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"REMEDIAL ACTION PLAN ADDENDUM FOR BUILDING 46 FORMER TANKS 46R, 46D, 46SUL AND 46UL NAS CECIL FIELD FL"
6/1/2000
TETRA TECH NUS INC

Remedial Action Plan Addendum
Building 46
Former Tanks 46R, 46D, 46SUL, and 46UL

for

Naval Air Station
Cecil Field

Jacksonville, Florida

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888

Contract Task Order 0065

June 2000

JUNE 2000

REMEDIAL ACTION PLAN ADDENDUM
FOR
BUILDING 46, FORMER TANKS 46R, 46D, 46SUL, AND 46UL

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Southern Division
Naval Facilities Engineering Command
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North Charleston, South Carolina 29406

Submitted by:
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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0065

JUNE 2000

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The engineering design and professional opinions rendered in this Remedial Action Plan Addendum, Building 46, Former Tanks 46R, 46D, 46 SUL, and 46UL, Naval Air Station Cecil Field, Jacksonville, Florida, were conducted or developed in accordance with commonly accepted procedures and are consistent with applicable standards of practice. If conditions during implementation are determined to be different than those described in this document, then the undersigned professional engineer should be notified to evaluate the effects the additional information has on the information described in this report.

Mark P. Speranza

Mark P. Speranza, P.E.
Professional Engineer No. PE0050304

Mark Speranza

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LIST OF ACRONYMS AND ABBREVIATIONS

AS	air spraying
AS/VE	air sparging/vapor extraction
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene and xylenes
cfh	cubic foot per hour
cfm	cubic foot per minute
CLEAN	Comprehensive Long-Term Environmental Action Navy
COP	cross-over protection
CTO	Contract Task Order
DIC	dissolved inorganic carbon
DO	dissolved oxygen
DOE	Department of Energy
DPT	direct-push technology
EPA	United States Environmental Protection Agency
F.A.C	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
ft^2	square foot/square feet
HLA	Harding Lawson Associates
IDW	investigation-derived waste
KAG	Kerosene analyte group
LEL	Lower Explosive Level
mg/L	milligram per liter
ml	milliliter
MTBE	methyl tertbutyl ether
NA	natural attenuation
NAS	Naval Air Station
NPW	net present worth
O&M	operation and maintenance
ORNL	Oak Ridge National Laboratory
ORP	oxidation/reduction potential
OVA	organic vapor analyzer
PAH	polynuclear aromatic hydrocarbon
psi	pound per square inch
psig	pound per square inch gauge
PVC	polyvinyl chloride

RAP	Remedial Action Plan
SAR	Site Assessment Report
SOUTHDIVNAVFACENGCOM	Southern Division Naval Facility Engineering Command
TEP	triethylphosphate
TRPH	total recoverable petroleum hydrocarbon
TtNUS	Tetra Tech NUS, Inc.
UIC	Underground Injection Control
UST	underground storage tank
VE	vapor extractor
VOC	volatile organic compound

1.0 INTRODUCTION

This Remedial Action Plan (RAP) Addendum for Naval Air Station (NAS) Cecil Field, Building 46, Former Tanks 46R, 46D, 46SUL, and 46UL (Building 46) has been prepared by Tetra Tech NUS, Inc. (TtNUS) for the Southern Division Naval Facilities Engineering Command (SOUTHDIVNAVFACENGCOM) under the Navy Comprehensive Long-Term Environmental Action Navy (CLEAN) Program, Contract Number N62467-94-D-0888, Contract Task Order (CTO) 0065. The purpose of this RAP Addendum is to provide the conceptual design of a modification to the previously selected remedial alternative at Building 46. This remedial action is being performed according to Florida Administrative Code (F.A.C) regulations covering leaks and discharges of petroleum products, as described in F.A.C 62-770.

Building 46 was the former base gas station and featured eight underground storage tanks (USTs), all of which were removed in June 1988. Four of these tanks were in operation before 1970. These four tanks were unidentified and their contents were unknown, but facility drawings indicate that these tanks each had a 2,000-gallon capacity and were located just south of Building 46. The remaining four tanks, identified as 46R, 46D, 46SUL, and 46UL were installed in 1970 adjacent to Building 46 itself. Tanks 46R and 46UL both had a 10,000-gallon capacity and were used to store regular and unleaded gasoline, respectively. Tanks 46D and 46SUL both had a 6,000-gallon capacity and were used to store diesel and super unleaded gasoline, respectively.

The Site Assessment Report (SAR) prepared for Building 46 (Harding Lawson Associates [HLA], 1998) concluded that operation of the USTs had resulted in contamination of soil and groundwater with fuel-related compounds, including benzene, toluene, ethylbenzene, and xylenes (BTEX), methyl-tertbutylether (MTBE), naphthalene, and total recoverable petroleum hydrocarbons (TRPHs). The SAR determined that an area of soil approximately 5,500 square feet (ft^2) in size at the location of the former USTs was highly contaminated down to a depth of 7 feet below ground surface (bgs) and acted as a source of groundwater contamination. The SAR also established that the areal extent of the groundwater contaminant plume in the shallow (7 to 25 ft bgs), intermediate (25 to 50 ft bgs), and deep (50 to 92 ft bgs) zones of the surficial aquifer were approximately 25,300 ft^2, 95,700 ft^2, and 31,000 ft^2, respectively. Figure 1-1 illustrates the approximate horizontal extent of groundwater contamination.

A RAP for Building 46 was previously prepared and submitted by TtNUS in March 1999 (TtNUS, 1999). The 1999 RAP described a remedial action that included the following components:

- Air Sparging/Vapor Extraction (AS/VE) for the remediation of the highly contaminated soil and groundwater in the source area

- Monitored natural attenuation (NA) for the remediation of the remainder of the groundwater contaminant plume.

Since the issuance of the 1999 RAP, the Navy has identified an opportunity to improve the proposed remedial action by integrating an innovative technology that would allow for more effective site cleanup because it would actively address not only the highly contaminated soil and groundwater of the source area but also the less-contaminated remainder of the groundwater plume. This technology features a nutrient-enhanced biosparging system known as the PHOSter Nutrient Injection System. The process will improve the effectiveness of the air sparging (AS) component of the previously proposed remedy through pulsed injection of oxygen, nitrogen, and phosphorus, which stimulates the growth of indigenous petrophilic microorganisms. This results in a significantly wider radius of influence for each air sparging well, allowing active remediation of the entire groundwater contaminant plume with a reasonable number of wells. By shifting the primary contaminant removal mechanism from physical volatilization to biodegradation, integration of the PHOSter technology also allows elimination of the vapor extraction (VE) component of the previously proposed remedy.

Use of the PHOSter technology has been recognized as appropriate for the remediation of petroleum-contaminated sites by the Florida Department of Environmental Protection (FDEP), as evidenced by the letter of review and approval attached as Appendix A.

This RAP Addendum has four sections. Section 1.0 provides this brief introduction. Section 2.0 provides a design and cost estimate for the proposed modified remedial system. Section 3.0 describes the installation, startup, and operation and maintenance (O&M) of the proposed modified remedial system. Section 4.0 describes the revised groundwater monitoring program.

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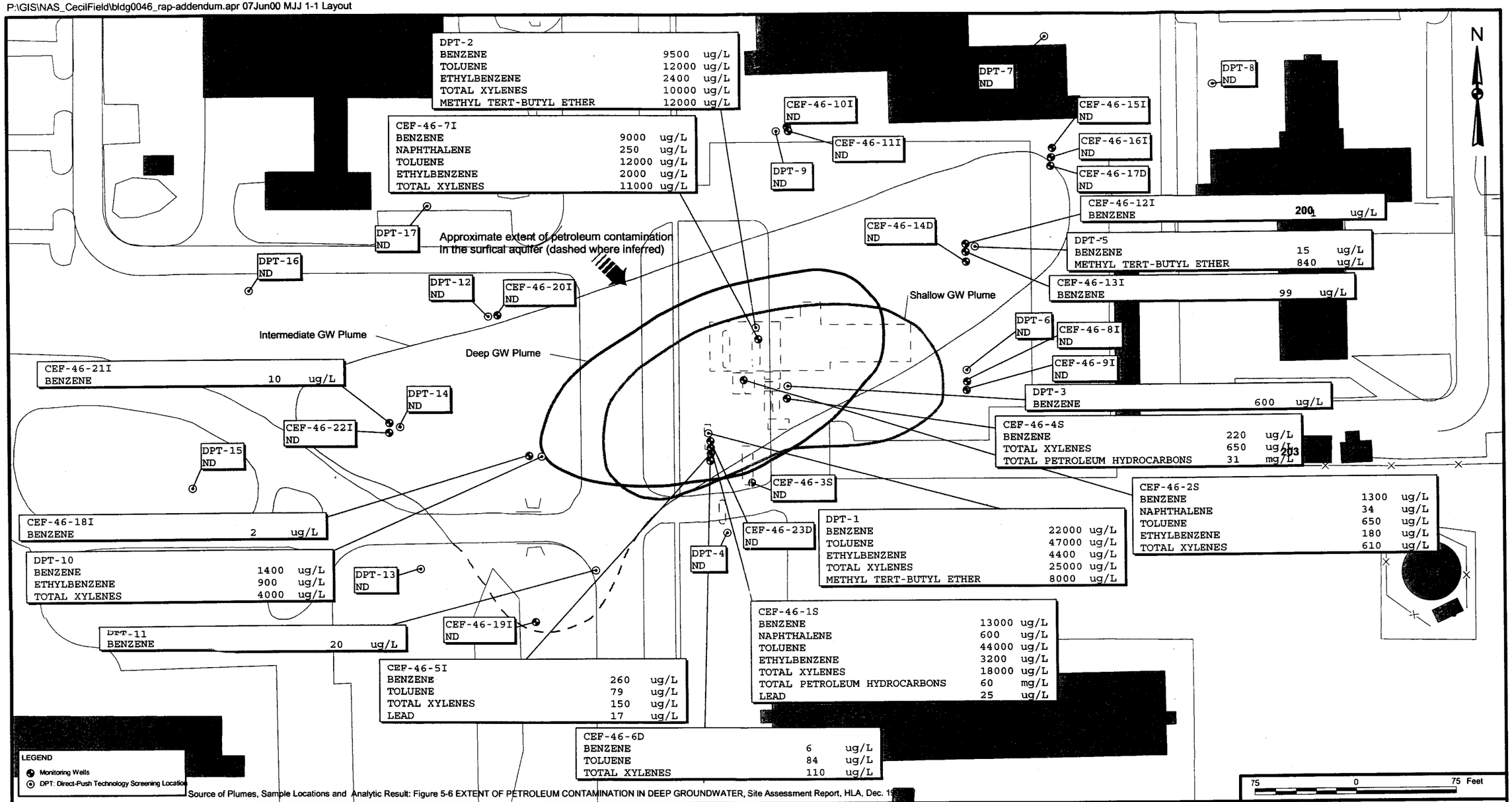

Source of Plumes, Sample Locations and Analytic Result: Figure 5-6 EXTENT OF PETROLEUM CONTAMINATION IN DEEP GROUNDWATER, Site Assessment Report, HLA, Dec. 19

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PETROLEUM CONTAMINANTS EXCEEDING CLEANUP TARGET LEVELS IN THE SURFICIAL AQUIFER BUILDING 46, RAP ADDENDUM NAS CECIL FIELD JACKSONVILLE, FLORIDA

CONTRACT NO. 7895
APPROVED BY DATE 06/12/00
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2.0 MODIFIED REMEDIATION SYSTEM DESIGN

2.1 PHOSTER NUTRIENT INJECTION SYSTEM PROCESS OVERVIEW

The PHOSter Nutrient Injection System was developed by a team from the Westinghouse Savannah River Technology Center at the Oak Ridge National Laboratory (ORNL) and the Evoca Corporation at the Department of Energy's (DOE) Savannah River Site. This technology provides an effective means of subsurface delivery of oxygen, nitrogen, and phosphorus to enhance the development of naturally occurring heterotrophic bacteria that have the capability of metabolizing petroleum wastes.

In the PHOSter Nutrient Injection System, oxygen, nitrogen, and phosphorus are injected as gases through wells installed into the contaminated aquifer. A compressor is used to inject air as the oxygen source and the air flow is mixed with nitrous oxide and vapor-phase triethylphosphate (TEP) to provide nitrogen and phosphorus, respectively. Towards the end of cleanup operations, when contaminant concentrations have been reduced to the point where insufficient food (contaminants) is available to sustain an effective microorganism population, propane is also injected as a carbon source. The gaseous mixture travels down the injection wells and is released through the screened intervals, which allows for a much more homogeneous distribution of nutrients throughout the contaminant plume as compared to that achieved with the more traditional injection of liquid nutrients.

2.2 SYSTEM DESIGN

The PHOSter Nutrient Injection System is a patented system. As such, the necessary design parameters are proprietary. The Navy has retained a licensed vendor of this system, Priester & Associates, to supply these parameters. Priester & Associates will also supply the necessary trailer-mounted equipment and operate and maintain the system during its active operation.

2.2.1 Injection Wells and Distribution Piping

Based upon Preister & Associates' experience of operating the PHOSter system in similar lithologies, the radius of influence of each injection well is anticipated to be 30 to 35 feet for those wells installed in the intermediate zone of the surficial aquifer (25 to 50 ft bgs) and 40 to 45 feet for those wells installed in the deep zone of the surficial aquifer (50 to 90 ft bgs).

Accordingly, the PHOSter Nutrient Injection System proposed for remediation of the Building 46 site will feature a total of 30 injections wells, including 16 installed in the intermediate zone of the surficial aquifer and 14 installed in the deep zone of the surficial aquifer. To break up the relatively large areal extent of the contaminant plume and to allow for even gas distribution, these wells will be divided into two areas,

including a West Area featuring 8 intermediate and 3 deep wells and an East Area featuring 8 intermediate and 11 deep wells. Figure 2-1 shows the proposed layout of the injection wells and distribution piping.

Injection wells will be constructed of Schedule 40 carbon steel pipe with 5 feet of 0.020-inch slotted stainless steel pipe and a carbon steel cap. Inside diameter of the casing will be ½-inch for the intermediate wells and ¾-inch for the deep wells. The intermediate wells will be installed to 40 feet bgs, and the deep wells will be installed to 90 feet bgs. To minimize installation costs and the generation of investigation-derived waste (IDW), the intermediate injection wells will be installed using direct push technology (DPT). The deep injection wells will be installed with hollow-stem auger or Rotosonic drilling. Figure 2-2 shows typical injection well construction details.

Distribution piping will be constructed of ½- or ¾-inch diameter, 200 pounds-per-square-inch-(psi)-rated industrial rubber hose. In unpaved areas, piping will be installed in a shallow (18 inches deep) trench. In paved areas (parking lots), piping will be laid on the surface and encased in high-strength plastic single- or five-channel cross-over protection (COP) elements. Typical cross-sections of the piping trenches and COP elements are shown on Figure 2-3.

2.2.2 Gas Injection

The flow rate of gas injection will be approximately 3 to 5 cubic feet per minute (cfm) per well. Accordingly the total gas injection flow rate will be 33 to 55 cfm for the West Area and 57 to 95 cfm for the East Area.

Injection pressure is estimated at 20 psi gauge (psig) for the intermediate wells and 50 psig for the deep wells.

Gas injection will not be continuous but pulsed. This pulsing action ensures that the PHOSter system does not over- or under-stimulate the indigenous microorganisms by injecting too much or too little nutrients. The PHOSter system features a programmable injection cycle controller so that the correct amounts of nutrients will be applied to the subsurface. The use of pulsed injection cycles also minimizes volatilization of petroleum compounds, resulting in negligible volatile emissions. Injection cycles will be initially programmed to last 12 hours per day. Once the system has been started, the duration will be adjusted depending on the degree of volatilization experienced.

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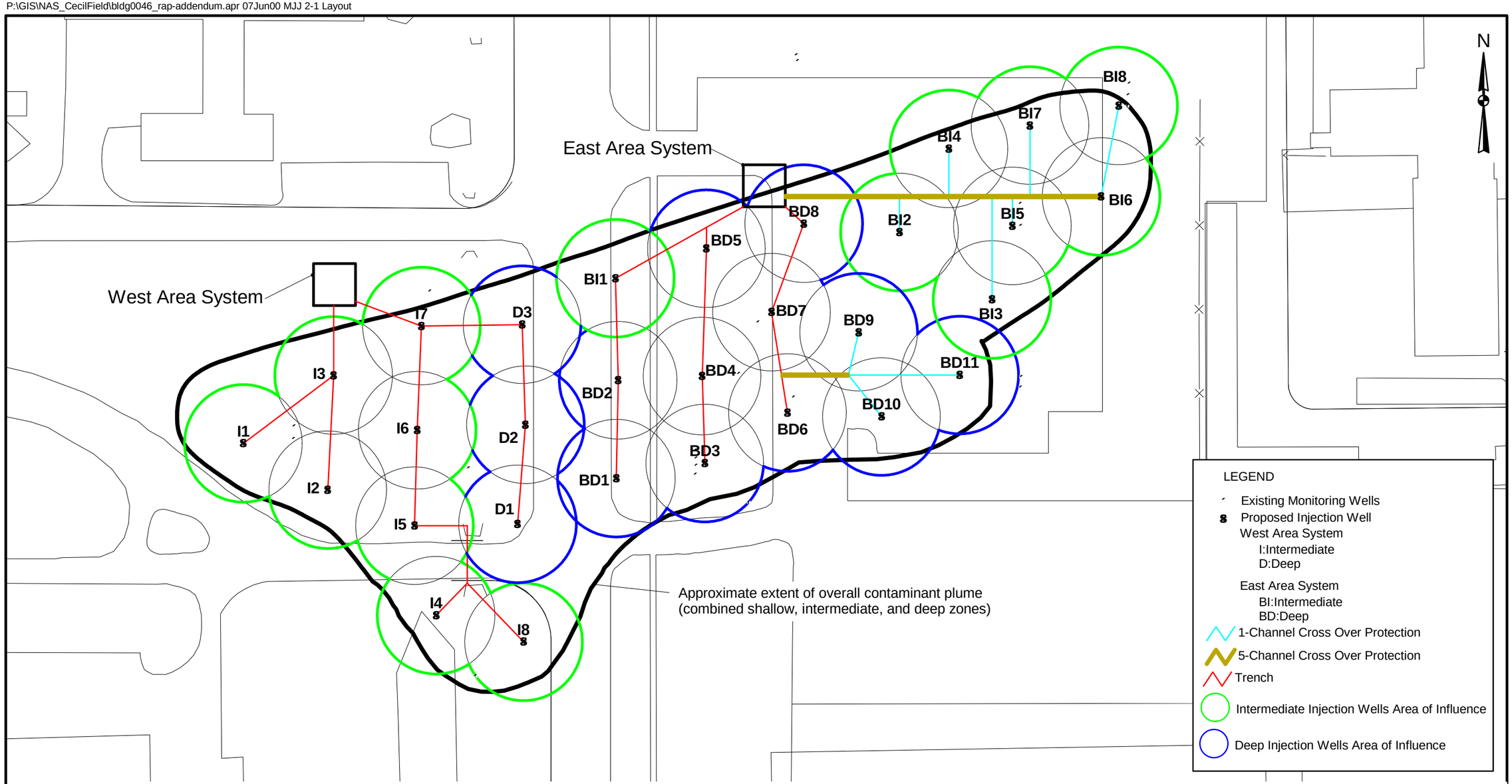

Source of Plumes, Sample Locations and Analytic Result: Figure 5-6 EXTENT OF PETROLEUM CONTAMINATION IN DEEP GROUNDWATER, Site Assessment Report, HLA, Dec. 1998.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

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SCALE	AS NOTED

INJECTION WELLS AND
DISTRUTION PIPING LAYOUT
BUILDING 46, RAP ADDENDUM
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

CONTRACT NO.	7895
APPROVED BY	DATE
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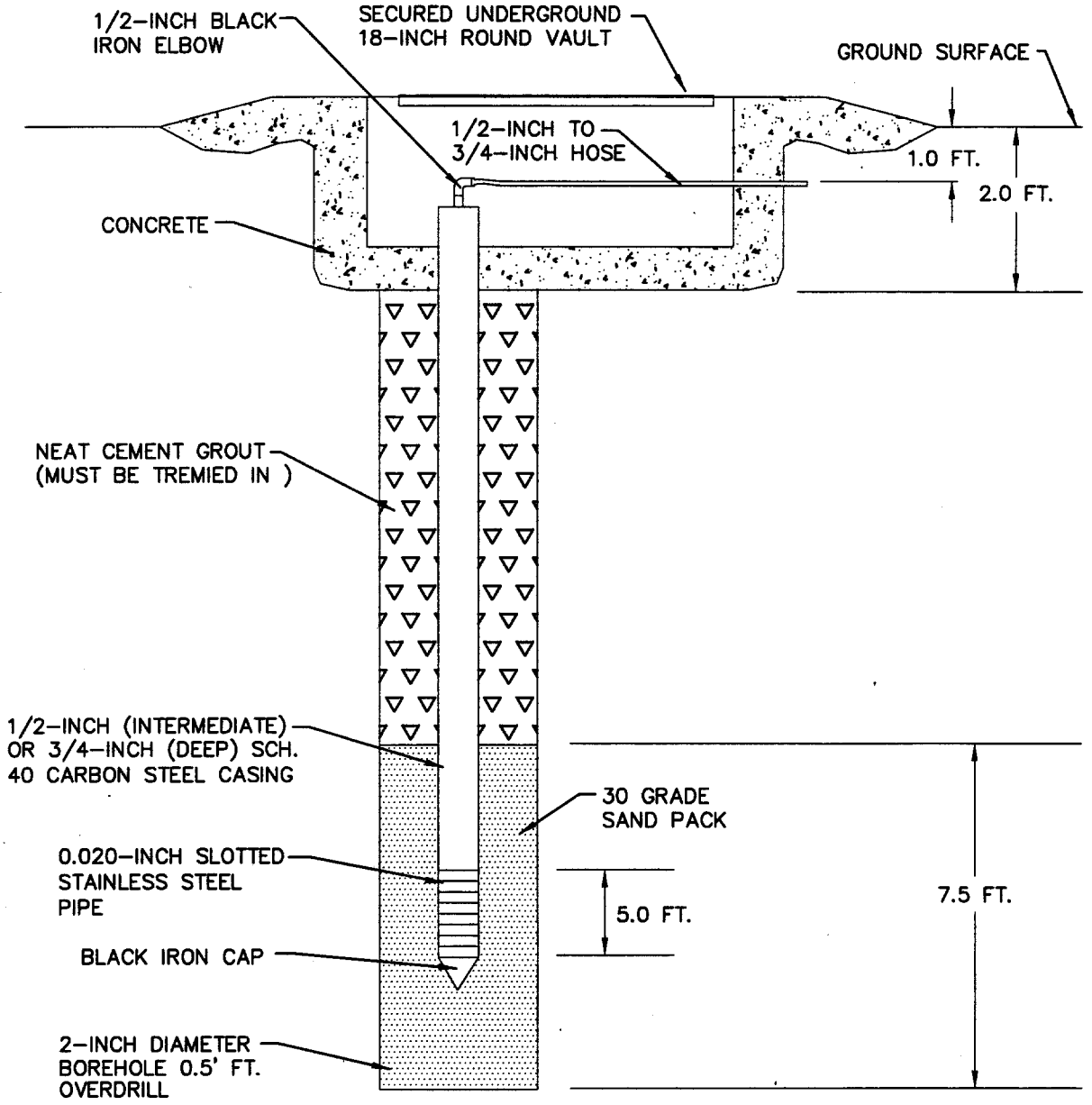

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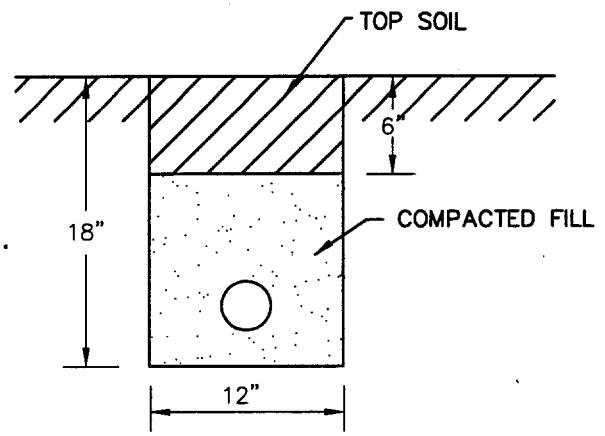

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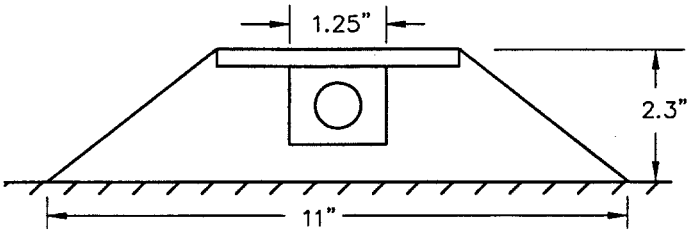

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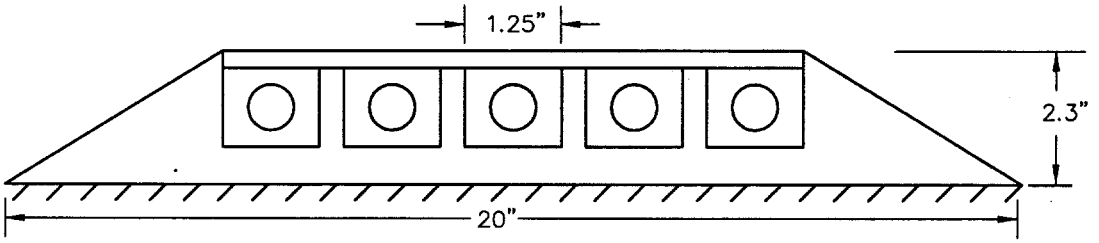

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CROSS-OVER PROTECTION (COP) (PAVED AREAS)

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2.2.3 Nutrient Quantities

Based upon an estimated cleanup time of 12 months, the quantities of nutrients to be injected over the life of the project are estimated as follows:

- Oxygen: 3 to 5 cfm of air per well, or approximately 2,730,000 pounds of air or 546,000 pounds of oxygen
- Nitrous oxide: From 0.07 to 0.1 percent by volume of air flow, or approximately 2,700 pounds
- Triethylphosphate: From 0.007 to 0.01 percent by volume of air flow, or approximately 270 pounds
- Propane (last 8 weeks only): 50 percent of lower explosive level (LEL) in air, or 38 cubic feet per hour (cfh) for 6 hours once every other week, or approximately 148 pounds.

2.2.4 Underground Injection Control Permit

The information required by the Division of Water Facilities for an Underground Injection Control (UIC) permit is provided in Appendix B. The proposed monitoring plan described in Section 4.0 provides the additional analyses required by the UIC program.

2.3 COSTS

Estimated costs of the PHOSter Nutrient Injection System for the Building 46 site may be summarized as follows:

Capital:	$599,378
O&M:	$11,150 to 65,700/year
Net Present Worth (NPW):	$706,895

Detailed cost estimates are provided in Appendix C.

3.0 INSTALLATION, START UP, AND OPERATION AND MAINTENANCE

3.1 PRE-INSTALLATION SOIL SAMPLING

In order to obtain the additional data necessary for a more accurate delineation of the source-area soil contamination which exceeds cleanup goals, additional sampling and analysis will be performed before installing the PHOSter Nutrient Injection System. Twelve soil borings will be advanced to the water table on a 20-to-25-foot grid spacing covering the currently assumed source area of 5,500 ft^2. The soil samples will be analyzed for Kerosene analyte group (KAG) fractions previously detected at the site (Table 4-1). Based on these results, the location of the injection wells described in Section 2.2.1 and shown on Figure 2-1 may require adjustment.

3.2 SYSTEM INSTALLATION

Installation of the PHOSter Nutrient Injection System will include the following sequence of activities:

- Obtain required local and state permits
- Install 30 injection wells
- Coordinate delivery of the trailer-mounted nutrient injection equipment, including the West Area and East Area Nutrient Injection Systems
- Lay down the West and East Area Nutrient Injection Systems in appropriate locations
- Trench and install gas distribution piping from each of the trailer-mounted Nutrient Injection System to the appropriate injection wells
- Restore the site to its pre-construction condition
- Install 230 volt, single-phase, 100 amp electrical service to both the West Area and East Area Injection Systems locations and hookup electrical equipment
- Coordinate power connection with local electrical utility.

General construction specifications are provided in Appendix D.

3.3 SYSTEM START-UP

Following installation, the treatment system will go through a period of startup testing. During this time, selected monitoring wells will be tested for pressure and analyzed for dissolved oxygen (DO) to verify the predicted extent of the injection wells radii of influence. System modifications will be made, if necessary.

As-built drawings, certified by a Florida-registered Professional Engineer, will be prepared within six weeks of start up.

3.4 SYSTEM OPERATION AND MAINTENANCE

Priester & Associates will be responsible for the O&M of the PHOSter Nutrient Injection System during active remediation. Priester & Associates personnel will make regular site visits to inspect the system, make adjustments as may be required, perform equipment maintenance in accordance to manufacturers' specifications, and replenish the supply of nitrous oxide, triethylphosphate, and propane, as necessary.

4.0 MONITORING OF REMEDIAL PROGRESS

4.1 OVERVIEW

This section describes the sampling and analysis program that will be conducted to monitor the progress of the remedial action and verify that no migration of contaminated groundwater is occurring.

To achieve these objectives, this program will include sampling and analysis of soil and groundwater within the area of known contamination and sampling and analysis of groundwater downgradient from this area.

4.2 NEW MONITORING WELL INSTALLATION

A sufficient number of existing monitoring wells is available to evaluate the progress of the remedial action within the area of known contamination. Sufficient existing monitoring wells are also available to verify that the groundwater contaminant plume is not further expanding in a northeasterly direction from the source area. To verify that the groundwater contaminant plume is not further expanding in a southwesterly direction from the source area, one new deep monitoring well and two new intermediate monitoring wells will be installed in the surficial aquifer at the locations shown on Figure 4-1.

These wells will be designated as CEF-46-24D, and CEF-46-25I and CEF-46-26I, respectively. Well CEF-46-24D will be installed to a depth of 90 feet bgs and screened at a depth interval of 80 to 90 feet bgs. Wells CEF-46-25I and CEF-46-26I will be installed to a depth of 50 feet bgs and screened at a depth interval of 40 to 50 feet bgs. Well casings and screens will be constructed of 2-inch diameter Schedule 40 polyvinyl chloride (PVC).

The new monitoring wells will be installed and developed in accordance to the SOUTHDIVNAVFACENGCOM's "Monitoring Well Design, Installation, Construction, and Development Guidelines" (SOUTHDIVNAVFACENGCOM, 1997), the United States Environmental Protection Agency's (EPA) "Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells" (EPA, 1990), and EPA Region IV Science and Ecosystem Support Division "Environmental Investigation Standard Operating Procedures and Quality Assurance Manual" (EPA Region IV, 1996). New monitoring well construction detail is illustrated on Figure 4-2.

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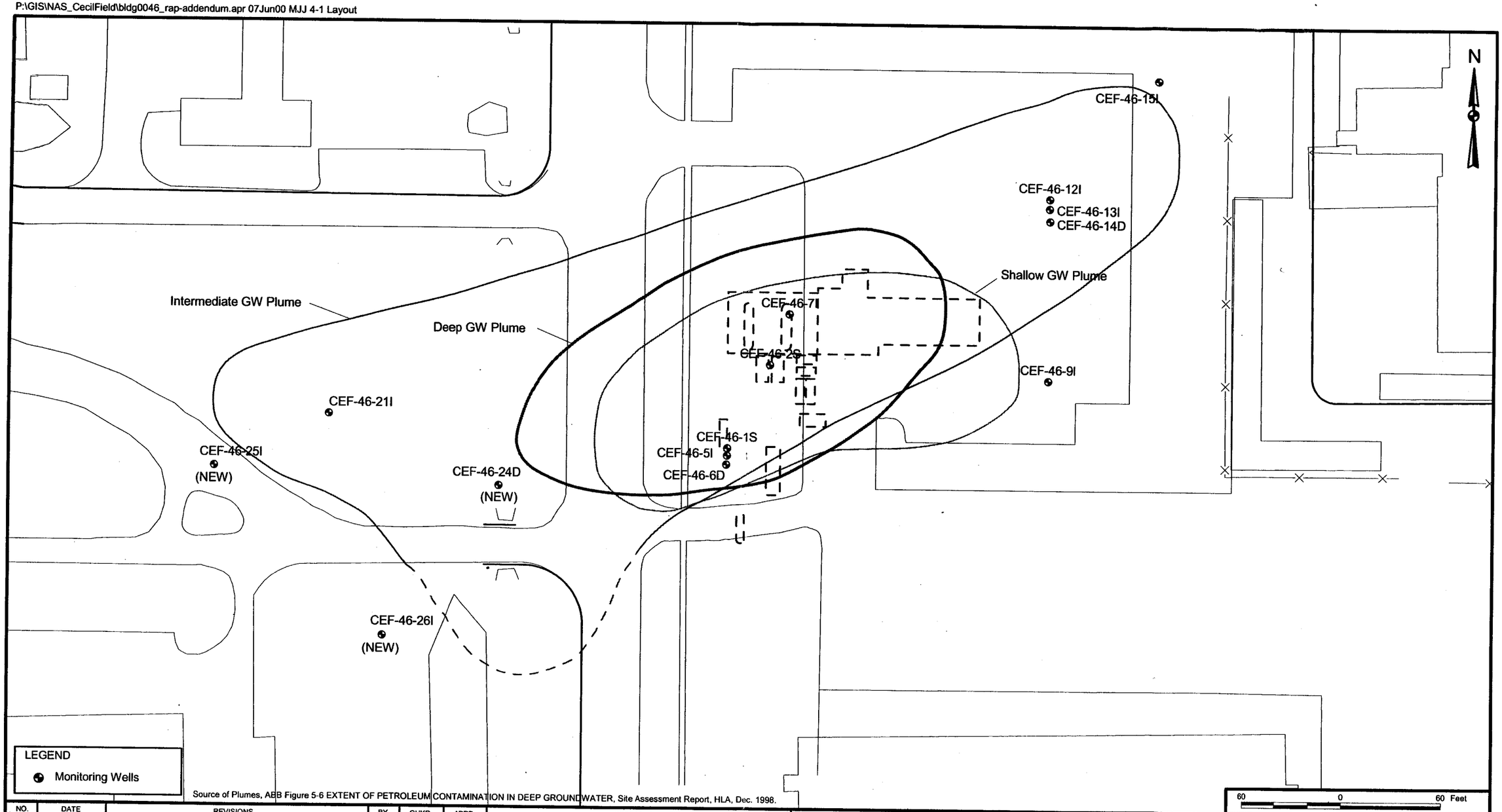

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PROPOSED GROUNDWATER SAMPLING LOCATIONS
REMEDIAL ACTION PLAN
BUILDING 46, RAP ADDENDUM
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

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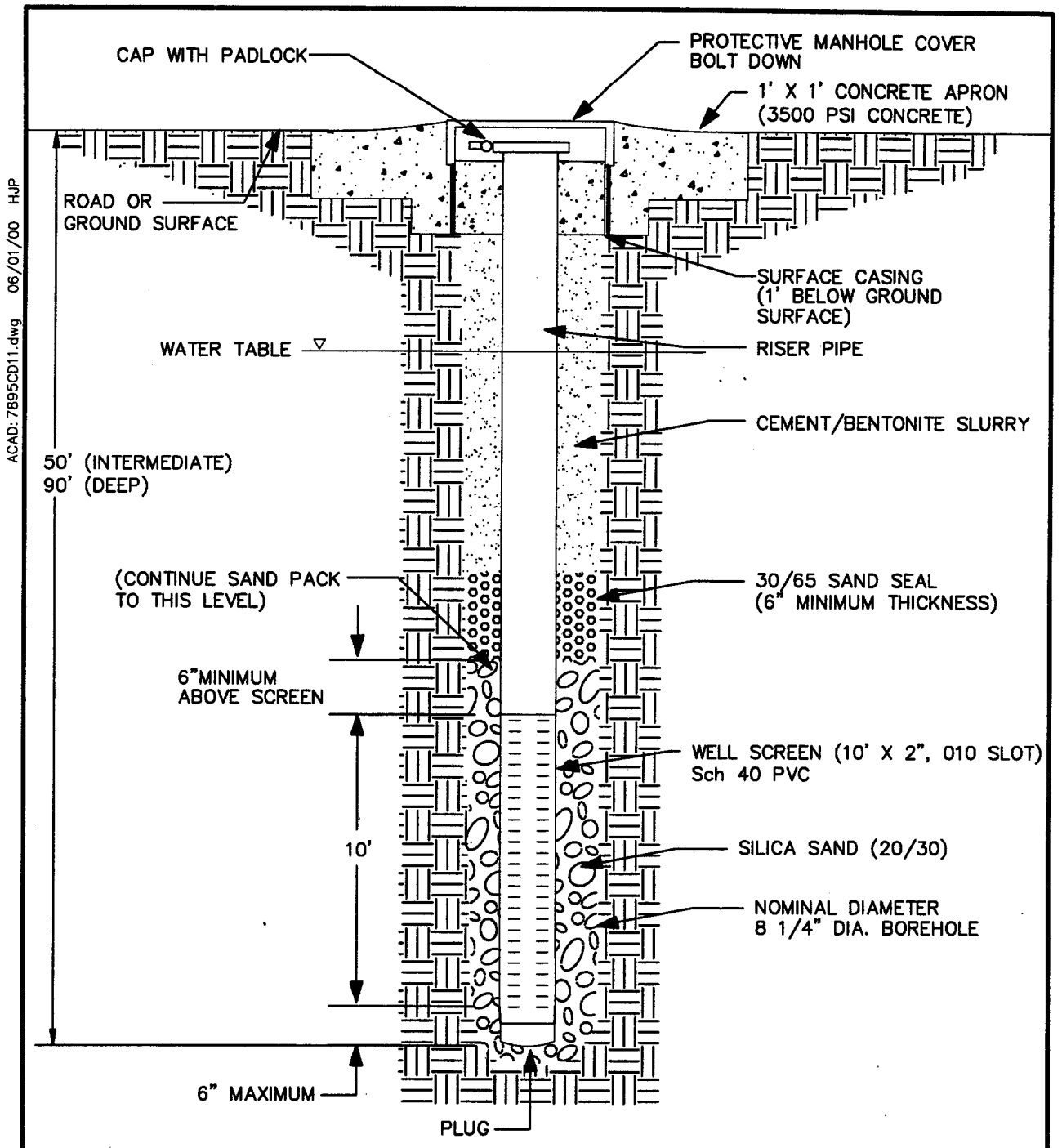

PROPOSED MONITORING WELL
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4.3 SAMPLING AND ANALYSIS

4.3.1 Soil Sampling and Analysis

Three soil borings will be installed quarterly during the 1 year of operation of the PHOSter Nutrient Injection System. These borings will be installed within the contaminant source area at the locations shown on Figure 4-3. The data from the soil borings will be used to verify the cleanup of vadose zone soil.

Soil borings will be advanced to the water table. Soil samples will be collected from each boring starting at a depth of 1 foot bgs and from every 2-foot interval thereafter. Samples will be field-screened with an organic vapor analyzer (OVA) in accordance with F.A.C Chapter 62-770.200. For each boring, the sample from the interval with the highest OVA reading will be analyzed for the KAG fractions previously detected at the site, as defined in Table 4-1.

After soil samples have been obtained, the borings will be backfilled with sand and the top of the borings sealed at grade with either a 6-inch layer of top soil in unpaved areas or with asphalt in paved areas.

4.3.2 Groundwater Sampling and Analysis

Groundwater samples will collected and analyzed to monitor contaminant reduction within the contaminant plume and to verify that this plume is not expanding.

4.3.2.1 Sampling Locations

The following eight existing monitoring wells will be used to monitor groundwater contaminant reduction:

- CEF-46-1S
- CEF-46-2S
- CEF-46-5I
- CEF-46-6D
- CEF-46-7I
- CEF-46-12I
- CEF-46-13I
- CEF-46-21I

Six monitoring wells, including three existing and three new, will be used to verify that the groundwater contaminant plume is not expanding, including:

- CEF-46-9I (existing)
- CEF-46-14D (existing)
- CEF-46-15I (existing)
- CEF-46-24D (new)
- CEF-46-25I (new)
- CEF-46-26I (new)

TABLE 4-1

ANALYTICAL REQUIREMENTS
SOIL AND GROUNDWATER MONITORING
BUILDING 46 REMEDIAL ACTION PLAN ADDENDUM
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

Parameter	Soil Analytical Method	Groundwater Analytical Method
KEROSENE ANALYTE GROUP		
BTEX and MTBE	EPA SW-846 8021B	EPA SW-846 8021B
Naphthalene and 15 method-listed PAHs	EPA SW-846 8310	EPA SW-846 8310
TRPHs	FDEP FL-PRO	FDEP FL-PRO
NUTRIENTS		
Nitrates, Nitrites, Orthophosphates	Not Required	EPA 300.0

NOTES:

BTEX benzene, toluene, ethylbenzene, and xylenes
EPA United States Environmental Protection Agency
FDEP Florida Department of Environmental Protection
MTBE methyl tertbutyl ether
PAHs polynuclear aromatic hydrocarbons
TRPHs total recoverable petroleum hydrocarbons
VOCs volatile organic compounds

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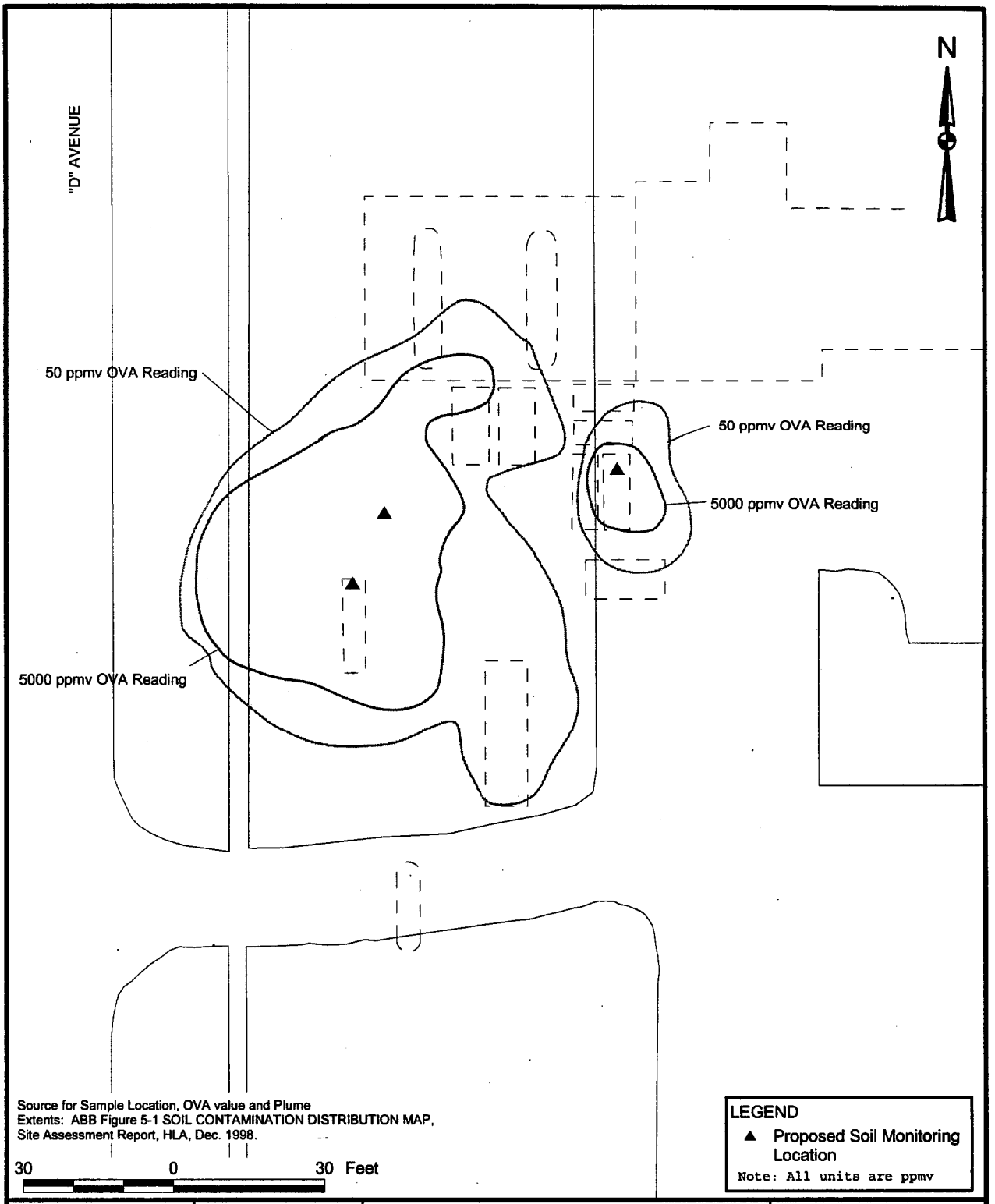

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COST/SCHEDULE-AREA			APPROVED BY DATE
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Sampling locations are shown on Figure 4-1.

4.3.2.2 Monitoring Phases

Four sequential phases of monitoring will be performed, including:

- Initial Baseline Monitoring
- Active Remediation Monitoring
- Natural Attenuation Monitoring
- Post-Remediation Monitoring

Initial baseline monitoring will consist of collecting one round of groundwater samples from the 14 monitoring wells listed above to establish site conditions before active remediation begins.

Active remediation monitoring will consist of collecting quarterly groundwater samples from the 14 monitoring wells listed above during the one year operation of the PHOSter Nutrient Injection System to evaluate contaminant reduction and verify that the plume is not expanding.

Natural attenuation monitoring will consist of collecting semi-annual groundwater samples from the 14 monitoring wells listed above for a period of 2 years after operation of the PHOSter Nutrient Injection System to verify the permanence of the contaminant reduction achieved through active remediation, evaluate the removal of residual contamination through natural attenuation, and verify that contaminant migration is not occurring.

Post-remediation monitoring will consist of collecting one additional round of groundwater samples from the 14 monitoring wells listed above one year after completion of the natural attenuation monitoring to verify the permanence of the contaminant reduction achieved through active remediation and natural attenuation and continue to verify that contaminant migration is not occurring.

Groundwater samples will be analyzed for the KAG fractions previously detected at the site and nutrients, including nitrates (NO_3^-), nitrites (NO_2^-), and orthophosphates (PO_4^{3-}) as defined in Table 4-1. In addition, samples collected for the initial baseline event and during the natural attenuation and post-remediation monitoring phases will also be analyzed for selected natural attenuation field parameters as defined in Table 4-2.

4.4 MONITORING REPORT

Following installation of the PHOSter Nutrient Injection System and new monitoring wells and the baseline sampling event, an initial monitoring report will be prepared. This report will describe field construction and sampling activities and present analytical results.

Following, each sampling event, the initial monitoring report will be updated to include a description of the latest sampling activities and analytical results. As the remedial action progresses, the monitoring report will also include an analysis of trends in contamination levels over time and an assessment of the effectiveness of the PHOSter Nutrient Injection System and natural attenuation process.

At the conclusion of the operation of the PHOSter Nutrient Injection System, the monitoring report will also provide conclusions and recommendations for future actions, as may be required.

4.5 CONTINGENCY MEASURES

Based on the conclusions and recommendations presented in the monitoring report, a decision will be made regarding the acceptability of the remedial action, and a modification to remedial approach may be considered. The modification could consist of continuing operation of the same or a modified PHOSter system or of applying one of the other potential remedial technologies evaluated in Section 4.0 of the RAP (TtNUS, 1999).

TABLE 4-2

GROUNDWATER NATURAL ATTENUATION PARAMETERS
FIELD ANALYTICAL METHODS
BUILDING 46 REMEDIAL ACTION PLAN ADDENDUM
NAS CECIL FIELD, JACKSONVILLE, FLORIDA
PAGE 1 OF 2

Parameter	Method[2]/ Reference	Data Use	Sample Volume, Container, & Preservation
Temperature	Direct-reading thermometer	Biological processes are temperature dependent.	100-250 ml in glass or plastic container. Analyze immediately.
Dissolved Oxygen	CHEMetrics Test Kit K7501 or 7512 - Vacuum vials/Rhodazine D and indigo carmine	Concentration of less than 1 mg/L indicates anaerobic conditions.	Follow test kit instructions. Analyze immediately to nearest 0.2 mg/L.
pH	Direct-reading meter	Biological processes are pH sensitive.	100-250 ml in glass or plastic container. Analyze immediately.
Conductivity	Direct-reading meter	General water quality parameter used to verify that site samples are obtained from the same groundwater system.	100-250 ml in glass or plastic container. Analyze immediately.
Alkalinity/Dissolved Inorganic Carbon (DIC)	HACH Test Kit Number AL-DT - Digital Titration - Phenolphthalein and Total Method (HACH Method 8203)	DIC concentrations, in comparison to total alkalinity, provide an indication of the amount of CO_2 generated during aerobic or anaerobic reduction of a hydrocarbon.	Follow test kit instructions. Analyze immediately to determine carbonate, bicarbonate, and hydroxide ions to the nearest 10 mg/L.
Ferrous Iron (Fe^{+2})	HACH Test Kit Number IR-18C - Color Disc 1,10 Phenanthroline Method	Presence of ferrous iron may indicate presence of an anaerobic degradation process due to depletion of oxygen, nitrate, and manganese.	Follow test kit instructions. Analyze immediately to nearest 0.2 mg/L.
Hydrogen Sulfide (H_2S)	HACH Test Kit Number HS-C - Color Chart or DR-850 colorimeter Effervescence of H_2S	Provides evidence of sulfate-based anaerobic degradation. May also indicate natural H_2S production.	Follow test kit instructions. Do not aerate or agitate. Analyze immediately. Analyze to nearest 0.1 mg/L.
Oxidation/Reduction Potential (ORP)	Direct-Reading Meter	ORP provides information on Red/Ox conditions and to interpret the nature and state of chemical compounds and biological conditions. ORP typically ranges from +200mV in normal aerobic oxidizing conditions to -400mV in strongly anaerobic, reductive conditions.	10-250 ml in glass container filling from the bottom. Do not aerate or agitate. Analyze immediately.

TABLE 4-2

GROUNDWATER NATURAL ATTENUATION PARAMETERS
FIELD ANALYTICAL METHODS
BUILDING 46 REMEDIAL ACTION PLAN ADDENDUM
NAS CECIL FIELD, JACKSONVILLE, FLORIDA
PAGE 2 OF 2

Parameter	Method[2]/ Reference	Data Use	Sample Volume, Container, & Preservation
Carbon Dioxide (CO_2)	HACH Test Kit Number CA-DT - Digital Titration - Sodium Hydroxide & Phenolphthalein Method (HACH Method 8205)	May be compared with background values as an indication of aerobic and anaerobic process. Is produced during aerobic respiration as well as anaerobic processes. Is utilized during methanogenesis.	Follow test kit instructions. Do not aerate or agitate. Analyze immediately. Analyze to nearest 0.1 mg/L.

NOTES:

1 Table adapted from the Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater (EPA, 1998).
2 Method refers to EPA test methods. Standard Methods are based on Standard Methods for the Examination of Water and Wastewater (Clesceri, et al., 1992)

REFERENCES

Clesceri, et al., 1992. *Standard Methods for the Examination of Water and Wastewater*.

EPA (United States Environmental Protection Agency), 1990. *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells.* EPA/600/4-89/034. April.

EPA Region IV, 1996. *Environmental Investigation Standard Operating Procedures and Quality Assurance Manual*, Science and Ecosystems Support Division.

EPA, 1998. *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater*, EPA/600/R-98/128, September.

HLA (Harding Lawson Associates, Inc.), 1998. *Site Assessment Report, Building 46, Tanks 46R, 46D, 46SUL, and 46UL, Base Realignment and Closure Miscellaneous Tank Sites, Naval Air Station Cecil Field, Jacksonville, Florida.* Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina. December.

SOUTHNAVFACENGCOM (Southern Division, Naval Facilities Engineering Command), 1997. *Monitoring Well Design, Installation, Construction, and Development Guidelines*.

TtNUS, 1999. *Remedial Action Plan, Building 46, Former Tanks 46R, 46D, 46SUL, and 46UL, NAS Cecil Field, Jacksonville, Florida.* Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina. March.

APPENDIX A

FDEP TECHNOLOGY APPROVAL LETTER

Department of
Environmental Protection

Jeb Bush
Governor

Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

David B. Struhs
Secretary

October 19, 1999

Mr. L. Chip Priester
Priester and Associates, Inc.
1345 Garner Lane, Suite 105
Columbia, South Carolina 29210

Re: PHOSter Nutrient Injection System

Dear Mr. Priester:

The Bureau of Petroleum Storage Systems hereby acknowledges that Priester and Associates is a licensee of the PHOSter vapor-phase nutrient injection system, for in situ bioremediation of petroleum hydrocarbons in soil and groundwater by indigenous microorganisms. It is our understanding that this system was developed by the U.S. Department of Energy and the Savannah River Technology Center, and is now being commercialized through agreements with the Department of Energy.

An official letter of acceptance for the PHOSter system was first issued on August 8, 1997. And although it is not necessary for all licensees to hold an identical but separate letter, this bureau is willing to acknowledgement Priester and Associates as a licensee, in order to increase the visibility of innovative products and processes in Florida. The content of this letter is identical to that of the original August 8, 1997 acceptance, but the format has been modified for the sake of clarity.

The bureau recognizes the PHOSter system as a viable technology for the remediation of petroleum contaminated sites in Florida, pursuant to Chapter 62-770, Florida Administrative Code (F.A.C.). There are no objections to its use, provided: (a) the considerations of this letter are taken into account; (b) a Remedial Action Plan is approved by the Department for each site prior to the commencement of work; and (c) appropriate and applicable underground injection control rules are observed.

While the Department of Environmental Protection does not provide endorsement of specific or brand name remediation products or processes, it does recognize the need to determine their acceptability from an environmental standpoint with respect to applicable rules and regulations, and the interests of public health, safety, and welfare. Vendor's must then market the products and processes on their own merits regarding performance, cost, and safety in comparison to competing alternatives in the marketplace. For the PHOSter system, the major environmental and regulatory items of interest are discussed in enclosure 1.

Preparers of Remedial Action Plans for state-funded cleanups are advised to include a copy of this letter in the appendix of plans they submit, and call attention to it in the text of their document. In this way,

technical reviewers throughout the state and its contracted local reviewing programs will be informed that you have contacted the Department of Environmental Protection to inquire about the environmental acceptability of this process. To aid those reviewers, the Bureau of Petroleum Storage Systems provides supplemental information as enclosure 2.

The Department reserves the right to revoke its acceptance of a product or process if the nature or composition of its ingredients, or its performance, has been falsely represented. Additionally, Department acceptance of any product or process does not imply it has been deemed applicable for all cleanup situations, or that it is preferred over other treatment or cleanup techniques in any particular case. A site specific evaluation of applicability and cost-effectiveness must be considered for any product or process, whether conventional or innovative, and adequate site specific design details must be provided in Remedial Action Plans prescribing the product or process. You may contact me at 850/487-3299 if there are any questions.

Sincerely,

Rick Ruscito, P.E.
Bureau of Petroleum Storage Systems

cc: T. Conrardy - FDEP/Tallahassee

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ENCLOSURE 1

PHOSter SYSTEM: ENVIRONMENTAL AND REGULATORY INFORMATION

For the PHOSter system, the major environmental and regulatory concerns are discussed below.

1. Applicable regulations: The following chapters of the Florida Administrative Code are cited, as portions of them may be applicable to the PHOSter system: Chapter 62-550, F.A.C., for primary and secondary water quality standards; Chapter 62-520, F.A.C. for groundwater classes and standards; Chapter 62-522, F.A.C., for groundwater permitting and monitoring requirements; and Chapter 62-528, F.A.C., for underground injection control, particularly Part V, for Class V, Group 4 aquifer remediation projects.

2. Vapor-phase injections: Even though Chapter 62-528, F.A.C., is a comprehensive document pertaining to underground injection, it could not have anticipated technological advances creating the need to regulate vapor-phase injection concentrations for the purpose of aquifer remediation, just those of a liquid. And Chapter 62-550, F.A.C., whose primary and secondary drinking water standards are cited as criteria for the underground injection of fluids, pertains only to liquid-phase concentrations as well. The Department, in response to this situation, instead of using the usual front-end approach to protecting groundwater quality by ensuring that an injected liquid meets drinking water standards, will seek assurance, through monitoring, that injected gases cause no primary or secondary water quality standards or background values to be exceeded. The onus shall therefore be on users of the PHOSter system to ensure that all applicable groundwater contaminant standards will be met at the time of project completion for any residuals associated with the injected substances, any byproducts produced as a result of the chemical transformation of those substances or the petroleum, and the remaining traces of the original petroleum contaminants.

3. Background samples: Prior to commencement of remediation, at least one (1) monitoring well located outside the petroleum contamination plume shall be sampled and analyzed for background concentration of nitrates, nitrites, and phosphorus. If only one well is sampled, then it should be upgradient, pursuant to Rule 62-520.420(3), F.A.C. If more than one well is sampled, then the average value of each parameter can be used as the background value for the site. As a matter of good practice, but not as a regulatory requirement, it may be beneficial to obtain background values of dissolved oxygen, pH, temperature, total dissolved solids, hydraulic conductivity, moisture content of soil (if soil is to be remediated) and other pertinent bioremediation parameters or micronutrients of interest.

4. Groundwater monitoring: During active remediation, the appropriate petroleum contaminants of concern shall be sampled in accordance with the frequency specified in Rule 62-770.700(3)(i), F.A.C. For the cleanup of sites where the period of active remediation is expected to be brief (60 to 90 days for example) it may be necessary to conduct sampling more frequently than quarterly, in order to accurately gauge the progress of the cleanup.

Like any other petroleum site remediation project, PHOSter system projects shall include at least one (1) year of quarterly post remediation groundwater monitoring for the petroleum contaminants of concern, at a minimum of two (2) wells, one located in the area of maximum contamination, the other downgradient, pursuant to Section 62-770.750, F.A.C.

For underground injection control, during both the active and post remediation periods, the Department has determined that the frequency and parameters of groundwater monitoring, for tracking PHOSter system byproducts, shall be at least quarterly, for nitrates, nitrites, and total phosphorus. The sampling shall be conducted at a minimum of two (2) wells, one located in the central region of the PHOSter injection points, the other downgradient. For a given remediation site, costs may be kept to a minimum by installing two monitoring wells in locations such that they may serve as both the petroleum remediation tracking wells, pursuant to Section 62-770.750, F.A.C., and the PHOSter parameters tracking wells, pursuant to Rule 62-528.615(2), F.A.C. The PHOSter system parameters to be sampled for comparison to drinking water standards listed in Chapter 62-550, F.A.C., (or a site's background concentrations) are as follows: nitrate [10,000 micrograms per liter (ug/L) maximum, as nitrogen, N], nitrite (1,000 ug/L maximum, as N), and total phosphorus [groundwater concentration not regulated, (as P)].

The selection of nitrate, nitrite, and phosphorus for underground injection monitoring purposes is a technical decision to track the fate of nitrogen and phosphorus atoms contained in the originally injected nitrous oxide and triethylphosphate, neither of which is a regulated primary or secondary drinking water contaminant. In the event that chemical or biochemical processes transform the nitrogen to nitrate and/or nitrite, in concentrations which exceed primary drinking water standards, then monitoring will detect the problem.

Phosphorus tracking does not allow for a comparison to groundwater or primary or secondary drinking water standards, since phosphorus compounds in groundwater are not regulated. Attention usually focuses on the eutrophication of surface waters. So, in cases where a PHOSter groundwater remediation project may impact surface water, it is advised that the concentration of phosphorus in the surface water not be raised above the 0.1 microgram per liter (ug/L), as P, concentration set forth in Rule 62-302.530(54), F.A.C., for surface water quality standards.

For oxygen injected by the PHOSter system in the form of compressed air, the Department determines that tracking shall not be mandatory for injection control purposes, since the presence of dissolved oxygen in a groundwater is generally not considered to be a problem. It is, however, recommended that dissolved oxygen concentration be measured as a matter of good bioremediation practice.

5. UIC Inventory: PHOSter system Remedial Action Plans shall include information pursuant to Rule 62-528.630(2)(c)1 through 6, F.A.C., for the inventory purposes of underground injection control. Per Rule 62-528.630(2)(c), F.A.C., aquifer remediation projects involving injection wells are authorized under the provisions of a Remedial Action Plan, provided the construction, operation, and monitoring requirements of Chapter 62-528, F.A.C., are met. A

memorandum outlining the information to be transferred from the Bureau of Petroleum Storage Systems to the Underground Injection Control Section within the Department is enclosed.

6. Operation:

   a. Avoidance of migration: Injection of nutrients shall be performed in such a way, and at such a rate and volume, that no undesirable migration of either nutrients or petroleum contaminants in the aquifer results, pursuant to Rule 62-528.630(3), F.A.C. Placing injection points around the perimeter of the contamination plume may be one way of preventing migration, since groundwater flowing out of the plume area will be treated as it passes through those points.

   b. Operating permit: Although an operating permit is not required for aquifer remediation wells pursuant to Rule 62-528.640(1)(b), and 62-528.640(1)(c), F.A.C., since no movement of the petroleum contamination plume is expected to accompany the PHOSter treatment process, the Department requests that the information items listed in Rule 62-528.640(1)(b), F.A.C., be considered and included in Remedial Action Plan proposals as a matter of good design practice. Briefly summarized, they are: quality of water in the aquifer; quality of the injected fluid; existing and potential uses of the affected aquifer; and well construction details. **Additionally, each Remedial Action Plan should include an estimate of the total mass of nutrients to be injected over the life of the project, with a breakdown showing at least the number of pounds of nitrous oxide (on a pure basis) and the number of pounds of triethylphosphate (on a pure basis).**

7. Abandonment: Upon issuance of a petroleum Site Rehabilitation Completion Order, or a declaration of "No Further Action", PHOSter system injection wells shall be abandoned pursuant to Section 62-528.645, F.A.C. The Underground Injection Control Section of the Department shall be notified so that the injection wells can be removed from the inventory tracking list.

ENCLOSURE 2

PHOSter SYSTEM: SUPPLEMENTAL INFORMATION

1. Description of the process: The process is a pulsed injection system that stimulates the growth of indigenous petrophilic microorganisms by supplying an optimum quantity and ratio of oxygen, nitrogen, and phosphorus. Briefly, compressed air (the oxygen source) is contacted with liquid triethylphosphate (TEP) (the phosphate source) in a vessel, and emerges as air laden with triethylphosphate. This TEP-laden air is mixed with nitrous oxide (the nitrogen source) and the entire air-TEP-nitrous oxide mixture is then forced into the soil or groundwater to be remediated via injection wells, each of which has a timer to control its pulsed injection cycle. Indigenous microorganisms utilize the injected nutrients to aerobically degrade petroleum contamination, producing biomass, carbon dioxide, and water.

2. Nutrient ratio: **The 20:12:1 molar ratio of oxygen, nitrogen, and phosphorus is the cornerstone of the PHOSter technology. The objective is to encourage microorganism growth by supplying these essential nutrients in a ratio that closely approximates their molar ratios in a standard cell of composition $C_{60}H_{87}O_{23}N_{12}P$.** The general equations describing the biological oxidation process for a hydrocarbon, and an example of an approximately balanced equation for the oxidation of ethylbenzene (C_8H_{10}), using nitrous oxide (N_2O) as the nitrogen source and triethylphosphate [$(C_2H_5O)_3PO$] as the phosphorus source are:

HYDROCARBON + OXYGEN + NITROGEN + PHOSPHORUS --> CELL MASS + CARBON DIOXIDE + WATER

$C_8H_{10} + 2.857O_2 + 0.857N_2O + 0.143\ (C_2H_5O)_3PO \rightarrow 0.143\ C_{60}H_{87}O_{23}N_{12}P + 0.286CO_2 + 2.43\ H_2O$

It should be noted that not all of the carbon in the ethylbenzene is converted directly to carbon dioxide, and that a large portion is assimilated as cell mass, which will, in turn, degrade when the microorganisms die.

3. Mass ratios: If the molar ratios of the equation in the preceding paragraph are converted to mass ratios, then for every pound of C_8H_{10} contaminant degraded it can be seen that 0.862 pounds of O_2, 0.356 pounds of N_2O, and 0.232 pounds of $(C_2H_5O)_3PO$ must be injected via the PHOSter system. Since ethylbenzene is one of the heaviest molecules in the BTEX group (benzene, toluene, ethylbenzene, and xylene), thereby requiring the largest injection quantities of N_2O, O_2, and $(C_2H_5O)_3PO$ for degradation, it may be reasonable to use the above mass ratios to make a quick and conservatively high estimate of the injection amounts needed to remediate a BTEX mixture of any proportions at any site.

4. Nitrogen source: Bottled nitrous oxide is used as the nitrogen source because it readily dissolves in water: 1.0 liter of it dissolves in 1.5 liters of water at 20 degrees Centigrade and 2 atmospheres. Atmospheric nitrogen (N_2), which enters the system by way of the air compressor, is not believed to play a substantial

role in the PHOSter process, as not all microorganisms are capable of directly utilizing the diatomic molecule.

5. Cleanup time: 3 to 6 months, or less, depending on site conditions and the nature of contaminants.

6. Free product: The PHOSter system may be able to handle a small amount of free product if it is 1/8-inch or less in thickness.

7. Installation: trailer-mounted.

8. Design and operating parameters: Remedial Action Plans prescribing the PHOSter system should include all pertinent design and operating parameters, including but not necessarily limited to: radius of influence; number of injection cycles per day; number of injection wells; location of injection wells; injection gas flow rates; the mass of petroleum contaminants to be remediated; the mass of nutrients to be injected over the life of the project; injection pressure; well construction details; a sampling plan, including a pre-remediation background sampling for nitrates, nitrites, and phosphorus; and the estimated cleanup time.

9. Pulsing: Injection of vapor-phase nutrients is pulsed on a timed cycle to keep microorganisms fed at an optimum rate. Too little nutrient addition causes them to die, while too much will be wasteful. For the petroleum test sites in Georgia and South Carolina, the vapor-phase nutrient injection portion of the cycle was 3 hours, followed by nutrient utilization of at least 3 hours. **The strategy of the PHOSter system is to inject vapor-phase nutrients in small enough timed intervals and quantities to keep the microorganisms fed at an optimum rate. Therefore, very little injected material is wasted, and the risk of overdosing is minimal, which in turn minimizes the risk of injecting unnecessary and excessive quantities of nitrogen and phosphorus into the aquifer.**

10. Test sites: The PHOSter system has been used at petroleum test sites in Georgia, South Carolina, and Panama City, Florida. Baseline total phosphate at the Panama City site was measured at 800 and 1,100 ug/L in the upgradient and downgradient monitoring wells, respectively.

11. Equipment: A refrigerated compressed air dryer is used to cool and dry the compressed air, and a filter is used to remove oil prior to injection.

12. Triethylphosphate: This compound is also known as triethyl ester phosphoric acid. Its vapor pressure is 1 millimeter of mercury (mm Hg) at 39°C. It has been indicated to the Department that microorganisms utilize the phosphorus component of this molecule as a nutrient, and consume the ethyl groups as a food source.

13. Phosphorus: There are no groundwater or primary or secondary drinking water standards for phosphorus. For reference purposes only, it may be helpful to know that the European Economic Community guide level is 400 micrograms per liter (ug/L), as P_2O_5, for drinking water, and that a recent surficial aquifer sample at a petroleum remediation site in Volusia County contained 1,200 ug/L of naturally occurring phosphorus, as PO_4. This concentration may not be unusual for Florida.

14. Advantage of vapor-phase injection: **It is believed that quicker and more thorough dispersal of nutrients can occur if they are injected in the vapor-phase, rather than as liquids or solids, especially at sites where permeability of the soil is low.** For a petroleum test site in Aiken, South Carolina, where significant contaminant reductions were obtained in 131 days, the soil permeability was relatively low: 10^{-8} cm^2.

15. Radius of influence: A pilot test to determine a site specific radius of influence, for design purposes, may be necessary. Such a test could be more of a quick and inexpensive pressure sensing at various distances from an air injection point, and not an expensive in depth study involving all aspects of bioremediation. Also, the Department should not object to the bypassing of a radius of influence pilot test if the preparer of a Remedial Action Plan believes there is enough experience and data on hand from geologically similar sites in Florida. The radii of influence for petroleum test sites in Aiken, South Carolina and Augusta, Georgia were 5 and 15 feet, respectively. The delivery system producing those radii for those sites operated at 4 standard cubic feet per minute (scfm) and 30 pounds per square inch (psi) in Aiken and 1 scfm and 10 psi in Augusta.

16. Dedication of monitoring wells: Nutrients should not be injected into monitoring wells which are intended to track the progress of remediation at a site, since a premature and false indication of complete remediation may result when those wells are sampled. However, if there is an abundance of monitoring wells at a site, and not all of them are needed for tracking the progress of remediation, then some of the spare monitoring wells can be used as injection points.

17. Air emissions: No air emissions monitoring is necessary for the PHOSter system since injection gas flow rates will not be high enough to volatilize appreciable amounts of petroleum.

18. Underground Injection Control notification: Reviewers of PHOSter system Remedial Action Plans, regardless of whether in Tallahassee or Department district offices, must fill in the blanks on the enclosed memorandum, whose subject is "Proposed Injection Well(s) for In Situ Aquifer Remediation at a Petroleum Remedial Action Site". The completed form must be submitted to the Underground Injection Control Section at 2600 Blair Stone Road, Tallahassee, Florida 32399-2400. It will be necessary to modify appropriate portions of the memorandum to report PHOSter system vapor-phase injections in terms of pounds of gas, purity of gas, and cubic feet per minute, instead of the units listed, which were intended to cover only liquid-phase injections.

Memorandum

Florida Department of
Environmental Protection

TO: Richard Deuerling, Mail Station 3530
Division of Water Facilities
Bureau of Resource Protection
Underground Injection Control Section

FROM: _____ (Local programs see Note 1.)
_____
_____

DATE: _____

SUBJ: **Proposed Injection Well(s) for In Situ Aquifer Remediation at a Petroleum Remedial Action Site**

This is to notify you of proposed injection well(s) construction for the in situ remediation of groundwater at a petroleum contaminated site. The following is a description of the site location.

Name:_____
Address:_____
City/County:_____
Latitude/Longitude:_____
FDEP Facility Number:_____

The design of the injection-type aquifer remediation system consists of the following:

Areal extent of contamination (square feet):_____
Number of injection wells:_____
Composition of injected fluid (See note 2)
(ingredient, wt. %):_____
_____
_____
_____

Injection volume per well (gallons):_____
Single or multiple injection events:_____
Injection volume total (all wells, all events):_____

Note 1. Local programs are not authorized to approve underground injections into aquifers. Reason: The Department, per agreement with EPA, has been delegated this authority but is not allowed to delegate it any further. Local programs, after reviewing a Remedial Action Plan or an injection proposal document, should follow instructions in a September 29, 1998 memorandum to arrange for Department headquarters' execution of an approval order.

Note 2. Complete chemical analysis of injected fluid is required by Chapter 62-528, Florida Administrative Code (no exceptions). Proprietary formulations shall make confidential disclosure. Injected fluids must meet drinking water standards of Chapter 62-550, F.A.C., unless an exemption or variance has been granted.

Site name:_____
FDEP facility no.:_____

A site map showing the areal extent of the groundwater contamination plume and the location and spacing of injection wells is attached.

Excerpts from the remediation plan which describe the site lithology are attached. The following is a summary description of the affected aquifer:

Name of aquifer:_____
Depth to groundwater (feet):_____
Aquifer thickness (feet):_____

A schematic of the injection well(s) is attached. The following is a summary:

Depth of well (feet):_____
Screened interval:_____ to _____ feet below surface
Well casing diameter (inches):_____
Bore hole diameter:_____
If direct-push type well(s), indicate
diameter (inches):_____ and depth (feet):_____

The in situ injection-type aquifer remediation plan for this petroleum contaminated site is intended to meet the groundwater petroleum cleanup criteria set forth in Chapter 62-770, F.A.C. Additionally, all other groundwater standards will be met at the time of project completion for any residuals associated with the ingredients of the injected remediation products, and any by-products or intermediates produced as a result of the chemical or biochemical transformation of those ingredients or the contaminating petroleum during their use. Applicable primary and secondary drinking water standards are set forth in Chapter 62-550, F.A.C., and additional groudwater quality criteria are set forth in Chapter 62-520, F.A.C.

The remediation plan estimates that site remediation will take _____ months. We will notify you if there are any modifications to the remediation strategy which will affect the injection well design or the chemical composition and volume of the injected remediation product(s).

The proposed remediation plan was approved on _____ by an enforceable approval order. A copy is attached. The remediation system installation is expected to commence within 60 days. Please call me at _____ if you require additional information.

APPENDIX B

DRAFT UNDERGROUND INJECTION CONTROL PERMIT APPLICATION

Memorandum

Florida Department of
Environmental Protection

TO: Richard Deuerling, Mail Station 3530
Division of Water Facilities
Bureau of Resource Protection
Underground Injection Control Section

FROM: _____ (Local programs see Note 1.)

DATE: _____

SUBJ: **Proposed Injection Well(s) for In Situ Aquifer Remediation at a Petroleum Remedial Action Site**

This is to notify you of proposed injection well(s) construction for the in situ remediation of groundwater at a petroleum contaminated site. The following is a description of the site location.

Name: Naval Air Station Cecil Field
Address: Building 46, Former Tanks 46R, 46D, 46SUL and 46UL
City/County: Jacksonville
Latitude/Longitude: _____
FDEP Facility Number: _____

The design of the injection-type aquifer remediation system consists of the following:

Areal extent of contamination (square feet): 95,700
Number of injection wells: 30 (16 Intermediate, 14 Deep)
Composition of injected fluid (See note 2)
(ingredient, wt. %):
Compressed air with: Oxygen 20%
Nitrous Oxide 0.1%
Triethyl Phosphate 0.01%

Injection volume per well ~~(gallons)~~: Variable air at 3-5 scfm
Single or multiple injection events: Multiple
Injection volume total (all wells, all events): Oxygen: 546,000 pounds, Nitrous Oxide: 2,700 pounds
Triethyl Phosphate: 270 pounds

Note 1. Local programs are not authorized to approve underground injections into aquifers. Reason: The Department, per agreement with EPA, has been delegated this authority but is not allowed to delegate it any further. Local programs, after reviewing a Remedial Action Plan or an injection proposal document, should follow instructions in a September 29, 1998 memorandum to arrange for Department headquarters' execution of an approval order.

Note 2. Complete chemical analysis of injected fluid is required by Chapter 62-528, Florida Administrative Code (no exceptions). Proprietary formulations shall make confidential disclosure. Injected fluids must meet drinking water standards of Chapter 62-550, F.A.C., unless an exemption or variance has been granted.

Site name:_____
FDEP facility no.:_____

A site map showing the areal extent of the groundwater contamination plume and the location and spacing of injection wells is attached.

Excerpts from the remediation plan which describe the site lithology are attached. The following is a summary description of the affected aquifer:

Name of aquifer: **Surficial**
Depth to groundwater (feet): **5 to 7**
Aquifer thickness (feet): **Approximately 90**

A schematic of the injection well(s) is attached. The following is a summary:

Depth of well (feet): **Intermediate 40', Deep 90**
Screened interval: **35/85** to **40/90** feet below surface
Well casing diameter (inches): **1/2**
Bore hole diameter: **Intermediate 2", Deep 8"**
If direct-push type well(s), indicate **Intermediate only**
diameter (inches): **1/2** and depth (feet): **40**

The in situ injection-type aquifer remediation plan for this petroleum contaminated site is intended to meet the groundwater petroleum cleanup criteria set forth in Chapter 62-770, F.A.C. Additionally, all other groundwater standards will be met at the time of project completion for any residuals associated with the ingredients of the injected remediation products, and any by-products or intermediates produced as a result of the chemical or biochemical transformation of those ingredients or the contaminating petroleum during their use. Applicable primary and secondary drinking water standards are set forth in Chapter 62-550, F.A.C., and additional groudwater quality criteria are set forth in Chapter 62-520, F.A.C.

The remediation plan estimates that site remediation will take **12** months. We will notify you if there are any modifications to the remediation strategy which will affect the injection well design or the chemical composition and volume of the injected remediation product(s).

The proposed remediation plan was approved on _____ by an enforceable approval order. A copy is attached. The remediation system installation is expected to commence within 60 days. Please call me at _____ if you require additional information.

APPENDIX C

COST ESTIMATE

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46 REMEDIAL ACTION PLAN ADDENDUM
ALTERNATIVE: PHOSter Nutrient Injection and Monitoring
CAPITAL COST

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
1 PROJECT PLANNING												
1.1 Prepare Remedial Action Plan	300	hr			$35.00		$0	$0	$10,500	$0	$10,500	
2 MOBILIZATION/DEMOBILIZATION												
2.1 Office Trailer	2	mo	$200.50				$401	$0	$0	$0	$401	
2.2 Storage Trailer	2	mo	$85.00				$170	$0	$0	$0	$170	
2.3 Construction Survey	1	ls	$2,500.00				$2,500	$0	$0	$0	$2,500	
2.4 Equipment Mobilization/Demobilization	1	ls			$800.00	$3,500.00	$0	$0	$800	$3,500	$4,300	
2.5 Mobilization/Demobilization Drill Rig	1	ls	$2,500.00				$2,500	$0	$0	$0	$2,500	
2.6 Site Utilities & Office Equipment	2	mo	$1,000.00				$2,000	$0	$0	$0	$2,000	
3 DECONTAMINATION												
3.1 Decontamination Trailer	2	mo	$2,275.00				$4,550	$0	$0	$0	$4,550	
3.2 Temporary Decon Pad	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105	
3.3 Decon Water	2,000	gal		$0.20			$0	$400	$0	$0	$400	
3.4 Decon Water Storage Tank, 6,000 gallon	2	mo	$600.00				$1,200	$0	$0	$0	$1,200	
3.5 Clean Water Storage Tank, 4,000 gallon	2	mo	$540.00				$1,080	$0	$0	$0	$1,080	
3.6 PPE (5 p * 5 days * 8 Weeks)	200	day		$30.00			$0	$6,000	$0	$0	$6,000	
3.7 Disposal of Decon Waste (liquid & solid)	2	mo	$4,500.00				$9,000	$0	$0	$0	$9,000	
4 MONITORING WELL INSTALLATION												
4.1 Install Monitoring Wells - 2" PVC	190	lf	$23.75				$4,513	$0	$0	$0	$4,513	
4.2 Well Development	6	hour	$35.00				$210	$0	$0	$0	$210	
4.3 Collect/Containerize IDW	6	ea	$50.00				$300	$0	$0	$0	$300	
4.4 Transport/Dispose IDW Off Site	6	drum	$150.00				$900	$0	$0	$0	$900	
4.5 Stick-up Pad w/ Posts	3	ea	$500.00				$1,500	$0	$0	$0	$1,500	
5 SOURCE AREA SOIL CHARACTERIZATION												
5.1 Soil Borings	1	ls		$2,400.00	$2,750.00	$600.00	$0	$2,400	$2,750	$600	$5,750	
5.2 Analysis Soil (KAG)	13	ea	$300.00				$3,900	$0	$0	$0	$3,900	
6 NUTRIENT INJECTION WELLS INSTALLATION												
6.1 Install Nutrient Injection Wells (DPT)	1,900	ft	$12.00				$22,800	$0	$0	$0	$22,800	
6.2 Install Casing & Screen	1,900	ft			$3.49	$2.68	$0	$0	$6,631	$5,092	$11,723	
6.3 Well Development	60	hr	$35.00				$2,100	$0	$0	$0	$2,100	2 hours per well
7 INJECTION SYSTEM PIPING AND ELECTRIC SUPPLY												
7.1 Trench, 12" by 18"	1,300	lf			$0.26	$2.68	$0	$0	$338	$3,484	$3,822	
7.2 Distribution Piping, Install	2,500	lf			$3.49	$2.68	$0	$0	$8,725	$6,700	$15,425	
7.3 Electric Equipment Supply	1	ls	$13,600.00				$13,600	$0	$0	$0	$13,600	
8 SYSTEM REMOVAL												
8.1 Nutrient Well Abandonment	1,900	lf	$12.00				$22,800	$0	$0	$0	$22,800	after one year
8.2 Equipment Removal	1	ls			$7,000.00	$1,500.00	$0	$0	$7,000	$1,500	$8,500	
9 INSTITUTIONAL CONTROLS												
9.1 Prepare Deed Restrictions & LUCIPs	100	hour			$35.00		$0	$0	$3,500	$0	$3,500	
10 SITE RESTORATION												
10.1 Vegetate Disturbed Areas	1	ls		$750.00	$750.00		$0	$750	$750	$0	$1,500	
Subtotal Direct Costs less Subcontract								$10,050	$41,444	$21,031	$72,525	
Local Area Adjustments								99%	88%	88%		
								$9,909	$36,471	$18,507	$64,887	
Overhead on Labor Cost @ 30%									$10,941		$10,941	
G & A on Labor Cost @ 10%									$3,647		$3,647	
G & A on Material Cost @ 10%								$991			$991	
Total Direct Cost								$10,900	$51,059	$18,507	$80,467	
Indirects on Total Direct Labor Cost @ 75%									$38,294		$38,294	
Profit on Total Direct Cost @ 10%											$8,047	
Subtotal											$126,807	
Health & Safety Monitoring @ 3%			(Includes Subcontractor cost)								$6,685	
Total Field Cost											**$133,492**	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46 REMEDIAL ACTION PLAN ADDENDUM
ALTERNATIVE: PHOSter Nutrient Injection and Monitoring
CAPITAL COST

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal	Comments
Subtotal Subcontractor Cost							$96,024				$96,024	
G & A on Subcontract Cost @ 10%							$9,602				$9,602	
Profit on Subcontractor Cost @ 5%											$4,801	
Subcontractor Cost											**$110,427**	
Contingency on Total Field and Subcontractor Costs @ 20%											**$48,784**	
Engineering on Total Field Cost @ 5%											**$6,675**	
SUBTOTAL COST											**$299,378**	
PHOSter Nutrient Injection System (contracted directly by the Navy)											**$300,000**	
GRAND TOTAL COST											**$599,378**	

NOTE:

All equipment and materials for the PHOSter Nutrient Injection System, including injection wells castings and screens, distribution piping and COP elements, and trailer-mounted nutrient injection equipment and controls will be provide by the licensed technology vendor, Priester & Associates (PHA). PHA will also operator and maintain the equipment and furnish nutrients. The PHOSter Nutrient Injection System will be installed by the Navy's RAC. TtNUS will install the new monitoring well and perform the soil and groundwater monitoring.

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46 REMEDIAL ACTION PLAN ADDENDUM
ALTERNATIVE: PHOSter Nutrient Injection and Monitoring
Annual Cost

Item	Item Cost Year 1	Item Cost Years 2 & 3	Item Cost Year 4	Notes
Electric Cost	$3,200			Electric for 1 year (52,300 Kw-hr)
Sampling	$21,000	$8,000	$4,000	Labor, Mob/Demob, Field Equipment and Supplies for Soil/Water
Analysis/Soil	$3,300			Analyze highest sample from 3 borings at depths 1, 3, & 5 bgs for KAG. Collect quarterly for 1 year.
Analysis/Water	$23,200	$9,250	$4,650	Analyze samples from 14 wells for KAG and nutrients. First round collected prior to system installation, quarterly for year 1; semi-annually years 2 & 3 and annually year 4.
Report	$15,000	$5,000	$2,500	Document sampling events and results
TOTALS	$65,700	$22,250	$11,150	

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA
BUILDING 46 REMEDIAL ACTION PLAN ADDENDUM
ALTERNATIVE: PHOSter Nutrient Injection and Monitoring
Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$599,378		$599,378	1.000	$599,378
1		$65,700	$65,700	0.935	$61,430
2		$22,250	$22,250	0.873	$19,424
3		$22,250	$22,250	0.816	$18,156
4		$11,150	$11,150	0.763	$8,507
				TOTAL PRESENT WORTH	$706,895

APPENDIX D

GENERAL CONSTRUCTION SPECIFICATIONS

GENERAL CONSTRUCTION SPECIFICATIONS

GENERAL

Obtain all required local and state permits to construction.

All work to be done in accordance with local, state and federal codes.

Obtain utility clearances with local utility companies prior to construction.

Contractor personnel shall have all required health and safety training (29 CFR 1910.120 (e)) and protection equipment.

SECTION 1. TRENCHING, BACKFILLING, AND COMPACTING

Excavation contractor shall be responsible for the location and verification of all existing underground utilities and obstacles prior to beginning work. It is the excavation contractor's responsibility to repair and/or remedy all damages caused by excavation operations.

Excavations shall be wide enough to allow for inspection and trade work, (or as specified) and must comply with OSHA safety standards (20 CFR 1926.651 Subpart P).

Topsoils shall be segregated and stockpiled for replacement as originally found. Contaminated soils shall be segregated and placed on plastic sheeting. Final placement of contaminated soils shall be coordinated with Owner's personnel.

All backfill shall be compacted with a plate-type mechanical compactor. Backfill within excavations shall be placed on loose lift thickness not to exceed 10 inches.

Any debris remaining from excavation work shall be removed and disposed of in accordance with local regulations or direction from the Owner.

Existing obstructions in the line of work shall be removed and replaced/restored to prior existing conditions unless specifically directed otherwise. Trees and shrubs shall not be cut, removed or injured.

Any site improvements, such as monuments, landscapes and structures, not in the direct line of work, shall be protected from damage by the excavation contractor.

All prudent or regulated safety measures shall be observed, including warning barricades, signage, lights and coverings, to protect the public from open excavations.

Soil erosion control must be practiced and any erosion onto adjoining properties or public ways shall be promptly cleaned up and corrected. Use of barriers is required where potential for runoff exists.

SECTION 2. PIPE INSTALLATION

Furnish all labor, materials and construction related equipment required for the complete installation of the mechanical system, including piping and plumbing of equipment.

All soil, waste, vent and drainage piping shall be tested with air at 5 psi gauge pressure and shall remain constant without addition for 15 minutes.

All liquid pressure piping shall be tested with water pressure, which shall remain constant without addition for 60 minutes.

All general pipe and fittings shall be PVC Schedule 40 wherever practical or as specified. Joints can be slip or screw thread type. Thread-type fittings shall be coated with a Teflon™ based thread sealant prior to connection. All underground 90 degree and 45 degree fittings should be sweep type fittings. Slip type fittings shall be prepared with a PVC cleaning solvent prior to performing a solvent weld.

Installation of all meters and valves shall be accompanied by true union fittings, unless otherwise directed.

All hanging pipe shall be supported by suitable hangers and supports according to the following Schedule:

SIZE	SPACING, O.C.
¼" – 3/8"	36"
1 ¼" – 2"	120"
2 ½" – 5"	144"
6" – 12"	168"

SECTION 3. CONCRETE

Concrete quality for slabs and mountings, unless directed otherwise, shall be Type 1 Portland cement with fiber reinforcement, 3500 psi minimum unconfined compressive strength. Placed thickness shall be 4 inches for slab and 6 inches for trench or as specified.

Concrete shall be mechanically worked with a standard concrete vibrator (after placement/prior to finishing).

Steel reinforcement, wire mesh and jointing/cutting is not required, unless otherwise directed.

Concrete for slabs shall be placed in a continuous manner, with a slight drainage slope. Slab surface finish shall be uniform, without high/low or ponding areas. Finish shall be coarse broom type.

No more than 350 ft^2 of concrete per person shall be poured and finished at any given time.

Concrete shall not be poured on a Friday, unless otherwise directed or unless excavation contractor is on site the following day (Saturday).

It is the excavation contractor's responsibility to be aware of weather conditions prior to pouring concrete. Excavation contractor is responsible for repair/replacement of any concrete damaged by inclement weather.

Waste concrete materials and form work shall be completely removed from the site upon completion.

SECTION 4A. WOODEN FENCING

Fencing shall be erected by skilled mechanics in accordance with the recommendations of the manufacturer. Installer shall be responsible for location and proper avoidance of underground utilities. Installer shall repair or remedy all damages to such utilities caused by fencing construction. Fencing shall be constructed to withstand 110 mph winds or in accordance with local codes.

Fence height shall be 72 inches, with posts spaced no more than 6 feet apart. Posts shall be set a minimum of two feet below grade, and shall be surrounded with at least 6 inches of concrete on all sides. Fence posts and cross bracing shall be pressure treated. Fence pickets shall be cypress or pressure treated wood with minimal spacing between pickets.

Gates shall be properly braced and trussed to prevent sagging and have a pad lockable latch mechanism. Gate opening width shall be 49 inches minimum and hung after concrete posts have set.

Fencing exterior shall be painted to match the existing buildings on site if required by property owner. Paint shall be exterior grade suitable for outdoor fencing.

SECTION 4B. CHAIN LINK FENCES AND GATES

Fencing shall be erected by skilled mechanics in accordance with the recommendations of the manufacturer. Installer shall be responsible for location and proper avoidance of underground utilities. Installer shall repair or remedy all damages to such utilities caused by fencing construction. Fencing shall be constructed to withstand 110 mph winds or in accordance with local codes.

Fence shall be constructed of 9 gauge, zinc coated wire with 2-inch size mesh (or code). Posts, rails and braces shall be constructed of galvanized steel pipe conforming to ASTM A53, Schedule 40.

Fence height shall be 72 inches, with posts spaced no more than 10 feet apart. Set corner, end, pull and gate posts 42 inches into concrete total depth of concrete shall be 6 inches greater than required for post embedment. Set line posts 36 inches into concrete.

Gates shall be properly hinged and hung and have a pad-lockable mechanism. Walk gate openings shall be 48 inches minimum. Double gate openings shall be 10 feet minimum opening (or as specified). Double gate openings shall have a swing type and a lockable shear rod mechanism.

Barbed wire shall be double strand 12 ½ gauge steel wire with 14 gauge, 4 point round steel barbs spaced approximately 5 inches on center or in accordance with local codes.

SECTION 5. ELECTRICAL WORK

Work scope to include all materials and labor necessary to provide an operational system as intended by plans.

Electric service shall be more than adequate to operate specified equipment and controls. The electrical service shall be complete with meter, mast and grounding rod.

Raceways are to be either liquid tight flexible conduit or intermediate metal conduit (IMC).

Liquid tight conduit shall be type LA or UA as manufactured by Liquatite, Sealtite or similar.

Conduit shall be spirally wound, square, locked, hot dipped galvanized steel strip with a continuous copper ground built into the core. Conduit shall have a continuous liquid tight, flame resistant, PVC jacket.

Connectors and fittings shall be grounding type and shall be so designed to clamp the PVC jacket of the conduit so as not to allow it to pull away from the connection and expose the conduit metal.

As-built wiring diagrams of all work to be furnished upon completion by contractor.

Install one 20 ampere duplex receptacle for general service on the control panel with weather caps and ground fault interruption circuit protection.

All necessary conduit, panel and box supports shall be furnished and be of Unistrut™ system, or equal.

All boxes, junctions and panels shall be NEMA 4 rated or equipped for outdoor weather exposure with gaskets and seals.

Main disconnect box shall be readily lockable.

All metal surfaces to be painted shall be degreased and free of dust and dirt. Rust and corrosion shall be wire-brushed and sanded as required. Color shall be selected by the engineer.

SECTION 6. EQUIPMENT INSTALLATION

Equipment shall be installed in a professional and workmanlike manner, with all components properly secured supported and anchored to resist normal forces of the system, wind and personnel. Unless otherwise directed, equipment shall be installed plumb, level and true to lines and elevations. Corrosion resistant fasteners and wire/cables suitable for outdoor shall be used.

Equipment shall be installed per manufacturer's recommendations and as specified in construction drawings/plans.

shall be provided with all equipment manuals and warranty information.

SECTION 7. SITE RESTORATION

Unless directed otherwise grading shall be finished to elevations and contours existing prior to excavation.

Restoration of grassed or other areas shall be the responsibility of the contractor. Sodding and replanting shall be equal or similar to existing features.

The site shall be completed and finished to a condition equivalent to the original. All waste and debris shall be removed and disposed of prior to the last day of work.

SECTION 8. START-UP

System shall be operational as designed within time frame as specified in contractor's cost estimate, assuming no unforeseen delays.

Contractor(s) shall provide assistance with start-up and operation of mechanical system. Contractor(s) shall walk through all control and fail-safe devices.