*
Modeled Area Width*	420	*(ft)*
Simulation Time*	21.6	*(yr)*

L, W

6. SOURCE DATA

Source Thickness in Sat.Zone* 35 *(ft)*

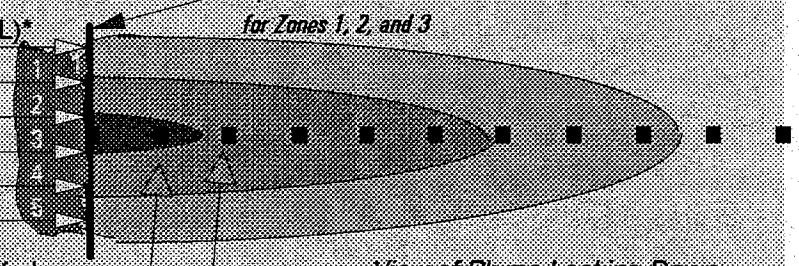
Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

Source Zones:

Width* (ft)	Conc. (mg/L)*
84	1
84	8
84	21
84	8
84	1

Source Decay (see Help):

ourceHalflife*	20 - 90	*(yr)*
Soluble Mass	↑ or	
In NAPL, Soil	2086	*(Kg)*



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	0		0			0		0		0	0
Dist. from Source (ft)	0	92	184	276	368	460	552	644	736	828	920

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE — View Output

RUN ARRAY — View Output

Help

Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Figure I-4 BIOSCREEN Input: RNA with 5 IWA wells.

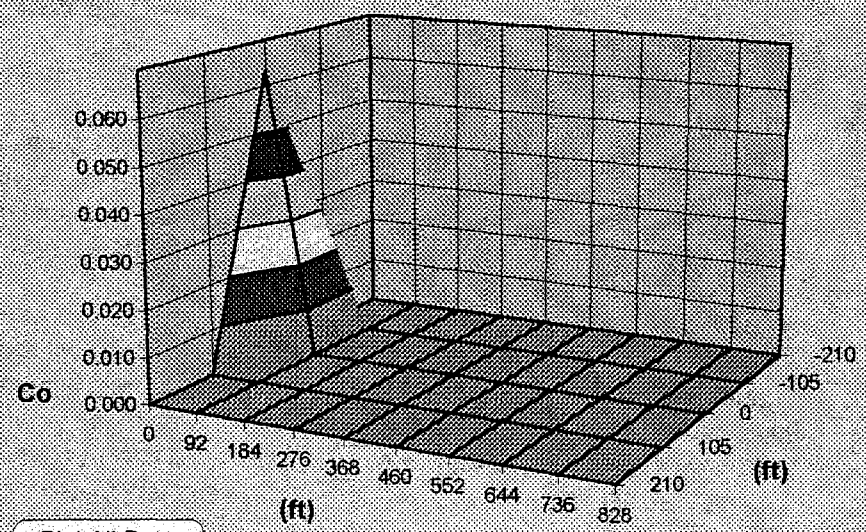
DISSOLVED HYDROCARBON CONCENTRATIONS IN PLUME (mg/L at Z=0)

Transverse Distance (ft) ↓ / Distance from Source (ft) →	0	92	184	276	368	460	552	644	736	828	920
210	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
105	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	0.063	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-105	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-210	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Model to Display:

- No Degradation Model
- 1st Order Decay Model
- Instantaneous Reaction Model

Time: 21.6 Years Target Level: 0.005 mg/L Displayed Model: Inst. Reaction



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	1047.5	(Kg)
Actual Plume Mass	0.3	(Kg)
= Plume Mass Removed by Biodeg	1047.3	(Kg) (100 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	Nitrate	Iron II	Sulfate	Methane	
-3.7	+0.0	+89.2	-272.5	+767.5	(Kg)

Original Mass In Source (Time = 0 Years)	2086.0	(Kg)
Mass in Source Now (Time = 21.6Years)	1038.5	(Kg)
Current Volume of Groundwater in Plume	1.9	(ac-ft)
Flowrate of Water Through Source Zone	1.636	(ac-ft/yr)

Mass HELP Recalculate

Figure [illegible] (cont.). Centerline Output RNA with 5 IWA Wells.

IN-SITU STRIPPING DESIGN CALCULATIONS
NAS Cecil Field, North Fuel Farm Site

Based on a paper by Battelle (attached), the time to cleanup for the in-well aeration scenario was calculated. Table I-7 shows that if 25 in-well aeration wells are installed to treat the intermediate plume, it will take approximately 42 years to clean up.

Table I-8 presents a limited in-well aeration scenario. If five wells are installed in the hot areas, it will take approximately 10 years to bring TVOA concentrations from an average of 20,000 ppb to 5,000 ppb.

Table I-7: Time to Cleanup for 25 In-well Aeration Wells

In-Situ Stripping Design Calculations								
Date: 1/27/97		Project: NFF KAP			Engineer:	KGK	Reviewed by:	SG
Reference: Paper by Todd and Less Parrington, Batelle Publications								
Hydrostatic Head, H								
rw	well radius					4.00	inches	assumed
Qair	air flow rate					10.00	cfm	assumed
Vs	superficial air velocity					0.15	m/s	calculated
L	saturated thickness of the aquifer					50.00	ft	given
H/L	vertical hydraulic gradient					0.27	m/m	Graph 1
H	hydrostatic head generated due to air flow					13.65	ft	calculated
Flow Rate, Qc								
Kr	radial hydraulic conductivity					5.00	ft/day	Slug Tests
Kz	vertical hydraulic conductivity					0.40	ft/day	Assumed
rwD	dimensionless well radius					0.0019		Calculated
QD	dimensionless flow rate					0.15		Graph 2
Qc	flow rate					2.74	GPM	Calculated
Time for ROI development								
ROI/L	ratio of ROI to saturated thickness					1.00		typical
ROI	radius of influence					50.00	ft	calculated
V	volume of sphere of influence					523598.78	ft^3	calculated
n	porosity					0.25		assumed
Vw	volume of water in the sphere of influence					979129.71	gal.	calculated
S.F.	Factor of Safety					2.00		
t	time for ROI development (i.e., one pore volume)					496.84	days	calculated
Hydrodynamic Retardation Factor								
Koc	partitioning coefficient of benzene					100.00		literature
foc	fraction of organics					0.50	%	analyses
Kd	distribution coefficient of benzene					0.50		calculated
B	bulk density					170.00	lb/ft^3	estimated
Rh	hydrodynamic retardation factor					5.09		calculated
Ci	initial concentration					21000.00	ug/L	analyses
Co	target concentration					50.00	ug/L	given
Co/Ci	fraction remainig					0.00		calculated
N	number of pore volumes					30.72		calculated
T	total time to flush N porevolumes					41.82	yrs.	calculated

Table I-8: Time to Cleanup for 5 In-well Aeration Wells

In-Situ Stripping Design Calculations

Date: 1/27/97	Project: NFF RAP	Engineer: KGK	Reviewed by: SG	
Reference: Paper by Todd and Less Parrington, Batelle Publications				
Hydrostatic Head, H				
rw	well radius	4.00	inches	assumed
Qair	air flow rate	10.00	cfm	assumed
Vs	superficial air velocity	0.15	m/s	calculated
L	saturated thickness of the aquifer	50.00	ft	given
H/L	vertical hydraulic gradient	0.27	m/m	Graph 1
H	hydrostatic head generated due to air flow	***13.65***	ft	calculated
Flow Rate, Qc				
Kr	radial hydraulic conductivity	5.00	ft/day	Slug Tests
Kz	vertical hydraulic conductivity	0.40	ft/day	Assumed
rwD	dimensionless well radius	0.0019		Calculated
QD	dimensionless flow rate	0.15		Graph 2
Qc	flow rate	***2.74***	GPM	Calculated
Time for ROI development				
ROI/L	ratio of ROI to saturated thickness	1.00		typical
ROI	radius of influence	50.00	ft	calculated
V	volume of sphere of influence	523598.78	ft^3	calculated
n	porosity	0.25		assumed
Vw	volume of water in the sphere of influence	979129.71	gal.	calculated
S.F.	Factor of Safety	2.00		
t	time for ROI development (i.e., one pore volume)	***496.84***	days	calculated
Hydrodynamic Retardation Factor				
Koc	partitioning coefficient of benzene	100.00		literature
foc	fraction of organics	0.50	%	analyses
Kd	distribution coefficient of benzene	0.50		calculated
B	bulk density	170.00	lb/ft^3	estimated
Rh	hydrodynamic retardation factor	5.09		calculated
Ci	initial concentration	21000.00	ug/L	analyses
Co	target concentration	5000.00	ug/L	given
Co/Ci	fraction remainig	0.24		calculated
N	number of pore volumes	7.30		calculated
T	total time to flush N porevolumes	***9.94***	yrs.	calculated

COST ESTIMATE

NATURAL ATTENUATION MONITORING

ANNUAL OPERATING, MAINTENANCE, AND MONITORING COSTS (YEAR 1):

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
Monitoring Costs:				
Labor (2 technicians 5 days per 1/2 year @ 10 hour days)	200	hour	$41.00	$8,200
Groundwater:				
Volatile Organics EPA Method 602 (20 samples semiannually, Year 1)	48	ea	$162.00	$7,776
Polynuclear Aromatic Hydrocarbons EPA Method 610	48	ea	$170.78	$8,197
(20 samples semiannually)				
Natural Attenuation Analysis (semiannually, Year 1)				
Test kits (Iron, Chloride, Alkalinity, Carbon Dioxide, Oxygen)	1	ls	$163.00	$163
Test kit reagents	36	ls	$28.00	$1,008
Nitrates EPA Method 353.2	36	ea	$25.00	$900
Sulfates EPA Method 375.4	36	ea	$15.00	$540
Methane Modified EPA Method 8015	36	ea	$100.00	$3,600
Dissolved Organic Carbon EPA Method 415.1	36	ea	$30.00	$1,080
Reporting (1 Engineer, 7 days per event @2 events)	112	hour	$46.00	$5,152
Total Operation, Maintenance, and Monitoring Costs (Year 1):				$36,616

There will be twenty wells sampled:
All Twenty will be sampled for EPA Method 601/602.
Fourteen wells will be sampled for natural attenuation parameters.

Parameter	601/602	RNA
# of wells	20	14
Duplicates	2	2
Equipment Blanks	1	1
Trip Blanks	1	1
Total Per Event	24	18
Total Per Year	48	36

COSTS FOR NATURAL ATTENUATION AND IN-WELL AERATION

Costs Associated With Natural Attenuation and In-Well Aeration

Project Name: Remedial Action Plan, North Fuel Farm Site, Jacksonville, FL.

Date: January 5, 1997 Engineer: TIM KELLY Reviewed by: KGK

Costs Prior to Source Removal

Description	Capital Unit	Capital Total	O&M Unit (per annum)	# of years	O&M Total	Gross	Unit Sampling	# of years	Sampling Total	Total
Installation of 25 In-well Aeration units	$10,000	$250,000	$5,000	42	$210,000	$460,000	$24,173	52	$1,256,996	$1,716,996
Installation of 5 In-well Aeration units and RNA	$10,000	$50,000	$5,000	10	$50,000	$100,000	$36,616	42	$1,537,872	$1,637,872
Remediation by Natural Attenuation Only	$0	$0	$0	39	$0	$0	$36,616	49	$1,794,184	$1,794,184

Costs After Source Removal

Description	Capital Unit	Capital Total	O&M Unit	# of years	O&M Total	Gross	Sampling Unit	# of years	Sampling Total	Total
Installation of 25 In-well Aeration units	$10,000	$250,000	$5,000	42	$210,000	$460,000	$24,173	42	$1,015,266	$1,475,266
Installation of 5 In-well Aeration units and RNA	$10,000	$50,000	$5,000	10	$50,000	$100,000	$36,616	32	$1,171,712	$1,271,712
Remediation by Natural Attenuation Only	$0	$0	$0	39	$0	$0	$36,616	39	$1,428,024	$1,428,024

Note: It is assumed to take 10 years for source removal.

ABB ENVIRONMENTAL SERVICES, INC
TREATABILITY LABORATORY
LABORATORY ANALYSIS REPORT

Prepared For:

Jim Williams/Gopi Kanchibhutla
ABB Environmental Services, Inc.
2590 Executive Center
Circle East, Berkeley Building
Tallahassee, FL 32301-5001

11/19/96

Prepared By:

ABB Environmental Services, Inc.
107 Audubon Road
Wakefield, MA 01880

Patricia Byrnes
Treatability Laboratory Manager

Patricia D. Byrnes/Wake/USEVS/ABB
11/15/96 03:26 PM (Phone: +)

To: Gopi Kanchibhatla/Tall/USEVS/ABB
cc: Maureen D. Dooley/Wake/USEVS/ABB
Subject: reissuing Cecil results

I am reissuing the Cecil Field results to you today. I will send them fedex this afternoon. If you are still missing results after review this results package (except for the most recent sampling event) please let me know. I will sent the most recent sampling event results out on Monday.

ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY

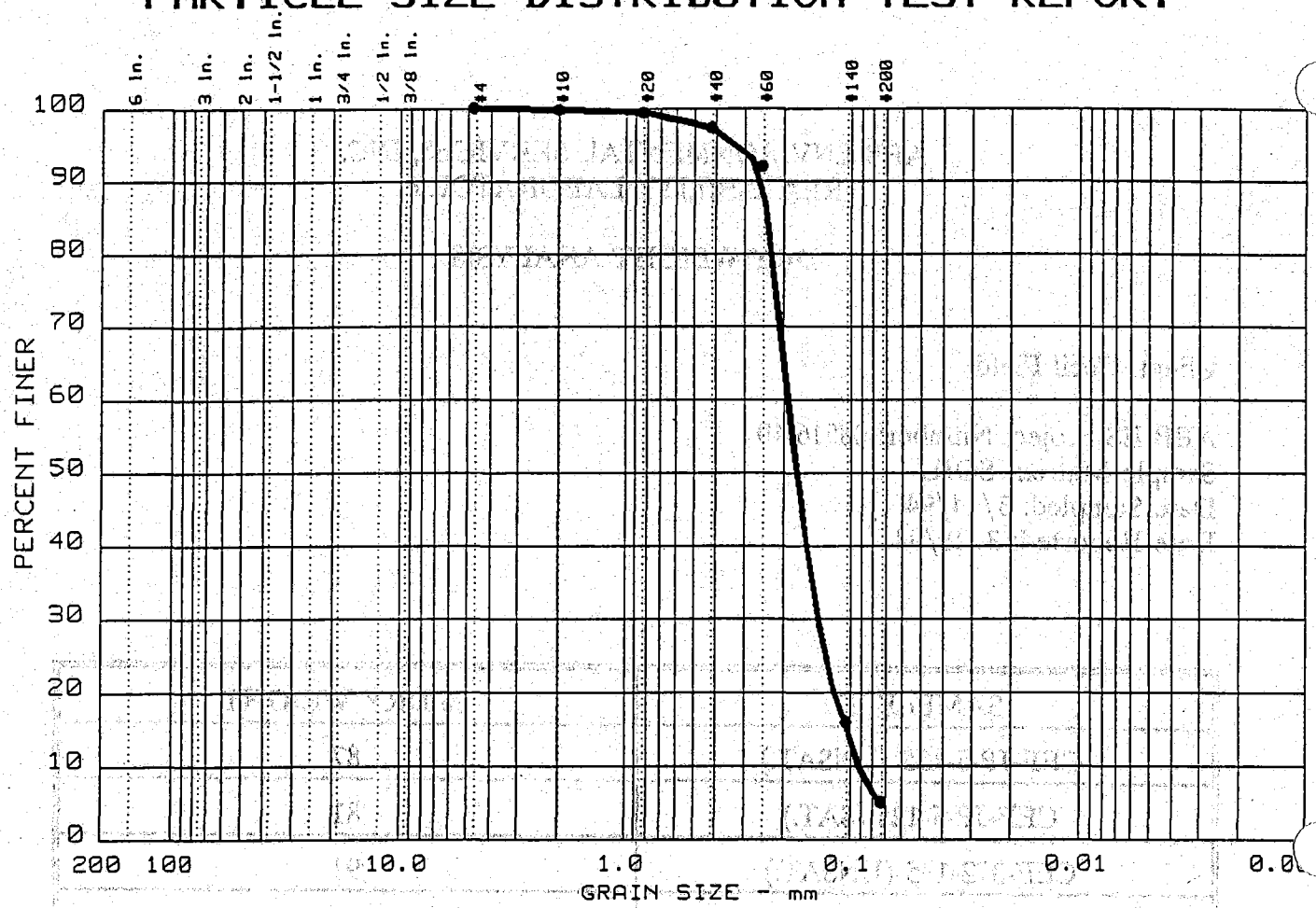
DRY WEIGHT ANALYSIS

Client: Cecil Field

ABB-ES Project Number: 08516-40
Sample Matrix: SOIL
Date Sampled: 3/14/94
Date Reported: 3/28/94

SAMPLE ID	% DRY WEIGHT
CEF-JP-5-125 (UNSAT.)	87
CEF-JP-5-125 (SAT.)	81
CEF-372-135 (UNSAT.)	91
CEF-372-135 (SAT.)	88
CEF-076-315 (UNSAT.)	93
CEF-076-315 (SAT.)	80

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	2	0.0	0.0	94.9	5.1		SP-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.19		
D_{30}	0.14		
D_{10}	0.09		
	COEFFICIENTS		
C_c	1.10		
C_u	2.1		

SIEVE number size	PERCENT FINER ●		
4	100.0		
10	99.8		
20	99.5		
40	97.3		
60	91.9		
140	16.0		
200	5.1		

Sample information:
● CEF-JP5-125

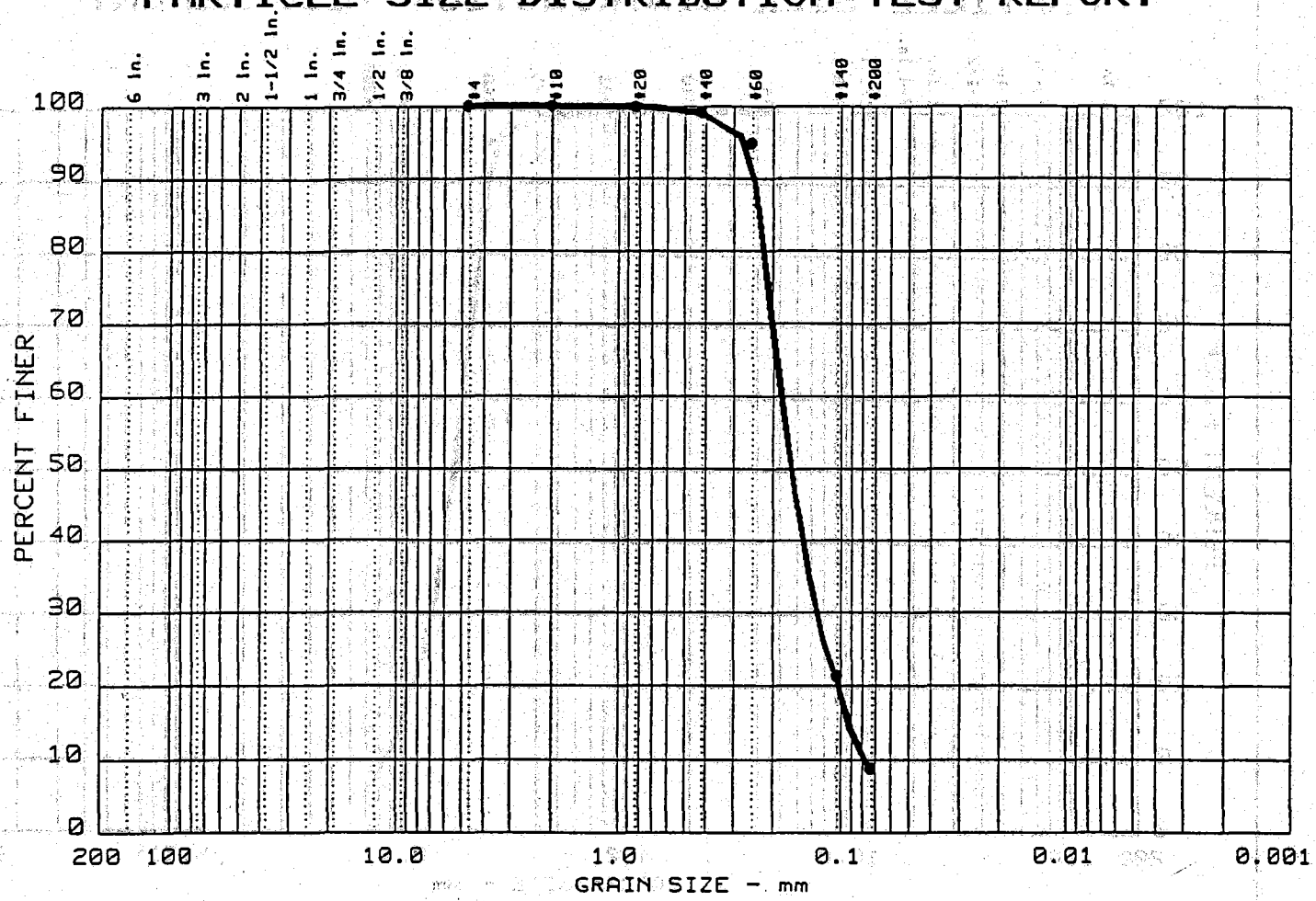
Remarks:
sieve analysis only

ABB Environmental Services, Inc.

Project No.: 08516-40
Project: NAS Cecil Field

Date: 3/30/94 Data Sheet No. ——

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	2	0.0	0.0	91.2	8.8		SP-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.18		
D_{30}	0.13		
D_{10}	0.07		
	COEFFICIENTS		
C_c	1.16		
C_u	2.4		

SIEVE number size	PERCENT FINER ●		
4	100.0		
10	100.0		
20	100.0		
40	99.1		
60	94.8		
140	21.4		
200	8.8		

Sample information:
● CEF-076-315

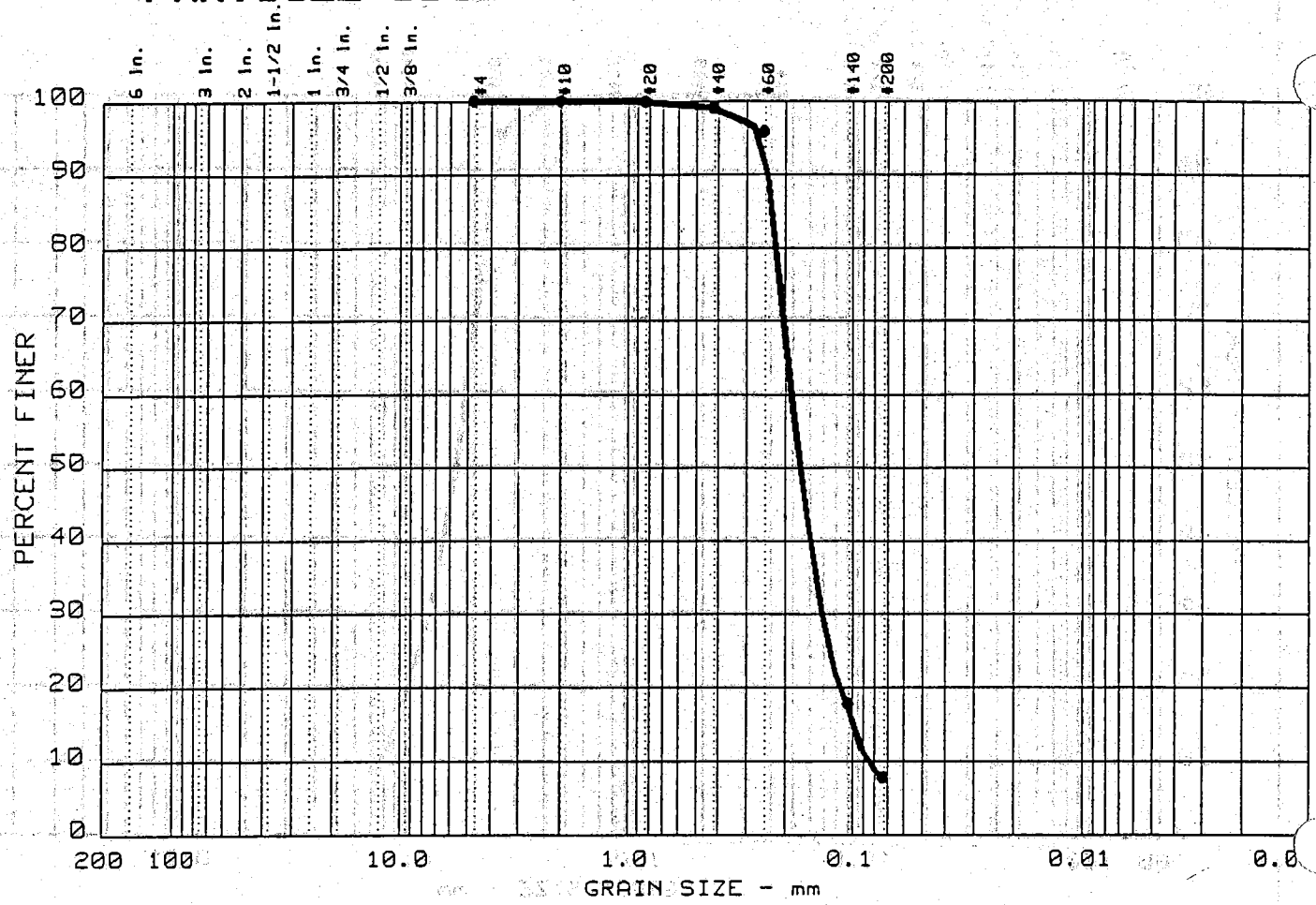
Remarks:
sieve analysis only

ABB Environmental Services, Inc.

Project No.: 08516-40
Project: NAS Cecil Field

Date: 3/30/94 Data Sheet No. ____

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	2	0.0	0.0	92.2	7.8		SP-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.19		
D_{30}	0.14		
D_{10}	0.08		
	COEFFICIENTS		
C_c	1.17		
C_u	2.2		

SIEVE number size	PERCENT FINER ●		
4	100.0		
10	100.0		
20	99.9		
40	99.0		
60	95.8		
140	17.8		
200	7.8		

Sample information:
● CEF-372-135

Remarks:
sieve analysis only

ABB Environmental Services, Inc.

Project No.: 08516-40
Project: NAS Cecil Field

Date: 3/30/94 Data Sheet No. ____

ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY

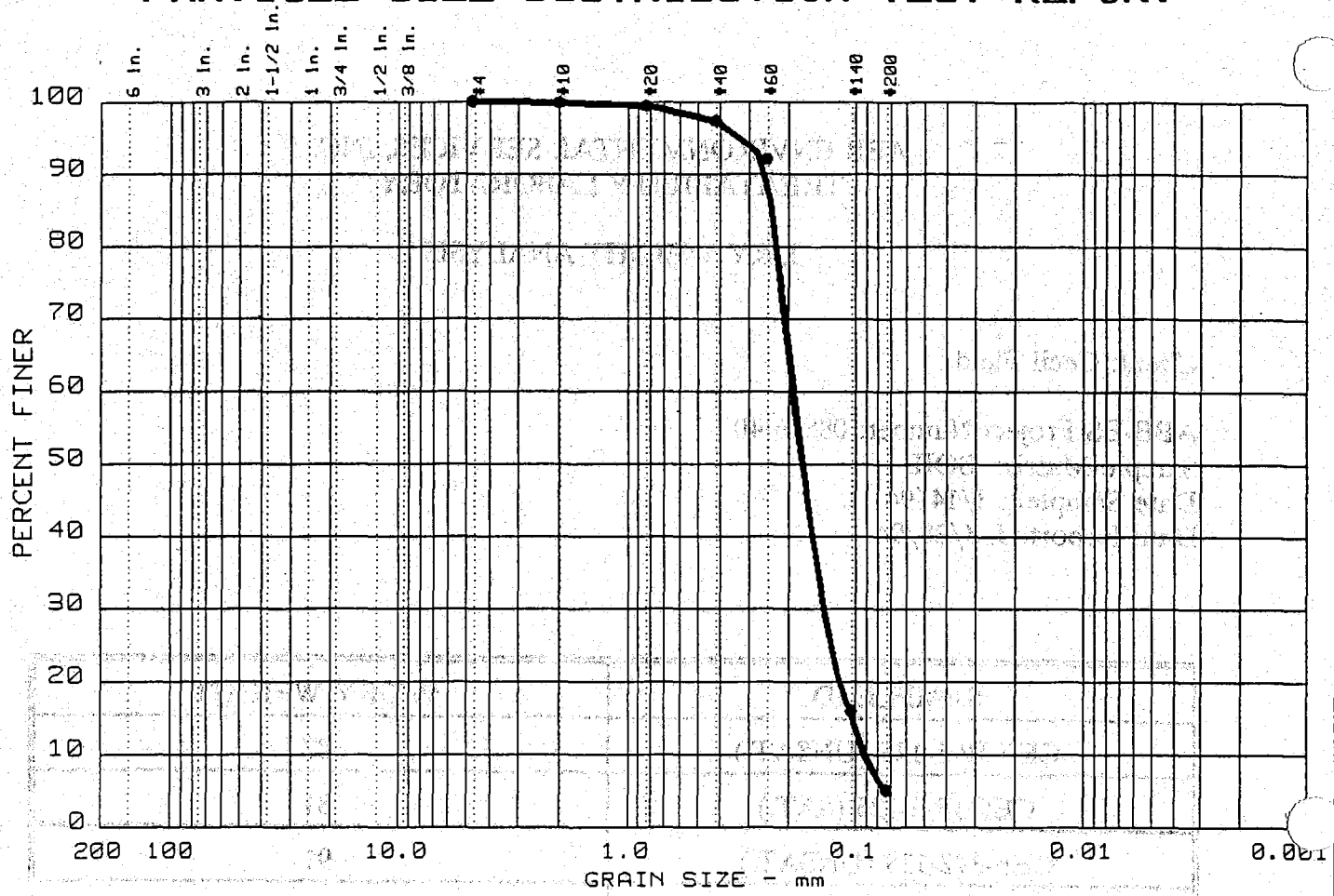
DRY WEIGHT ANALYSIS

Client: Cecil Field

ABB-ES Project Number: 08516-40
Sample Matrix: SOIL
Date Sampled: 3/14/94
Date Reported: 3/28/94

SAMPLE ID	% DRY WEIGHT
CEF-JP-5-125 (UNSAT.)	87
CEF-JP-5-125 (SAT.)	81
CEF-372-135 (UNSAT.)	91
CEF-372-135 (SAT.)	88
CEF-076-315 (UNSAT.)	93
CEF-076-315 (SAT.)	80

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	2	0.0	0.0	94.9	5.1		SP-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.19		
D_{30}	0.14		
D_{10}	0.09		
	COEFFICIENTS		
C_c	1.10		
C_u	2.1		

SIEVE number size	PERCENT FINER ●		
4	100.0		
10	99.8		
20	99.5		
40	97.3		
60	91.9		
140	16.0		
200	5.1		

Sample information:
● CEF-JP5-125

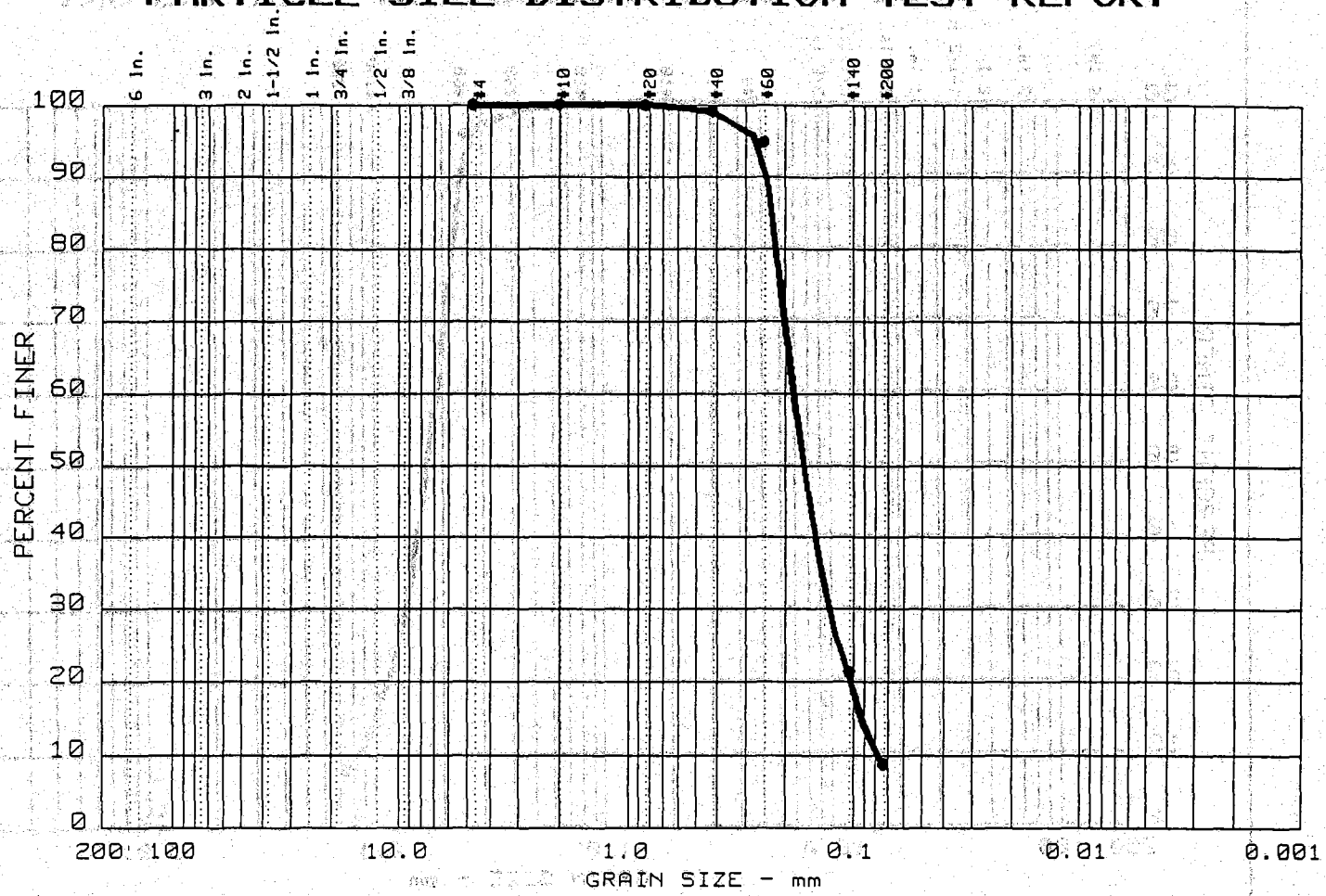
Remarks:
sieve analysis only

ABB Environmental Services, Inc.

Project No.: 08516-40
Project: NAS Cecil Field

Date: 3/30/94 Data Sheet No. ——

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	2	0.0	0.0	91.2	8.8		SP-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.18		
D_{30}	0.13		
D_{10}	0.07		
	COEFFICIENTS		
C_c	1.16		
C_u	2.4		

SIEVE number size	PERCENT FINER ●		
4	100.0		
10	100.0		
20	100.0		
40	99.1		
60	94.8		
140	21.4		
200	8.8		

Sample information:
● CEF-076-315

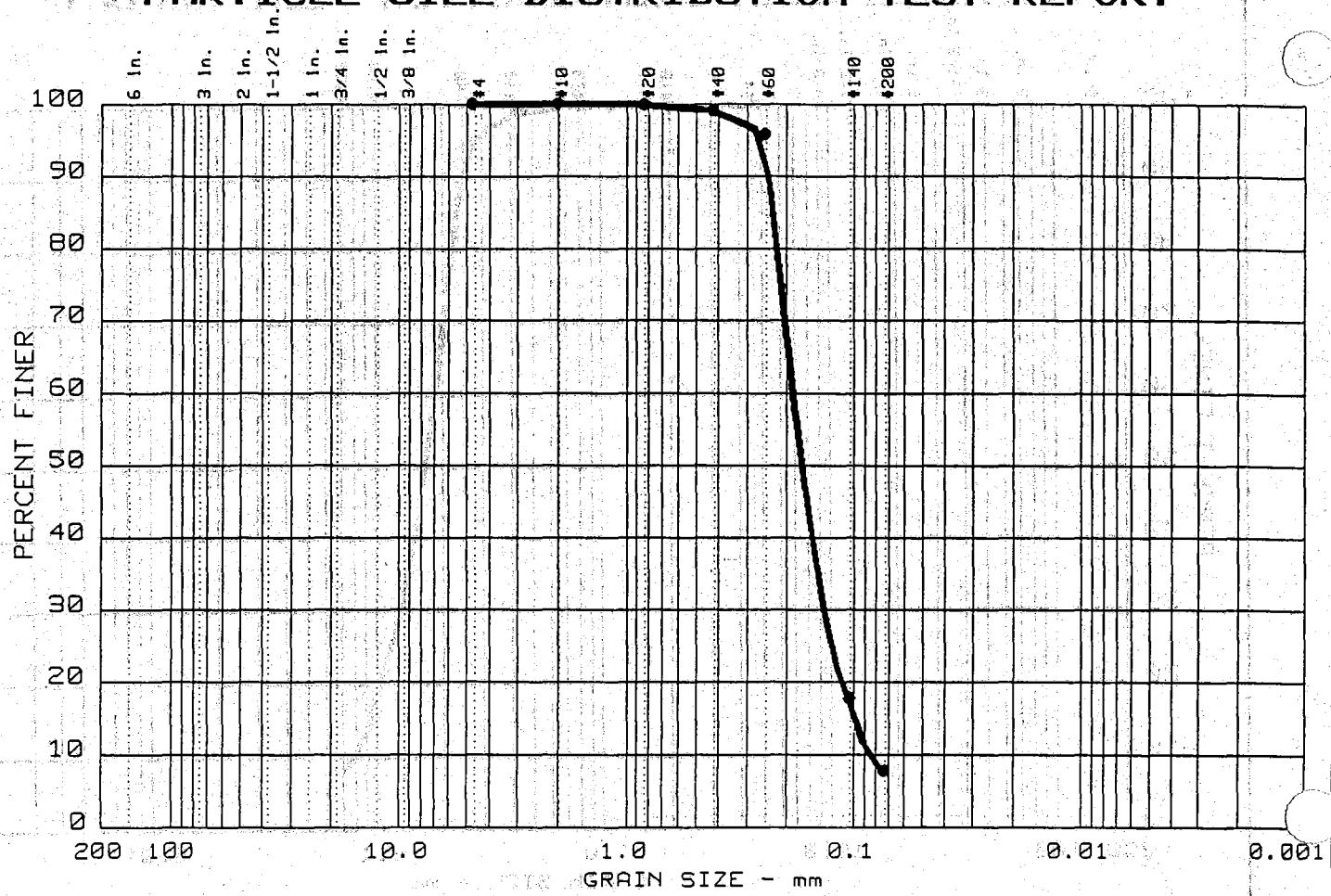
Remarks:
sieve analysis only

ABB Environmental Services, Inc.

Project No.: 08516-40
Project: NAS Cecil Field

Date: 3/30/94 Data Sheet No. ____

PARTICLE SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	2	0.0	0.0	92.2	7.8		SP-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.19		
D_{30}	0.14		
D_{10}	0.08		
	COEFFICIENTS		
C_c	1.17		
C_u	2.2		

SIEVE number size	PERCENT FINER ●		
4	100.0		
10	100.0		
20	99.9		
40	99.0		
60	95.8		
140	17.8		
200	7.8		

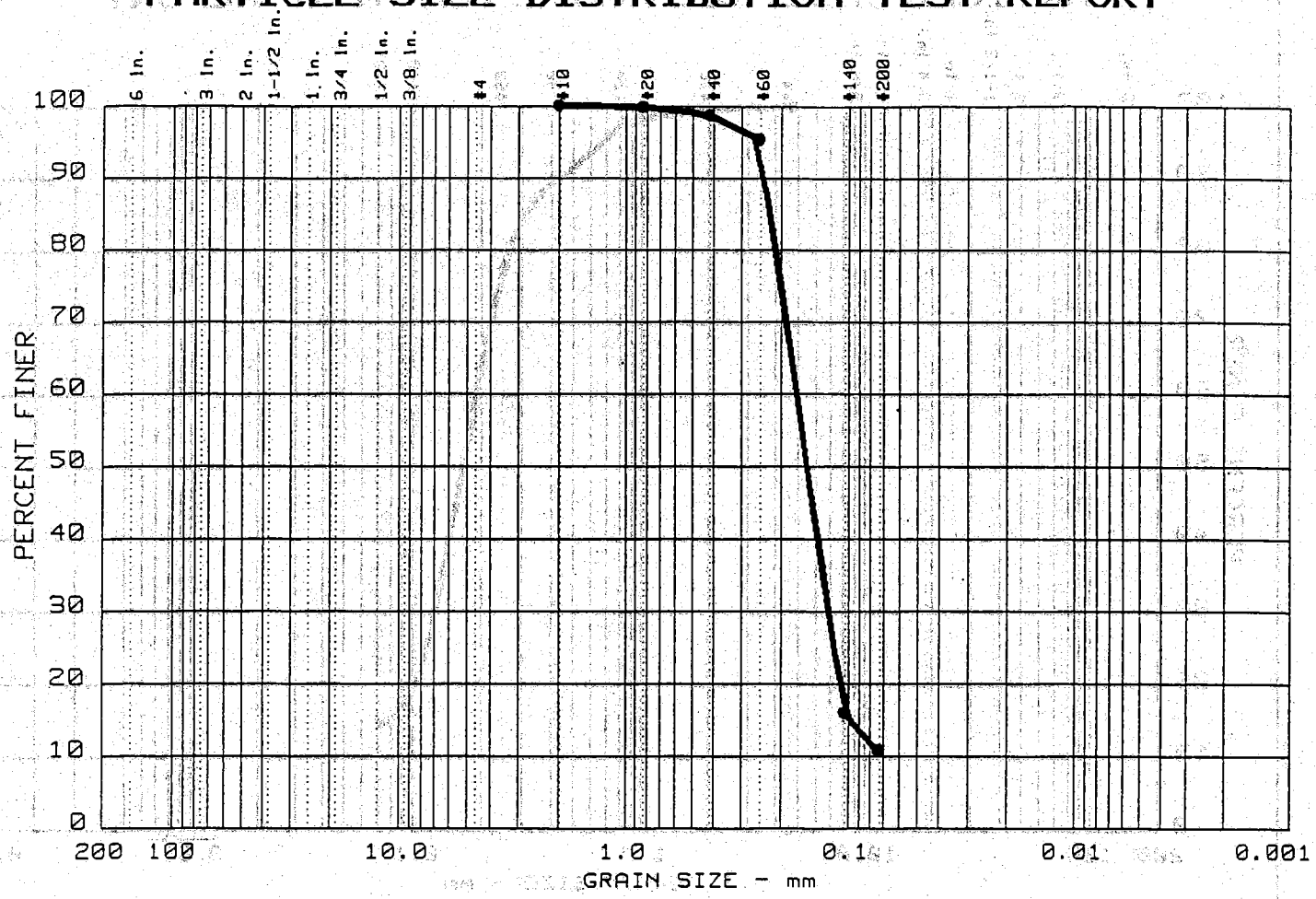
Sample information:
● CEF-372-135

Remarks:
sieve analysis only

ABB Environmental Services, Inc.

Project No.: 08516-40
Project: NAS Cecil Field
Date: 3/30/94
Data Sheet No. ____

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	0.0	89.2	10.8		SP-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.17		
D_{30}	0.12		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
10	100.0		
20	99.8		
40	98.7		
60	95.4		
140	16.1		
200	10.8		

Sample information:
● CEF-076-62D (0-50)

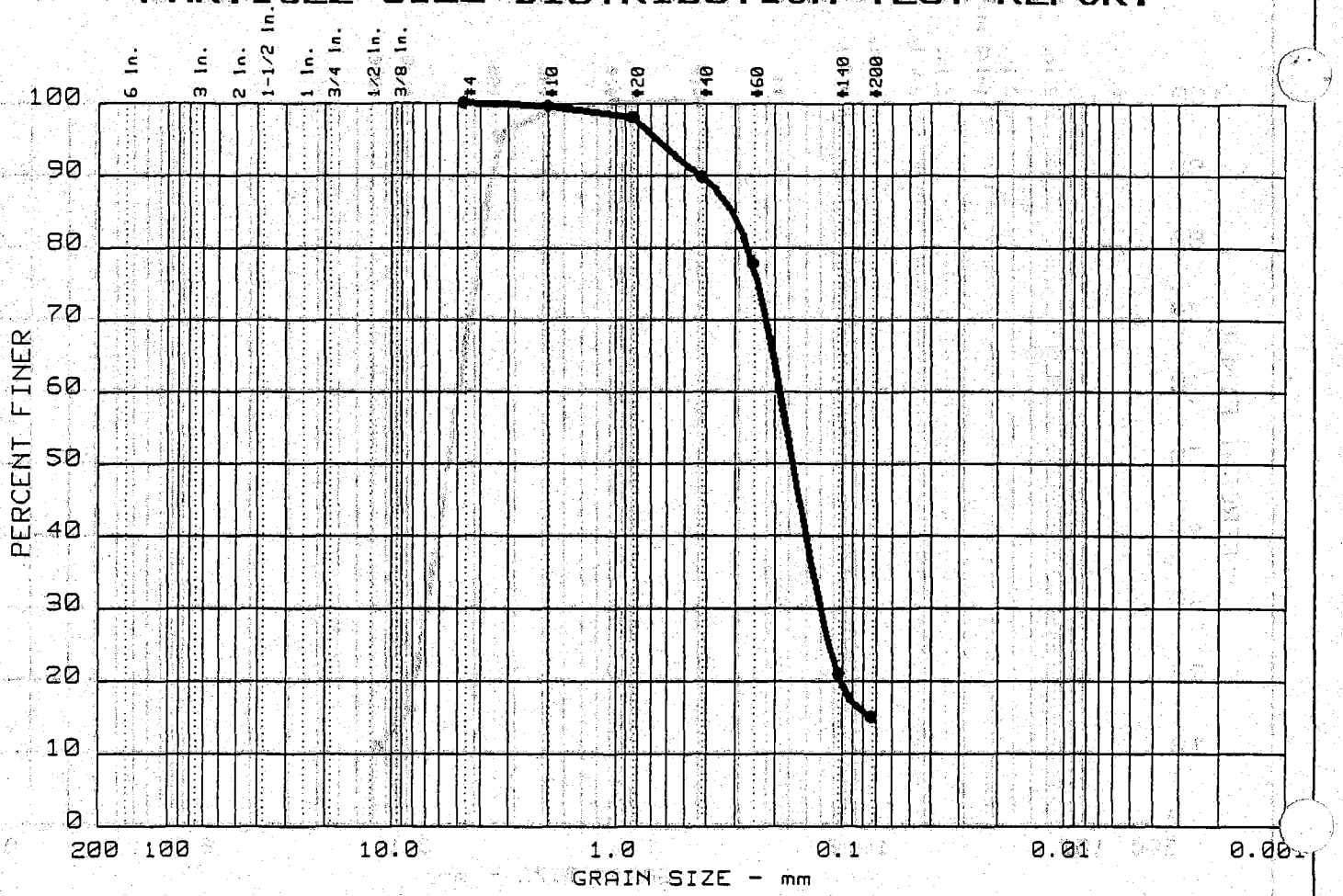
Remarks:
Sieve Analysis Only

ABB Environmental Services, Inc.

Project No.: 08520.82
Project: CECIL FIELD

Date: 6/8/95 Data Sheet No. ——

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	0.0	84.9	15.1		SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.19		
D_{30}	0.13		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	100.0		
10	99.6		
20	98.0		
40	89.7		
60	77.8		
140	21.0		
200	15.1		

Sample Information:
● CEF-076-62D (55-99)

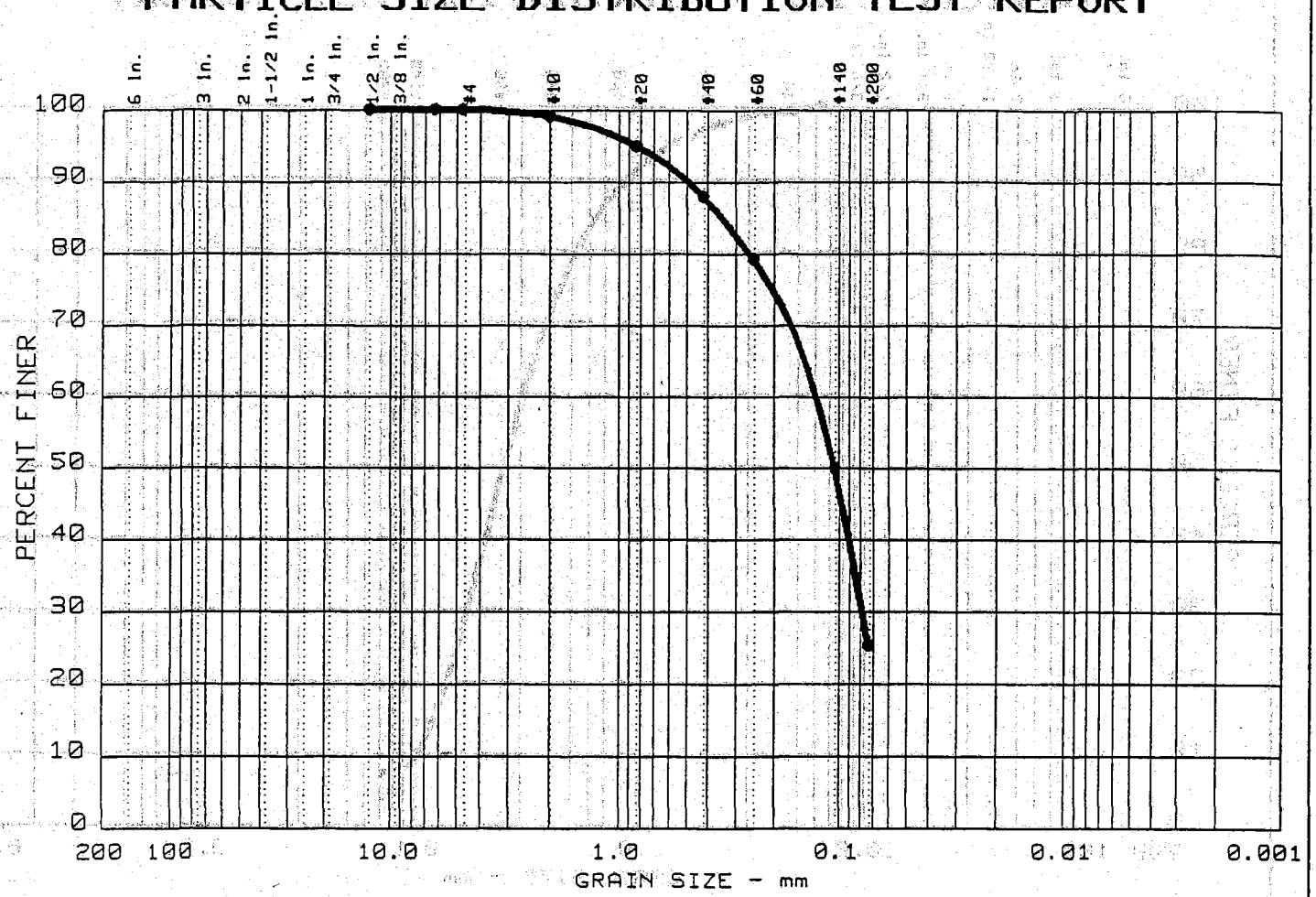
Remarks:
Sieve Analysis Only

ABB Environmental Services, Inc.

Project No.: 08520.82
Project: CECIL FIELD

Date: 6/8/95 Data Sheet No. ——

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	0.0	74.6	25.4		SM		

SIEVE inches size	PERCENT FINER ●		
0.5	100.0		
0.25	100.0		
	GRAIN SIZE		
D_{60}	0.13		
D_{30}	0.08		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	100.0		
10	99.1		
20	95.0		
40	87.9		
60	79.2		
140	50.0		
200	25.4		

Sample information:
● CEF-076-62D (100-116)

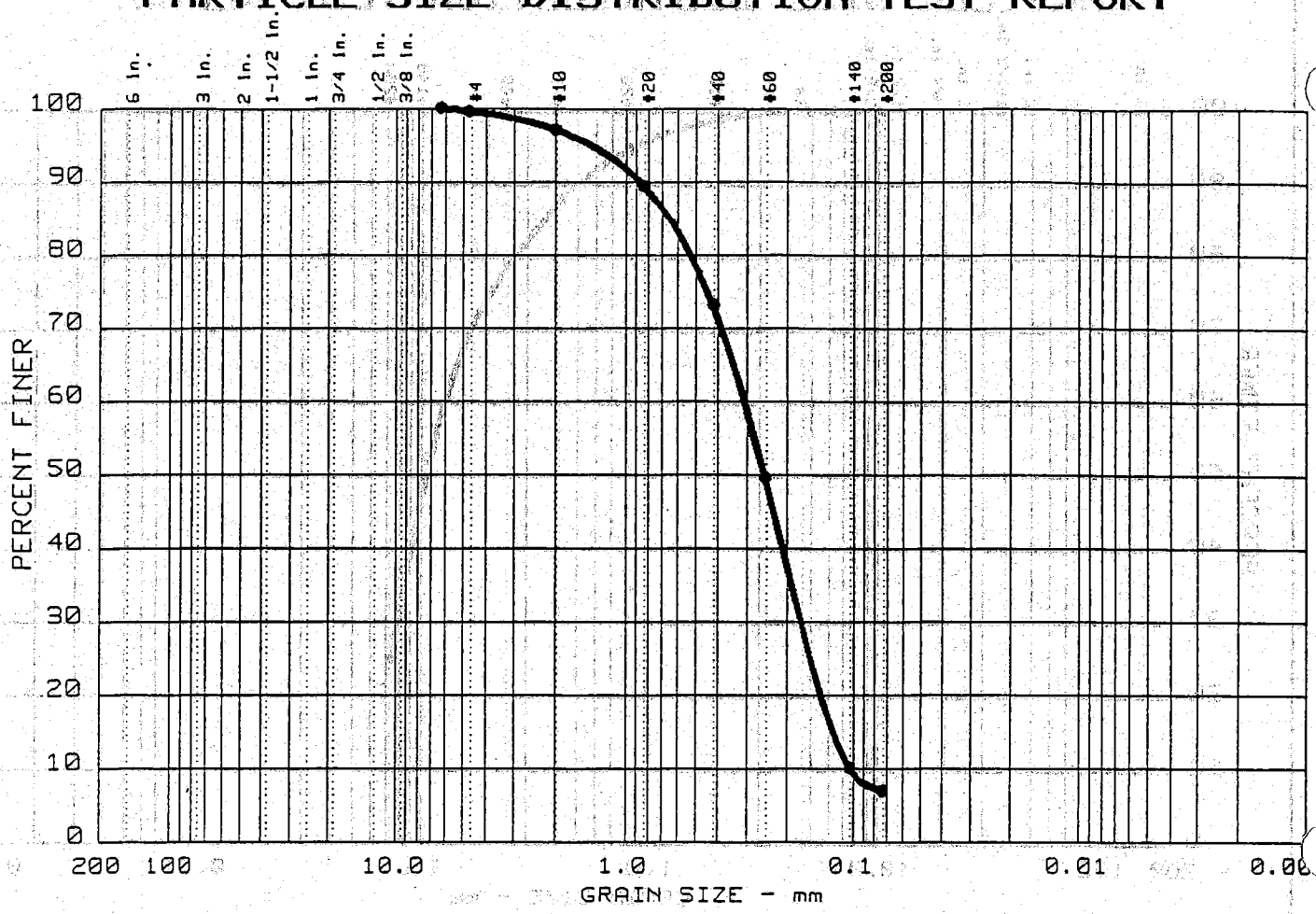
Remarks:
Sieve Analysis Only

ABB Environmental Services, Inc.

Project No.: 08520.82
Project: CECIL FIELD

Date: 6/8/95 Data Sheet No. ____

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	0.5	92.5	7.0		SP-SM		

SIEVE inches size	PERCENT FINER ●		
0.25	100.0		
	GRAIN SIZE		
D_{60}	0.31		
D_{30}	0.17		
D_{10}	0.10		
	COEFFICIENTS		
C_c	0.95		
C_u	3.0		

SIEVE number size	PERCENT FINER ●		
4	99.5		
10	97.0		
20	89.4		
40	73.1		
60	49.6		
140	10.1		
200	7.0		

Sample information:
● CEF-076-55I

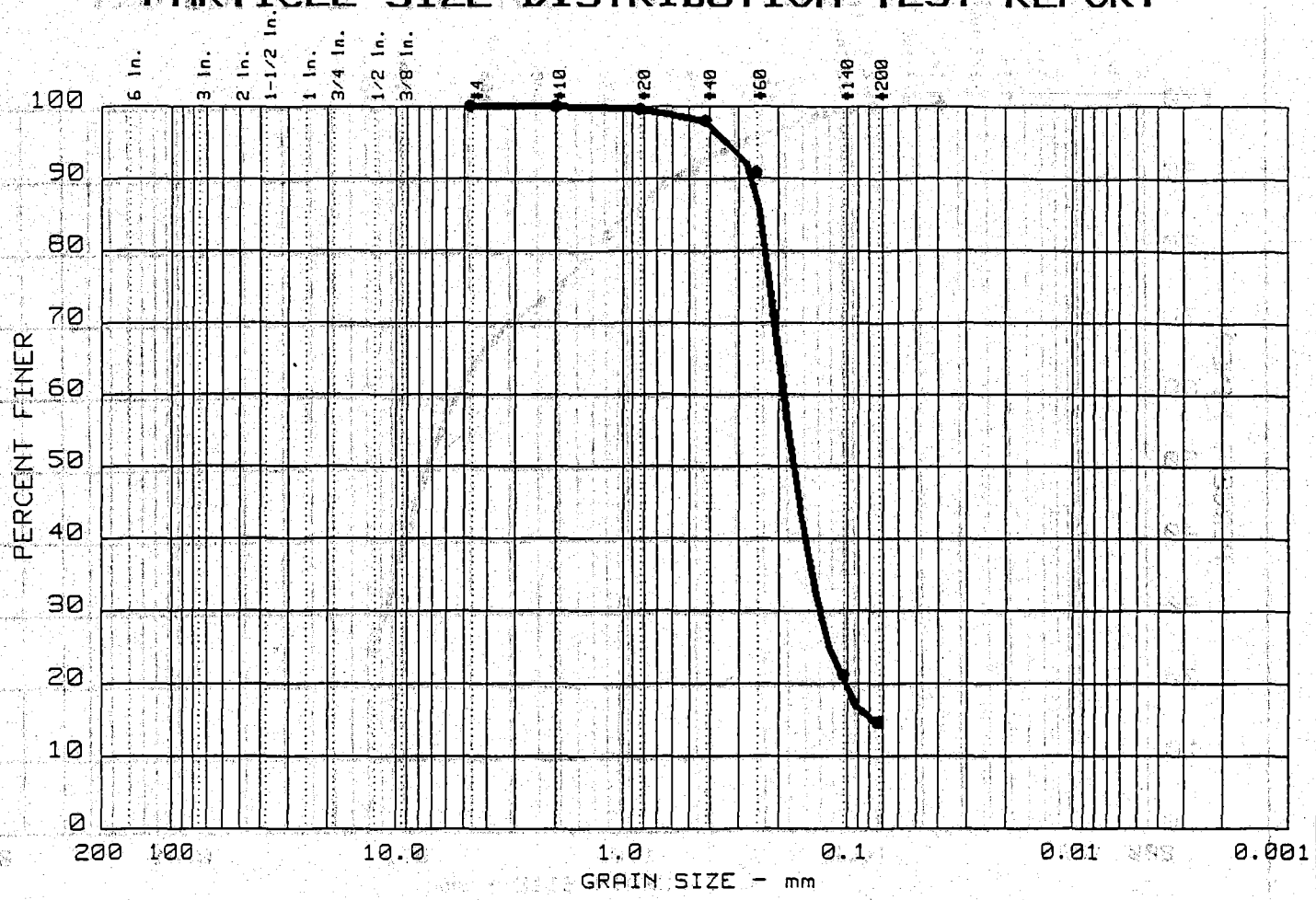
Remarks:
Sieve Analysis Only

ABB Environmental Services, Inc.

Project No.: 08520.82
Project: CECIL FIELD

Date: 6/8/95 Data Sheet No. ____

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	0.0	85.3	14.7		SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.19		
D_{30}	0.13		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	100.0		
10	100.0		
20	99.5		
40	97.9		
60	90.7		
140	21.2		
200	14.7		

Sample information:
● CEF-076-74D (0-50')

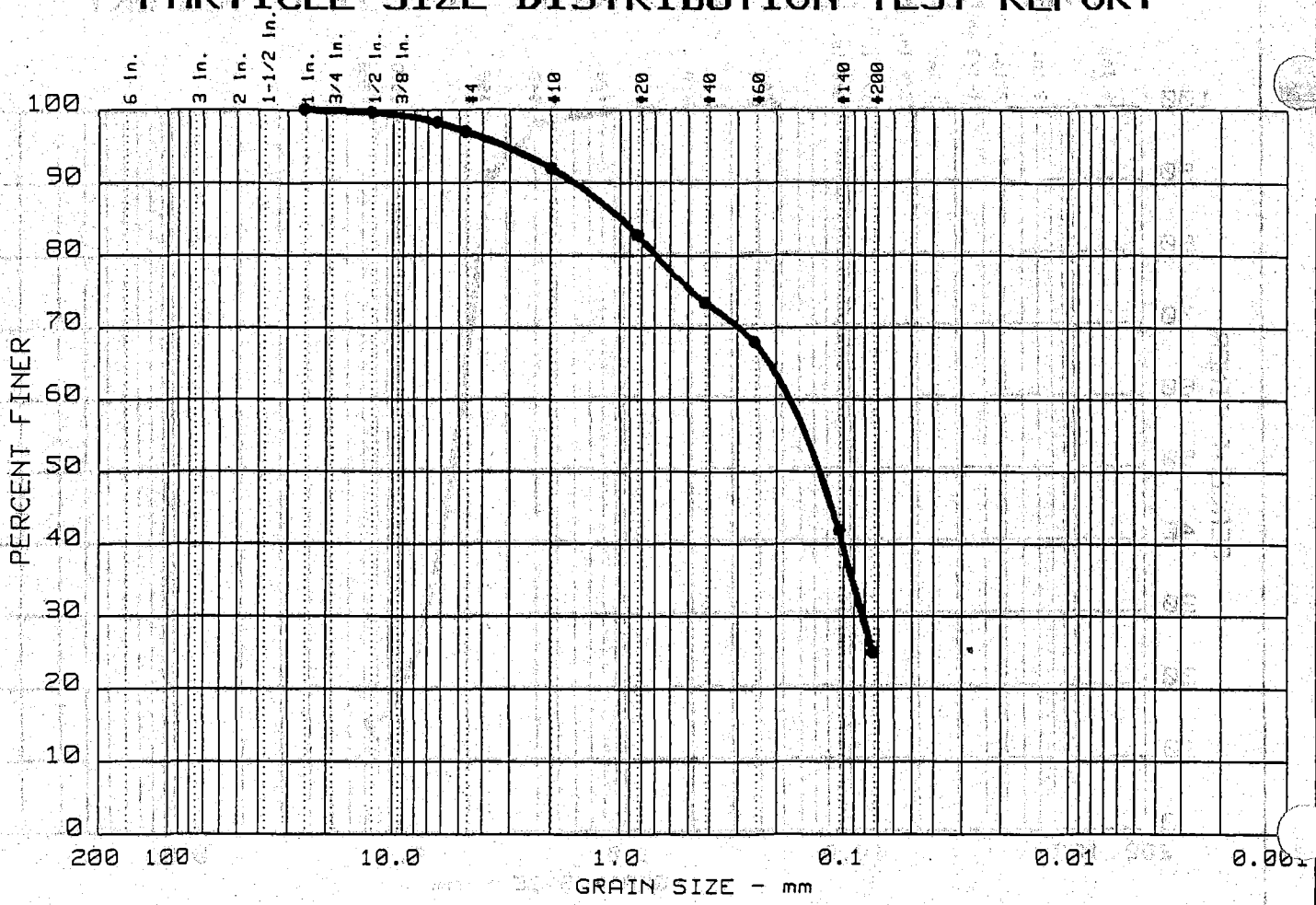
Remarks:
Sieve Analysis Only

ABB Environmental Services, Inc.

Project No.: 08520.82
Project: CECIL FIELD

Date: 6/8/95 Data Sheet No. ____

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	3.1	71.9	25.0		SM		

SIEVE inches size	PERCENT FINER ●		
1	100.0		
0.5	99.5		
0.25	98.2		
	GRAIN SIZE		
D_{60}	0.17		
D_{30}	0.08		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	96.9		
10	91.9		
20	82.8		
40	73.4		
60	68.0		
140	41.9		
200	25.0		

Sample information:
● CEF-076-51D (100-116')

Remarks:
Sieve Analysis Only

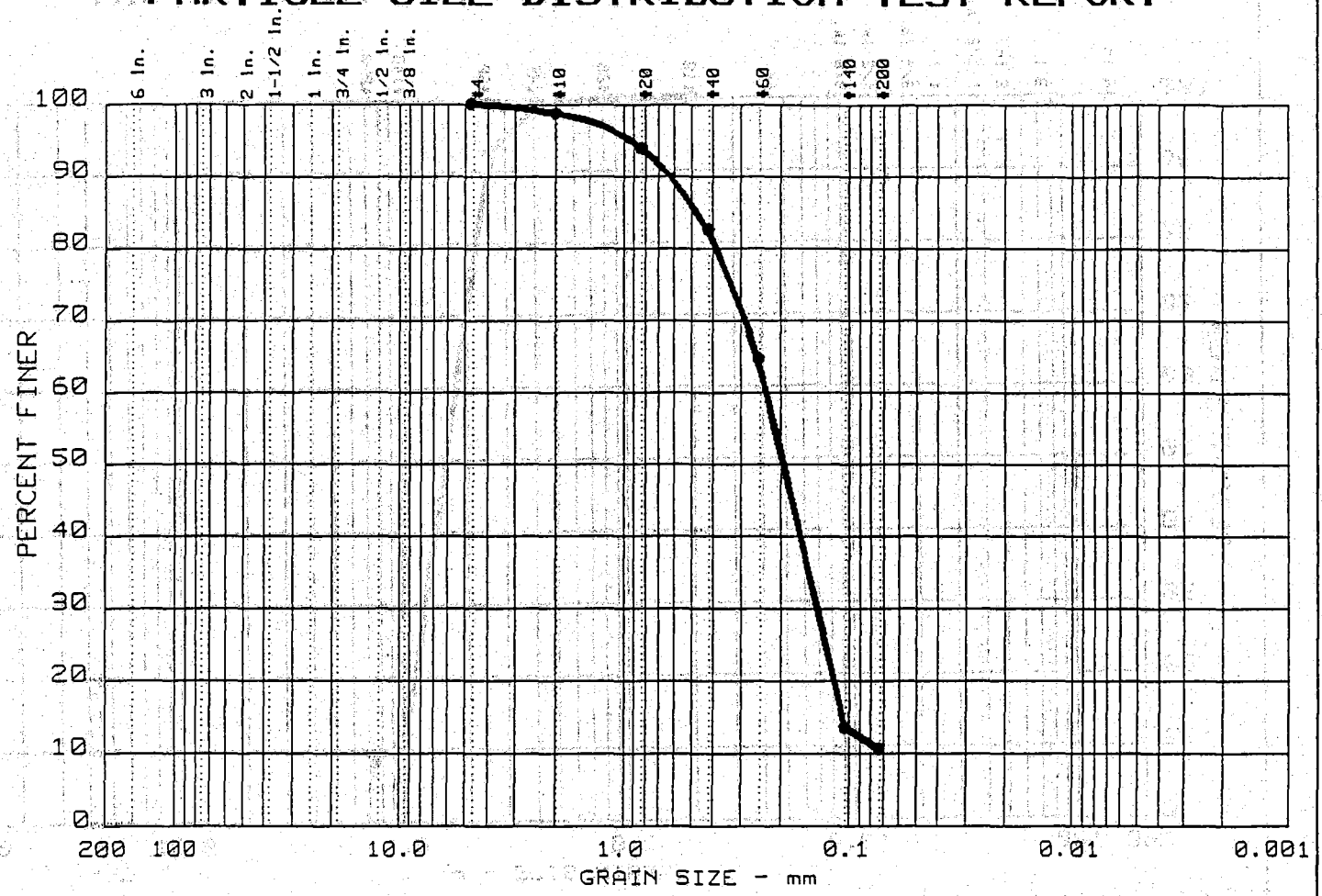
ABB Environmental Services, Inc.

Project No.: 08520.82
Project: CECIL FIELD

Date: 6/8/95

Data Sheet No. ——

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	0.0	89.3	10.7		SP-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.23		
D_{30}	0.14		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	100.0		
10	98.7		
20	93.9		
40	82.6		
60	64.7		
140	13.6		
200	10.7		

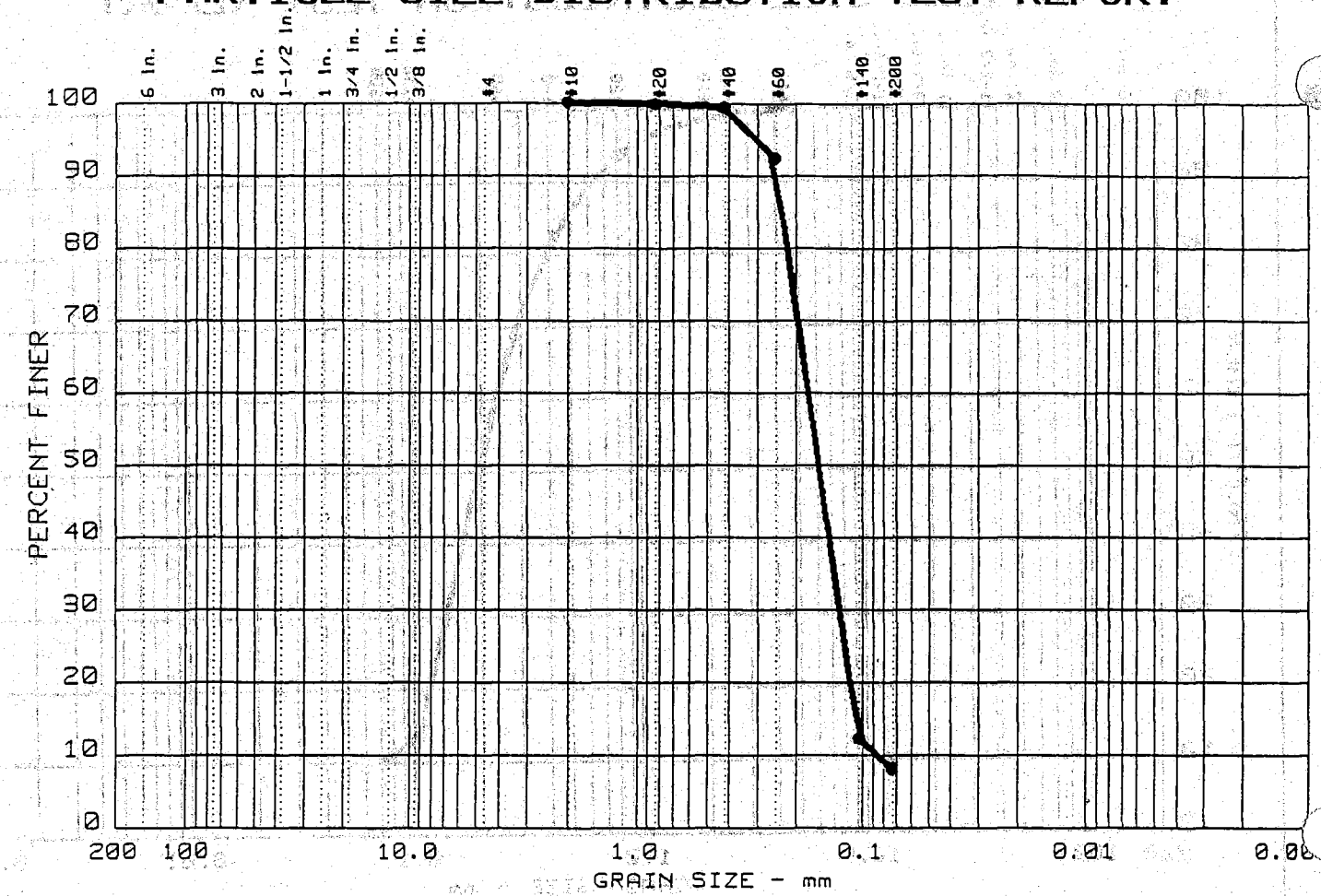
Sample information:
● CEF-076-S1D (55-99')

Remarks:
Sieve Analysis Only

ABB Environmental Services, Inc.

Project No.: 08520.82
Project: CECIL FIELD
Date: 6/8/95
Data Sheet No. ____

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	0.0	91.8	8.2		SP-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.18		
D_{30}	0.13		
D_{10}	0.08		
	COEFFICIENTS		
C_c	1.07		
C_u	2.1		

SIEVE number size	PERCENT FINER ●		
10	100.0		
20	100.0		
40	99.4		
60	92.4		
140	12.3		
200	8.2		

Sample information:
● CEF-076-51D (0-50')

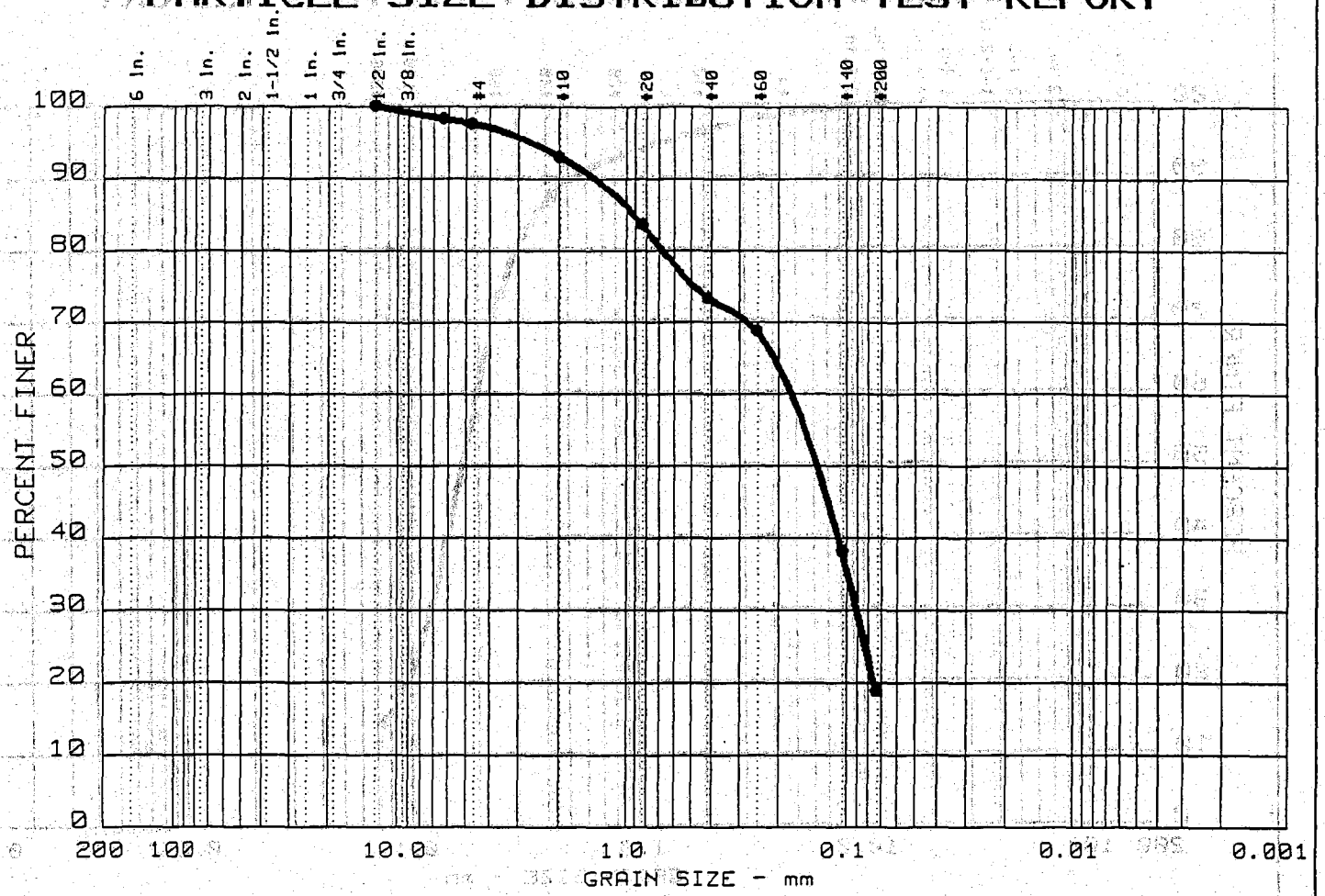
Remarks:
Sieve Analysis Only

ABB Environmental Services, Inc.

Project No.: 08520.82
Project: CECIL FIELD

Date: 6/8/95 Data Sheet No. ——

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	2.5	78.6	18.9		SM		

SIEVE inches size	PERCENT FINER ●		
0.5	100.0		
0.25	98.2		
	GRAIN SIZE		
D_{60}	0.17		
D_{30}	0.09		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	97.5		
10	93.0		
20	83.6		
40	73.3		
60	68.7		
140	38.2		
200	18.9		

Sample information:
● CEF-076-74D (100-116')

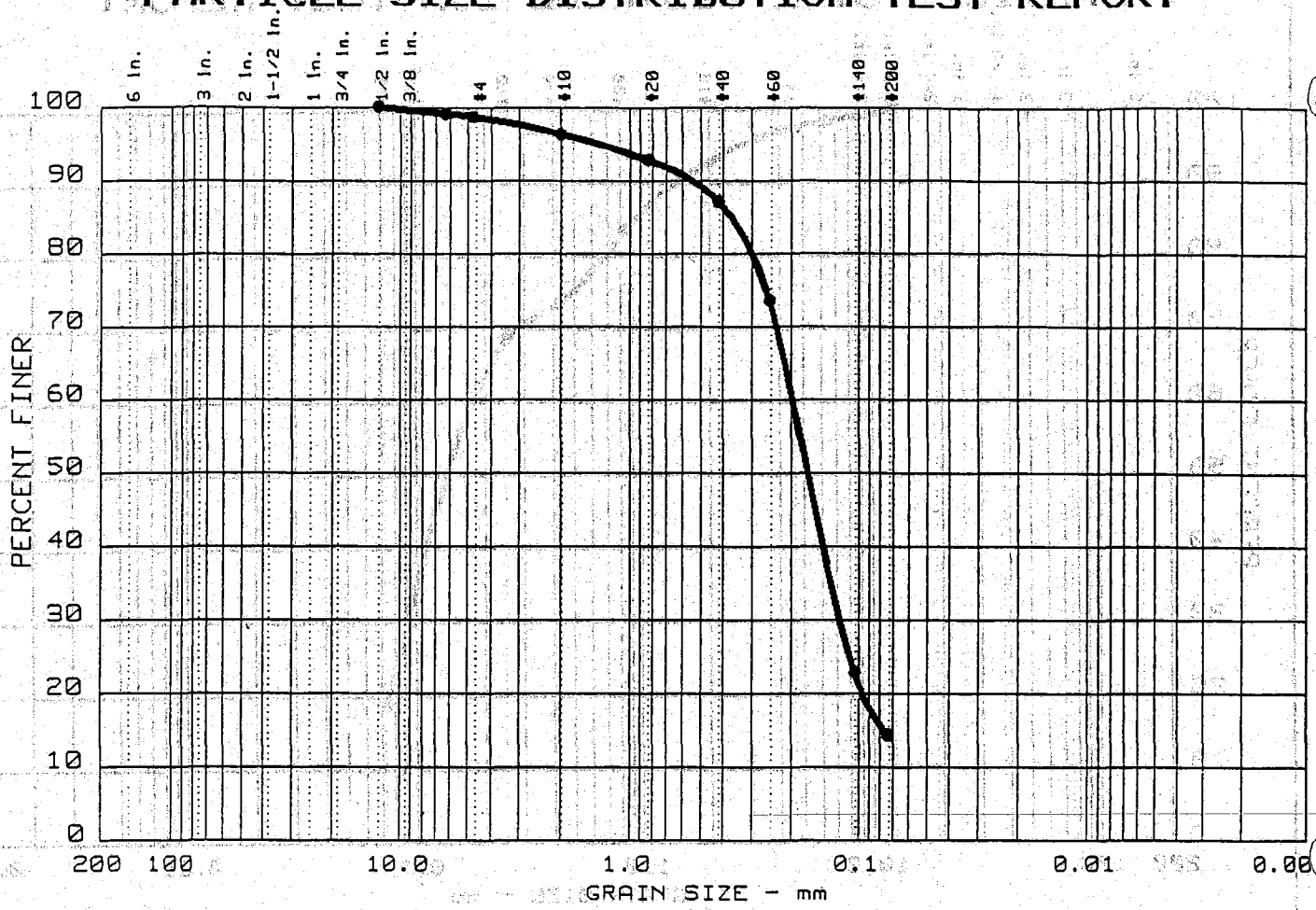
Remarks:
Sieve Analysis Only

ABB Environmental Services, Inc.

Project No.: 08520.82
Project: CECIL FIELD

Date: 6/8/95 Data Sheet No. ____

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	1.3	84.2	14.5		SM		

SIEVE inches size	PERCENT FINER ●		
0.5	100.0		
0.25	99.1		
	GRAIN SIZE		
D_{60}	0.20		
D_{30}	0.12		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	98.7		
10	96.3		
20	92.8		
40	87.0		
60	73.6		
140	22.9		
200	14.4		

Sample information:
● CEF-076-74D (55-99')

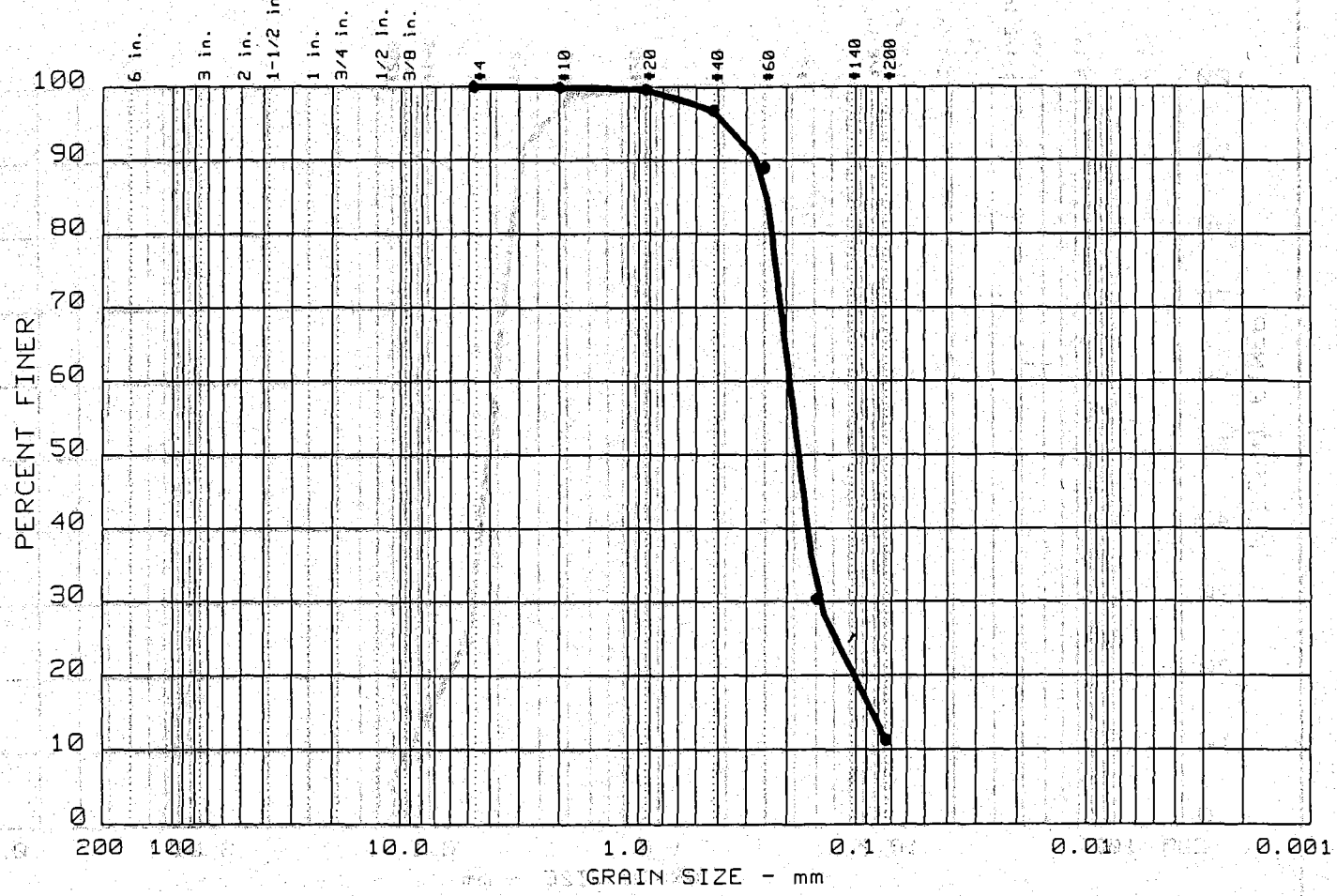
Remarks:
Sieve Analysis Only

ABB Environmental Services, Inc.

Project No.: 08520.82
Project: CECIL FIELD

Date: 6/8/95 Data Sheet No. ____

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	0.0	88.7	11.3		SP-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.19		
D_{30}	0.15		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	100.0		
10	100.0		
20	99.6		
40	96.8		
60	89.0		
100	30.3		
200	11.3		

Sample information:
● 76B07701
F SAND; Lttl Si;
Tr M and C Sa.

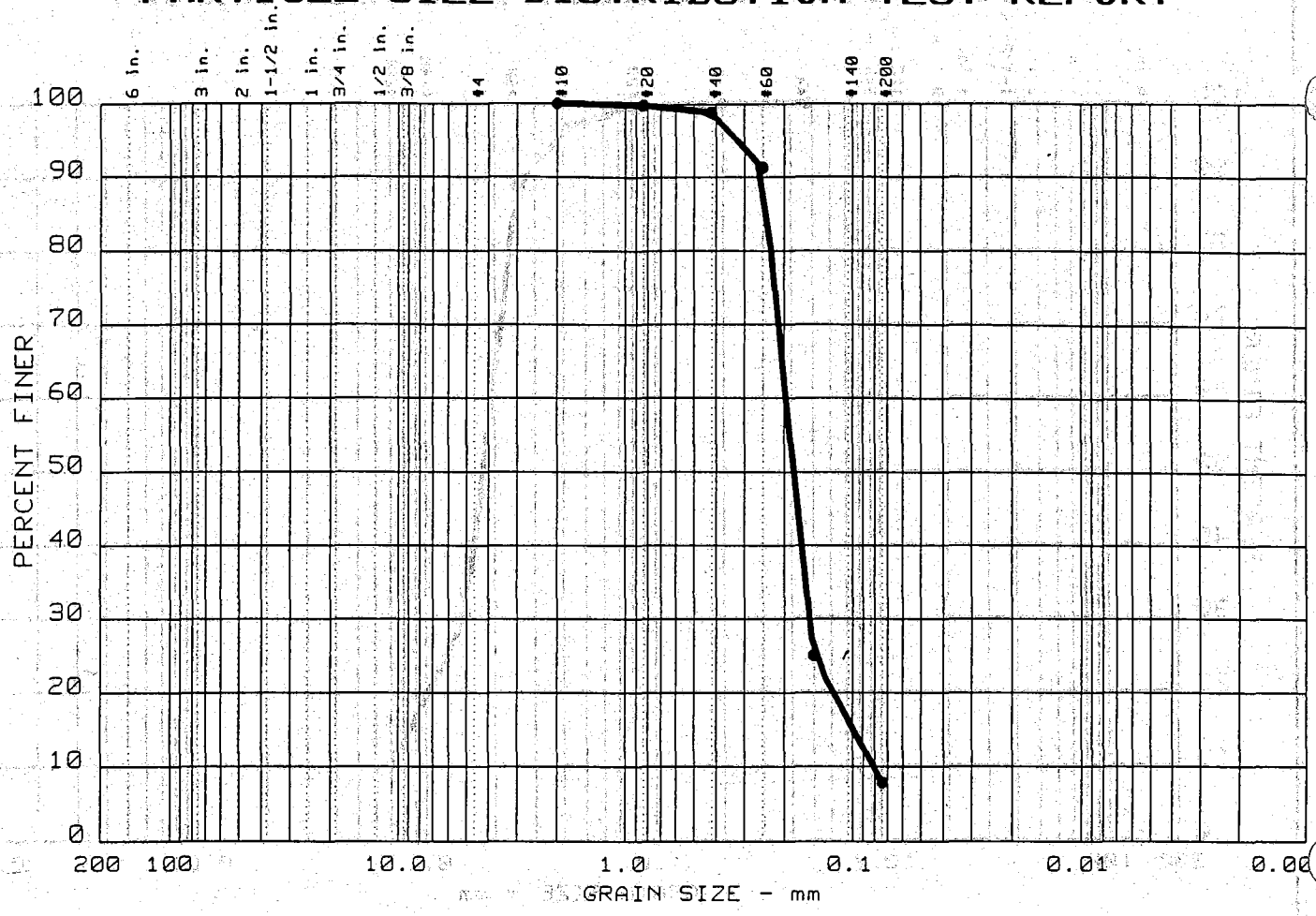
Remarks:
SIEVE ANALYSIS

ABB Environmental Services, Inc.

Project No.: 08520.92
Project: NAS CECIL FIELD NFF

Date: 10/10/96 Data Sheet No. 21

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	0.0	92.1	7.9		SP-SM		

SIEVE inches size	PERCENT FINER ●		
	GRAIN SIZE		
D_{60}	0.20		
D_{30}	0.15		
D_{10}	0.08		
	COEFFICIENTS		
C_c	1.52		
C_u	2.4		

SIEVE number size	PERCENT FINER ●		
10	100.0		
20	99.9		
40	98.9		
60	91.3		
100	25.1		
200	7.9		

Sample information:
● 76B07702
F SAND; Tr Si and M Sa.

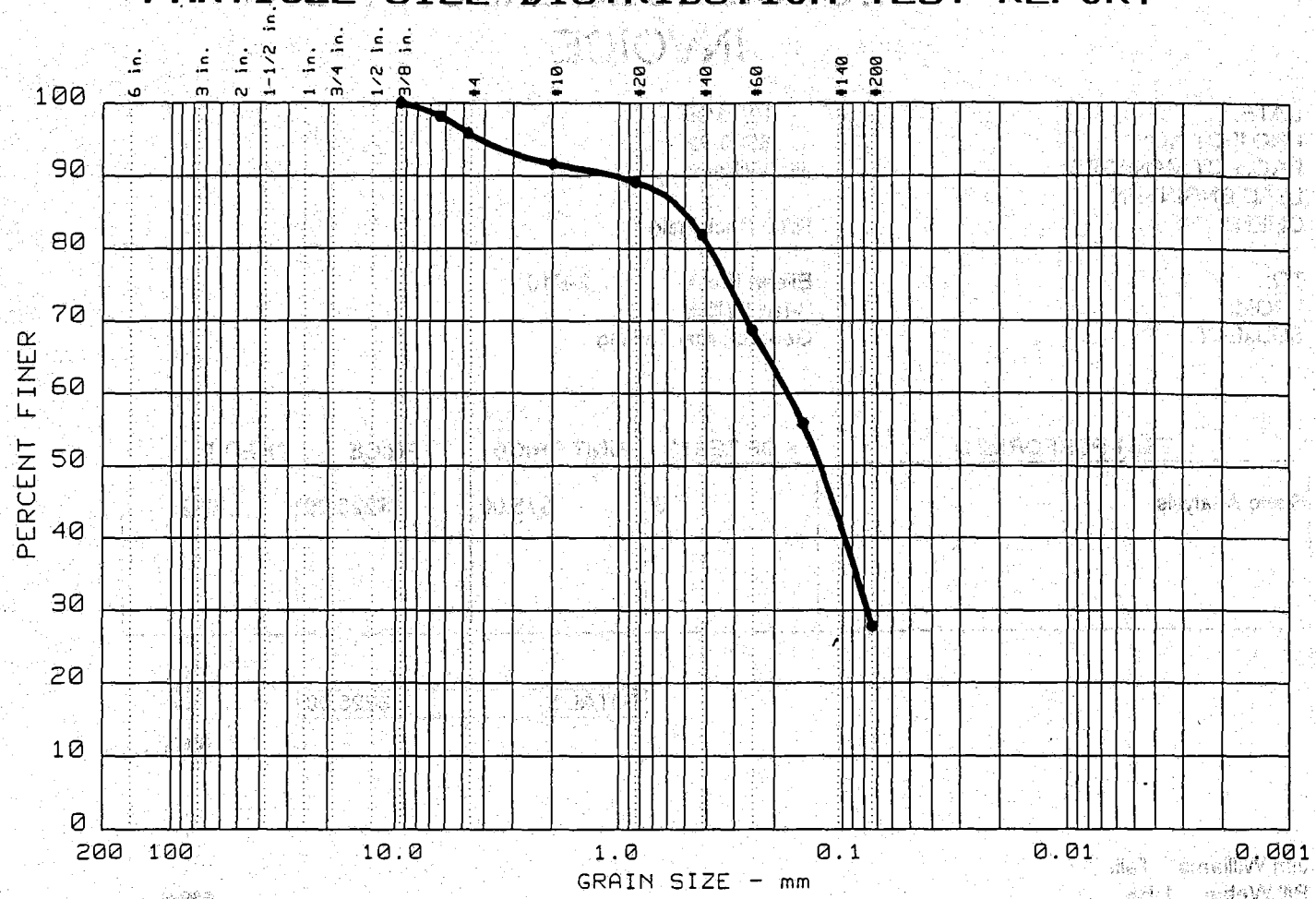
Remarks:
SIEVE ANALYSIS

ABB Environmental Services, Inc.

Project No.: 08520.92
Project: NAS CECIL FIELD NFF

Date: 10/10/96 Data Sheet No. 21

PARTICLE SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	4.2	67.9	27.9		SM		

SIEVE Inches size	PERCENT FINER ●		
0.375	100.0		
0.25	98.1		
	GRAIN SIZE		
D_{60}	0.17		
D_{30}	0.08		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	95.8		
10	91.6		
20	89.2		
40	81.9		
60	68.8		
100	55.9		
200	27.9		

Sample information:

● 76B07703
F SAND; Sm Si; Tr M and C Sa and F Gvl.

Remarks:
SIEVE ANALYSIS
The gravel and coarse sand fraction is mostly crushed white shells.

ABB Environmental Services, Inc.

Project No.: 08520.92
Project: NAS CECIL FIELD NFF

Date: 10/10/96 Data Sheet No. 21

GEOSCIENCES LABORATORY
INVOICE

DATE: 10/18/96
PROJECT NO: 8520-92
PROJECT MANAGER: Jim Williams
LEAD ENGINEER
CLIENT: NAS Cecil Field

TO: Eileen Frost 2-E10
FROM: Brian Sellick
SUBJECT: Geotechnical Testing

TEST PERFORMED	# OF TESTS	UNIT PRICE	PRICE	CREDIT
Sieve Analysis	3	$75.00	$225.00	L-662

TOTAL $ $225.00

Jim Williams Tall.
Bill Weber 1-B8

ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY
BACTERIA ANALYSIS
ANALYSIS REPORT

Project: Cecil Field
Project Number: 08516-40
Date of Analysis: 3/14/94
Date Reported: 3/30/94

Sample ID	Date Sampled	Total Bacteria (CFU/ml)	Hydrocarbon Bacteria (CFU/ml)
CEF-JP5-12	2/28/94	9.0×10^4	9.0×10^3

BACTERIA.FRM/1

ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY
BACTERIA ANALYSIS
ANALYSIS REPORT

Project: Cecil Field
Project Number: 08516-40
Date of Analysis: 3/16/94
Date Reported: 3/30/94

Sample ID	Date Sampled	Total Bacteria (CFU/ml)	Hydrocarbon Bacteria (CFU/ml)
CEF-076-31	3/1/94	8.7×10^5	1.7×10^5

BACTERIA.FRM/1

ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY
BACTERIA ANALYSIS
ANALYSIS REPORT

Project: Cecil Field
Project Number: 08516-40
Date of Analysis: 3/22/94
Date Reported: 3/30/94

Sample ID	Date Sampled	Total Bacteria (CFU/g)	Hydrocarbon Bacteria (CFU/g)
CEF-JP5-125	3/14/94	5.7×10^5	5.3×10^4
CEF-372-135	3/14/94	4.0×10^6	4.7×10^5
CEF-076-315	3/14/94	3.0×10^5	3.3×10^4

BACTERIA.FRM/1

ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY
BACTERIA ANALYSIS
ANALYSIS REPORT

Project: Cecil Field
Project Number: 08516-40
Date of Analysis: 3/22/94
Date Reported: 3/30/94

Sample ID	Date Sampled	Total Bacteria (CFU/g)	Hydrocarbon Bacteria (CFU/g)
CEF-JP5-125	3/14/94	5.7×10^5	5.3×10^4
CEF-372-135	3/14/94	4.0×10^6	4.7×10^5
CEF-076-315	3/14/94	3.0×10^5	3.3×10^4

BACTERIA.FRM/1

ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY
BACTERIA ANALYSIS FOR WATER AND SOIL SAMPLES
ANALYSIS REPORT

Project: NAS Cecil Field Site 8
Project Number: 8520.22
Date of Analysis: 04/27/95
Date Reported: 05/12/95

Carbon source used for specific degraders: Disel Fuel

Sample ID	Date Sampled	Matrix	Total Bacteria (CFU/ml,g)	Hydrocarbon Bacteria (CFU/ml,g)
CF8FS1	04/26/95	Soil	7.0×10^4	3.3×10^4
CF8MW10S	04/26/95	Water	3.2×10^4	4.0×10^3

ABB

ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY
BACTERIA ANALYSIS - SOIL
ANALYSIS REPORT

Project: NAS Cecil Field
Project Number: 08520.82
Date of Analysis: 5/31/95
Date Reported: 6/23/95
Work Order No.: 95-05-009

Sample ID	Date Sampled	Total Bacteria (CFU/g)	Hydrocarbon Bacteria (CFU/g)
CEF-076-55I 60-90'	5/22/95	2.3×10^3	1.3×10^3
CEF-076-51D (HP-9) 100-110'	5/26/95	5.7×10^4	2.3×10^4

ABB Environmental Services, Inc.

Corporate Place 128
107 Audubon Road
Wakefield, MA 01880

Telephone
(617) 245-6606

Fax
(617) 246-5060

ABB

ABB Environmental Services, Inc.
Treatability Laboratory
Bacteria Analysis - Soil
Analysis Report

Project: NAS Cecil Field
Project Number: 08520.82
Date of Analysis: 5/31/95
Date Reported: 6/23/95
Work Order No.: 95-06-001

Sample ID	Date Sampled	Total Bacteria (CFU/g)	Hydrocarbon Bacteria (CFU/g)
CEF-076-59D (HP-1) 30-45'	6/8/95	5.7×10^6	1.3×10^6
CEF-076-59D (HP-1) 60-90'	6/8/95	2.3×10^6	1.3×10^6

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Fax
(617) 246-5060

ABB

ABB Environmental Services, Inc.
Treatability Laboratory
Bacteria Analysis - Soil
Analysis Report

Project: NAS Cecil Field
Project Number: 08520.82
Date of Analysis: 6/16/95
Date Reported: 7/7/95
Work Order No.: 95-06-012

Sample ID	Date Sampled	Total Bacteria (CFU/g)	Hydrocarbon Bacteria (CFU/g)
CEF-076-67I 25-55'	6/8/95	7.7×10^4	4.0×10^3
CEF-076-67I 60-90'	6/8/95	5.8×10^4	9.7×10^3

BACTERIA.FRM/1

ABB Environmental Services, Inc.

Corporate Place 128
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Wakefield, MA 01880

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(617) 246-5060

ABB

ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY
BACTERIA ANALYSIS - SOIL
ANALYSIS REPORT

Project: NAS Cecil Field
Project Number: 08520.82
Date of Analysis: 8/30/95

Sample ID	Date Sampled	Total Bacteria (CFU/g)	Hydrocarbon Bacteria (CFU/g)
CEF-076-70I	8/7/95	2.3×10^4	130
CEF-076-71D	8/7/95	3.0×10^5	2.7×10^4
CEF-076-69S	8/7/95	3.0×10^4	2.0×10^3

ABB Environmental Services Inc.

Corporate Place 128
107 Audubon Road
Wakefield, MA 01880

Telephone (617) 245-6606
Fax (617) 246-5060

ABB Environmental Services
Treatability Laboratory
Bacteria Analysis Report

Project: NAS Cecil Field
Site: North Fuel Farm

Sample ID	Matrix	Date Sampled	Total Bacteria CFU/g or ml	Hydrocarbon Bacteria CFU/g or ml
CEF-076-59D(30'-45')	Soil	5/31/95	570×10^4	130×10^4
CEF-076-59D(60'-90')	Soil	5/31/95	230×10^4	130×10^4
CEF-076-67I(25'-55')	Soil	6/8/95	7.7×10^4	0.4×10^4
CEF-076-67I(60'-90')	Soil	6/8/95	5.8×10^4	1.0×10^4
CEF-076-71D(100'-110')	Soil	6/19/96	47×10^4	0.8×10^4
CEF-076-70I	Aqueous	8/7/95	2.3×10^4	0.01×10^4
CEF-076-71D	Aqueous	8/7/95	30×10^4	2.7×10^4
CEF-076-69S	Aqueous	8/7/95	3.0×10^4	0.2×10^4

ABB

To: Jim Williams

From: Brian Sellick

Date: October 18, 1996

Subject: Report of Geotechnical Testing Results
Site: NAS Cecil Field

On October 04, 1996 testing was assigned for soil samples collected at the subject site. All testing was done in the ABB-ES Wakefield Laboratory.

A total of 3 sieve analyses were completed in accordance with ASTM D 422. The curves were primarily fine sands. The gradation curves are attached.

If you have any questions please, do not hesitate to contact either myself at (617) 245-6606, or Brian Johnson at (207) 828-3413.

ABB Environmental Services Inc.

107 Audubon Road
Wakefield, MA 01880

Telephone (617) 245-6606
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ABB Environmental Services
Treatability Laboratory
Bacteria Analysis Report

Site: NAS Cecil Field, North Fuel Farm
Project No.: 8520.52

Sample ID	Matrix	Date Sampled	Date Analyzed	Total Bacteria CFU/g	Petroleum Bacteria CFU/g
76B07701	Soil	10/1/96	10/8/96	1.1×10^4	6.7×10^2
76B07702	Soil	10/1/96	10/8/96	4.3×10^4	5.0×10^3
76B07703	Soil	10/3/96	10/8/96	1.5×10^5	6.7×10^4

CFU = Colony Forming Units

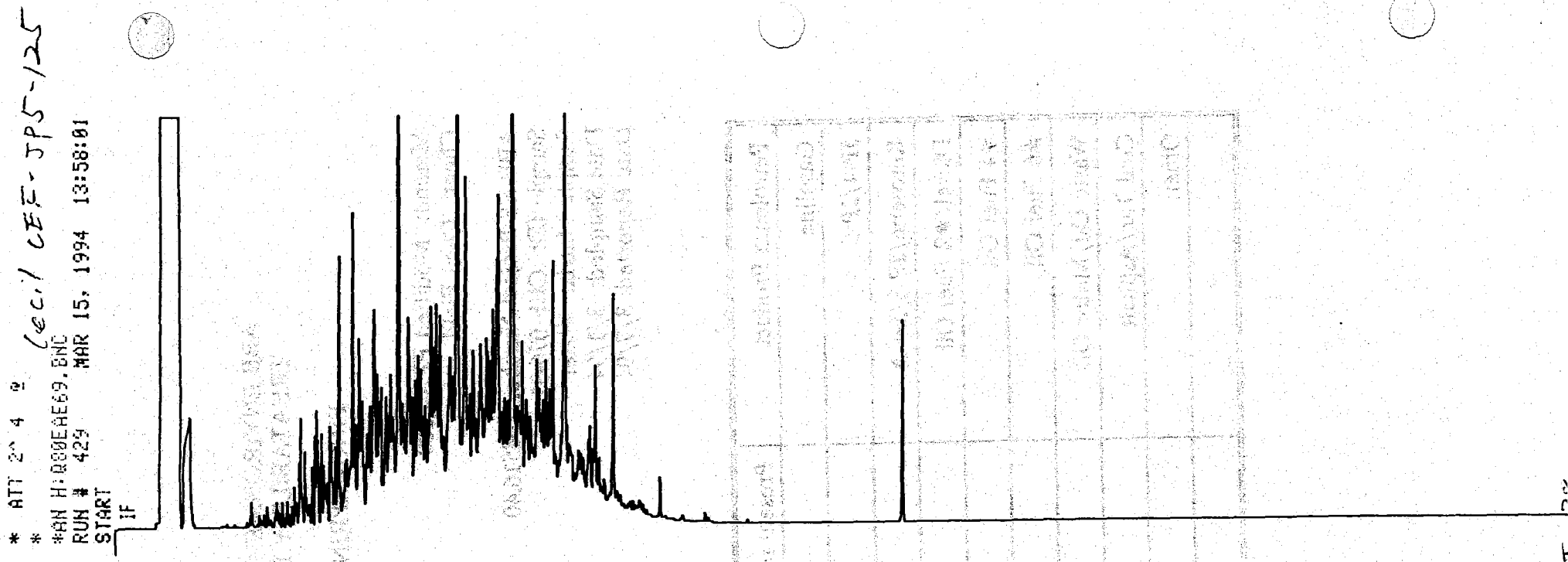
ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY

FINGERPRINT ANALYSIS REPORT

Method: Modified EPA 8100
Client: Cecil Field

ABB-ES Project Number: 08516.40
Sample ID: CEF-076-31
Sample Matrix: Water
Date Sampled: 3/1/94
Date Reported: 3/7/94

Petroleum Product	Present in Sample	Evidence of Weathering
Gasoline		
JP-4/JP-5		
Kerosene/JP-8/Jet A	X	
Diesel/#2 Fuel Oil		
#4 Fuel Oil		
#6 Fuel Oil		
Waste Oil/Motor Oil		
Coal Tar/Asphalt		
Other:		



(ec:/

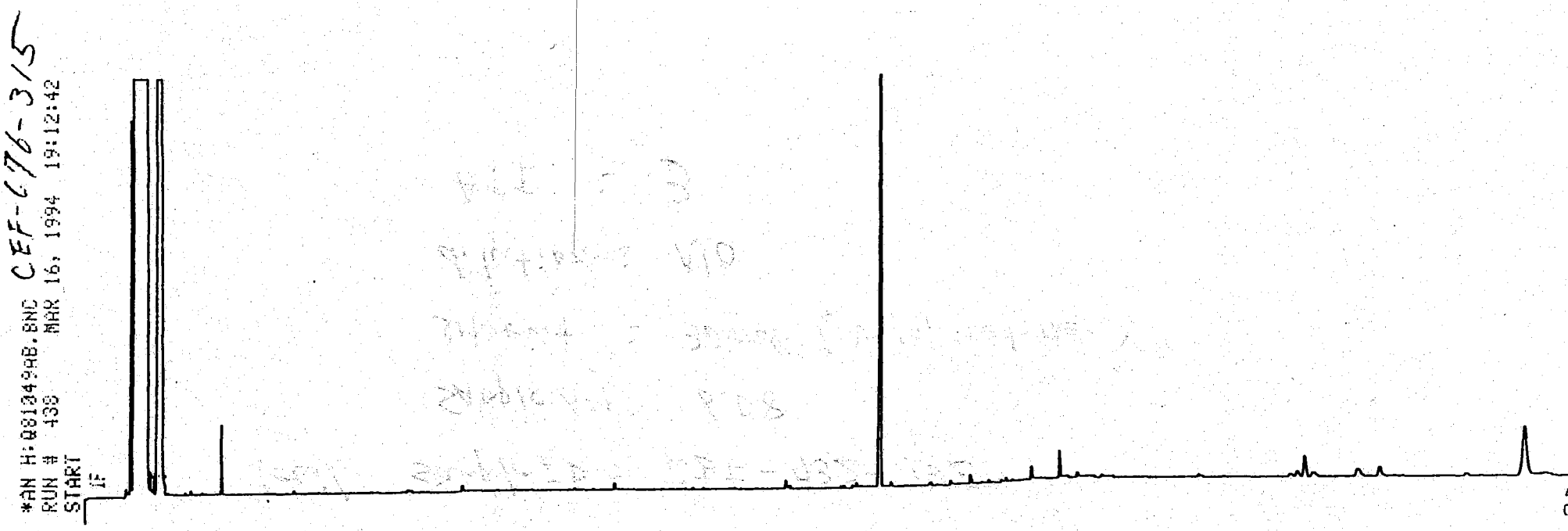
SampleID CEF-JP5-125

Suple AM. 6.08

solvent : 30ml (DCM/Acetone)

Dilution : NO

ATT = 4



(ecil sampleID. CEF-076-315

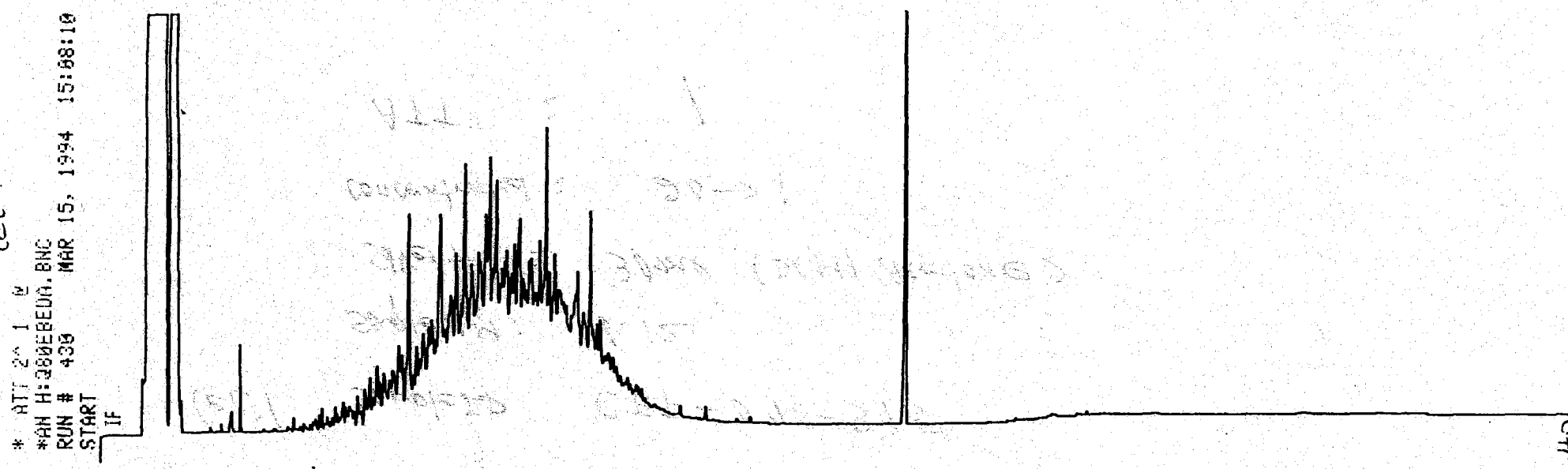
sapleAM: 6.12

Solvent : 30ml (DCM/ Acetone)

concentrated : 20 → 1

ATT : 1

Cecil CEF-732-135



lecil sample ID : CEF-732-135

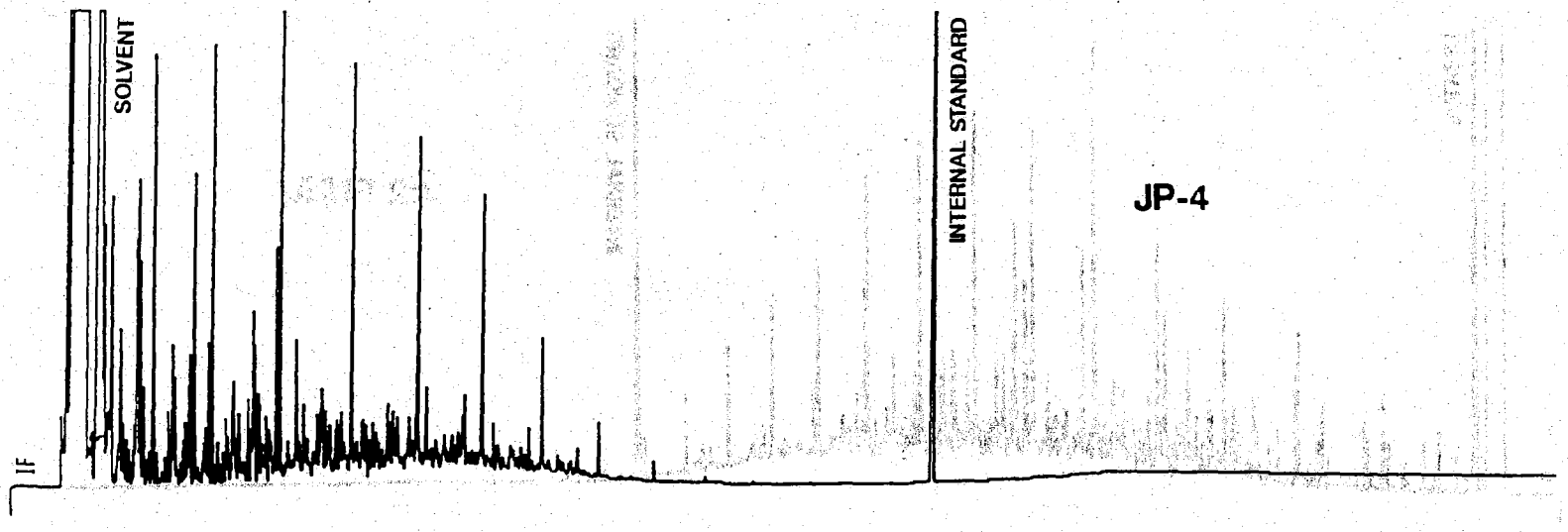
Sample AM : 6.08

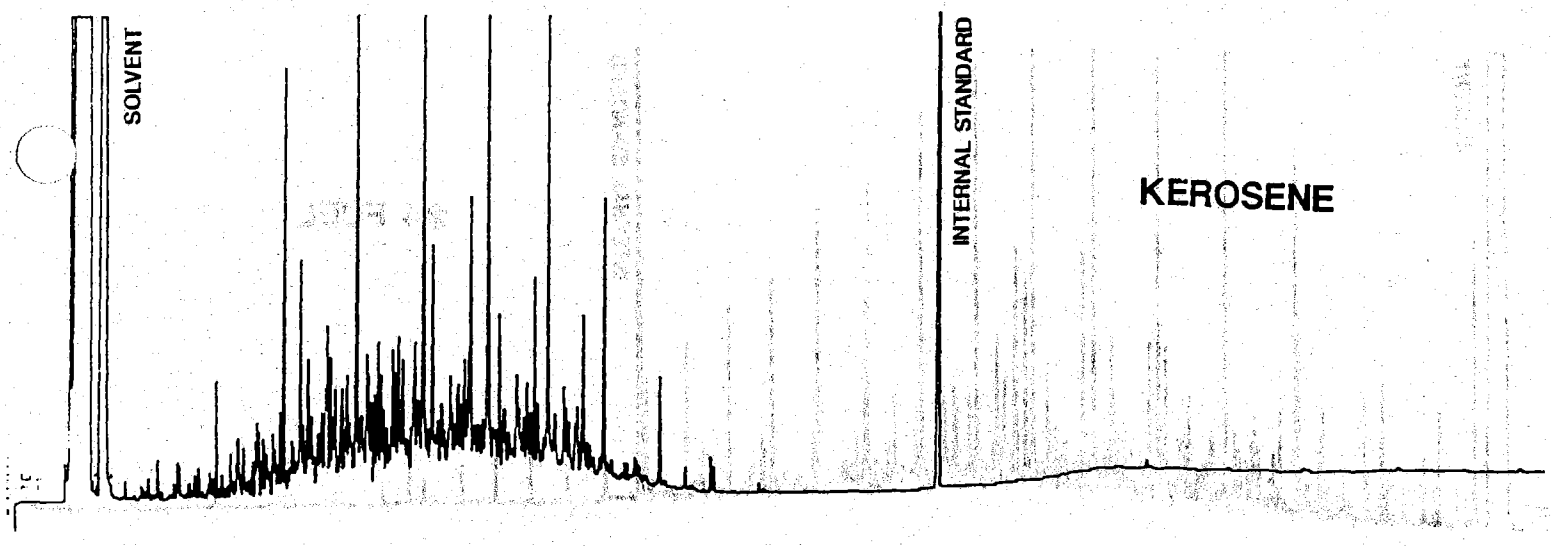
solvent : 30ml (DCM/Aletone)

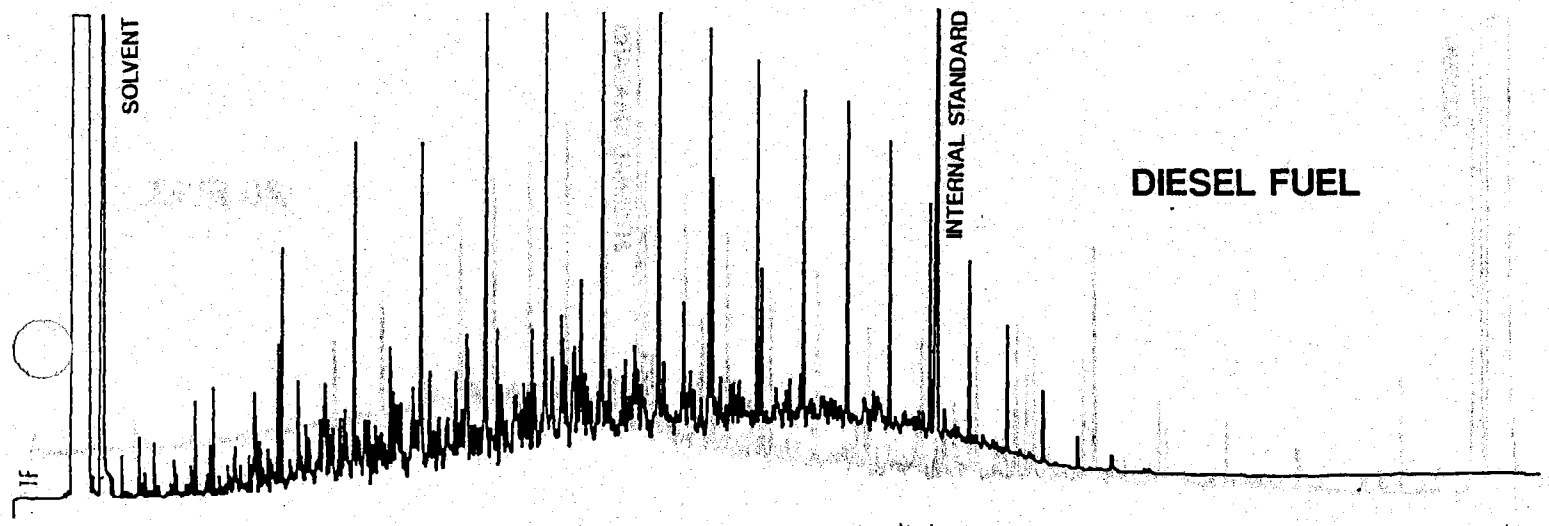
dilution : NO

ATT : 3

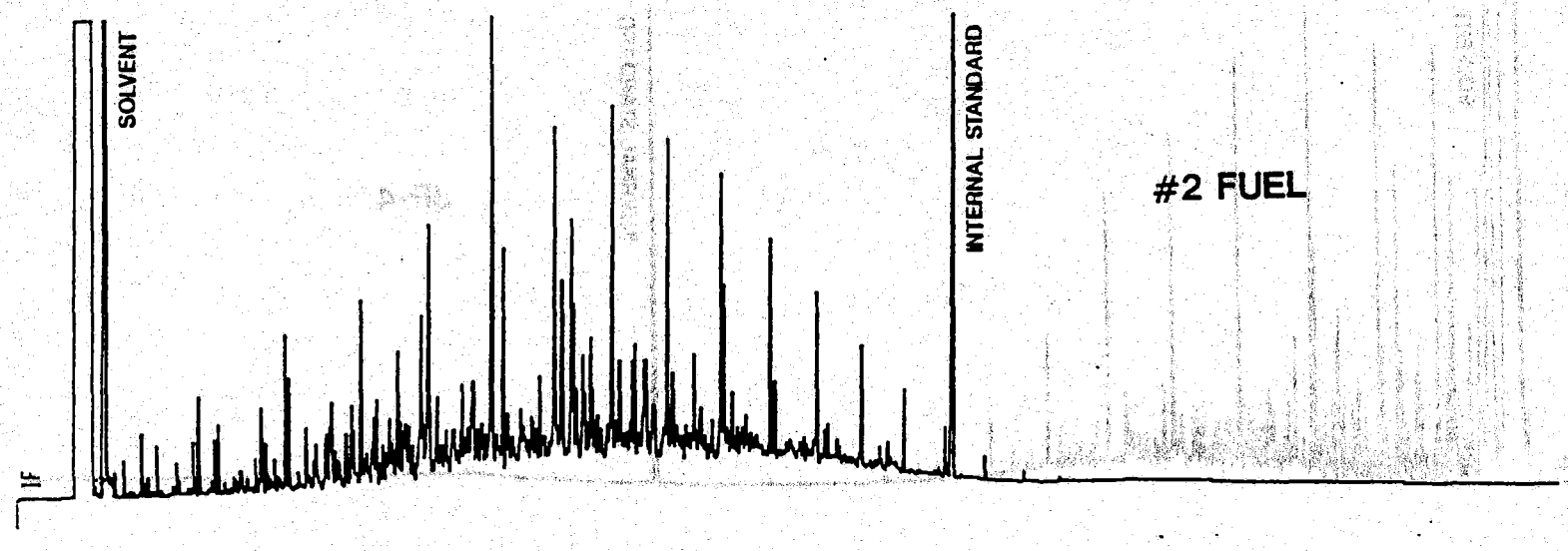
PETROLEUM FINGERPRINT
MODIFIED 3550/8100
Project: Cecil Field

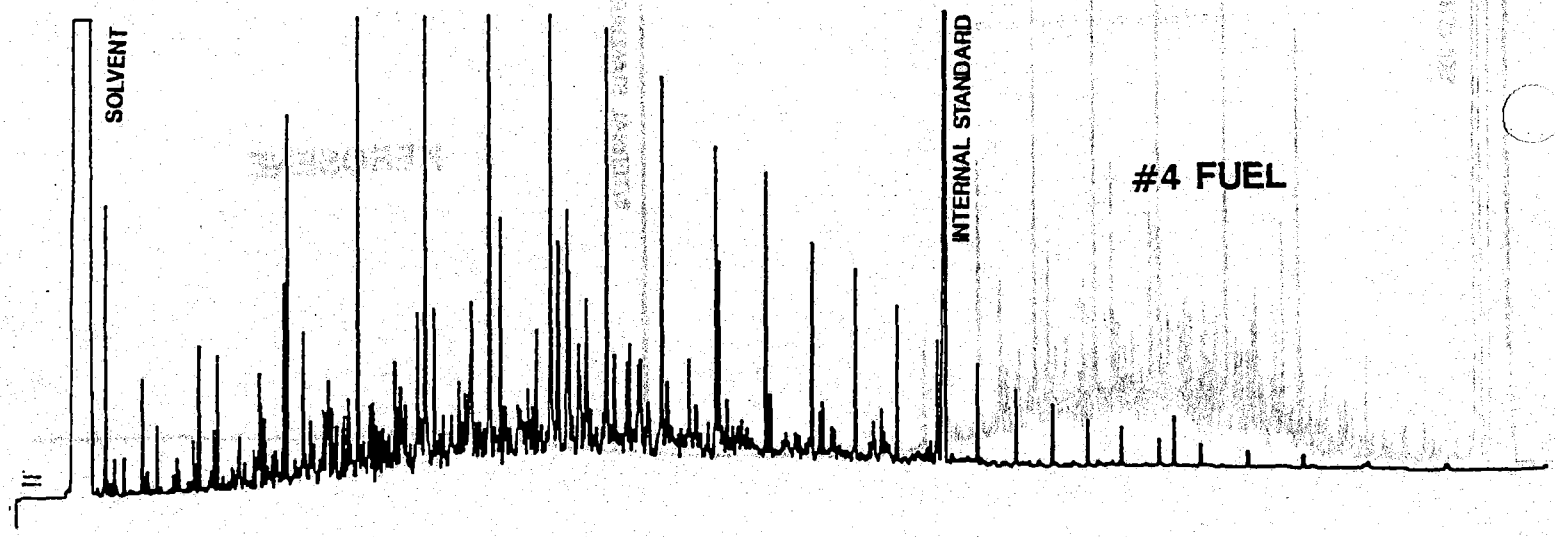






PETROLEUM FINGERPRINT
MODIFIED 3550/8100
Project: Cecil Field





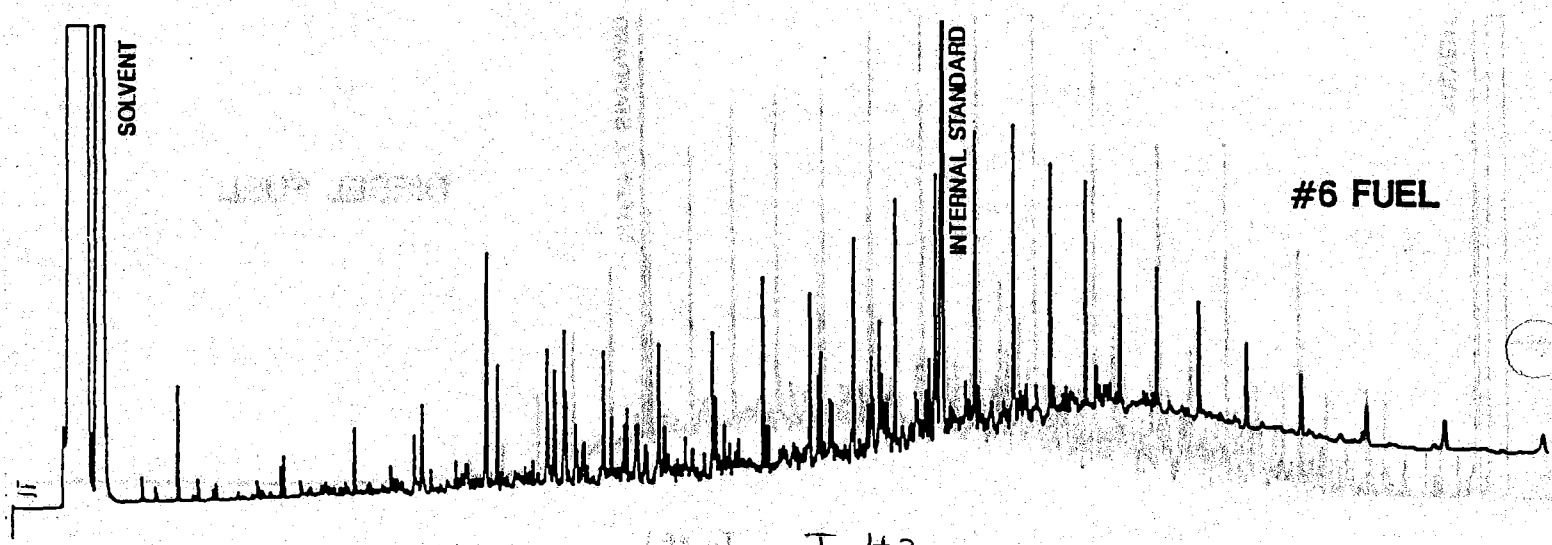


ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY

FINGERPRINT ANALYSIS REPORT

Method: Modified EPA 8100
Client: Cecil Field

ABB-ES Project Number: 08516-40
Sample ID: CEF-076-315
Sample Matrix: soil
Date Sampled: 3/14/94
Date Reported: 3/28/94

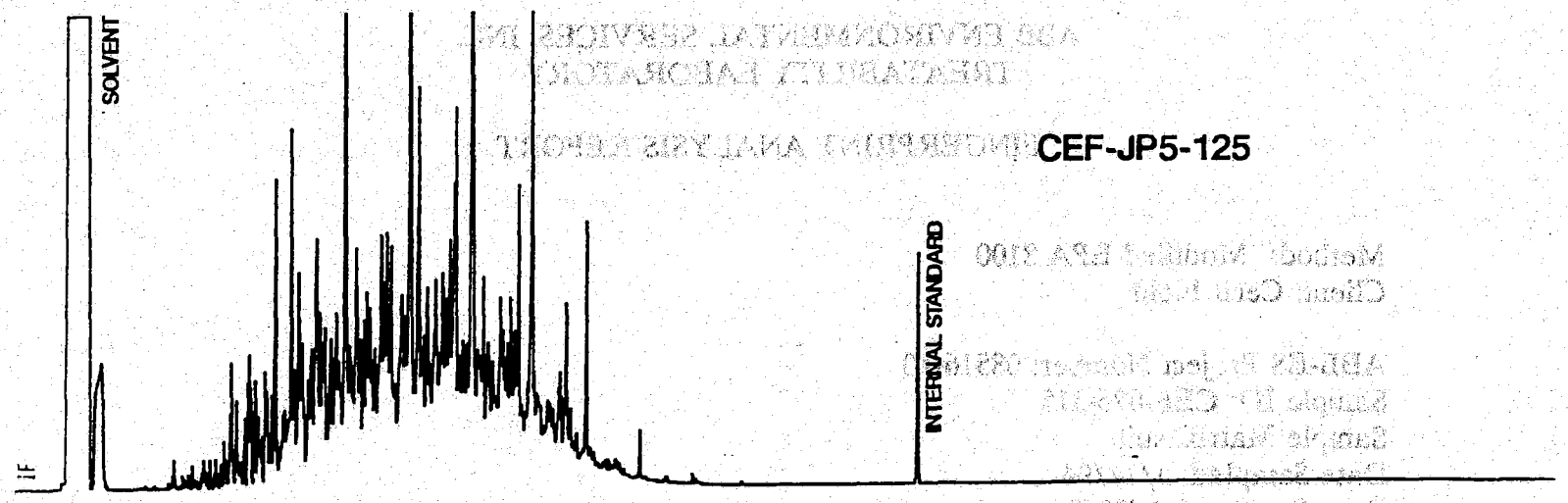
Petroleum Product	Present in Sample	Evidence of Weathering
Gasoline		
JP-4		
Kerosene/JP-8		
Diesel/#2 Fuel Oil		
#4 Fuel Oil		
#6 Fuel Oil		
Waste Oil/Motor Oil		
Coal Tar/Asphalt		
Other:		

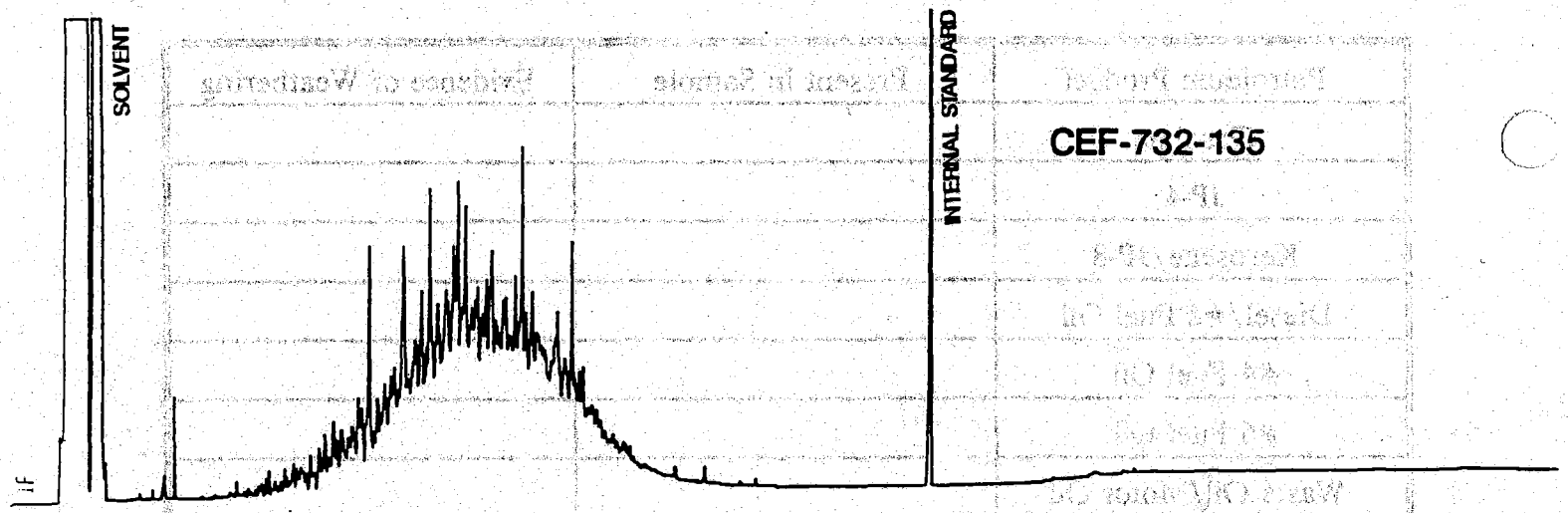
No evidence of petroleum observed.

PETROLEUM FINGERPRINT

MODIFIED 3550/8100

Project: Cecil Field





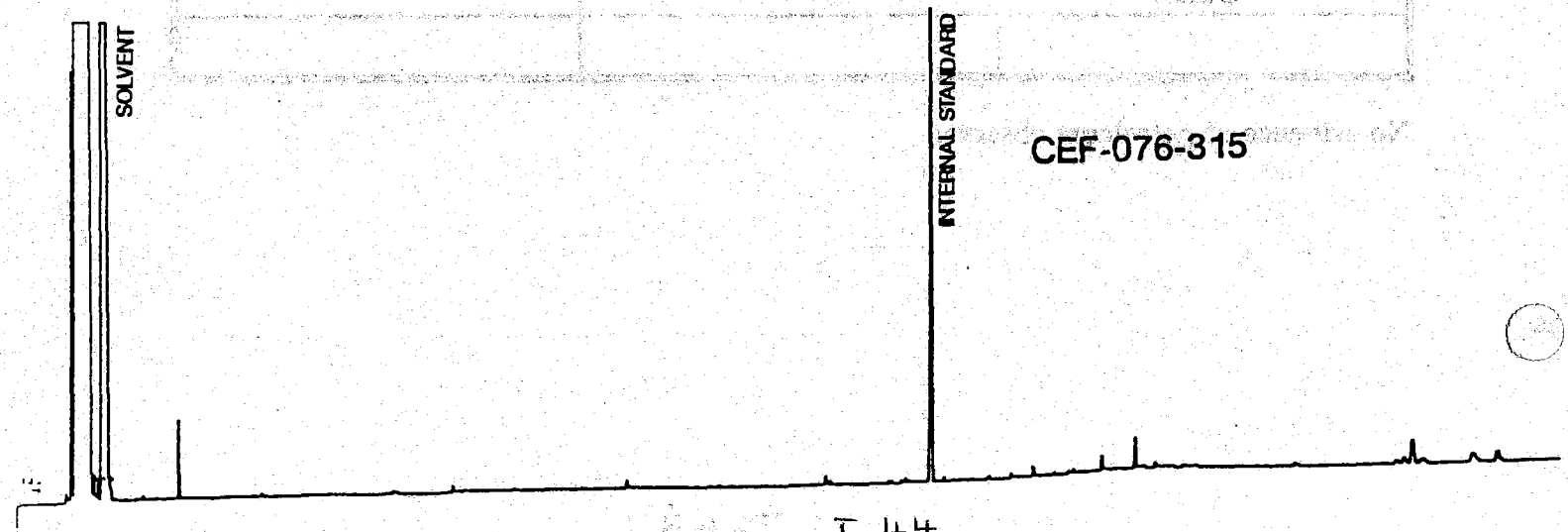


ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY

FINGERPRINT ANALYSIS REPORT

Method: Modified EPA 8100
Client: Cecil Field

ABB-ES Project Number: 08516-40
Sample ID: CEF-JP5-125
Sample Matrix: soil
Date Sampled: 3/14/94
Date Reported: 3/28/94

Petroleum Product	Present in Sample	Evidence of Weathering
Gasoline		
JP-4		
Kerosene/JP-8/Jet A	probable	X
Diesel/#2 Fuel Oil		
#4 Fuel Oil		
#6 Fuel Oil		
Waste Oil/Motor Oil		
Coal Tar/Asphalt		
Other:		

ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY

FINGERPRINT ANALYSIS REPORT

Method: Modified EPA 8100
Client: Cecil Field

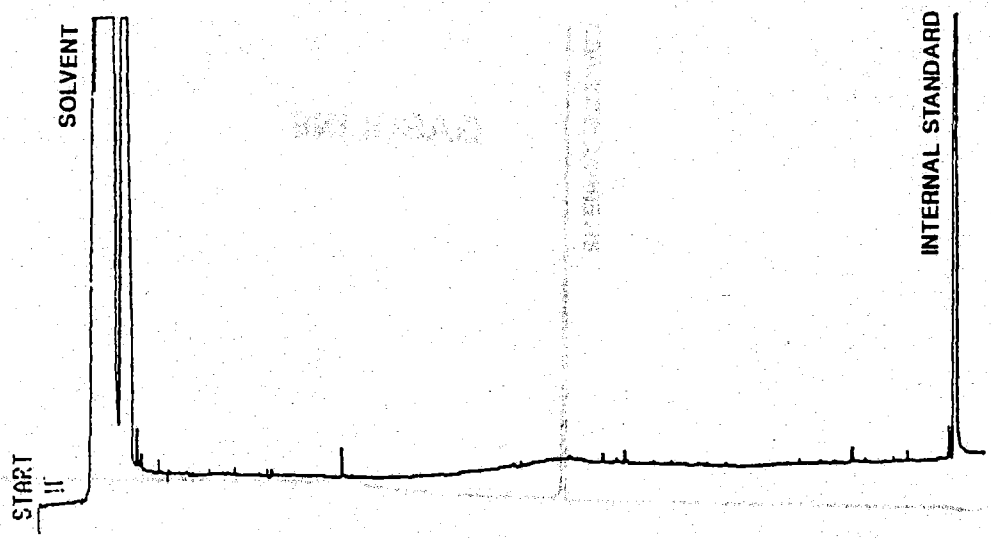
ABB-ES Project Number: 08516-40
Sample ID: CEF-732-135
Sample Matrix: soil
Date Sampled: 3/14/94
Date Reported: 3/28/94

Petroleum Product	Present in Sample	Evidence of Weathering
Gasoline		
JP-4		
Kerosene/JP-8/Jet A	probable	X
Diesel/#2 Fuel Oil		
#4 Fuel Oil		
#6 Fuel Oil		
Waste Oil/Motor Oil		
Coal Tar/Asphalt		
Other:		

PETROLEUM FINGERPRINT

MODIFIED 3550/8100

Project: Cecil Deep Plume



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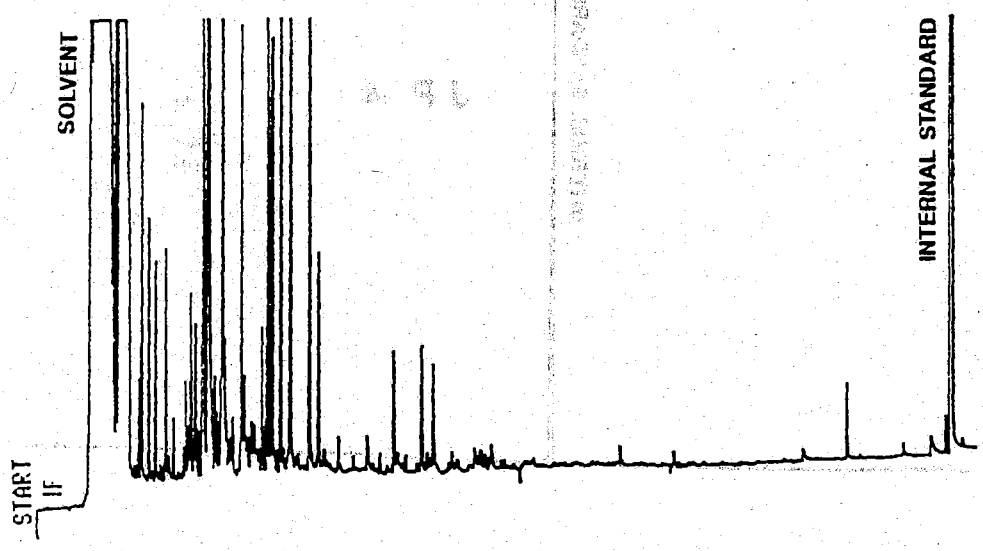
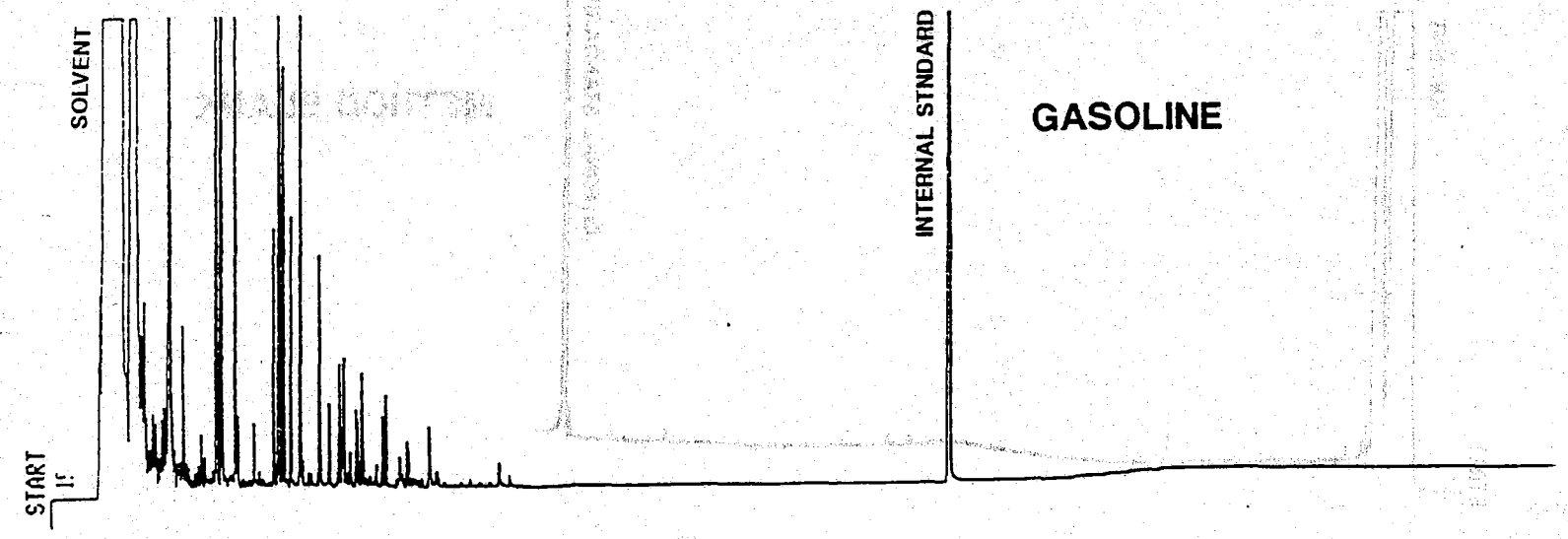


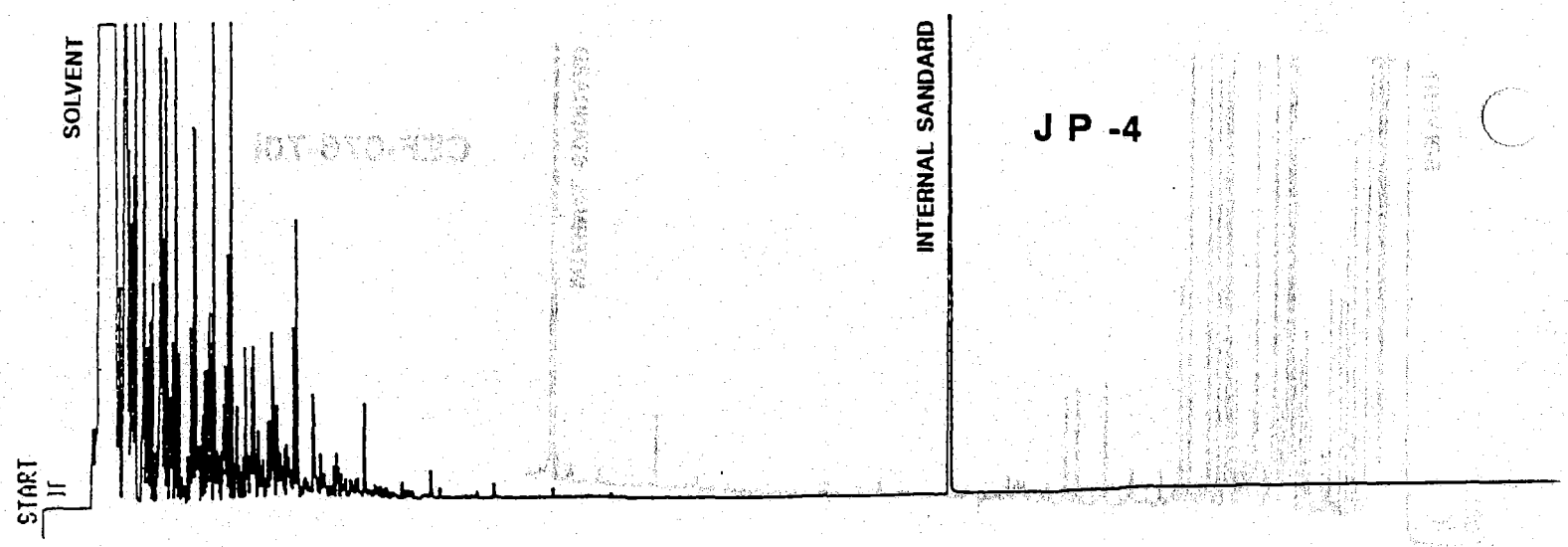
CEF-076-70I

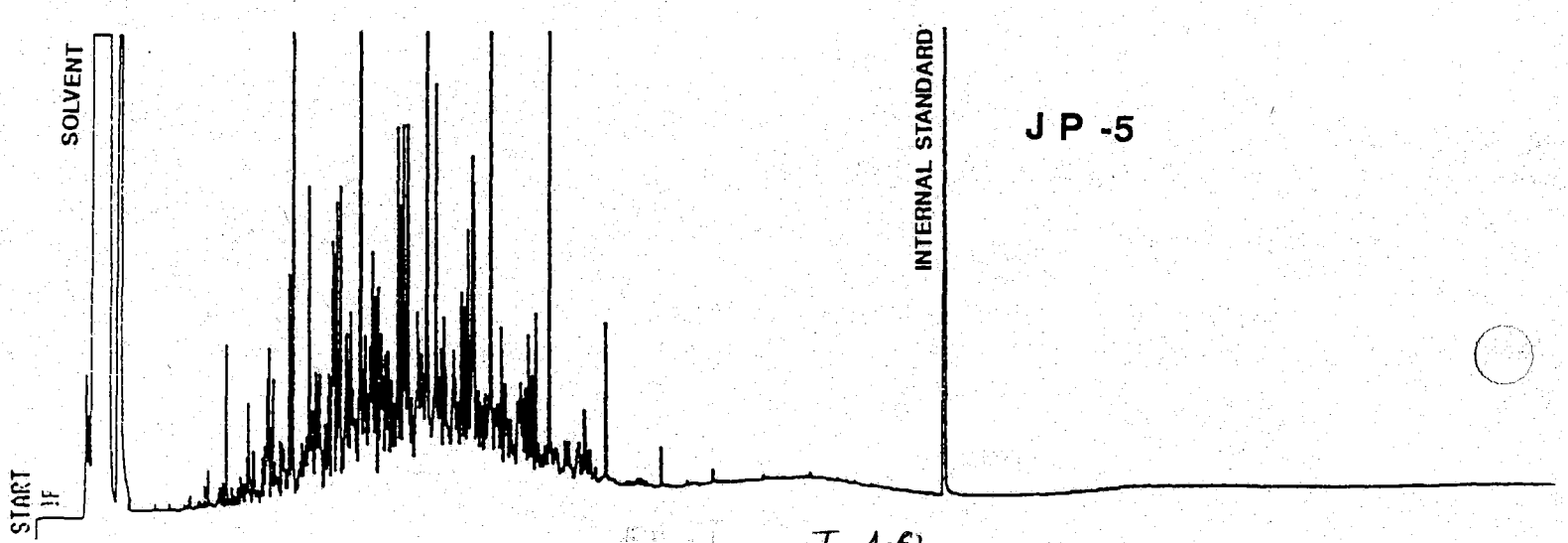
PETROLEUM FINGERPRINT

MODIFIED 3550/8100

Project: Cecil Deep Plume



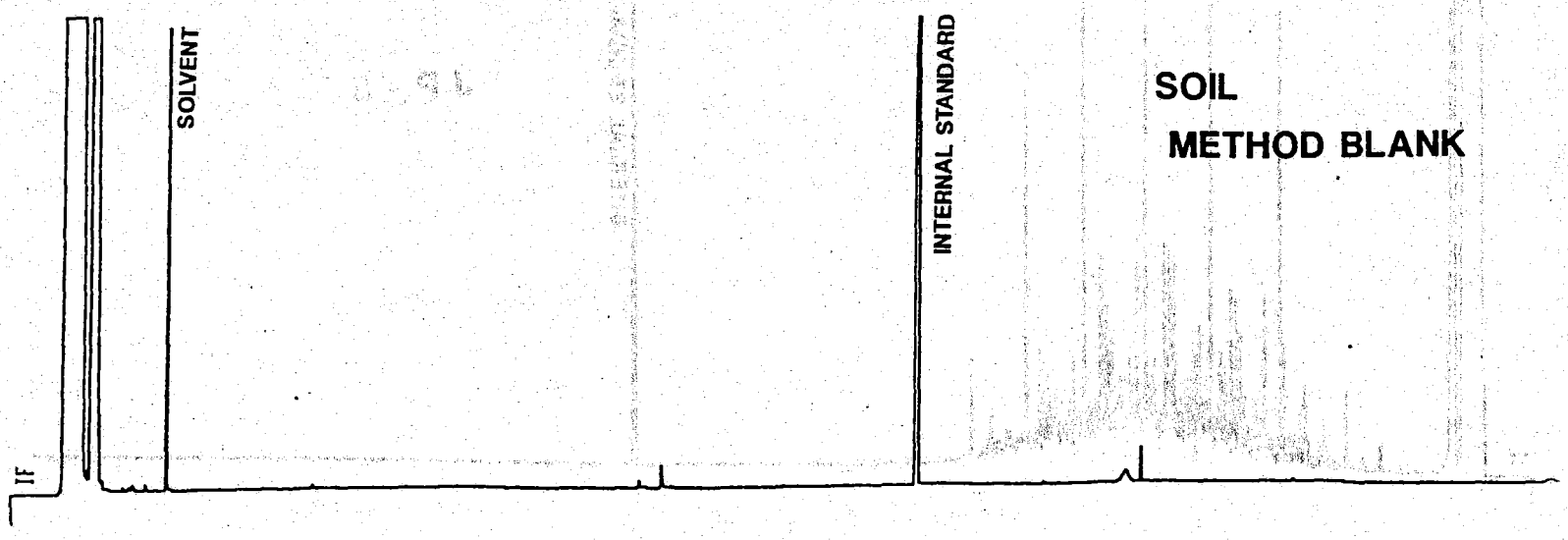


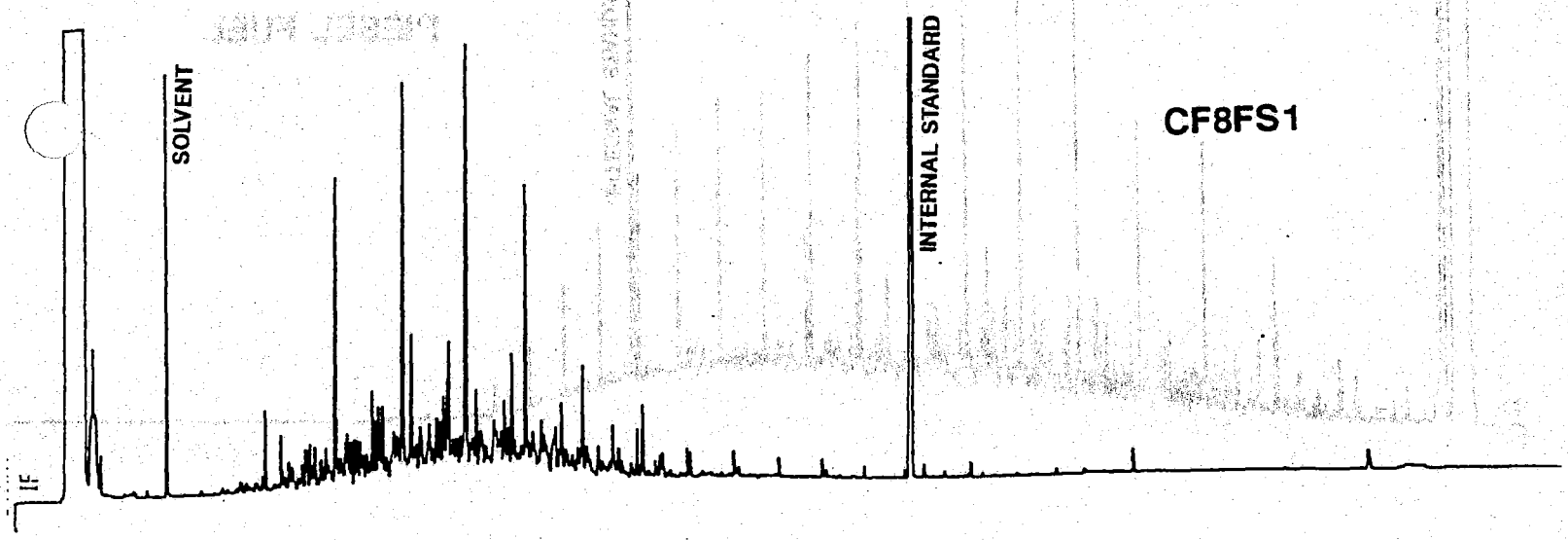


PETROLEUM FINGERPRINT

MODIFIED 3550/8100

Project: Cecil Field

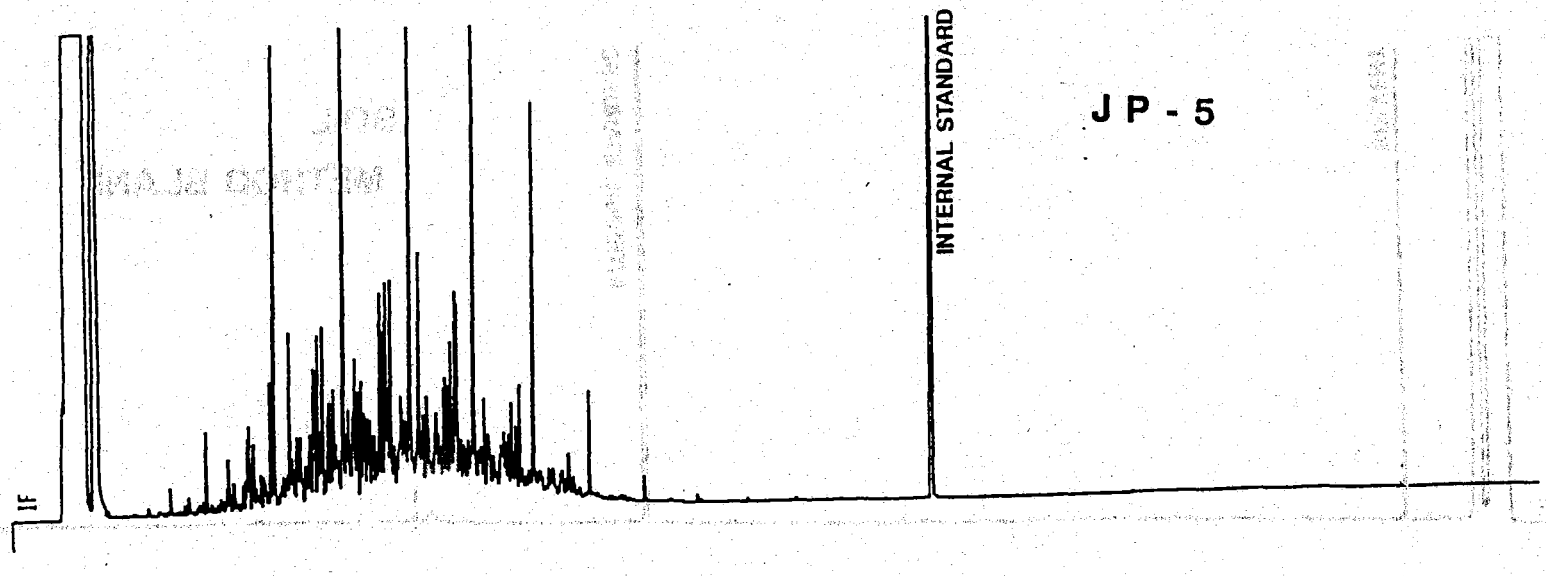


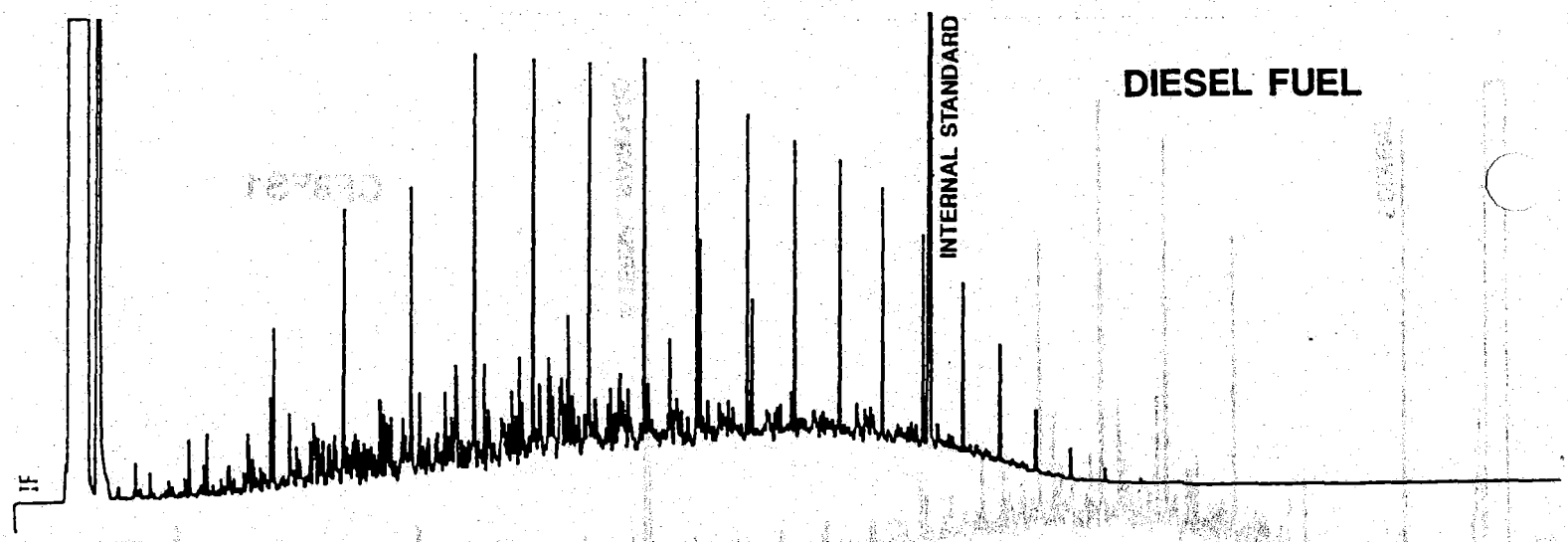


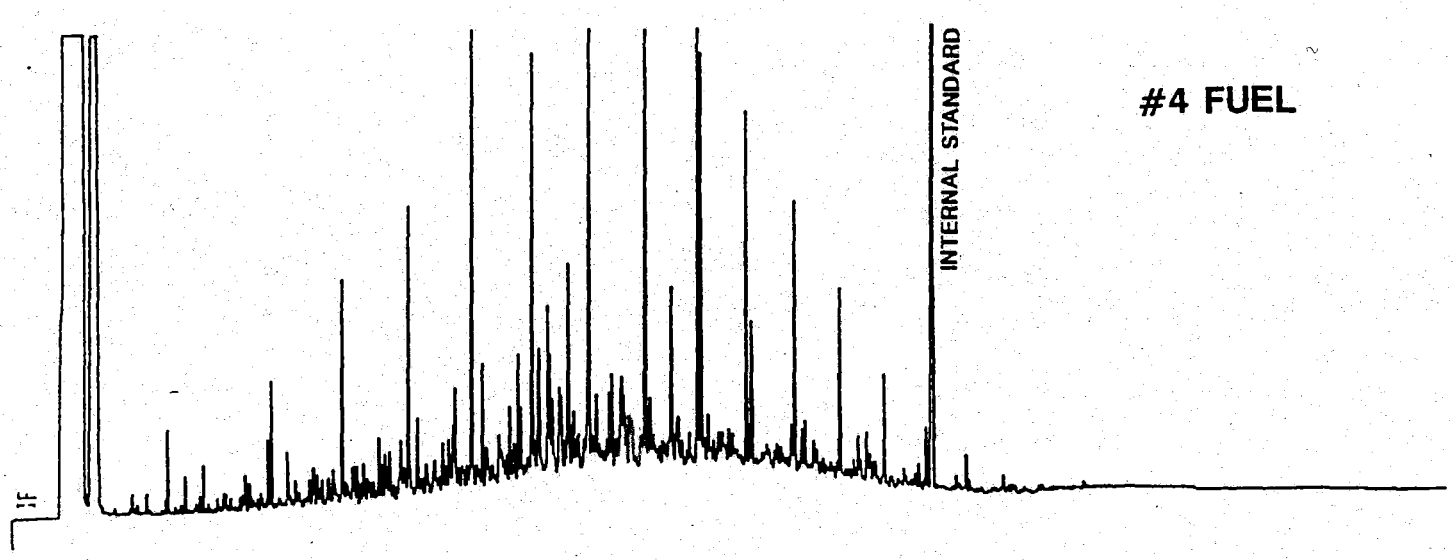
PETROLEUM FINGERPRINT

MODIFIED 3550/8100

Project: Cecil Field



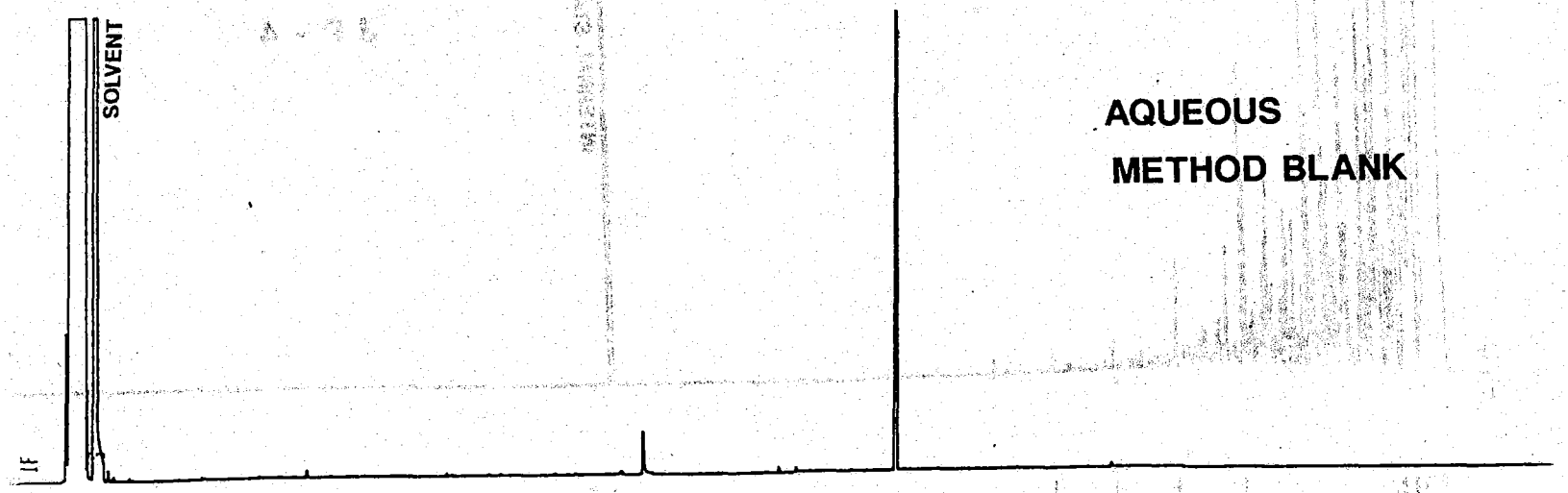


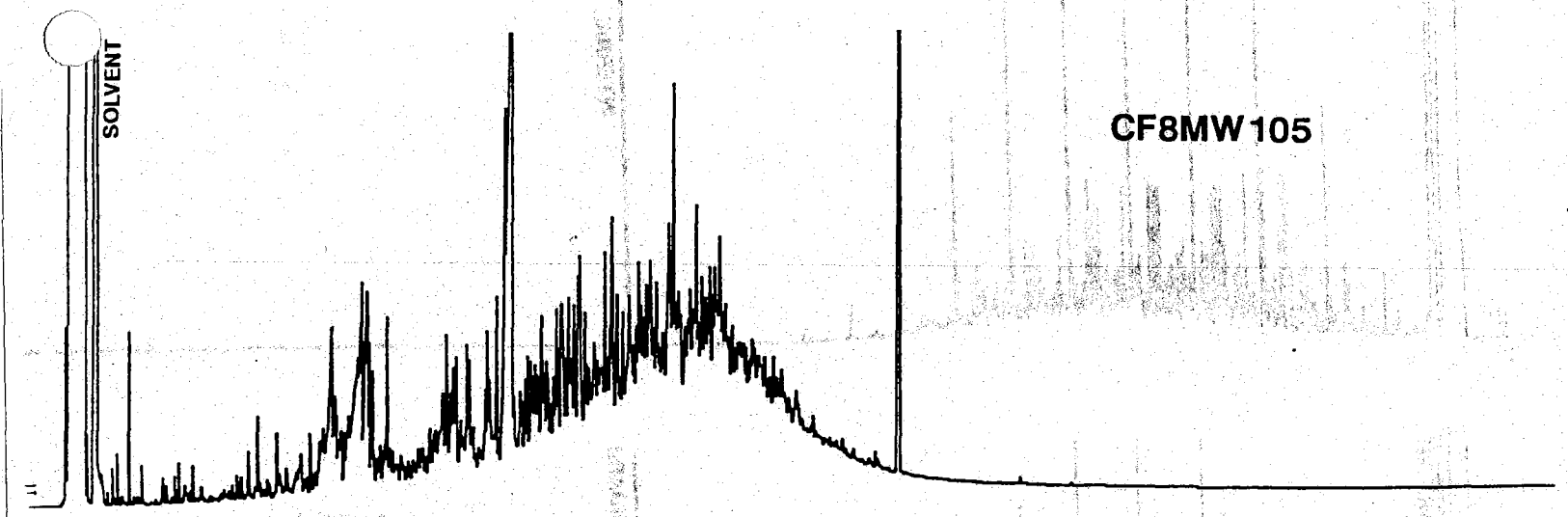


PETROLEUM FINGERPRINT

MODIFIED 3550/8100

Project: Cecil Field

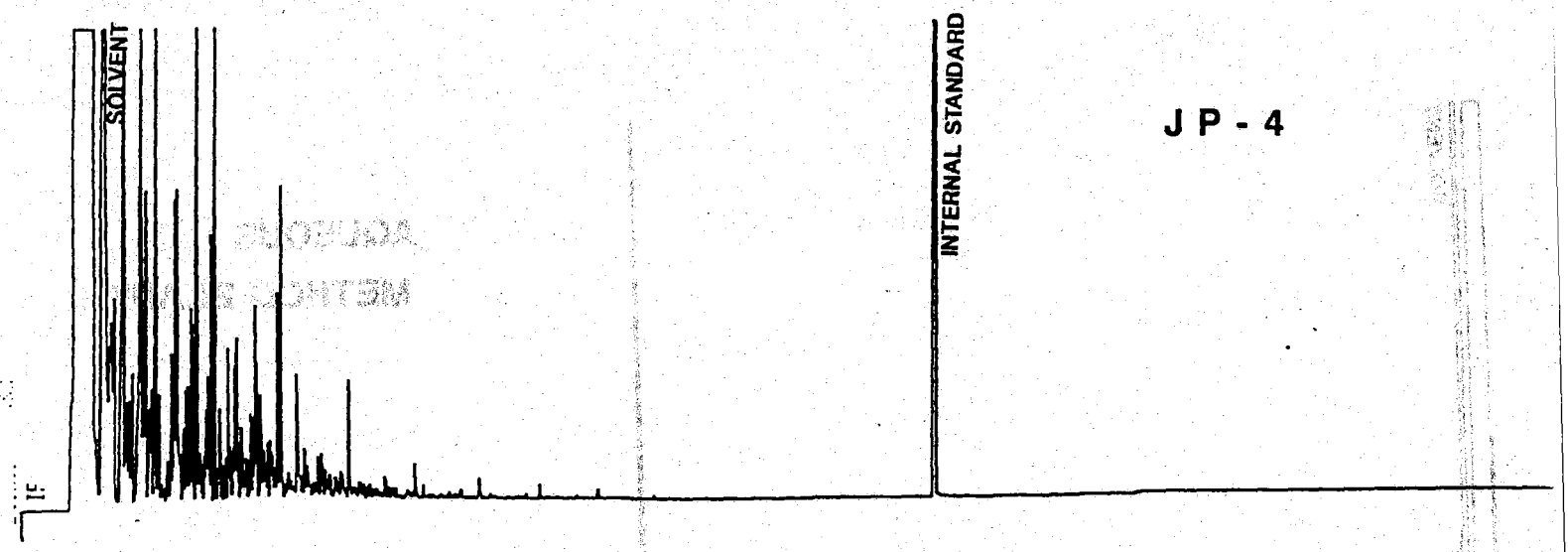


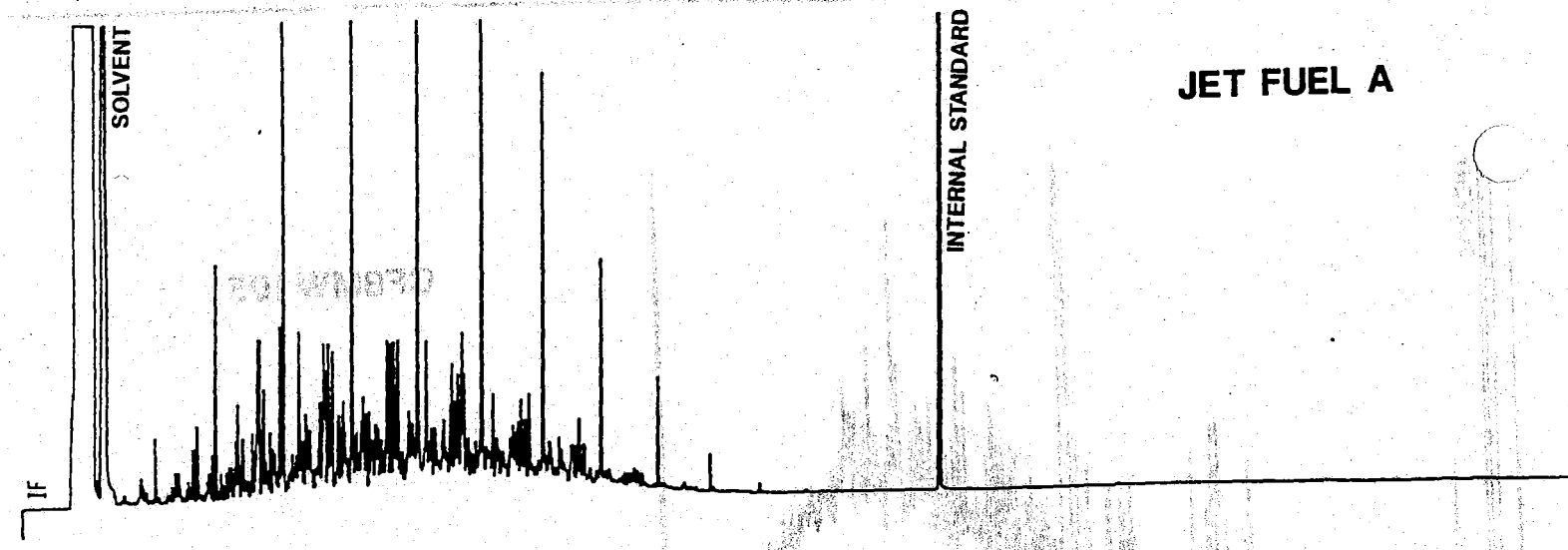


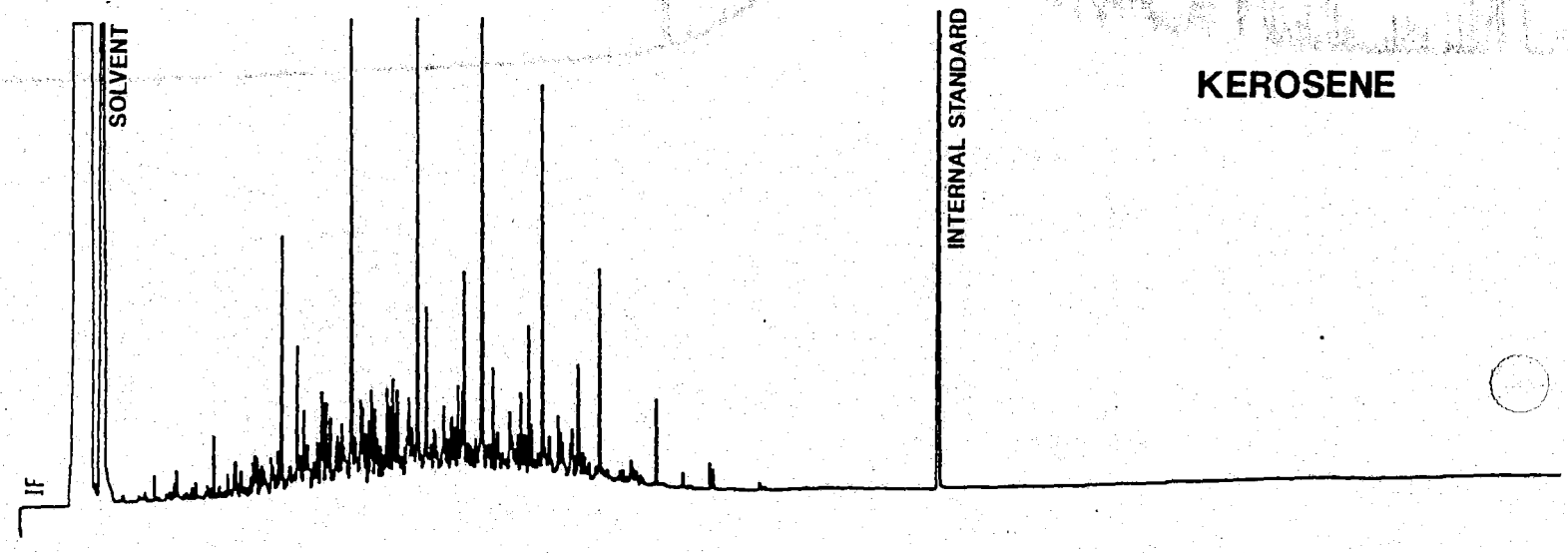
PETROLEUM FINGERPRINT

MODIFIED 3550/8100

Project: Cecil Field



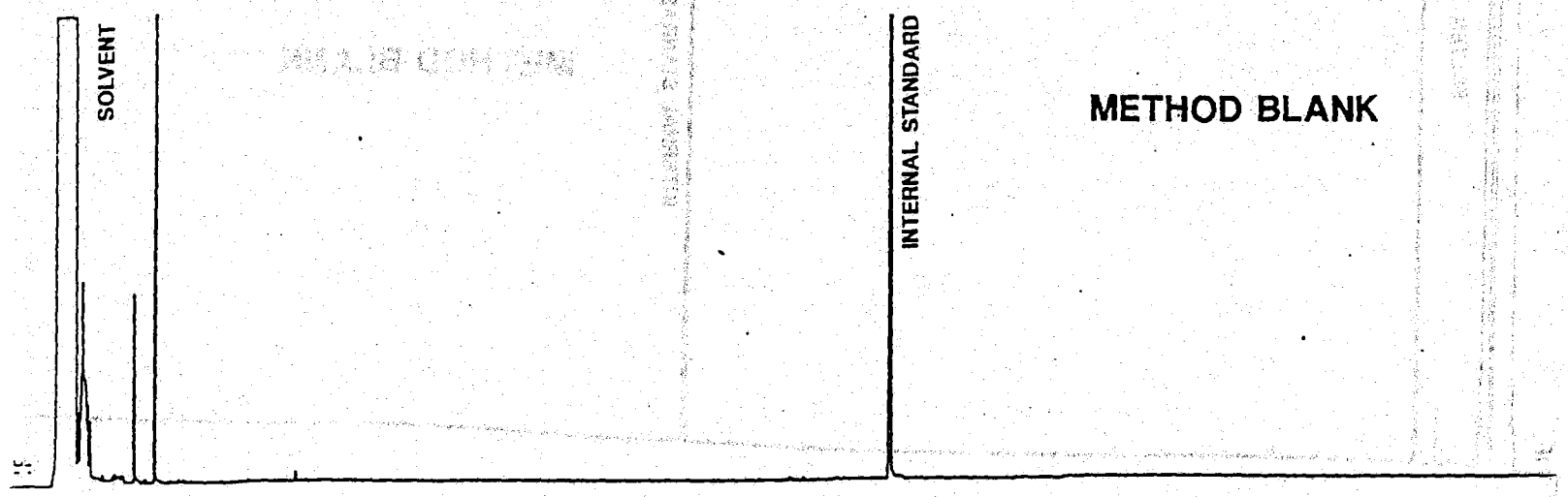




PETROLEUM FINGERPRINT

MODIFIED 3550/8100

Project: CECIL FLD



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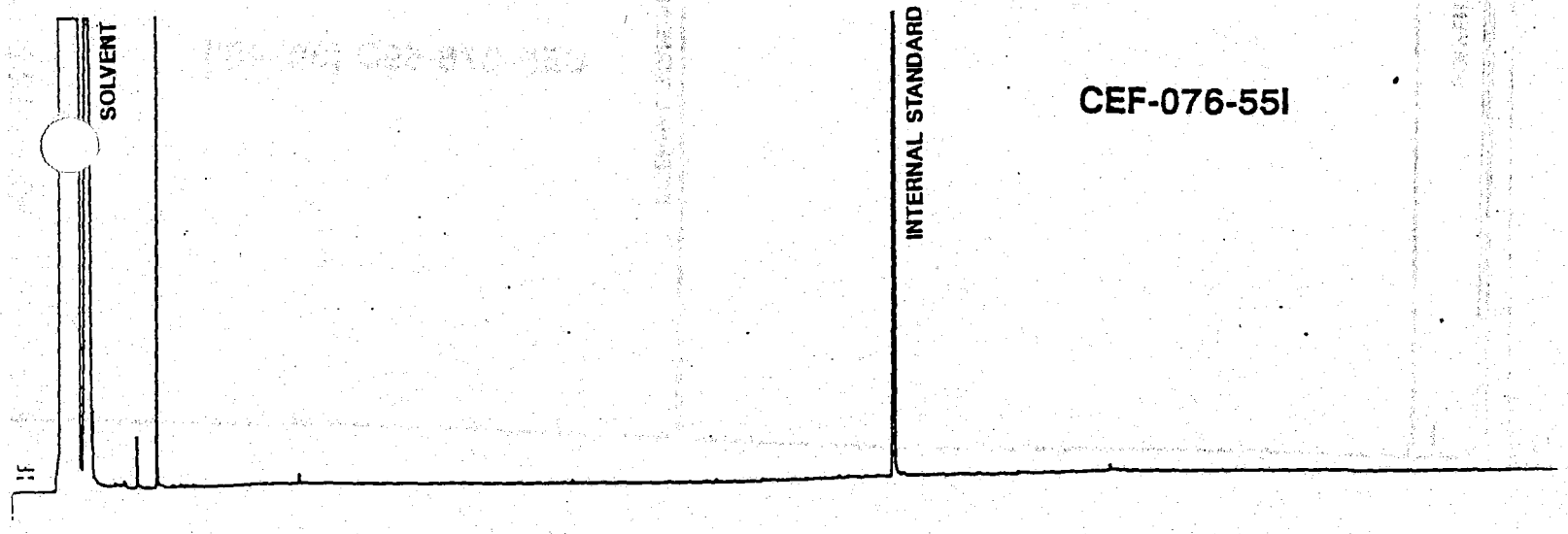
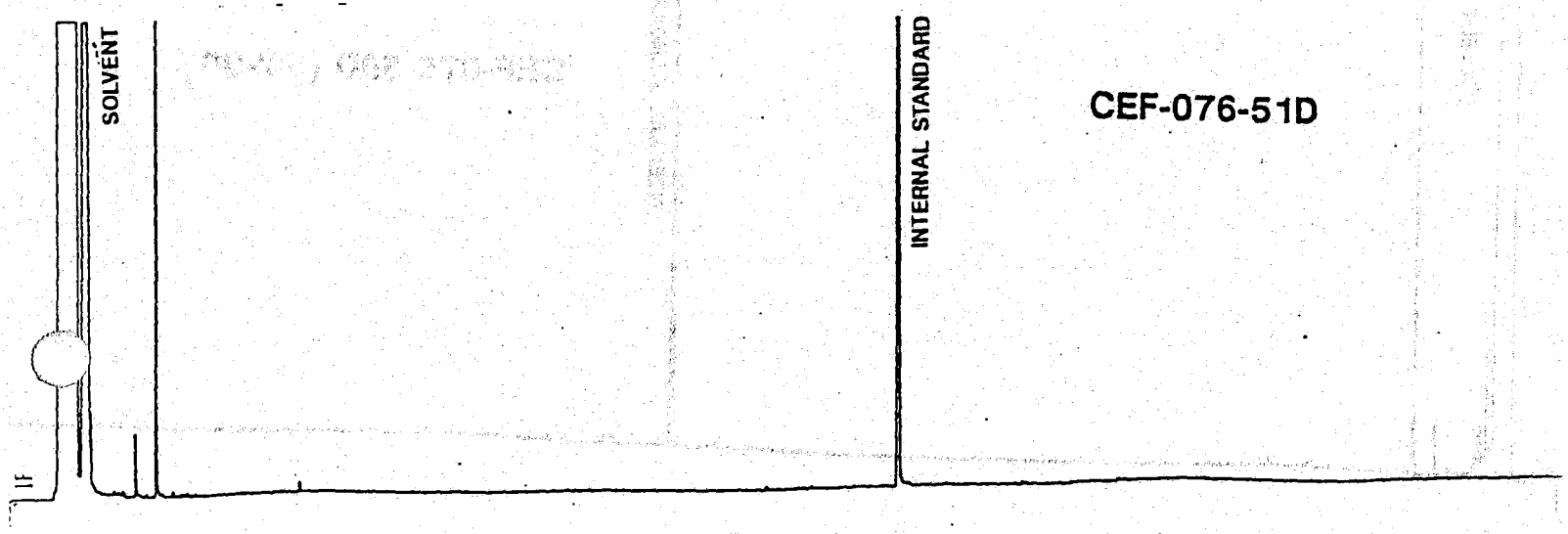


CEF-076-55I

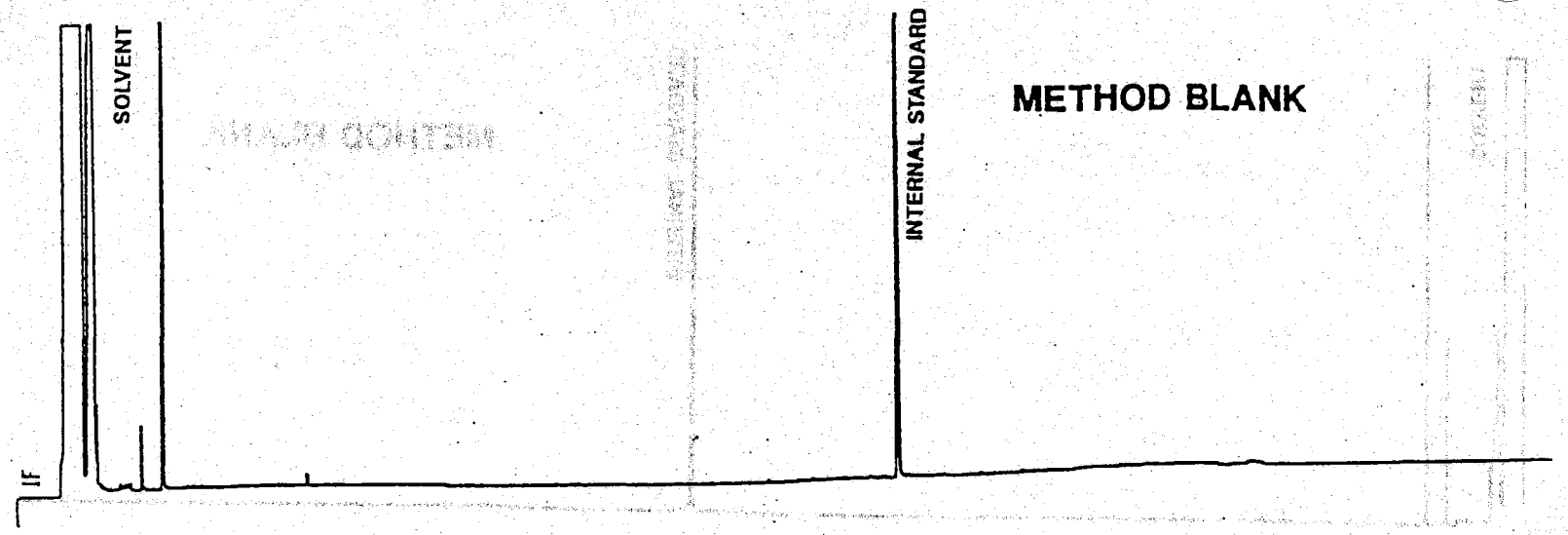


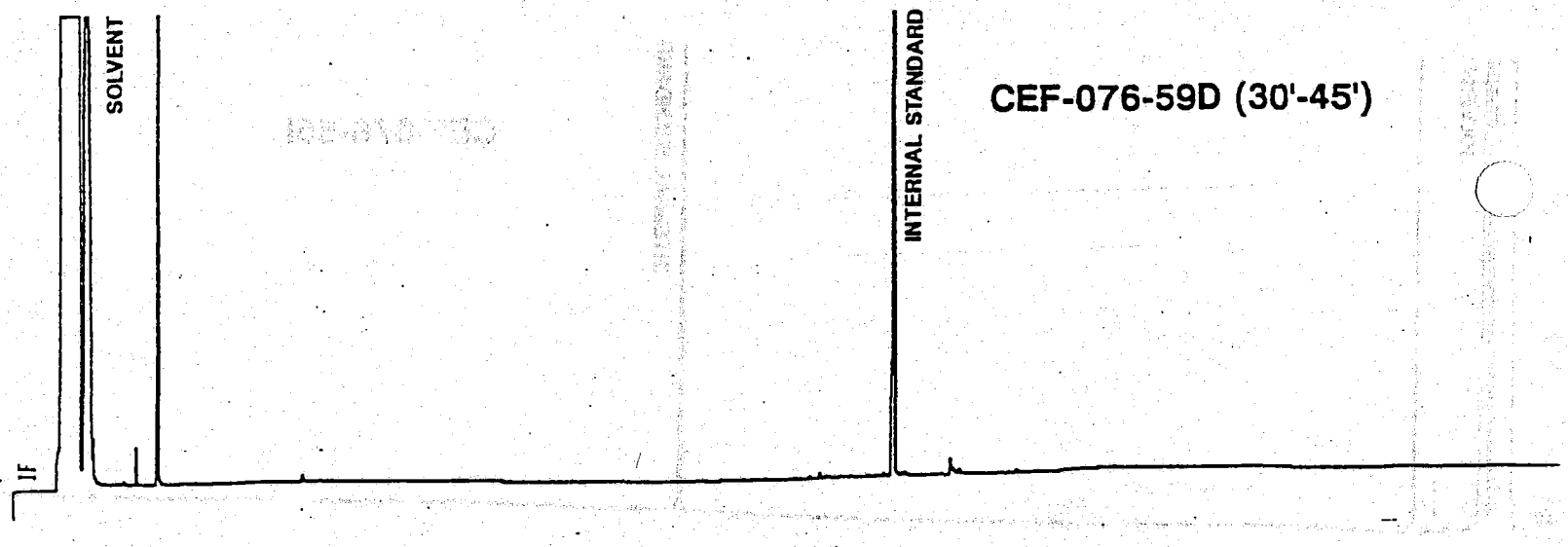
CEF-076-51D

PETROLEUM FINGERPRINT

MODIFIED 3550/8100

Project: CECIL FLD





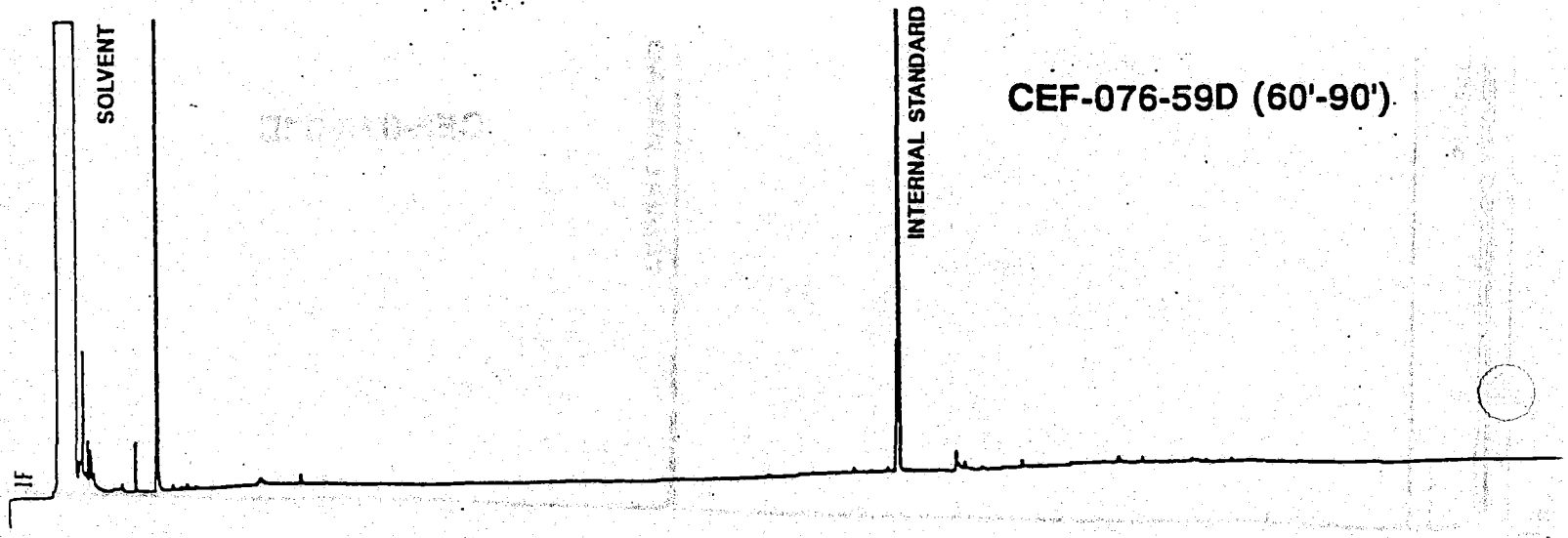


ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY

FRACTION ORGANIC CARBON

Client: Cecil Field

ABB-ES Project Number: 08516-40
Sample Matrix: SOIL
Date Sampled: 3/14/94
Date Reported: 3/28/94

SAMPLE ID	FOC (%)
CEF-JP-5-125 (UNSAT.)	1.1
CEF-JP-5-125 (UNSAT.) duplicate	1.1
CEF-JP-5-125 (SAT.)	1.3
CEF-JP-5-125 (SAT.) duplicate	1.3
CEF-372-135 (UNSAT.)	0.7
CEF-372-135 (UNSAT.) duplicate	0.6
CEF-372-135 (SAT.)	0.7
CEF-372-135 (SAT.) duplicate	0.7
CEF-076-315 (UNSAT.)	0.6
CEF-076-315 (UNSAT.) duplicate	0.6
CEF-076-315 (SAT.)	0.9
CEF-076-315 (SAT.) duplicate	0.9

ABB

ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY
TOTAL PETROLEUM HYDROCARBON ANALYSIS FOR SOIL

Project: NAS Ceciel Field FLD
Project Number: 08520.82
Date Prepared: 6/6/95

Total Petroleum Hydrocarbon Method: EPA Method 418.1			
Sample ID	Date Sampled	Date Analyzed	PPM (mg/kg)
CEF-076-59D(30'-45')	5/31/95	6/6/95	32E
CEF-076-59D(60'-90')	5/31/95	6/6/95	32E
CEF-076-59D(60'-90') DUPLICATE	5/31/95	6/6/95	28E

E:Estimated value below detection limit

ABB

ABB ENVIRONMENTAL SERVICES, INC.
ANALYTICAL LABORATORY
FRACTION ORGANIC CARBON
ANALYSIS REPORT

Project: NAS Cecil Field
Project Number: 08520.82
Date of Analysis: 6/8/95
Date Reported: 6/23/95
Work Order No.: 95-06-001

Sample ID	Date Sampled	% Volatilzed	Approx. % Organic Carbon
CEF-076-62D 30-45'	5/31/95	0.3	0.1
CEF-076-62D 60-90'	5/31/95	0.8	0.4
CEF-076-62D 60-90' DUP	5/31/95	0.8	0.4

ABB Environmental Services, Inc.

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ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY
TOTAL PETROLEUM HYDROCARBON ANALYSIS FOR SOIL

Project: NAS Ceciel Field FLD
Project Number: 08520.82
Date Prepared: 5/31/95

Total Petroleum Hydrocarbon Method: EPA Method 418.1			
Sample ID	Date Sampled	Date Analyzed	PPM (mg/kg)
CEF-076-55I	5/22/95	5/30/95	42E
CEF-076-51D	5/26/95	5/30/95	42E

E: Estimated value below detection limit

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(617) 246-5060

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ABB ENVIRONMENTAL SERVICES, INC.
ANALYTICAL LABORATORY
FRACTION ORGANIC CARBON
ANALYSIS REPORT

Project: NAS Cecil Field
Project Number: 08520.82
Date of Analysis: 6/8/95
Date Reported: 6/23/95
Work Order No.: 95-05-009

Sample ID	Date Sampled	% Volatilzed	Approx. % Organic Carbon
CEF-076-55I 60-90'	5/22/95	1.2	0.6
CEF-076-51D (HP-9) 100-110'	5/26/95	0.8	0.4

BACTERIA.FRM/1

ABB Environmental Services, Inc.

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ABB ENVIRONMENTAL SERVICES, INC.
ANALYTICAL LABORATORY
FRACTION ORGANIC CARBON
ANALYSIS REPORT

Project: NAS Cecil Field
Project Number: 08520.82
Date of Analysis: 6/12/95
Date Reported: 7/7/95
Work order #: 95-06-012

Sample ID	Date Sampled	% Volatilzed	Approx. % Organic Carbon
CEF-076-67I 25-55'	6/8/95	0.2	0.1
CEF-076-67I 25-55' DUP	6/8/95	0.18	0.1
CEF-076-67I 60-90'	6/8/95	2.9	1.4
CEF-076-67I 60-90' DUP	6/8/95	2.7	1.4

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ABB ENVIRONMENTAL SERVICES, INC.
TREATABILITY LABORATORY
TOTAL PETROLEUM HYDROCARBON ANALYSIS FOR SOIL

Project: NAS Cecil Field NFF
Project Number: 8520.92
Date Prepared: 10/30/96

Total Petroleum Hydrocarbon Method: EPA Method 418.1			
Sample ID	Date Sampled	Date Analyzed	PPM (mg/kg)
76B07701	10/1/96	10/7/96	106
76B07701 DUP	10/1/96	10/7/96	88
76B07702	10/1/96	10/7/96	< 50
76B07702 DUP	10/1/96	10/7/96	< 50
76B07703	10/3/96	10/7/96	< 50
76B07703 DUP	10/3/96	10/7/96	< 50
BLANK	10/7/96	10/7/96	< 50

ABB Environmental Services, Inc
Treatability Laboratory
Fraction Organic Carbon Analysis Report

Project: NAS CECIL FIELD NFF
Project No.: 08520-92
Date of Analyzed: 10/8/96
Workorder: 96-10-003

Sample ID	Sampled Date	% Volatilized Solids	Fraction Organic Carbon (%)	Average Fraction Organic Carbon (%)
76B07701	10/1/96	1.01	0.504	0.51
76B07701 Duplicate		1.04	0.522	
76B07702	10/1/96	0.48	0.24	0.22
76B07702 Duplicate		0.41	0.206	
76B07703	10/3/96	1.39	0.693	0.69
76B07703 Duplicate		1.37	0.683	

ABB ENVIRONMENTAL SERVICES, INC
ANALYTICAL LABORATORY
INORGANIC CONSTITUENTS
ANALYSIS REPORT

Project: Cecil Field NFF
Project Number: 8520.52
Date Reported: 10/18/96
Work Order No.: 96-10-003

Sample ID	Date Sampled	Date Analyzed	NH_4-N ppm	NO_3-N ppm	NO_2 ppm	PO_4-PO_4 ppm	Total PO_4 ppm	pH
76B07701	10/1/96	10/11/96	< 5	< 1.3	< 0.5	< 5	< 5	5
76B07702	10/1/96	10/11/96	< 5	< 1.3	< 0.5	< 5	< 5	5
76B077013	10/3/96	10/11/96	< 5	< 1.3	< 0.5	< 5	< 5	5

ANALYTICAL REPORT

Report To: Mr. Russ Johnson
ABB Environmental, Inc.
Corporate Place 128
107 Audubon Road
Wakefield, MA 01880

Project: NAS CECIL FIELD/NFF
Job: TKN in Soil

10/28/1996

NET Job Number: 96.03311

National Environmental Testing, Inc.

Cambridge Division
12 Oak Park
Bedford, MA 01730

Massachusetts Certification Number
M MA023

NET Cambridge Division

ANALYTICAL REPORT

Report To:	Reported By:
Mr. Russ Johnson ABB Environmental, Inc. Corporate Place 128 107 Audubon Road Wakefield, MA 01880	National Environmental Testing NET Atlantic, Incorporated Cambridge Division 12 Oak Park Bedford, MA 01730

Report Date: 10/28/1996 NET Job Number: 96.03311

Project: NAS CECIL FIELD/NFF NET Client No: 10800

P.O. No: WR#805-MO Collected By: ABB Shipped Via: FEDEX

Job Description: TKN in Soil Airbill No: # 1369460385

This report has been approved and certified for release by the following staff. Please feel free to call the NET Project Manager at 617-275-3535 with any questions or comments.

Antonia S. Benney
NET Project Manager

Report prepared by
NET Reports Group

Analytical data for the following samples are included in this data report.

SAMPLE ID	NET ID	DATE TAKEN	TIME TAKEN	DATE REC'D	MATRIX
76B07701	155595	10/01/1996		10/12/1996	SOIL
76B07702	155596	10/01/1996		10/12/1996	SOIL
76B07703	155597	10/01/1996		10/12/1996	SOIL

NET Cambridge Division

ANALYTICAL REPORT

Report Date: 10/28/1996

Report To: ABB Environmental, Inc. NET Job No: 96.03311

Project: NAS CECIL FIELD/NFF Date Rec'd: 10/12/1996

Sample ID	NET ID	Result	Units	Run Batch	Analysis Date	Analyst
Kjeldahl Nitrogen, Total	S	EPA 351.2				
76B07701	155595	100	mg/Kg N	41	10/24/1996	dec
76B07702	155596	75	mg/Kg N	41	10/24/1996	dec
76B07703	155597	120	mg/Kg N	41	10/24/1996	dec

NET Cambridge Division
BATCH QUALITY CONTROL DATA

Report To: ABB Environmental, Inc.

NET Job No: 96.03311

Program: NAS CECIL FIELD/NFF

Report Date: 10/28/1996

Parameter		LCS % Recovery	Method Blank	Spike % Recovery	Sample (Run 1)	Duplicate (Run 2)	RPD	Analyst
Kjeldahl Nitrogen, Total	S	130	<2.5	62.5	100	93	7.2	dec

Please note that the data reported for the Duplicates and Spikes were analyzed in the same batch, but may not necessarily be that of your sample.

LCS - Laboratory Control Sample. For analyses not requiring sample digestion/preparation, independent control check sample result is reported.

96.03311

CHAIN OF CUSTODY RECORD

Page ___ of ___

PROJECT NO.: 8520-92

PROJECT NAME: NAS Cecil Field / NFF

SAMPLERS (SIGNATURE):

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	SAMPLE TYPE: TKN											REMARKS (INDICATE SOIL/WATER/AIR SEDIMENT/SLUDGE)
	10-1-96			X	76B07701	1	X											SOIL
	10-1-96			X	76B07702	1	X											SOIL
	10-1-96			X	76B07703	1	X											SOIL

RELINQUISHED BY: (SIGNATURE)	DATE/TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	DATE/TIME	RECEIVED BY: (SIGNATURE)
[signature]	10/11/96	[signature]	Fedex # 136946 0385		[signature]
RELINQUISHED BY: (SIGNATURE)	DATE/TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	DATE/TIME	RECEIVED BY: (SIGNATURE)
[signature]				10/12 1200	[signature]
RELINQUISHED BY: (SIGNATURE)	DATE/TIME	RECEIVED FOR DISPOSAL BY: (SIGNATURE)	DATE/TIME	REMARKS	

Cooler Temp 5°C

Maureen Dooley
ABB-ES
107 Audubon Rd
Wakefield MA 01880
617 245-6606

Antonia Bonni-

ABB Environmental Services, Inc.

OH-62

WORK ORDER

PROJECT NAME: NAS Cecil Field / JPS Area

Work Number: 94-3-09

CHARGE TO: DR 867 - 00 - LBI

QC Level _____

DATE: 3/15/94

REQUESTED BY: _____

Rush analysis Y / N (Please specify below)

SAMPLE ID	SAMPLING DATE	TYPE	GC/FID oil	GC/FID Cecil	GC/FID mod. integ.	VOC Poly chlor	VOC 8020 chem	TPH	TPH modified	Bac Total	Bac specific	Ammonia-N	Nitrate-N	P-ext	T-P	pH	Chloride	% solids	% moisture	Current test	Nutrient AD	percent stab	TCD	Sulfate	GC/ECD	TOC	Grain size
CEF-JP-5-125 UNSAT	3/14/94	Soil	X						X	X															X		
SATUR																									X		
Grain size																										X	
CEF-372-135- UNSAT			X						X	X															X		
SATUR																									X		
Grain																										X	
CEF-076-315 UNSAT			X						X	X															X		
SATUR																									X		
Grain																										X	

SPECIAL INSTRUCTIONS

DATE EXTRACTED _____
DATE ANALYZED _____
DATE COMPLETED _____
SIGNATURE _____

Results sent 3/30/94 PBJ
Invoice entered 3/31/94 PBJ

A copy of this work order must be signed, dated and turned in with the data when the work is completed.

WORK ORDER

PROJECT NAME

ACCOUNT NO.

DATE

REQUESTED BY:

Rush analysis: Y / N (Please specify below)

SAMPLE ID	SAMPLING DATE	TYPE
[illegible]	[illegible]	[illegible]

SPECIAL INSTRUCTIONS

DATE RECEIVED

DATE STARTED

DATE COMPLETED

INITIALS

A copy of this work order must be signed, dated and returned ... with the work is completed.

APPENDIX K

COST ESTIMATES

Cost Summary for the North Fuel Farm
NAS Cecil Field, Jacksonville, Florida

This appendix describes the costs associated with the various remedial activities at the North Fuel Farm.

1) Dig and haul approximately 8,000 cubic yards of petroleum contaminated soil.
2) Install a soil vapor extraction system on the mound.
3) Biosparge the shallow groundwater.
4) Install 5 in-well aeration wells
5) Remediate the intermediate plume via natural attenuation.

Table K-1
Remediation Costs for First Year

Remedial Action Plan - North Fuel Farm
Naval Air Station Cecil Field
Jacksonville, Florida

Remedial Technology	Capital and First Year O&M Costs
Excavate Soil	$800,000
Soil Vapor Extraction	$310,000
Bioslurping	N/A
Biosparging	$160,000
Five Recirculation Wells	$91,000
Natural Attenuation	$36,600

Table K-2
Sampling and Analysis Schedule

Remedial Action Plan - North Fuel Farm
Naval Air Station Cecil Field
Jacksonville, Florida

Remedial Alternative	Media	Groundwater[A] Water Table	Groundwater[A] Shallow (15-55 ft)	Groundwater[A] Intermediate (55-100 ft)	Groundwater[A] Deep (100 -110 ft)	Off Gas[B]	Soil Borings/Samples[C]
Excavate Soil							X
Soil Vapor Extraction						X	X
Bioslurping						X	X
Biosparging			X				
Recirculation Wells			X	X	X		
Natural Attenuation			X	X	X		

NOTES:
[a] Groundwater samples will be analyzed for EPA Method 601/602 and natural attenuation parameters.
[b] Offgas will be monitored for TVOCs as per Method T-14
[c] Soil Samples will be collected from soil borings for confirmatory analysis per 62-770.

K-3

Cost to Dig and Haul Petroleum Contaminated Soil
NAS Cecil Field, Jacksonville, Florida

Approximately 8,000 cubic yards of excessively contaminated soil will need to be excavated, transported, and disposed of offsite. Costs associated with this dig and haul scenario vary widely, by a conservative estimate of $100.00 per cubic yard will be used. The total cost for digging and hauling petroleum contaminated soil is approximately $800,000.

Cost for Soil Vapor Extraction
NAS Cecil Field, Jacksonville, Florida

Direct cost were determined based on RACER software. Costs include capital costs, O&M costs, and construction oversight.

The total direct costs for SVE is $310,000.

DETAIL COST REPORT

Project:
NFF RAP
Cecil Field FL
Remedial Action Plan, NFF Site
Gopi. K
01/09/97

Project Comments:

Site:
NFF RAP - SVE
SVE
Gopi. K
01/09/97

Site Comments:

		Quantity	$/UM	Totals
33	REMEDIAL ACTION			
33.02	Monitoring, Sampling, Testing, Analysis			
33.02.97	Sampling & Analysis			
33.02.97.01	Sampling & Analysis - Capital Costs			
	Field Technician	54.00 HR	14.78	798.15
	Staff Engineer	54.00 HR	23.40	1,263.73
	Mobilize Crew, 250 Miles, Per Person	24.00 EA	485.00	11,640.00
	Per Diem	24.00 DAY	72.75	1,746.00
	Van Or Pickup Rental	12.00 DAY	29.10	349.20
	Disposable Materials Per Sample	20.00 EA	5.50	110.00
	Decontamination Materials Per Sample	20.00 EA	5.09	101.85
	60 Quart Ice Chest	12.00 EA	43.31	519.73
	Hydrocarbon Speciation, C1-C22, GC/FID, Air (TO-12/14)	20.00 EA	213.40	4,268.00
	Total Capital Costs			20,796.66
33.02.97.99	Sampling & Analysis - O&M Costs			

DETAIL COST REPORT

		Quantity	$/UM	Totals
33	REMEDIAL ACTION			
33.02	Monitoring, Sampling, Testing, Analysis			
33.02.97	Sampling & Analysis			
33.02.97.99	Sampling & Analysis - O&M Costs			
	Field Technician	67.00 HR	14.78	990.29
	Staff Engineer	67.00 HR	23.40	1,567.96
	Mobilize Crew, 250 Miles, Per Person	24.00 EA	485.00	11,640.00
	Per Diem	24.00 DAY	72.75	1,746.00
	Van Or Pickup Rental	12.00 DAY	29.10	349.20
	Disposable Materials Per Sample	25.00 EA	5.50	137.50
	Decontamination Materials Per Sample	25.00 EA	5.09	127.31
	60 Quart Ice Chest	12.00 EA	43.31	519.73
	Hydrocarbon Speciation, C1-C22, GC/FID, Air (TO-12/14)	25.00 EA	213.40	5,335.00
	Total O&M Costs			22,412.99
	Total Sampling & Analysis			43,209.65
33.13	Physical Treatment			
33.13.23	Vapor Extraction			
33.13.23.01	Vapor Extraction - Capital Costs			
	5 HP, 230V, 280 SCFM, Vapor Recovery System	3.00 EA	7,554.57	22,663.73
	Field Technician	96.00 HR	14.78	1,418.93
	DOT Steel Drum, 55 Gal	3.00 EA	41.56	124.69
	Electrical Charge (KWH)	30,150.00 KWH	0.04	1,462.28
	Surface Pad, Concrete, 4' X 4' X 4"	23.00 EA	13.45	309.48
	Furnish 55 Gal Drum For Drilling Cuttings & Devel Water	30.00 EA	41.56	1,246.94

DETAIL COST REPORT

		Quantity	$/UM	Totals
33	REMEDIAL ACTION			
33.13	Physical Treatment			
33.13.23	Vapor Extraction			
33.13.23.01	Vapor Extraction - Capital Costs			
	2" Well, Portland Cement Grout	23.00 LF	0.87	20.08
	2" Screen, Filter Pack	506.00 LF	8.84	4,474.04
	4" Iron Body Checkvalve	2.00 EA	343.64	687.28
	2" Well, Bentonite Seal	23.00 EA	26.57	611.28
	2" PVC, Sch 40, Connection Piping	403.00 LF	2.50	1,008.18
	2" PVC, 90 Degree, Elbow	23.00 EA	13.50	310.60
	4"x2" Reducer, PVC Sch 40	23.00 EA	7.17	165.09
	4" PVC, Sch 40, Tee	23.00 EA	46.35	1,066.12
	2" PVC, Well Plug	23.00 EA	12.34	284.02
	4" PVC, Sch 40, Manifold Piping	202.00 LF	5.93	1,197.98
	2" PVC, Sch 40, Well Casing	138.00 LF	4.53	625.17
	2" PVC, Sch 40, Well Screen	460.00 LF	9.01	4,148.23
	OVA Rental, Per Day	10.00 DAY	97.00	970.01
	Pressure Gauge	23.00 EA	112.82	2,595.05
	Mob/Demob Drilling Rig & Crew	1.00 LS	1,112.95	1,112.95
	Move Rig/Equipment Around Site	22.00 EA	34.77	765.15
	Split Spoon Sample, 2" x 24", During Drilling	138.00 EA	24.25	3,346.50
	Decontaminate Rig, Augers, Screen (Rental Equipment)	8.00 DAY	131.92	1,055.36
	H Stem, 8" OD Borehole For 2" Well	621.00 LF	20.23	12,567.00
	Total Capital Costs			64,236.14
33.13.23.99	Vapor Extraction - O&M Costs			

DETAIL COST REPORT

		Quantity	$/UM	Totals
33	REMEDIAL ACTION			
33.13	Physical Treatment			
33.13.23	Vapor Extraction			
33.13.23.99	Vapor Extraction - O&M Costs			
	Field Technician	192.00 HR	14.78	2,837.85
	Electrical Charge (KWH)	130,647.00 KWH	0.04	6,336.38
	Total O&M Costs			9,174.23
	Total Vapor Extraction			73,410.37
33.14	Thermal Treatment			
33.14.92	Thermal and Catalytic Oxidation			
33.14.92.01	Thermal & Catalytic Oxidation - Cap Csts			
	1000 scfm Simple Thermal Oxidizer	1.00 EA	50,550.11	50,550.11
	Electrical Charge (KWH)	1,765.00 KWH	0.04	85.60
	Natural Gas Usage, per 1000 cf	3,756.00 MCF	4.85	18,216.60
	4" PVC, Sch 40, Well Casing	30.00 LF	7.95	238.65
	4" PVC, 90 Degree, Elbow	2.00 EA	34.24	68.49
	Field Technician	48.00 HR	14.78	709.46
	8" Structural Slab On Grade	100.00 SF	4.89	489.36
	Total Capital Costs			70,358.27
33.14.92.99	Thermal & Catalytic Oxidation - O&M Csts			
	Electrical Charge (KWH)	7,640.00 KWH	0.04	370.54
	Natural Gas Usage, per 1000 cf	16,150.00 MCF	4.85	78,327.50
	Field Technician	192.00 HR	14.78	2,837.85
	Total O&M Costs			81,535.89
	Total Thermal and Catalytic Oxidation			151,894.16
33.80	Contractor Oversight			
33.80.01	Professional Labor			
33.80.01.01	Construction Support			

DETAIL COST REPORT

		Quantity	$/UM	Totals
33	REMEDIAL ACTION			
33.80	Contractor Oversight			
33.80.01	Professional Labor			
33.80.01.01	Construction Support			
	Project Engineer	48.00 HR	30.79	1,478.05
	Staff Engineer	480.00 HR	23.40	11,233.17
	Staff Hydrogeologist	557.00 HR	23.40	13,035.16
	Field Technician	240.00 HR	14.78	3,547.32
	Certified Industrial Hygienist	24.00 HR	30.79	739.02
	Other Direct Costs	1.00 LS	472.39	472.39
33.80.01.04	"As Built" Drawings			
	Staff Engineer	4.00 HR	23.40	93.61
	Surveyor	6.00 HR	18.47	110.85
	Field Technician	8.00 HR	14.78	118.24
	Draftsman/CADD Operator	24.00 HR	14.78	354.73
	Word Processing/Clerical	8.00 HR	12.31	98.54
	Other Direct Costs	1.00 LS	11.64	11.64
33.80.01.05	Operation and Maintenance Manuals			
	Staff Engineer	10.00 HR	23.40	234.02
	Field Technician	10.00 HR	14.78	147.80
	Word Processing/Clerical	10.00 HR	12.31	123.17
	Other Direct Costs	1.00 LS	7.76	7.76
33.80.01.06	Monitoring Reports			
	Project Engineer	6.00 HR	30.79	184.76

DETAIL COST REPORT

		Quantity	$/UM	Totals
33	REMEDIAL ACTION			
33.80	Contractor Oversight			
33.80.01	Professional Labor			
33.80.01.06	Monitoring Reports			
	Staff Engineer	24.00 HR	23.40	561.66
	Staff Hydrogeologist	32.00 HR	23.40	748.88
	Field Technician	40.00 HR	14.78	591.22
	Draftsman/CADD Operator	24.00 HR	14.78	354.73
	Word Processing/Clerical	24.00 HR	12.31	295.61
	Other Direct Costs	1.00 LS	42.68	42.68
33.80.01.24	Sampling and Analysis Plan			
	Project Engineer	4.00 HR	30.79	123.17
	Staff Engineer	10.00 HR	23.40	234.02
	Staff Hydrogeologist	10.00 HR	23.40	234.02
	Word Processing/Clerical	20.00 HR	12.31	246.34
	Certified Industrial Hygienist	4.00 HR	30.79	123.17
	Other Direct Costs	1.00 LS	14.55	14.55
33.80.01.32	Health and Safety Plan			
	Project Engineer	6.00 HR	30.79	184.76
	Certified Industrial Hygienist	60.00 HR	30.79	1,847.56
	Other Direct Costs	1.00 LS	32.01	32.01
33.80.01.46	Work Plan Amendments			
	Project Engineer	15.00 HR	30.79	461.89
	Staff Engineer	30.00 HR	23.40	702.07

DETAIL COST REPORT

		Quantity	$/UM	Totals
33	REMEDIAL ACTION			
33.80	Contractor Oversight			
33.80.01	Professional Labor			
33.80.01.46	Work Plan Amendments			
	Staff Hydrogeologist	20.00 HR	23.40	468.05
	Word Processing/Clerical	48.00 HR	12.31	591.22
	Certified Industrial Hygienist	5.00 HR	30.79	153.96
	Other Direct Costs	1.00 LS	36.86	36.86
	Total Capital Costs			40,038.66
	Total Professional Labor			40,038.66
	TOTAL DIRECT COSTS REMEDIAL ACTION			308,552.84

* * * * This System Intended For Government Use Only * * * *

Cost for Biosparging
NAS Cecil Field, Jacksonville, Florida

Costs associated with biosparging shallow groundwater was determined based on the RACER software. Costs include capital, O&M, and construction oversight.

The total direct costs for biosparging is approximately $160,000.

DETAIL COST REPORT

Project:
NORTH FUEL FARM
Cecil Field FL
Biosparging
Timothy M. Kelly
12/23/96

Project Comments:

Site:
NFF
Biosparging
Timothy M. Kelly
01/24/97

Site Comments:

			Labor	Equip	Material
33	REMEDIAL ACTION				
33.02	Monitoring, Sampling, Testing, Analysis				
33.02.97	Sampling & Analysis				
33.02.97.01	Sampling & Analysis - Capital Costs				
	Field Technician				
		96.00 HR	1,418.93	0.00	0.00
	Mobilize Crew, 250 Miles, Per Person				
		24.00 EA	0.00	0.00	11,640.00
	Per Diem				
		24.00 DAY	0.00	0.00	1,746.00
	Van Or Pickup Rental				
		12.00 DAY	0.00	0.00	349.20
	Disposable Materials Per Sample				
		24.00 EA	0.00	0.00	132.00
	Decontamination Materials Per Sample				
		24.00 EA	0.00	0.00	122.22
	60 Quart Ice Chest				
		12.00 EA	0.00	0.00	519.73
	Total Dissolved Solids (EPA 160.1)				
		4.00 EA	0.00	0.00	38.80
	Gasoline Group (Mod EPA 601/602, Lead, EDB)				
		20.00 EA	0.00	0.00	4,365.00
	Total Capital Costs		1,418.93	0.00	18,912.95
33.02.97.99	Sampling & Analysis - O&M Costs				

DETAIL COST REPORT

		Labor	Equip	Material
33	REMEDIAL ACTION			
33.02	Monitoring, Sampling, Testing, Analysis			
33.02.97	Sampling & Analysis			
33.02.97.99	Sampling & Analysis - O&M Costs			
	Field Technician			
	96.00 HR	1,418.93	0.00	0.00
	Mobilize Crew, 250 Miles, Per Person			
	24.00 EA	0.00	0.00	11,640.00
	Per Diem			
	24.00 DAY	0.00	0.00	1,746.00
	Van Or Pickup Rental			
	12.00 DAY	0.00	0.00	349.20
	Disposable Materials Per Sample			
	6.00 EA	0.00	0.00	33.00
	Decontamination Materials Per Sample			
	6.00 EA	0.00	0.00	30.56
	60 Quart Ice Chest			
	12.00 EA	0.00	0.00	519.73
	Total Dissolved Solids (EPA 160.1)			
	4.00 EA	0.00	0.00	38.80
	Gasoline Group (Mod EPA 601/602, Lead, EDB)			
	2.00 EA	0.00	0.00	436.50
	Total O&M Costs	1,418.93	0.00	14,793.79
	Total Sampling & Analysis	2,837.86	0.00	33,706.74
33.13	Physical Treatment			
33.13.90	Air Sparging			
33.13.90.01	Air Sparging - Capital Costs			
	Surface Pad, Concrete, 2' X 2' X 4"			
	22.00 EA	16.22	0.88	56.90
	Furnish 55 Gal Drum For Drilling Cuttings & Devel Water			
	46.00 EA	0.00	0.00	1,911.97
	OVA Rental, Per Day			
	14.00 DAY	0.00	0.00	1,358.01
	Mob/Demob Drilling Rig & Crew			
	1.00 LS	408.63	704.32	0.00
	Decontaminate Rig, Augers, Screen (Rental Equipment)			
	11.00 DAY	0.00	0.00	1,451.12
	Move Rig/Equipment Around Site			
	21.00 EA	268.16	462.21	0.00

DETAIL COST REPORT

		Labor	Equip	Material
33	REMEDIAL ACTION			
33.13	Physical Treatment			
33.13.90	Air Sparging			
33.13.90.01	Air Sparging - Capital Costs			
	Split Spoon Sample, 2" x 24", During Drilling			
	242.00 EA	0.00	0.00	5,868.50
	Pressure Gauge			
	22.00 EA	712.57	8.59	1,761.07
	2" Well, Bentonite Seal			
	22.00 EA	101.15	174.33	309.23
	2" Well, Portland Cement Grout			
	1,122.00 LF	0.00	0.00	979.51
	2" Screen, Filter Pack			
	66.00 LF	76.42	131.71	375.44
	2" Iron Body Checkvalve			
	22.00 EA	563.08	6.80	3,526.44
	H Stem, 8" OD Borehole For 2" Well			
	1,210.00 LF	8,990.93	15,495.50	0.00
	2" PVC, Sch 40, Connection Piping			
	248.00 LF	432.23	7.22	180.97
	2" PVC, 90 Degree, Elbow			
	22.00 EA	276.69	4.62	15.78
	2" PVC, Sch 40, Tee			
	22.00 EA	468.21	17.51	19.32
	2" PVC, Well Plug			
	22.00 EA	44.95	77.48	149.24
	2" PVC, Sch 40, Manifold Piping			
	83.00 LF	144.66	2.42	60.57
	2" PVC, Sch 40, Well Casing			
	1,144.00 LF	1,558.43	2,685.88	938.23
	2" PVC, Sch 40, Well Screen			
	44.00 LF	77.32	133.26	186.20
	Blower 426 SCFM, 84 HP, 30 PSI			
	1.00 EA	912.61	14.73	7,187.70
	Electrical Charge (KWH)			
	112,558.00 KWH	0.00	0.00	5,459.06
	Field Technician			
	80.00 HR	1,182.44	0.00	0.00
	Total Capital Costs	16,234.70	19,927.46	31,795.26
33.13.90.99	Air Sparging - O&M Costs			
	Field Technician			
	192.00 HR	2,837.85	0.00	0.00

DETAIL COST REPORT

		Labor	Equip	Material
33	REMEDIAL ACTION			
33.13	Physical Treatment			
33.13.90	Air Sparging			
33.13.90.99	Air Sparging - O&M Costs			
	Electrical Charge (KWH)			
	731,622.00 KWH	0.00	0.00	35,483.67
	Total O&M Costs	2,837.85	0.00	35,483.67
	Total Air Sparging	19,072.55	19,927.46	67,278.93
33.80	Contractor Oversight			
33.80.01	Professional Labor			
33.80.01.01	Construction Support			
	Project Engineer			
	12.00 HR	369.51	0.00	0.00
	Staff Engineer			
	120.00 HR	2,808.29	0.00	0.00
	Staff Hydrogeologist			
	225.00 HR	5,265.55	0.00	0.00
	Field Technician			
	60.00 HR	886.83	0.00	0.00
	Certified Industrial Hygienist			
	6.00 HR	184.76	0.00	0.00
	Other Direct Costs			
	1.00 LS	0.00	0.00	149.38
33.80.01.04	"As Built" Drawings			
	Staff Engineer			
	1.00 HR	23.40	0.00	0.00
	Surveyor			
	2.00 HR	36.95	0.00	0.00
	Field Technician			
	2.00 HR	29.56	0.00	0.00
	Draftsman/CADD Operator			
	6.00 HR	88.68	0.00	0.00
	Word Processing/Clerical			
	2.00 HR	24.63	0.00	0.00
	Other Direct Costs			
	1.00 LS	0.00	0.00	2.91
33.80.01.05	Operation and Maintenance Manuals			

DETAIL COST REPORT

		Labor	Equip	Material
33	REMEDIAL ACTION			
33.80	Contractor Oversight			
33.80.01	Professional Labor			
33.80.01.05	Operation and Maintenance Manuals			
	Staff Engineer			
	3.00 HR	70.21	0.00	0.00
	Field Technician			
	3.00 HR	44.34	0.00	0.00
	Word Processing/Clerical			
	3.00 HR	36.95	0.00	0.00
	Other Direct Costs			
	1.00 LS	0.00	0.00	1.94
33.80.01.06	Monitoring Reports			
	Project Engineer			
	2.00 HR	61.59	0.00	0.00
	Staff Engineer			
	6.00 HR	140.41	0.00	0.00
	Staff Hydrogeologist			
	10.00 HR	234.02	0.00	0.00
	Field Technician			
	12.00 HR	177.37	0.00	0.00
	Draftsman/CADD Operator			
	12.00 HR	177.37	0.00	0.00
	Word Processing/Clerical			
	8.00 HR	98.54	0.00	0.00
	Other Direct Costs			
	1.00 LS	0.00	0.00	13.58
33.80.01.24	Sampling and Analysis Plan			
	Project Engineer			
	1.00 HR	30.79	0.00	0.00
	Staff Engineer			
	3.00 HR	70.21	0.00	0.00
	Staff Hydrogeologist			
	3.00 HR	70.21	0.00	0.00
	Word Processing/Clerical			
	5.00 HR	61.59	0.00	0.00
	Certified Industrial Hygienist			
	1.00 HR	30.79	0.00	0.00
	Other Direct Costs			
	1.00 LS	0.00	0.00	3.88
33.80.01.32	Health and Safety Plan			

DETAIL COST REPORT

		Labor	Equip	Material
33	REMEDIAL ACTION			
33.80	Contractor Oversight			
33.80.01	Professional Labor			
33.80.01.32	Health and Safety Plan			
	Project Engineer			
	2.00 HR	61.59	0.00	0.00
	Certified Industrial Hygienist			
	20.00 HR	615.85	0.00	0.00
	Other Direct Costs			
	1.00 LS	0.00	0.00	10.67
33.80.01.46	Work Plan Amendments			
	Project Engineer			
	6.00 HR	184.76	0.00	0.00
	Staff Engineer			
	10.00 HR	234.02	0.00	0.00
	Staff Hydrogeologist			
	5.00 HR	117.01	0.00	0.00
	Word Processing/Clerical			
	16.00 HR	197.07	0.00	0.00
	Certified Industrial Hygienist			
	3.00 HR	92.38	0.00	0.00
	Other Direct Costs			
	1.00 LS	0.00	0.00	12.61
	Total Capital Costs	12,525.23	0.00	194.97
	Total Professional Labor	12,525.23	0.00	194.97
	TOTAL DIRECT COSTS REMEDIAL ACTION	34,435.64	19,927.46	101,180.64

* * * * This System Intended For Government Use Only * * * *