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REMEDIAL ACTION PLAN FOR BUILDING 7174 MCCOY ANNEX NTC ORLANDO FL
9/1/1998
HARDING LAWSON ASSOCIATES

REMEDIAL ACTION PLAN

BUILDING 7174, MCCOY ANNEX

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

Unit Identification Code: N65928

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September 1998

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CERTIFICATION OF TECHNICAL
DATA CONFORMITY (MAY 1987)

The Contractor, Harding Lawson Associates, hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No.: N62467-89-D-0317/107 are complete and accurate and comply with all requirements of this contract.

DATE: September 25, 1998

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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, 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 (*State Underground Petroleum Environmental Response*) regulations on petroleum contamination in Florida's environment as a result of spills or leaking tanks or pipelines.

Questions regarding this report at Naval Training Center, Orlando should be addressed to Mr. Nick Ugolini, Code 1843, at 803-820-5596.

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Naval Training Center
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GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
acfm	actual cubic feet per minute
AST	aboveground storage tank
BTEX	benzene, toluene, ethylbenzene, and xylenes
bls	below land surface
CAR	contamination assessment report
CTL	cleanup target level
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
ft/ft	feet per foot
HLA	Harding Lawson Associates
$\mu g/\ell$	micrograms per liter
mg/ℓ	milligrams per liter
NTC	Naval Training Center
OVA	organic vapor analyzer
PCA	preliminary contamination assessment
ppm	parts per million
psi	pounds-force per square inch
PWC	Public Works Center
RAP	remedial action plan
SOUTHNAV-FACENGCOM	Southern Division Naval Facilities Engineering Command
SVE	soil vapor extraction
UST	underground storage tank
VOA	volatile organic aromatic
yd^3	cubic yard

1.0 INTRODUCTION

This report was prepared by Harding Lawson Associates (HLA) and presents the remedial action plan recommended for contaminated soil and groundwater at Building 7174, Naval Training Center (NTC), Orlando, Florida.

1.1 BACKGROUND. Building 7174 is located on the northeast corner of the intersection of Binnacle Way and Daetwyler Drive in the central part of the NTC, Orlando, McCoy Annex, in Orange County, Florida. Figure 1-1 shows the site location and a map of the surrounding area. The site lies within the southwest part of Section 32, Township 23 South and Range 30 East, as shown on the Pine Castle, Florida, U.S. Geological Survey Quadrangle Map. The site and surrounding area is shown on Figure 1-2.

Building 7174 is a one-story building constructed of concrete block with a flat corrugated metal roof. It is currently vacant, but was formerly used as the McCoy Annex base exchange service station.

In 1942, six gasoline storage tanks (7174-1 through 7174-6) were installed at the site (one 3,000-gallon tank and five 5,000-gallon tanks). The tanks were abandoned in place under the pump island in 1986, and were filled with sand to conform with Florida Department of Environmental Protection (FDEP) abandonment procedures. However no closure records are currently available. In 1986, four 10,000-gallon fiberglass underground storage tanks (USTs) (7174-9 through 7174-12) were installed to replace the abandoned tanks. Four compliance monitoring wells were installed (OLD-7174-1 through OLD-7174-4) in association with the new tank construction to meet FDEP monitoring requirements. During sampling of the compliance monitoring wells by Naval personnel on June 15, 1988, a petroleum odor was detected in wells OLD-7174-1, OLD-7174-2, and OLD-7174-3.

1.2 SITE HISTORY. E.C. Jordan was contacted to conduct a preliminary contamination assessment (PCA) on the site as a result of the positive leak detection. E.C. Jordan personnel completed a PCA in 1988 that included precision testing of the four USTs (7174-9 through 7174-12) and their associated piping. During the PCA, E.C. Jordan installed an additional six monitoring wells (OLD-7174-5 through OLD-7174-10). Results from the PCA showed that the tanks and their associated piping were not leaking; however, it was observed that the annuli around the tank fill ports were not properly sealed. Groundwater testing confirmed that contamination was present and it was recommended that a contamination assessment (CA) be conducted at the site.

In late June 1991, ABB Environmental Services, Inc. (ABB-ES) (formerly E.C. Jordan) personnel conducted a CA at the site. During the CA, eight additional 2-inch-diameter shallow monitoring wells (OLD-7174-11 through OLD-7174-16, OLD-7174-18 and OLD-7174-19) and one 4-inch-diameter monitoring well (OLD-7174-7) were installed. Groundwater samples were collected by ABB-ES (presently HLA) personnel and analyzed by Savannah Laboratories and Environmental Services, Inc. A groundwater elevation survey was completed and aquifer slug tests for hydraulic conductivity were performed. Organic vapor analyzer (OVA) readings were taken on October 11, 1991, on soil samples that were collected during the CA. OVA readings confirmed that soil contamination existed at the site. Based on the

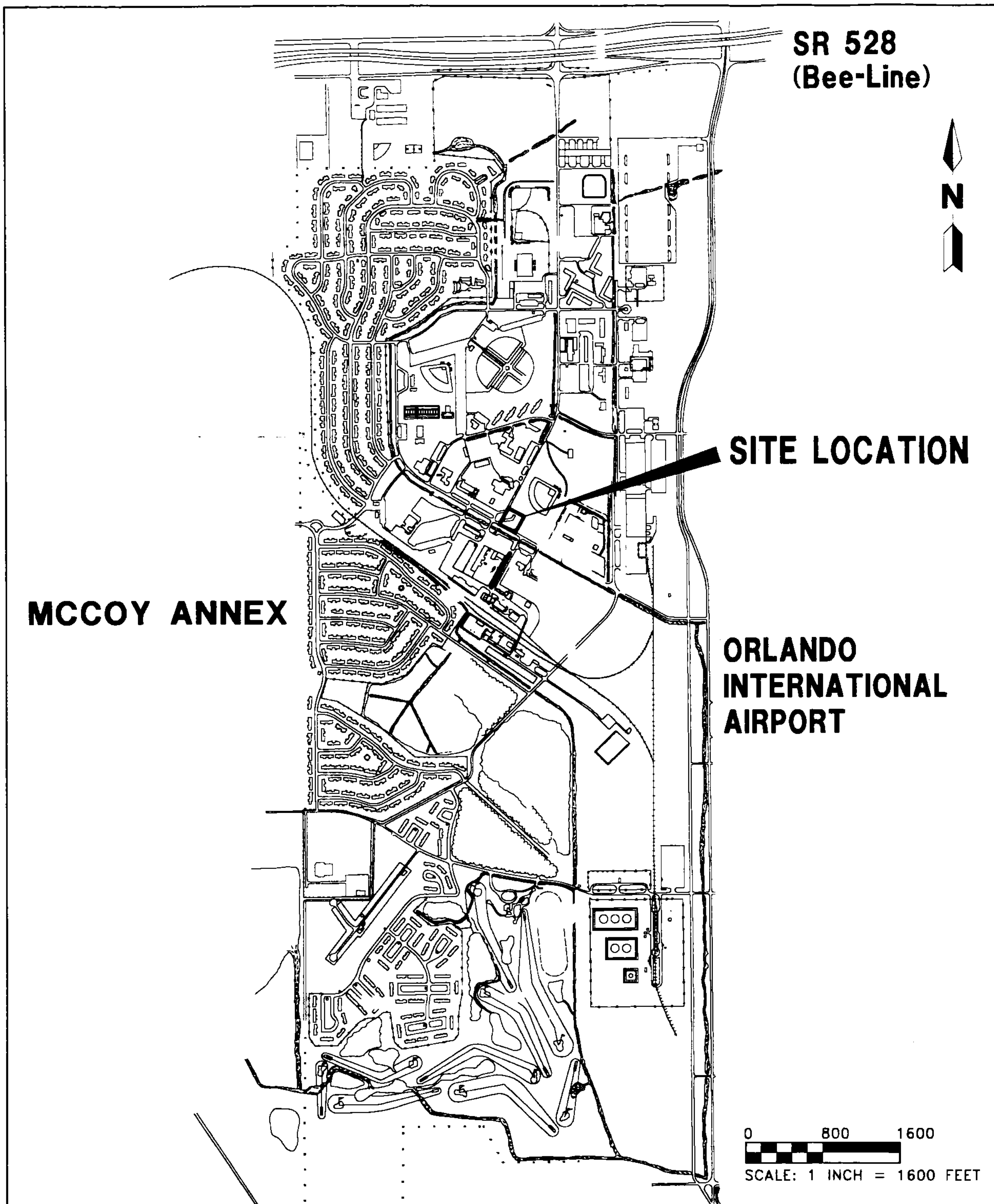

FIGURE 1-1
SITE VICINITY MAP

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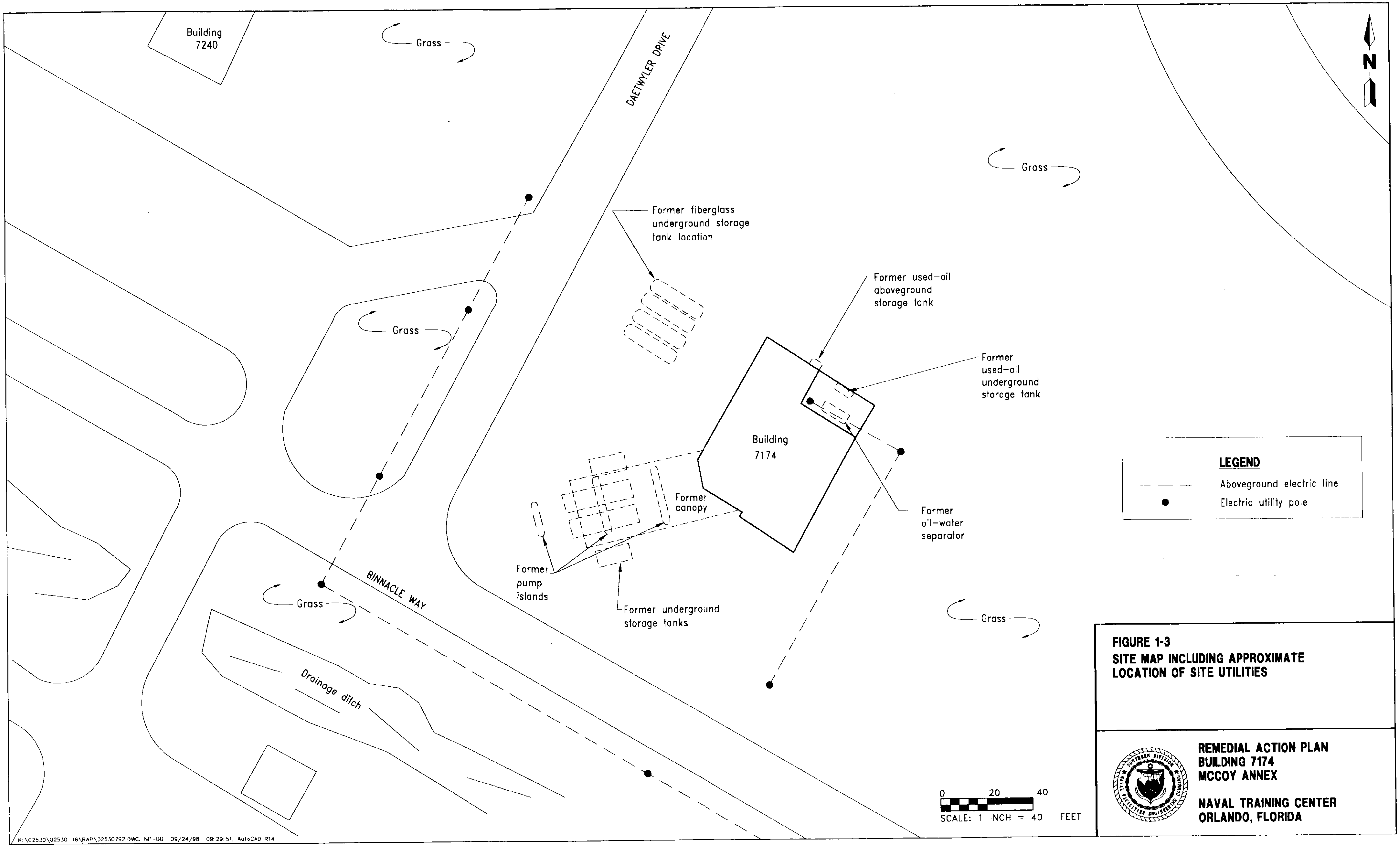

FIGURE 1-3
SITE MAP INCLUDING APPROXIMATE LOCATION OF SITE UTILITIES

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results of the CA investigation, ABB-ES recommended a remedial action plan (RAP) be prepared for this site.

In April 1993, ABB-ES prepared the RAP for the site (ABB-ES, 1993) and in May 1993, OHM Inc., prepared an RAP addendum (OHM, 1993). Both reports presented a plan for cleanup of the petroleum contamination at the site. The groundwater contamination was to be treated by installing a pump-and-treat system that included the installation of four groundwater recovery wells and an air stripper to remove volatile organic compounds from the contaminated water. The levels of soil contamination were to be reduced by a vacuum extraction system and treated with a carbon adsorption system. These systems would have been operated until the petroleum-related contamination in both the groundwater and the soil reached the required cleanup target levels (CTLs).

On July 6 and 7, 1994, a meeting was held at NTC, Orlando with Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), NTC, Orlando personnel, ABB-ES, and the remedial action contractor (Bechtel Environmental, Inc.). One result of the meeting was to plan the removal of the four 10,000-gallon USTs installed in 1986. From December 27, 1994 to January 3, 1995, the four tanks were excavated and removed. Approximately 257.89 cubic yards (yd^3) of excessively contaminated soil was also excavated from the tank area for off-site thermal treatment. During the tank removal, monitoring wells OLD-7174-1 through OLD 7174-4 were damaged. Clean fill was placed in the excavation and four inches of concrete were placed over the tank area to assist in the planned soil vapor extraction (SVE).

In January 1995, ABB-ES further investigated disposal options for effluent generated during implementation of the proposed RAP. A second RAP addendum was prepared which presented a plan for effluent disposal via a storm sewer system under a National Pollutant Discharge Elimination System permit. Other changes included monitoring plan modifications and a filter size change for the removal of lead.

On May 2, 1995, a technical memorandum was prepared incorporating minor modifications to the planned groundwater recovery system to account for a slight increase in groundwater contaminant concentrations and changes in the aerial extent of the contaminants. Following these modifications it was determined that the SVE system would also be affected by the repositioning of the groundwater recovery wells. This also called into question the extent of the soil contamination that was last investigated on October 10, 1991. ABB-ES mobilized on May 2, 1995, to conduct confirmatory sampling of soil southeast of the groundwater contaminant plume, an area in which groundwater remedial plan modifications had the greatest impact on the proposed SVE system. Six soil borings were advanced, with samples collected and OVA headspace readings taken, which confirmed that soil contamination concentrations had increased. At that time, ABB-ES recommended further assessment of the soil contamination at the site.

On October 4 and 5, 1995, 35 additional soil borings were installed at the site to complete the horizontal assessment of the soil contamination. Since late June 1995, the plume has traveled further to the south and east.

In October 1996, a contamination assessment report (CAR) was completed by ABB-ES, which included the installation of four new shallow monitoring wells and nine piezometers. The piezometers were installed to assess the extent of free product discovered near the former petroleum pipeline in the vicinity of the pump island.

Based on the CAR results, two actions were considered for Site 7174 during the Orlando Partnering Team meeting in November 1996. The first was to remove the eight USTs filled with sand, the free product, and the excessively contaminated soil saturated with free product for off-site thermal treatment. The second was to landfarm the contaminated soil surrounding the USTs.

In May and June 1997, eight USTs and associated piping were removed from the site: six USTs near the pump islands on the southwest side of Building 7174 (five 5,000-gallon USTs and one 3,000-gallon gasoline UST), two 1,000-gallon USTs (7174-7 and 7174-8) used to store waste oil, and an oil-water separator connected to one of these tanks (7174-7) from the southeast side of Building 7174 (shown on Figure 1-3).

During tank removal and soil excavation, two separate stockpiles of soil were stored on site. The first pile was approximately 1,900 yd^3 of excessively contaminated soil (soil vapor that exhibits organic vapors exceeding 500 parts per million [ppm]). The second pile was approximately 200 yd^3 of soil saturated with free product.

The unsaturated contaminated soil (1,900 yd^3) was transported on June 12, 1997, to two separate areas. The landfarm areas were designed by the Navy Public Works Center (PWC), Pensacola, with impervious surfaces, berms, and cover to prevent rain water from entering the landfarm area. The soil was tilled daily for the first week, then once a week thereafter. PWC, Pensacola was responsible for the maintenance of the landfarm areas. The soil was covered with clear plastic after tilling. ABB-ES was responsible for sampling the soil at the landfarm area. The OVA results indicated concentrations were greater than 1,000 ppm in most of the sampled locations within the landfarms. On July 16, 1997, SOUTHNAVFACENGCOM decided to thermally treat the 1,900 yd^3 of petroleum-contaminated soil.

The saturated soil (200 yd^3) and the excessively contaminated soil (1,900 yd^3) was transported by PWC, Pensacola to C.A. Mere Paving and Construction Co., in Clermonte, Florida, to be thermally treated.

The site contamination was reassessed between December 1997 and May 1998. A Site Assessment Report was submitted for regulatory review and approval in May 1998.

1.3 PREVIOUS DOCUMENTATION. This section consists of a listing of documents that have been prepared during the study and assessment of Building 7174. Important actions and decisions are also included. Years listed are followed by the months and actions performed.

1988 E.C. Jordan conducted a PCA based on petroleum odor and conducted a CAR.
1991 August: CAR completed by ABB-ES.
1993 RAP plus 2 addenda completed by ABB-ES and OHM.
1995 January: Four fiber tanks were removed with 250 cubic yards.
April: Redesign based on plume change.
May: RAP delayed because of change in site conditions.
July: FDEP issues letter to redo CAR and RAP.

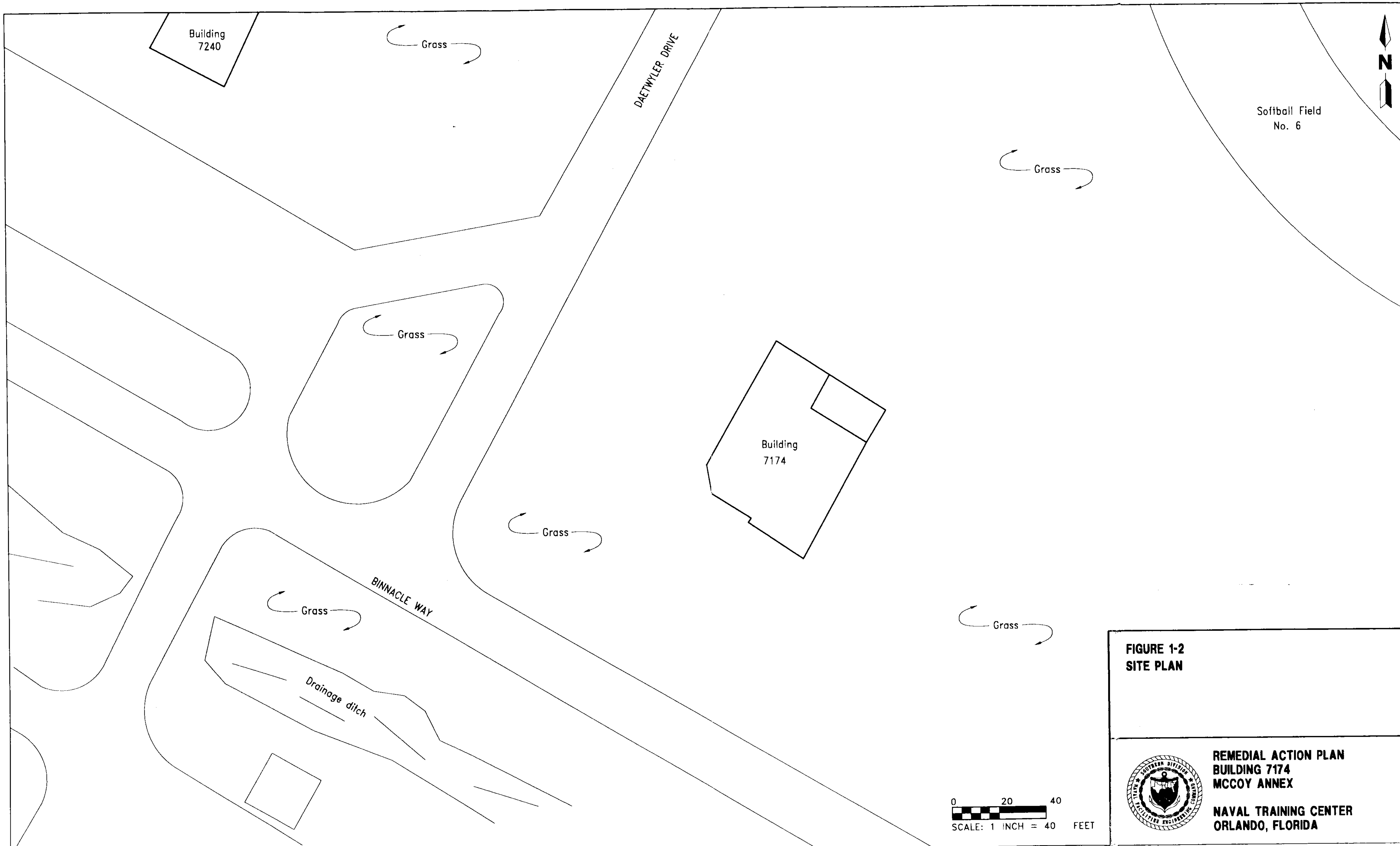

FIGURE 1-2
SITE PLAN

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October: Resample Soil.
1996 CAR assessment completed.
1997 October: Initial Remedial Action.
1998 May: Site Assessment Report.

1.4 SCOPE AND PURPOSE. The scope of work for this project involved the following tasks:

- reviewing existing hydrogeologic and soil and groundwater quality data for the site;
- developing a conceptual model of the contamination in the subsurface, possible preferential pathways, and receptors;
- evaluating remedial alternatives;
- providing a conceptual design for the selected remedial alternative based on site-specific effectiveness;
- providing a long-term monitoring plan including a sampling and analysis plan; and
- developing a cost estimate for the proposed remedial actions.

2.0 SITE ASSESSMENT

This section describes the results of the previously reported site assessment and the supplemental assessment activities completed during the preparation of this report.

2.1 SUMMARY OF SAR RESULTS. Site assessment activities were conducted after the tank and soil removal from December 1997 to May 1998. On December 2, 3, 8, and 9, 1997, soil borings were advanced in the vicinity of the former tank areas to assess whether or not petroleum-impacted soil was present. Evidence of petroleum-impacted soil was detected from 2 to 8 feet below land surface (bls) near the former location of the USTs. Soil samples were collected and shipped to Savannah Laboratories and Environmental Services, Inc., to confirm petroleum impact to soil found with the OVA.

On January 5 and 6, 1998, eight shallow monitoring wells (OLD-7174-24 through OLD-7174-31) were installed to assess the horizontal extent of dissolved petroleum hydrocarbon contamination in the shallow aquifer.

On January 20, 21, 22 and 23, 1998, groundwater analytical results from samples collected from the monitoring wells indicated that dissolved petroleum hydrocarbon contamination exceeding Chapter 62-770, Florida Administrative Code (FAC) cleanup target levels, was present in monitoring wells OLD-7174-24, OLD-7174-25, OLD-7174-28, OLD-7174-30 and OLD-7174-31.

On March 5 and 6, 1998, one deep lithologic soil boring (SS-1) and one deep monitoring well (OLD-7174-32), were installed to further assess the horizontal and vertical extent of petroleum impact in the shallow aquifer. All shallow monitoring wells were installed to 15 feet bls and the deep well was installed to 35 feet bls with 5 feet of screen and 30 feet of surface casing. All monitoring well locations are shown on Figure 2-1.

On March 18, 1998, groundwater samples collected from the deep monitoring well OLD-7174-32 indicated that dissolved hydrocarbon contamination is below laboratory standard detection limits.

The groundwater flow direction was determined to be from north to south with a hydraulic gradient of 1.27×10^{-2} feet per foot (ft/ft) (Figure 2-2). The hydraulic conductivity was calculated to be 2.25 ft/day. The groundwater flow velocity was estimated to be 29.8 feet per year, and the transmissivity was estimated to be 707 gallons per day per foot.

No active potable water wells are located within 0.25 mile of this site.

2.2 ASSESSMENT OF BIODEGRADATION ACTIVITY. The most important consideration when assessing the feasibility of natural attenuation is the extent to which 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 Building 7174, electron acceptor concentrations and other physical parameters such as pH and temperature were measured to evaluate if natural degradation is occurring. These data are provided in Table 2-1. An analysis of

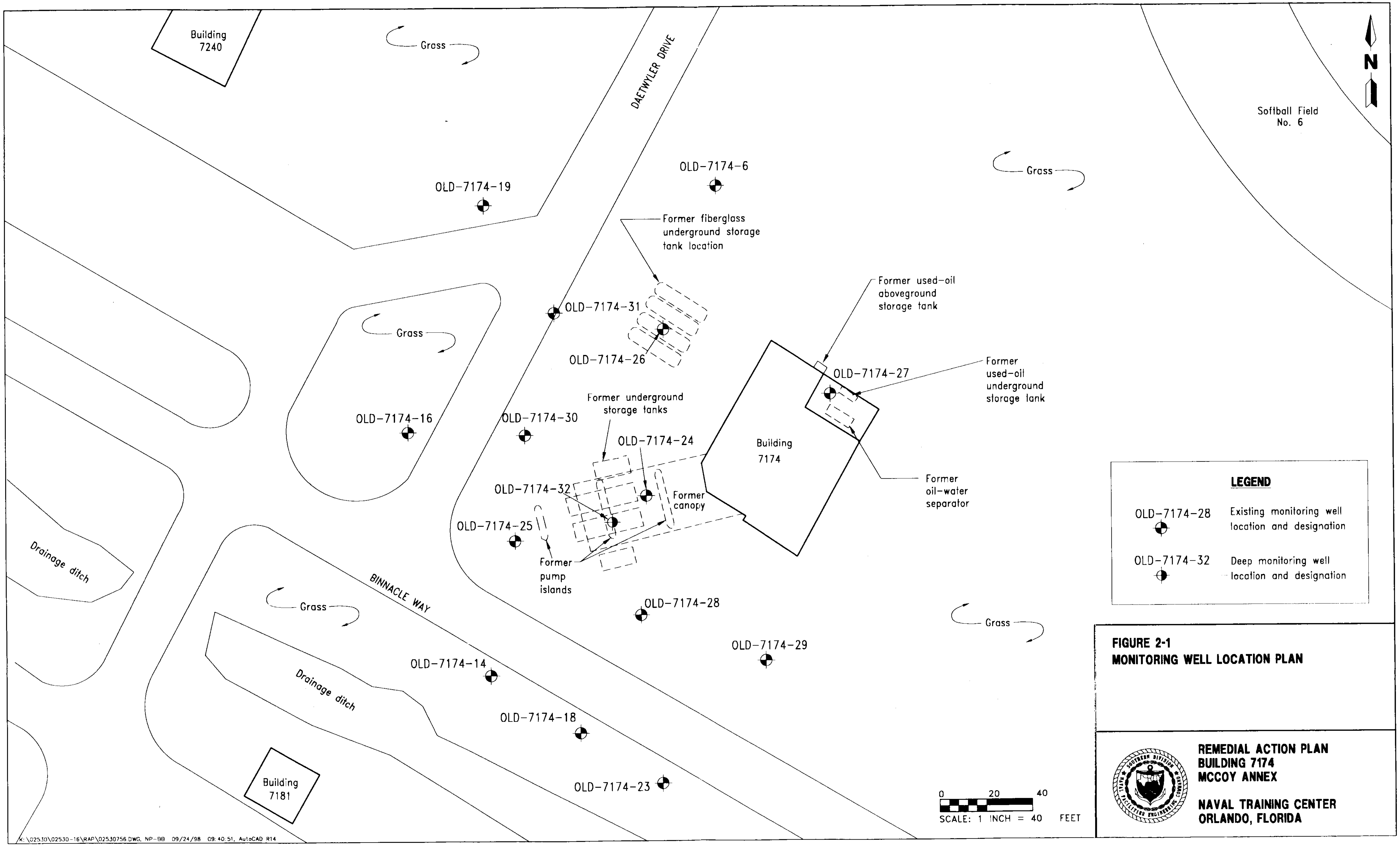

FIGURE 2-1
MONITORING WELL LOCATION PLAN

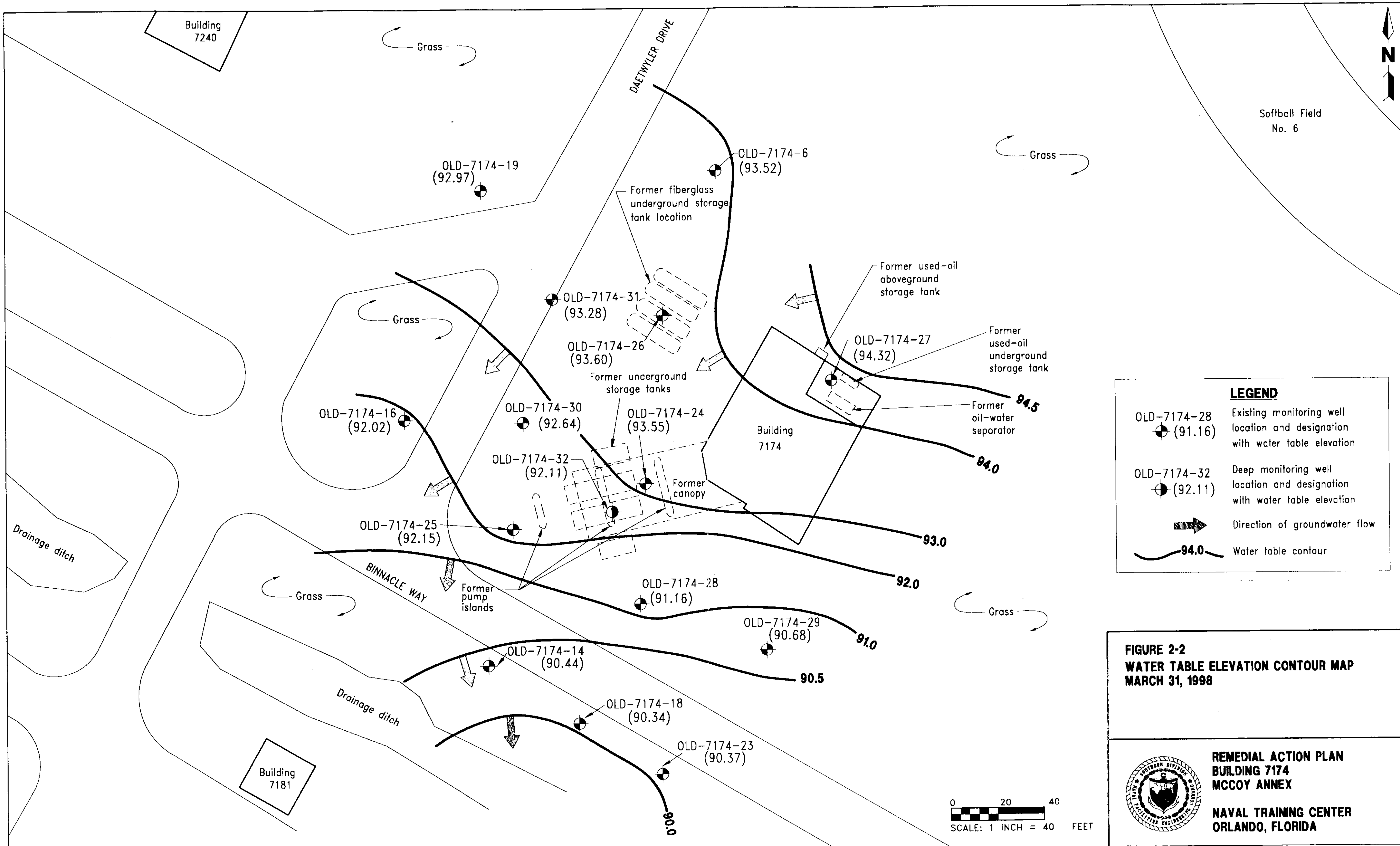

FIGURE 2-2
WATER TABLE ELEVATION CONTOUR MAP
MARCH 31, 1998

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the data, as they pertain to each electron acceptor and microbial process, is provided in this section.

Table 2-1
Natural Attenuation Monitoring, August 20, 1998

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Monitoring Parameters	Monitoring Wells OLD-7174-			
	27	18	24	25
Ferrous iron (mg/ℓ)	0.58	0.56	2.07	0.35
Nitrate (mg/ℓ)	0	0	0	0
Sulfate (mg/ℓ)	80	0	0	0.011
Dissolved oxygen (mg/ℓ)	0.018	0.014	0	0

Notes: mg/ℓ = milligrams per liter.

2.2.1 Electron Acceptors and Other Indicators of Biodegradation 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 and iron (II), in known areas of groundwater contamination. These indicators and other parameters are described in the subsections below.

2.2.1.1 **Dissolved Oxygen** A depleted concentration of dissolved oxygen in the source area is a strong indication of aerobic biodegradation. Field measurements indicate that dissolved oxygen at Building 7174 is at or near zero in the contaminated area. The concentration for dissolved oxygen, based on measurements taken from wells outside of the contaminated zone, was 0.018 milligram per liter (mg/ℓ).

2.2.1.2 **Nitrate** Concentrations of nitrate were measured in the field using a HACH test kit. A concentration of 0 mg/ℓ was measured at the source zone associated with monitoring well MW-24; nitrate also was measured at 0 mg/ℓ in the downgradient well MW-18 and at 0 mg/ℓ in the upgradient well MW-27.

2.2.1.3 **Iron II** Under anaerobic conditions, iron III may be used as an electron acceptor. Although iron III available to microorganisms cannot be measured without knowing the degree of crystallinity, iron II, an end product in the reaction, can be used as an indicator. Elevated levels of iron II corresponding to elevated levels of benzene, toluene, ethylbenzene, and xylenes (BTEX) indicate that biodegradation via iron III reduction is likely occurring. This appears to be the case at Building 7174, where the highest iron II concentration of 2.07 mg/ℓ corresponds with the source well MW-24. The concentration of iron II was 0.56 mg/ℓ in the downgradient well MW-18 and 0.58 mg/ℓ at the upgradient well, MW-27.

2.2.1.4 **Sulfate** Sulfate concentrations were measured using a HACH test kit. Sulfate was not detected in the downgradient well MW-18, was measured at 80 mg/ℓ at the upgradient well MW-27, and was 0 mg/ℓ at the source well MW-24. This indicates sulfanogensis is occurring, but it is not likely to significantly contribute to biodegradation of the contaminants.

3.0 REMEDIAL ALTERNATIVES

3.1 CONTAMINANTS OF CONCERN. Contaminants of concern for Building 7174 are associated with past releases of gasoline resulting in contaminants dissolved in groundwater. Free product has not been observed at the site since the most recent remedial action was completed and soil contamination exceeding FDEP standards was not observed during the site assessment. Therefore, the remedial objectives are centered around addressing the dissolved contaminant plume and the site contaminants of concern are those listed in Chapter 62-770, FAC, and presented in Table 3-1.

Table 3-1
Site Contaminants of Concern and
Groundwater Target Concentrations

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Parameter	Groundwater Target Concentration ($\mu g/\ell$)
Benzene	1
Toluene	1,000
Ethylbenzene	700
TRPH	5,000
Naphthalene	20

Notes: TRPH = total recoverable petroleum hydrocarbons.
$\mu g/\ell$ = micrograms per liter.

3.2 SOIL AND GROUNDWATER CLEANUP LEVELS. Standards and regulations regarding required remedial goals for soil and groundwater are contained in Chapter 62-770, FAC (September 1997). Based on the available data and requirements in Chapter 62-770, FAC, the constituents of the Gasoline Analytical Group are the basis for remedial actions. The target concentrations for each contaminant of concern that exceeded State regulatory criteria and target cleanup concentrations are presented in Table 3-1.

3.3 EXTENT OF CONTAMINATION. The area of contamination at Building 7174 generally corresponds to the former locations of USTs and fuel pump islands. The approximate extent of contamination is depicted on Figure 3-1. The extent of benzene contamination was used to represent all site contamination because it is the most extensive.

3.4 SITE-SPECIFIC LIMITATIONS TO ALTERNATIVES. The site contamination is primarily located beneath grassy areas adjacent to Building 7174 and extending partially under the building (see Figure 3-1). This is an inactive area and, in

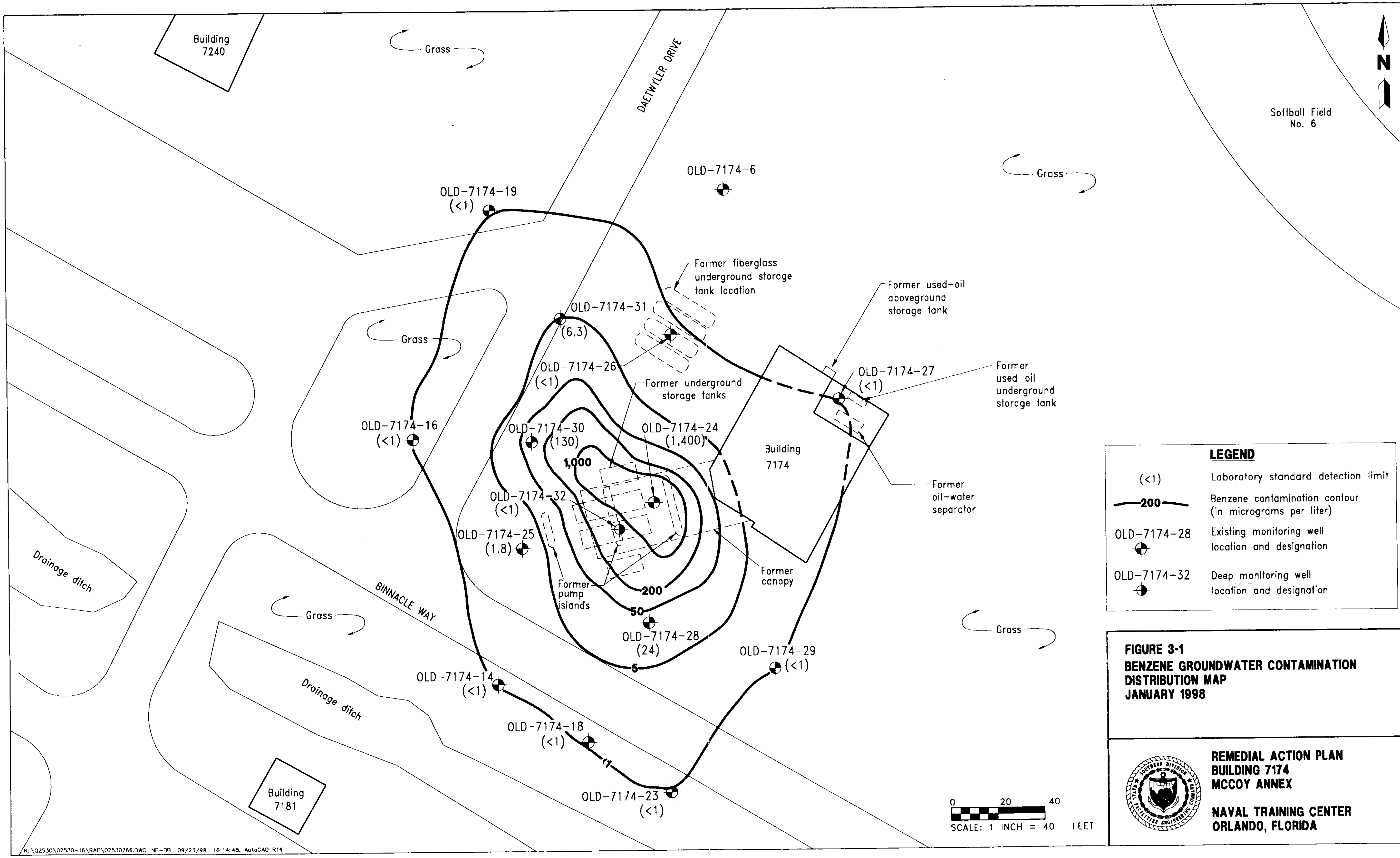

FIGURE 3-1
BENZENE GROUNDWATER CONTAMINATION DISTRIBUTION MAP
JANUARY 1998

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general, any remedial construction or operation and maintenance activities would not be restricted by site activities.

3.5 REMEDIAL STRATEGY. Remedial actions at Building 7174 should implement a strategy of "hot spot" contaminant concentration reduction followed by natural attenuation to achieve the target cleanup levels. This strategy is expected to be more cost effective than complete cleanup by active remediation. This is because it reduces the size of the plume targeted for active treatment and uses a low-cost passive approach to address the final cleanup of low concentrations which are most difficult to address through active approaches. For remedial design purposes, the targeted plume will be defined as groundwater with benzene concentrations of 5 micrograms per liter ($\mu g/\ell$) or greater.

3.6 REMEDIAL ALTERNATIVES SELECTION. When considering remedial options for a hot spot reduction strategy the targeted plume, the exposure pathways, and potential receptors should be identified. Once this is accomplished, the most cost-effective remedy can be selected and implemented to provide the necessary protection of human health and the environment while meeting the remedial action objectives.

Potential receptors of contaminants from Building 7174 could be individuals who consume contaminated groundwater from drinking water wells completed in the surficial aquifer. Contaminated groundwater could also migrate off site and discharge to the drainage ditch south of Binnacle Way, potentially impacting that surface water.

At this time, there are no known drinking water wells completed in the surficial aquifer within a 0.25-mile radius of the site. A potable well survey for the surrounding area is included in the McCoy Annex CAR (ABB-ES, 1996). No active potable wells were reported in the immediate site vicinity. Two potable wells, currently not in service, are located in the McCoy Annex area, including WW-3, 0.3 mile north and WW-4, 0.4 mile northeast. Three other potable wells were recently abandoned near the site, including WW-5, 0.2 mile north; WW-2, 0.4 mile north; and WW-1, 0.7 mile north. In addition, two irrigation wells are located in the area. Well WW-6 is located 1 mile northeast of the site and WW-7 is located 1 mile south.

The nearest surface water body is located in the drainage ditch running northwest to southeast, along Binnacle Way, approximately 50 feet south of the site. Local groundwater flow is influenced and partially intercepted by the ditch. Therefore, contaminant migration off site would eventually result in discharges to the surface water.

3.6.1 Technology Screening The screening of technologies for groundwater treatment is provided in Table 3-2.

Table 3-2
Screening of Groundwater Remedial Technologies

Remedial Action Plan
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Remedial Technology	Advantages	Disadvantages	Screening Status	Comments
Natural attenuation	• Disturbance to site operations is minimal. • The technology can be used in locations that are difficult to treat due to obstructions (i.e., under buildings, etc.)	• The technology is not suitable at sites where free product or highly impacted groundwater is present. • Natural attenuation may not be suitable if receptors could be affected by migration of contaminants. • Treatment times are normally longer than for active remedial measures.	Retained	May be used in conjunction with other technologies.
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.	Eliminated	Plume containment is not part of the remedial strategy.
Groundwater extraction wells (pump and treat)	• Some existing wells may be used.	• Wells must be strategically located so that cones of depression intersect and capture all contaminated groundwater. • Disposal of treated effluent may require permits.	Retained	Several recovery wells are located near the targeted area of contamination.
Air sparging	• Injected air may volatilize hydrocarbons. • Effective for VOCs when used in conjunction with soil vapor extraction.	• Extensive monitoring and operational adjustments may be required during start-up to attain proper dispersion rates. • Extensive soil, air, structural stability and groundwater monitoring are required.	Retained	Biosparging may be preferred as vapor recovery or vapor concentrations would be minimized.

See notes at end of table.

Table 3-2 (Continued)
Screening of Groundwater Remedial Technologies

Remedial Action Plan
Building 7174
Naval Training Center, McCoy Annex
Orlando, 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. • Extensive monitoring and operational adjustments may be required during start-up to attain proper dispersion rates. • Extensive soil, air, structural stability and groundwater monitoring required.	Retained	Low air flow rates may cause less structural instability in the subsurface soils than flow rates associated with air sparging and reduce need for off-gas treatment.
Wastewater treatment facility disposal	• May involve only pumping groundwater to treatment facility. • May only require the use of an oil-water separator.	• Treatability studies would be required to determine effect on treatment processes. • Approval required by operating agency.	Eliminated	Groundwater recovery is not preferred.
Groundwater reinjection	• 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	Groundwater recovery is not preferred.
Discharge to surface water	• Could discharge to nearby drainage ditch.	• NPDES permit required.	Eliminated	Groundwater recovery is not preferred.

Notes: Shading indicates technology was eliminated.
VOC = volatile organic compound.
NPDES = National Pollution Discharge Elimination System.

3.6.2 Technology Selection Based on existing site conditions and the remedial strategy proposed in Section 3.5, a biosparging system is proposed to actively remediate the groundwater plume. The active treatment will be used to reduce the contaminant concentrations to the low microgram per liter range and will be followed by natural attenuation to reduce concentrations to no further action levels. If necessary, a vapor collection and treatment system will be included to control air emissions.

4.0 REMEDIAL DESIGN

This chapter presents details of the proposed system for reducing groundwater contaminants, including benzene, total volatile organic aromatics and total naphthalenes in surficial groundwater. Biosparging will be used to reduce groundwater contamination to concentrations that can be naturally attenuated within a reasonable time frame. A pilot study is not recommended because of the use of biosparging and the straightforward nature of the site. System optimization will be performed during the start-up period.

4.1 BIOSPARGING SYSTEM DESCRIPTION. Biosparging is defined as 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 contaminants 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. Because 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 (e.g., 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 (e.g., clays), the system may resist the movement of oxygen through the aquifer and create pockets of untreated contamination.

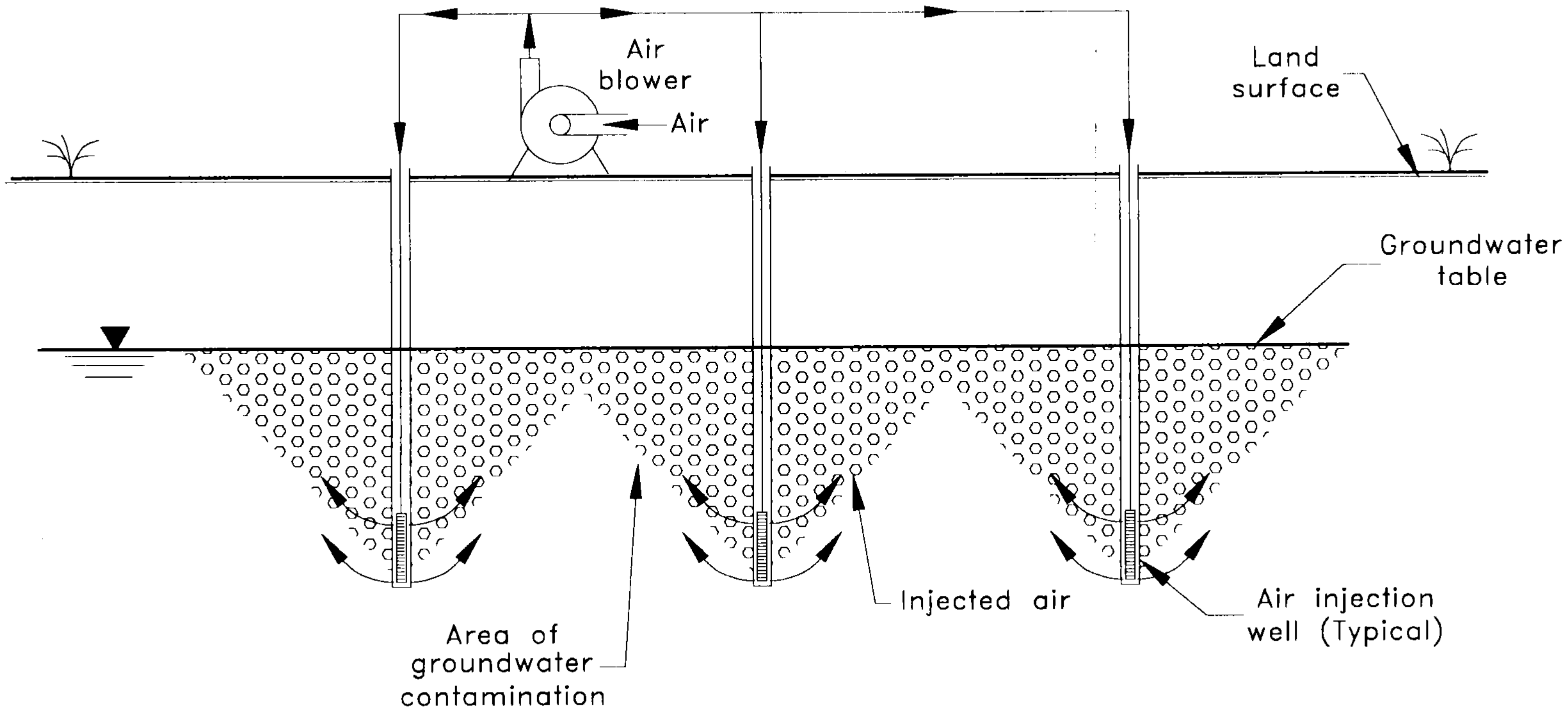
Because biodegradation is the goal of this remedial action, and the primary factor limiting biodegradation rates is the lack of available oxygen, biosparging has the potential to increase biological activity.

Components of a biosparging system include the following:

- biosparging wells,
- manifold piping,
- compressed air equipment, and
- monitoring and controls.

Figure 4-1 presents a schematic of a biosparging system.

4.1.1 Biosparge System Design The design of the biosparging system is geared towards introducing a sufficient amount of oxygen into the aquifer matrix using a series of injection wells. Figure 4-2 shows the estimated extent of groundwater contamination addressed by this biosparge system (greater than 5 $\mu g/\ell$ benzene).



Not To Scale

FIGURE 4-1
SCHEMATIC OF BIOSPARGING

REMEDIAL ACTION PLAN
BUILDING 7174
MCCOY ANNEX

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

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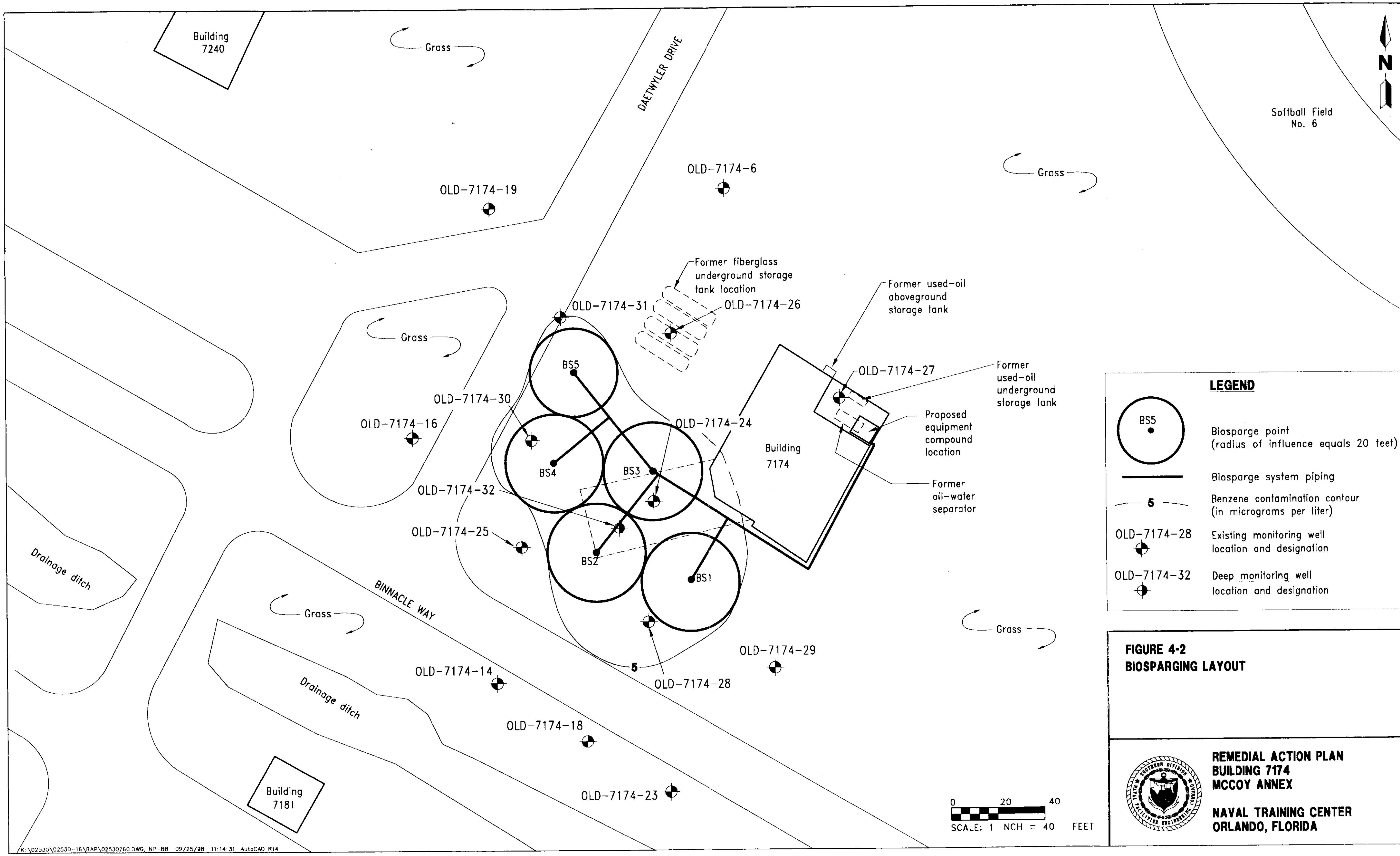


FIGURE 4-2
BIOSPARGING LAYOUT

A design radius of influence of 20 feet per well was selected based on available site information and experience at other sites. With this radius of influence, a total of 5 biosparging wells is required to cover the targeted area (greater than 5 $\mu g/\ell$ benzene). Location of biosparge wells is presented on Figure 4-2. Construction details for the biosparge wells are included on Figure 4-3.

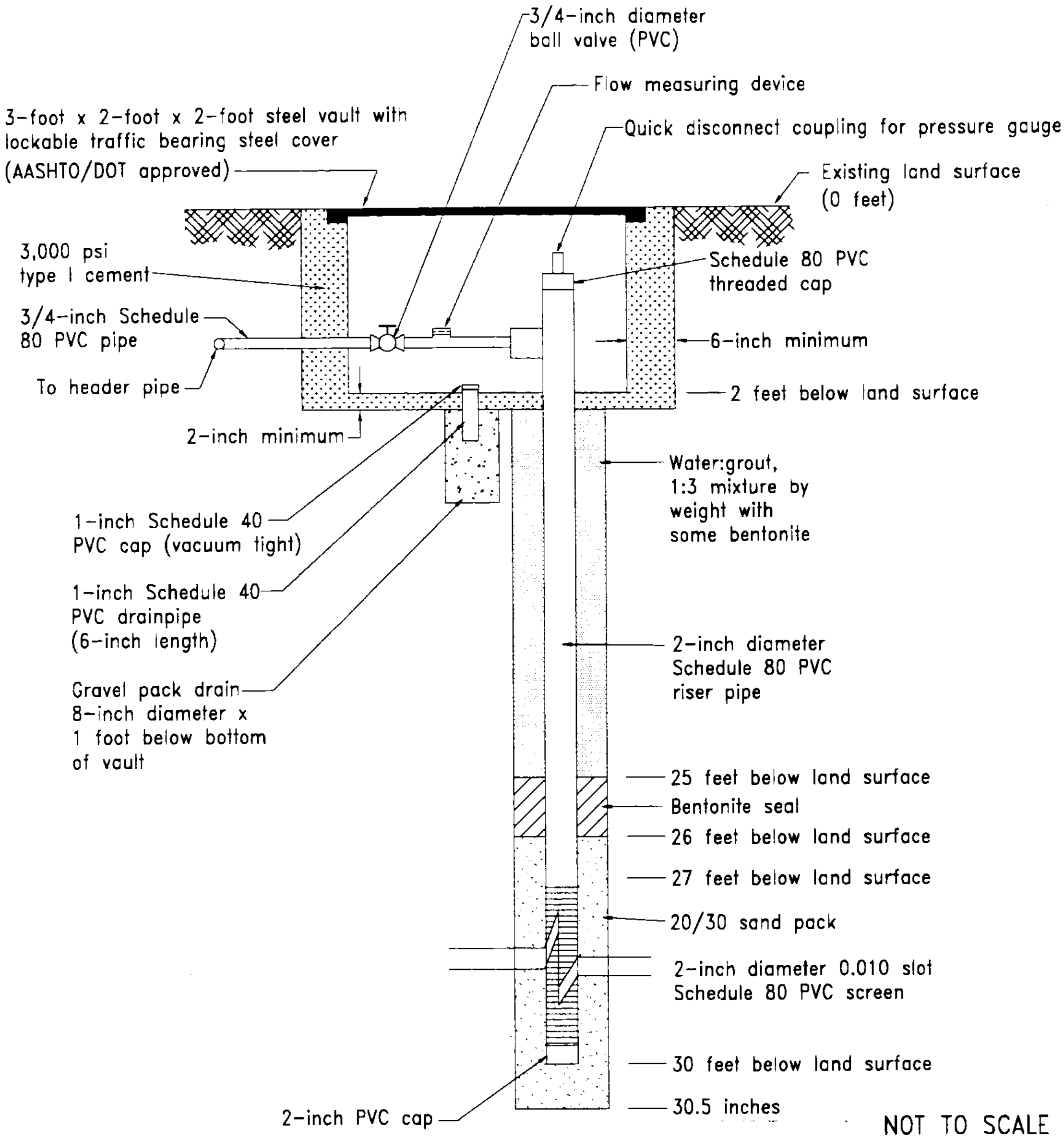
To size the compressor, the actual pressure and flow rate for the system was calculated taking into account pressure and dynamic losses and employing a safety factor of 1.5. The estimated total flow rate and design pressure is 8 actual cubic feet per minute (acfm) and 14 pounds-force per square inch (psi), respectively. These calculations can be found in Appendix A. Based on these requirements, the recommended compressor for the site is a Kaeser Model Number SX-6 Screw-type Air Compressor or an approved equivalent. The compressor is capable of delivering air at a pressure of 110 psi at a maximum flow rate of 21 acfm. Existing power poles will be used to deliver 3-phase power to the compressor. To help increase the life of the compressor, a 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 and air tank will be located in an equipment compound. The approximate location of the equipment compound in relation to the biosparge wells is shown on Figure 4-2. The equipment compound layout will be determined in the field during system installation. 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.

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 polyvinyl chloride (PVC) pipe. The system will deliver air to each well at a flow rate of approximately 1 acfm at an in-line pressure of 11 psi. Piping inside the compound will be galvanized steel. Figure 4-4 presents the process and instrumentation diagram of the biosparging system for the Building 7174 site.

<u>4.1.2 System Start-up</u> Upon approval by the regulatory agencies of this RAP, the installation 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 officer in charge of construction, 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 one 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.



LEGEND

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

NOTES:

1. Concrete pad should be constructed to shed runoff water from the vault.
2. Vault configuration may be modified to accomodate the flow measuring device.
3. Flow measuring device should be placed in line in accordance with manufacturers specifications.

FIGURE 4-3
BIOSPARGE WELL CONSTRUCTION DETAIL

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REMEDIAL ACTION PLAN
BUILDING 7174
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ORLANDO, FLORIDA

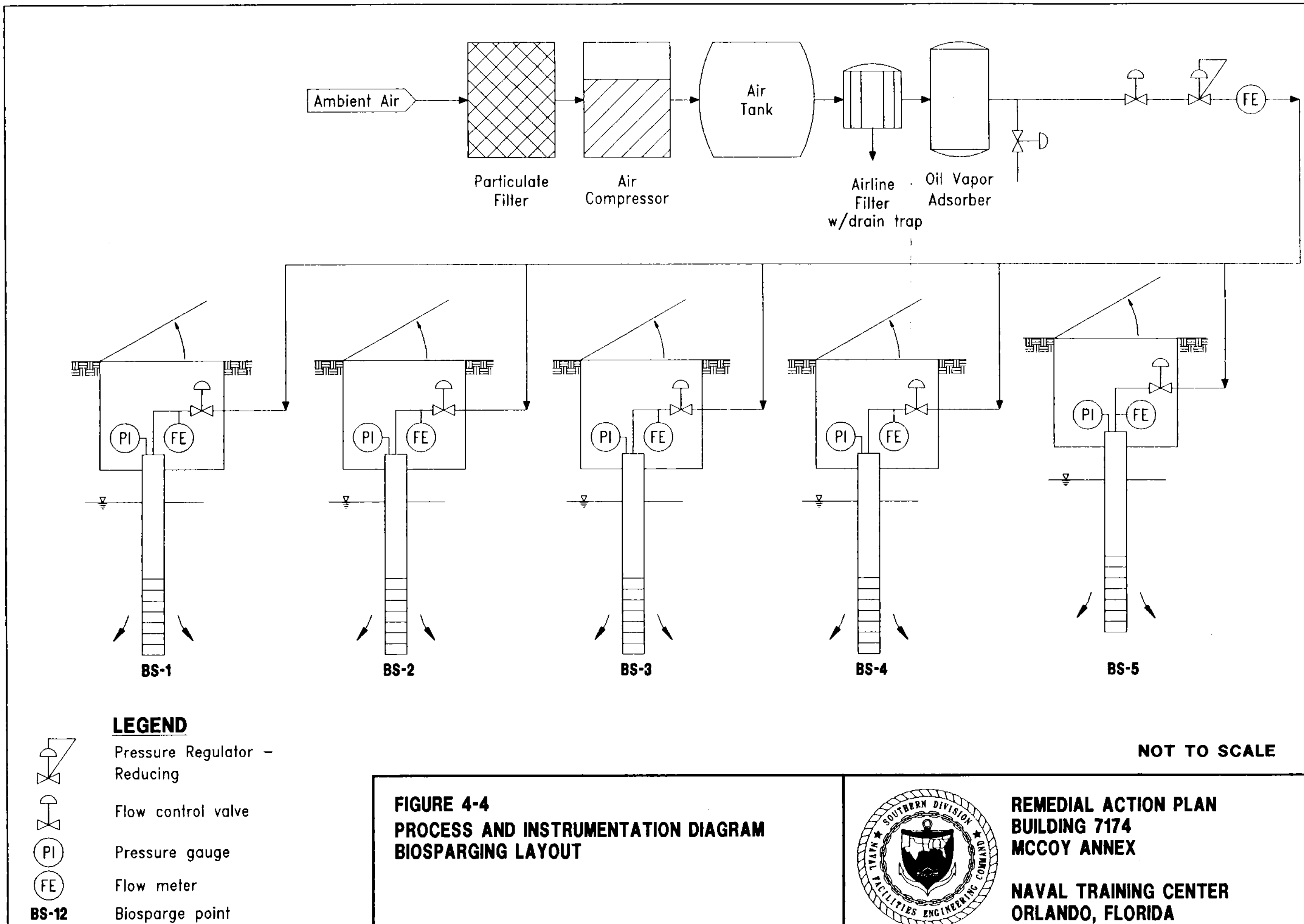

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FIGURE 4-4
PROCESS AND INSTRUMENTATION DIAGRAM BIOSPARGING LAYOUT

REMEDIAL ACTION PLAN
BUILDING 7174
MCCOY ANNEX

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

Five biosparging wells will be installed. Figure 4-2 shows the location of the biosparging wells, and Figure 4-4 shows the typical construction details for these wells. Soil samples will be collected at 2-foot intervals in the unsaturated zone and analyzed using an OVA during the installation of these wells. Groundwater samples shall be collected at 5-foot intervals beneath the groundwater table and analyzed using a field gas chromatograph in order to better evaluate the baseline contamination in the plume.

The compressor for the biosparge system 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 A. Equipment maintenance will be provided according to the manufacturer's recommendations during monthly operations and maintenance visits to the site.

4.2 **VAPOR EMISSIONS**. Preliminary estimates of vapor emissions from the biosparge system indicate that a VCS is not warranted. Supporting calculations are included in Appendix A. To verify these estimates, vapor emission monitoring will be conducted during the start-up period. Vapor emission samples will be collected from three locations within the biosparge area. The sample locations will be determined in the field during start-up. Samples will be collected using standard soil gas sampling methods and analyzed by U.S. Environmental Protection Agency Method TO-14. The results of these analyses along with the actual air injection rate will be used to estimate the actual vapor emission rate. If the emission rate exceeds the criteria of 13.7 pounds of total VOA per day, actions will be implemented to either reduce the emission rate to within the criteria or install a vapor collection system to capture and treat the vapors. Because the need for a vapor collection system is not anticipated, all necessary system design will be prepared if and when the requirement arises and will not be addressed in this report.

5.0 NATURAL ATTENUATION AND LONG-TERM MONITORING PLAN

5.1 OVERVIEW. The monitoring program described in this chapter is designed to evaluate the performance, progress, and effectiveness of the biosparging system and natural attenuation to reduce contaminants and retard their migration while monitoring any plume migration that may occur over time. Natural attenuation modeling was not included in this RAP because the low contaminant concentrations expected to be present following the active remediation phase do not warrant it. Any modeling at this time would be subject to variable site conditions which may exist following the active remediation phase. A qualitative evaluation based on the data described in Section 2.2 and previous experience indicates that natural attenuation can reasonably be expected to reduce the contaminant concentrations to no further action levels following the active remediation.

5.2 MONITORING WELL LOCATIONS. Four monitoring wells will be used as long-term monitoring wells to observe the remediation and degradation of the contaminants and plume retardation. The location of these wells is shown on Figure 5-1. Monitoring well OLD-7174-27 will be used to monitor upgradient site conditions. Monitoring well OLD-7174-24 will be used to monitor the area of highest contaminant concentrations, near the former UST location. Monitoring well OLD-7174-28 will be used to further characterize remedial progress. Monitoring well OLD-7174-18 will be used to monitor any downgradient contaminant migration.

5.3 GROUNDWATER SAMPLING. Sampling will be conducted quarterly during the operation of the biosparging system and for the first year after biosparging is stopped, then semiannually for additional years, if necessary, to verify that the contaminant mass and mobility are being effectively reduced. Water-level measurements will be collected during each sampling event. Samples will be collected from wells designated for long-term monitoring only and analyzed using the test methods shown in Table 5-1. Biodegradation parameters listed in Table 5-2 will be collected from the same monitoring wells and analyzed on a yearly basis. If the data collected support the anticipated effectiveness of the remedial alternative at this site, monitoring frequency may be reduced to once per year, subject to FDEP approval. If the data collected at any time during the monitoring period indicate plume migration or a risk to human health, the sampling frequency will be adjusted accordingly and/or a contingency plan will be developed, approved by FDEP, and implemented.

5.4 REPORTING. Within 60 days of each sampling event, a report will be prepared and submitted to SOUTHNAVFACENGCOM. The report will include sampling results and recommendations for future actions.

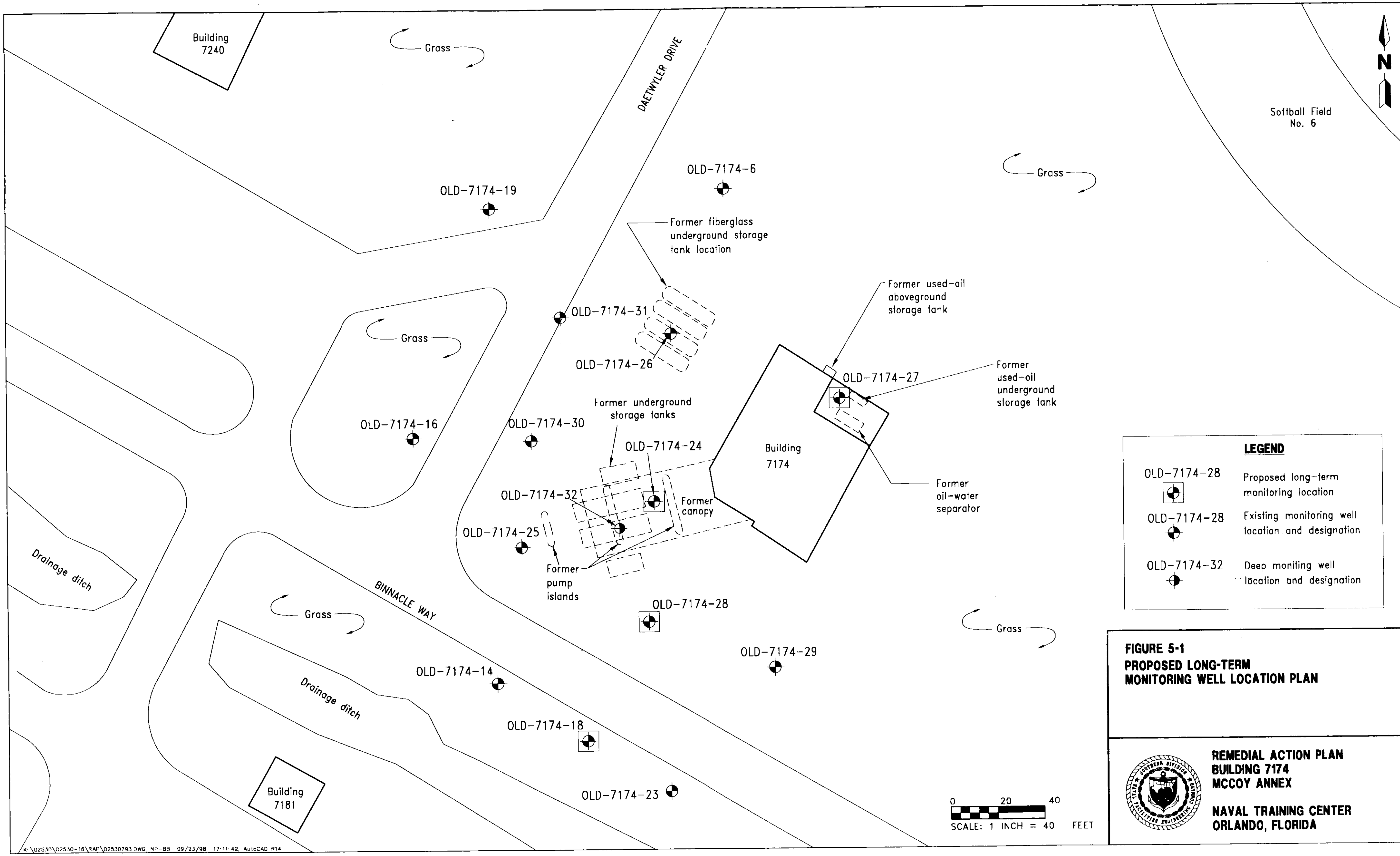

FIGURE 5-1
PROPOSED LONG-TERM MONITORING WELL LOCATION PLAN

Table 5-1
Groundwater Sampling and Analysis for Contaminant Monitoring

Remedial Action Plan
Building 7174, McCoy Annex
Naval Training Center
Orlando, Florida

Analyte	Method[1]/ Reference	Data Use	Sample Volume, Sample Container, and Sample Preservation	Field- or Fixed-Base Laboratory
Aromatic hydrocarbons	602; GC/MS	Method of analysis for BTEX.	Collect water samples in a 40 mℓ VOA vial; cool to 4°C; add hydrochloric acid to pH 2.	Fixed
Semivolatile aromatic compounds	625; semivolatile extractables	Method of analysis for semivolatiles such as total naphthalenes.	Collect water samples in a 1 liter amber-tinted glass bottle; cool to 4°C.	Fixed

[1] Method refers to U.S. Environmental Protection Agency test methods.

Notes: GC/MS = gas chromatography and mass spectroscopy.
BTEX = benzene, toluene, ethylbenzene, and xylenes.
mℓ = milliliter.
VOA = volatile organic aromatic.
°C = degrees Celsius.

Table 5-2
Groundwater Sampling and Analysis for Biodegradation Monitoring[1]

Remedial Action Plan
Building 7174, McCoy Annex
Naval Training Center
Orlando, Florida

Analysis	Method[2]/ Reference	Data Use	Sample Volume, Sample Container, Sample Preservation	Field- or Fixed-Base Laboratory
Temperature	170.1, Direct-reading thermometer	Well development; biological processes are temperature dependent.	Conduct *in situ*	Field
Dissolved oxygen	HACH Colorimeter	The oxygen concentration is a data input to most biological models; concentrations less than 1 mg/ℓ generally indicate an anaerobic pathway.	AccuVac Ampuls	Field
pH	150.1, Direct-reading meter	Biological processes are pH sensitive.	Collect 100 to 250 mℓ of water in a glass or plastic container, analyze immediately.	Field
Conductivity	120.1, Direct-reading meter	General water quality parameter used to verify that site samples are obtained from the same groundwater system.	Collect 100 to 250 mℓ of water in a glass or plastic container, analyze immediately.	Field
Alkalinity	HACH Colorimeter	General water quality parameter used to verify that site samples are obtained from the same groundwater system and to measure the buffering capacity of groundwater.	AccuVac Ampuls	Field
Ferrous Iron (Fe^{+2})	HACH Colorimeter	May indicate an anaerobic degradation process due to depletion of oxygen, nitrate, and manganese.	AccuVac Ampuls	Field
Nitrate (NO_3^{-1})	HACH Colorimeter	Substrate for microbial respiration if oxygen is depleted.	AccuVac Ampuls	Field
Sulfate (SO_4^{-2})	HACH Colorimeter	Substrate for anaerobic microbial respiration.	AccuVac Ampuls	Field

[1] Table adapted from the *Technical Protocol for Implementing the Intrinsic Remediation with Long-Term Monitoring Option for Natural Attenuation of Dissolved-Phase Fuel Contamination in Ground Water* (Wiedemeier, 1995).
[2] Method refers to United States Environmental Protection Agency test methods.

Notes: HACH refers to the HACH Company catalog.

mg/ℓ = milligrams per liter.
mℓ = milliliter.
°C = degrees Celsius.

6.0 COST ESTIMATE

A cost estimate for the excavation and treatment of contaminated soil and ongoing monitoring of Building 7174 has been prepared. To facilitate the Navy's procurement procedures, the cost estimate is being submitted under a separate cover.

7.0 SCHEDULE

Implementation of this RAP can begin upon FDEP approval. Following notice to proceed, approximately 2 months should be budgeted for implementation of remedial activities at Building 7174. This includes approximately 1 month for procurement. It is estimated that approximately 3 weeks would be necessary for site mobilization and site staging for the installation of the biosparging system. Preparation of any permit applications should begin immediately upon notice to proceed from the Navy. The location of all underground utilities should also be determined and marked during this time period.

The remedial subcontractor should be an approved contractor for the remediation of petroleum-contaminated soil and groundwater and should meet all applicable permit requirements. Well permits from the St. Johns River Water Management District for the abandonment and installation of shallow monitoring wells will be required. This permitting process is expected to take approximately 1 week. Within 60 days of completion of system installation, record drawings signed and sealed by a registered Professional Engineer should be submitted to the FDEP.

Site monitoring would subsequently occur on a quarterly basis.

8.0 PROFESSIONAL REVIEW CERTIFICATION

This RAP was prepared using standard engineering practices and designs. The plan for remediating this site is based on the information collected through August 1998 as described herein and engineering detailed in the text and appended to this report. If conditions are determined to exist differently than those described, the undersigned Professional Engineer should be notified to evaluate the effects of any additional information on the design described in this report.

This RAP was developed for Building 7174, McCoy Annex, Orlando, Florida, and should not be construed to apply to any other site.

HARDING LAWSON ASSOCIATES
2590 Executive Center Circle East
Tallahassee, Florida 32301

Michael K. Dunaway
9/25/98

Michael K. Dunaway, P.E., P.G.
Professional Engineer
State of Florida License No.: 39451

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APPENDIX A

CALCULATIONS

BIOSPARGE SYSTEM DESIGN
Building 7174, NTC Orlando, McCoy Annex

Date: 9/4/98

Engineer: MKD Checked by:

Description	Value	Units	Source
Groundwater depth below land surface	6	ft bls	measured
Design depth of contaminant plume	20 - 25	ft bls	estimated
Design sparge well depth	30	ft	selected
Design screen length	3	ft	selected
Design air injection depth	27	ft bls	calculated
Height of water column in well	21	ft	calculated
Estimated breakthrough pressure	9.1035	psi	calculated
Number of sparge wells	5		selected
Design air flow rate per well	1	cfm	selected
Total design air flow rate	5	cfm	calculated

Air Sparging Head loss Calculation

NTC Orlando, Building 7174, McCoy Annex, Remedial Action Plan

Total Required Flow Rate = 7.5 cfm

Total Required Pressure = 13.67 PSIG

NTC Orlando, McCoy Annex, Building 7174

Date: 4 September 1998 | Engineer: MKD | Checked By:

	Run from the Equipment compound to each well				
Component	BS-1	BS-2	BS-3	BS-4	BS-5
Piping length, 2-inch (ft)	105	135	145	170	200
Tee, 2-inch, stem (each)	0	0	0	0	0
Tee, 2-inch, line (each)	0	1	2	3	4
90 deg. elbow, short(each)	2	2	2	2	2
Piping length, 3/4-inch (ft)	25	50	10	30	10
Tee, 3/4-inch, stem (each)	1	1	1	1	1
Hand Valve/Globe Valve (each)	2	2	2	2	2
Flow meter/Globe Valve (each)	2	2	2	2	2

	Equivalent Length				
Pipe Diameter	BS-1	BS-2	BS-3	BS-4	BS-5
2	122	160	177	210	248
0.75	111	136	96	116	96

Equivalent pipe length	Length of straight Pipe in Diameters
Tee, stem (each)	72
Tee, line (each)	46
Hand Valve/Globe Valve (each)	325
Flow meter/Globe Valve (each)	325
90 deg. elbow, short(each)	51
assume turbulent flow where $N_R > 4000$	

	Maximum flow rate per 2-inch piping section (CFM					Flow Rate per section (cfm)
	BS-1	BS-2	BS-3	BS-4	BS-5	
Total Length of Run	105	135	145	170	200	
Compound to BS-1 junction	105	105	105	105	105	5
BS-1 junction to BS-2 junction		30	30	30	30	4
BS-2 junction to BS-3			10	10	10	3
BS-3 to BS-4 junction				25	25	2
BS-4 junction to BS-5					30	1
Section length						0
Section length						0
Section length						0
Section length						0
Section length						0
Section length						0
Length Weighted Average Flow rate (cfm)	5.0	4.8	4.7	4.3	3.8	
Length Weighted Average Velocity (ft/min)	229.2	219.0	213.4	195.5	173.0	

	Maximum flow rate per 3/4-inch piping section (CF					Flow Rate per section (cfm)
	BS-1	BS-2	BS-3	BS-4	BS-5	
Total Length of Run	25	50	10	30	10	
section length	25	50	10	30	10	1
Length Weighted Average Flow rate (cfm)	1	1	1	1	1	
Length Weighted Average Velocity (ft/min)	325.9	325.9	325.9	325.9	325.9	

Note: Since the velocity is less than 1000 feet per minute in both the 2-inch and 3/4-inch pipes and the flow rate of 5 cfm in a 2-inch pipe and 1cfm in a 3/4 inch pipe are not approached in the attached chart, a h_f of 0.014 per foot of tubing will be used.

H_f per foot of tubing for 2- and 3/4-inch pipe= 0.014 inches of water per foot of tubing (from attached table)

	Friction Head loss for each piping run.				
	BS-1	BS-2	BS-3	BS-4	BS-5
h_f in inches of H_2O =	3.2585	4.13583	3.82317	4.5605	4.8078
h_f in PSI =	0.0080	0.0102	0.0094	0.0112	0.0118

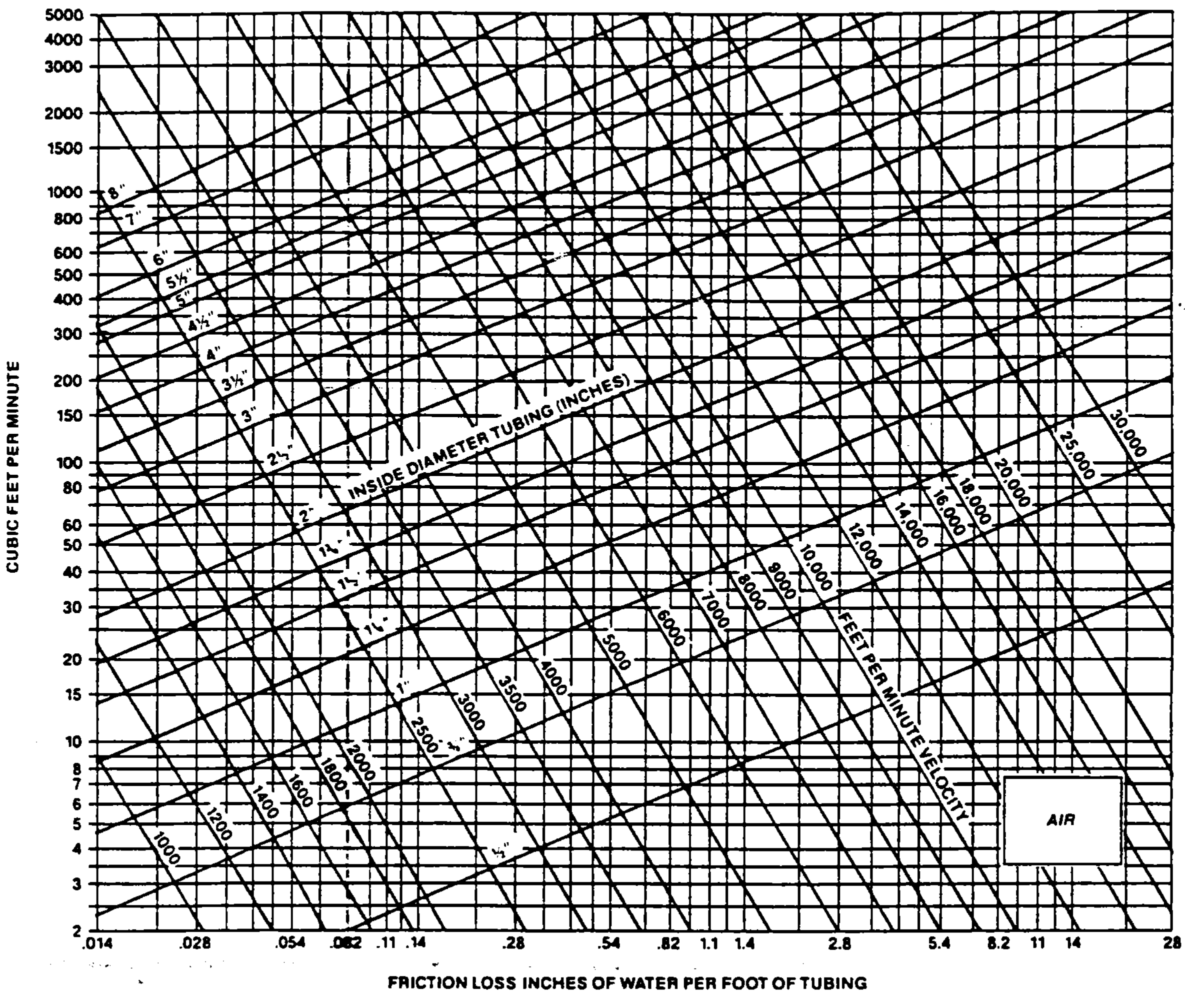
Total Required Flow = design flow * number of wells * S.F.

Total Required Flow = 1 cfm/well * 5 wells * 1.5 = 7.5 cfm

Total Pressure Required = (Design Pressure + max h_f) * S.F.

Total Pressure Required =(9.1 psi + 0.012) * 1.5 = 13.668 psig

Friction Loss Per Foot of Tubing



Friction Loss in Fittings

To calculate friction loss in fittings use chart below. This chart will yield equivalent lengths (in feet) of tubing. Use this length with graph above to find friction loss in inches of water column.

NOMINAL PIPE SIZE (INCHES)	EQUIVALENT TUBING LENGTH (FEET)	
	90° EL	45° EL
1¼	3	1.5
1½	4	2
2	5	2.5
2½	6	3
3	7	4
4	10	5
5	12	6
6	15	7.5
8	20	10

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

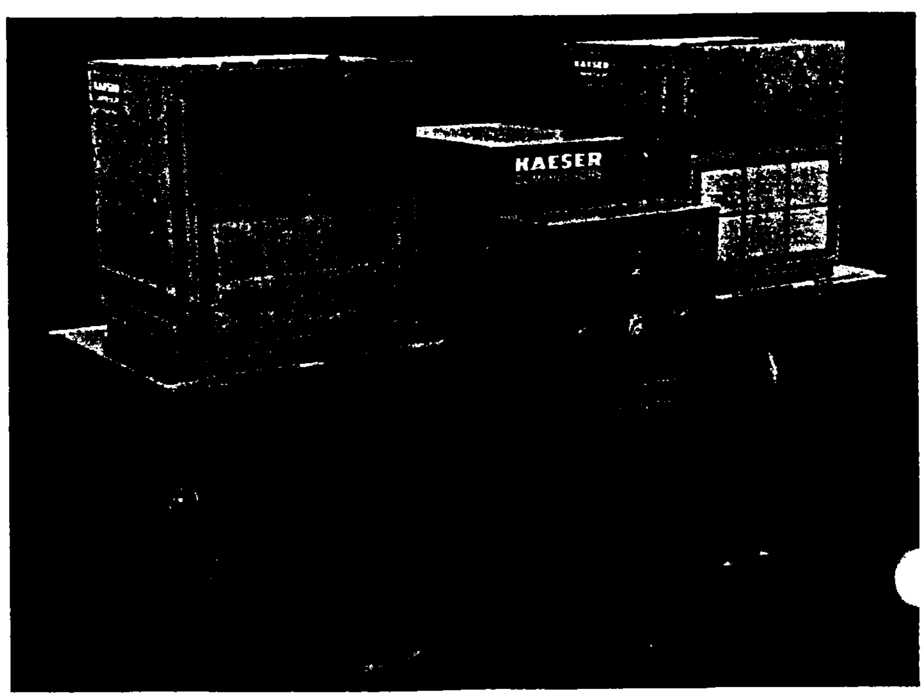
Kaeser Sigma Profile rotary screw compressors, refrigerated dryers and filters are matched with an appropriately sized tank to make a reliable compact system. All inter-connecting piping and wiring is completed at the factory.

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

CALCULATION OF MASS FRACTIONS FROM SITE DATA

NTC Orlando, Bldg. 7174

OLD-7174-24

Parameter	Observed Concentration (ug/l)	Mass Fraction
2-methylpentane	0	0
3-methylpentane	0	0
n-hexane	0	0
benzene	1400	0.120378332
2,3-dimethylpentane	0	0
2-methylhexane	0	0
n-heptane	0	0
toluene	3900	0.335339639
ethylbenzene	920	0.079105761
o-xylene	5300	0.455717971
n-decane	0	0
n-undecane	0	0
n-dodecane	0	0
n-tetradecane	0	0
n-pentadecane	0	0
n-hexadecane	0	0
napthalene	110	0.009458298
1-methylnaphthalene	0	0
2-methylnaphthalene	0	0
Total Mass per Liter	11630 ug	100 percent

WEIGHTED HENRY'S LAW CONSTANT AND Koc FOR COMPOSITE FUEL CONTAMINATION

NTC Orlando, Bldg. 7174

Biosparge System Air Emissions Characterization

PROJECT NAME:

MASS OF CONTAMINANT

DATE: ENGINEER: MKD CHECKED BY:

Compound	Mass Fraction	Molecular Weight	Molecular Weight * Mass Fract.	Vapor Pressure atm	Boiling Point C	Water Solubility mg/l	Kow	Calculated Henry's Law Const atm*m^3/mole	Henry's Law Constant dimensionless	Weighted Hc	Koc	Calculated Koc	Weighted Koc
2-methylpentane	0	86.2	0	0.21	60	14	6457	1.293	53.779	0	3830	3830	0
3-methylpentane	0	86.2	0	0.2	64	13	6457	1.326153846	55.158	0	3830	3830	0
n-hexane	0	86.2	0	0.16	68.7	13	8710	1.060923077	44.126	0	3830	3830	0
benzene	0.1203783	78.1	9.401547721	0.1	80.1	1780	135	0.00438764	0.182	0.02196815	65	65	7.8245916
2,3-dimethylpentane	0	100.2	0	0.072	89.8	5.3	16600	1.361207547	56.616	0		10235.5	0.0
2-methylhexane	0	100.2	0	0.064	90	4	22400	1.6032	66.681	0	6070	6070	0
n-heptane	0	100.2	0	0.046	98	3	30000	1.5364	63.903	0		18497.9	0.0
toluene	0.3353396	92.1	30.88478074	0.029	110.6	535	490	0.004992336	0.208	0.06963103	240	240	80.481513
ethylbenzene	0.0791058	106.2	8.401031814	0.01119	136.2	152	1400	0.007818276	0.325	0.02572369		863.2	68.3
o-xylene	0.455718	106.2	48.3972485	0.00066	144	175	890	0.000400526	0.017	0.00759173	700	700	319.00258
n-decane	0	142.3	0	0.00355	174.1	0.009		56.12944444	2334.559	0		165154.9	0.0
n-undecane	0	156.3	0	0.0004	196	0.004		15.63	650.089	0		272958.3	0.0
n-dodecane	0	170.3	0	0.0004	216	0.004		17.03	708.319	0		272958.3	0.0
n-tetradecane	0	198.4	0	0.0004	253.7	0.0022		36.07272727	1500.352	0		395332.1	0.0
n-pentadecane	0	212.4	0	0.0004	270.6	0.001		84.96	3533.691	0		644347.2	0.0
n-hexadecane	0	226.5	0	0.0004	287	0.0004		226.5	9420.681	0		1136776.8	0.0
napthalene	0.0094583	128.2	1.21255374	0.00014	218	33	1738	0.000543879	0.023	0.00021396	962	962	9.1
1-methylnaphthalene	0	142.2	0	0.00005	244.6	25	7413	0.0002844	0.012	0	3570	3570	0
2-methylnaphthalene	0	142.2	0	0.00005	241	27	7943	0.000263333	0.011	0	3570	3570	0
	1.00												
AVERAGE FORMULA WEIGHT:			98.29716251						Weighted Average Hc:	0.12512856		Weighted Average Koc:	484.69427

(TAKEN FROM GRAM FORMULA WEIGHTS x MASS FRACTION)

NTC Orlando, McCoy Annex, Building 7174				
Biosparge System Air Emissions Estimate				
Engineer:	MKD		Checked By:	
Date:	31-Aug-98		Project #	2530.16
Key Assumptions:				
1.)	The air injection rate equals the air release rate.			
2.)	The maximum contaminant vapor concentration is equal to the vapor concentration			
	expected under equilibrium conditions with the maximum observed groundwater concentration.			
3.)	Contaminant characteristics are based on site-specific weighted averages.			
Variable	Description	Value	Units	Source
Cw	highest observed total hydrocarbon concentration	20270	ug/l	SAR
	in water			
Hc	weighted average Henry's Law Constant	0.125129	dimensionless	calculated
Ca	vapor concentration in air emissions	2536364.83	ug/m^3	calculated
	conversion	2.53636483	g/m^3	calculated
Qa	air flow rate	5	cfm	selected
	conversion	0.1416	m^3/min	calculated
Md	daily mass emitted	517.174934	g/day	calculated
	conversion	1.14037073	lb/day	calculated

NTC Orlando, McCoy Annex, Building 7174

Time to Cleanup by Biosparging

Engineer:	MKD			Checked By:	
Date:	28-Aug-98			Project #	2530.16

Key Assumptions:

1.) The primary means of degradation are biological in nature.

2.) The biological reaction is only limited by the dissolved oxygen of the surficial aquifer.

3.) On a mass to mass ratio, 3.08 grams of usable oxygen are required to degrade 1 gram of BTEX.

4.) This spreadsheet will likely overestimate the time to cleanup due to other cleanup factors not accounted for such as volatilization, dispersion, etc.

5.) Rate of degradation with oxygen is instantaneous.

6.) Oxygen levels will not become toxic to the microbes.

7.) 20.9 percent of air injected is oxygen (299 E3 mg m-3) at 10% utilization.

8.) In estimating contaminant masses, hexane will be used as a surrogate for all gasoline constituents.

9.) Site porosity is 0.35, fraction of organic carbon is 0.1%, soil bulk density is 1.7 g/cm^3.

10.)

Variable	Description	Value	Units	Source
Kd	distribution coefficient	3.83	cm^3/g	Calculated
Ka	aquifer partitioning coefficent	18.60285714	dimensionless	Calculated
AREA 1	SAR Figure H-2			SAR
GWconc	Groundwater concentration	77.00	ug/l	SAR
GWvol	Volume of groundwater	3360608.00	l	SAR
Mdis	Dissolved Mass of Contaminant	258.77	grams	Calculated
MTRXconc	Concentration in saturated aquifer matrix	1432.42	ug/kg	Calculated
MTRXvol	Mass of aquifer matrix	16326593.28	kg	Calculated
Msorb	Sorbed Mass of Contaminant	23386.54	grams	Calculated
AREA 2	SAR Figure H-2			SAR
GWconc	Groundwater concentration	1475.00	ug/l	SAR
GWvol	Volume of groundwater	2189033.00	l	SAR
Cdis	Dissolved Mass of Contaminant	3228.82	grams	Calculated
MTRXconc	Concentration in saturated aquifer matrix	27439.21	ug/kg	Calculated
MTRXvol	Mass of aquifer matrix	10634817.02	kg	Calculated
Msorb	Sorbed Mass of Contaminant	291811.02	grams	Calculated
AREA 3	SAR Figure H-2			SAR
GWconc	Groundwater concentration	20270.00	ug/l	SAR
GWvol	Volume of groundwater	499453.00	l	SAR
Cdis	Dissolved Mass of Contaminant	10123.91	grams	Calculated
MTRXconc	Concentration in saturated aquifer matrix	377079.91	ug/kg	Calculated
MTRXvol	Mass of aquifer matrix	2426457.60	kg	Calculated
Msorb	Sorbed Mass of Contaminant	914968.42	grams	Calculated
Cmass	Total Mass of Contaminant	1243.78	kg	Calculated
DOnec	Necessary dissolved oxygen to			
	degrade the Mass of Cont.	3830.83	kg	Calculated
Omass	Mass of oxygen per cubic meter			
	of air delivered	0.299	kg/m^3	Estimate
%USED	Percent of oxygen actually used by microbes	10.00	%	Estimate
O2used	Actual mass of oxygen used by microbes	0.03	kg/m^3	Estimate
Airvol	Volume of air to be injected	128121.56	m^3	Estimate
	Conversion	4524569.35	ft^3	Estimate
Ainj	Air injection rate	5.00	cfm	Estimate
Tc	Time to cleanup	904913.87	minutes	Calculated
	Conversion	628.41	days	Calculated
fs	Safety factor	2.00	unitless	Selected
Tc(est)	***Estimated time to cleanup***	***1256.82***	***days***	***Calculated***
	Conversion	***3.44***	***year***	***Calculated***