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Final

Basis of Design for Site 7–Sodium Lactate Injection

NSWC White Oak Silver Spring, Maryland

Contract Task Order Number 0020

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Contents

Acronyms and Abbreviations ..... **v**

1 Introduction **1-1**
1.1 Scope and Purpose 1-1
1.2 Site Background 1-1
1.2.1 Site History 1-1
1.2.2 Site Geology and Hydrogeology 1-2
1.2.3 Soil Removal Action 1-2
1.3 Site Groundwater Evaluation 1-2
1.3.1 Nature and Extent of Groundwater Contamination 1-2
1.3.2 Trends in Contaminant Concentrations 1-3
1.4 Remedial Action 1-4

2 Technical Approach **2-1**
2.1 Treatment Technology Description 2-1
2.1.1 Electron Donor Selection 2-1
2.1.2 Dosing Parameters 2-1
2.2 Target Remediation Zone 2-2
2.3 Injection Well Siting and Construction 2-2
2.4 Electron Donor Injection 2-4

3 Project Requirements **3-1**
3.1 Well Permitting Requirements 3-1
3.2 Well Development Requirements 3-1
3.3 Investigation Derived Material Disposal Requirements 3-1
3.4 Surveying Requirements 3-1
3.5 Post Construction Reporting Requirements 3-2
3.6 Groundwater Monitoring Requirements 3-2
3.6.1 Monitoring Frequency 3-2
3.6.2 Monitoring Network 3-2
3.6.3 Analytical Parameters 3-3

Appendixes

A Groundwater Data Summary for Site 7 Wells
B Electron Donor Dosing Calculations
C Boring Logs and Well Construction Diagrams of Existing Wells
D Cost Estimate

Tables

1-1 PRGs for Site 7 Contaminants of Concern (COCs)

2-1 Spacing, Configuration, and Construction Specifications for the Injection Wells
2-2 Sodium Lactate Injection

Figures

1-1 Site 7 with Cross-Section Location
1-2 Cross-Section D-D' through Site 7
1-3 Site 7 - Target Remediation Zone and Maximum Contaminant Concentrations in Groundwater

2-1 Site Plan of Injection Wells and Monitoring Wells
2-2 Well Construction Specification

Acronyms and Abbreviations

ARAR	applicable or relevant and appropriate requirement
BOD	Basis of Design
COC	contaminants of concern
MCL	maximum contaminant level
NSWC	Naval Surface Warfare Center
PRG	preliminary remediation goal
RAC	Remedial Action Contractor

SECTION 1

Introduction

This Basis of Design (BOD) report has been prepared for the remedial action at Site 7, the Ordnance Burn Area, at the former Naval Surface Warfare Center (NSWC) White Oak, Silver Spring, Maryland.

1.1 Scope and Purpose

The purpose of this BOD report is to outline the conceptual design and performance criteria for implementing in-situ bioremediation of groundwater at Site 7, the Ordnance Burn Area, at the former NSWC - White Oak. This action is part of the final remedial action selected for Site 7 groundwater in the Record of Decision for the site. This portion of the remedy will involve the construction of a system of injection wells, and the injection of sodium lactate into the contaminated groundwater underlying the former Site 7 source area. The contaminants of concern (COCs) in the site groundwater are primarily nitroaromatic and nitroaliphatic compounds (trinitrotoluene [TNT], amino-dinitrotoluene [a-DNT] and RDX) and, to a lesser degree, trichloroethylene (TCE). The BoD serves as a starting point in the design process from which the Remedial Action Contractor (RAC) will prepare the remedial action work plan.

Plans for the other portions of the selected remedy: groundwater monitoring and institutional controls, will be provided in separate documents.

1.2 Site Background

1.2.1 Site History

Site 7 is located in the northeast corner of NSWC White Oak (Figure 1-1). Also known as the Ordnance Burn Area, Site 7 consists of a large shallow ditch approximately 20 feet wide and 400 feet long which reportedly was used to dispose of waste ordnance compounds between 1948 and 1968. Wastes disposed at this site included various types of explosives, primarily nitroaromatic and nitroaliphatic compounds, which were placed in the ditch and ignited. It has been reported that approximately 33,000 pounds of explosives were burned here over 20 years. The intent of the disposal operations was to burn all of the waste residue, so that no solid wastes remained in the ditch. However, investigations indicate that surface soil and groundwater were affected by site operations.

The source of the contaminated groundwater associated with Site 7 coincides with the historic area of explosive residue burning. Contaminated soil at the site has been excavated and disposed offsite as described below. The soil remaining at the site no longer poses an unacceptable human health or ecological risk nor does it represent a source of contamination to the underlying groundwater or nearby surface water.

1.2.2 Site Geology and Hydrogeology

Site 7 consists of a slightly depressed swale. The rest of the area adjacent to the swale is relatively flat with a gentle eastward slope. Located just east of Site 7 is a dry swale leading east into a stream that runs along the eastern boundary of the former White Oak property and Floral Drive. This is referred to as the Floral Drive stream. The Floral Drive stream, which is southeast of Site 7, flows south into Paint Branch.

A cross-section through the Site 7 area is shown in Figure 1-2. Depth to groundwater is about 40 feet, increasing from north to south across the site from about 36 to 55 feet. The aquifer is about 25 feet thick. The site consists primarily of Coastal Plain deposits, which are silty sand, sand, and gravel underlain by clayey sand with gravel or silt. Coastal Plain deposits are underlain with saprolite. Data from well 07GW201, screened in the saprolite, indicate that contamination is present only in the groundwater in the Coastal Plain deposits.

Groundwater flow is to the southeast and south with the hydraulic gradient estimated at 0.006 feet/foot. The hydraulic conductivity in the Coastal Plain deposits was estimated at 6.6 feet/day from slug tests performed at the site wells. Using an effective porosity of 0.25, an average groundwater velocity of 59 feet per year is assumed.

1.2.3 Soil Removal Action

Soil contaminated with explosives was excavated from the site between November 2002 and January 2003 as part of a removal action. The area of excavation measured 400 feet long by 20 feet wide on average. The depth of soil excavation ranged from 4 feet below ground surface (bgs) to approximately 12 feet bgs. The objective of the excavation was to remove all soil that may either represent a source of groundwater contamination or pose a risk that would prevent future unrestricted use of the property. The subsequent risk assessment conducted on the site soil concluded that these objectives were met. The results of the removal action and risk assessment are presented in the draft Post Removal Action Report for Site 7 (TtNUS, February 2003).

As part of the removal action site restoration, the excavation was backfilled with sand and a 2-foot layer of mulch. Approximately 2,000 gallons of vegetable oil were also mixed into the mulch and sand. The purpose of this action was to help stimulate the anaerobic bioremediation of any explosive compounds that may still be present in the subsurface soil and underlying groundwater.

1.3 Site Groundwater Evaluation

1.3.1 Nature and Extent of Groundwater Contamination

The contaminants that exceed preliminary remediation goals (PRGs) in the groundwater at the Site 7 source area consist of four explosives and TCE. These compounds, which are identified as COCs for the Site 7 groundwater, are listed below along with the maximum concentrations detected in Site 7 groundwater between 1999 and 2003:

- 2-amino-4,6-DNT—140 µg/L
- 4-amino-2,6-DNT—210 µg/L
- 2,4,6-TNT—410 µg/L

- RDX—1,300 µg/L
- TCE —17 µg/L

While TCE has been detected in the groundwater at Site 7 at a concentration exceeding the maximum contaminant level (MCL), it is considered to be coming from an upgradient source (Site 4) and not from Site 7. TCE has only been found in the Site 7 wells that are also downgradient of Site 4 and has not been found in the wells at the Site 7 source area. While not the focus of the remedial action, TCE will also be remediated by the selected remedy.

While not considered a COC, perchlorate (maximum concentration 29 µg/L) and HMX (maximum concentration 610 µg/L) have also been detected in the Site 7 groundwater and are considered in the development of this BoD.

The highest observed concentrations of COCs are found in groundwater samples in the aquifer directly below the footprint of the former Ordnance Burning Area, in the vicinity of wells 07GW08 and 07GW104. The areal extent of the zone targeted for groundwater remediation is approximately 240 feet long in a northeast-southwest orientation, which is roughly perpendicular to groundwater flow, by 15 to 30 feet wide.

Maximum contaminant concentrations in groundwater from Site 7 wells between January 1999 and February 2003 are shown in Figure 1-3. A summary of relevant groundwater data from historic sampling events for Site 7 groundwater monitoring wells are provided in Appendix A. The data shows the general trends in contaminant concentrations including a comparison of RDX concentration versus water levels at the site.

1.3.2 Trends in Contaminant Concentrations

The level of explosives contamination in groundwater in the Site 7 area drops sharply (one order of magnitude) within 150 feet downgradient of the site.

Most of the wells near the Site 7 source area have only been sampled as far back as 1999 and show relatively little change in contaminant concentration over that time. However well 07GW08, which was installed in 1985, has shown a significant decrease in concentrations of 2,4,6-TNT (from approximately 1600 µg/L in 1985 to 137 µg/L in 2001) and RDX (from 2000 µg/L in 1985 to 800 µg/L in 2001). Graphs showing recent trends in RDX concentrations in monitoring wells 07GW08 and 07GW104, which are within the most contaminated area of the site, and 07GW103, which lies just downgradient of the most contaminated area, are provided in Appendix A.

The increase in contaminant concentrations observed early in 2003 may be the result of the flushing out of contaminants in the soil during the November 2002 removal action activities. The removal action took place over a 2-month period of relatively wet weather, during which the excavation was left open. This would have resulted in a significant increase in infiltration in the area at a time when there was still a large amount of contaminated soil present. In addition, the removal action would have resulted in altered groundwater chemistry conditions which may have mobilized contaminants.

Concentrations observed during the four rounds of groundwater samples collected since the removal action have shown a gradual decrease in concentration after the initial spike. The reason for the decrease is not completely certain, but may be a result of the removal action,

the addition of the vegetable oil, or dilution caused by the large volume of rainfall which occurred in 2003 and the subsequent dramatic rise in the water table, as shown in Figures A-1 through A-3 of Appendix A.

1.4 Remedial Action

Enhanced anaerobic bioremediation with institutional controls and monitoring was the selected remedy for groundwater contamination at Site 7. No further action was the selected remedy for soil contamination at Site 7. As described in more detail in Section 1.2, contaminated soil at the site has been excavated and disposed offsite as part of a removal action conducted prior to the ROD, and a determination was made that the soil remaining at the site no longer poses an unacceptable human health or ecological risk. In addition, the onsite soil no longer represents a source of contamination to the underlying groundwater or nearby surface water. Results of risk assessment and ongoing monitoring support the selection of enhanced anaerobic bioremediation with institutional controls and monitoring for groundwater and no further action for soil at Site 7.

The overall objective of the selected remedy is to mitigate unacceptable risks to human receptors from exposure to contaminants in the environment, and to the extent practicable, restore groundwater to beneficial and unrestricted use. For Site 7, this translates to reducing contaminant levels in the groundwater to the PRGs identified in the Site 7 ROD. The PRGs for the area are provided in Table 1-1.

TABLE 1-1
PRGs for Site 7 Contaminants of Concern (COCs)
Site 7, Former NSWC White Oak

COC	PRG (µg/L)
2-amino-4,6-DNT	0.11
4-amino-2,6-DNT	0.11
2,4,6-TNT	6.8
RDX	30
TCE	5

These PRGs are considered applicable or relevant and appropriate requirements (ARARs) for Site 7. Other ARARs and technical requirements that pertain to the construction of the remedy and injection of lactate are discussed in Section 3. This design complies with the ARARs identified in the ROD.

The selected remedy will include implementing an in-situ anaerobic bioremediation approach. This approach includes the injection of an electron donor to enhance and stimulate reductive dechlorination and anaerobic degradation of contaminants at the site. Lactate, a highly soluble compound, has been selected as the electron donor for this application. This selection is based on success rates of lactate to degrade similar compounds in both bench test studies and field applications at White Oak Site 9.

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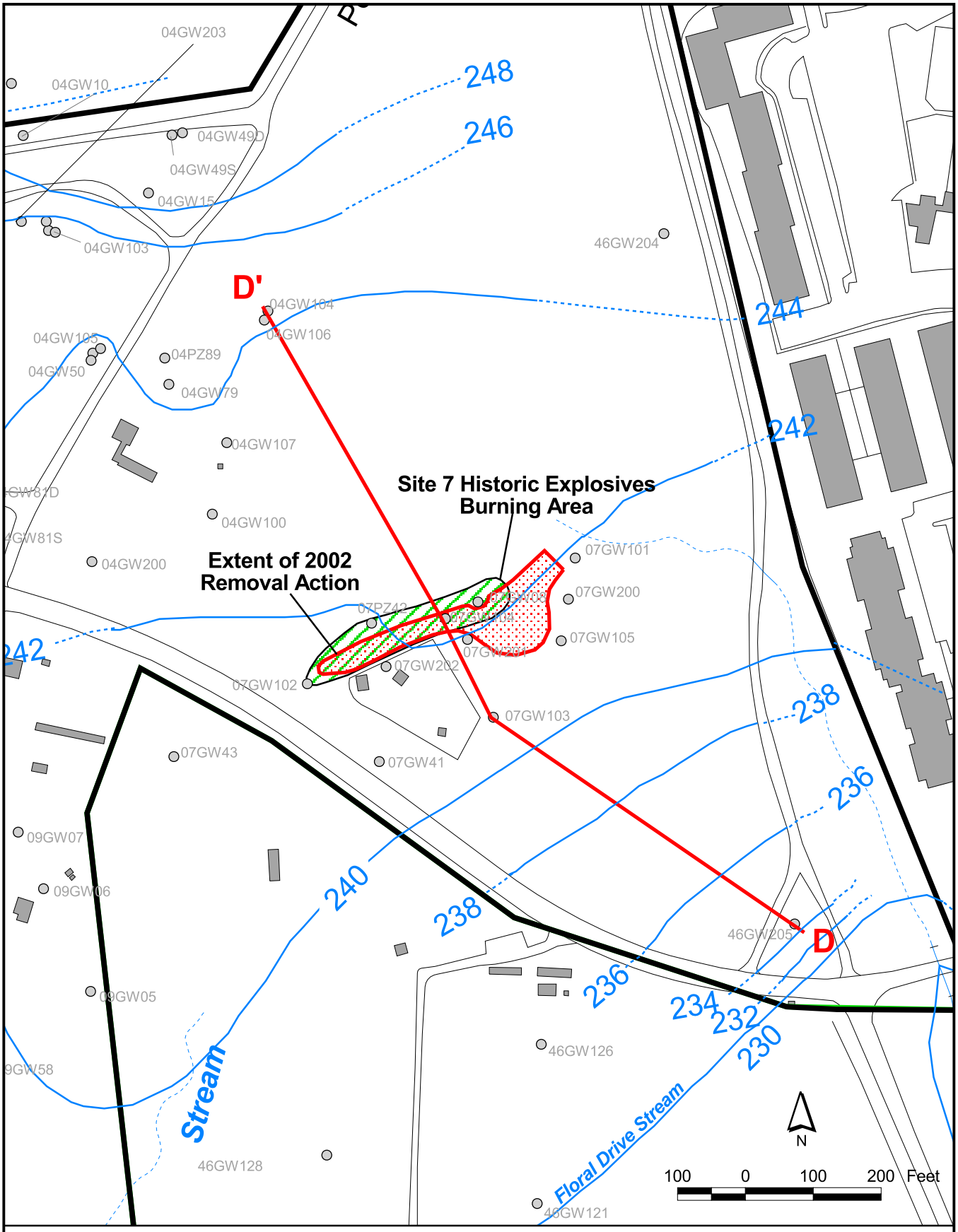

SAMPLING LOCATIONS
- Monitoring Wells

BASE MAP FEATURES
- Former NSWC White Oak Property Boundary
- Buildings and Other Structures
- Roads and Paved Areas
- Perennial Stream
- Intermittent Stream

Figure 1-1
Site 7 with Cross-Section Location
Site 7 Basis of Design
NSWC White Oak, Silver Spring, Maryland

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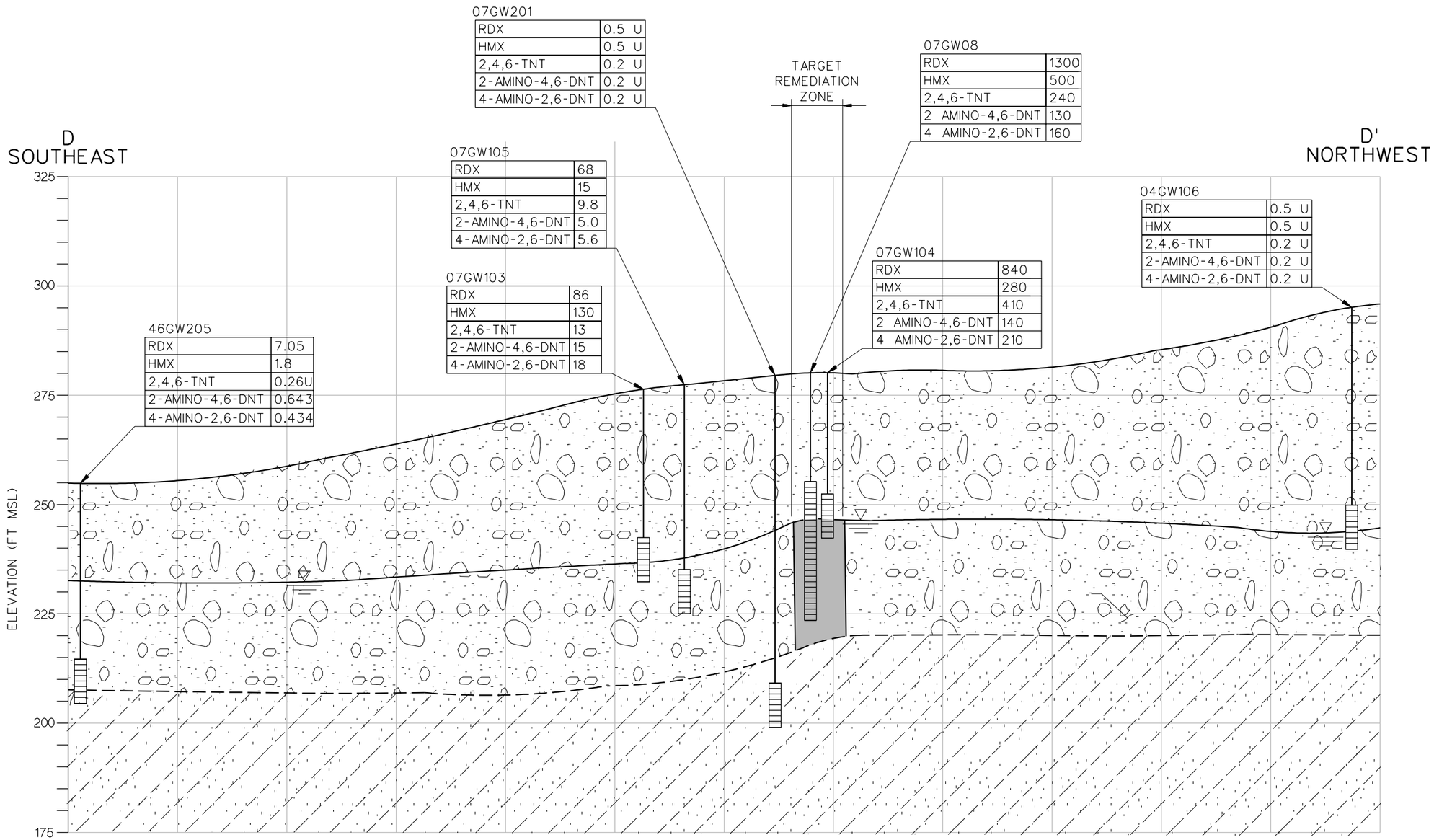

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- MONITORING WELL SCREEN
- WATER-TABLE SURFACE (SEPT, 2001)
- INFERRED BOUNDARY BETWEEN GEOLOGIC UNITS
- COASTAL PLAIN SEDIMENTS
- SAPROLITE
- TARGET REMEDIATION ZONE

NOTES:

1. GROUNDWATER CONCENTRATION DATA IS IN UG/L. DATA ARE MAXIMUM CONCENTRATIONS DETECTED JAN 1999-Through Feb. 2003
"U" INDICATES NOT DETECTED AT STATED DETECTION LIMIT.

25'

100'

SCALE
1"= 25' VERTICALLY
1"= 100' HORIZONTALLY

Figure 1-2
CROSS-SECTION D-D' THROUGH SITE 7
Site 7 Basis Of Design
Former NSWC - White Oak, Silver Spring, Maryland

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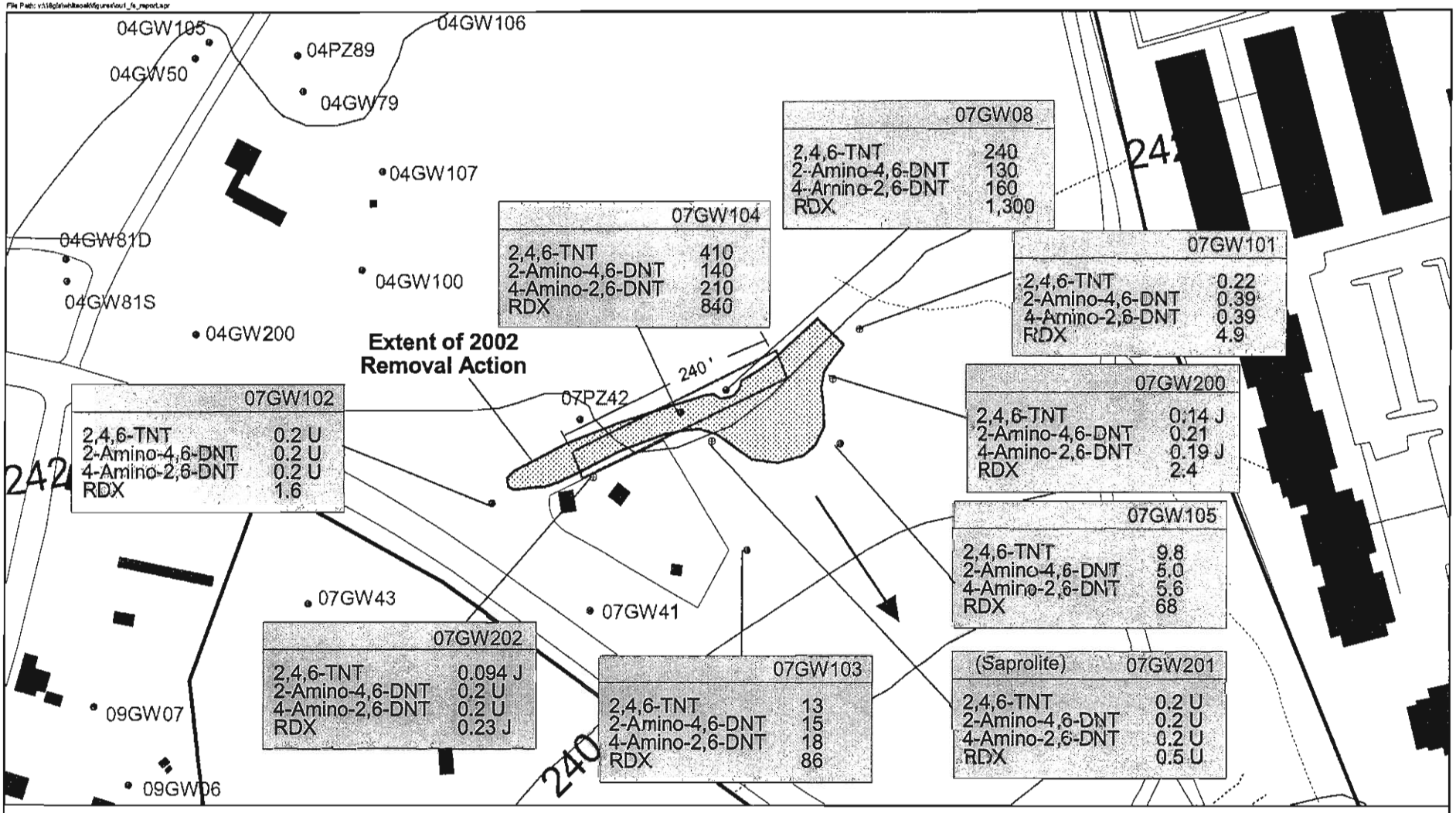

Figure 1-3
Site 7 - Target Remediation Zone and Maximum Contaminant Concentrations in Groundwater
Between January 1999 and February 2003
Site 7 Basis of Design
Former NSWC White Oak, Silver Spring, MD

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SECTION 2

Technical Approach

2.1 Treatment Technology Description

The COCs in groundwater at the site are primarily RDX; 2,4,6-TNT; 2-amino-4,6-DNT; and 4-amino-2,6-DNT. Anaerobic biodegradation pathways have been identified and documented for these compounds. While anaerobic biodegradation is a natural process, rates of biodegradation are dependant on prevailing geochemical conditions which may or may not be sufficient to meet remediation goals.

Treatability testing on the same contaminants at other facilities has indicated that rates of COC degradation can be enhanced through the addition of electron donor. The addition of electron donor will stimulate existing populations of microorganisms that are naturally present in the soil and increase their populations. These explosives are known to be degraded via mixed anaerobic consortia. The goal is to increase the biodegradation rates of the contaminants by indigenous anaerobic microorganisms, which typically possess the ability to degrade these explosives when supplemented with an additional energy source (i.e., electron donor), typically via cometabolism.

To encourage biological degradation of the site contaminants under reducing conditions, the target area containing the COCs will be supplemented with sodium lactate as an electron donor.

2.1.1 Electron Donor Selection

Sodium lactate has been selected as the electron donor for this site. This selection is based on success rates of lactate to degrade RDX in both bench test studies and field applications. In addition, lactate is environmentally safe. Lactic acid is metabolized by certain kinds of fermentative microorganisms, with the primary pathway being conversion of lactic acid to propionic or pyruvic acid and, in turn, the propionic/pyruvic acid to acetic acid. All of these metabolites can serve as electron donors. Sodium lactate is a relatively common additive to groundwater for this type of remediation, is considered to be safe for the environment, and does not present a risk to human health.

Sodium lactate is fermented rather rapidly to acetate and hydrogen (H_2), resulting in high H_2 levels that persist for only short periods of time as various H_2-using organisms make use of H_2 as electron donors. Anaerobic bacteria such as methanogens or sulfate reducers cleave the acetate into CO_2 and methane and further reduce CO_2 to methane using H_2 produced by other bacteria as the electron donor. These bacteria, or other H_2 metabolizing organisms will control the overall reaction by consuming H_2.

2.1.2 Dosing Parameters

Demand factors and site dosages were estimated based on previous site results. The electron donor dosages recommended are conservative to account for competing electron acceptors intrinsic to the site. Dosage amounts are based on stoichiometric electron donor demand

which is primarily driven by the concentrations of the electron acceptors with a safety factor to allow for the variability in site conditions, contaminant concentrations, and microbial activity. Electron acceptors including nitrate, sulfate, and dissolved oxygen, and naturally occurring metals were evaluated for Site 7. At Site 7, sulfate concentrations essentially control the lactate dosing, whereas nitrate and dissolved oxygen concentrations at the site are sufficiently low as to have little impact on dosing. A high average value for these site parameters are included in the dosage calculations. The lactate dosage calculations are provided in Appendix B.

Groundwater pH in the area targeted for remediation in the months following the soil remedial action has ranged from about 4.8 to 5.6 Research have shown that most bacteria can function optimally between a pH range of 5 to 8 and can function well at pH between 4 and 8. Sodium hydroxide will be added with the injection solution in an effort to raise pH to levels greater than a pH of 5 within the groundwater.

2.2 Target Remediation Zone

The area exhibiting the highest groundwater concentrations of COCs was selected as the Target Remediation Zone (the area in which lactate will be injected), as illustrated in Figure 2-1.

The Target Remediation Zone for the Site 7 area is the aquifer directly below the footprint of the former Ordnance Burning Area. The areal extent of the zone targeted for groundwater remediation (240 feet by 15 feet) encompasses the suspected zone of explosives contamination that is serving as the source of groundwater contamination.

The 240-foot width of the Target Remediation Zone is a conservative estimate based on the distance between wells 07GW200 and 07GW202, both of which contain no concentrations of explosive contaminants above PRGs. The thickness of the contaminated aquifer in the Target Remediation Zone is 25 feet and extends from the water table at a depth of approximately 40 feet bgs to the top of the saprolite at a depth of approximately 65 feet bgs. Assuming an effective porosity of 0.25, an estimated 170,000 gallons of groundwater lies within the target remediation zone. The precise distribution of contamination is unknown, so dosage calculations were based on the maximum concentrations of contaminants found in the wells located in the Target Remediation Zone since January 1999. Sampling results following the soil removal action completed in 2003 represent the highest concentrations in many cases. It should be noted that these concentrations are based on the dissolved phase, and do not include contaminants that are adsorbed to the aquifer sediments; however, because they use the highest observed concentrations, they are considered conservative estimates.

2.3 Injection Well Siting and Construction

The electron donor injection will specifically target groundwater within the Coastal Plain sediments of the unconfined aquifer. The thickness of the contaminated aquifer in the target treatment zone is approximately 25 feet and extends from the water table, at a depth of approximately 40 feet bgs, to the top of the saprolite at a depth of approximately 65 feet bgs. The spacing, configuration, and construction specifications for the injection wells are

summarized in Table 2-1 and shown in Figure 2-1 (Site Plan - Well Layout) and Figure 2-2 (Well Construction Specification). A total of 19 injection wells will be installed for the electron donor injection.

The reusable injection wells will consist of 4-inch-diameter, Schedule 80 PVC pipe with a 25-foot screened interval (to roughly span the thickness of the aquifer). The injection wells will be 65 feet deep on average in order to allow delivery of the electron donor throughout the depth of the saturated zone. It is assumed they will be installed using hollow-stem-auger drilling methods.

TABLE 2-1
Spacing, Configuration, and Construction Specifications for the Injection Wells
Site 7, Former NSWC White Oak

Target Remediation Zone Dimensions	240 ft by 15 ft + 60 ft by 15 ft downgradient area
Radius of Distribution per Injection Well	8 ft
Number of Injection Wells and Spacing	Primary Row – 15 wells spaced at 16 ft Secondary Row – 4 wells spaced at 16 ft
Depth of Wells (feet below ground surface)	
Bottom of well screen	Coastal Plain/saprolite interface (~60-65 ft)
Top of well screen	Water Table (approximately ~ 30-40 ft)
Well Construction (see Figure 2-2)	
Casing	4-in ID schedule 80 PVC
Screen	0.020-slot schedule 80 PVC
Sand and grout specifications	Morie No. 2, clean, washed sand, uniformity coefficient <2.5 Portland cement: bentonite, 20:1
Surface casing/protection	8-in steel
Well head connection	To be determined by subcontractor

Figure 2-1 shows the placement of the injection wells. The primary row of 15 wells will be spaced approximately 16 feet apart in order to cover the 240-foot injection span. The secondary row of 4 wells will be located downgradient of the monitoring wells showing the greatest contamination and will also be spaced approximately 16 feet apart per the radius of influence.

The secondary row of injection wells will allow for injection of additional lactate in the vicinity of the most contaminated areas, while lessening the risk of biofouling. With the use of additional injection wells, the dosing per individual well will be lessened so as to reduce the potential for biofouling.

Biofouling is a potential problem that may occur with injection wells in general. Such conditions, if left untreated, could restrict the efficiency of future injections. Biofouling may occur in wells where the chemical conditions are conducive to the overgrowth of certain

types of naturally occurring bacteria, but in the context of injection wells, may be minimized by correct electron donor dosing. If biofouling of the injection wells becomes problematic, it can be addressed by mechanical cleaning or chemical treatment to restore the well screens prior to future injections.

All injection wells will be placed at least 7 feet away from the monitoring wells in the vicinity of the injection zone, and will be placed slightly upgradient (approximately 3 feet) of the bottom of the swale, as shown on Figure 2-1.

2.4 Electron Donor Injection

Sodium lactate will be injected under pressure via the designated injection wells shown in Figure 2-1.

A total of about 313 gallons of 60 percent sodium lactate will be injected during the injection event. The sodium lactate volume per injection well is summarized in Table 2-2. The sodium lactate solution will be diluted onsite to a concentration of approximately 10 percent prior to the injection, and will be followed with flush water as summarized in the table. The pH of the injection fluid will be adjusted to 10 with the addition of sodium hydroxide to raise the pH of the groundwater within the injection zone above 5.

TABLE 2-2
Sodium Lactate Injection
Site 7, Former NSWC White Oak

	60% Sodium Lactate Volume	**Dilution Water**	**Flush Water**
Volumes per well	17 gal	82 gal	300 gal
Total Volumes required	**Total** 313 gal	**Total** 1563 gal	**Total** 5700 gal

The injection pressure should be controlled to be approximately 10 psi but not higher than 15 psi. It is important not to exceed the maximum pressure because at 30 feet below grade, the lithostatic pressure is about 23 psi, and injection pressures above this value may induce fracturing. The unintended fracturing may lead to uneven distribution of the electron donor. The recommended maximum pressure of no more than 15 psi follows another "rule-of-thumb" for injection wells; the positive head should be less than 0.2 h, where h=depth to top-of-screen, which in this case is 36 feet, or approximately 16 psi, although the injection fluids additives will increase this value somewhat. (Driscoll, F.G., 1986, Groundwater and Wells, Second Edition, Johnson Filtration Systems, St. Paul, Minnesota).

The injection wells are designed to allow for reinjection at a later date, if required. The need for re-injection of sodium lactate will be determined by the perseverance of metabolic acids and reduction in contaminant concentrations as observed in the groundwater monitoring results.

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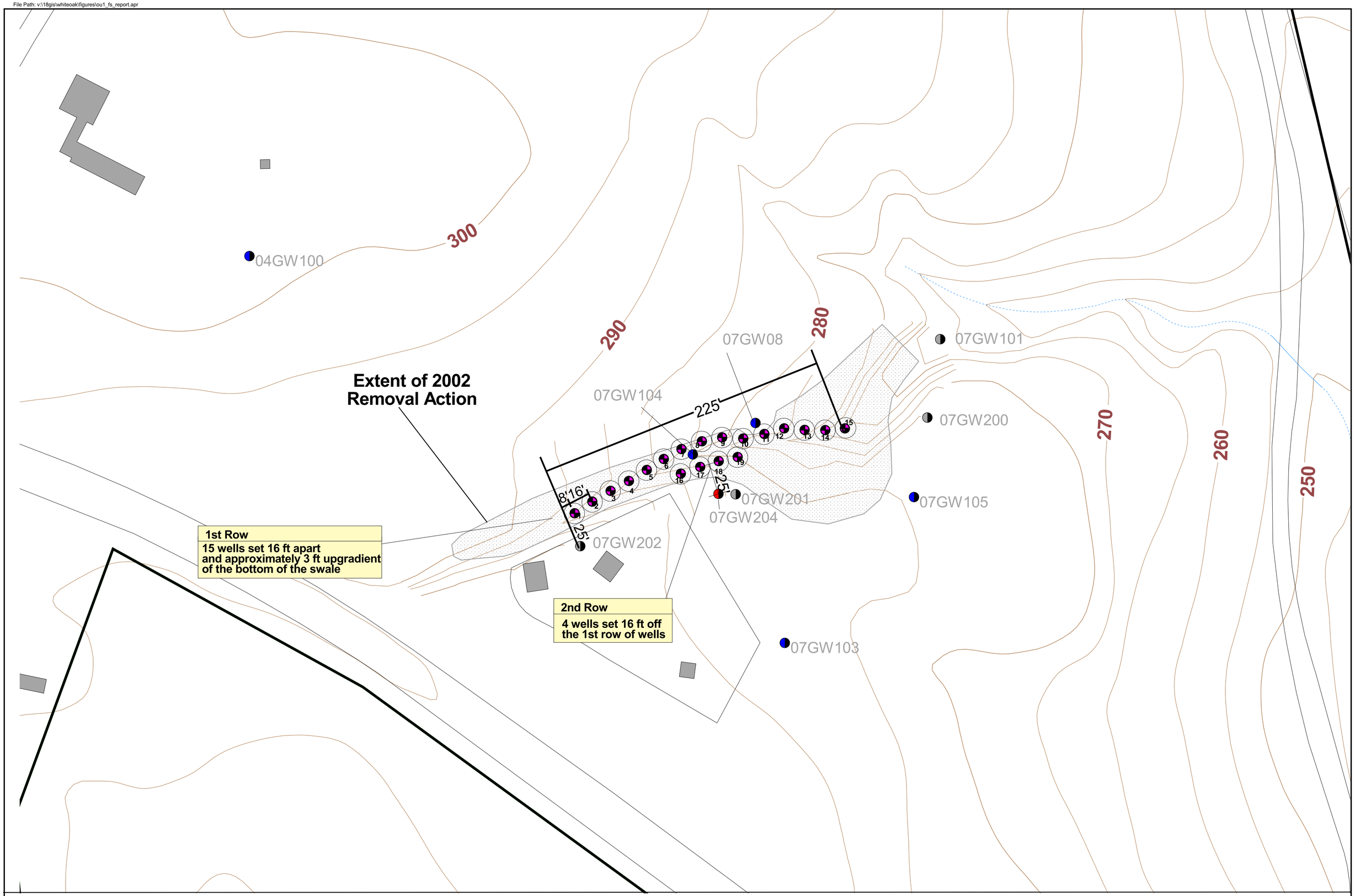

LEGEND

- Existing Monitoring Wells for Remedial Action
- Proposed Injection Wells
- Base Boundary
- Roads
- Perennial Stream
- Intermittent Stream
- Proposed New Monitoring Well
- Other Existing Monitoring Wells
- Buildings
- Target Remediation Zone for Site 7 Groundwater

N

50 0 50 100 Feet

Figure 2-1
Site Plan of Injection Wells and Monitoring Wells
Site 7 Basis of Design Report
Former NSWC White Oak, Silver Spring, MD

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PROJECT NUMBER	WELL NUMBER
	SHEET 1 OF 1

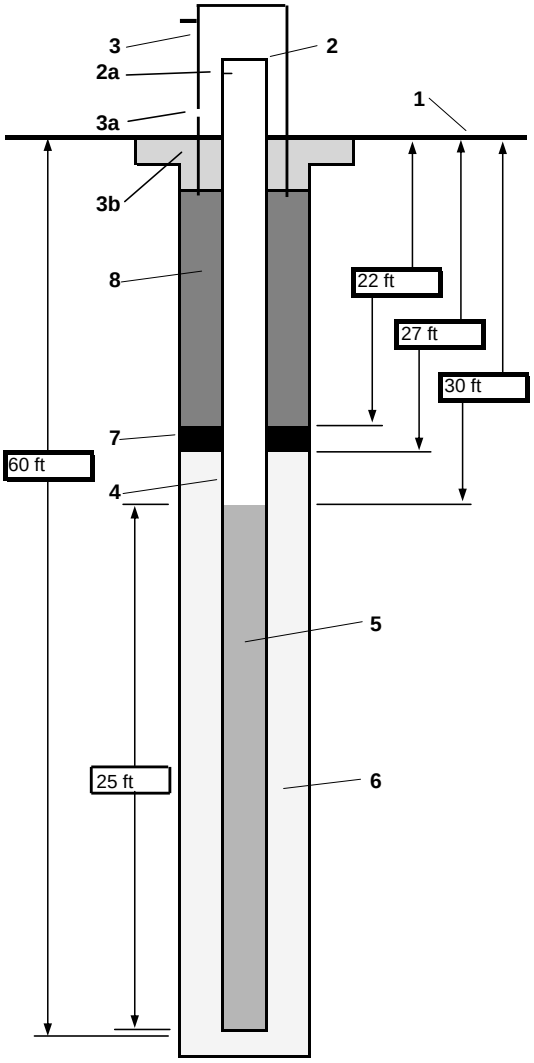
Figure 2-2 Well Construction Specifications

PROJECT : **White Oak Site 07 Injection Wells** LOCATION :

DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :



1- Ground elevation at well _____

2- Top of casing elevation: Grade plus 2.5 feet
   a) vent hole?: No

3- Wellhead protection cover type: 8-inch steel
   a) weep hole?: Yes
   b) concrete pad dimensions: 3-foot x 3-foot x 0.5-foot

4- Dia./type of well casing: 4-inch ID, Sch. 80 PVC

5- Type/slot size of screen: Three 10-foot, continuous wire, 0.020-slot Sch. 80 PVC

6- Type screen filter: Morie No.2, clean, washed sand, UC<2.5
   a) Quantity used _____

7- Type of seal: Bentonite pellets or slurry
   a) Quantity used _____

8- Grout
   a) Grout mix used: Portland cement: bentonite, 20:1
   b) Method of placement: Pressure grout, side discharge
   c) Vol. of well casing grout _____

Development method: Surge & overpump

Development time _____

Estimated purge volume _____

Comments _____

SECTION 3

Project Requirements

This section discusses how the ARARs and other technical requirements that pertain to the construction and implementation of the remedial action will be met. ARARs and other requirements pertaining to site closure and institutional controls (e.g., land-use controls) are discussed in separate documents.

3.1 Well Permitting Requirements

Each of the proposed injection wells must be registered with Prince George's County prior to installation. The County will provide permit tags to be placed on each well.

3.2 Well Development Requirements

All new injection wells shall be developed after construction and prior to lactate injection. Development shall include: (1) surge blocking the saturated well screen interval until the water is free from sand, silt, and turbidity (2) removing water from the well using a submersible pump capable of flow rates from 0.5 to 2 gallons per minute; and (3) transferring development water to 55-gallon drums. Pumps used for well development shall be decontaminated.

3.3 Investigation Derived Material Disposal Requirements

Soil and other potentially contaminated solid material (such as drilling mud if mud rotary methods are required for well installation) and water generate during drilling, decontamination, and well development), must be properly characterized and disposed of off site at an appropriately licensed facility. Drill cuttings from previous work at Site 7 have been characterized and disposed of as solid, non-hazardous waste. Water has previously been characterized as nonhazardous waste. While awaiting off site disposal, the material must a stored on site in a contained area such as a closed drum, tank or covered roll-off container.

3.4 Surveying Requirements

The locations and elevations of all installed wells will be surveyed by a surveyor licensed in the state of Maryland. Survey datum will be:

- Vertical: NAVD 1929
- Horizontal: NAD 1983

3.5 Post Construction Reporting Requirements

A post-construction report shall be prepared that shall include the following information:

- Injection well boring logs and as-built well construction diagrams
- Coordinates and elevations of the injection wells
- Actual injection volumes of lactate, flush water, sodium hydroxide
- Injection pressures and rates of injection.
- Field notes

3.6 Groundwater Monitoring Requirements

Groundwater samples will be collected and analyzed for selected parameters prior to the injection of the electron donor (baseline sampling) and at pertinent intervals after injection in order to monitor and assess the effectiveness of the remedy and modify it if needed. The purpose of this section is to outline the general sampling parameters (sampling network, sampling frequency, analytical parameters, reporting requirements). A separate, more detailed sampling and analysis plan will be developed prior to implementation which will specify sampling analysis procedures, QA/QC requirements, data validation procedures, data management and reporting. The sampling and analysis plan will be approved by EPA and MDE.

3.6.1 Monitoring Frequency

Baseline sampling will be conducted approximately 45 days prior to the injection of the electron donor so that data will be available before the injection takes place.

Post injection sampling will take place 1 month, 3 months, 6 months, 9 months, and 12 months after injection and then annually until PRGs are achieved. If a second injection is required during of after the first year, these frequencies may be adjusted.

Field sampling efforts may be conducted more frequently for parameters such as dissolved oxygen, oxidation reduction potential (indicators of reducing conditions), metabolic acids (an indicator of the presence and breakdown of lactate), and pH (an indicator of optimum conditions for microbial action). These parameters will help determine if additional lactate or additional pH adjustment is necessary.

3.6.2 Monitoring Network

Locations of sampling points for monitoring and analysis are to be as follows:

- One upgradient well: 04GW100
- Three wells in the Target Remediation Zone: 07GW08, 07GW104, and one injection well)
- Three downgradient wells: 07GW103, 07GW105 and 07GW204 (a new well located 30 feet downgradient of the line of injection wells as shown in Figure 2-1)

3.6.3 Analytical Parameters

During the baseline sampling and each of the proposed post-injection monitoring events the following general types of parameters will be analyzed:

- Target and secondary contaminants – to assess overall effectiveness and progress toward achieving PRGs
- Sodium lactate indicators – to assess presence and half-life of sodium lactate and determine if and when additional lactate injection is needed
- Primary natural attenuation parameters – to determine if the appropriate chemical and biological conditions conducive to COC degradation are being created in the aquifer and for how long they remain following the injection of lactate. To verify the primary processes for contaminant disappearance and to troubleshoot the remedy if the predicted responses are not observed.
- Standard field parameters - to determine if the appropriate chemical and biological conditions conducive to COC degradation are being created in the aquifer and for how long they remain following the injection of lactate. To verify the primary processes for contaminant disappearance and to troubleshoot the remedy if the predicted responses are not observed.

Target and secondary contaminants:

- Nitroaromatics and Nitroamines (includes RDX, HMX, 2-amino-4,6-DNT, 4-amino-2,6-DNT, 2,4,6-TNT)
- Chlorinated ethenes (includes TCE)
- Perchlorate

Sodium lactate indicators:

- Metabolic acids
- Sodium
- Hydrogen

Primary natural attenuation parameters and field parameters:

<u>Organics:</u>

- Total organic carbon
- Methane, ethane, ethene
- Carbon dioxide

<u>Electron Acceptors:</u>

- Dissolved Oxygen
- Nitrate
- Sulfate
- Chemical Oxygen Demand (COD)

General Water Chemistry:

- Temperature
- Alkalinity
- Chloride
- Iron (II)
- Sulfide
- pH
- Eh or ORP

Appendix A
Groundwater Data Summary for Site 7 Wells

Figure A-1
Observed Trends in RDX Concentrations
Well 07GW08
Former NSWC White Oak, Silver Spring, MD

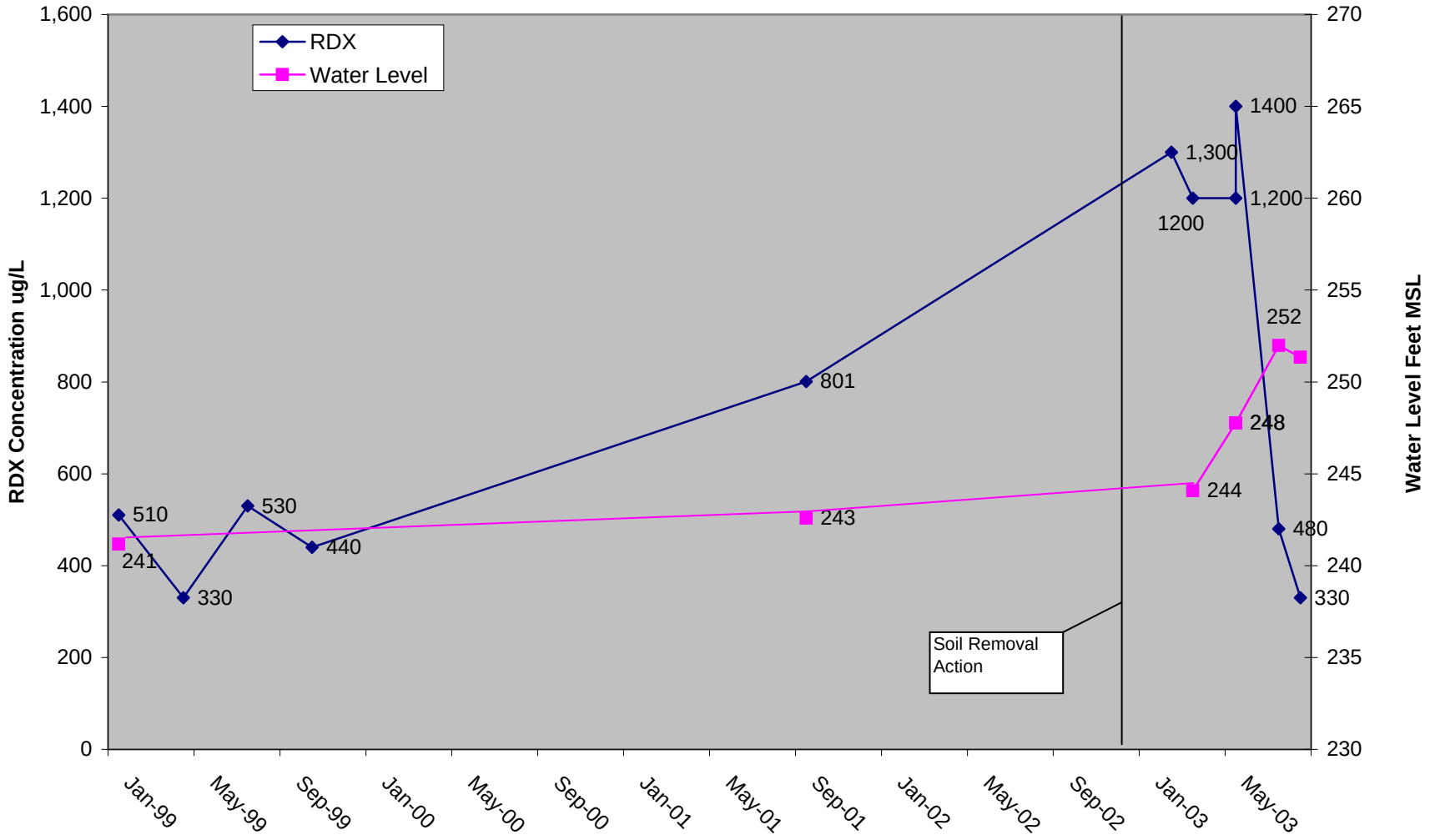


Figure A-2
Observed Trends in RDX Concentrations
Well 07GW103
Former NSWC White Oak, Silver Spring, MD

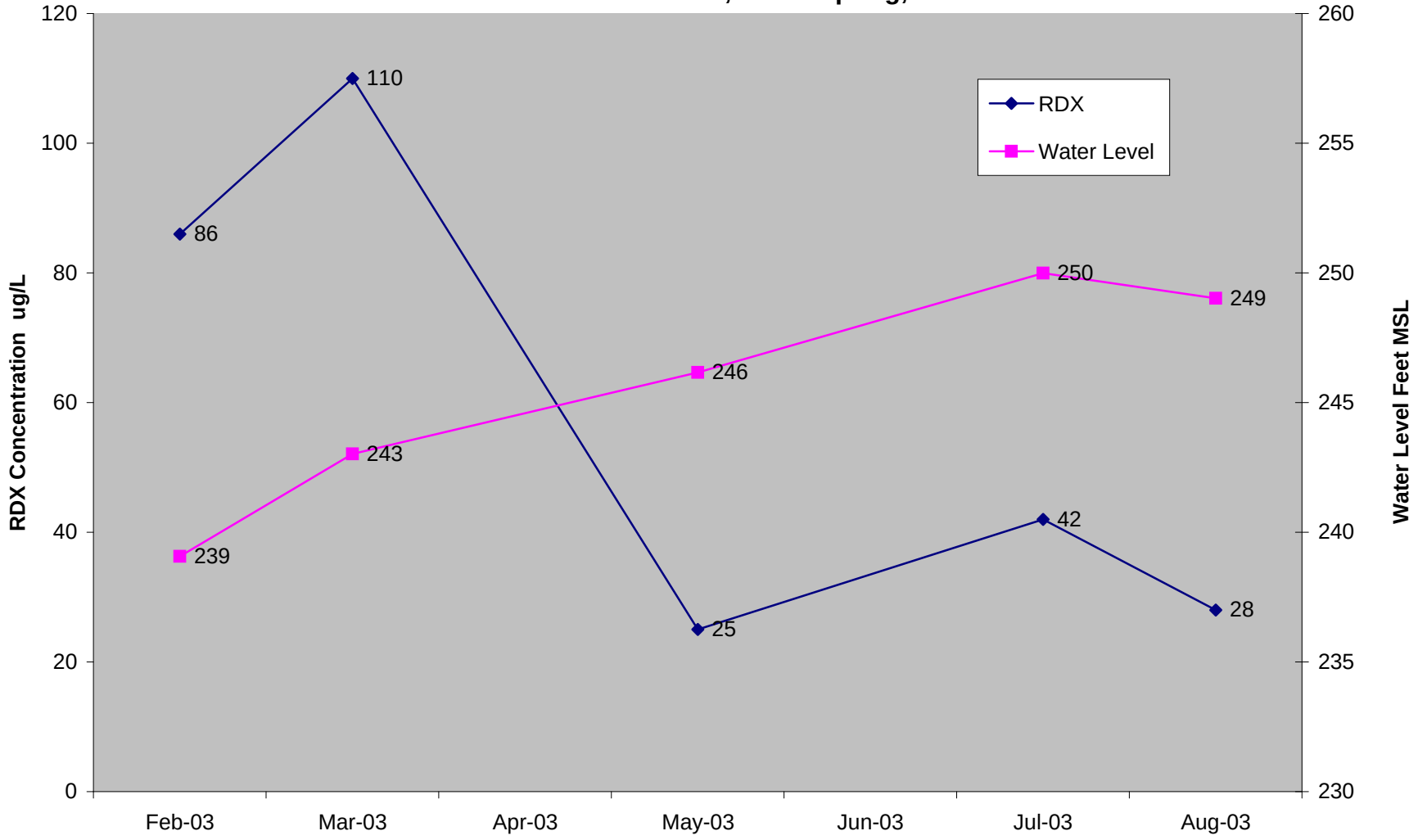


Figure A-3
Observed Trends in RDX Concentrations
Well 07GW104
Former NSWC White Oak, Silver Spring, MD

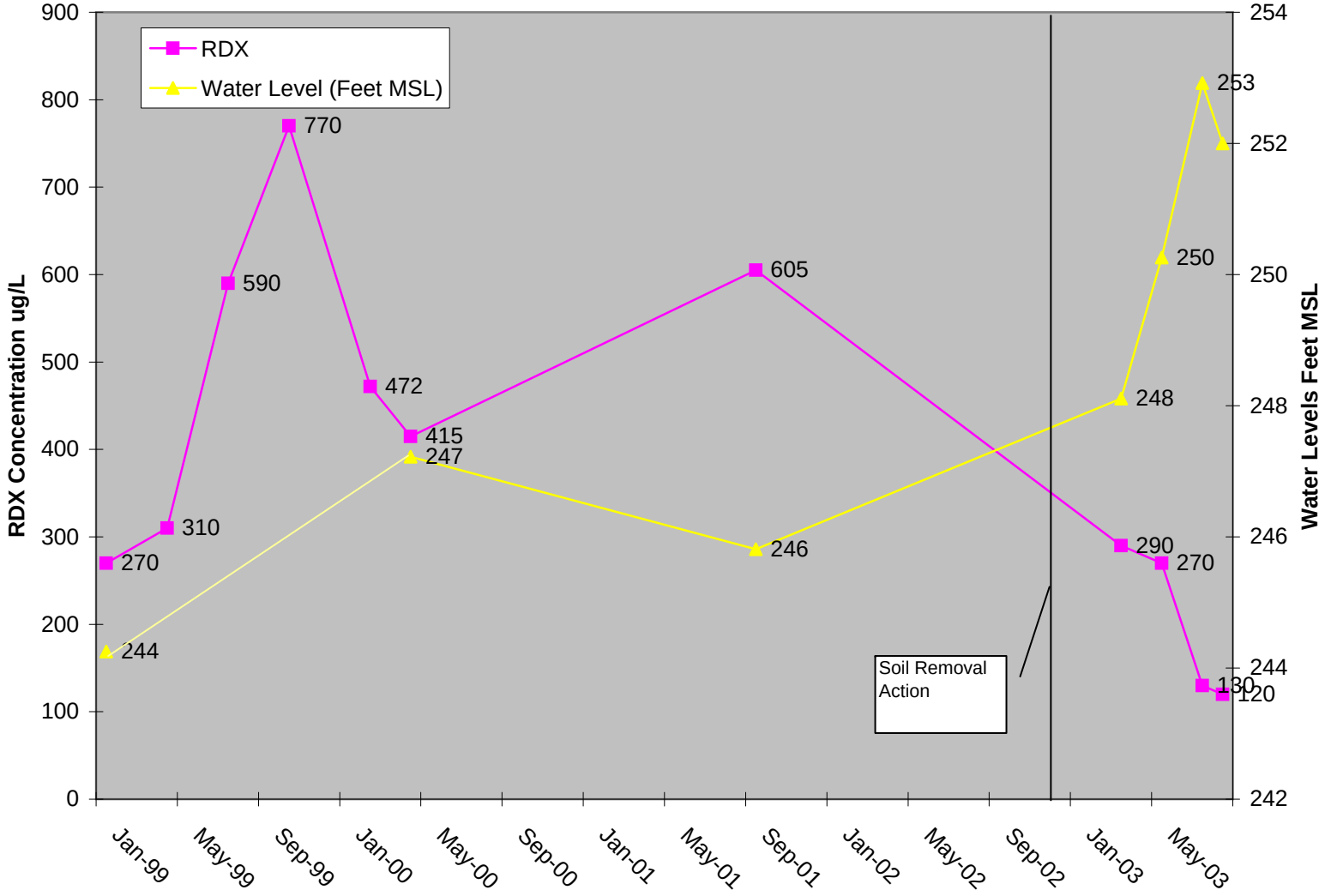


Table A-1
Compounds Detected at Monitoring Well 07GW08
February - August 2003
Former NSWC White Oak, Silver Spring, Maryland

Station ID	07GW08																	
Sample ID						007GW0080009		007GW0080010		007GW0080011		007GW0089911		007GW0080012		007GW0080013	
Sample Date	1/26/1999	4/6/1999	7/12/1999	10/7/1999	9/26/2001	2/13/2003		3/26/2003		5/9/2003		5/9/2003		7/8/2003		8/20/2003	
Chemical Name																	
Explosives (UG/L)																	
2,4,6-Trinitrotoluene	210	150	240	180	137	190		130		160		180		34		26	
2-Amino-4,6-dinitrotoluene	62	42	70	64	67	130		100		130		140		45		32	
4-Amino-2,6-dinitrotoluene	110	69	110	100	43	160		110		150		160		53		37	
HMX					357	500		440		520		610		210		130	
RDX	510	330	530	440	801	1,300		1,200		1,200		1,400		480		330	
Dissolved Metals (UG/L)																	
Iron						42	U	42	U	42	U	42	U	42	U	260	
Manganese						20		25		31		37		120		180	
Water Level (Feet MSL)	241.18				242.58			244.08		247.77		247.77		251.98		251.34	
	(reading 2/99)																
Wet Chemistry (MG/L)																	
Chloride						6		6.7		7		6.9		7.5		8.8	
Nitrate						4.1		4		2		2		0.95		0.94	
Nitrite						0.1	U	0.1	U	15		0.1	U	0.1	U	0.053	
Sulfate						10.2		10.4		NA		NA		17		13.7	
Total organic carbon (TOC)						2		2		1	U	1	U	4		4	

NA - Not analyzed
U - Analyte not detected

Table A-2
Compounds Detected at Monitoring Well 07GW103
February - August 2003
Former NSWC White Oak, Silver Spring, Maryland

Station ID	07GW103									
Sample ID	007GW1030009		007GW1030010		007GW1030011		007GW1030012		007GW1030013	
Sample Date	2/13/2003		3/25/2003		5/8/2003		7/8/2003		8/20/2003	
Chemical Name										
Explosives (UG/L)										
1,3,5-TRINITROBENZENE							1.2	J	1.4	
2,4,6-Trinitrotoluene	13		2.2	J	5.3		23		22	
2.4-Dinitrotoluene									0.28	J
2-Amino-4,6-dinitrotoluene	15		11		5.7		5.7		3.6	
4-Amino-2,6-dinitrotoluene	18		13		6.8		9		5	
HMX	130		120		40		19		9.4	
RDX	86		110		25		42		28	
Dissolved Metals (UG/L)										
Iron									120	
Manganese	3	J	10	J	10	J	24		31	
Water Level (Feet MSL)	239.07		243.02		246.16		249.99		249.02	
Wet Chemistry (MG/L)										
Chloride	11.5		6.1		7.6		7.3		10.6	
Nitrate	1.4		1.2		1.3		1.7		1.4	
Sulfate	18.3		15.3		11.9		21.9		33.4	
Total organic carbon (TOC)	1		2		1	U	1		2	

NA - Not analyzed
J - Reported value is estimated
U - Analyte not detected

Table A-3
Compounds Detected at Monitoring Well 07GW104
February - August 2003
Former NSWC White Oak, Silver Spring, Maryland

Station ID	07GW104											
Sample ID								007GW1040010	007GW1040011	07GW104001	07GW1040013	
Sample Date	01/27/99	04/07/99	07/08/99	10/20/99	02/15/00	04/25/00	09/26/01	03/25/03	05/09/03	07/08/03	08/20/03	
Chemical Name												
Explosives (UG/L)												
2,4,6-Trinitrotoluene	110	150	300	410	263	232	137	120	100	55	38	
2-Amino-4,6-dinitrotoluene	38	48	94	120	89	75.6	66.8	50	42	24	22	
4-Amino-2,6-dinitrotoluene	66	84	150	210	101	78.2	42.9	63	56	31	27	
HMX							161	180	150	82	71	
RDX	270	310	590	770	472	415	605	290	270	130	120	
Water Level (Feet MSL)	244.25					247.22	245.81	248.11	250.26	252.92	252	
	(reading 2/99)				(reading 3/00)							
Dissolved Metals (UG/L)												
Iron								48	58	42	150	
Manganese								14	51	20	12	J
Wet Chemistry (MG/L)												
Chloride								9.4	10.1	7.9	7.9	
Nitrate								1.4	2.4	1.6	2.1	
Sulfate								6.4	130	51.1	95.5	
Total organic carbon (TOC)								1	1	1	2	

NA - Not analyzed
B - Analyte not detected above associated blank
J - Reported value is estimated
U - Analyte not detected

Table A-4
Compounds Detected at Monitoring Well 07GW105
February - August 2003
Former NSWC White Oak, Silver Spring, Maryland

Station ID					**07GW105**													
Sample ID							007GW1050009		007GW1050010		007GW1059910		007GW1050011		007GW1050012		007GW1050013	
Sample Date	01/25/99		04/07/99		07/12/99	10/07/99	09/26/01	02/13/03		03/26/03		03/26/03		05/09/03		07/08/03		08/20/03	
Chemical Name																			
Explosives (UG/L)																			
2,4,6-Trinitrotoluene	2.2		3.6		4	7.1	3.07	9.8		12		12		12		5.4		3.7	
2-Amino-4,6-dinitrotoluene	1.4		2.3		2.7	4.3	2.44	5		9.9		10		6.9		3.6		2.3	
4-Amino-2,6-dinitrotoluene	1.4		2.3		2.7	4.4	50	5.6		9.1		9.7		6.6		3.2		1.9	
HMX							10.9	15		38		40		22		15		11	
RDX	20		29		33	50	24.6	68		150		150		90		56		38	
Dissolved Metals (UG/L)																			
Iron								57	B	50	J	42	U	42	U	42	U	36	J
Manganese								27		25		23		24		26		25	
Water Level (Feet MSL)	240.15						241.09	239.99		243.18		243.18		245.97		249.6		248.66	
	(reading 2/99)																		
Wet Chemistry (MG/L)																			
Chloride								9.8		9.9		9.8		10.3		11.4		10.5	
Nitrate								3.9		4.1		4.2		4.2		4.4		3.6	
Sulfate							13.4	21.3		18.7		18.2		18.8		25		20.8	
Total organic carbon (TOC)								1	U	1	U	1	U	0.7	J	1			

NA - Not analyzed
B - Analyte not detected above associated blank
J - Reported value is estimated
U - Analyte not detected

Appendix B
Electron Donor Dosing Calculations

SODIUM LACTATE QUANTITY ESTIMATE

ERD - Lactate Injection

Site 7, NSWC White Oak, Silver Spring, MD

Parameter	Concentration (mg/L)	eletron demand/mol	Molecular Weight (g/mol)	(mmol/L)
DO (O_2)	3	2	32	0.188
Sulfate (SO_4^{2-})	42	4	96	1.750
Nitrate (NO^{3-})	2.4	3	62	0.116
Iron	0.074	1	55.85	0.001
Manganese	0.069	1	54.94	0.001
TCE (C_2HCl_3)	0.017	1	131	0.000
Perchlorate (ClO4)	0.029	4	99.45	0.001
RDX(C3H6N6O6)	1.3	2	222.12	0.012
TNT (C7H5N3O6)	0.41	3	227.13	0.005
DNT	0.35	2	197.5	0.004
Total Electron Donor Demand =				**2.0782**

Sodium Lactate Molecular Weight (g/mol) =	112.1	
Mass of Lactate Required (mg/L water) =	232.96	
Desired Final Lactate Concentration (5X demand) =	**1165**	mg/L (at 100% conc)

60% Sodium Lactate Density = 11.0 lbs/gal

Treatment Area/Volume	Imperial		SI	
Length	240	ft	73	m
Width	15	ft	5	m
Area	3,600	ft^2	335	m^2
Depth (Saturated Thickness)	25	ft	7.6	m
Treatment Zone Volume (including solids)	90,000	ft^3	2,550	m^3
Porosity	0.25			
Treatment Zone Volume (corrected for 0.25 porosity)	22,500	ft^3	638	m^3
	168,300	gals	637,619	liters
Number of Primary Injection Borings =	15			
Treatment Zone per injection boring	1,500	ft^3	43	m^3
	11,220	gals	42,508	liters
Lactate per PRIMARY injection boring	109	lbs	50	kg
Total Number of Borings at Site =	19			
Total Lactate (at 100% conc)	2070	lbs	941	kg
Lactate per injection boring (at 60% conc)	182	lbs	83	kg
	16	gals		
Total Lactate (at 60% conc) - weight	3449	lbs	1568	kg
Total Lactate (at 60% conc) - volume	313	gals		

Since lactate comes in a convenient delivery container of 260 gallons

We'll need 2 drums or 520 gallons of 60% sodium lactate

5738 lb shipment of 60% sodium lactate

Preferred dilution strength	6	x
Total injection volume	1876	gal
Dilution water volume	1563	gal
This equated to	0.011	pore volumes
Assuming preferred inject of approx.	313	gallons
And there will be	1	injection intervals per boring
This equates to	17	gallons of 60% lactate & 82 gallons of dilution water per injection location
This will be followed by approximately	300	gallons of flush water per injection point
	5700	gallons of flush water total

Appendix C
Boring Logs and Well Construction Diagrams of Existing Wells

Form No. 309

BORING LOG

118-L Underwood Lane
Sterling, Virginia 22170
(703) 471-5374

07GW-08

SINCE 1861

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING/CHEMICAL
"ONE HUNDRED YEARS OF SERVICE"

DATE January 7, 1986

Project No. C-72-457

Client: Malcolm Pirnie, Inc.

Project: Naval Surface Weapons Center, White Oak, Maryland

Boring No.: 8 | Total Depth: 55 ft. | Elevation: * | Location: See Boring Location Sketch

Type of Boring: Hollow-stem auger | Started: 11-26-85 | Completed: | Driller: Dew / CME-55

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	% Core Recovery	REMARKS
		Brown, moist, med. dense to dense Silty SAND and GRAVEL (SM-GM)				GROUNDWATER DATA 38 ft. while drilling
	5		4 8-11	5		* Provided by client
	10		15 20-17	10		
	15		14 20-25	15		25 feet riser 30 feet screen
	20		10 13-20	20		
	25		17 17-17	25		
	28	Brown, wet, med. dense to dense Silty SAND and GRAVEL (SM-GM)				
	30		14 13-12	30		
	35		16 16-16	35		
	40		16 14-16	40		

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

* Scale 1"=5' unless otherwise noted

BORING LOG

118-L Underwood Lane
Sterling, Virginia 22170
(703) 471-5274

Ø7GWØ8

SINCE 1881
FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERING/CHEMICAL
"ONE HUNDRED YEARS OF SERVICE"

Report No. C-72-457 DATE January 7, 1986

Sent: Malcolm Pirnie, Inc.

Project: Naval Surface Weapons Center, White Oak, Maryland

Boring No.: 8 | Total Depth: 55 | Elevation: | Location:

Type of Boring: | Started: 11-26-85 | Completed: | Driller:

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows*	Sample Depth (Feet)	% Core Recovery	REMARKS
		Brown, wet, med. dense to dense Silty SAND and GRAVEL (SM-GM)				GROUNDWATER DATA
			6 8-9	45		
	45					
			48 48-50	50		
	50					
			17 19-19	55		
	55					
	60					
	65					
	70					
	75					

*No. of blows req'd. for a 140 lb. hammer dropping 30 in. to drive 2 in O.D., 1.375 in. I.D. sampler a total of 18 inches in three 6 in. increments. The sum of the last two increments of penetration is termed the standard penetration resistance, N.

Scale 1"=5' unless otherwise noted

BORING LOG

PROJECT NAME: NSWC White Oak
PROJECT NUMBER: CTO-298
DRILLING COMPANY: Parratt Wolff, Inc.
DRILLING RIG: Truck Mount

BORING NUMBER: 76W103
DATE: 12/3/98
GEOLOGIST: Charles C. Lawey III
DRILLER: Arnold Chapel

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery & Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Sample Remarks Remarks PID Reading (ppm)	PID/FID Readings (ppm): Sample PPM	Sampler BZ	Borehole**	Driller BZ**
1	1	2/3	1.6'	Dry	Loose	BRN	SAND with a trace amount of silt	S	0.0	0.0			
	2	3/4		"	"	"	" "	S	0.0	0.0			
2	3	15/25	1.6'	"	Slightly Loose	TAN	SAND with some silt & many medium cobbles	S	0.0	0.0			
	4	30/34		"	"	"	" "	S	0.0	0.0			
3	5	32/34	2.0'	"	Hard	"	Silty SAND with a few small pebbles.	SM	0.0	0.0			
	6	33/40		"	"	"	" "	SM	0.0	0.0			
4	7	32/35	1.0'	"	"	LT. TAN	Silty SAND with some mottled white CLAY & a few small pebbles	SM	0.0	0.0			
	8	35/37		"	"	"	" "	SM	0.0	0.0			
5	9	25/24	1.5'	"	Slightly Loose	"	SAND with some silt and some small to medium cobbles	S	0.0	0.0			
	10	19/20		"	"	"	" "	S	0.0	0.0			
6	11	9/8	1.0'	"	Loose	"	" "	S	0.0	0.0			
	12	21/17		"	"	"	" "	S	0.0	0.0			
7	13	18/21	1.0'	"	"	"	SAND with a trace amount of silt & numerous small to medium cobbles	S	0.0	0.0			
	14	21/23		"	"	"	" "	S	0.0	0.0			
8	15	10/15	1.2'	"	Slightly Loose	TAN	Silty SAND with some CLAY & numerous quartz rock fragments	SM-CL	0.0	0.0			
	16	14/17		"	"	"	" "	SM-CL	0.0	0.0			
9	17	28/25	1.2'	Slightly moist	"	"	" "	SM-CL	0.0	0.0			
	18	21/24		"	"	"	" "	SM-CL	0.0	0.0			
10	19	24/22	1.0'	"	Compact	OBS. BRN	Silty SAND with some CLAY & some small to medium cobbles	SM-CL	0.0	0.0			
	20	21/23		"	"	"	" "	SM-CL	0.0	0.0			
11	21	21/19	1.0'	"	Loose	LT. BRN TO TAN	SAND with some silt & distinct color banding	S	0.0	0.0			
	22	9/12		"	"	"	" "	S	0.0	0.0			
12	23	14/11	Ø	—	—	—	NO RECOVERY	—	—	—			
	24	14/13		—	—	—	NO RECOVERY	—	—	—			

* When rock coring, enter rock brokenness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks:

Drilling Area Background (ppm): -

Converted to Well: Yes ✓ No ____ Well I.D. #: 76W103

BORING LOG

PROJECT NAME: NSWC White Oak
PROJECT NUMBER: CTO-298
DRILLING COMPANY: Parratt Wolff, Inc.
DRILLING RIG: Truck Mount
BORING NUMBER: 76W103
DATE: 12/3/98 - 12/9/98
GEOLOGIST: Charles C. Lanney III
DRILLER: Arnold C.

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS	Sample Readings Remarks PID Reading (PPm)	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole*	Drillers BZ*
13	25	10/11	1.0'	Slightly moist	Loose	Tan	SAND with trace silt.	S	0.0	0.0			
	26	14/10		"	"	"	" "	S	0.0	0.0			
14	27	9/11		"	Loose	Light tan	" "	S	0.0	0.0			
	28	12/10		"	Hard	Lt. Brown to Brn.	Sandy CLAY with some silt and a few large Pebbles →	Sandy CLAY CLS	0.0	0.0			
15	29	34"	Ø	—	—	—	NO RECOVERY	—	—	—			
	30			—	—	—	No RECOVERY	—	—	—			
16	31	19/15	1.0'	Slightly moist	Compact	Olive Brn.	Sandy CLAY with some silt & large fragments of Qtz. Rock	CLS	0.0	0.0			
	32	16/17		"	"	"	" "	CLS	0.0	0.0			
17	33	19/20	1.2'	"	"	"	Sandy CLAY with some silt & Lenses of White CLAY & Large Qtz. Frags	CLS	0.0	0.0			
	34	19/15		"	"	"	" "	CLS	0.0	0.0			
18	35	19/21	2.0'	"	"	"	" "	CLS	0.0	0.0			
	36	21/24		"	"	"	" "	CLS	0.0	0.0			
19	37	18/17	2.0'	Wet	"	"	" "	CLS	0.0	0.0			
	38	18/21		"	"	"	" "	CLS	0.0	0.0			
20	39	11/11	2.0'	"	"	"	" "	CLS	0.0	0.0			
	40	12/11		"	"	"	" "	CLS	0.0	0.0			
21	41	11/12	0.5'	"	"	"	" "	CLS	0.0	0.0			
	42	19/12		Moist	Hard	Lt. Gray	SILT with a trace amount of CLAY		0.0	0.0			
22	43	19/22	2.0'	"	"	"	SILT with a trace amount of CLAY & Micas		0.0	0.0			
	44	23/21		"	"	"	" "		0.0	0.0			
23	45	25/32	1.0'	Wet	Semi Hard	Org. Brn	Sand with some silt, lenses of S white CLAY + Medium sized cobbles		0.0	0.0			
	46	31/32		Wet	"	"	" "	S	0.0	0.0			
24	47	21/20	2.0'	Wet	"	"	Sand with some silt and medium sized cobbles	S	0.0	0.0			
	48	23/25		Wet	"	"	" "	S	0.0	0.0			
							TOTAL DEPTH = 50' bgs						

*When rock coring, enter rock brokenness.

*Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: Decision is made to set the well at 50' bgs. Thin layer found on well screen beginning at 44' bgs.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ✓ No ____ Well I.D. #: 76W103

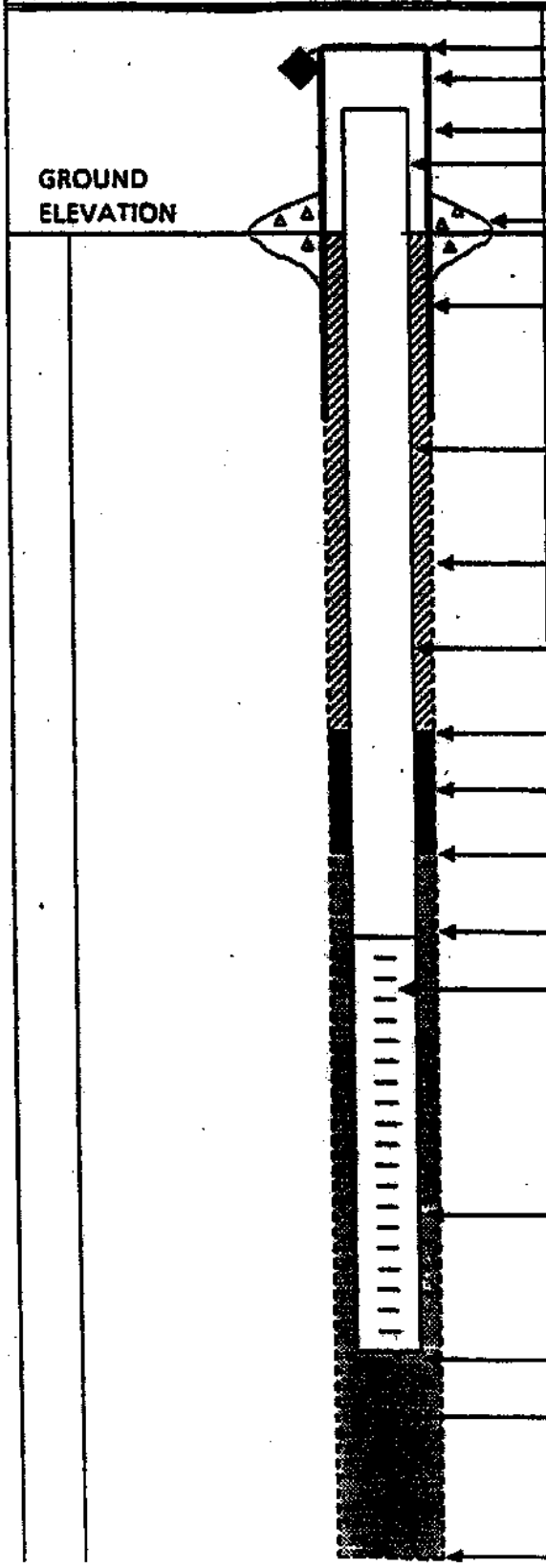
BORING NO.: 76W 10

OVERBURDEN
MONITORING WELL SHEET

PROJECT: NSWC White Oak
PROJECT NO.: CTO 298
ELEVATION:
FIELD GEOLOGIST: Charles C. Laney III

LOCATION: Site 7
BORING: 76W103
DATE: 12/3/98 → 12/4/98

DRILLER: Prent
DRILLING METHOD: HSA
DEVELOPMENT METHOD:



ELEVATION OF TOP OF SURFACE CASING:
ELEVATION OF TOP OF RISER PIPE:
STICK - UP TOP OF SURFACE CASING:
STICK - UP RISER PIPE:
TYPE OF SURFACE SEAL: Concrete
I.D. OF SURFACE CASING: N/A
TYPE OF SURFACE CASING: N/A
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: PVC
BOREHOLE DIAMETER: 8"
TYPE OF BACKFILL: Cement / Bentonite Grout
~~ELEVATION~~ / DEPTH TOP OF SEAL: 32'
TYPE OF SEAL: 3/8" Bentonite Chips
DEPTH TOP OF SAND PACK: 38'
~~ELEVATION~~ / DEPTH TOP OF SCREEN: 40'
TYPE OF SCREEN: PVC
SLOT SIZE x LENGTH: 0.10 Slot - 10' Length
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: #2 Silica
~~ELEVATION~~ / DEPTH BOTTOM OF SCREEN: 5'
~~ELEVATION~~ / DEPTH BOTTOM OF SAND PACK: 50'
TYPE OF BACKFILL BELOW OBSERVATION WELL: N/A
~~ELEVATION~~ / DEPTH OF HOLE: 50'

BORING LOG

PROJECT NAME: NSWC WHITE OAK
PROJECT NUMBER: CTO - 298
DRILLING COMPANY: Parratt Wolff, Inc.
DRILLING RIG: Truck Mount

BORING NUMBER: 76W104
DATE: 12/1/98
GEOLOGIST: Charles C Laney III
DRILLER: Arnold Chapel

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery & Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Sample Readings Remarks PID Reading (ppm)	PID/FID Reading (ppm): Sample PPM	Sampler BZ	Borehole**	Driller BZ**
1	1	7/3	1.5'	moist	Loose	Tan	SAND with Small pebbles	S	0.0	0.0			
	2	7/7		"	"	"	" "	S	0.0	0.0			
2	3	7/8	1.5'	DRY	"	"	SAND with large Pebbles	S	0.0	0.0			
	4	14/15		"	"	"	" "	S	0.0	0.0			
3	5	7/23	1.5'	"	"	"	SAND with large Quartz Cobbles	S	0.0	0.0			
	6	25/29		"	"	"	" "	S	0.0	0.0			
4	7	20/20	1.5'	"	"	"	" "	S	0.0	0.0			
	8	23/21		"	"	"	" "	S	0.0	0.0			
5	9	17/23	0.3'	"	"	"	" "	S	0.0	0.0			
	10	24/23		"	"	"	" "	S	0.0	0.0			
6	11	19/30	1.0'	"	Hard	LT. Tan	" "	S	0.0	0.0			
	12	27/33		"	"	"	" "	S	0.0	0.0			
7	13	11/19	1.5'	"	"	"	" "	S	0.0	0.0			
	14	34/40		"	"	"	" "	S	0.0	0.0			
8	15	17/19	1.3'	"	"	"	" "	S	0.0	0.0			
	16	20/22		"	"	"	" "	S	0.0	0.0			
9	17	24/20	1.3'	"	"	"	SAND with large Quartz Cobbles & lenses of White	S-CL CLAY	0.0	0.0			
	18	21/30		"	"	"	" "	S-CL	0.0	0.0			
10	19	20/22	1.3'	Slightly moist	Loose	"	SAND with Some Small cobbles	S	0.0	0.0			
	20	19/20		Slightly moist	"	"	" "	S	0.0	0.0			
11	21	21/23	Ø	—	—	—	No RECOVERY	—	—	—			
	22	25/19		—	—	—	No RECOVERY	—	—	—			
12	23	12/14	1.5'	Slightly moist	Loose	LT Tan	SAND with Some Small Pebbles	S	0.0	0.0			
	24	15/19		"	"	"	" "	S	0.0	0.0			

* When rock coring, enter rock broteneas.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm) 0.0

Remarks:

Converted to Well: Yes ✓ No ____ Well I.D. #: 76W104

BORING LOG

PROJECT NAME: NSWC WHITE OAK
PROJECT NUMBER: CTO-298
DRILLING COMPANY: Parratt Wolff, Inc.
DRILLING RIG: Truck Mount
BORING NUMBER: 76W104
DATE: 12/1/98 → 12/2/98
GEOLOGIST: Charles C. Lowery III
DRILLER: Arnold Chapel

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows/6" or RQD (%)	Sample Recovery & Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/Consistency or Rock Hardness	Color	Material Classification	USCS*	Sample Readings Remarks PID Reading (ppm)	MSA/PID Reading: Sample PPM	Sampler BZ	Borehole**	Driller BZ**
13	25	7/8	1.6'	Slightly Moist	Loose	LT TAN	SAND with large Cobbles	S	0.0	0.0			
	26	17/19		"	"	"	" "	S	0.0	0.0			
14	27	20/20	1.7'	"	HARD	TAN	Sandy CLAY with large Cobbles	CLS	0.0	0.0			
	28	26/29		"	"	"	" "	CLS	0.0	0.0			
15	29	13/13	1.0'	"	"	"	Sand with some Silt + Clay + large Pebbles	S-SM	0.0	0.0			
	30	12/15		"	"	"	" "	S-SM	0.0	0.0			
16	31	15/9	1.2'	MOIST TO WET	Slightly Loose	"	Silty SAND with Some large Pebbles	SM	0.0	0.0			
	32	11/15		MOIST TO WET	"	"	" "	SM	0.0	0.0			
17	33	19/21	0.5'	WET	"	"	" "	SM	0.0	0.0			
	34	23/21		WET	"	"	" "	SM	0.0	0.0			
							TOTAL Depth = 38' bgs						

* When rock coring, enter rock broken ess.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: Decision made in Field To Set Bottom of Well To 38' bgs. This well will be completed in The Field with grout at This Time Due To Sand Collapsing Conditions

Drilling Area Background (ppm): [ ]

Converted to Well: Yes ✓ No _____ **Well I.D. #:** 76W104

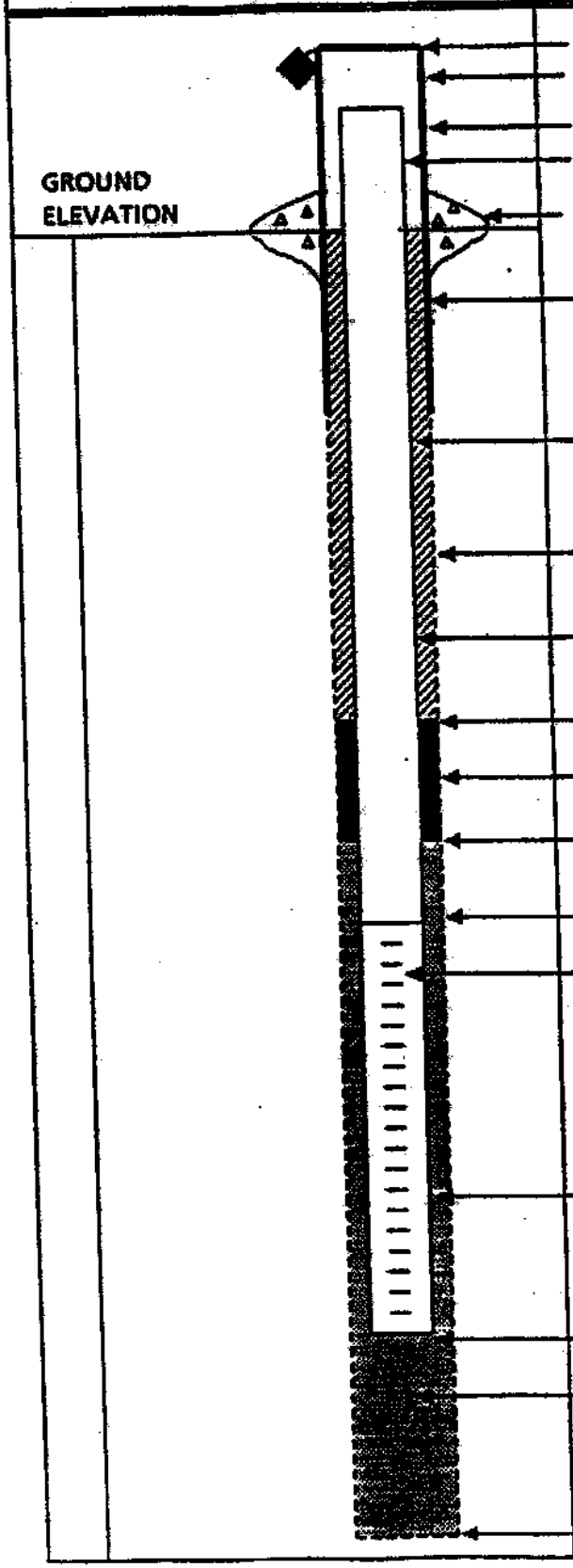
BORING NO.: 76W104

OVERBURDEN
MONITORING WELL SHEET

PROJECT: NSWC White Oak
PROJECT NO.: CTO 298
ELEVATION:
FIELD GEOLOGIST: Charles C. Lovey III

LOCATION: Site 7
BORING: 76W104
DATE: 12/1/98 – 12/2/98

DRILLER: Parratt-Wolff
DRILLING METHOD: HSA
DEVELOPMENT METHOD:



ELEVATION OF TOP OF SURFACE CASING:
ELEVATION OF TOP OF RISER PIPE:
STICK - UP TOP OF SURFACE CASING:
STICK - UP RISER PIPE:
TYPE OF SURFACE SEAL: Concrete
I.D. OF SURFACE CASING: N/A
TYPE OF SURFACE CASING: N/A
RISER PIPE I.D. 2"
TYPE OF RISER PIPE: PVC
BOREHOLE DIAMETER: 8"
TYPE OF BACKFILL: Cement / Bentonite Grout
~~ELEVATION~~ / DEPTH TOP OF SEAL: 22' /
TYPE OF SEAL: 3/8" Bentonite Chips
DEPTH TOP OF SAND PACK: 25.5'
~~ELEVATION~~ / DEPTH TOP OF SCREEN: 28' /
TYPE OF SCREEN: PVC
SLOT SIZE x LENGTH: 0.10 Slot – 10' Length
I.D. OF SCREEN: 2"
TYPE OF SAND PACK: #7 Silica
~~ELEVATION~~ / DEPTH BOTTOM OF SCREEN: 38' /
~~ELEVATION~~ / DEPTH BOTTOM OF SAND PACK: /
TYPE OF BACKFILL BELOW OBSERVATION WELL: N/A
~~ELEVATION~~ / DEPTH OF HOLE: 38' /

CH2MHILL

PROJECT NUMBER	BORING NUMBER	
150741.DA.DI.07	07GW200	SHEET 1 OF 2

SOIL BORING LOG

PROJECT : White Oak — LOCATION : Silver Spring, Maryland

ELEVATION : — DRILLING CONTRACTOR : Parratt Wolff

DRILLING METHOD AND EQUIPMENT USED : 4.25' Hollow Stem Auger & 2-foot long split spoons

WATER LEVELS : — START : 01/19/2003 — END : 1/19/2003 — GEOLOGIST : E. Carpenetti

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone	Above Hole
0							
5							
	5'-7'	0.5'		23,25,21,13	Medium sand and gravel yellowish brown 10YR 5/6 in color.	- 0	0
10							
	10'-12'	1'		7,15,23,24	Yellowish brown sand 10YR 5/6 grading to quartz grave with yellow 10YR 7/6 sand.	- 0	0
15							
	15'-17'	1'		8,24,20,18	Pink sand and gravel 10YR 7/4.	- 0	0
20							
	20'-22'	1'		11,21,21,25	Medium to course angular sand mixed with pink quartz gravel strong brown 7.5YR 5/6 in color.	- 0	0
25							
	25'-27'	1'		20,15,18,16	Strong brown 10YR 4/6 medium to course sand with some pebbles and gravel grading to pink 7.5YR 7/4 gravel	- 0	0
30							

CH2MHILL

PROJECT NUMBER	BORING NUMBER	
150741.DA.DL07	07GW200	SHEET 1 OF 2

SOIL BORING LOG

PROJECT : White Oak — LOCATION : Silver Spring, Maryland

ELEVATION : — DRILLING CONTRACTOR : Parratt Wolff

DRILLING METHOD AND EQUIPMENT USED : 4.25" Hollow Stem Auger & 2-foot long split spoons

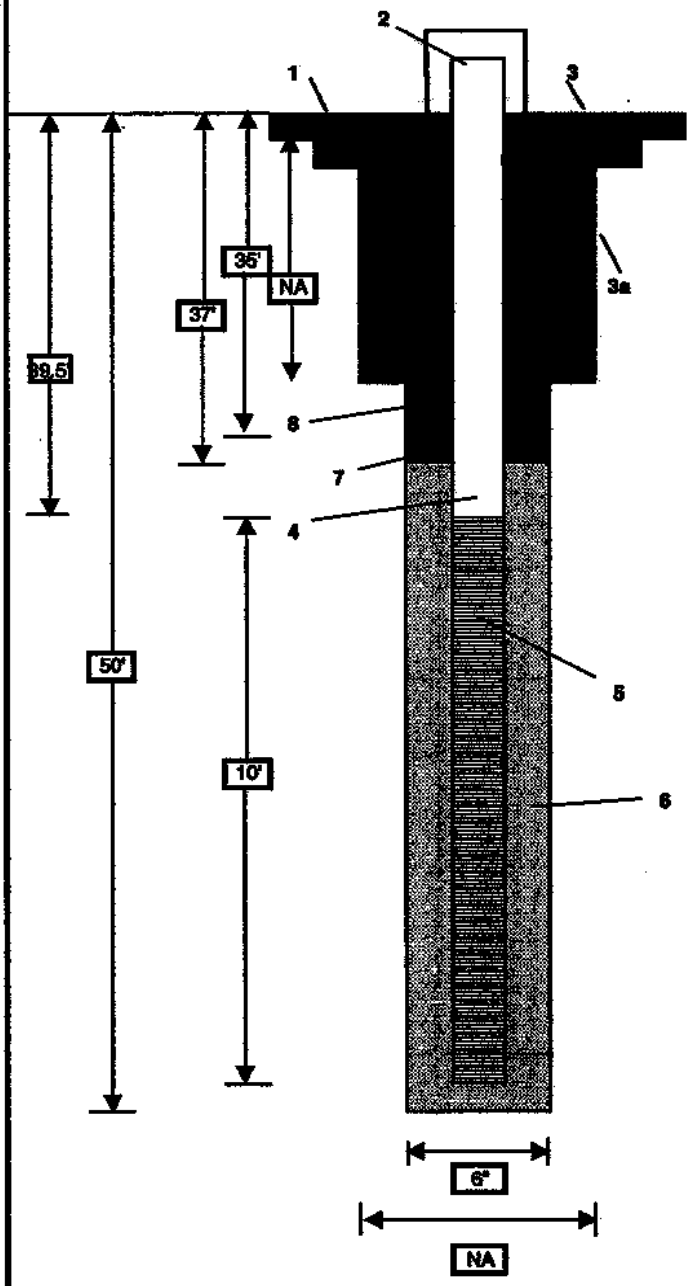
WATER LEVELS : — START : 01/19/2003 — END : 1/19/2003 — GEOLOGIST : E. Carpenetti

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone	Above Hole
	30'-32'	0.5'		25,28,35,18	Gravel at the bottom of the spoon yellowish brown 10YR 4/6	- 0	0
35							
	35'-37'	1'		7,15,20,21	Medium sand and gravel yellowish brown 10YR 5/6 in color	- 0	0
40							
	40'-42'	1'		20,24,20,18	Medium to course sand and gravel. Very pale brown 10YR 7/3 in color.	- 0	0
45							
	45'-47'	1.5'		1,10,35,33	Fine to medium sand with a trace of gravel very pale brown 10Yr 7/4 in color grading to course sand and gravel yellowish brown 10YR 6/6 in color.	- 0	0
50							
55							
60							

CH2MHILL	PROJECT NUMBER 150741	WELL NUMBER 07GW200 SHEET 1 OF 1

WELL COMPLETION DIAGRAM

PROJECT : NSWC-White Oak
LOCATION : Silver Spring, Maryland
DRILLING METHOD AND EQUIPMENT USED : HAS & Mud Rotary
DRILLING CONTRACTOR : Parratt Wolff START : 1/19/2003 END : 1/20/2003 GEOLOGIST : E. Carpenetti



1- Ground elevation at well 278.1

2- Top of casing elevation PVC = 281.39

3- Wellhead protection cover type 3' Stickup
a) Dia./type of outer surface casing 4" Steel Casing
b) concrete pad dimensions 2' x 2'

4- Dia./type of inner well casing 2" I.D. Sch 40 PVC

5- Type/slot size of screen 2" PVC Screen (.010 mm)

6- Type screen filter #1 Sand

7- Type of seal Bentonite seal
a) Quantity used

8- Grout
a) Grout mix used 1 bag Portland + 5 lbs bentonite per 8 gal water
b) Method of placement Tremmie pipe

CH2MHILL

PROJECT NUMBER	BORING NUMBER	
160741.DA.DI.07	07GW201	SHEET 1 OF 2

SOIL BORING LOG

PROJECT : White Oak — LOCATION : Silver Spring, Maryland

ELEVATION : — DRILLING CONTRACTOR : Parratt Wolff

DRILLING METHOD AND EQUIPMENT USED : 4.25" Hollow Stem Auger & 2-foot long split spoons

WATER LEVELS : — START : 01/27/2003 — END : 1/27/2003 — GEOLOGIST : E. Carpenetti

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	w/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY; SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone	Above Hole
0							
5							
	5'-7'	2'		7,9,9,1	Fine to medium sand with a trace of gravel. Reddish yellow 7.5YR 6/6 in color.	- 0	0
10							
	10'-12'	1.5'		10,14,29,34	Medium sand and gravel reddish yellow 7.5YR 6/6 in color.	- 0	0
15							
	15'-17'	1'		20,24,31,28	Quartz gravel with some sand. The sand was probably washed out the end of the spoon.	- 0	0
20							
	20'-22'	0.5'		16,19,28,24	Sand and gravel reddish yellow 7.5YR 6/6 in color.	- 0	0
25							
	25'-27'	0.5'		19,22,21,20	Gravel.	- 0	0
30							
	30'-32'	1'		38,26,37,30	Sand and gravel reddish yellow 7.5YR 7/6 in color	- 0	0
35							

CH2MHILL

PROJECT NUMBER	BORING NUMBER	
150741.DA.DL07	07GW201	SHEET 1 OF 2

SOIL BORING LOG

PROJECT : White Oak — LOCATION : Silver Spring, Maryland

ELEVATION : — DRILLING CONTRACTOR : Parratt Wolff

DRILLING METHOD AND EQUIPMENT USED : 4.25" Hollow Stem Auger & 2-foot long split spoons

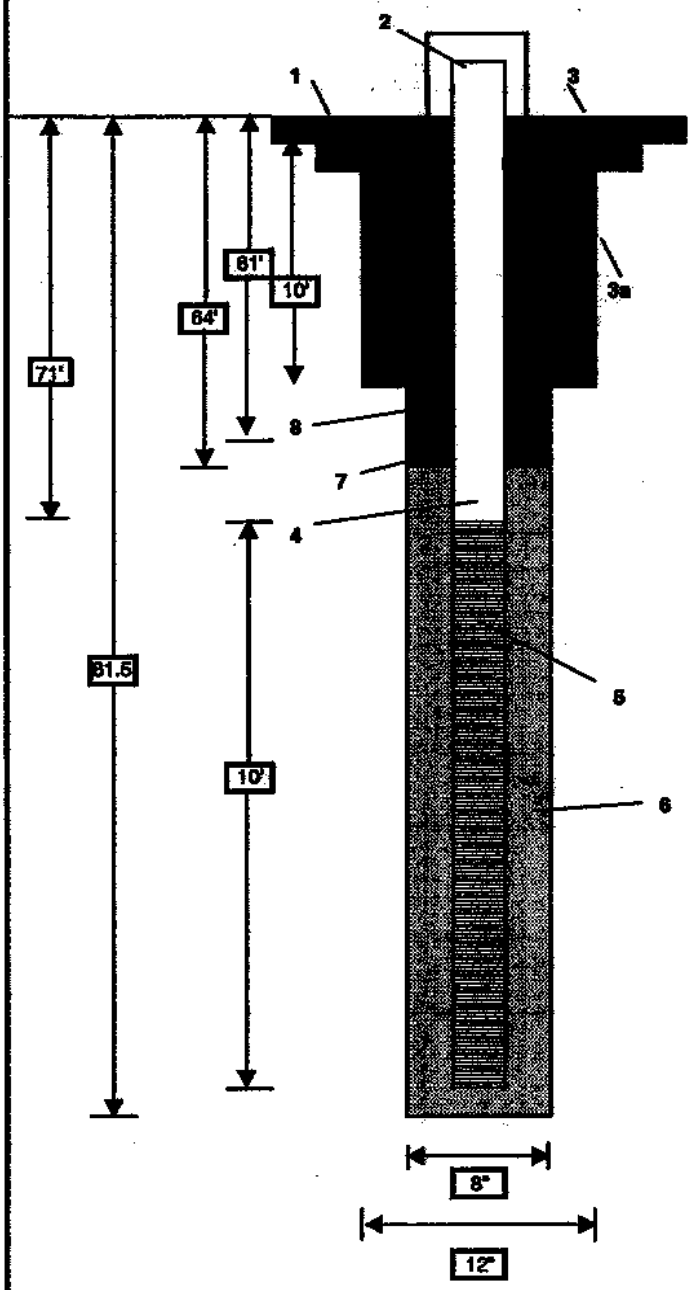
WATER LEVELS : — START : 01/27/2003 — END : 1/27/2003 — GEOLOGIST : E. Carpenetti

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY. SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone	Above Hole
	36'-37'	0.5'		25,24,23,27	Gravel	- 0	0
40							
	40'-42'	2'		17,10,9,7	Course angular sand and gravel reddish yellow 7.5YR 7/6 grading to a white silty clay 7.5YR 8/6 at the bottom 4-inches of the spoon.	- 0	0
45							
	45'-47'	2'		45,48,62,63	Fine silty clay white 7.5YR 8/1 grading to fine sand at the bottom 3-inches. Iron staining throughout the spoon.	- 0	0
	48'-50'	2'		10,10,11,17	Fine to medium sand reddish yellow 7.5YR 7/6 in color grading to a fine sand silt mix light grey 10YR 7/2 in color.	- 0	0
50							
	53'-55'	2'		15,23,31,35	Medium and course sand with gravel ranging in color from very pale brown 10YR 7/4 to brownish yellow 10YR 6/6.	- 0	0
55							
	58'-60'	1'		-	Medium sand varying in color form weak red 10YR 5/4 to very pale brown 10YR 7/3.	- 0	0
60							
65							

CH2MHILL	PROJECT NUMBER 150741	WELL NUMBER 07GW201 SHEET 1 OF 1

WELL COMPLETION DIAGRAM

PROJECT : NSWC-White Oak
LOCATION : Silver Spring, Maryland
DRILLING METHOD AND EQUIPMENT USED : HAS & Mud Rotary
DRILLING CONTRACTOR : Parratt Wolff START : 1/27/2003 END : 1/30/2003 GEOLOGIST : E. Carpenetti



1- Ground elevation at well 282.1

2- Top of casing elevation PVC = 285.60

3- Wellhead protection cover type 3' Stickup
a) Dia./type of outer surface casing 4" Steel Casing
b) concrete pad dimensions 2' x 2'

4- Dia./type of inner well casing 2" I.D. Sch 40 PVC

5- Type/slot size of screen 2" PVC Screen (.010 mm)

6- Type screen filter #1 Sand

7- Type of seal Bentonite seal
a) Quantity used

8- Grout
a) Grout mix used 1 bag Portland + 5 lbs bentonite per 8 gal water
b) Method of placement Tremmie pipe

CH2MHILL

PROJECT NUMBER	BORING NUMBER	
150741.DA.DL07	07GW202	SHEET 1 OF 2

SOIL BORING LOG

PROJECT : White Oak — LOCATION : Silver Spring, Maryland

ELEVATION : — DRILLING CONTRACTOR : Parratt Wolff

DRILLING METHOD AND EQUIPMENT USED : 4.25" Hollow Stem Auger & 2-foot long split spoons

WATER LEVELS : — START : 01/21/2003 — END : 1/21/2003 — GEOLOGIST : E. Carpenetti

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	MTYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone	Above Hole
0							
5							
	5'-7'	2'		5,8,8,5	Medium sand with a trace of gravel yellow 10YR 7/6 in color.	- 0	0
10							
	10'-12'	2'		4,4,5,6	Medium to course sand with a trace of gravel yellowish brown 10YR 5/4 in color.	- 0	0
15							
	15'-17'	2'		4,6,6,4	Medium to course sand with a trace of pebbles yellow 10YR 5/6.	- 0	0
20							
	20'-22'	2'		10,15,15,18	Medium to course sand with a trace of gravel yellow 10YR 7/6.	- 0	0
25							
	25'-27'	2'		8,12,12,30	Medium sand dark yellowish brown 10YR 4/6 grading to course sand and gravel yellow 10YR 5/6.	- 0	0
30							

CH2MHILL

PROJECT NUMBER	BORING NUMBER	
150741.DA.DI.07	07GW202	SHEET 1 OF 2

SOIL BORING LOG

PROJECT : White Oak — LOCATION : Silver Spring, Maryland

ELEVATION : — DRILLING CONTRACTOR : Parratt Wolff

DRILLING METHOD AND EQUIPMENT USED : 4.25" Hollow Stem Auger & 2-foot long split spoons

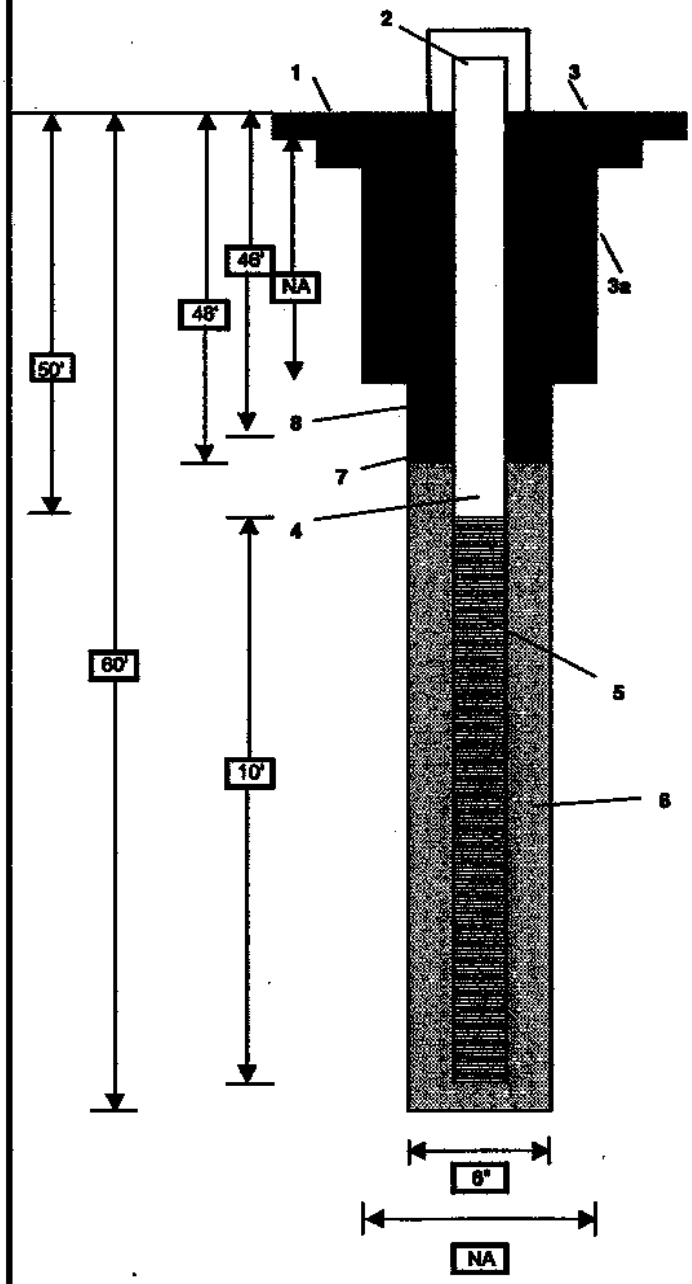
WATER LEVELS : — START : 01/21/2003 — END : 1/21/2003 — GEOLOGIST : E. Carpenetti

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone	Above Hole
	30'-32'	2'		8,14,15,21	Medium to course sand with gravel very pale brown 10YR 8/4 to 10YR 7/4. The bottom 4-inches of the spoon was a lense of clayey silt very pale brown 10YR 7/3 in color.	- 0	0
35							
	35'-37'	2'		21,26,20,25	Medium to course sand and gravel light yellowish brown 10YR 6/4 in color.	- 0	0
40							
	40'-42'	1.5'		8,8,12,14	Fine to medium sand reddish yellow 7.5YR 6/8 in color grades to a silt approximately 8-inches in length white 7.5YR 8/1 grading back to a course sand reddish yellow 7.5YR 6/8	- 0	0
45							
	45'-47'	1.5'		6,8,14,14	Medium to course sand and gravel reddish yellow 7.5YR 6/6 in color.	- 0	0
50							
	50'-52'	0'		47,50/3	No recovery.	- 0	0
55							
	55'-57'	1'		9,10,9,8	Course angular sand yellow 10YR 8/6 in color.	- 0	0
60							

CH2MHILL	PROJECT NUMBER 150741	WELL NUMBER 07GW202 SHEET 1 OF 1

WELL COMPLETION DIAGRAM

PROJECT : NSWC-White Oak
LOCATION : Silver Spring, Maryland
DRILLING METHOD AND EQUIPMENT USED : HAS
DRILLING CONTRACTOR : Parratt Wolff START : 1/19/2003 END : 1/22/2003 GEOLOGIST : E. Carpenetti



1- Ground elevation at well 290.0

2- Top of casing elevation PVC = 293.32

3- Wellhead protection cover type 3' Stickup
a) Dia./type of outer surface casing 4" Steel Casing
b) concrete pad dimensions 2' x 2'

4- Dia./type of inner well casing 2" I.D. Sch 40 PVC

5- Type/slot size of screen 2" PVC Screen (.010 mm)

6- Type screen filter #1 Sand

7- Type of seal Bentonite seal
a) Quantity used

8- Grout
a) Grout mix used 1 bag Portland + 5 lbs bentonite per 8 gal water
b) Method of placement Tremmie pipe

Appendix D
Cost Estimate

COST ESTIMATE

PROJECT: **Site 7 BOD for Groundwater Remediation**
SITE: **Site 7, NSWC - White Oak, Silver Spring, Maryland**
DESCRIPTION: **Enhanced Anaerobic Bioremediation**

Assumptions

The accuracy of the cost estimate expected to be plus 30 percent/minus 15 percent of the estimated cost.

Capital Costs

Number of Injection Wells to be installed = 19 wells

INJECTION/REMEDIAL ACTIVITY COST

Item/Activity	Qty	Unit	Unit Cost	Cost	Comments and References
Injection Well Installation					
Injection Well Installation and IDW (see attached sheet)	1	ls	$ 83,577.63	$ 83,578	See attached spreadsheet; install/components, IDW mgmt.
Well Permits	19	ea	$ 100	$ 1,900	Required (site is in PG County, MD)
Well Survey	1	ls	$ 1,500	$ 1,500	BOA Rates; survey completed in one day
Reagent Injection					
Mob/Demob	1	ls	$ 3,000	$ 3,000	
On-site Injection Program Support	1	ls	$ 2,500	$ 2,500	
Field Crew (2 persons)	5	day	$ 480	$ 2,400	
Injection Pump, meter, and equipment	1	wk	$ 2,200	$ 2,200	See Attached spreadsheet
Injection Reagents (sodium lactate)	5740	lb	$ 0.72	$ 4,133	Quote for White Oak - 260 gal totes of 60% soln, 11 lb/gal
Reagent transport to site	1	ls	$ 500	$ 500	Quote for White Oak
Subtotal Injection Well Installation/Injection				$ 101,710	
Site Work Allowance	5%	of	$ 101,710	$ 5,086	
Mechanical Allowance	0%	of	$ 101,710	$ -	
Instrumentation and Controls Allowance	0%	of	$ 101,710	$ -	
Electrical Allowance	0%	of	$ 101,710	$ -	
Miscellaneous Equipment Allowance	2%	of	$ 101,710	$ 2,034	
Subtotal Capital Cost				**$ 108,830**	
OH&P	15%	of	$108,830	$ 16,325	
General Mob/Demob/Ins	5%	of	$108,830	$ 5,442	
Contingency	15%	of	$108,830	$ 16,325	
TOTAL CAPITAL COST				**$ 147,000**	
Project Management	5%	of	$ 147,000	$ 7,350	
Construction Management	10%	of	$ 147,000	$ 14,700	
Remedial Action Work Plan	1	ls	$ 10,000	$ 10,000	
Reporting	1	ls	$ 10,000	$ 10,000	
TOTAL PROJECT COST				**$ 189,000**	

SITE: **Site 7, NSWC - White Oak, Silver Spring, Maryland**

Well Installation Cost Estimate

Number of wells: 19 Injection wells

Item Description	Unit	MD/DC Area		
		Quantity	Unit Price ($)	Total ($)
Mobilization				
Truck mounted rig	lump sum	1	900.00	$ 900
Soil Boring (for injection wells, each at 65 ft)				
8 inch augering				
0-50 feet	per foot	950	25.00	$ 23,750
over 50 feet (from 50 to 65 feet)	per foot	285	30.00	$ 8,550
Alternate Boring Techniques				
Mud Rotary (8-inch)				
0-50 feet	per foot	0	20.00	$ -
50-100 feet	per foot	0	30.00	$ -
Soil Sampling				
Split Spoon ASTM Method D-1586 (2-inch) -- 3 per well				
0-50 feet	each	57	15.00	$ 855
4-inch Extraction Well Construction				
0-50 feet	per foot	950	13.00	$ 12,350
51-100 feet	per foot	285	13.00	$ 3,705
4-inch Schedule 80 PVC well riser	per foot	950	2.50	$ 2,375
4-inch Schedule 80 PVC well screen				
25-foot length	each	19	115.00	$ 2,185
Miscellaneous				
Installation of Protective Casing	per well	19	425.00	$ 8,075
Development	per hour	19	65.00	$ 1,235
Standby time	per hour	8	150.00	$ 1,200
Per Diem (two-man crew)	per day	10	125.00	$ 1,250
Per Diem (additional crew member)	per day	10	62.50	$ 625
Decontamination of Equipment	per hour	19	150.00	$ 2,850
Temporary decontamination pad	per location	1	200.00	$ 200
Backhoe for moving IDW soil	per day	2	200.00	$ 400
IDW Costs (see attached sheet)	lump sum	1	11,872.63	$ 11,873
Handling Investigation-Derived Waste	per hour	8	150.00	$ 1,200
Total for Drilling				**$ 83,578**

PROJECT: Site 7 BOD for Groundwater Remediation
SITE: Site 7, NSWC - White Oak, Silver Spring, Maryland

Injection Supplies	Qty	Unit	Unit Cost	Cost	Comments
Skid-Mounted Injection Pump Assembly	1	week	$1,000	$1,000	7 days quote from Probe Lease, Inc.
Pressure Gauge, 0-1000 psi	1	ea	$50	$50	Grainger, 2C452, liquid-filled Ashcroft
High-Pressure Hose, 3/4" ID	10	ea	$35	$350	Grainger, 2F677, 36-in lengths
Heavy Fork Lift Rental	1	week	$300	$300	3,000 lb capacity
Miscellaneous fittings, supplies	1	LS	$500	$500	
Subtotal				$2,200	

Waste Disposal Calculations

# of	Purpose	TD (ft bgs)	Screen Interval (ft bgs)	Construction Details
19	Injection - Coastal Plain	65	40-65	4-in Sch80 PVC
Total Coastal Plain Drilling (lf)		1235		

Waste Disposal

Number of wells to be developed =	19	wells
Total length of 8-in auger drilling =	1235	lf
Total volume of spoils =	970	cf
Approx. weight of spoils =	56	tons (assume 115 lbs/cf)

Well Development Purge Water Disposal (4" wells)

Average depth of water =	25	ft bgs
Total number of volumes to be purged =	5	casing volumes
Total lineal feet of water to be purged =	2375	ft
Total volume of waste purge volume =	1550	gallons

IDW: Water and Soil from Well Installation/Development, & IDW Sampling				
	Unit	**Qty**	**Unit Cost**	**Cost**
Polytank Rental (water mgmt)				
Delivery/Cleaning	ls	1	$1,700	$1,700
Rental	week	2	$200	$400
Rolloff (spoils mgmt)				
Rolloff Mobilization/Demobilization/Cleaning	Lump Sum	2	$300	$600
Roll-off weekly rental (15 cubic yards)	Per week	6	$85	$510
Soil and Water Characterization				
Soil Characterization	each	2	$890	$1,780
Water Characterization	each	1	$260	$260
Manifesting, Transport, & Disposal				
Manifesting & transport of non-hazardous IDW soil (in rolloffs)	each	2	$425	$850
Disposal of non-hazardous IDW soil (in rolloffs)	Per ton	60	$75	$4,500
Manifesting, transport, & disposal of non-hazardous IDW water	each	1	$575	$575
Disposal of non-hazardous water	per gal	1,550	$0.45	$698
Total: Water and Soil fr Well Install				**$11,873**