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FEASIBILITY STUDY
for
SITE 5 - FIRE TRAINING AREA GROUNDWATER (OU 2)

NAVAL AIR STATION
JOINT RESERVE BASE
WILLOW GROVE, PENNSYLVANIA

Engineering Field Activity Northeast
Naval Facilities Engineering Command
Contract No. N62472-03-D-0057
Contract Task Order 003

SEPTEMBER 2004

TETRA TECH NUS, INC.

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COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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EXECUTIVE SUMMARY

Under the Department of Defense's Installation Restoration Program (IRP), the Navy, in agreement with the United States Environmental Protection Agency (EPA) and in consultation with the Pennsylvania Department of Environmental Protection (PADEP), is in the process of completing the remedial investigation and feasibility study (RI/FS) of Site 5 at the Naval Air Station Joint Reserve Base (NAS JRB) Willow Grove. This feasibility study (FS) has been prepared for the Navy by Tetra Tech NUS (TtNUS) in response to Contract Task Order No. 003 under Contract N62472-93-D-0057, Comprehensive Long-Term Environmental Action Navy (CLEAN). This work is part of the Navy's Installation Restoration Program (IRP), which is designed to identify and characterize contamination of Navy and Marine Corps facilities resulting from past operations and to institute corrective measures as appropriate.

This FS includes a discussion of remedial alternatives for Operable Unit 2 (OU 2), which comprises groundwater at Site 5 (the former Fire Training Area). The FS considered a range of remedial alternatives that address potential risks to human health and the environment posed by site-related contaminants identified previously under the RI.

For a full understanding of site conditions, the RI Report for Site 5 - Fire Training Area, February 2002, must be reviewed. The RI report is the essential companion document to this FS; both were prepared as part of the prescribed Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) RI/FS development procedure.

A range of remedial alternatives has been developed in this document for review by the Navy, regulatory community and restoration advisory board (RAB) members to select a preferred remedy for Site 5 groundwater. A Proposed Remedial Action Plan will then be prepared to present the selected remedy for public comment. After the public comment period has concluded, all questions and concerns from the public will be addressed in a Responsiveness Summary and the selected remedy will be documented in a Record of Decision.

NAS JRB Willow Grove Site Summary

Naval Air Station Joint Reserve Base (NAS JRB) Willow Grove, Pennsylvania (formerly NAS, Willow Grove) is located in Horsham Township, Montgomery County in southeastern Pennsylvania, approximately 15 miles north of the city of Philadelphia. The base occupies approximately 1,000 acres of flat to slightly rolling terrain and is generally bounded by State Route 611 to the east, State Route 463 to the southwest, and Keith Valley Road to the north.

The primary mission of NAS JRB Willow Grove is to provide support for operations involving aviation activities and to train Navy reservists. NAS JRB Willow Grove supports other tenants such as the Marines, Air Force, and Army reserve units. The base provides facilities, services, materials, and training in direct support of all assigned units. These units include anti-submarine warfare squadrons, a helicopter squadron, a fleet logistic support squadron, and other Navy and Marine units. The Willow Grove Air Reserve Station (ARS) occupies approximately 162 acres of land in the northeastern section and shares common facilities with NAS JRB Willow Grove.

Of 17 sites included within the Navy's preliminary assessment (Initial Assessment Study) at NAS JRB Willow Grove site inspection (SI) work was performed at 12 sites, and RI/FS activities have subsequently been completed or are underway at eight sites.

Site 5 - Fire Training Area

The former fire training area is located near the southern end of the Navy's property, west of the runways and south of Taxiway Juliet, and covers an irregularly shaped area of approximately 1.25 acres. Fire training operations included storage and burning of flammable liquid wastes generated by the air station in the period from 1942 through 1975, when burning exercises ceased.

Regulatory and Investigative History

Preliminary Assessment and Site Inspection

During the SI, four monitoring wells were installed and sampled. Soil samples were also collected from four soil borings. These samples were analyzed for volatile organics and petroleum hydrocarbons. All the analytical results were presented in the SI report (EA, May 1990).

Phase I Remedial Investigation

Phase I RI activities at Site 5 were conducted by Halliburton NUS in 1993 at NAS JRB Willow Grove. The OU 2 groundwater was included in the investigation. The RI field investigation included drilling 12 soil borings, installing six monitoring wells, and sampling surface water and sediments. Ten groundwater samples were analyzed for volatile organics.

Phase II Remedial Investigation

Phase II RI activities at Site 5 were conducted by Brown & Root Environmental in 1997. The OU 2 groundwater was included in the investigation. The RI field investigation included drilling and installing 11 monitoring wells and sampling surface soil, subsurface soil, surface water, groundwater, and sediments. Geophysical logging of all newly drilled boreholes and one existing borehole was also performed. Twenty-

one Groundwater samples were analyzed for Target Compound List (TCL) volatile organic compounds (VOCs), TCL semivolatile organic compounds (SVOCs), TCL PCB/pesticides, Target Analyte List (TAL) inorganics, and cyanide. Surface and subsurface soil samples were analyzed for various TCL and TAL analyses depending on site data requirements and specific locations. Surface water and sediment samples were analyzed for TCL VOCs, TCL SVOCs, TCL PCB/pesticides, TAL inorganics, and cyanide. Sediment samples were also tested for total organic carbon (TOC) and grain size. Background samples were also collected and analyzed.

All RI results are presented and discussed in the Site 5 RI report (TtNUS, February 2002).

Phase II Follow-On Remedial Investigation

Phase II follow-on RI investigations were performed in September 2000 by the Navy to respond to specific questions from EPA regarding the site to further delineate extent of contamination and to ensure that reliable downgradient sentinel wells were in place to monitor potential advance of the groundwater plume at the NAS JRB Willow Grove property boundary. Twenty-six groundwater samples were analyzed for TCL VOC and "monitored natural attenuation" (MNA) parameters. The follow-on Phase II RI investigations generally confirmed the Phase II RI investigation results, provided the natural attenuation evidence needed for the FS, and clarified that the downgradient edge of the Site 5 VOC plume was not migrating off Base. The Site 5 risk assessment was not revised based on the follow-on Phase II RI findings. Follow-on Phase II RI results are discussed in the Site 5 RI report (TtNUS, February 2002).

Additional groundwater monitoring for contaminant movement was conducted in June 2004. Results will be evaluated when available.

Contaminant Fate and Transport

Ten monitoring wells (shallow zone wells 05MW01S through 05MW07S, shallow intermediate zone wells 05MW01SI and 05MW06SI, and intermediate zone well 05MW07I) were sampled for TCL VOCs during the Phase I RI. During Phase II, 21 monitoring wells (shallow zone wells 05MW01S through 05MW10S, shallow intermediate zone wells 05MW06SI, and 05MW08 through 05MW10SI, intermediate zone wells 05MW01I, 05MW03I, 05MW06I, and 05MW08 through 05MW10I, and deep well 05MW01D) were sampled. Twenty-six monitoring wells (all Phase II wells plus follow-on monitoring wells) were analyzed for TCL VOC and MNA parameters for the Phase II follow-on remedial investigation.

Groundwater from Site 5 does not appear to encounter surface water and has no impact on Site 5 ecology.

The principal contaminants associated with Site 5 groundwater are VOCs; as historically disposed at Site 5. VOCs were detected in groundwater samples from well clusters 05MW01, 05MW02, 05MW03, 05MW07, 05MW09, and 05MW10. Trichloroethene (TCE) and its degradation products and benzene were detected above reference criteria and background in the shallow, shallow-intermediate, and intermediate zones at 05MW01; only tetrachloroethene (PCE) was detected in the deep zone at this cluster. The highest concentrations of VOCs in this cluster were in the shallow zone and decreased with depth. VOCs exceeding reference criteria in this cluster included 1,1,1-trichloroethane (1,1,1-TCA) (up to 960 ug/l), 1,1-dichloroethene (1,1-DCE) (up to 300J ug/l), 1,2-DCE (total) (up to 99 ug/l), benzene (up to 28 ug/l), and TCE (up to 300 ug/l). Only 1,1-DCE was detected above regulatory criteria in the other well clusters, at levels ranging from 4J ug/l to 120 ug/l at 05MW10SI.

Results from the Phase II RI show that the area near Monitoring Well 05MW01 is the source area for the groundwater VOCs contamination in the former Fire Training Area. However, the analytical results indicate that DNAPL does not exist either at, or downdip from, the source area.

Horsham Township Municipal Authority (HTMA) operates a water supply well No. 26 located approximately 1,800 feet southwest of the Site 5 Monitoring Well 05MW01. This supply well is reportedly 400 feet deep, and pumps at a rate of approximately 275 gpm. The well pumps when it is triggered by demand and is controlled by the water levels in its holding and storage tanks. Interpretations of the plume geometry at Site 5 indicated that the groundwater plume was generally migrating to the southwest, or toward the HTMA Well No. 26, although no chlorinated solvents had ever been reported in this well. Results reported by USGS (in Appendix O of the Site 5 RI Report) indicate that the pumping of HTMA No. 26 has very little, if any, influence on hydraulic head at Site 5.

No SVOCs were detected in Site 5 groundwater samples. Lead, arsenic, and beryllium were the only inorganics detected in Site 5 groundwater at levels above reference criteria. Statistical tests conducted during the RI data analysis indicated that these inorganics are not site related.

Objective of the FS

The overall objective of this FS is to develop and evaluate alternatives that address source control and groundwater remediation actions for Site 5. The general FS process is described below:

- Develop remedial action objectives (RAOs) that incorporate clean-up goals protective of human health and the environment. The RAOs specify the contaminants, media of interest, exposure pathways, and preliminary remediation goals (PRGs). The PRGs (numeric criteria) are developed based on

chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs), when available, and site-specific risk-related factors.

- Develop general response actions to address each medium of interest. Each response action may be implemented singly or in combination with other actions to satisfy the RAOs.

- Identify and screen technologies applicable to each general response action. Technologies and process options that are not technically implementable are eliminated. Representative process options for the remaining technologies are then evaluated for their effectiveness, implementability, and cost.

- Assemble and screen remedial alternatives from the retained technologies. The alternatives consist of a range of remedial technologies for source control or groundwater remediation.

- Prepare a detailed analysis of individual alternatives following the criteria specified in the National Contingency Plan (NCP) and the RI/FS guidance document. Finally, compare and evaluate the alternatives.

Remedial Action Objectives (RAOs)

Based on the RI results, the baseline human health and ecological risk assessments for Site 5, the site-specific RAOs were developed to address contaminated environmental media (groundwater) present at NAS JRB Willow Grove Site 5 and to determine the appropriate remedial actions that will protect human health and the environment as follows:

Protection of the Environment

To reduce or prevent the detrimental effects of site-related contaminants on degradation of groundwater quality underlying Site 5, the RAO for protection of the environment is to mitigate migration of VOC contaminants in groundwater and restore the aquifer to applicable standards.

Protection of Human Health

The groundwater RAO for protection of human health is to prevent potential human exposure to contaminated groundwater that may pose excess health risks to humans by taking remedial action warranted to protect human health.

Technology Screening and Alternatives D velopm nt

In the screening process, alternatives that address contaminated groundwater and the RAOs are evaluated generally with regard to effectiveness, implementability, and cost. The purpose of the evaluation is to control the number of alternatives that will undergo a more thorough and extensive analysis. If applicable, the alternatives carried forward for detailed evaluation should include the full range of alternatives recommended in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and EPA RI/FS Guidance: no action, treatment, and containment.

The alternative screening process for Site 5 resulted in all of the identified alternatives being retained for further evaluation in order to preserve a full range of plausible remedial actions. These alternatives provide variable levels of protection to human health and the environment, as well as compliance with ARARs. Remedial alternatives included no action and source control actions such as monitored natural attenuation, in-situ treatment, and pump-and-treat systems with air stripping, groundwater recirculation, institutional controls, and long-term monitoring of the entire plume or the plume source zone.

The remedial alternatives that passed the screening steps for Site 5 groundwater remediation were further evaluated and a comparison analysis was performed. Summaries of the evaluation and comparison analysis are presented below.

Sit 5 Remedial Alternatives Evaluation and Comparison Analysis

Detailed evaluation of remedial alternatives were performed for this FS in accordance with the requirements of the NCP and the EPA RI/FS Guidance Document. Comparisons of the remedial alternatives were made to identify differences between the alternatives and how site contaminant threats are addressed. The following seven criteria, as established by the NCP, were used for the detailed analysis of alternatives:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of mobility, toxicity, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Two other evaluation criteria, state and community acceptance, will be addressed in the Record of Decision following the receipt of comments during public comment period, after the Proposed Remedial Action Plan has been presented to the public.

The five alternatives that were subject to the above evaluation criteria and comparative analysis are presented below.

Alternative 1: No Action

Alternative Description:

The no-action alternative was developed as a baseline to which other alternatives may be compared, as required by the NCP. No remedial actions would be taken to protect human health or the environment. The purpose of the alternative is to evaluate the overall human health and environmental protection provided by the site in its present state for a comparison to the remedial alternatives developed. There would be no activities conducted under this alternative.

Alternative Evaluation:

The no-action alternative would provide only limited protection of human health and the environment. Contaminants within the groundwater would not be remediated or isolated and would continue to pose risk and adversely impact the environment. This alternative would not comply with chemical-specific ARARs or TBCs and would have limited long-term effectiveness or permanence since it would not remedy the underlying aquifer or prevent exposure to contaminated groundwater. Short-term effectiveness is not relevant to this alternative since no remedial action would be performed. The no-action alternative would not reduce the toxicity, mobility, or volume of contamination. No capital costs or operations and maintenance costs are associated with the no-action alternative.

Alternative 2: Monitored Natural Attenuation

Alternative Description:

Alternative 2 is a low-cost remedial alternative that aims to protect human health primarily through long-term groundwater monitoring. Under this alternative, five new monitoring wells would be installed, data would be evaluated, a predictive attenuation model would be constructed and maintained, and institutional controls to preclude contact with Site 5 groundwater would be employed. Groundwater would be sampled periodically to monitor quality Monitoring data would be evaluated to confirm the efficacy of the attenuation processes and to evaluate the need for additional response actions if deemed necessary. Because contaminants would remain on site, a review of site conditions and risks would be conducted every 5 years, as required by the NCP.

Alternative Evaluation:

For this alternative, the natural attenuation of contaminants would eventually reduce contaminant concentrations to PRGs for groundwater. Preliminary modeling indicates that the groundwater at the site may attain the PRG for TCE around the year 2030. In the long term, this alternative would comply with chemical-specific ARARs and TBCs. Although no remedial actions would occur under Alternative 2, reduction in contaminant concentrations would occur over time due to natural attenuation (NA) processes. The estimated rate of attenuation is slow. Until that time, risks associated with groundwater contamination would remain. This alternative would gradually reduce the toxicity, mobility, or volume of contamination through NA processes, but would not satisfy the statutory preference for remedies that employ treatment as a principal element. Effectiveness of this alternative would be realized over a long period of application. The net present-worth cost for this alternative is estimated to be $919,000, which includes capital costs, annual monitoring and O&M costs, and 5-year reviews over a projected 30-year period.

Alternative 3A: Groundwater Pump and Treatment of Entire Plume and Discharge to On-Site Sewer System

Alternative Description:

Alternative 3A employs groundwater pumping and treatment, long-term monitoring, institutional controls, and 5-year reviews to protect human health and the environment. After pre-design studies, a groundwater containment system consisting of groundwater extraction wells would be placed near the downgradient edge of the plume, and the groundwater would be extracted and treated above ground by air stripping. Additional groundwater extraction wells would be placed in the vicinity of the high-concentration plume center, also for groundwater pumping and above-ground treatment. Because of the relatively low concentration and diffuse nature of VOCs in groundwater, a portion of the groundwater contaminants would be difficult to capture using the groundwater extraction system. Institutional controls would be implemented to prevent exposure to contaminated groundwater for the duration of the groundwater treatment period, until the preliminary remediation goals PRGs are achieved. Long-term monitoring would be conducted for the duration of the remediation period to assess the effectiveness of the remedial action and to determine when the remediation is complete. Site conditions and risks would be reviewed every 5 years until the groundwater remediation is complete.

Alternative Evaluation:

Implementation of Alternative 3A would result in the overall protection of human health and the environment for site groundwater contaminated with VOCs. The use of pump and treat should be effective for the reduction of VOC concentrations in the fractures, but reduction of concentrations in the competent bedrock may be very slow using this technique. Alternative 3A would eventually comply with

chemical-specific ARARs, such as maximum contaminant levels (MCLs) throughout the plume, and location- and action-specific ARARs. Alternative 3A would be effective in minimizing the migration of VOCs from Site 5. The reliability of the pump-and-treat system is expected to be high. This alternative would reduce the toxicity, mobility, and volume of contamination through extraction and treatment of contaminated groundwater. The groundwater extraction and treatment system is readily implementable. The net present-worth costs, including capital costs, annual O&M costs, and five-year reviews, are estimated to be $4,756,000 for Alternative 3A over a projected 30-year remediation period.

Alternative 4: In-Situ Enhanced Biological Treatment of Groundwater by Anaerobic Reductive Dehalogenation, Groundwater Recirculating, and Monitored Natural Attenuation

Alternative Description:

Alternative 4 employs in-situ enhanced biological treatment by anaerobic reductive dehalogenation process with groundwater recirculation followed by MNA for remediation of the VOC-contaminated site groundwater. A laboratory treatability study and a pilot- or field-scale test are to be conducted to evaluate and verify the effectiveness of several different electron donors with the site aquifer materials, including soils and groundwater. When the majority of site VOCs have been biodegraded (i.e., biological treatment efficacy has been leveled off), treatment of Site 5 groundwater may be continued by NA processes to achieve groundwater PRGs. Similar to Alternative 2, the NA processes consist of a variety of physical, chemical, or biological processes that act to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. This alternative also utilizes institutional controls, long-term monitoring, and 5-year reviews until PRGs are achieved.

Alternative Evaluation:

The implementation of Alternative 4 would result in long-term overall protection of human health and the environment. The recirculating anaerobic biological treatment processes would facilitate continuing biodegradation of VOCs in the groundwater and flush residual constituents present in the subsurface by recirculating a portion or entire extracted volume of groundwater after biostimulation and/or bioaugmentation processes. Alternative 4 would eventually comply with chemical-specific ARARs, such as MCLs, and location- and action-specific ARARs. During remediation, protection of human health would depend on adequate enforcement of groundwater use restrictions. The groundwater underlying Site 5 is not currently used as a potable water supply and there are no existing plans for its use. In-situ bioremediation would reduce the toxicity, mobility and volume of the VOCs in the site groundwater. The implementation of Alternative 4 would have minimal concerns of short-term effectiveness by complying with site-specific health and safety procedures during construction, start-up, and operation of the on-site feed preparation and delivery systems. Alternative 4 utilizes proven technologies that are relatively easy to implement. The net present-worth costs,

including capital costs, annual O&M costs, and five-year reviews, are estimated to be $1,211,000 for Alternative 4 over a projected 15-year remediation period.

Alternative 5: In-Situ Treatment of Groundwater by Chemical Oxidation Process, Institutional Control, and Long-Term Monitoring

Alternative Description:

Alternative 5 employs in-situ treatment of VOC-contaminated site groundwater by chemical oxidation process. The effectiveness of this technology is highly dependent on the design and applications of oxidant injection, delivery, and distribution, the subsurface hydrogeology of the site, the nature and extent of contamination, and other site-specific conditions such as presence of total organic carbon (TOC), which can competitively interfere with target contaminants for available oxidants.

A bench-scale treatability study would be required to investigate the site-specific effectiveness of in-situ chemical oxidation (ISCO) for mitigating contaminant concentrations in both dissolved and sorbed-phase conditions. The ISCO bench-scale treatability study will provide design data for subsequent pilot- or field-scale ISCO injection programs. Following completion of the bench-scale ISCO study (i.e., with positive results indicating that ISCO would be effective for treatment of the chlorinated VOC at the site), a pilot test would be conducted to obtain additional site-specific design information, to confirm and evaluate the performance of the delivery system and vertical well injection techniques, to evaluate the in-situ effectiveness of the treatment, and to obtain additional site hydrogeologic and chemical characteristics. Data generated during the pilot test would also be used to refine the expected number and duration of injection events required to achieve target remedial goals. Following the successful completion of bench-scale and pilot studies, a full-scale ISCO treatment system would be implemented by injecting the oxidant blend through the vertical injection wells converted from the existing monitoring wells in the source areas (where the highest concentrations of contaminants were observed). Monitoring would be conducted during the treatment process to confirm the presence of chemical oxidation indicators throughout the remedial target areas, to maintain an effective remediation zone, and to monitor for treatment effectiveness with respect to the RAOs. Contaminant concentrations, as well as ISCO indicator parameters, pH, total dissolved solids, and temperature would be monitored on a regular basis. These parameters provide a direct indication of the presence of the ISCO solution at radial locations from the injection point. The pH and temperature would both be measured with water quality parameter instrumentation. Fluctuations in pH and/or increases in temperature due to exothermic reactions are both indications of ISCO activity. Similarly, the total dissolved solids concentration would be measured with water quality parameter instrumentation. An increase in total dissolved solids provides an indication of ISCO due to the presence of dissolved matter in the reagents. Existing monitoring wells in two tiers down-gradient from the injection wells would be used to collect aqueous ISCO monitoring samples. Number and

spacing of monitoring wells between the injection and compliance wells or receptors will be determined by the pre-design investigations and treatability and /or pilot studies. Some previous ISCO treatment sites indicated that the ISCO treatment would take approximately 1-2 years to achieve the RAOs. Continued monitoring for several additional years would be needed to monitor the water quality to assure no rebound or dissolution of site contaminants. This alternative also utilizes institutional controls to prevent exposure to contaminated groundwater for the duration of the groundwater remediation period, until PRGs are achieved. Site conditions and risks would be reviewed every 5 years until the groundwater remediation is complete.

Alternative Evaluation:

Alternative 5 may be low in overall protection of human health and the environment for site groundwater contaminated with VOCs, due to the inability of ISCO in removing or eliminating the sorbed-phase contaminant mass in a few applications as described by other similar projects. It is assumed that long-term, permanent protection would be achieved after 2 years of active ISCO treatment and 10 additional years of monitoring for the groundwater. In the interim period, until remediation goals for site groundwater have been achieved, human health would be protected through the use of institutional controls that would restrict use of untreated contaminated groundwater as drinking water. Alternative 5 would comply with chemical-specific ARARs, such as MCLs, although initially, groundwater contaminated with VOCs at levels above PRGs would continue to migrate through the downgradient plume edge. Alternative 5 would also comply with location- and action-specific ARARs. This alternative would be effective in long-term reduction of VOCs migration from Site 5. During the remediation period, however, protection of human health would depend on adequate enforcement of groundwater use restrictions. ISCO potentially will reduce the toxicity, mobility, and the volume of sorbed-phase, and ultimately dissolved-phases residual contamination in the Site 5 groundwater. Treatability study and pilot-/field-scale testing would be performed to confirm the effectiveness of ISCO process before the full-scale remediation is implemented. Alternative 5 may provide short-term effectiveness in reducing human health risks through the use of ISCO. However, possible short-term risks to operation and maintenance workers include the handling and injection of oxidizing/reducing agents during chemical injections. ISCO is a proven technology that can be constructed using standard wells, pipes, plumbing, pumps etc, and should not lead to schedule delays. Design of the treatment train may require specialized technical expertise. The application of ISCO also requires specialized personnel, but many are readily available. The net present-worth costs, including capital costs, annual O&M costs, and five-year reviews, are estimated to be $1,705,000 for Alternative 5 over a projected 12-year remediation period.

Table ES-1 presents summaries of the evaluation and comparative analysis for each alternative.

TABLE ES-1
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SITE 5 GROUNDWATER
NAS JRB WILLOW GROVE, PENNSYLVANIA

CRITERION:	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: MONITORED NATURAL ATTENUATION	ALTERNATIVE 3A: PUMP AND TREAT ENTIRE PLUME	ALTERNATIVE 4: IN-SITU BIOLOGICAL TREATMENT MONITORED NATURAL ATTENUATION	ALTERNATIVE 5: IN-SITU CHEMICAL OXIDATION
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT					
Prevent Human Exposure to Contaminated Groundwater	Would provide no additional protection against human exposure to contaminated groundwater. Carcinogenic and non-carcinogenic risks exceeding EPA's target risk range would remain. No institutional controls implemented to restrict use of untreated contaminated groundwater for drinking water.	Over a long period of time, contaminant concentrations would reach levels that would not pose excess risk. Institutional controls would minimize potential exposure to site groundwater by prohibiting its use as drinking water. Long-term periodic monitoring and review, combined with predictive modeling, would provide the Navy and regulatory agencies the opportunity to review site conditions and perform additional remedial actions if they become warranted. Time required for natural attenuation to reduce contaminants to levels that would not pose risk may be longer than for other alternatives, except Alternative 1.	Would provide collection and ex-situ treatment of the advancing contaminant plume. Upon completion of construction, the proposed remediation would prevent exposure to potential downgradient receptors by treating the advancing plume. Institutional controls would minimize potential exposure to site groundwater during the remediation period by prohibiting its use as drinking water. Long-term periodic monitoring and review would provide the Navy and regulatory agencies the opportunity to review site conditions and perform additional remedial actions if they become warranted. Time required to meet PRGs would be the longest of the 3 alternatives (3A, 4, and 5) that employ active treatment.	Would provide in-situ treatment of the contaminant plume. Upon completion of construction, the proposed remediation would begin to reduce exposure to potential downgradient receptors by treating the source of the contaminant plume. Enhanced natural attenuation ultimately would reduce groundwater contaminant concentrations to levels that would not pose excess risk. Institutional controls would minimize potential exposure to site groundwater during the remediation period by prohibiting its use as drinking water. Long-term periodic monitoring and review would provide the Navy and regulatory agencies the opportunity to review site conditions and perform additional remedial actions if they become warranted. Time required to meet PRGs would be the medium of the 3 alternatives (3A, 4, and 5) that employ active treatment.	Would provide in-situ treatment of the contaminant plume. Would provide active reduction of contaminant concentration and volume in the concentrated source. The plume may enlarge initially due to contaminants dissolution and partial degradation. Contaminant rebound may occur in the interim. Multiple applications of ISCO are usually needed. Institutional controls would minimize potential exposure to site groundwater during the remediation period by prohibiting its use as drinking water. Long-term periodic monitoring and review would provide the Navy and regulatory agencies the opportunity to review site conditions and perform additional remedial actions if they become warranted. Time required to meet PRGs would be the shortest of the 3 alternatives (3A, 4, and 5) that employ active treatment.
Mitigate Migration of VOC Contaminated Groundwater	No actions taken to reduce migration of contaminated groundwater. Relies on natural attenuation.	No actions taken to reduce migration of contaminated groundwater. Relies on natural attenuation.	The groundwater extraction and treatment system, installed immediately downgradient of the contaminant plume, would prevent further migration of contaminated groundwater.	The groundwater would be extracted from downgradient locations, mixed with electron donors and biomass, and recirculated to injection wells. This alternative would prevent some or all migration of contaminated groundwater.	The groundwater treatment system would enlarge the plume initially due to contaminants dissolution and partial degradation. Would eventually prevent migration of contaminated groundwater.
COMPLIANCE WITH ARARS					
Chemical-Specific ARARs	Would not comply with state or federal groundwater quality standards or statutory requirements. No institutional controls to protect potential (future) receptors would be implemented.	Groundwater contaminant concentrations would initially exceed PRGs. Over time, PRGs would be achieved by natural attenuation. Institutional controls to protect potential receptors would be implemented.	Groundwater contaminant concentrations would initially exceed PRGs. Over time, active treatment would reduce contaminant levels below PRGs. Institutional controls to protect potential receptors would be implemented.	Groundwater contaminant concentrations would initially exceed PRGs. Over time, active treatment and natural attenuation would reduce contaminant levels below PRGs. Institutional controls to protect potential receptors would be implemented.	Groundwater contaminant concentrations would initially exceed PRGs. Contaminant rebounding may occur. After multiple applications, contaminant levels would be reduced below PRGs. Institutional controls to protect potential receptors would be implemented.
Location-Specific ARARs	Not applicable.	Not applicable.	The on-site treatment facility would be constructed in accordance with applicable federal and state storm water regulations.	The on-site facility for in-situ treatment would be constructed in accordance with applicable federal and state storm water regulations.	The on-site facility for in-situ treatment would be constructed in accordance with applicable federal and state storm water regulations.

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COMPLIANCE WITH ARARS (Continued)					
Action-Specific ARARs	Not applicable.	Not applicable.	The on-site treatment facility would be constructed and operated in accordance with federal and state regulations. Treatment residues determined to be hazardous would be handled by approved RCRA facilities according to applicable transportation, storage, and disposal regulations. Materials disposed off site would comply with RCRA Land Disposal Restrictions.	The on-site facility for in-situ treatment would be constructed and operated in accordance with applicable federal and state hazardous TSD facility regulations. Federal and state regulatory requirements related to injection will be complied with.	The on-site facility for in-situ treatment would be constructed and operated in accordance with applicable federal and state hazardous TSD facility regulations. Federal and state regulatory requirements related to injection will be complied with.
LONG-TERM EFFECTIVENESS AND PERMANENCE					
Magnitude of Residual Risk	Existing risks would remain. Future residential receptor of site groundwater would remain exposed to potential 8 x 10^{-4} (RME) carcinogenic risk and potential non-carcinogenic risks greater than 1.	Implementation and enforcement of institutional controls would reduce risks from exposure to site groundwater to less than 1 x 10^{-6} and HI would remain greater than 1.0. Over time, natural attenuation would result in permanently reduced risks.	Groundwater treatment would result in a permanent reduction of potential risks from exposure to site groundwater to less than 1 x 10^{-6} and an HI less than 1.0. In the interim, until groundwater remediation goals are achieved, implementation and enforcement of institutional controls would reduce risks from exposure to site groundwater to less than 1 x 10^{-6} and an HI less than 1.0.	Groundwater treatment would result in a permanent reduction of potential risks from exposure to site groundwater to less than 1 x 10^{-6} and an HI less than 1.0. In the interim, until groundwater remediation goals are achieved, implementation and enforcement of institutional controls would reduce risks from exposure to site groundwater to less than 1 x 10^{-6} and an HI less than 1.0.	Groundwater treatment would result in permanent reduction of potential risks from exposure to site groundwater to less than 1 x 10^{-6} and an HI less than 1.0. In the interim, until groundwater remediation goals are achieved, implementation and enforcement of institutional controls would reduce risks from exposure to site groundwater to less than 1 x 10^{-6} and an HI less than 1.0.
Adequacy and Reliability of Controls	No new controls implemented.	Long-term enforcement of institutional controls would be required to ensure their effectiveness for preventing use of contaminated groundwater.	Groundwater extraction and air stripping are widely used, effective technologies for the remediation of VOC-contaminated groundwater. There are some uncertainties associated with long-term effectiveness and reliability of the system because the rate of contaminant capture may be very slow. The process would be easily monitored and maintained. Routine maintenance and replacement of system components could be accomplished with little interruption of system operation. Long-term enforcement of institutional controls would be required to ensure their effectiveness for preventing use of contaminated groundwater.	In-situ biological treatment is a proven technology and has been field demonstrated for the remediation of VOC-contaminated groundwater. There is little uncertainty associated with long-term effectiveness and reliability of the system. Treatability study and pilot-/field-scale testing are used before full-scale application. The process would be easily monitored and maintained. Routine maintenance and replacement of system components could be accomplished with little interruption of system operation. Long-term enforcement of institutional controls would be required to ensure their effectiveness for preventing use of contaminated groundwater.	In-situ chemical oxidation is a proven technology and has been field demonstrated for the remediation of VOC-contaminated groundwater. Rebound of contaminants is of concern. Otherwise, there is little uncertainty associated with long-term effectiveness and reliability of the system. Treatability study and pilot-/field-scale testing are used before full-scale application. The process would be easily monitored and maintained. Routine maintenance and replacement of system components could be accomplished with little interruption of system operation. Long-term enforcement of institutional controls would be required to ensure their effectiveness for preventing use of contaminated groundwater.

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LONG-TERM EFFECTIVENESS AND PERMANENCE (Continued)					
Need for 5-Year Review	None.	Review would be required since groundwater contaminants would be left in place and institutional controls would be implemented.	Review would be required for the duration of the groundwater remediation period since groundwater contaminants would remain above remediation goals and institutional controls would be implemented.	Review would be required for the duration of the groundwater remediation period since groundwater contaminants would remain above remediation goals and institutional controls would be implemented.	Review would be required for the duration of the groundwater remediation period since groundwater contaminants would remain above remediation goals and institutional controls would be implemented.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT					
Treatment Process Used	None.	None.	Air stripping with activated carbon polishing.	In-situ biological treatment by anaerobic reductive dehalogenation and monitored natural attenuation	In-situ chemical oxidation treatment.
Amount Treated or Destroyed	None.	None.	100 million gallons of contaminated groundwater, containing approximately 181 pounds of VOCs, remediated per year for up to 30 years.	Majority of sorbed- and dissolved-phase contaminants would be treated or destroyed in an estimated 15 years.	Majority of sorbed- and dissolved-phase contaminants would be treated or destroyed in an estimated 12 years.
Reduction of Toxicity, Mobility, or Volume Through Treatment	No reduction, since no treatment would be employed.	Slow reduction through passive treatment by natural attenuation.	The groundwater extraction and treatment system would contain the contaminant plume and remove the VOCs to reduce the toxicity, mobility, and volume of contaminated groundwater. Over a period of less than 30 years, the contaminants of concern in site groundwater would be reduced to PRG levels.	The in-situ groundwater treatment system would treat the contaminant plume, destroy the VOCs, and reduce the toxicity, mobility, and volume of contaminated groundwater. Over a period of 15 years, the contaminants of concern in site groundwater would be reduced to PRG levels.	The in-situ groundwater treatment system would treat the contaminant plume, destroy the VOCs, and reduce the toxicity, mobility, and volume of contaminated groundwater. Over a period of 12 years, the contaminants of concern in site groundwater would be reduced to PRG levels.
Irreversible Treatment	Not applicable.	Passive treatment.	Contaminants would be removed for off site treatment and disposal.	Irreversible treatment is applied, contaminants would be destroyed.	Irreversible treatment is applied, contaminants would be destroyed.
Statutory Preference for Treatment	No.	No.	Complies with statutory preference for treatment.	Complies with statutory preference for treatment.	Complies with statutory preference for treatment.
SHORT-TERM EFFECTIVENESS					
Community Protection	No additional risk to the community or the environment.	No significant risk to community anticipated. Engineering controls would be used during implementation to mitigate risks.	No significant risk to community anticipated. Engineering controls would be used during implementation to mitigate risks.	In-situ treatment poses no risk to community. Engineering controls would be used during implementation to mitigate risks.	In-situ treatment poses no risk to community. Engineering controls would be used during implementation to mitigate risks.
Worker Protection	No risk to workers anticipated.	No risk to workers anticipated if proper PPE is used during long-term monitoring.	No significant risk to workers anticipated if proper PPE and safe work practice are used during installation of the treatment facilities, operation and maintenance, and long-term monitoring.	No significant risk to workers anticipated if proper PPE and safe work practice are used during installation of the treatment facilities, operation and maintenance, and long-term monitoring.	Minimal risk to workers anticipated if proper PPE and safe work practice are used during operation and maintenance of the system. Installation and long-term monitoring carry no significant risks.

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SHORT-TERM EFFECTIVENESS (Continued)					
Environmental Impacts	No additional adverse impacts to the environment anticipated.	No adverse impacts to the environment anticipated.	No adverse impacts to the environment anticipated, if properly operated. Engineering controls would be used during construction and operations to mitigate risks.	No adverse impacts to the environment anticipated, if properly operated. Engineering controls would be used during construction and operations to mitigate risks.	No adverse impacts to the environment anticipated, if properly operated. Engineering controls would be used during construction and operations to mitigate risks.
Time Until Action is Complete	Not applicable.	More than 30 years are estimated until contaminants would be reduced to acceptable concentrations by natural attenuation.	Less than 30 years until RAO for mitigating migration of VOC contaminated groundwater would be achieved. Less than approximately 30 years until contaminants would be reduced to PRGs by groundwater treatment.	5 years until RAO for mitigating migration of VOC contaminated groundwater would be achieved. Approximately 15 years until contaminants would be reduced to PRGs by active treatment and monitored natural attenuation.	2 years until RAO for mitigating migration of VOC contaminated groundwater would be achieved. Approximately 12 years until contaminants would be reduced to PRGs by active treatment and verified by monitoring.
IMPLEMENTABILITY					
Ability to Construct and Operate	No construction or operation involved.	No construction or operational difficulties anticipated.	No significant construction or operational difficulties anticipated. Common construction equipment and construction techniques used for installation of groundwater extraction and treatment system.	No significant construction or operational difficulties anticipated. Common construction equipment and construction techniques used for installation of groundwater in-situ treatment system.	No significant construction or operational difficulties anticipated. Common construction equipment and construction techniques used for installation of groundwater in-situ treatment system.
Ease of Doing More Action if Needed	Additional actions would be easily implemented if required.	Additional actions would be easily implemented if required.	Additional actions would be easily implemented if required.	Additional actions would be easily implemented if required.	Additional actions would be easily implemented if required.
Ability to Monitor Effectiveness	Not applicable.	Groundwater monitoring would provide assessment of contaminant presence, migration, and changes in site conditions.	Groundwater monitoring would provide assessment of contaminant presence, migration, and changes in site conditions.	Groundwater monitoring would provide assessment of contaminant presence, migration, and changes in site conditions.	Groundwater monitoring would provide assessment of contaminant presence, migration, and changes in site conditions.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable..	Coordination for 5-year reviews may be required and would be obtainable.	Coordination with the state would be required for NPDES discharge permit revision.	Coordination with the state would be required for discharge limitations revision and underground injection control.	Coordination with the state would be required for discharge limitations revision and underground injection control.
Availability of Treatment, Storage Capacities, and Disposal Services	None required.	None required.	Sufficient commercial transportation, treatment and disposal capacity is available for materials requiring disposal.	Sufficient commercial transportation, treatment and disposal capacity is available for materials requiring disposal.	Sufficient commercial transportation, treatment and disposal capacity is available for materials requiring disposal.
Availability of Equipment, Specialists, and Materials	None required.	Ample availability of companies with trained personnel, equipment, and materials to perform natural attenuation modeling, long-term monitoring, and 5-year reviews.	Ample availability of companies with trained personnel, equipment, and materials to perform treatment system installation and operation, long-term monitoring, and 5-year reviews.	Ample availability of specialty companies with trained personnel, equipment, and materials to perform treatment system installation and operation, long-term monitoring, and 5-year reviews.	Ample availability of specialty companies with trained personnel, equipment, and materials to perform treatment system installation and operation, long-term monitoring, and 5-year reviews.

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IMPLEMENTABILITY (Continued)					
Availability of Technology	Not required.	Not required.	Groundwater extraction and air stripping are widely used, conventional technologies available from a variety of companies.	Treatment technology is proven and well-demonstrated, technologies available from a variety of companies.	Treatment technology is proven and well-demonstrated, technologies available from a variety of companies.
COST					
Capital Cost (including preliminary and final designs)	$0	$189,800	$1,423,800	$609,400	$757,800
Annual O&M and Monitoring Costs During Active Treatment	$0	$91,300 (Years 1 through 3)	$342,700 (Years 1 through 3)	$122,100 (Year 1) $85,300 (Years 2 through 5)	$206,600 (Years 1 through 2) $131,200 (Years 3 through 5)
Annual O&M and Monitoring Costs During Passive Treatment	$0	$45,600 (Yr 4 through 30)	$244,300 (Years 4 through 30)	$51,600 (Year 6) $35,000 (Years 7 through 15)	$62,000 (Years 6 through 12)
Five-Year Reviews (per event)	$0	$20,000	$20,000	$20,000	$15, 000 to $20,000
Present Worth Cost*	$0	$919,000	$4,756,000	$1,211,000	$1,705,000

*Present worth cost is based on discount rate of 7% per OSWER Directive No. 9355.3-20, June 1993.

1.0 INTRODUCTION AND BACKGROUND INFORMATION

Tetra Tech NUS (TtNUS) submits this Feasibility Study (FS) report for the Naval Air Station Joint Reserve Base (NAS JRB) Willow Grove in response to Contract Task Order No. 003 under Contract N62472-03-D-0057, Comprehensive Long-Term Environmental Action Navy (CLEAN). This work is part of the Navy's Installation Restoration Program (IRP), which is designed to identify and characterize contamination of Navy and Marine Corps facilities resulting from past operations and to institute corrective measures as appropriate.

This FS was prepared consistent with requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 and the National Oil and Hazardous Substance Contingency Plan (NCP). Preparation of this report followed the Interim Final Guidance for Conducting Feasibility Studies Under CERCLA (EPA. October 1988).

The remedial alternatives developed will be used by the Navy and the United States Environmental Protection Agency (EPA) to select a preferred remedy to deal with contaminated groundwater at NAS JRB Willow Grove Site 5. The preferred remedy will be presented in the Proposed Remedial Action Plan (PRAP) that will be presented to the local community during a public meeting and will be subject to a 30-day public comment period. After consideration of comments, the selected remedy will be documented in a Record of Decision (ROD) according to the prescribed process.

Section 1.0 presents an overview of NAS JRB Willow Grove military operations and the regional environmental setting. A summary of previous investigative activities and a discussion of human health and ecological risks for the site have also been presented. For a full understanding of site conditions, the Remedial Investigation (RI) Report for Site 5 - Fire Training Area, February 2002, must be reviewed. The RI report is the essential companion document to this FS; both were prepared as part of the prescribed RI/FS development procedure.

Section 2.0 provides a discussion of potential chemical-specific, location-specific, and action-specific Applicable or Relevant and Appropriate Requirements (ARARs) and criteria to be considered (TBCs). This section also addresses remedial action objectives (RAOs), preliminary remedial goals (PRGs), and general response actions. RAOs and PRGs are addressed on a site-specific basis for the identification, screening, and evaluation of remedial technologies and process options. Selected remedial options are also presented.

Remedial alternatives for Site 5 groundwater are developed in Section 3.0. The rationale for selection of the alternatives and a description of each alternative, including a no-action alternative, are presented.

Section 4.0 provides a detailed analysis and comparison of the alternatives developed in Section 3.0.

1.1 SITE DESCRIPTION AND SETTING

This FS report includes a discussion of remedial alternatives for Operable Unit 2 (OU 2), which comprises groundwater at Site 5 (the former Fire Training Area). Other Operable Units (portions of NAS JRB Willow Grove IR sites identified by the Navy and EPA for remedial action consideration) include OU 4, contaminated soil at Site 5. A full listing and description of Navy IR program operable units at NAS JRB Willow Grove can be found in the Federal Facilities Agreement (FFA) between the Navy and EPA.

NAS JRB Willow Grove, Pennsylvania (formerly Naval Air Station (NAS), Willow Grove) is located in Horsham Township, Montgomery County in southeastern Pennsylvania, approximately 20 miles north of the city of Philadelphia (Figure 1-1). The Navy Base occupies approximately 1,000 acres of approximately 1,200 acres the Department of Defense maintains at the Air Station. The Willow Grove Air Reserve Station (ARS) of the Air Force occupies approximately 200 acres of land in the northeastern section of the Air Station and shares common facilities with the NAS JRB. The Air Station is comprised of flat to slightly rolling terrain and is generally bounded by State Route 611 to the east, State Route 463 to the southwest, and Keith Valley Road to the north.

The primary mission of NAS JRB Willow Grove is to provide support for operations involving aviation activities and to train Navy reservists. NAS JRB Willow Grove supports DoD tenants such as the Marine Reserves, Pennsylvania Air National Guard, the Air Force Reserve, and the Army Reserve. The base provides facilities, services, materials, and training in direct support of all assigned units. These units include anti-submarine warfare squadrons, a helicopter squadron, a fleet logistic support squadron, and other Navy and Marine units.

The former fire training area is located in the south central portion of NAS JRB, approximately mid way between runway 10/28 and State Route 463 (Figure 1-2), and covers an irregularly shaped area of approximately 1.25 acres. Fire training operations included storage and burning of flammable liquid wastes generated by the air station in the period from 1942 through 1975, when burning exercises ceased. As a result of the historical storage and burning operations, groundwater has been impacted.

The Fire Training Area is primarily covered by grasses, with some woody and brushy vegetation present within the southern portion of the area. The actual burn area was located in the south-central portion of the site. The ground surface in the vicinity of the Fire Training Area slopes toward the south at a grade of approximately two percent. Runoff during normal precipitation events should be minimized by the relatively gentle slope and the abundant vegetation, which serves to decrease runoff velocity and increase infiltration.

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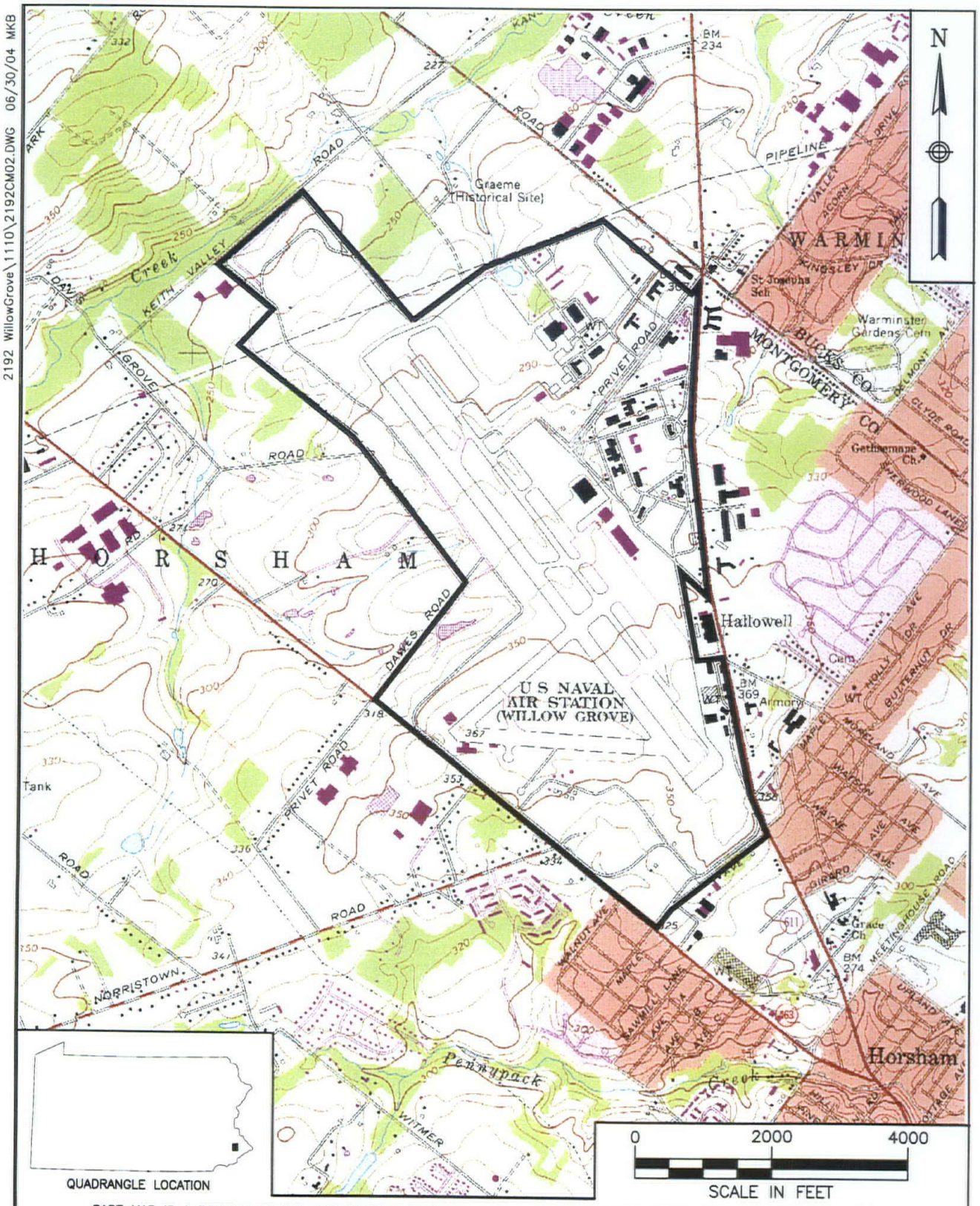
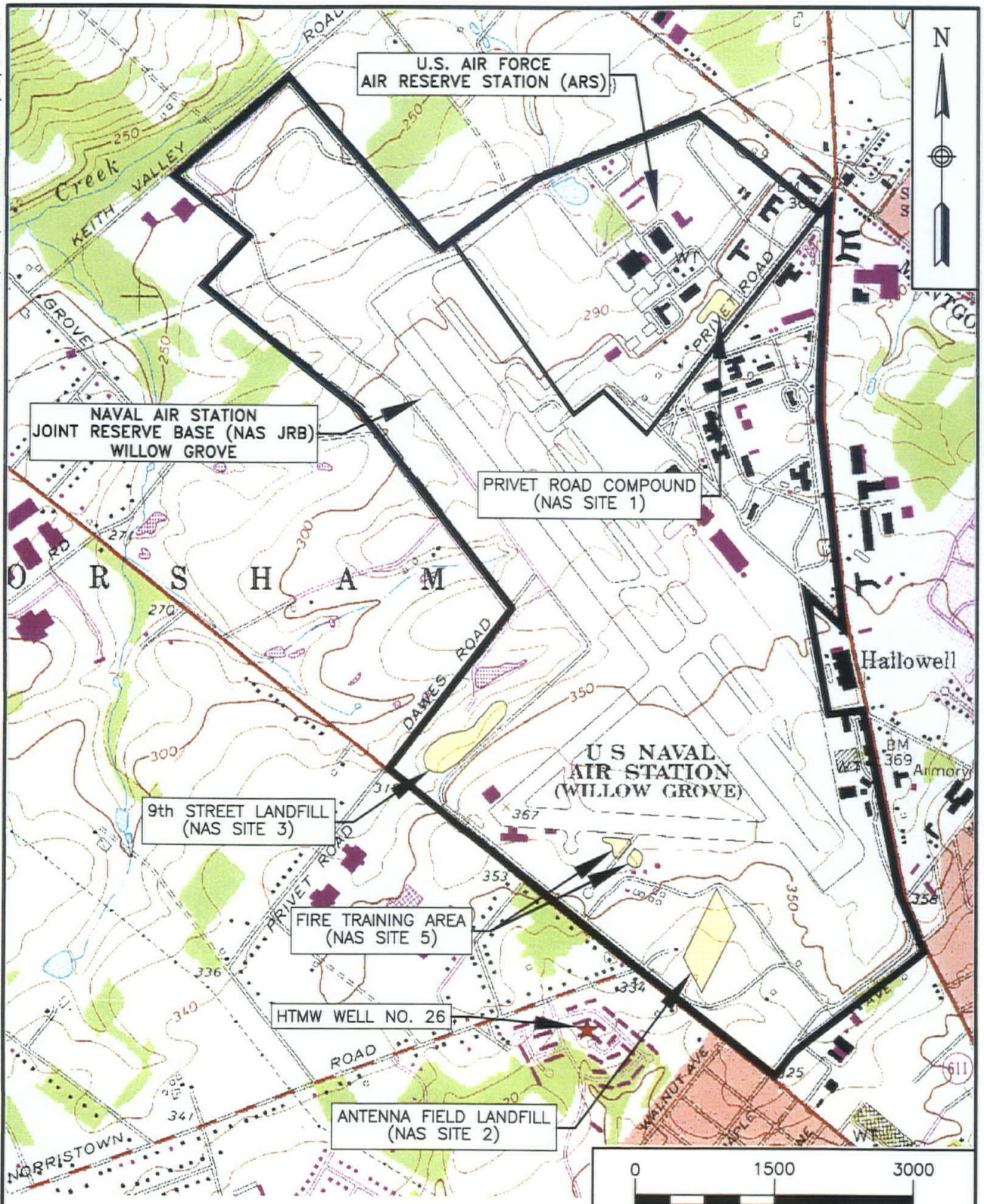


QUADRANGLE LOCATION

BASE MAP IS A PORTION OF THE AMBLER, PA U.S.G.S. 7.5 MINUTE QUADRANGLE MAP, DATED 1963, PHOTOREVISED IN 1983.

DRAWN BY MKB DATE 06/30/04	Tetra Tech NUS, Inc.	CONTRACT NO.: 2192	OWNER NO.: 0401
CHECKED BY DATE	LOCATION MAP NAS JRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	DRAWING INFORMATION:	
REVISED BY DATE		APPROVED BY: DATE	
SCALE AS NOTED		DRAWING NO.: FIGURE 1-1	REV.

2192 WillowGrove\1110\2192CM01.DWG 07/19/04 MKB



BASE MAP IS A PORTION OF THE AMBLER, PA U.S.G.S. 7.5 MINUTE QUADRANGLE MAP, DATED 1963, PHOTOREVISED IN 1983.

DRAWN BY MKB DATE 06/30/04	Tetra Tech NUS, Inc.	CONTRACT NO.: 2192	OWNER NO.: 0401
CHECKED BY DATE	LOCATION OF RI SITES SITE 5 – FIRE TRAINING AREA NAS JRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	DRAWING INFORMATION:	
REVISED BY DATE		APPROVED BY: DATE	
SCALE AS NOTED		DRAWING NO.: FIGURE 1–2	REV.

Two small ponds are located within 100 feet south of the site in the downslope direction. The two small ponds do not always contain water and tend to dry out.

1.1.1 Geology

NAS JRB Willow Grove is located within the Triassic Basin of southeastern Pennsylvania. The geologic interpretation of the former Fire Training Area is based on the subsurface data (boring logs and geophysical logs) obtained during previous site investigations. These data indicate that the geology beneath this site is generally consistent with the regional geology. Current and previous environmental investigations indicate that the top of bedrock at the Air Station is generally found in the range of 5 feet to 25 feet below ground surface (bgs).

Soil borings performed at the site encountered a variably thick overburden layer underlain by weathered siltstone and sandstone. The overburden generally consisted of silty clay and clay, with minor amounts of silty sand. The thickness of the overburden (or the depth to the top of the weathered bedrock) ranged from 9 to 18 feet.

In general, the bedrock beneath this site was characterized by its predominantly coarser-grained lithology. The maximum depth of the monitoring well boreholes at Site 5 is 261 feet. Because the boreholes typically were backfilled in order to screen the most significant water-bearing zone, the corresponding monitoring well installed was generally shallower than the total depth of the borehole at that location. The bedrock to this depth typically consisted of alternating sequences of siltstone and sandstone. Thin but laterally consistent beds of mudstone and claystone were encountered within the lower portions of the penetrated section.

The structural geology beneath the site is illustrated by a series of cross-sections in the RI Report for Site 5 (TtNUS, 2002). These cross-sections indicate that the structure (dip) of the bedrock is similar to that predicted by the regional geology. A three-point correlation of geophysical logs from the intermediate boreholes at Site 5 produced a bedrock strike of North 76 degrees East and a bedrock dip of 7 degrees Northwest.

1.1.2 Hydrogeology

The sandstones, shales, and conglomerates of the Triassic Basin are relatively good water-bearing formations. They generally yield abundant supplies to wells (Hall, 1934). The groundwater ranges from soft to hard; the average hardness is greater than that of most other formations in southeastern Pennsylvania.

The major source of groundwater in the vicinity of NAS JRB Willow Grove is the fractured bedrock of the Stockton Formation (Earth Data, Inc., 1985). These rocks form a multi-aquifer system of relatively discrete water-bearing zones separated by less permeable zones. Transmissivity and groundwater movement within water-bearing zones are greater parallel to bedding than across bedding. Groundwater can generally be found between 5 and 25 feet bgs.

Groundwater within the Stockton Formation occurs locally under both unconfined and confined conditions. The unconfined conditions generally extend to a subsurface depth of about 75 to 100 feet, depending on the local lithologies. Confined conditions are generally encountered below a depth of about 150 feet. A semi-confined or transitional aquifer lies between the unconfined and confined aquifers. Vertical or nearly vertical fractures that cut across bedding and the weathering of various beds are expected to permit varying degrees of seepage between individual water-bearing zones, particularly at shallower depths.

Although significant amounts of groundwater may be held in storage within the primary porosity of the fine- to medium-grained sandstones, groundwater migration is chiefly through the secondary porosity created by fractures and joints and along bedding-plane partings. The finer grained shale and siltstone beds typically have very low permeabilities. In addition, fractures and joints are typically not as well developed in these finer grained beds. Consequently, the shale and siltstone units often act as confining layers to groundwater flow. The occurrence and distribution of groundwater within the bedrock were similar to those typically reported for aquifers within the Triassic Basin. During drilling, the bulk of the groundwater entered the boreholes through discrete water-entry zones. Subsequent analyses of the drilling logs, borehole videotape (when present), and borehole geophysical logs revealed that the discrete water-entry zones were either bedding-plane partings at lithologic contacts or fractures within a relatively homogeneous lithologic unit. Typically, both types of water-entry zones were present within any particular borehole. The primary porosity of the various lithologic units (particularly the sandstones) most likely contributed groundwater to each borehole, but the volume or yield could not be quantified due to the low volume of groundwater entering the borehole through the primary pore spaces relative to the volume of groundwater entering through the secondary openings.

Numerous private (residential) and municipal production wells supply water for domestic and commercial uses in the NAS JRB Willow Grove vicinity. Figure 1-3 shows the approximate locations of public and private wells near the southern end of the Navy's property.

Seventeen monitoring wells were installed during the RI investigation to delineate the nature and horizontal and vertical extent of groundwater contamination and to provide the hydraulic head data needed to refine the hydrogeologic interpretation of the site. Site 5 monitoring well locations are illustrated in Figure 1-4. Construction details for all existing monitoring wells are listed in Table 1-1.

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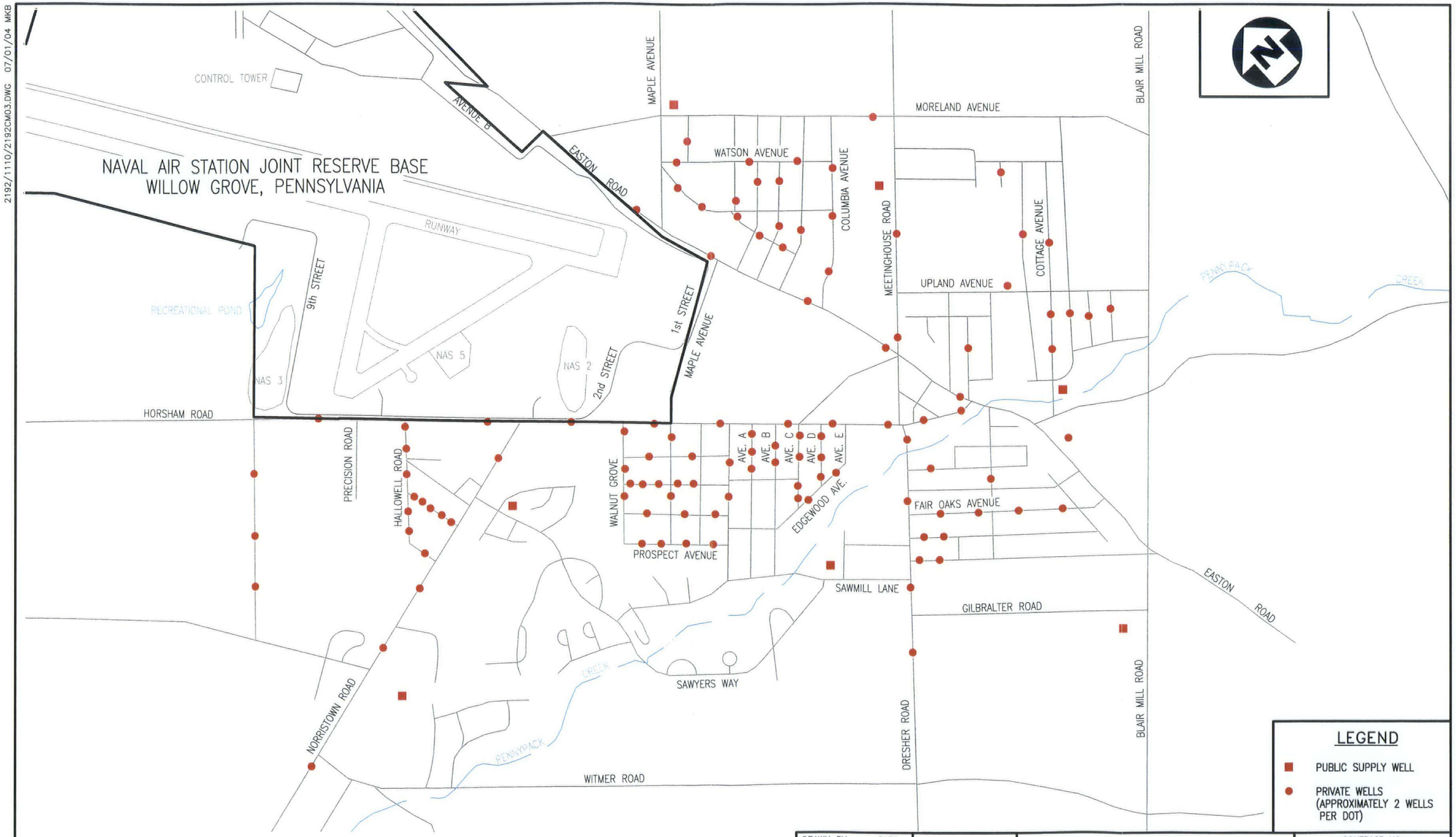

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SCALE AS NOTED			

CONTRACT NO. 2192	
OWNER NO. 0401 (FS SITE 5)	
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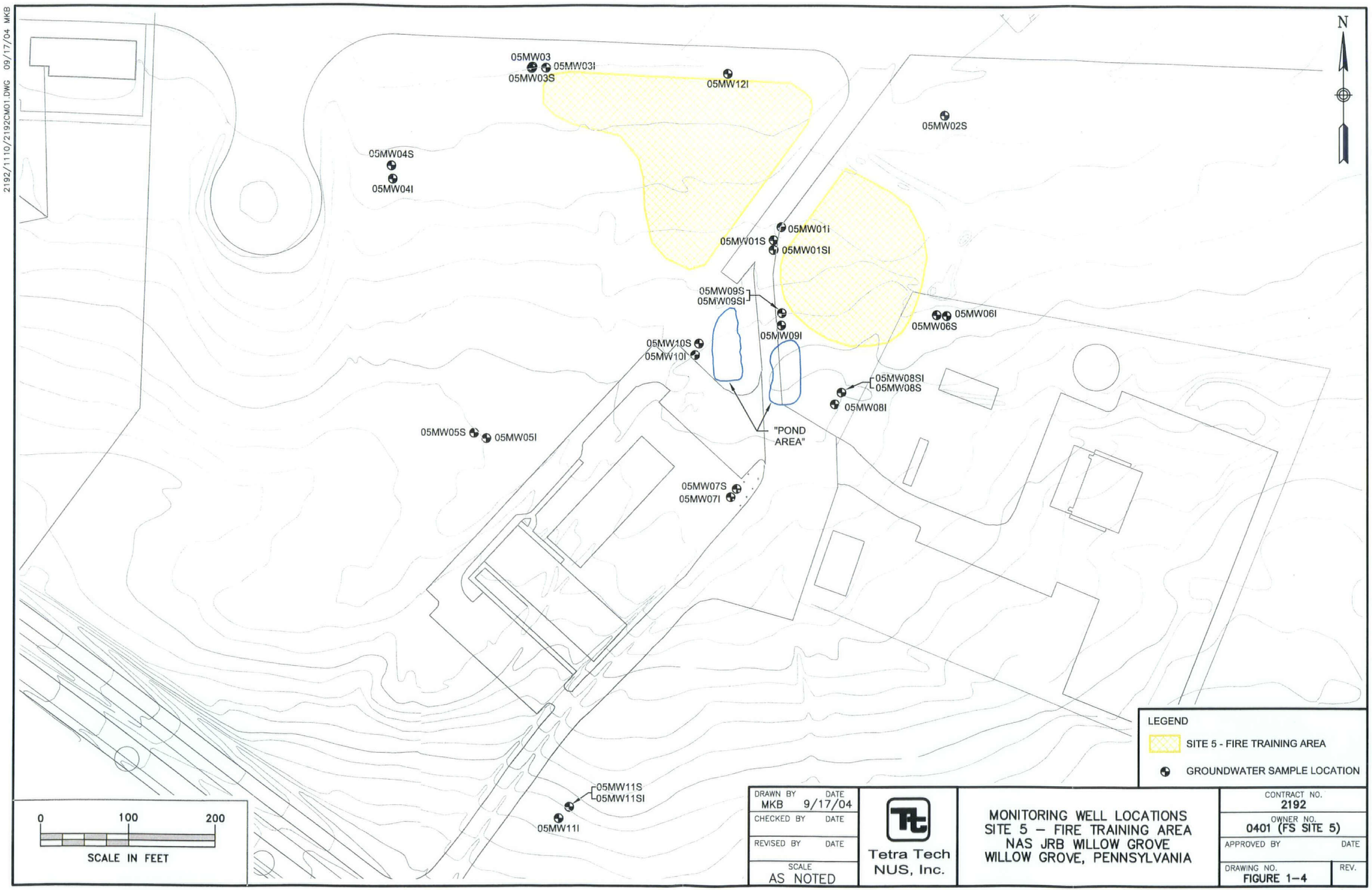

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Tetra Tech NUS, Inc.

MONITORING WELL LOCATIONS
SITE 5 – FIRE TRAINING AREA
NAS JRB WILLOW GROVE
WILLOW GROVE, PENNSYLVANIA

CONTRACT NO. 2192
OWNER NO. 0401 (FS SITE 5)
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TABLE 1-1
WELL CONSTRUCTION DETAILS
SITE 5 - FIRE TRAINING AREA
NAS JRB WILLOW GROVE, PENNSYLVANIA

Previous Designation	New Designation	Well Depth (feet bgs)	Screen Interval (feet bgs)	Elevation (TOC)	Monitored Zone
PREVIOUSLY EXISTING WELLS (ALL 4-INCH DIAMETER					
FTAW-1	05MW01S	32	12 - 32	364.11	Shallow
FTAW-1B	05MW01SI	84.5	74.5 - 84.5	363.64	Intermediate
FTAW-2	05MW02S	30	10 - 30	365.48	Shallow
FTAW-3	05MW03S	31	11 - 31	367.18	Shallow
FTAW-4	05MW04S	30	10 - 30	365.62	Shallow
FTAW-5	05MW05S	40	20 - 40	359.92	Shallow
FTAW-6	05MW06S	37.5	17.5 - 37.5	362.38	Shallow
FTAW-6B	05MW06I	84	74 - 84	361.08	Intermediate
FTAW-7	05MW07S	26	6 - 26	360.73	Shallow
FTAW-7B	05MW07I	84	74 - 84	360.20	Intermediate
NEW MONITORING WELLS (ALL 2-INCH DIAMETER)					
- -	05MW01I	135	125 - 135	363.99	Deep
- -	05MW03I	128	118 - 128	367.35	Intermediate
- -	05MW04I	84.5	74.5 - 84.5	364.75	Intermediate
- -	05MW05I	209.5	189.5 - 209.5	358.89	Deep
- -	05MW08S	36	26 - 36	360.88	Shallow
- -	05MW08SI	65	55 - 65	360.92	Shallow
- -	05MW08I	99	89 - 99	361.02	Intermediate
- -	05MW09S	32	27 - 32	361.91	Shallow
- -	05MW09SI	74	59 - 74	361.74	Intermediate
- -	05MW09I	106	96 - 106	362.11	Deep
- -	05MW10S	32	22 - 32	362.54	Shallow
- -	05MW10SI	94	79 - 94	362.44	Intermediate
- -	05MW10I	126	116 - 126	362.48	Deep
- -	05MW11S	25	20 - 25	349.50	Shallow
- -	05MW11I	50	40 - 50	349.51	Intermediate
- -	05MW11D	149	139 - 149	348.96	Deep
- -	05MW12I	113.5	103.5 - 113.5	365.98	Intermediate

TOC = Top of casing
bgs = Below ground surface

1.1.3 Hydrology

The former fire training area is situated atop a southwest-northeast-trending ridge that is the highest topographic feature within the region. This ridge serves as a divide for the regional surface water bodies (watershed divide); surface water to the north of the divide flows toward the Little Neshaminy Creek, and surface water to the south of the divide flows toward the Pennypack Creek. A United States Geological Survey (USGS) interpretation of a regional groundwater study indicates that the regional groundwater divide trends southwest-to-northeast in the vicinity of Site 5 and passes directly beneath the Fire Training Area.

The ground surface in the vicinity of the former Fire Training Area slopes toward the south at a grade of approximately two percent. Runoff during normal precipitation events is minimized by the relatively gentle slope and the abundant vegetation, which serves to decrease runoff velocity and increase infiltration.

Based on the local topography, any runoff from the site area may be expected to flow off base through a small intermittent drainage ditch that crosses the base boundary approximately 2,000 feet south of the Fire Training Area. This drainageway, which also carries runoff from the Antenna Field Landfill, flows into Pennypack Creek approximately 3,000 feet from the base property line.

1.1.4 Groundwater Occurrence and Flow Characteristics

The hydraulic head data collected indicate that two hydrogeologic units (an upper, unconfined zone and the deeper confined zone) exist beneath the former Fire Training Area. The vertical hydraulic gradient among wells completed in the shallow-intermediate and intermediate depths at all locations is very low, which suggests that these wells are monitoring different vertical zones within a common aquifer or hydrogeologic unit. Flow meter logs run in the open boreholes revealed that both upward and downward vertical gradients exist at Site 5. Typically, the vertical gradients were oriented downward in the shallower portions of the borehole and oriented upward in the deeper portions of the borehole, although not all boreholes exhibited an upward vertical gradient. The transition from downward to upward flow did not appear to be strictly controlled by lithology or stratigraphy.

The magnitude of the vertical hydraulic gradient within the unconfined zone is quite variable and complex at Site 5. The hydraulic head measurements at the monitoring well cluster locations (where wells monitor several subsurface depth zones at a single surface location) indicate that the vertical gradients between most wells (wells with screen elevations shallower than a subsurface depth of about 140 feet, or above a topographic elevation of approximately 230 feet above mean sea level (amsl) are fairly low, which suggests that these wells are monitoring different vertical zones within a common aquifer or hydrogeologic unit. The vertical gradient between the water table (an elevation of approximately 340 feet amsl) and an elevation of

230 feet amsl is typically in the range of hundredths of a foot of head difference per foot of vertical elevation. South of monitoring well cluster 05MW10, the vertical gradient increases considerably below an elevation of 230 feet amsl. Based on the hydraulic head measured in wells 05MW05I and 05MW11I, the vertical gradient between the water table and the deeper zones within the aquifer is one tenth of a foot of head difference per foot of vertical elevation, or an order of magnitude higher than the vertical gradient at the shallower depths (or higher elevations).

The horizontal hydraulic gradient across the site is very low, with the exception of the gradient at the water table in the vicinity of the runway. The horizontal gradient at the water table ranges from about 0.01 foot of head difference per foot of horizontal distance near the runway to about 0.002 foot of head difference per foot of horizontal distance near the source area at well cluster 05MW01. The horizontal gradients decrease markedly with increasing subsurface depth to a subsurface depth of about 140 feet (or an elevation of approximately 230 feet amsl), where the horizontal gradients range from about 0.002 foot of head difference per foot of horizontal distance near the source area at well cluster 05MW01 to about 0.0006 foot of head difference per foot of horizontal distance in the vicinity of well cluster 05MW04.

1.1.5 Groundwater Flow Directions

Groundwater flow directions beneath the Fire Training Area were determined from the contouring of the static water level elevations measured in the site's monitoring wells. Several complete rounds of static water level measurements were conducted for the RI. These data are included in the Site 5 RI Report. Contour maps in this FS report were plotted from the groundwater elevations collected in September 2000, since this represents the most inclusive data set and is consistent with previous measurements.

Groundwater flow directions were calculated for the shallow (water table) groundwater zone (Figure 1-5) and for an intermediate-depth groundwater zone (Figure 1-6). For the intermediate zone, the water level data were selected from wells screened from approximately the same elevations, to remove as much influence from the vertical hydraulic gradient as possible.

The groundwater flow directions calculated during the Phase I RI indicated that the direction of groundwater flow appeared to vary with depth. That is, groundwater appeared to flow to the south-southeast in the shallow (water table) zone, and to the southwest in the intermediate zone (to depths of about 80 feet). During the planning of the Phase II RI investigation, it was hypothesized that the difference in flow directions could be an artifact of data availability (there were less hydraulic head data available for the intermediate zone).

The groundwater flow directions calculated for the Phase II RI investigation indicate that the groundwater flow direction beneath the Fire Training Area does indeed vary with depth. Groundwater at the water table and within the shallow groundwater zone (which is most directly influenced by the surface topography) flows

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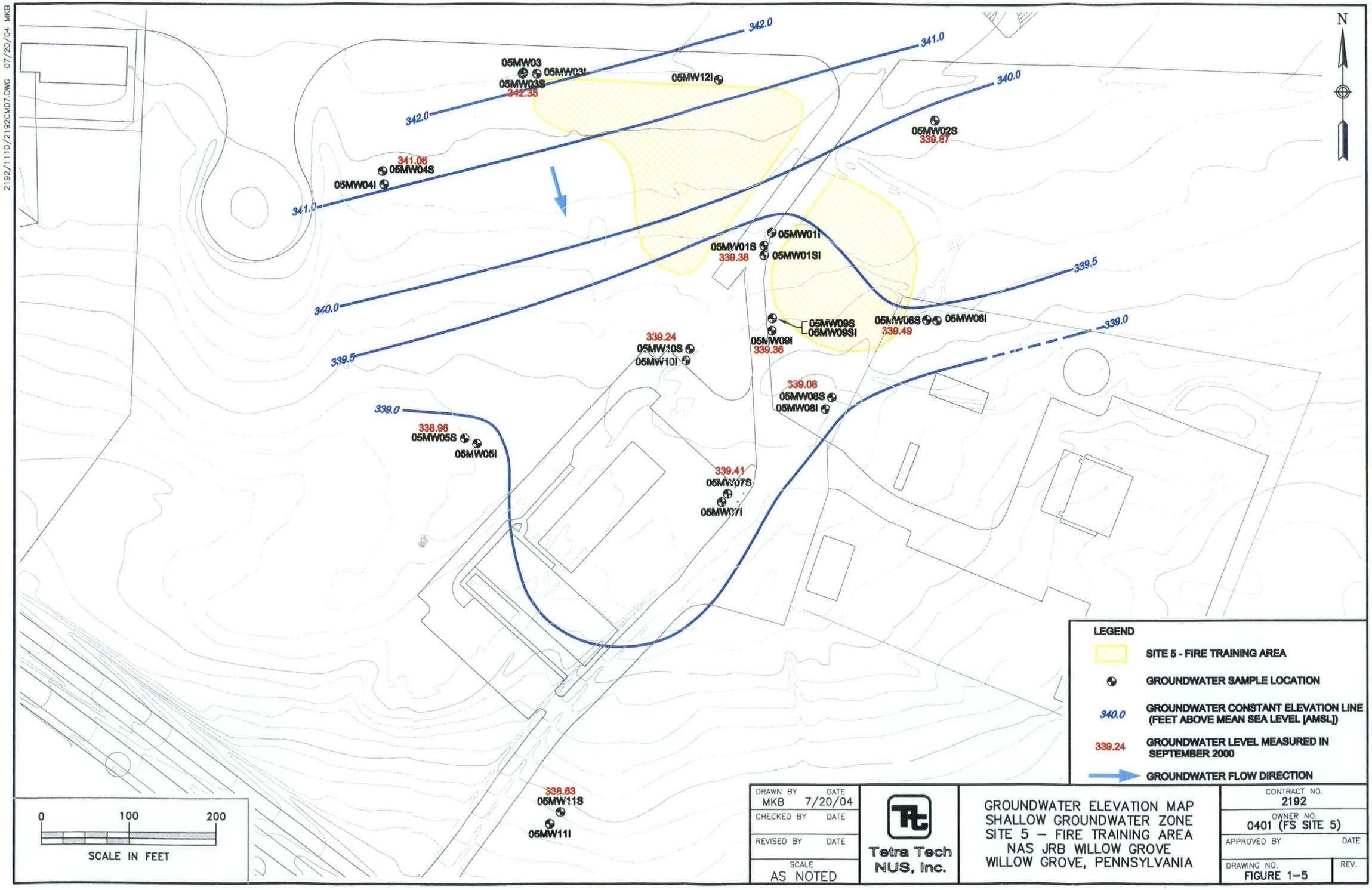

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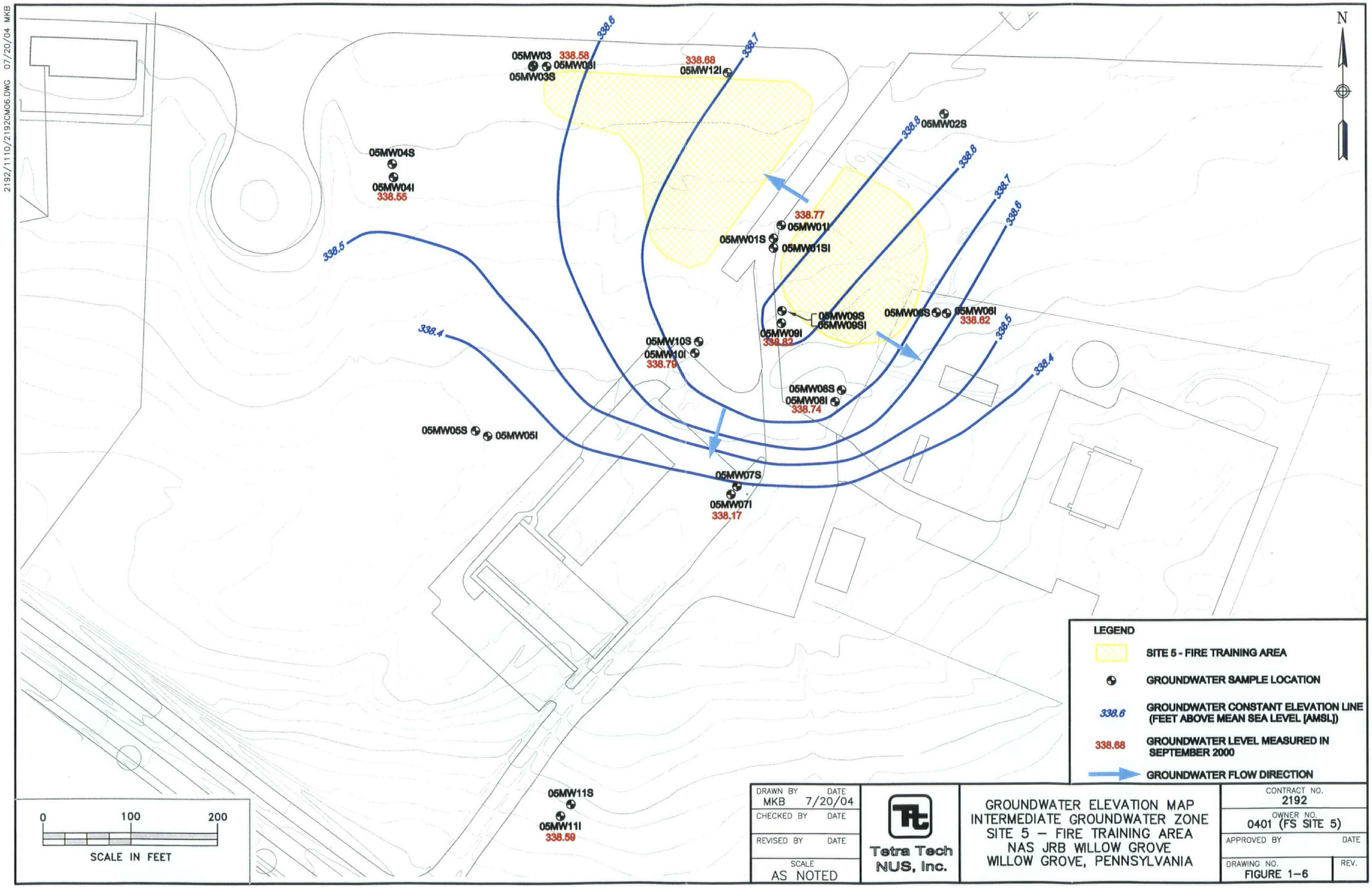

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REVISED BY DATE			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1–6 REV.

in an overall southeastward to southwestward direction, depending on surface location. The hydraulic gradient near the runway is relatively steep, but the gradient flattens considerably in the vicinity of the source area near monitoring well cluster 05MW01.

Groundwater within the intermediate groundwater zone is influenced by the regional groundwater divide that underlies the site (Figure 1-6). Based on the most recent round (September 2000) of comprehensive water level measurements, the groundwater divide is interpreted to trend southwest-northeast through the site and occur approximately 100 feet east of the source area near monitoring well cluster 05MW01. As discussed, the horizontal hydraulic gradient is very low in this area (which is not unusual in the area of a divide), and the divide has been defined on hydraulic head differences of 0.1 foot or less. However, the position and orientation of the divide agree well with the regional groundwater divide that coincides with a topographic ridge as interpreted by USGS (See Open File Report 01-149 "Altitude and Configuration of the Regional Potentiometric Surface, Willow Grove Naval Air Station/Joint Reserve Base and Vicinity, Horsham Township, Montgomery County, October 7-9, 1999).

Groundwater within the intermediate zone flows in variable directions ranging from southeast to northwest. The groundwater flow direction at any particular location is dependent on the position of that location relative to the groundwater divide. As mapped with the September 2000 hydraulic head data, the divide occurs just to the east of the depleted source area, creating a northwestward direction of groundwater flow in the vicinity of the source area. Because the divide is created and defined by differences in groundwater elevation of 0.1 foot or less, however, it is possible that the position of the divide may migrate laterally throughout the year as the hydraulic gradients vary.

The hydrogeologic cross-sections (in Figures 4-4 and 4-5 of the Phase II RI Report) illustrate the horizontal and vertical distribution of hydraulic head. These sections reflect the recharge and the dominantly downward flow of groundwater at the site, and the fact that although relatively low, the vertical gradient is still steeper than the horizontal gradient throughout most of the site. The vertical gradient increases considerably south of monitoring well cluster 05MW10. This same increasing vertical gradient is also reflected at well cluster 05MW05, which is not included on the cross-section, but is located at approximately the same southerly coordinates as 05MW07.

1.2 PREVIOUS SITE INVESTIGATION SUMMARY

A complete discussion of the activities performed, results obtained, and analysis of results for Site 5 groundwater can be found in the RI Report for Site 5 - Fire Training Area (TtNUS, 2002). The following subsections present a summary of the discussion in that report.

1.2.1 Preliminary Assessment (PA) and Site Inspection (SI)

During the SI, four monitoring wells were installed and sampled. Soil samples were also collected from four soil borings. These samples were analyzed for volatile organics and petroleum hydrocarbons. All the analytical results were presented in the Site Inspection Report (EA, May 1990).

1.2.2 Phase I Remedial Investigation

Phase I RI activities at Site 5 were conducted by Halliburton NUS in 1993 at NAS JRB Willow Grove. The OU 2 groundwater was included in the investigation. The RI field investigation included drilling 12 soil borings, installing of six monitoring wells, and sampling surface water and sediments. Ten groundwater samples were analyzed for volatile organics.

1.2.3 Phase II Remedial Investigation

Phase II RI activities at Site 5 were conducted by Brown & Root Environmental in 1997. The OU 2 groundwater was included in the investigation. The RI field investigation included drilling and installing 11 monitoring wells and sampling surface soil, subsurface soil, surface water, groundwater, and sediments. Geophysical logging of all newly drilled boreholes and one existing borehole was also performed. Twenty-one Groundwater samples were analyzed for Target Compound List (TCL) volatile organic compounds (VOCs), TCL semivolatile organic compounds (SVOCs), TCL PCB/pesticides, Target Analyte List (TAL) inorganics, and cyanide. Surface and subsurface soil samples were analyzed for various TCL and TAL analyses depending on site data requirements and specific locations. Surface water and sediment samples were analyzed for TCL VOCs, TCL SVOCs, TCL PCB/pesticides, TAL inorganics, and cyanide. Sediment samples were also tested for total organic carbon (TOC) and grain size. Background samples were also collected and analyzed.

All RI results are presented and discussed in the Site 5 RI report (TtNUS, February 2002).

1.2.4 Phase II Follow-On Remedial Investigation

Phase II follow-on RI investigations were performed in September 2000 by the Navy to respond to specific questions from EPA regarding the site to further delineate extent of contamination and to ensure that reliable downgradient sentinel wells were in place to monitor potential advance of the groundwater plume at the NAS JRB Willow Grove property boundary. Twenty-six groundwater samples were analyzed for TCL VOC and "monitored natural attenuation" MNA parameters. The follow-on Phase II RI investigations generally confirmed the Phase II RI investigation results, provided the natural attenuation evidence needed for the FS, and clarified that the downgradient edge of the Site 5 VOC plume was not migrating off

Base. The Site 5 risk assessment was not revised based on the follow-on Phase II RI findings. Follow-on Phase II RI results are discussed in the Site 5 RI report (TtNUS, February 2002).

Additional groundwater monitoring for contaminant movement was conducted in June 2004. Results will be evaluated when available.

1.3 NATURE AND EXTENT OF CONTAMINATION

Section 4.5 of the February 2002 RI Report provides a detailed discussion of the nature and extent of contamination at Site 5. Sampling data from the 1991 Phase I RI, the Phase II RI (including 1997/98 initial field activities), and the 2000 follow-on field activities was evaluated. As part of the evaluation, the data were compared to various criteria, including ARARs and background concentrations.

The principal contaminants associated with Site 5 are VOCs in groundwater, polycyclic aromatic hydrocarbons (PAHs) in soils and sediments, and PCBs in soils. Pesticides were detected in sediment samples but do not appear to be site related.

PAHs identified in soils (mostly in the area of the former burning ring, but also at other discrete areas) were deemed by earlier investigations to present potential exposure risk to ecological receptors such as small mammals or birds.

Potential ecological risk to aquatic or semi-aquatic receptors in or near the two (sometimes dry) ponds appears to be low. It does not appear that contaminants from the burn area have migrated to the ponds. Regrading the site area and covering the potential hot spot areas with soil has addressed the marginal risk to sediments and surface water by dealing with the source of PAHs, ensuring no future migration to surface water or sediment. No further action is recommended for site sediments and surface water.

PCB immunoassay results exceeded reference criteria at seven surface soil and one subsurface soil locations. However, immunoassay is a field screening technique that provides only an approximation of detected concentrations. No PCBs were detected in Phase II surface water or sediment samples. Therefore, PCB contamination does not appear to have migrated from the site.

VOCs historically disposed at the site appear to have impacted the groundwater. However, low levels of residual VOC contamination in soil are not considered to be a continuing source of VOCs to groundwater. The following discussions are focused on the contamination in site groundwater.

Ten monitoring wells (shallow zone wells 05MW01S through 05MW07S, shallow intermediate zone wells 05MW01SI and 05MW06SI, and intermediate zone well 05MW07I) were sampled for TCL VOCs during

the Phase I RI. During Phase II, 21 monitoring wells (shallow zone wells 05MW01S through 05MW10S, shallow intermediate zone wells 05MW06SI, and 05MW08 through 05MW10SI, intermediate zone wells 05MW01I, 05MW03I, 05MW06I, and 05MW08 through 05MW10I, and deep well 05MW01D) were sampled.

Figure 1-7 presents sampling locations. Table 1-2 presents the occurrence and distribution of inorganic and organic chemicals detected in groundwater samples and compares them to background. Table 1-3 presents results from the background comparison tests. Table 1-4 presents a comparison of detected compounds to ARARS and TBCs. Table 1-5 shows the results of analysis performed in September 2000 to gauge the potential for natural attenuation of VOCs in place. Figures 1-8 and 1-9 show sample locations and concentrations of compounds that exceed ARARS and TBCs.

1.3.1 Inorganics

Lead (05MW07I), arsenic (05MW10S), and beryllium (05MW10S) were the only inorganics detected in Site 5 groundwater at levels above reference criteria. Statistical tests conducted during the RI data analysis indicate these inorganics are not site related.

1.3.2 Organics

No SVOCs were detected in Site 5 groundwater samples. The pesticide dieldrin exceeded reference criteria in 05MW07S (0.3 ug/l) and 05MW10S (0.09J ug/l). VOCs were detected in groundwater samples from well clusters 05MW01, 05MW02, 05MW03, 05MW07, 05MW09, and 05MW10. TCE and its degradation products and benzene were detected above reference criteria and background in the shallow, shallow-intermediate, and intermediate zones at 05MW01; only PCE was detected in the deep zone at this cluster. The highest concentrations of VOCs in this cluster are in the shallow zone and decrease with depth. VOCs exceeding reference criteria in this cluster include 1,1,1-TCA (up to 960 ug/l), 1,1-DCE (up to 300J ug/l), 1,2-DCE (total) (up to 99 ug/l), benzene (up to 28 ug/l), and TCE (up to 300 ug/l). Only 1,1-DCE was detected above regulatory criteria in the other well clusters, at levels ranging from 4J ug/l to 120 ug/l at 05MW10SI.

1.3.3 Potential Effect of Geological Structure on Plume Migration

During the RI, EPA questioned if the dip of the bedrock to the northwest could cause a solvent DNAPL to migrate from the former Fire Training Area to the northwest. Monitoring wells 05MW03I and 05MW12I

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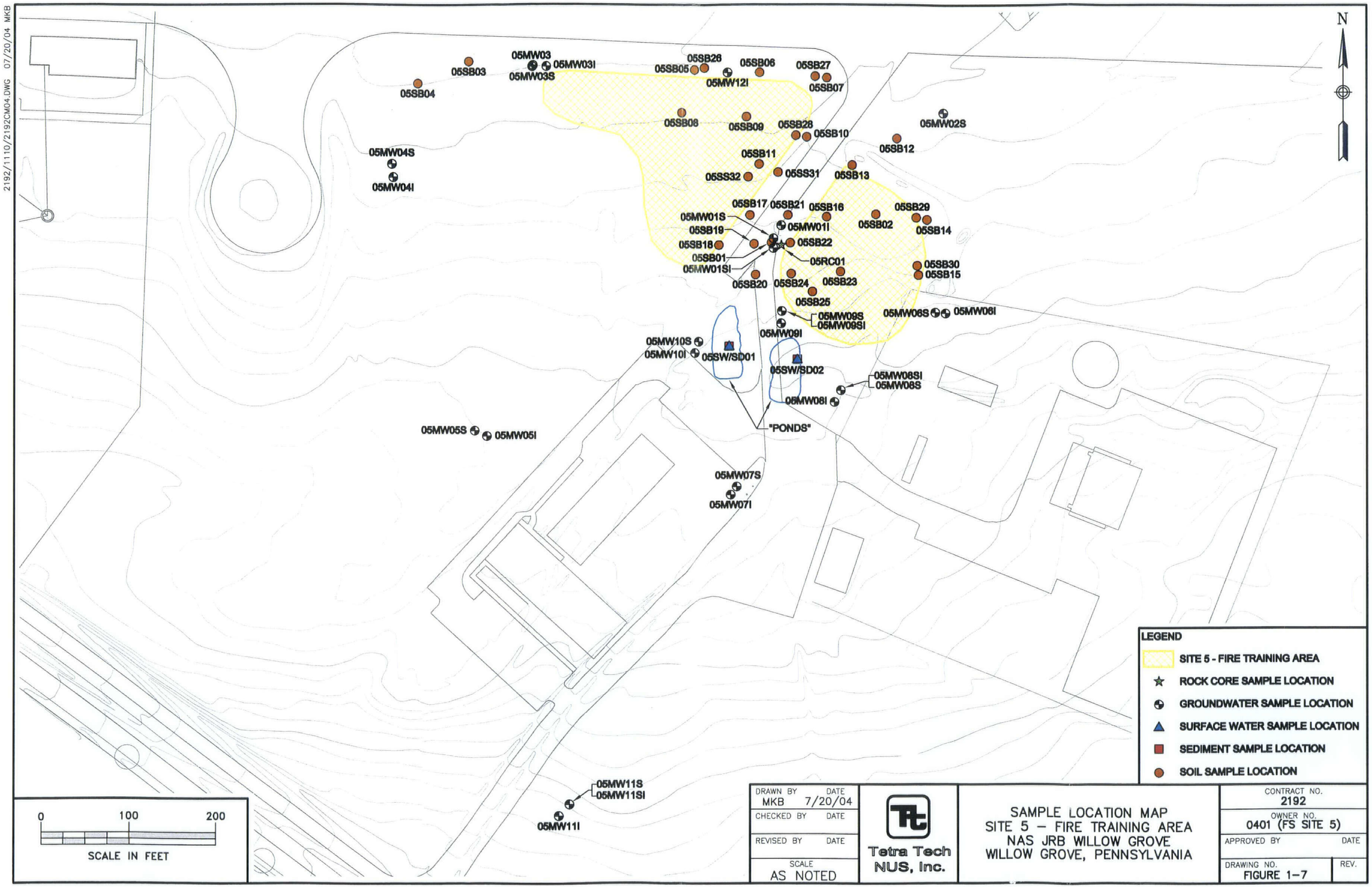

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Table 1-2
Occurrence and Distribution of Organics and In rganics in Groundwater, Site 5
NASJRB Will w Grove, P nnsylvania

Substance	Background Data					Site-Related Data				
	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Representative Concentration
aluminum		-				7/16	59.9	6970	540	05MW10S 06/24/97	1310
arsenic		-				1/21	2	2	0.571	05MW10S 06/24/97	0.633
barium		-				21/21	43.8	1430	317	05MW10S 06/24/97	575
beryllium		-				1/21	2.8	2.8	0.61	05MW10S 06/24/97	0.683
calcium		-				21/21	5740	39000	22300	05MW08SI 06/23/97	33100
chromium		-				7/21	6	40.8	5.72	05MW10S 06/24/97	7.32
cobalt		-				3/21	5.1	18.8	3.67	05MW09SI 06/23/97	4.31
iron		-				18/21	61.4	7440	533	05MW10S 06/24/97	858
lead		-				1/8	18.1	18.1	2.7	05MW07I 06/23/97	12.6
magnesium		-				21/21	1820	12000	6260	05MW01D 07/07/97	7430
manganese		-				19/21	5	397	81.5	05MW01S 06/23/97	356
nickel		-				1/21	74.3	74.3	13.1	05MW10S 06/24/97	14.6
potassium		-				9/21	1630	26000	3360	05MW06I 06/25/97	5400
sodium		-				21/21	7680	29100	14700	05MW10S 06/24/97	17200
vanadium		-				1/21	5	5	2.62	05MW10S 06/24/97	2.77
zinc		-				5/9	27.7	457	68.5	05MW10S 06/24/97	457
dieldrin		-				2/21	0.09	0.3	0.0638	05MW07S 06/23/97	0.0723
1,1,1-trichloroethane		-				10/21	2	960	66	05MW01S 06/23/97	114
1,1,2-trichloroethane		-				1/21	10	10	5.24	05MW01S 06/23/97	5.55
1,1-dichloroethane		-				9/21	4	350	30	05MW01S 06/23/97	45.9
1,1-dichloroethene		-				9/21	6	300	31.2	05MW01S 06/23/97	52.9
1,2-dichloroethane		-				2/21	3	4	4.86	05MW01S 06/23/97	4
1,2-dichloroethene (total)						7/21	1	99	8.95	05MW01S 06/23/97	11
benzene		-				2/21	3	28	6	05MW01S 06/23/97	6.79
tetrachloroethene		-				8/21	1	35	6.86	05MW01D 07/07/97	9.48
trichloroethene		-				9/21	5	300	25.7	05MW01S 06/23/97	33.9

Notes:

Units are ug/L.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
The determination of representative concentrations is based on comparison of maximum to the 95 % UCL, which is presented in a separate table.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.

Table 1-3
Background Comparison Tests - Groundwater Data - Site 5
NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back.Freq. ?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev. ?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back. Freq.	Site Freq.	P Value	YN	Back. Mean°	Std.Dev. Back.°	t Value	L,N Q	Back. UTL	Site Max.	YN	r	k	P Value	YN	P Value	Test	Used	YN	Back. Mean°	Site Mean°	t Value	t Table	YN	Back. Distrib.	Site Distrib.	Std.Dev. Back.°	Std.Dev. Site°	F Value	F Table	YN
Substance																															
aluminum	N	0/0	7/16		NA						6970	NA				NA				NA		540			NA		nonpar.					NA
arsenic	N	0/0	1/21		NA						2	NA				NA				NA		0.571			NA		nonpar.					NA
barium	Y	0/0	21/21		NA						1430	NA				NA				NA		5.35			NA		lognor.		0.961			NA
beryllium	N	0/0	1/21		NA						2.8	NA				NA				NA		0.61			NA		nonpar.					NA
calcium	N	0/0	21/21		NA						39000	NA				NA				NA		22300			NA		nonpar.					NA
chromium	N	0/0	7/21		NA						40.8	NA				NA				NA		5.72			NA		nonpar.					NA
cobalt	N	0/0	3/21		NA						18.8	NA				NA				NA		3.67			NA		nonpar.					NA
iron	N	0/0	18/21		NA						7440	NA				NA				NA		533			NA		nonpar.					NA
lead	N	0/0	1/8		NA						18.1	NA				NA				NA		2.7			NA		nonpar.					NA
magnesium	N	0/0	21/21		NA						12000	NA				NA				NA		6260			NA		normal					NA
manganese	N	0/0	19/21		NA						397	NA				NA				NA		3.35			NA		lognor.		1.6			NA
nickel	N	0/0	1/21		NA						74.3	NA				NA				NA		13.1			NA		nonpar.					NA
potassium	N	0/0	9/21		NA						26000	NA				NA				NA		3360			NA		nonpar.					NA
sodium	Y	0/0	21/21		NA						29100	NA				NA				NA		9.52			NA		lognor.		0.377			NA
vanadium	N	0/0	1/21		NA						5	NA				NA				NA		2.62			NA							NA
zinc	Y	0/0	5/9		NA						457	NA				NA				NA		68.5			NA		lognor.					NA
dieldrin	N	0/0	2/21		NA						0.3	NA				NA				NA		0.0638			NA							NA
1,1,1-trichloroethane	Y	0/0	10/21		NA						960	NA				NA				NA		66			NA		nonpar.					NA
1,1,2-trichloroethane	N	0/0	1/21		NA						10	NA				NA				NA		5.24			NA							NA
1,1-dichloroethane	Y	0/0	9/21		NA						350	NA				NA				NA		30			NA		nonpar.					NA
1,1-dichloroethene	Y	0/0	9/21		NA						300	NA				NA				NA		31.2			NA							NA
1,2-dichloroethane	N	0/0	2/21		NA						4	NA				NA				NA		4.86			NA							NA
benzene	N	0/0	2/21		NA						28	NA				NA				NA		6			NA							NA
tetrachloroethene	N	0/0	8/21		NA						35	NA				NA				NA		6.86			NA		nonpar.					NA
trichloroethene	Y	0/0	9/21		NA						300	NA				NA				NA		25.7			NA		nonpar.					NA

Notes: Units are ug/L.
A statistical significance level (P value) of 0.05 is used for all tests that directly compare site to background. A two-sided significance level of 0.1 is used for Bartlett's test for equal variance.
UTL is the expected value for the upper 95 % quantile of the background population; there is an equal chance of the population's true 95 % quantile being either below or above this estimate.
For each test, a YES or NO decision is presented only if all assumptions are met. The overall decision (is site > background) for each chemical appears at the left and is based on four criteria:
(1) Overall decision is YES if any one of the UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results.
(2) Overall decision is NO if at least one of UTL, Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES.
(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA. Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results.

(4) Overall decision is NA if all tests are NA. (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment.)

Table 1-3
Background Comparison Tests - Groundwater Data - Site 5
NASJRB Willow Grove, Pennsylvania

Name of Test:	Detection Freq: Z or Fisher				95 % Upper Tolerance Limit (UTL)							Upper Ranks				Mann-Whitney/Gehan				Student's or Satterthwaite T-test					Bartlett's Test for Equal Standard Deviations						
Question Posed:	Site Freq. > Back.Freq.?				Site Maximum > UTL for Background Data ?							Majority are site?				Ranks of Site > Back?				Site Mean > Back. Mean ?					Site Standard Deviation =Background Std.Dev.?						
Assumptions Valid:	#ND & Pos.>=5 or use Fisher				Back. lognorm. or norm. If not, #b>18 for Quantile Test							# Site (s) in Top r				<40% ND or use Gehan				#s>2,#b>2,>=85% Pos; both norm/log					#s>2,#b>2, site & back both normal or both lognorm.						
Test Criterion:	P value <= 0.05 ?				Max >95% UTL (parametric). Or, Max >95% Quantile							P<=0.05 that #s>=k				P value <=0.05 ?				t-Value > t-Table					F-Value<=F-Table (Students T). If not, Satterthwaite						
Conclusion: Site > Back? YN	Back.	Site	P	YN	Back.	Std.Dev.	t	L,N	Back.	Site	YN	r	k	P	YN	P	Test	Used	YN	Back.	Site	t	t	YN	Back.	Site	Std.Dev.	Std.Dev.	F	F	YN
Substance	Freq.	Freq.	Value		Mean@	Back.@	Value	Q	UTL	Max.				Value		Value				Mean@	Mean@	Value	Table		Distrib.	Distrib.	Back.@	Site@	Value	Table	

Abbreviations:

# NDs or # Pos.	Number of non-detected (ND) or positive (Pos.) results in data set, not including rejected data or blank-qualified data.
# s or # b	Number of site (s) or background (b) samples, not including rejected data or blank-qualified data.
s = b	Standard deviation of site results must not be different from the standard deviation of background results.
P value	Probability or significance level is defined as the chance of a false positive. If P <= 0.05 then test determines site > background with 95 % confidence.
L, N, or Q	UTL is based on 95 % upper limit (using t-value) when data are lognormal (L) or normal (N). Otherwise, an upper 95 % quantile (Q) is used if there are > 18 back. points.
% ND	Mann-Whitney test used if < 40% of data non-detected and detection limits are uniformly below the range of positive values. If not, the Gehan Test is used.
@	Mean and standard deviations are shown of log-transformed data when distributions are of this type; i.e., if an (L) code appears for the UTL test or if site and background distributions both match lognormal and both T-test and Bartlett's test are applicable. (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA.)
r,k	The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined site and background data set comprise site data if both populations are in fact equal.

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW01D	05MW01I	05MW01I	05MW01S	05MW01S	SCREENING VALUES			
LOCATION:	05MW01I	05MW01I	05MW01I	05MW01S	05MW01S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	07/07/97	06/23/97	09/25/00	06/23/97	09/18/91				
INORGANICS	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
aluminum	89.4	50 U	n/a	50 U	n/a	-	-	-	37000
barium	363	502	n/a	266	n/a	2000	700	2000	2600
calcium	30100	31000	n/a	13100	n/a	-	-	-	-
chromium, total	10.7	5 U	n/a	5 U	n/a	100 *	1000	100	110
iron	220 J	142	n/a	71	n/a	-	-	-	11000
lead	1.2 B	2.5 B	n/a	7 B	n/a	15.0	-	5.00	15.0
magnesium	12000	8610	n/a	5750	n/a	-	-	-	-
manganese	81.5	55.1	n/a	397	n/a	-	-	-	730
potassium	9420	10700	n/a	1500 U	n/a	-	-	-	-
sodium	23400	15600	n/a	15800	n/a	-	-	-	-
zinc	6.2 B	18.1 B	n/a	21.8 B	n/a	-	2000 a	2000	11000
VOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
1,1,1-trichloroethane	10 U	54	10 U	960 E	2800 E	200	200 a	200	3200
1,1,2-trichloroethane	10 U	10 U	10 U	10 E J	250 U	5.00	3.00 a	5.00	0.190
1,1-dichloroethane	10 U	50 E	10 U	350 E	420 E	-	-	27.0	800
1,1-dichloroethene	10 U	35 E J	10 U	300 E J	840 E	7.00	7.00 a	7.00	0.0440
1,2-dichloroethane	10 U	3 E J	10 U	4 E J	250 U	5.00	700	5.00	0.120
1,2-dichloroethene (total)	10 U	6 J	n/a	99 E	180 E J	70.0 a	70.0 a	70.0	55.0
acetone	10 U	10 U	2.8 J	10 U	500 U	-	-	3700	610
benzene	10 U	10 U	10 U	28 E	250 U	5.00	200	5.00	0.320
methylene chloride	5 B	7 B	10 U	7 B	250 U	5.00	2000 d	5.00	4.10
tetrachloroethene	35 E	3 E J	10 U	24 E	500 U	5.00	10.0 a	5.00	1.10
trichloroethene	10 U	23 E	10 U	300 E	590 E	5.00	-	5.00	1.60

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW01S-RE-D	05MW01S-RE	05MW01SI	05MW01SI	05MW02S	SCREENING VALUES			
LOCATION:	05MW01S	05MW01S	05MW01SI	05MW01SI	05MW02S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/25/00	09/25/00	09/20/91	09/25/00	06/24/97				
INORGANICS	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
barium	n/a	n/a	n/a	n/a	43.8	2000	700	2000	2600
calcium	n/a	n/a	n/a	n/a	7200	-	-	-	-
magnesium	n/a	n/a	n/a	n/a	2230	-	-	-	-
sodium	n/a	n/a	n/a	n/a	9410	-	-	-	-
VOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
1,1,1-trichloroethane	2700 E	2400 E J	260 E	73	10 U	200	200 a	200	3200
1,1,2-trichloroethane	38 E J	42 E	5 U	10 U	10 U	5.00	3.00 a	5.00	0.190
1,1-dichloroethane	590 E	620 E J	84 E	54 E	10 U	-	-	27.0	800
1,1-dichloroethene	530 E	600 E J	120 E J	43 E	10 U	7.00	7.00 a	7.00	0.0440
1,2-dichlorobenzene	200 U	4.5 J	n/a	10 U	10 U	600	600 a	600	550
1,2-dichlorobenzene	200 U	4.5 J	n/a	10 U	10 U	600	600 a	600	550
1,2-dichloroethane	200 U	13 E	5 U	10 U	10 U	5.00	700	5.00	0.120
1,2-dichloroethene (total)	n/a	n/a	11 J	n/a	1 J	70.0 a	70.0 a	70.0	55.0
1,4-dichlorobenzene	200 U	21 E	n/a	10 U	10 U	75.0	75.0 a	75.0	0.470
1,4-dichlorobenzene	200 U	21 E	n/a	10 U	10 U	75.0	75.0 a	75.0	0.470
acetone	74 J	10 U	10 U	10 U	10 U	-	-	3700	610
benzene	53 E J	58 E	16 E J	10 U	10 U	5.00	200	5.00	0.320
chloroform	200 U	1.1 E J	5 U	10 U	10 U	80.0	4000	100	0.150
cis-1,2-dichloroethene	450 E	460 E J	n/a	9.8 J	n/a	70.0	70.0 a	70.0	61.0
methylcyclohexane	200 U	18	n/a	10 U	n/a				6300
methylene chloride	200 U	5.9 E J	6 B	10 U	5 B	5.00	2000 d	5.00	4.10
tetrachloroethene	79 E J	87 E	8 E	4.2 E J	1 J	5.00	10.0 a	5.00	1.10
toluene	200 U	10 U	3 B	10 U	10 U	1000	1000 a	1000	750
trans-1,2-dichloroethene	200 U	3.5 J	n/a	10 U	n/a	100	100 a	100	120
trichloroethene	890 E	740 E J	69 E J	29 E	10 U	5.00	-	5.00	1.60

TABLE1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW02S	05MW02S	05MW02S-DUP	05MW02S	05MW03I	SCREENING VALUES			
LOCATION:	05MW02S	05MW02S	05MW02S	05MW02S	05MW03I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	08/07/97	09/18/91	06/24/97	09/18/00	06/24/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	n/a	50 U	n/a	282	-	-	-	37000
barium	n/a	n/a	45.6	n/a	77.5	2000	700	2000	2600
calcium	n/a	n/a	7120	n/a	32700	-	-	-	-
chromium, total	n/a	n/a	5 U	n/a	7.2 K	100 *	1000	100	110
iron	n/a	n/a	50 U	n/a	357	-	-	-	11000
lead	n/a	n/a	2.1 B	n/a	1.2 B	15.0	-	5.00	15.0
magnesium	n/a	n/a	2220	n/a	3620	-	-	-	-
manganese	n/a	n/a	5 U	n/a	14 K	-	-	-	730
potassium	n/a	n/a	1500 U	n/a	3300	-	-	-	-
sodium	n/a	n/a	9320	n/a	17500	-	-	-	-
zinc	n/a	n/a	5 U	n/a	7.5 B	-	2000 a	2000	11000
SEMIVOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
di-n-butyl phthalate	2 B	n/a	10 U	n/a	10 U	-	-	3700	3700
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	n/a	5 U	10 U	10 U	13	200	200 a	200	3200
1,1-dichloroethane	n/a	5 U	10 U	10 U	18	-	-	27.0	800
1,1-dichloroethene	n/a	5 U	10 U	10 U	7 E J	7.00	7.00 a	7.00	0.0440
1,2-dichloroethene (total)	n/a	5 U	1 J	n/a	2 J	70.0 a	70.0 a	70.0	55.0
acetone	n/a	10 U	10 U	2.1 J	10 U	-	-	3700	610
cis-1,2-dichloroethene	n/a	n/a	n/a	2.7 J	n/a	70.0	70.0 a	70.0	61.0
methylene chloride	n/a	8 B	6 B	10 U	6 B	5.00	2000 d	5.00	4.10
tetrachloroethene	n/a	2 E J	2 E J	5.6 E J	2 E J	5.00	10.0 a	5.00	1.10
trichloroethene	n/a	5 U	10 U	10 U	5 E J	5.00	-	5.00	1.60

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW03I	05MW03S	05MW03S	05MW03S	05MW04I	SCREENING VALUES			
LOCATION:	05MW03I	05MW03S	05MW03S	05MW03S	05MW04I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/18/00	06/24/97	09/18/91	09/18/00	09/21/00				
INORGANICS	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
barium	n/a	44.5	n/a	n/a	136 B	2000	700	2000	2600
calcium	n/a	7300	n/a	n/a	n/a	-	-	-	-
chromium, total	n/a	6.3 K	n/a	n/a	1 U	100 *	1000	100	110
iron	n/a	124	n/a	n/a	n/a	-	-	-	11000
lead	n/a	2.1 B	n/a	n/a	1.9 U	15.0	-	5.00	15.0
magnesium	n/a	2110	n/a	n/a	n/a	-	-	-	-
manganese	n/a	7.5 K	n/a	n/a	n/a	-	-	-	730
sodium	n/a	7680	n/a	n/a	n/a	-	-	-	-
zinc	n/a	19.6 B	n/a	n/a	n/a	-	2000 a	2000	11000
VOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
1,1,1-trichloroethane	3.7 J	10 U	1 B	10 U	50	200	200 a	200	3200
1,1-dichloroethane	5.5 J	10 U	5 U	10 U	29 E	-	-	27.0	800
1,1-dichloroethene	3.5 E J	10 U	5 U	10 U	25 E	7.00	7.00 a	7.00	0.0440
acetone	2.1 J	10 U	10 U	2.2 J	3 J	-	-	3700	610
cis-1,2-dichloroethene	1.6 J	n/a	n/a	10 U	5 J	70.0	70.0 a	70.0	61.0
methylene chloride	10 U	6 B	4 B	10 U	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	2 E J	10 U	5 U	10 U	2.2 E J	5.00	10.0 a	5.00	1.10
trichloroethene	2.5 E J	10 U	5 U	10 U	18 E	5.00	-	5.00	1.60

TABLE1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW04S	05MW04S	05MW04S	05MW05I	05MW05I-F	SCREENING VALUES			
LOCATION:	05MW04S	05MW04S	05MW04S	05MW05I	05MW05I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Filt. Mon. Well				
SAMPLE DATE:	06/25/97	09/18/91	09/21/00	09/21/00	09/21/00				
INORGANICS	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
aluminum	82.9 B	n/a	n/a	n/a	n/a	-	-	-	37000
arsenic	1 UL	n/a	n/a	8.3 B	6.8 B	5.00	-	50.0	0.0450
barium	56.8	n/a	n/a	164 B	132 B	2000	700	2000	2600
calcium	5740	n/a	n/a	n/a	n/a	-	-	-	-
chromium, total	5 U	n/a	n/a	10.2	n/a	100 *	1000	100	110
iron	61.4	n/a	n/a	n/a	n/a	-	-	-	11000
lead	2.9 B	n/a	n/a	3.8	1.9 U	15.0	-	5.00	15.0
magnesium	2240	n/a	n/a	n/a	n/a	-	-	-	-
manganese	5 K	n/a	n/a	n/a	n/a	-	-	-	730
sodium	9200	n/a	n/a	n/a	n/a	-	-	-	-
zinc	39.2 B	n/a	n/a	n/a	n/a	-	2000 a	2000	11000
SEMIVOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
bis(2-ethylhexyl)phthalate	1 B	n/a	n/a	n/a	n/a	6.00	-	6.00	4.80
VOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
1,1,1-trichloroethane	10 U	3 B	10 U	7.3 J	n/a	200	200 a	200	3200
1,1-dichloroethane	10 U	5 U	10 U	2.9 J	n/a	-	-	27.0	800
1,1-dichloroethene	10 U	5 U	10 U	9.2 E J	n/a	7.00	7.00 a	7.00	0.0440
acetone	10 U	10 U	10 U	3.5 J	n/a	-	-	3700	610
methylene chloride	17 B	5 U	10 U	10 U	n/a	5.00	2000 d	5.00	4.10
trichloroethene	10 U	5 U	10 U	2.9 E J	n/a	5.00	-	5.00	1.60

TABLE1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW05S	05MW05S	05MW05S-DUP	05MW05S	05MW06I	SCREENING VALUES			
LOCATION:	05MW05S	05MW05S	05MW05S	05MW05S	05MW06I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	09/20/91	09/20/91	09/12/00	06/25/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	50 U	n/a	n/a	n/a	59.5 B	-	-	-	37000
barium	190	n/a	n/a	n/a	178	2000	700	2000	2600
calcium	6860	n/a	n/a	n/a	7640	-	-	-	-
chromium, total	6 K	n/a	n/a	n/a	5 U	100 *	1000	100	110
iron	85.9	n/a	n/a	n/a	50 U	-	-	-	11000
lead	3.4 B	n/a	n/a	n/a	1 U	15.0	-	5.00	15.0
magnesium	1820	n/a	n/a	n/a	5790	-	-	-	-
manganese	5.5 K	n/a	n/a	n/a	5 U	-	-	-	730
potassium	1500 U	n/a	n/a	n/a	26000	-	-	-	-
sodium	12300	n/a	n/a	n/a	25200	-	-	-	-
zinc	9 B	n/a	n/a	n/a	5 U	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
acetone	10 U	10 U	10 U	1.8 J	10 U	-	-	3700	610
methylene chloride	5 B	5 U	3 B	10 U	17 B	5.00	2000 d	5.00	4.10

TABLE1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW06I	05MW06I	05MW06S	05MW06S	05MW06S	SCREENING VALUES			
LOCATION:	05MW06I	05MW06I	05MW06S	05MW06S	05MW06S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/13/00	09/20/91	06/25/97	09/20/91	09/13/00				
INORGANICS	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
aluminum	n/a	n/a	68.3 B	n/a	n/a	-	-	-	37000
barium	n/a	n/a	111	n/a	n/a	2000	700	2000	2600
calcium	n/a	n/a	7320	n/a	n/a	-	-	-	-
lead	n/a	n/a	2.8 B	n/a	n/a	15.0	-	5.00	15.0
magnesium	n/a	n/a	3410	n/a	n/a	-	-	-	-
manganese	n/a	n/a	14.2 K	n/a	n/a	-	-	-	730
sodium	n/a	n/a	8510	n/a	n/a	-	-	-	-
VOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
acetone	2.2 J	10 U	10 U	10 U	2 J	-	-	3700	610
methylene chloride	10 U	5 U	16 B	5 U	10 U	5.00	2000 d	5.00	4.10
toluene	10 U	1 B	10 U	5 U	10 U	1000	1000 a	1000	750

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW07I	05MW07I	05MW07I	05MW07S	05MW07S	SCREENING VALUES			
LOCATION:	05MW07I	05MW07I	05MW07I	05MW07S	05MW07S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/23/97	09/14/00	09/20/91	06/23/97	09/20/91				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
barium	460	n/a	n/a	95.1	n/a	2000	700	2000	2600
calcium	35600	n/a	n/a	24300	n/a	-	-	-	-
iron	90.3	n/a	n/a	71.8	n/a	-	-	-	11000
lead	18.1 E	n/a	n/a	1 U	n/a	15.0	-	5.00	15.0
magnesium	6980	n/a	n/a	9850	n/a	-	-	-	-
manganese	142	n/a	n/a	6.4 K	n/a	-	-	-	730
potassium	2330	n/a	n/a	1500 U	n/a	-	-	-	-
sodium	10000	n/a	n/a	10700	n/a	-	-	-	-
zinc	5 U	n/a	n/a	24.1 B	n/a	-	2000 a	2000	11000
SEMIVOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
bis(2-ethylhexyl)phthalate	10 U	n/a	n/a	6 B	n/a	6.00	-	6.00	4.80
di-n-butyl phthalate	3 B	n/a	n/a	3 B	n/a	-	-	3700	3700
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	3.3 J	6	10 U	2 J	200	200 a	200	3200
1,1-dichloroethane	10 U	2.9 J	2 J	10 U	1 J	-	-	27.0	800
1,1-dichloroethene	10 U	5.4 E J	4 E J	10 U	5 U	7.00	7.00 a	7.00	0.0440
acetone	10 U	2.1 J	10 U	10 U	10 U	-	-	3700	610
methylene chloride	6 B	10 U	3 B	6 B	5 U	5.00	2000 d	5.00	4.10
toluene	10 U	10 U	2 B	10 U	1 B	1000	1000 a	1000	750
trichloroethene	10 U	2.4 E J	2 E J	10 U	5 U	5.00	-	5.00	1.60
PESTICIDES/PCBS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
dieldrin	0.1 U	n/a	n/a	0.3 E	n/a	-	0.500	0.0410	0.00420

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW07S	05MW08I	05MW08I-DUP	05MW08I	05MW08S	SCREENING VALUES			
LOCATION:	05MW07S	05MW08I	05MW08I	05MW08I	05MW08S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/14/00	06/23/97	06/23/97	09/15/00	06/25/97				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	n/a	230	213	n/a	173 B	-	-	-	37000
barium	n/a	372	378	n/a	75.9	2000	700	2000	2600
calcium	n/a	35100	35700	n/a	27300	-	-	-	-
iron	n/a	300	269	n/a	256	-	-	-	11000
lead	n/a	1 B	1.2 B	n/a	1 U	15.0	-	5.00	15.0
magnesium	n/a	8560	8710	n/a	6650	-	-	-	-
manganese	n/a	6.5 K	6.5 K	n/a	57.1	-	-	-	730
potassium	n/a	1500 U	1500 U	n/a	2770	-	-	-	-
sodium	n/a	10100	10100	n/a	15100	-	-	-	-
zinc	n/a	34.8 K	24.9 B	n/a	49.1	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	2 J	10 U	10 U	10 U	200	200 a	200	3200
acetone	2.1 J	10 U	10 U	3 J	10 U	-	-	3700	610
methylene chloride	10 U	7 B	6 B	10 U	16 B	5.00	2000 d	5.00	4.10

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW08S-DUP	05MW08S	05MW08SI	05MW08SI	05MW09I	SCREENING VALUES			
LOCATION:	05MW08S	05MW08S	05MW08S	05MW08SI	05MW09I	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/15/00	09/15/00	09/15/00	06/23/97	06/23/97				
INORGANICS	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
aluminum	n/a	n/a	n/a	679	162 B	-	-	-	37000
barium	n/a	n/a	n/a	487	594	2000	700	2000	2600
calcium	n/a	n/a	n/a	39000	38400	-	-	-	-
chromium, total	n/a	n/a	n/a	5 U	7.3 K	100 *	1000	100	110
cobalt	n/a	n/a	n/a	5 U	8.1 K	-	-	2200	2200
iron	n/a	n/a	n/a	765	450	-	-	-	11000
lead	n/a	n/a	n/a	1.5 B	2.2 B	15.0	-	5.00	15.0
magnesium	n/a	n/a	n/a	8450	10100	-	-	-	-
manganese	n/a	n/a	n/a	46.3	21.4 K	-	-	-	730
sodium	n/a	n/a	n/a	12400	10300	-	-	-	-
zinc	n/a	n/a	n/a	24.9 B	27.7 K	-	2000 a	2000	11000
VOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
1,1,1-trichloroethane	10 U	10 U	1.9 J	10 U	38	200	200 a	200	3200
1,1-dichloroethane	10 U	10 U	1.2 J	10 U	26	-	-	27.0	800
1,1-dichloroethene	10 U	10 U	3.7 E J	10 U	37 E J	7.00	7.00 a	7.00	0.0440
1,2-dichloroethene (total)	n/a	n/a	n/a	10 U	1 J	70.0 a	70.0 a	70.0	55.0
acetone	2 J	2 J	1.6 J	10 U	10 U	-	-	3700	610
methylene chloride	10 U	10 U	10 U	7 B	6 B	5.00	2000 d	5.00	4.10
trichloroethene	10 U	10 U	1.5 J	10 U	15 E	5.00	-	5.00	1.60

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW09I	05MW09S	05MW09S	05MW09SI	05MW09SI	SCREENING VALUES			
LOCATION:	05MW09I	05MW09S	05MW09S	05MW09SI	05MW09SI	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	09/21/00	06/24/97	09/26/00	06/23/97	09/21/00				
INORGANICS	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
aluminum	n/a	50 U	n/a	59.9	n/a	-	-	-	37000
barium	n/a	143	n/a	401	n/a	2000	700	2000	2600
calcium	n/a	9650	n/a	26700	n/a	-	-	-	-
chromium, total	n/a	5 U	n/a	6.9 K	n/a	100 *	1000	100	110
cobalt	n/a	5 U	n/a	18.8 K	n/a	-	-	2200	2200
iron	n/a	62.1	n/a	267	n/a	-	-	-	11000
lead	n/a	2.6 B	n/a	1 U	n/a	15.0	-	5.00	15.0
magnesium	n/a	3100	n/a	5460	n/a	-	-	-	-
manganese	n/a	148	n/a	244	n/a	-	-	-	730
potassium	n/a	1680	n/a	1500 U	n/a	-	-	-	-
sodium	n/a	20700	n/a	16100	n/a	-	-	-	-
zinc	n/a	13.7 B	n/a	37.6 K	n/a	-	2000 a	2000	11000
VOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
1,1,1-trichloroethane	11	28	11	64	41	200	200 a	200	3200
1,1-dichloroethane	12	27	12	42 E	35 E	-	-	27.0	800
1,1-dichloroethene	13 E	25 E J	20 E	53 E J	57 E	7.00	7.00 a	7.00	0.0440
1,2-dichloroethane	10 U	10 U	10 U	10 U	1.1 E J	5.00	700	5.00	0.120
1,2-dichloroethene (total)	n/a	10 U	n/a	3 J	n/a	70.0 a	70.0 a	70.0	55.0
benzene	10 U	10 U	1.2 E J	3 E J	10 U	5.00	200	5.00	0.320
cis-1,2-dichloroethene	10 U	n/a	10 U	n/a	2.1 J	70.0	70.0 a	70.0	61.0
methylene chloride	10 U	4 B	10 U	7 B	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	10 U	2 E J	1.6 E J	4 E J	2.9 E J	5.00	10.0 a	5.00	1.10
trichloroethene	5.5 E J	17 E	8.2 E J	32 E	26 E	5.00	-	5.00	1.60

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW10I	05MW10I	05MW10S	05MW10S	05MW10SI	SCREENING VALUES			
LOCATION:	05MW10I	05MW10I	05MW10S	05MW10S	05MW10S[illegible]	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	09/18/00	06/24/97	09/15/00	09/18/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	50 U	n/a	6970	n/a	n/a	-	-	-	37000
arsenic	1 U	n/a	2 E L	n/a	n/a	5.00	-	50.0	0.0450
barium	403	n/a	1430 E	n/a	n/a	2000	700	2000	2600
beryllium	1 U	n/a	2.8	n/a	n/a	4.00	30000	4.00	73.0
calcium	34500	n/a	16300	n/a	n/a	-	-	-	-
chromium, total	5 U	n/a	40.8	n/a	n/a	100 *	1000	100	110
cobalt	5 U	n/a	5.1	n/a	n/a	-	-	2200	2200
copper	10 U	n/a	20.8 B	n/a	n/a	1300	-	1000	1500
iron	87.5	n/a	7440	n/a	n/a	-	-	-	11000
lead	1 U	n/a	19.9 B	n/a	n/a	15.0	-	5.00	15.0
magnesium	10900	n/a	7220	n/a	n/a	-	-	-	-
manganese	22.4 K	n/a	356	n/a	n/a	-	-	-	730
nickel	20 U	n/a	74.3	n/a	n/a	-	100 a	100	730
potassium	1630	n/a	3770	n/a	n/a	-	-	-	-
sodium	11600	n/a	29100	n/a	n/a	-	-	-	-
vanadium	5 U	n/a	5 E	n/a	n/a	-	-	2.10	260
zinc	14.1 B	n/a	457	n/a	n/a	-	2000 a	2000	11000
SEMIVOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
bis(2-ethylhexyl)phthalate	10 U	n/a	1 B	n/a	n/a	6.00	-	6.00	4.80
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	18	5.5 J	13	4.8 J	120	200	200 a	200	3200
1,1,2-trichloroethane	10 U	10 U	10 U	10 U	2.5 E J	5.00	3.00 a	5.00	0.190
1,1-dichloroethane	9 J	4.3 J	4 J	3 J	52 E	-	-	27.0	800
1,1-dichloroethene	12 E J	7.6 E J	6 E J	7.3 E J	120 E	7.00	7.00 a	7.00	0.0440
1,2-dichloroethane	10 U	10 U	10 U	10 U	2 E J	5.00	700	5.00	0.120
acetone	10 U	2.3 J	10 U	1.8 J	2.5 J	-	-	3700	610
carbon tetrachloride	10 U	10 U	10 U	10 U	19 E	5.00	200 d	5.00	0.160
cis-1,2-dichloroethene	n/a	10 U	n/a	10 U	8.8 J	70.0	70.0 a	70.0	61.0

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW10I	05MW10I	05MW10S	05MW10S	05MW10SI	SCREENING VALUES			
LOCATION:	05MW10I	05MW10I	05MW10S	05MW10S	05MW10S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	09/18/00	06/24/97	09/15/00	09/18/00				
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
methylene chloride	4 B	10 U	17 B	10 U	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	10 U	10 U	10 U	10 U	8.7 E J	5.00	10.0 a	5.00	1.10
trichloroethene	8 E J	2.5 E J	5 E J	2.8 E J	68 E	5.00	-	5.00	1.60
PESTICIDES/PCBS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
dieldrin	0.1 U	n/a	0.09 E J	n/a	n/a	-	0.500	0.0410	0.00420

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW10SI	05MW11I	05MW11I	05MW11S	05MW11S	SCREENING VALUES			
LOCATION:	05MW10SI	05MW11I	05MW11I	05MW11S	05MW11S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	05/28/98	09/13/00	05/28/98	09/12/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	101	387	n/a	50.2	n/a	-	-	-	37000
antimony	20 U	1.9 B	n/a	1.9 B	n/a	6.00	6.00 a	6.00	15.0
arsenic	1 U	2.3 U	n/a	3.3 E	n/a	5.00	-	50.0	0.0450
barium	354	201	n/a	98.3	n/a	2000	700	2000	2600
beryllium	1 U	0.47 K	n/a	0.62 K	n/a	4.00	30000	4.00	73.0
cadmium	5 U	0.21 L	n/a	0.31 L	n/a	5.00	5.00 a	5.00	18.0
calcium	32100	64100	n/a	14200	n/a	-	-	-	-
chromium, total	5 U	8.4 K	n/a	1.8 K	n/a	100 *	1000	100	110
cobalt	5 U	3	n/a	0.87 K	n/a	-	-	2200	2200
copper	10 U	4.4	n/a	1.8 K	n/a	1300	-	1000	1500
cyanide	5 U	10.3	n/a	10 U	n/a	200	200	200	730
iron	263	769	n/a	83.5	n/a	-	-	-	11000
magnesium	6550	13300	n/a	3030	n/a	-	-	-	-
manganese	75.7	185	n/a	5 K	n/a	-	-	-	730
mercury	0.2 U	0.1	n/a	0.1 U	n/a	2.00	2.00	2.00	3.70
nickel	20 U	6.5	n/a	4	n/a	-	100 a	100	730
potassium	1500 U	7640	n/a	842	n/a	-	-	-	-
sodium	17700	19000	n/a	10100	n/a	-	-	-	-
vanadium	5 U	0.5 B	n/a	0.5 B	n/a	-	-	2.10	260
zinc	17.6 B	34.3	n/a	28.7	n/a	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	140	10 U	10 U	10 U	10 U	200	200 a	200	3200
1,1-dichloroethane	45 E	10 U	10 U	10 U	10 U	-	-	27.0	800
1,1-dichloroethene	120 E J	10 U	10 U	10 U	10 U	7.00	7.00 a	7.00	0.0440
1,2-dichloroethene (total)	6 J	10 U	n/a	10 U	n/a	70.0 a	70.0 a	70.0	55.0
acetone	10 U	6 B	2.5 J	6 B	14	-	-	3700	610
benzene	10 U	10 U	1.2 E J	10 U	10 U	5.00	200	5.00	0.320
chlorobenzene	10 U	10 U	1.3 J	10 U	10 U	-	-	100	110

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW10SI	05MW11I	05MW11I	05MW11S	05MW11S	SCREENING VALUES			
LOCATION:	05MW10SI	05MW11I	05MW11I	05MW11S	05MW11S	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	06/24/97	05/28/98	09/13/00	05/28/98	09/12/00				
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
chloroform	10 U	10 U	1 E J	10 U	10 U	80.0	4000	100	0.150
methylene chloride	20 B	2 B	1.3 J	3 B	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	8 E J	10 U	10 U	10 U	10 U	5.00	10.0 a	5.00	1.10
toluene	10 U	10 U	1.2 J	10 U	10 U	1000	1000 a	1000	750
trichloroethene	75 E	10 U	1.2 J	10 U	10 U	5.00	-	5.00	1.60
xylenes, total	10 U	10 U	1.4 J	10 U	10 U	10000	10000 a	10000	12000
PESTICIDES/PCBS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Aroclor-1221	2 UJ	2 U	n/a	0.98 B	n/a	0.500	-	1.30	0.0330
dieldrin	0.1 UJ	0.1 U	n/a	0.0051 E J	n/a	-	0.500	0.0410	0.00420
endrin aldehyde	0.1 UJ	0.021 B	n/a	0.054 B	n/a				11.0
gamma-chlordane	0.05 UJ	0.0049 J	n/a	0.05 U	n/a	2.00	60.0	2.00	0.190
heptachlor	0.05 UJ	0.014 B	n/a	0.02 B	n/a	0.400	10.0	0.400	0.0150

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW11SI	05MW11SI-DUP	05MW11SI	05MW12I	05MW12I-DUP	SCREENING VALUES			
LOCATION:	05MW11SI	05MW11SI	05MW11SI	05MW12I	05MW12I-DUP	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	05/28/98	05/28/98	09/12/00	09/21/00	09/21/00				
INORGANICS	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
aluminum	105	73.9	n/a	n/a	n/a	-	-	-	37000
antimony	1.9 B	1.9 B	n/a	n/a	n/a	6.00	6.00 a	6.00	15.0
barium	170	166	n/a	125 B	125 B	2000	700	2000	2600
beryllium	0.51 K	0.59 K	n/a	n/a	n/a	4.00	30000	4.00	73.0
cadmium	0.22 L	0.25 L	n/a	0.49 U	0.49 U	5.00	5.00 a	5.00	18.0
calcium	15300	15000	n/a	n/a	n/a	-	-	-	-
chromium, total	0.9 U	0.9 U	n/a	1.3 B	1.4 B	100 *	1000	100	110
cobalt	0.93 K	0.6 B	n/a	n/a	n/a	-	-	2200	2200
copper	1.6 K	1.5 K	n/a	n/a	n/a	1300	-	1000	1500
cyanide	10 UJ	160 J	n/a	n/a	n/a	200	200	200	730
iron	320 J	253 J	n/a	n/a	n/a	-	-	-	11000
lead	1.2 U	1.2 U	n/a	2.3 B	2.7 B	15.0	-	5.00	15.0
magnesium	3010	2930	n/a	n/a	n/a	-	-	-	-
manganese	15.3	13.9	n/a	n/a	n/a	-	-	-	730
nickel	3	2.2	n/a	n/a	n/a	-	100 a	100	730
potassium	869	837	n/a	n/a	n/a	-	-	-	-
selenium	3.5 UL	3.5 UL	n/a	2.9 B	2.1 U	50.0	50.0 a	50.0	180
sodium	10600	10400	n/a	n/a	n/a	-	-	-	-
vanadium	0.5 B	0.5 B	n/a	n/a	n/a	-	-	2.10	260
zinc	24.4	21	n/a	n/a	n/a	-	2000 a	2000	11000
VOLATILES	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
1,1,1-trichloroethane	10 U	10 U	10 U	5.4 J	5.3 J	200	200 a	200	3200
1,1-dichloroethane	10 U	10 U	10 U	9.5 J	12	-	-	27.0	800
1,1-dichloroethene	10 U	10 U	10 U	4.5 E J	4.2 E J	7.00	7.00 a	7.00	0.0440
acetone	10 U	6 B	10 U	10 U	3.1 J	-	-	3700	610
cis-1,2-dichloroethene	n/a	n/a	10 U	2.4 J	2.2 J	70.0	70.0 a	70.0	61.0
methylene chloride	2 B	2 B	10 U	10 U	10 U	5.00	2000 d	5.00	4.10
tetrachloroethene	10 U	10 U	10 U	2.9 E J	2.8 E J	5.00	10.0 a	5.00	1.10

TABLE 1-4

COMPARISON OF GROUNDWATER ANALYTICAL DATA TO SCREENING VALUES - Site 05

NASJRB, WILLOW GROVE, PENNSYLVANIA

SAMPLE NUMBER:	05MW11SI	05MW11SI-DUP	05MW11SI	05MW12I	05MW12I-DUP	SCREENING VALUES			
LOCATION:	05MW11SI	05MW11SI	05MW11SI	05MW12I	05MW12I-DUP	Maximum Contaminant Level (MCL)	Drinking Water Health Advisory (Lowest Criterion Shown)	PADEP Groundwater MSC (res.) <2500 TDS	Risk-Based Concentration for Tap Water Consumption
DATA SOURCE:	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well	Monitoring Well				
SAMPLE DATE:	05/28/98	05/28/98	09/12/00	09/21/00	09/21/00				
VOLATILES	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
trichloroethene	10 U	10 U	10 U	2.9 E J	2.8 E J	5.00	-	5.00	1.60
PESTICIDES/PCBS	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
Aroclor-1221	2 U	1.2 B	n/a	n/a	n/a	0.500	-	1.30	0.0330
dieldrin	0.1 U	0.004 J	n/a	n/a	n/a	-	0.500	0.0410	0.00420
endrin aldehyde	0.1 U	0.11 B	n/a	n/a	n/a				11.0
heptachlor	0.0046 B	0.058 B	n/a	n/a	n/a	0.400	10.0	0.400	0.0150

Footnotes to sample results:

U - Compound or element was not detected. Value is the detection limit (inorganics) or quantitation limit (organics).
UJ - Not detected. Detection limit or quantitation limit shown is considered estimated due to exceedance of data validation quality control criteria.
UL - Not detected. Detection limit or quantitation limit shown is considered biased low due to exceedance of data validation quality control criteria.
n/a - Constituent was not analyzed for in this sample.
B - (Organic Data). Value is considered a nondetected result due to blank contamination.
B - (Inorganic Data). Value is greater than the Instrument Detection Limit (IDL), but less than the Contract Required Detection Limit (CRDL).
J - Value is estimated because concentration is below the quantitation limit or because of exceedance of data validation quality control criteria.
L - Value is considered biased low because of exceedance of data validation quality control criteria.
K - Value is considered biased high because of exceedance of data validation quality control criteria.
E - Result exceeds one or more of the selected ARARs.

Footnotes to MCLs:

- - No standard is available for this chemical in this classification.
a - Where applicable, value(s) represent the more stringent of criteria for total, cis-, and trans- isomers.
* - Criteria are for total chromium.
** - Copper action level 1300 ug/L for water treatment technology for public water supply systems.
*** - Lead action level 15 ug/L for water treatment technology for public water supply systems.

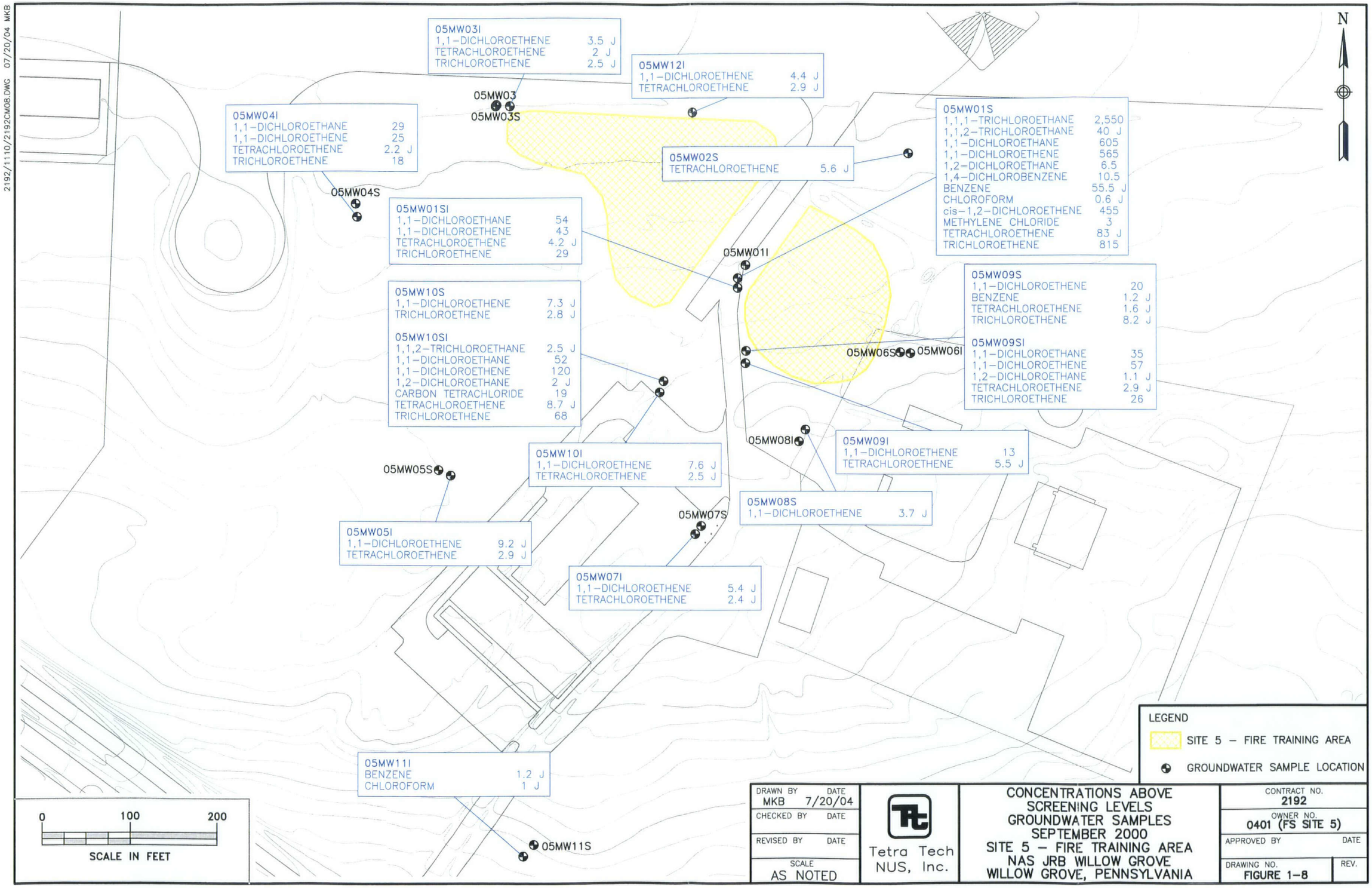
Footnotes to Health Advisories:

- - No standard is available for this chemical in this classification.
a - The listed health advisory criterion, lifetime adult, is equal to the most stringent of the EPA health advisories for this chemical.
b - The listed health advisory criterion, long-term adult, is equal to the most stringent of the EPA health advisories for this chemical.
c - The listed health advisory criterion, one-day child, is equal to the most stringent of the EPA health advisories for this chemical.
d - The listed health advisory criterion, ten-day child, is equal to the most stringent of the EPA health advisories for this chemical.
e - The listed health advisory criterion, long-term child, is equal to the most stringent of the EPA health advisories for this chemical.

Footnotes to PADEP Criteria:

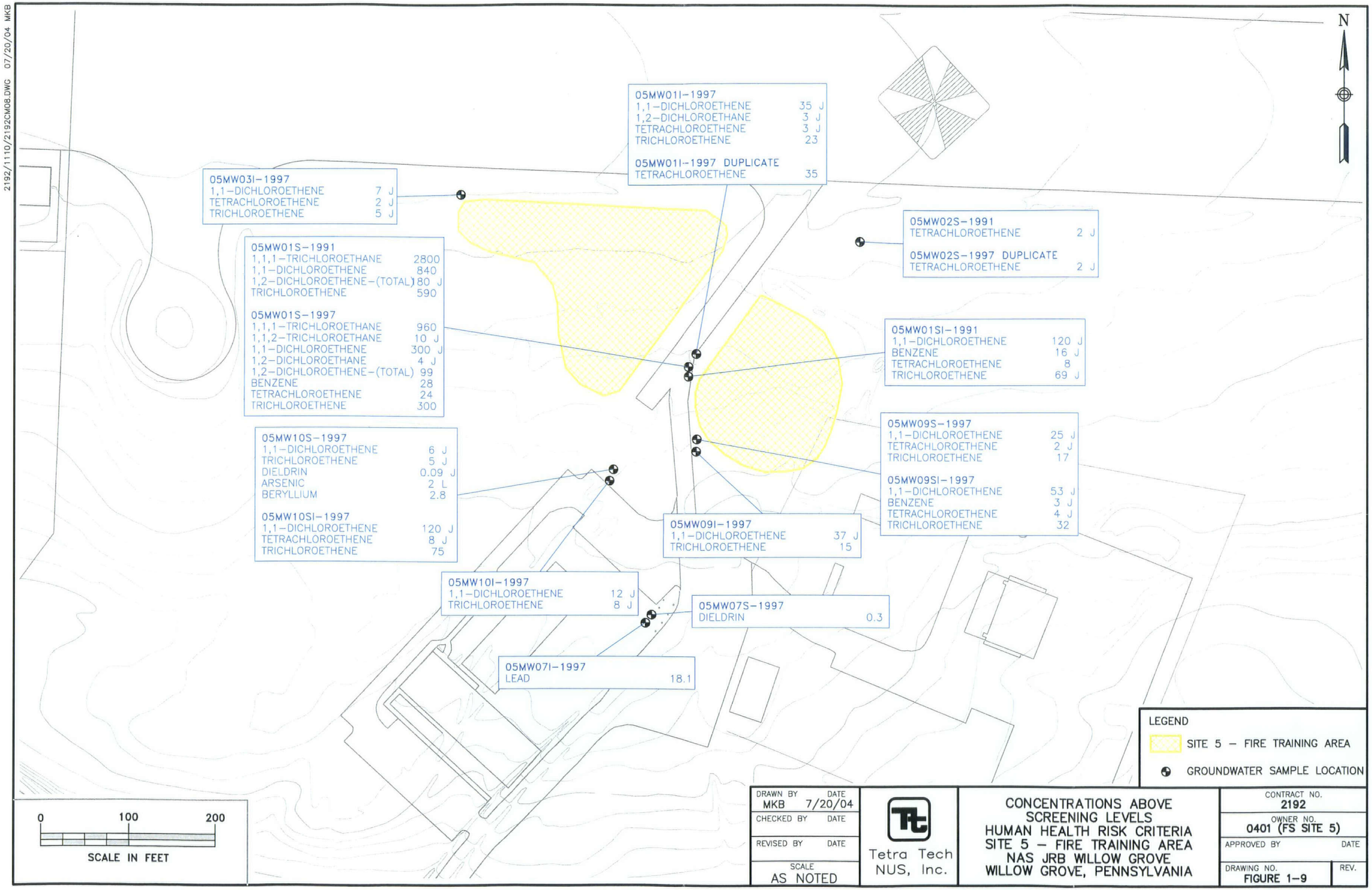
MSC - Medium-Specific Concentration.

2192/1110/2192CM08.DWG 07/20/04 MKB



DRAWN BY MKB DATE 7/20/04	Tetra Tech NUS, Inc.	CONCENTRATIONS ABOVE SCREENING LEVELS GROUNDWATER SAMPLES SEPTEMBER 2000 SITE 5 – FIRE TRAINING AREA NAS JRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	CONTRACT NO. 2192
CHECKED BY DATE			OWNER NO. 0401 (FS SITE 5)
REVISED BY DATE			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-8 REV.

2192/1110/2192CM08.DWG 07/20/04 MKB



DRAWN BY MKB DATE 7/20/04	Tetra Tech NUS, Inc.	CONCENTRATIONS ABOVE SCREENING LEVELS HUMAN HEALTH RISK CRITERIA SITE 5 – FIRE TRAINING AREA NAS JRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	CONTRACT NO. 2192
CHECKED BY DATE			OWNER NO. 0401 (FS SITE 5)
REVISED BY DATE			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-9 REV.

were subsequently installed just above a very fine-grained claystone unit that occurs beneath the source area near 05MW01 and sampled. Results from the Phase II RI indicate that DNAPL is not migrating downdip along bedding planes from the source area. In addition, there are no indications that DNAPL exists either at, or downdip from, the source area.

1.3.4 Public Supply Well - Horsham Township Municipal Authority Well No. 26

Horsham Township Municipal Authority (HTMA) Well No. 26 lies approximately 1,800 feet southwest of the Site 5 source area near 05MW01. This well is reportedly 400 feet deep, and pumps at a rate of approximately 275 gpm. The well does not pump continuously; pumping cycles are triggered by demand and are controlled by the water levels in holding and storage tanks. Previous interpretations of the plume geometry at Site 5 indicated that the groundwater plume was generally migrating to the southwest, or toward the HTMA Well No. 26, although no chlorinated solvents had ever been reported from this well. Due to the proximity of HTMA Well No. 26, monitoring well cluster 05MW11 was installed downgradient of the mapped plume, between the source area and well No. 26, and as close to the base boundary as possible (the presence of subsurface utilities at the fence line prevented the installation of monitoring wells there).

The subsurface conditions between the source area and cluster 05MW11 are illustrated in the hydrogeologic cross-section (Figure 4-4). Although the groundwater plume is presently interpreted to migrate principally to the northwest at depth (see Figure 4-12), this hydrogeologic cross-section suggests that there is also a southwestward component of groundwater flow and plume migration. No VOCs were detected at cluster 05MW11 in May 1998, shortly after the wells were installed. During the September 2000 sampling round however, several VOCs were detected at low levels in the deep well at that cluster, including; TCE (1.2 ug/L); xylene (1.4 ug/L); toluene (1.2 ug/L); benzene (1.2 ug/L); and chlorobenzene (1.3 ug/L). It cannot be stated for certain that the compounds detected at 05MW11 are from the source area at Site 5, although the compounds are similar (constituents of gasoline and solvents) to those found within the mapped groundwater plume. Also, if plume related, it is not known whether this southwestward component of plume migration is always present, or if it is a result of the temporary migration or movement of the groundwater divide in the intermediate groundwater zone relative to the position of the source area. The horizontal gradients within the intermediate zone are very low, and relatively small changes in head at one or more locations could substantially alter the groundwater flow pattern.

Results reported by USGS (in Appendix O of the Site 5 RI Report) indicate that the pumping of HTMA No. 26 has little measurable influence on the hydraulic head at Site 5. That is, the pumping of HTMA No. 26 is not influencing the migration of the Site 5 groundwater plume, and is not pulling the plume toward the HTMA No. 26 well. This does not mean, however (as discussed above), that the plume may not be

migrating towards the well at times under ambient hydraulic conditions, although the geometry of the plume (especially in the intermediate zone) would suggest that a northwestward migration of the plume is more typical.

1.3.5 Conclusions

Soil borings in the vicinity of well cluster 05MW01 and groundwater samples from this cluster show the highest levels of contamination at Site 5, with VOCs and other organic compounds present. These locations are near the former drum storage area and indicate that the site is likely the historical source of BTEX, VOC, and PAH contamination. The VOCs in groundwater form a generally predictable pattern that is consistent with the conceptual model of a dissolved groundwater plume that is migrating with the groundwater flow. In the shallow groundwater zone, the plume is concentrated in the vicinity of the source area near 05MW01. In response to the downward vertical gradient in hydraulic head, the plume migrates relatively quickly into the intermediate groundwater zone, where it subsequently migrates chiefly to the northwest. There does appear to be a component of groundwater flow (and plume migration) to the southwest, or toward off-site supply well HTMA No. 26, although it is not known if this component of flow is constant or due to temporary variations in the groundwater flow patterns within the intermediate and deep groundwater zone.

1.4 CONTAMINANT FATE AND TRANSPORT

The principal contaminants associated with Site 5 are VOCs in groundwater, PAHs in soils and sediments, and PCBs in soils. Pesticides were detected in sediment samples but do not appear to be site related.

1.4.1 Transport and Transformation of Detected Contaminants

VOCs, such as the chlorinated aliphatics and monocyclic aromatics, released to soils quickly vaporize to the atmosphere or readily leach to groundwater. Adsorption to sediments and bioaccumulation in aquatic organisms are not important environmental fate processes. Hydrolysis and direct photo degradation are not significant degradation processes for most compounds of this class.

Due to their large octanol-water partition coefficients, PAHs in the environment will partition primarily to soils and sediments. Leaching to groundwater is not an important transport pathway for PAHs. PCBs are extremely persistent in the environment. Due to such characteristics as thermal stability, resistance to acids, bases, oxidants and hydrolysis, low aqueous solubility, and low vapor pressure, PCBs were widely used in many industrial applications. These same properties serve to make PCBs very stable in the

environment. PCBs bind strongly to the organic fraction of soils and sediments and are relatively immobile in soils.

1.4.2 Natural Attenuation (NA) of Contaminants

The NA of chlorinated hydrocarbons in groundwater is a combination of the natural effects of dilution, absorption and biodegradation by the natural flow of water through the aquifer zone. NA of chlorinated hydrocarbons in groundwater, such as are found at Site 5, is generally promoted in anaerobic conditions, and would be characterized by the presence of high concentrations of hydrogen and daughter transformation products from the solvents of concern. The natural processes consist of a variety of physical, chemical or biological processes that act to reduce the mass, toxicity, mobility, volume or concentration of contaminants in soil or groundwater. These processes include volatilization, dilution, sorption, biodegradation, dispersion, chemical or biological stabilization, transformation, or destruction of contaminants. Some NA processes may result in the creation of transformation products that are more toxic than the original parent compound. For example, although reductive dehalogenation transforms TCE to 1,2-dichloroethene, an intermediate compound that in turn degrades to vinyl chloride (which is more toxic than TCE), the overall result is elimination of the contaminant from the groundwater system.

NA parameters were measured in the laboratory for groundwater samples collected at Site 5 in September 2001. Table 1-5 summarizes these results and provides a comparison to EPA typical NA indicator parameters. In general, hydrogen concentrations were high and oxygen concentrations were low, indicating that anaerobic conditions prevail at many of the sample locations. Halocarbons, such as TCE and PCE that predominate in Site 5 groundwater, are typically effectively treated naturally in anaerobic conditions. Laboratory analytical results of other indicator parameters such as the presence of chlorinated hydrocarbon degradation products (ethene, ethane and methane) indicate that NA of chlorinated hydrocarbon compounds would be favored in this matrix, and in fact is occurring in groundwater at Site 5.

1.4.3 Conclusions

VOCs detected in site soils at low levels, below reference criteria and EPA soil screening levels (SSLs), historically have impacted the groundwater. However, residual soil contamination does not appear to be a significant continuing source of VOCs to groundwater.

PAHs appear to have transported via erosion and runoff of sediments of nearby surface waters. This transport mechanism is probably minimal at present due to the heavy vegetation and flat topography of the site.

TABLE 1-5
NATURAL ATTENUATION PARAMETER RESULTS - SITE 5
NAS JRB WILLOW GROVE, PENNSYLVANIA

	H	CO2	O	Nitrogen	Methane	Ethane	Ethene	pH*
Well	(nM/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	
05MW01S	6.4	128.4	1.09	10.4	15.8	0.03	0.05	5.8
05MW01SI	8.8	71.9	0.75	13.6	0.3	nd	0.02	6.2
05MW01I	8.0	6.3	3.15	14.0	nd	nd	nd	7.3
05MW03S	4.1	23.2	5.3	8.0	nd	nd	nd	5.5
05MW03I	3.4	45.6	2.92	11.5	nd	0.01	0.01	6.1
05MW04S	7.1	38.2	5.07	10.5	nd	nd	nd	5.2
05MW04I	7.0	55.1	4.00	14.4	nd	nd	nd	6.0
05MW05S	S**	76.2	2.31	11.1	nd	nd	nd	5.9
05MW06S	S	95.6	2.46	11.7	nd	nd	nd	5.4
05MW06I	S	8.8	2.12	11.4	161.9	nd	nd	7.6
05MW07S	S	119.1	0.64	9.4	nd	nd	0.01	5.7
05MW07I	S	21.8	1.95	13.3	1.5	nd	nd	6.8
05MW08S	S	122	0.86	10.8	nd	nd	nd	5.7
05MW08SI	S	67.2	0.82	11.7	nd	nd	nd	6.4
05MW08I	S	16.1	2.33	10.9	nd	nd	nd	6.8
05MW09S	11.1	174.9	0.36	11.5	0.8	0.01	0.05	5.4
05MW09SI	6.6	90.5	0.73	12.5	nd	nd	0.02	6.2
05MW09I	7.0	21.8	1.92	12.8	nd	0.01	0.01	6.9
05MW10S	S	192.9	0.52	9.7	2.8	nd	0.01	5.5
05MW10SI	S	58.2	1.06	11.4	nd	0.01	0.01	6.5
05MW10I	S	6.5	3.89	16.8	nd	0.01	0.02	7.3
05MW11S	1.8	100.4	0.21	11.3	nd	nd	0.01	5.5
05MW11SI	2.5	83.5	3.05	8.5	nd	nd	nd	5.5
05MW11I	S	1.7	1.09	13	1.3	nd	nd	7.7
05MW12I	9.9	55.0	3.30	12.7	nd	nd	nd	5.7

Criteria (US EPA, 1998)

Tolerated	> 1	> 2 x backgr	< 0.5	< 1	> 0.5	> 0.1	> 0.01	5<pH<9
Score	3	1	3	2	3	3	2	0
Not tolerated	< 1		> 5	> 1	< 0.5			5>pH>9
Score	VC oxid.		-3	0	VC oxid.			-2

*pH data from Groundwater Sample Log Sheet (September 2000).

**S-Compound saturated detector, actual result > 50 nM/L.

nd - Not detected

The findings of the NA investigation indicate that natural degradation of chlorinated hydrocarbons is supported in the groundwater matrix at Site 5, resulting in ongoing natural remediation of the chlorinated hydrocarbons in the groundwater.

1.5 BASELINE HUMAN HEALTH RISK ASSESSMENT

A baseline human health risk assessment (HHRA) for the site was conducted to characterize the potential risks to likely human receptors under current and potential land use. Potential receptors identified and retained in the HHRA for quantitative evaluation included current occupational workers, current adolescent and adult trespassers, future excavation workers, future recreational children, and future residents. This section summarizes the baseline human health risk assessment for Site 5 groundwater, the impacted environmental media, at NAS JRB Willow Grove. Details of the methodologies and techniques used in the human health risk assessment for Site 5 can be found in Section 3 of the Site 5 RI Report.

1.5.1 Groundwater Compounds of Potential Concern

A list of the Compounds of Potential Concern (COPCs) was developed for groundwater. The COPCs were selected in accordance with the protocol established in Section 3 of the Site 5 RI Report. Only those chemicals found to be of potential concern were considered for evaluation in the quantitative risk assessment. A discussion of those chemicals identified as COPCs is provided in this section. The following chemicals were selected as COPCs in groundwater:

Inorganics	Organics
Aluminum	Dieldrin
Arsenic	1,1,1-TCA
Barium	1,1,2-TCA
Beryllium	1,1-DCA
Chromium	1,1-DCE
Iron	1,2-DCA
Lead	TCE
Manganese	PCE
Nickel	Benzene

The occurrence and distribution, COPC selection results, background comparisons, reference criteria comparisons, and representative concentrations for chemicals detected in Site 5 groundwater are presented in Table 1-6.

Tabl 1-6
Selection of Chemicals of Potential Conc rn in Gr undwater - Sit 5
NAS JRB Willow Grove, Pennsylvania

Substance	Site-Related Frequency of Detection	Range of Positive Detections for Site Minimum	Maximum	Representative Concentration For Site Data	Applicable Drinking Water MCL	Chemical Exceeds MCL?	Tap Water Risk-Based Concentration	Chemical Selected as a COPC ?
aluminum	7/16	59.9	6970	1310	-	N	3700	Y
arsenic	1/21	2	2	0.633	50	N	0.045	Y
barium	21/21	43.8	1430	575	2000	N	260	Y
beryllium	1/21	2.8	2.8	0.683	4	N	0.016	Y
calcium	21/21	5740	39000	33100	-	N	-	N
chromium	7/21	6	40.8	7.32	100	N	18	Y
cobalt	3/21	5.1	18.8	4.31	-	N	220	N
iron	18/21	61.4	7440	858	-	N	1100	Y
lead	1/8	18.1	18.1	12.6	-	N	15	Y
magnesium	21/21	1820	12000	7430	-	N	-	N
manganese	19/21	5	397	356	-	N	84	Y
nickel	1/21	74.3	74.3	14.6	100	N	73	Y
potassium	9/21	1630	26000	5400	-	N	-	N
sodium	21/21	7680	29100	17200	-	N	-	N
vanadium	1/21	5	5	2.77	-	N	26	N
zinc	5/9	27.7	457	457	-	N	1100	N
dieldrin	2/21	0.09	0.3	0.0723	-	N	0.0042	Y
1,1,1-trichloroethane	10/21	2	960	114	200	N	79	Y
1,1,2-trichloroethane	1/21	10	10	5.55	5	Y	0.19	Y
1,1-dichloroethane	9/21	4	350	45.9	-	N	81	Y
1,1-dichloroethene	9/21	6	300	52.9	7	Y	0.044	Y
1,2-dichloroethane	2/21	3	4	4	5	N	0.12	Y
1,2-dichloroethene (total)	7/21	1	99	11	70	N	5.5	Y
benzene	2/21	3	28	6.79	5	Y	0.36	Y
tetrachloroethene	8/21	1	35	9.48	5	N	1.1	Y
trichloroethene	9/21	5	300	33.9	5	N	1.6	Y

Notes:

Units are ug/L.
Metals are selected as COPCs if maximum values exceed risk-based screening levels (RBCs) and site results are either above background or background comparison tests are indeterminate (NA).
Minerals that are essential nutrients (calcium, magnesium, sodium, potassium) are not included as COPCs.

The determination of site results exceeding background is based on an overall evaluation of statistical tests presented in a separate table.
Because most organics are not naturally occuring, selection of organic COPCs is based solely on exceedance of RBCs.
RBCs represent concentrations associated with a 10^{-6} cancer risk level or a non-cancer Hazard Index of 0.1.
Tap water RBCs originate from EPA Region 3 RBCs for residential exposure, tap water ingestion, with non-cancer risk adjusted to 0.1 Hazard Index.
An RBC for lead based on cancer risk or Hazard Index is not available. The 15 ug/L EPA MCL is used as an applicable RBC for tap water ingestion.

1.5.2 Summary of Human Health Risk Assessment

The total cumulative carcinogenic risk for the current occupational worker is within EPA's acceptable risk range at Site 5 for the reasonable maximum exposure (RME) scenario. Noncarcinogenic HIs for the potential receptors at Site 5 are less than 1.0 under the current occupational worker exposure scenario. Dioxins, furans, and carcinogenic PAHs are the main COPCs selected at Site 5. These contaminants are consistent with past practices at Site 5, which was a fuel burning area (solvents, paint chemicals, xylenes, toluenes, and petroleum compounds). VOCs are the main COPCs in groundwater and these contaminants are also consistent with past practices of the site.

For the reasonable anticipated land use risk scenario, human health risk assessment indicates that exposure to groundwater would result in estimated risk levels within EPA's acceptable risk range. However, VOCs have been detected at levels above MCLs, which are federal concentration limits for drinking water.

1.6 ECOLOGICAL RISK ASSESSMENT SCREENING

A screening-level ecological risk assessment was conducted for Site 5 as part of the 2002 RI. The assessment included the initial two steps of the eight-step EPA process used for conducting environmental risk assessments and was based primarily on a conservative initial screening of site contaminant concentrations against contaminant-specific screening levels. In addition, for Site 5, in accordance with Navy and EPA guidance, the ecological risk assessment screening included a portion of Step 3. The refinement or further consideration of COPCs was incorporated into the Site 5 ecological risk assessment screening. Based on the evaluation, several inorganic and organic contaminants were present in Site 5 surface water, sediment, and surface soil samples at concentrations in exceedance of ecological screening levels and were therefore retained as COPCs. Several other contaminants were retained as COPCs since no screening levels were available. Most of these contaminants were eliminated as COCs in the risk management phase of the assessment for one or more reasons, including low frequency of detection, maximum concentrations comparable to or below background (primarily inorganics) or alternative screening levels, and spatial analysis of detections.

Potential risks to aquatic receptors that inhabit the two small ponds southwest of the burn pit appear to be low. Therefore, no COCs were selected for surface water and sediment in the ponds. It also does not appear that contaminants have migrated to the ponds from the burn pit area.

No inorganic COCs were selected for Site 5 surface soil. Organic compounds that could pose potential risks to terrestrial receptors on and near Site 5 were limited to PAH compounds. Concentrations of PAHs in surface soil samples collected west of the access road that borders the burn area were only slightly

elevated and that area may receive PAH inputs from the taxiway to the north. Conversely, concentrations of several PAHs in samples collected around the burn pit significantly exceeded screening levels for individual and total PAHs. Therefore, these PAHs were selected as COCs in Site 5 surface soils around the burn area, which is considered a hot spot of PAH contamination. Although terrestrial habitat in this area is marginal, it may attract ecological receptors such as small mammals and birds.

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

Remedial alternatives are developed by assembling combinations of technologies and the media to which they would be applied into an appropriate range of alternatives that address site contamination, risks, or threats. This section presents the preliminary phase of the remedial alternatives development process, which consists of identification and screening of remedial technologies, and includes the following:

- Developing RAOs that are protective of human health and the environment with regard to the contaminants and media of concern, exposure pathways, and the PRGs, which permit a range of treatment and containment alternatives to be developed.

- Developing general response actions for each medium of interest that define measures that may be taken singly or in combination to satisfy the RAOs for the site.

- Identifying the numbers, volumes, or areas of media to which the general response actions might be applied.

- Identifying and screening the technologies applicable to each general response action.

Section 2.1 presents a preliminary list of ARARs and other TBCs that were considered in the development of RAOs for the NASJRB Willow Grove OU 2 Site. Section 2.2 presents the approach used to develop site-specific RAOs. Section 2.3 summarizes the approach to develop the PRGs. Section 2.4 identifies the general response actions considered for NAS JRB Willow Grove Site 5 groundwater. Section 2.5 describes the process used for technology screening. General response actions and screening of remedial technologies and process options for Site 5 are presented in Section 2.6.

2.1 POTENTIAL ARARs AND TBCs

ARARs are promulgated, enforceable federal and state environmental or public health requirements that are determined to be legally applicable or relevant and appropriate to the hazardous substances, remedial actions, or other circumstances at a CERCLA site. NCP Section 300.430 states that on-site remedial actions at CERCLA sites must meet ARARs unless there are grounds to invoke a waiver. A waiver is required if ARARs cannot be achieved. The two classes of ARARs, "applicable" and "relevant and appropriate," are defined below.

- **Applicable Requirements** - Section 300.5 of the NCP defines applicable requirements as those clean-up standards, standards of control, and other substantive environmental protection

requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. For example, if a new municipal landfill is being considered, then regulatory requirements that specifically govern its construction, operation, and closure are applicable.

- **Relevant and Appropriate Requirements** - Section 300.5 of the NCP defines relevant and appropriate requirements as those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site. For example, a municipal landfill that was constructed and operated prior to the promulgation of landfill regulations may be closed in accordance with the "relevant and appropriate" requirements of those regulations that identify activities needed to close the landfill.

TBCs are non-promulgated advisories or guidance issued by federal or state governments that are not legally binding but may be considered during development of remedial alternatives. For example, EPA Health Advisories and reference doses are non-promulgated criteria that are used to assess health risks from contaminants present on CERCLA sites.

ARARs and TBCs are divided into three categories: chemical-specific, location-specific, and action-specific. In Sections 2.1.1.1 through 2.1.1.3, these categories are briefly described and general types of potential ARARs and TBCs that may be applied to the site are identified. Detailed discussions of the potential ARARs and TBCs for specific remedial alternatives are provided in Section 4.0.

2.1.1 Identification of ARARs and TBCs

Tables 2-1, 2-2, and 2-3 present a list of potential federal and state (i.e., Commonwealth of Pennsylvania) chemical-, location-, and action-specific ARARs and TBCs that may be applicable to the selection and/or implementation of remedial measures at Site 5. Most of these ARARs and TBCs provide some medium-specific guidance on acceptable or permissible concentrations of contaminants.

Currently, the only enforceable federal regulatory standards for exposure to groundwater are EPA MCLs. However, MCLs have not been specified for many of the COPCs encountered in Site 5 groundwater. Therefore, other regulatory guidelines may be used for comparative purposes to determine health risks and environmental impacts. Federal relevant regulatory guidelines that are referenced include Maximum Contaminant Level Goals (MCLGs), Ambient Water Quality Criteria (AWQCs), and EPA Drinking Water

TABLE 2-1
SUMMARY OF CHEMICAL-SPECIFIC ARARs AND TBCs
FOR POTENTIAL REMEDIAL MEASURES AT SITE 5
NAS JRB WILLOW GROVE, PENNSYLVANIA

ARAR OR TBC	RATIONALE FOR USE AT SITE
Safe Drinking Water Act (SDWA) - Maximum Contaminant Levels (MCLs) (40 CFR 141)	MCLs have been promulgated for a number of organic and inorganic contaminants to regulate the concentration of these compounds in public drinking water. MCLs are relevant to groundwater at the site because groundwater in the vicinity is used as drinking water.
Clean Water Act – Ambient Water Quality Criteria (AWQC)	Ambient water quality criteria are TBCs (i.e., non-promulgated) that have been developed for carcinogenic and non-carcinogenic compounds for the protection of human health and aquatic life. AWQC may be used to assess need for remediation of discharges to surface water or to use as benchmarks during long-term monitoring at the site.
Pennsylvania Water Quality Standards (25 PA Code 93)	Surface water quality standards promulgated for protection of human health and aquatic life. These may be used to assess need for remediation of discharges to surface water or to use as benchmarks during long-term monitoring.
Pennsylvania Water Quality Toxics Management Strategy (25 PA Code 16)	Water quality criteria for various toxic substances promulgated for protection of human health and aquatic life. These may be used to assess need for remediation of discharges to surface water or to use as benchmarks during long-tem monitoring.
Pennsylvania Land Recycling and Environmental Remediation Standards Act (Act 2) (25 PA Code 250)	Media Specific Concentrations (MSCs), including Statewide Health Standard (SHS), Site-specific Standard, and/or Background Standard, for inorganic and organic substances in groundwater and soil are promulgated for site remediation.
EPA Groundwater Protection Strategy (EPA, 1984)	Guidance on determining the classification and restoration goals for groundwater based on its value and vulnerability to contamination.
EPA Region III Risk-Based Concentrations (RBCs)	TBCs for soil and tap water that may be used for selecting contaminants for risk assessment and/or fate and transport modeling.
EPA Soil Screening Levels (SSLs) Guidance and Generic Levels	Guidance that provides a methodology to calculate risk-based, site-specific soil screening levels (SSLs) for contaminants in soil that may be used to identify areas needing further investigation. Also provides generic SSLs for a number of contaminants in soil.
Clean Air Act (42 CFR 85) of 1970	Promulgated national primary and secondary ambient air quality standards for air pollutants for protection of public health. May be applicable in design of treatment processes.
Pennsylvania Air Pollution Control Act (25 PA Code 131) of 1971	Ambient air quality standards for discharges of air pollutants. Potentially applicable to remedial design and implementation.
Pennsylvania Safe Drinking Water (25 PA Code 109)	Potentially applicable to site groundwater that is used as drinking water source.

TABLE 2-2
SUMMARY OF LOCATION-SPECIFIC ARARs AND TBCs
FOR POTENTIAL REMEDIAL MEASURES AT SITE 5
NAS JRB WILLOW GROVE, PENNSYLVANIA

ARAR OR TBC	RATIONALE FOR USE AT SITE
Protection of Wetlands and Floodplains (Executive Orders 11990 and 11988)	Potentially applicable to any remedial actions conducted within wetlands and/or floodplains.
Federal Water Pollution Control Act (40 CFR 116.3) (33 USC 26)	Potentially applicable to any discharges at the site.
Fish and Wildlife Coordination Act (16 USC 661)	Potentially applicable if surface water is diverted or disturbed during remedial actions.
Fish and Wildlife Improvement Act of 1978 (16 USC 742)	This Act protects fish and wildlife against impacts that may affect their protected habitats. May be potentially applicable for discharge of treated water.
Fish and Wildlife Conservation Act of 1980 (16 USC 2901)	May be potentially applicable for discharge of treated water.
Endangered Species Act of 1973 (50 CFR Part 200)	Potentially applicable if any endangered or threatened species or habitats are present where remediation activities may occur.
National Historic Preservation Act of 1966 (16 USC 470 et. Seq.)	Action will be taken to recover and to preserve historic artifacts that may be threatened as the result of land alteration. Potentially applicable if historic artifacts are encountered during active site remediation activities.
National Archeological and Historic Preservation Act of 1974 (132 CFR 229)	Action will be taken to recover and to preserve scientific, prehistoric, historic, or archaeological artifacts that may be threatened as the result of land alteration. Potentially applicable if artifacts are encountered during active site remediation activities.
Delaware River Basin Commission-Ground Water Protected Area Regulations, Southeastern Pennsylvania (Resolution No. 80-18)	Regulations to assure the effective management of water withdrawals to avoid depletion of natural stream flows and groundwater's and to protect the quality of such water.

TABLE 2-3
SUMMARY OF ACTION-SPECIFIC ARARs AND TBCs
FOR POTENTIAL REMEDIAL MEASURES AT SITE 5
NAS JRB WILLOW GROVE, PENNSYLVANIA

ARAR OR TBC	RATIONALE FOR USE AT SITE
Resource Conservation and Recovery Act (RCRA) – Hazardous Waste Generator and Transporter Requirements (40 CFR Parts 262 and 263)	Establishes responsibilities of generators and transporters of hazardous waste in the handling, transportation, and management of waste. Potentially applicable for disposal of sediments or wastes produced by groundwater treatment processes.
Department of Transportation (DOT) – Hazardous Materials Transport (49 CFR Parts 107 and 171-179)	Regulations for the transportation of hazardous materials including packaging, marking, labeling, and transportation methods. Off-site shipments of any contaminated materials (i.e., sediments, spent carbon canisters) from the site would have to comply with these regulations.
Clean Water Act – Natural Pollutant Discharge Elimination System (NPDES)	These requirements are potentially applicable to any alternatives that include a water discharge.
National Environmental Policy Act of 1970 (NEPA) (42 USC 4321)	Requires federal agencies to evaluate the environmental impacts associated with major actions that they fund, support, permit, or implement. Alternatives could constitute significant activities, thereby making NEPA requirements ARARs.
Occupational Health and Safety Act (29 USC 651-678) of 1970	Regulates worker health and safety during implementation of remedial actions. Applicable to any investigative or remedial tasks conducted at the site.
Pennsylvania National Pollutant Discharge Elimination System (25 PA Code 92)	Potentially applicable to any remedial actions that would involve discharge of water.
Pennsylvania Land Recycling Program (25 PA Code 250) – Vapor Intrusion	Chemicals of Potential Indoor Air Concern (COPIACs) are promulgated to address vapor intrusion into buildings from soil and groundwater during certain remedial activities.
Pennsylvania Land Recycling Program (25 PA Code 250) – Fill Policy	Pennsylvania established policy for "clean fill" and "regulated fill" that may be utilized as fill materials during certain remedial activities.
Pennsylvania Stormwater Management Act of 1978 (Act No. 167)	Requires the implementation of measures to control stormwater runoff. Potentially applicable for certain remedial activities.
Pennsylvania Erosion Control Regulations (25 PA Code 102)	Requires the implementation of measures to control erosion and stormwater runoff. Potentially applicable for certain remedial activities.
Pennsylvania Drilling Water Wells (17 PA Code 47)	Requirements for the installation and construction of groundwater wells. Potentially applicable for alternatives involving well installation.
Pennsylvania Hazardous Substances Transportation Regulations (PA Code, Title 13 and 15)	Regulations that govern the transport of flammable liquids and solids, oxidizing materials, poisons and corrosive liquids. Potentially applicable to any off-site shipments of hazardous materials.

Health Advisories (DWHAs). Pennsylvania relevant regulatory standards that are referenced include ACT 2 Statewide Health Standards for soils (residential and non-residential ingestion of soil and soil to groundwater pathway) and groundwater (groundwater aquifer ingestion) and Pennsylvania Code Title 25 Chapter 16 Water Quality Toxics Management Strategy (fish and aquatic life continuous criteria concentration and human health criteria).

Maximum Contaminant Levels (MCLs)

MCLs are enforceable standards promulgated under the Safe Drinking Water Act (SDWA) and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with lifetime exposure (70 years) of an average adult (weighing 70 kilograms) consuming 2 liters of water per day, but they also reflect technical limits on removing the contaminant from water. These enforceable standards are also based upon the amount of toxicant that can be absorbed by the gastrointestinal tract.

Ambient Water Quality Criteria (AWQCs)

AWQCs were developed under the Clean Water Act and are not enforceable federal regulatory guidelines but are a primary utility in assessing the potential for toxic effects in aquatic organisms and human receptors. AWQCs consider acute and chronic human health effects from ingestion of both water (2 liters per day) and aquatic organisms (6.5 grams per day). The AWQC may also be adjusted to consider ingestion of water alone (2 liters per day). The AWQC for protection of human health for carcinogenic substances is based on EPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 100,000 to 10,000,000 persons and is generally based on older toxicological data.

Clean Air Act

Clean Air Act - National Emissions Standards for Hazardous Air Pollutants (40 CFR, Part 61) set forth standards promulgated for air emissions from specific source categories. This act is related to any emissions from treatment equipment such as air strippers and soil treatment equipment.

Pennsylvania Regulatory Standards, Guidelines, and Policies

Pennsylvania Safe Drinking Water Regulations (PA Code, Title 25, Chapter 109) set forth drinking-water-quality standards at least as stringent as the federal drinking water standards. MCLs that are promulgated by EPA are automatically incorporated in the Pennsylvania SDWA. If an MCL does not exist for a

contaminant, the Pennsylvania SDWA requires the maximum allowable concentration to be determined in the following order: the concentration that EPA has proposed to set or is considered setting as a primary MCL for the contaminant; the concentration associated with a lifetime cancer risk of 10^{-6} for carcinogenic contaminants or the lifetime drinking water health advisory concentration for noncarcinogenic contaminants, provided that this concentration is equal to or greater than the practical quantitation level and the level achievable through the use of available treatment technology; or the lowest concentration achievable considering the practical quantitation level and available treatment technology.

The Pennsylvania Land Recycling and Environmental Remediation Standards Act (ACT 2) is the primary law establishing the land recycling program and provides the foundation for standards, procedures, clean-up liability limits, and funding for environmental studies and clean-ups. Persons who propose or are required to respond to the release of a regulated substance at a site and who wish to be eligible for clean-up liability protection must select and attain one or more of the environmental standards in ACT 2. The three types of clean-up standards are background, statewide health, and site-specific standards. Background is the concentration of a regulated substance that is present at a site but is not related to the release of regulated substances at the site. Statewide health standards consist of all numerical residential and non-residential standards adopted by the Pennsylvania Department of Environmental Protection (PADEP) and the federal government. Groundwater in aquifers intended for drinking or agricultural purposes is required to comply with the MCL or Health Advisory Level established for drinking water, except where naturally occurring groundwater has concentrations of total dissolved solids greater than 2,500 mg/L. Site-specific standards are developed using specific risk factors. For site remediation managed under Act 2, a Notice of Intent to remediate and public notice are required for clean-ups planned to achieve background, statewide health, and site-specific standards. In addition, for clean-ups to site-specific standards, there is a public comment period and public involvement.

During data evaluation for the draft RI report, interim Act 2 standards issued by PADEP (revision dated November 1996) were applied for comparison purposes. At the time of implementation of remedial measures, final promulgated standards, if available, will supersede the interim PADEP guidelines. As of this writing, Pennsylvania has promulgated its medium-specific concentrations (MSCs), as amended, in the Pennsylvania Land Recycling and Environmental Remediation Standards Act (ACT 2) (PA Code, Title 25, Chapter 250).

Pennsylvania Water Quality Standards (PA Code, Title 25, Chapter 93) are based upon water uses that are to be protected and considered by PADEP in its regulation of discharges to surface water. The standards may be applicable for actions involving the discharge of pollutants to surface water.

Pennsylvania Water Quality Toxic Management Strategy - Statement of Policy (PA Code, Title 25, Chapter 16) specifies guidelines and procedures for the development of criteria for toxic substances and

lists those limits that have been developed to date. The water quality criteria in Chapter 16 are the numeric limits for stream conditions that need to be maintained or attained to prevent or eliminate pollution and are designed to protect the water uses listed in Chapter 93.

Values of the available regulatory standards and guidelines are presented in Table 2-4. This table presents values for the COPCs that are human, probable human, or possible human carcinogens, for chemicals having only noncarcinogenic effects, and for chemicals having both carcinogenic and noncarcinogenic effects.

2.1.1.1 Potential Chemical-Specific ARARs and TBCs

Chemical-specific ARARs and TBCs are usually health- or risk-based numerical values that are used to establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the environment. In general, chemical-specific requirements are set for a single chemical or a closely related group of chemicals. These requirements do not consider the mixture of chemicals. Typical chemical-specific ARARs are federal and state drinking water standards. Summaries of the potential federal and state chemical-specific ARARs, TBCs, and their consideration in the FS are provided in Table 2-1.

Groundwater at Site 5 is not currently used for drinking water or potable water, but groundwater for private and public water supplies is extracted from the aquifer in the vicinity of the site. Federal chemical-specific ARARs such as the Safe Drinking Water Act (SDWA) MCLs [40 CFR 141], Clean Water Act (federal AWQCs for the Protection of Aquatic Life) [33 U.S.C. S1314], and the Clean Air Act (National Emissions Standards for Hazardous Air Pollutants) [40 CFR 61] may be relevant and appropriate requirements in establishing groundwater clean-up levels. Non-zero MCLGs are non-promulgated health-based drinking water supply limits that are to be considered during the development of groundwater clean-up goals. EPA reference doses, carcinogen potency factors, and health advisories, when available, are all factors used to assess potential risks and can be used to derive risk-based clean-up limits.

The TBC regulations that may affect remediation objectives include: the Integrated Risk Information System (IRIS), Health Effects Assessments, EPA Health Advisories on Drinking Water, and the EPA Region 3 Risk-Based Concentration Tables.

TABLE 2-4

ARARS AND TO-BE-CONSIDERED CRITERIA
NASJRB, WILLOW GROVE, PENNSYLVANIA

Substance	FEDERAL DRINKING WATER STANDARDS AND GUIDELINES [a]			FEDERAL HEALTH ADVISORIES [a]					FEDERAL AWQC			PADEP ACT 2 HUMAN HEALTH STANDARDS [a]				TITLE 25 CHAPTER 16 WATER QUALITY STANDARDS FOR TOXIC SUBSTANCES [a]	
	Maximum Contaminant Level (MCL) (ug/L)	Maximum Contaminant Level Goal (MCLG) (ug/L)	Secondary Maximum Contaminant Levels (SMCL) (ug/L)	Lifetime Adult (ug/L)	Longer-Term Adult (ug/L)	One-Day Child (ug/L)	Ten-Day Child (ug/L)	Longer-Term Child (ug/L)	Freshwater Chronic Aquatic Life [a] (ug/L)	Ingestion of Water and Fish [b] (ug/L)	Ingestion of Fish Only [b] (ug/L)	PADEP Groundwater MSC <=2,500 TDS (ug/L)	Soils Ingestion Residential (ug/Kg)	Soils Ingestion Non-Residential (ug/Kg)	Soil to Groundwater Pathway (ug/Kg)	Fish and Aquatic Life Criteria Continuous Concentrations (ug/L)	Human Health Criteria (ug/L)
Metals																	
aluminum	-	-	2.00E+02	-	-	-	-	-	-	-	-	-	-	-	-	-	-
antimony	6.00E+00	6.00E+00	-	3.00E+00	1.50E+01	1.00E+01	1.00E+01	1.00E+01	-	1.40E+01	4.30E+03	6.00E+00	3.00E+01	4.00E+02	6.00E-01	2.19E+02	1.00E+01
arsenic	5.00E+01	-	-	-	-	-	-	-	1.89E+02	1.80E-02	1.40E-01	5.00E+01	3.00E+00	4.00E+00	5.00E+00	1.90E+02 [12]	5.00E+01
barium	2.00E+03	2.00E+03	-	2.00E+03	-	-	-	-	-	-	-	2.00E+03	5.00E+03	7.00E+04	2.00E+02	4.10E+03	1.00E+03
beryllium	4.00E+00	4.00E+00	-	-	2.00E+04	3.00E+04	3.00E+04	4.00E+03	-	-	-	4.00E+00	1.00E+00	1.30E+00	4.00E-01	0.01 x 96hr LC50	-
cadmium	5.00E+00	5.00E+00	-	5.00E+00	2.00E+01	4.00E+01	4.00E+01	5.00E+00	1.10E+00 [6]	-	-	5.00E+00	2.00E+01	5.00E+02	5.00E-01	1.00E+00 [6,12]	1.00E+01
chromium, total	1.00E+02 [1]	1.00E+02 [1]	-	1.00E+02 [1]	8.00E+02 [1]	1.00E+03 [1]	1.00E+03 [1]	2.00E+02 [1]	2.09E+02 [6]	-	-	1.00E+02	-	-	-	1.00E+01 [12]	-
cobalt	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.90E+01	-
copper	1.30E+03 [7]	1.30E+03	1.00E+03	-	-	-	-	-	1.10E+01 [6]	-	-	1.00E+03	7.00E+02	3.70E+04	1.00E+02	1.10E+01 [6,12]	1.00E+03
cyanide	2.00E+02	2.00E+02	-	2.00E+02	8.00E+02	2.00E+02	2.00E+02	2.00E+02	5.20E+00	7.00E+02	2.20E+05	2.00E+02	1.00E+03	2.00E+04	2.00E+01	5.00E+00	7.00E+02
iron	-	-	3.00E+02	-	-	-	-	-	-	-	-	-	-	-	-	-	-
lead	1.50E+01 [3]	0.00E+00	-	-	-	-	-	-	3.20E+00 [6]	-	-	5.00E+00	5.00E+02	1.00E+03	-	2.50E+00 [6,12]	5.00E+01
manganese	-	-	5.00E+01	-	-	-	-	-	-	-	-	-	-	-	-	-	-
mercury	2.00E+00	2.00E+00	-	2.00E+00	2.00E+00	-	-	-	1.20E-02 [6]	1.40E-01	1.50E-01	2.00E+00	2.00E+01	3.00E+02	-	1.20E-02	1.44E-01
nickel	1.00E+02	1.00E+02	-	1.00E+02	1.70E+03	1.00E+03	1.00E+03	5.00E+02	1.60E+02 [6]	6.10E+02	4.60E+03	1.00E+02	2.00E+02	2.00E+04	-	1.60E+02 [6,12]	6.00E+02
selenium	5.00E+01	5.00E+01	-	-	-	-	-	-	5.00E+00	-	-	5.00E+01	6.00E+01	5.00E+03	5.00E+00	4.60E+00 [6,12]	-
silver	-	-	1.00E+02	1.00E+02	2.00E+02	2.00E+02	2.00E+02	2.00E+02	1.90E+00 [12]	-	-	1.00E+02	-	-	-	2.00E-01	2.00E+02
thallium	2.00E+00	5.00E-01	-	5.00E-01	2.00E+01	7.00E+00	7.00E+00	7.00E+00	- [7]	1.70E+00	6.30E+00	2.00E+00	6.00E+00	8.00E+01	2.00E-01	1.30E+01	-
vanadium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.03E+02	2.00E+00
zinc	-	-	5.00E+03	2.00E+03	1.00E+04	6.00E+03	6.00E+03	3.00E+03	1.01E+02 [6]	-	-	-	-	-	-	1.00E+02 [6,12]	5.00E+03
Pesticides/PCBs																	
4,4'-DDD	-	-	-	-	-	-	-	-	-	8.30E-04	8.40E-04	-	2.00E+04	2.40E+04	5.00E+05	1.00E-03	-
4,4'-DDE	-	-	-	-	-	-	-	-	-	5.90E-04	5.90E-04	-	1.00E+04	1.70E+04	5.00E+05	1.00E-03	N.D.
4,4'-DDT	-	-	-	-	-	-	-	-	1.00E-03	5.90E-04	5.90E-04	-	1.00E+04	1.70E+04	5.00E+05	1.00E-03	N.D.
aldrin	-	-	-	-	3.00E-01	3.00E-01	3.00E-01	3.00E-01	-	1.30E-04	1.40E-04	2.00E-03	2.60E+02	3.40E+02	5.00E+05	1.00E-01	1.00E-04
alpha-chlordane	2.00E+00 [4]	0.00E+00 [4]	-	-	-	6.00E+01 [4]	6.00E+01 [4]	-	4.30E-03 [4]	5.70E-04 [4]	5.90E-04 [4]	2.00E+00 [4]	3.00E+03	4.00E+03	5.00E+05	4.30E-03 [4]	5.00E-04 [4]
Aroclor-1254 [5]	5.00E-01	0.00E+00	-	-	-	-	-	-	1.40E-02 [6]	4.40E-05	4.50E-05	5.00E-01	5.00E+03	-	-	1.40E-02	4.00E-05
Aroclor-1260 [5]	5.00E-01	0.00E+00	-	-	-	-	-	-	1.40E-02 [6]	4.40E-05	4.50E-05	5.00E-01	5.00E+03	-	-	1.40E-02	4.00E-05
beta-BHC	-	-	-	-	-	-	-	-	-	1.40E-02	4.60E-02	-	2.00E+03	3.00E+03	4.00E+04	-	2.00E-02
dieldrin	-	-	-	-	2.00E+00	5.00E-01	5.00E-01	5.00E-01	-	-	-	2.00E-03	3.00E+02	4.00E+02	9.00E+04	1.90E-03	1.00E-04
endosulfan I	-	-	-	-	-	-	-	-	5.60E-02	9.30E-01	2.00E+00	-	5.00E+05	6.00E+06	7.00E+04	2.30E-03	9.00E-01
endrin	2.00E+00	2.00E+00	-	2.00E+00	1.00E+01	2.00E+01	2.00E+01	3.00E+00	2.30E-03	7.60E-01	8.10E-01	2.00E+00	2.00E+04	3.00E+05	5.00E+05	5.60E-02	8.00E-01
gamma-chlordane	2.00E+00 [4]	0.00E+00 [4]	-	-	-	6.00E+01 [4]	6.00E+01 [4]	-	4.30E-03 [4]	5.70E-04 [4]	5.90E-04 [4]	2.00E+00 [4]	3.00E+03	4.00E+03	5.00E+05	4.30E-03 [4]	5.00E-04 [4]
heptachlor	4.00E-01	0.00E+00	-	-	5.00E+00	1.00E+01	1.00E+01	5.00E+00	3.80E-03	2.10E-04	2.10E-04	4.00E-01	1.00E+03	1.30E+03	4.00E+05	3.80E-03	6.00E-04
heptachlor epoxide	2.00E-01	0.00E+00	-	-	1.00E-01	1.00E+01	-	1.00E-01	3.80E-03	1.00E-04	1.10E-04	2.00E-01	5.00E+02	6.00E+02	5.00E+05	1.00E-01	N.D.
Dioxins/Furans																	
2,3,7,8-TCDD	3.00E-05	0.00E+00	-	-	4.00E-05	1.00E-03	1.00E-04	1.00E-05	-	-	-	3.00E-05	3.00E-02	4.00E-02	-	-	1.00E-08
Semivolatiles																	
1,2,4-trichlorobenzene	7.00E+01	7.00E+01	-	4.00E+01	5.00E+02	1.00E+02	1.00E+02	1.00E+02	-	-	-	7.00E+01	8.00E+05	1.00E+07	2.00E+04	2.60E+01	7.00E+02
1,2-dichlorobenzene	6.00E+02	6.00E+02	-	3.00E+03	3.00E+04	9.00E+03	9.00E+03	9.00E+03	-	2.70E+03	1.70E+04	6.00E+02	7.00E+06	9.00E+07	6.00E+04	1.64E+02	4.00E+02 [8]
1,4-dichlorobenzene	7.50E+01	7.50E+01	-	7.50E+01	4.00E+04	1.00E+04	1.00E+04	1.00E+04	- [8]	4.00E+02	2.60E+03	7.50E+01	1.00E+05	2.00E+05	8.00E+03	1.46E+02	4.00E+02 [8]
2,4-dinitrotoluene	-	-	-	-	1.00E+03	5.00E+02	5.00E+02	3.00E+02	-	1.10E-01	2.10E+00	5.00E-02	1.56E+05	2.00E+06	1.00E+03	3.18E+02	5.00E-02
2,6-dinitrotoluene	-	-	-	-	1.00E+03	4.00E+02	4.00E+02	4.00E+02	-	-	-	5.00E-02	7.60E+04	1.00E+06	1.00E+03	1.98E+02	5.00E-02
2-chlorophenol	-	-	-	4.00E+01	2.00E+03	5.00E+02	5.00E+02	5.00E+02	-	-	-	4.00E+01	4.00E+05	5.00E+06	4.00E+03	-	-
2-methylnaphthalene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	-	-	-	-	-
2-methylphenol	-	-	-	1.00E+02	7.00E+03	2.00E+03	2.00E+03	2.00E+03	-	-	-	-	-	-	-	-	-
4-nitrophenol	-	-	-	6.00E+01	3.00E+03	8.00E+02	8.00E+02	8.00E+02	-	-	-	6.00E+01	5.00E+06	6.00E+07	6.00E+03	-	-
acenaphthene	-	-	-	-	-	-	-	-	5.20E+02	1.20E+03	2.70E+03	-	5.00E+06	6.00E+07	3.00E+04	1.70E+01	2.00E+01
acenaphthylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
anthracene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	2.30E+07	3.00E+08	7.00E+04	-	1.00E+04
benzo(a)anthracene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	6.00E+03	8.00E+03	5.00E+05	1.00E-01	3.00E-03
benzo(a)pyrene	2.00E+00	0.00E+00	-	-	-	-	-	-	-	2.80E-03	3.11E-02	2.00E-01	6.00E+02	8.00E+02	5.00E+05	-	3.00E-03

TABLE 2-4

ARARS AND TO-BE-CONSIDERED CRITERIA
NASJRB, WILLOW GROVE, PENNSYLVANIA

Substance	FEDERAL DRINKING WATER STANDARDS AND GUIDELINES [a]			FEDERAL HEALTH ADVISORIES [b]					FEDERAL AWQC			PADEP ACT 2 HUMAN HEALTH STANDARDS [d]				TITLE 25 CHAPTER 16 WATER QUALITY STANDARDS FOR TOXIC SUBSTANCES [e]	
	Maximum Contaminant Level (MCL) (ug/L)	Maximum Contaminant Level Goal (MCLG) (ug/L)	Secondary Maximum Contaminant Levels (SMCL) (ug/L)	Lifetime Adult (ug/L)	Longer-Term Adult (ug/L)	One-Day Child (ug/L)	Ten-Day Child (ug/L)	Longer-Term Child (ug/L)	Freshwater Chronic Aquatic Life [c] (ug/L)	Ingestion of Water and Fish [g] (ug/L)	Ingestion of Fish Only [h] (ug/L)	PADEP Groundwater MSC <=2,500 TDS (ug/L)	Soils Ingestion Residential (ug/Kg)	Soils Ingestion Non-Residential (ug/Kg)	Soil to Groundwater Pathway (ug/Kg)	Fish and Aquatic Life Criteria Continuous Concentrations (ug/L)	Human Health Criteria (ug/L)
benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	6.00E+03	8.00E+03	5.00E+05	-	3.00E-03
benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	-	-	5.00E+05	-	-
benzo(k)fluoranthene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-02	3.11E-02	-	6.00E+04	8.00E+04	5.00E+05	-	3.00E-03
benzoic acid	-	-	-	-	-	-	-	-	-	-	-	-	3.00E+08	1.00E+09	8.00E+02	-	-
bis(2-ethylhexyl)phthalate	-	0.00E+00	-	-	-	-	-	-	3.00E+00	1.80E+00	5.90E+00	6.00E+00	3.00E+05	4.00E+05	4.00E+05	5.40E+01	-
butylbenzylphthalate	-	-	-	-	-	-	-	-	3.00E+00	3.00E+03	5.20E+03	-	1.60E+07	2.00E+08	1.00E+05	3.50E+01	3.00E+02
carbazole	-	-	-	-	-	-	-	-	3.00E+02	-	-	-	-	-	-	-	-
chrysene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	6.00E+05	8.00E+05	5.00E+05	-	3.00E-03
di-n-butylphthalate	-	-	-	-	-	-	-	-	3.00E+00	2.70E+03	1.20E+04	-	-	-	-	2.10E+01	3.00E+03
di-n-octylphthalate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	6.00E+02	8.00E+02	5.00E+05	-	3.00E-03
dibenzofuran	-	-	-	-	-	-	-	-	3.00E+02	-	-	-	-	-	3.00E+04	-	-
diethylphthalate	-	-	-	5.00E+03	-	-	-	-	3.00E+00	2.30E+04	1.20E+05	5.00E+03	6.00E+07	8.00E+08	5.00E+05	8.00E+02	2.00E+04
fluoranthene	-	-	-	-	-	-	-	-	3.98E+03	4.20E+01	5.40E+01	-	3.00E+06	4.00E+07	4.00E+05	4.00E+01	3.00E+02
fluorene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	3.00E+06	4.00E+07	4.00E+04	-	1.00E+03
indeno(1,2,3-cd)pyrene	-	-	-	-	-	-	-	-	3.00E+02	2.80E-03	3.11E-02	-	6.00E+03	8.00E+03	5.00E+05	-	3.00E-03
N-nitrosodiphenylamine	-	-	-	2.00E+02	1.00E+03	1.00E+03	1.00E+03	3.00E+02	-	5.00E+00	1.60E+01	-	-	-	1.00E+03	5.90E+01	5.00E+00
naphthalene	-	-	-	2.00E+01	1.00E+03	5.00E+02	5.00E+02	4.00E+02	6.20E+02	-	-	2.00E+01	3.00E+06	4.00E+07	8.00E+03	4.30E+01	1.00E+01
phenanthrene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	-	-	8.00E+04	1.00E+00	-
phenol	-	-	-	4.00E+03	2.00E+04	6.00E+03	6.00E+03	6.00E+03	-	2.10E+04	4.60E+06	4.00E+03	4.00E+07	6.00E+08	4.00E+04	2.00E+01	3.00E+02
pyrene	-	-	-	-	-	-	-	-	-	2.80E-03	3.11E-02	-	2.00E+06	3.00E+07	3.00E+05	-	1.00E+03
Volatiles																	
1,1,1-trichloroethane	2.00E+02	2.00E+02	-	2.00E+02	1.00E+05	1.00E+05	4.00E+04	4.00E+04	3.12E+04	3.10E+03	1.70E+05	2.00E+02	7.00E+06	9.00E+07	2.00E+04	6.05E+02	1.00E+03
1,1,2-trichloroethane	3.00E+00	3.00E+00	-	3.00E+00	1.00E+03	6.00E+02	4.00E+02	4.00E+02	- [7]	6.00E-01	4.20E+01	5.00E+00	3.00E+05	4.00E+06	8.00E+02	6.78E+02	6.00E-01
1,1-dichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	7.00E+06	1.00E+08	5.00E+02	-	-
1,1-dichloroethene	7.00E+00	7.00E+00	-	7.00E+00	4.00E+03	2.00E+03	1.00E+03	1.00E+03	1.16E+04	5.70E-02	3.20E+00	-	7.00E+05	9.00E+06	1.00E+03	1.492E+03	6.00E-02
1,2-dichloroethane	5.00E+00	0.00E+00	-	-	2.60E+03	7.00E+02	7.00E+02	7.00E+02	- [7]	3.80E-01	9.90E+01	5.00E+00	5.00E+04	6.00E+04	5.00E+02	3.088E+03	4.00E-01
1,2-dichloroethene (total)	7.00E+01 [5]	7.00E+01 [5]	-	7.00E+01 [5]	6.00E+03 [5]	4.00E+03 [5]	2.00E+03 [5]	2.00E+03 [5]	1.16E+04	-	-	7.00E+01	8.00E+05	1.00E+07	7.00E+03	1.35E+03	7.00E+02
2-butanone	-	-	-	-	-	-	-	-	-	-	-	-	4.00E+07	6.00E+08	5.00E+01	3.22E+04	2.00E+03
2-hexanone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4-methyl-2-pentanone	-	-	-	-	-	-	-	-	-	-	-	-	6.00E+06	8.00E+07	2.00E+02	-	-
acetone	-	-	-	-	-	-	-	-	-	-	-	-	8.00E+06	1.00E+08	3.00E+01	8.60E+04	4.00E+03
benzene	5.00E+00	0.00E+00	-	-	-	2.00E+02	2.00E+02	-	5.30E+03	1.20E+00	7.10E+01	5.00E+00	1.00E+05	2.00E+05	8.00E+02	1.28E+02	1.00E+00
bromodichloromethane	1.00E+02 [11]	0.00E+00 [11]	-	-	1.30E+04	6.00E+03	6.00E+03	4.00E+03	-	2.70E-01	2.20E+01	1.00E+02 [11]	7.00E+04	9.00E+04	1.00E+04	-	3.00E-01
bromoform	1.00E+02 [11]	0.00E+00 [11]	-	-	6.00E+03	5.00E+03	2.00E+03	2.00E+03	-	4.30E+00	3.60E+02	1.00E+02 [11]	5.00E+05	7.00E+05	1.00E+04	3.65E+02	4.00E+00
carbon disulfide	-	-	-	-	-	-	-	-	-	-	-	-	7.00E+06	1.00E+08	8.00E+02	-	-
carbon tetrachloride	5.00E+00	0.00E+00	-	-	3.00E+02	4.00E+03	2.00E+02	7.00E+01	-	-	-	5.00E+00	3.40E+04	4.40E+04	2.10E+03	5.56E+02	3.00E-01
chlorobenzene	-	-	-	-	-	-	-	-	-	6.80E+02	2.10E+04	-	1.00E+06	2.00E+07	1.00E+05	2.36E+02	2.00E+01
chloroform	1.00E+02 [11]	0.00E+00 [11]	-	-	4.00E+02	4.00E+03	4.00E+03	1.00E+02	1.24E+03 [7]	5.70E+00	4.70E+02	1.00E+02 [11]	7.00E+05	9.00E+05	1.00E+04	3.89E+02	6.00E+00
chloromethane	-	-	-	3.00E+00	1.00E+03	9.00E+03	4.00E+02	4.00E+02	-	-	-	1.00E+02	-	-	-	-	-
dibromochloromethane	1.00E+02 [11]	6.00E+01 [11]	-	6.00E+01	8.00E+03	6.00E+03	6.00E+03	2.00E+03	-	4.10E-01	3.40E+01	1.00E+02 [11]	-	-	-	-	4.00E-01
ethylbenzene	7.00E+02	7.00E+02	-	7.00E+02	3.00E+03	3.00E+04	3.00E+03	1.00E+03	3.20E+04	3.10E+03	2.90E+04	7.00E+02	7.00E+06	1.00E+08	7.00E+04	5.80E+02	3.00E+03
methyl tert-butyl ether	-	-	-	2.00E+01	1.20E+04	2.40E+04	2.40E+04	3.00E+03	-	-	-	2.00E+01	4.00E+05	5.00E+06	2.00E+03	-	-
methylene chloride	5.00E+00	0.00E+00	-	2.00E+01	-	1.00E+04	2.00E+03	-	-	4.70E+00	1.60E+03	5.00E+00	6.00E+05	8.00E+05	5.00E+02	2.368E+03	5.00E+00
tetrachloroethene	5.00E+00	0.00E+00	-	-	5.00E+03	2.00E+03	2.00E+03	1.00E+03	8.40E+02 [7]	8.00E-01	8.85E+00	5.00E+00	7.00E+05	1.00E+07	2.00E+03	1.39E+02	7.00E-01
toluene	1.00E+03	1.00E+03	-	1.00E+03	7.00E+03	2.00E+04	2.00E+03	2.00E+03	1.75E+04	1.00E+04	3.00E+05	1.00E+03	1.60E+07	2.00E+08	1.00E+05	3.30E+02	7.00E+03
trichloroethene	5.00E+00	0.00E+00	-	-	-	-	-	-	2.19E+04 [7]	2.70E+00	8.10E+01	5.00E+00	4.00E+05	5.00E+05	2.00E+03	4.50E+02	3.00E+00

TABLE 2-4

ARARS AND TO-BE-CONSIDERED CRITERIA
NASJRB, WILLOW GR VE, PENNSYLVANIA

Substance	FEDERAL DRINKING WATER STANDARDS AND GUIDELINES [a]			FEDERAL HEALTH ADVISORIES [a]					FEDERAL AWQC			PADEP ACT 2 HUMAN HEALTH STANDARDS [g]				TITLE 25 CHAPTER 16 WATER QUALITY STANDARDS FOR TOXIC SUBSTANCES [h]	
	Maximum Contaminant Level (MCL) (ug/L)	Maximum Contaminant Level Goal (MCLG) (ug/L)	Secondary Maximum Contaminant Levels (SMCL) (ug/L)	Lifetime Adult (ug/L)	Longer-Term Adult (ug/L)	One-Day Child (ug/L)	Ten-Day Child (ug/L)	Longer-Term Child (ug/L)	Freshwater Chronic Aquatic Life [b] (ug/L)	Ingestion of Water and Fish [c] (ug/L)	Ingestion of Fish Only [c] (ug/L)	PADEP Groundwater MSC <=2,500 TDS (ug/L)	Soils Ingestion Residential (ug/Kg) [i]	Soils Ingestion Non-Residential (ug/Kg)	Soil to Groundwater Pathway (ug/Kg)	Fish and Aquatic Life Criteria Continuous Concentrations (ug/L)	Human Health Criteria (ug/L)
xylene (total)	1.00E+04	1.00E+04	-	1.00E+04	1.00E+05	4.00E+04	4.00E+04	4.00E+04	-	-	-	1.00E+04	-	-	5.00E+03	2.11E+02	3.00E+02

[1] Criteria are for total chromium
[2] Action Level is 1,300 ug/L
[3] Action Level is 15 ug/L
[4] Criteria are for chlordane
[5] Where applicable, value(s) represent the more stringent of criteria for cis- and trans- isomers
[6] Hardness dependent criteria (100 mg/L used)
[7] Insufficient data to develop criteria. Value given is for Lowest Observable Effect Level (LOEL)
[8] Value given is for PCBs
[9] Value given is for dichlorobenzene
[10] pH dependent criteria (pH 7.8 used)
[11] Criteria are for total trihalomethanes
[12] Value is for dissolved metal
[a] EPA. Drinking Water Regulations and Health Advisories. October 1996. EPA 822-B-96-002
[b] EPA. Quality Criteria for Water 1986. Updated 1991 and December 22, 1992
[c] EPA. Quality Criteria for Water 1986. Update 2, May 1, 1987 and Updates December 22, 1992 and May 4, 1995
[d] Land Recycling and Environmental Remediation Standards Act. May 19, 1995. (ACT 2)
[h] Title 25 Chapter 16 Water Quality Toxics Management Strategy. May 18, 1996.

Note: MCLs that are promulgated by EPA are automatically incorporated into the Pennsylvania Safe Drinking Water Act.

IRIS is an EPA database containing up-to-date health risk and EPA regulatory information for numerous chemicals. IRIS contains only those reference doses (RfDs) and cancer slope factors that have been verified by the RfD or Carcinogen Risk Assessment Verification Endeavor Workgroups and is the preferred source of toxicity information. Health Effects Assessments determine the chemical-specific health effects that are based on non-enforceable toxicity data. The EPA Health Advisory on Drinking Water is a set of non-enforceable guidelines for public water supply systems. The EPA Region 3 Risk-Based Concentration Tables are non-enforceable guidelines primarily used for chemical screening during baseline risk assessments.

2.1.1.2 Potential Location-Specific ARARs and TBCs

Location-specific ARARs are restrictions placed on the concentrations of hazardous substances or the conduct of activities solely because the substances or activities are in specific areas. The general types of location-specific ARARs that may be applied to the sites are briefly described below. Summaries of the potential location-specific ARARs and TBCs and their consideration in this FS are provided in Table 2-2.

Several federal and state regulations govern activities in wetlands and floodplains that may result in their degradation or impairment of their functions. Potential location-specific ARARs include Executive Orders 11990 and 11988 for wetlands and floodplains, respectively; the RCRA Location Standards governing the siting of treatment, storage, and disposal facilities in a 100-year floodplain; the Delaware River Basin Commission Ground Water Protected Area Regulations; National Environmental Policy Act; and the Clean Water Act. A potential location-specific TBC is the Ground Water Protection Strategy of 1984 [EPA 440/6-84-002].

The Endangered Species Act of 1978 [16 U.S.C. 1531; 50 C.F.R. Part 402] is a potential ARAR that protects wildlife and endangered species (if present or encountered) during remediation.

If historic or archeological artifacts are encountered during remediation, then the Archeological and Historic Preservation Act of 1974 [16 U.S.C. 469] may be a potential ARAR that would be invoked to prevent the loss of significant scientific, historical, or archeological data.

A cultural resources survey was conducted for the Navy at NAS JRB Willow Grove in April 1996. The objectives of the study were to evaluate the air station's buildings in terms of significance to the National Register of Historical Places Criteria for Evaluation and to assess the potential impact of Navy property to contain prehistoric and historic period archeological resources. The cultural resources study was performed under Contract N62472-94-D-1397 Appendix U. The executive summary and findings of the study are included in Appendix A.

The National Environmental Policy Act [40 C.F.R. Part 6 Appendix A] is a potential ARAR that may affect remediation within wetland areas. This act requires that any activity that may adversely affect wetlands will not be permitted unless there is no practicable alternative.

Another ARAR that may impact site remediation is the Delaware River Basin Commission (DRBC) Ground Water Protected Areas Regulations (GWPA) [18 C.F.R. Part 430]. The DRBC regulations establish requirements for the extraction of groundwater within the Delaware River Basin. Approval from the DRBC is necessary for all projects with groundwater extraction of 10,000 gallons per day in a groundwater-protected area (GWPA). All of Montgomery County is designated as a GWPA in accordance with DRBC Resolution No. 80-18.

The Ground Water Protection Strategy of 1984 identifies groundwater quality to be achieved during remedial actions based on aquifer characteristics and use.

2.1.1.3 Potential Action-Specific ARARs and TBCs

Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are generally focused on actions taken to remediate, handle, treat, transport, or dispose of hazardous wastes. These action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how certain activities within the alternative must be achieved. Summaries of the potential action-specific ARARs and TBCs and their consideration in the FS are provided in Table 2-3.

If site soils, sediments, buried materials, or treatment residues are determined to be hazardous by characteristic or are listed wastes (per RCRA Identification and Listing of Hazardous Waste [40 CFR 261]), then these action-specific ARARs may potentially be applicable to how they are treated, stored, or disposed or to the treatment processes that are considered. These ARARs include federal regulations governing the off-site transport of hazardous wastes [40 CFR 262 and 263], general facility standards [40 CFR 265 Subpart B], preparedness and prevention [40 CFR 265 Subpart C], contingency plan and emergency procedures [40 CFR 265 Subpart D], manifesting and recordkeeping [40 CFR 265 Subpart E], closure and post-closure of municipal landfills [40 CFR 258 Subpart F], land treatment [40 CFR 265 Subpart P], thermal treatment [40 CFR 265 Subpart X], and miscellaneous treatment units [40 CFR 264 Subpart X].

Under Pennsylvania Land Recycling Program, PADEP established regulatory requirements for vapor intrusion from site soils or groundwater that may be applicable to the building(s) on site or to be constructed for site remedial action. PADEP also established policy for clean fill and regulated fill that may be utilized during certain remedial activities.

2.2 REMEDIAL ACTION OBJECTIVES

2.2.1 Methodology for Development of Remedial Action Objectives

The development of the medium-specific RAOs for a site is typically based on the risks posed by site-related contaminants to human and ecological receptors, threats to or continued degradation of groundwater, and comparison of detected contaminant levels to available regulatory standards.

Generally, human health RAOs are formulated to prevent exposures to site-related contaminants that result in excess carcinogenic and non-carcinogenic health risks or to contaminants that exceed regulatory requirements (e.g., MCLs in potable water).

Ecological RAOs are formulated to reduce or prevent the detrimental effects of site-related contaminants on environmental media (e.g., degradation of groundwater quality) or to address contaminant concentrations that exceed regulatory standards.

RAO development for Site 5 is presented below.

2.2.2 Site 5 Remedial Action Objectives

The results of the RI, previous investigations, and the human health and ecological risk assessments for Site 5 were evaluated to determine the remedial actions that may be needed to protect human health and the environment and then to develop the site-specific RAOs.

Human Health Protection Considerations

Exposure to contaminated groundwater may pose excess health risks to humans, and remedial action is warranted to protect human health. Risk assessment results indicate that, under a future residential land use scenario, exposure to contaminated groundwater through ingestion, dermal contact, and inhalation poses potential risks that exceed the EPA's target maximum risk range of 1 E-06 to 1 E-04 carcinogenic risk and the HI for target organs exceeds 1.0. Therefore, remedial actions may be needed to mitigate potential human health risks through exposure to contaminated groundwater.

The underlying groundwater immediately below Site 5 is not used as a potable water supply, although there are private and municipal water supply wells in the vicinity. There are no plans for base closure or realignment that would result in Site 5 being considered for future residential land use.

Ecological Receptors Risk Considerations

Infiltrating precipitation can cause the contamination of subsurface soil and groundwater. After reaching the water table, contaminants can be carried with the flow of groundwater to downgradient locations. Contaminants transported in groundwater to surface water can subsequently be deposited in sediment or surface water and potentially accumulate in the tissues of aquatic organisms in the ponds. Groundwater beneath the site flows to the southeast or southwest (depending on location). The nearest surface water into which site groundwater could discharge is Pennypack Creek, approximately 3,000 feet south of the site. Surface water samples taken from the Pennypack Creek do not contain concentrations of any compound of concern from Site 5 at levels exceeding reference guidelines. There is no evidence from the RI indicating that groundwater discharges to the Pennypack Creek; therefore, ecological risk as a result of groundwater is very low.

Environmental Media Protection Considerations

The RI determined that the Site 5 groundwater was contaminated with VOCs at concentrations in excess of health-based criteria. If source controls are implemented, then a reduction in groundwater contaminant concentrations to below health-based levels can be expected in the long term. Source control measures would likely result in a significant reduction of subsequent migration in the underlying aquifer, thereby reducing groundwater contamination in the long term. Current groundwater VOCs would be attenuated through a combination of degradation and attenuation processes. Physical processes may include advection, convection, dispersion, volatilization (of VOCs to unsaturated pore spaces), adsorption, and absorption. Chemical processes may include partitioning, oxidation and reduction, hydrolysis, and acid/base reactions. Biological processes may include aerobic and anaerobic degradation.

Groundwater in the vicinity of well cluster 05MW01 shows the highest levels of contamination. This location is in the suspected former drum storage area.

2.2.3 RAOs Selection

Based on the reasons provided, the following remedial action objectives have been selected:

Protection of Human Health RAO:

- Prevent potential human exposures to contaminated groundwater.

Protection of the Environment RAO:

- Mitigate migration of VOC contaminants in groundwater and restore the aquifer to applicable standards.

2.3 PRELIMINARY REMEDIATION GOALS

2.3.1 Methodology for Development of Preliminary Remediation Goals

The determination of numerical remediation goals is an iterative process beginning with the development of a range of medium- and chemical-specific contaminant levels that would be protective of human health or the environment if present in site soils and groundwater. Remediation goals that establish acceptable contaminant levels or ranges of levels that must be achieved under the remedial action are ultimately chosen from the range of PRGs when the remedy is selected.

A range of PRGs for OU 2 was developed for groundwater COPCs based on the results of the RI, human health risk assessment, and chemical-specific ARARs. Additionally, background concentrations of COPCs and analytical detection limits were identified as potential PRGs to ensure selection of clean-up goals that are reasonably attainable and measurable. A set of PRGs was developed and the basis for selection is presented.

Typically, a promulgated regulated ARAR is selected as the proposed PRG unless background levels or the analytical detection limit is higher. If no ARAR is available, then the higher of either the risk-based value or the maximum background value (inorganic) was selected.

2.3.2 Site 5 Preliminary Remediation Goals

Data from the RI, the human health risk assessment, and the ARARs were reviewed to identify the Site 5 COCs that would be used to identify and select the appropriate PRGs. COCs are a set of compounds derived from the larger list of COPCs after a set of statistical analyses is applied. No COCs for soils were identified since site-related contaminants are not present at concentrations that pose human health or ecological risks. If excavation is necessary as a component of remedial action for the suspected source (associated soils/rock), then the State Soil Impact to Groundwater Clean-up Criteria, or some other agreed-to standard, e.g., ACT 2 standards and policies, for VOCs could be used to determine the extent of soils and rock removal or fill that may be needed.

TABLE 2-5
PRELIMINARY REMEDIATION GOALS
FOR SITE 5 AREA GROUNDWATER
NAS JRB WILLOW GROVE, PENNSYLVANIA

Site-Specific COPC	Range of Positive Detection[1]			Exceeds Background	Exceeds Federal SDWA[1]	Proposed PRG VALUES[1]
	Min		Max	(Y)es/(N)o/NA	(Y)es/(N)o/NA	
Barium	43.8	-	1,430	Y	N	260 (3)
1,1,1-trichloroethane	2	-	960	Y	Y	200 (2)
1,1,2-trichloroethane	10	-	10	N	Y	5 (2)
1,1-dichloroethane	3	-	350	Y	NA	81 (3)
1,1-dichloroethene	6	-	300	Y	Y	7 (2)
1,2-dichloroethane	3	-	4	N	N	5 (2)
Benzene	3	-	28	N	Y	5 (2)
Tetrachloroethene	1	-	35	N	Y	5 (2)
Trichloroethene	5	-	300	Y	Y	5 (2)

(1) Units are µg/L.
(2) MCL.
(3) RBC - Risk Based Concentration for Tap Water, EPA Region 3.
NA - Not applicable.

The summary and basis for selecting groundwater COPCs, based on exceedance of regulatory requirements and risks to human health, are presented in Table 1-5. The organics and metal contaminants in groundwater that would contribute to excess human health carcinogenic risk (greater than 1 E-04 total) or HI (greater than 1.0) were selected as human health risk-based COPCs. PRGs for groundwater contaminants used the applicable numerical values, risk-based groundwater concentrations that do not result in carcinogenic risks exceeding 1 E-06 or HI greater than 0.1, and maximum detected background concentrations. A set of proposed Site 5 PRGs for groundwater is presented in Table 2-5, along with the basis for selection. These proposed groundwater PRGs can be used to estimate the volume of contaminated groundwater that may need to be evaluated for potential remedial action.

2.4 DEVELOPMENT OF GENERAL RESPONSE ACTIONS

The RAOs were used to develop general response actions that describe medium-specific measures that will satisfy the RAOs. General response actions presented in Office of Solid Waste and Emergency Response (OSWER) Directive No. 9355.3-01, Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, were evaluated for their applicability to each site's specific conditions, environmental media, the nature of the contaminants, and how the potential risks would be mitigated.

General response actions that are specific to Site 5 were selected based on the RAOs, the types and extent of contaminants present, and the mitigation of contaminated groundwater. General response actions that address potential human exposure to groundwater and continued migration of contaminated groundwater include:

- No action
- Monitored natural attenuation
- Institutional controls (limited action)
- Containment
- Collection, treatment (ex-situ), and discharge
- In-situ treatment

2.5 METHODOLOGY FOR IDENTIFICATION, SCREENING, AND EVALUATION OF REMEDIAL TECHNOLOGIES

During this phase of alternatives formulation, preliminary screening is performed to reduce the universe of potentially applicable technology types and process options. The purpose of screening is to investigate all available technologies and process options and to eliminate those obviously not applicable to specific conditions at each site, based on the established remedial action objectives and general response actions.

The technology identification considers the demonstrated performance of each technology with site conditions and contaminants.

Potential remedial technologies and process options are identified and screened according to their overall applicability (technical implementability) to the media (soils, groundwater, etc.), primary contaminants of concern (VOCs), and conditions present at the site, including heterogeneous soils, leaching of contaminants to underlying groundwater, erosion and runoff of contaminated materials, vertical hydraulic gradients, etc.

A detailed evaluation of technologies and process options retained in the preliminary screening step is conducted to further focus the alternatives development process. In this step, process options are evaluated with respect to other processes in the same technology category. One representative process option is selected, if possible, for each technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedy selection or remedial design. The evaluation of technologies and process options utilizes three criteria: effectiveness, implementability, and relative cost. The Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (Interim Final), (EPA, 1988) suggests that this evaluation focus on the effectiveness criterion, with less emphasis directed at the implementability and relative cost criteria. Brief definitions of effectiveness, implementability, and relative cost, as they apply to the evaluation process, follow:

Effectiveness - This criterion focuses on the potential effectiveness of process options in handling the estimated volume of media and meeting the remediation goals; the potential impacts to human health and the environment during construction and implementation; and how proven and reliable the process is with respect to the contaminants and conditions at the site.

Implementability - The implementability evaluation encompasses both the technical and institutional feasibility of implementing a process. Technical implementability was used in developing general response actions as an initial screen of technology types and process options, to eliminate those that are clearly ineffective or unworkable at a site. Therefore, this subsequent, more detailed evaluation of process options places greater emphasis on the institutional aspects of implementability, such as the ability to obtain permits, availability of treatment, storage, and disposal services, and availability of necessary equipment and resources.

Cost - Cost plays a limited role in this screening. The cost analysis is based on engineering judgment, and each process is evaluated as to whether costs are high, low, or medium relative to the other options in the same technology type. If there is only one process option, costs are compared to other candidate technologies.

2.6 TECHNOLOGY SCREENING

The selection of viable remedial technologies and process options for assemblage into remedial alternatives for Site 5 is presented in this section. Screening of the remedial technologies considered their overall applicability to the media of concern, primary contaminants (VOCs), known site conditions, and planned use of the site. During the screening step, process option and entire technology types were eliminated from further consideration on the basis of technical implementability. Site conditions that were considered included the presence of a VOC plume in groundwater extending away from the source of contamination and the continued migration of groundwater contaminants. The preliminary identification, screening and evaluation of groundwater response technologies are presented in Table 2-6.

The technologies and process options that are not likely to be implementable or effective or that would result in higher implementation costs were eliminated from further consideration. Site-specific considerations were also factors in the elimination of candidate technologies and process options. The remedial technologies that were retained after the detailed evaluation process are identified in Table 2-6. For contaminated groundwater, the following technology types and process options were retained for further considerations:

- No action
- Limited action
  - Deed restrictions and/or notices
  - Monitoring
- Natural attenuation
- Containment
  - Hydraulic barrier (injection/extraction wells)
- Extraction
  - Extraction wells
- In-Situ Treatment
  - Biological treatment
    - Anaerobic process
  - Chemical treatment
    - Chemical oxidation

TABLE 2-6
PRELIMINARY IDENTIFICATION, SCREENING AND EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR CONTAMINATED GROUNDWATER - SITE 5
NAS JRB WILLOW GROVE, PENNSYLVANIA
SHEET 1 OF 6

General Response Action	Technology	Process Options	Description	Screening Comment
No Action	None	Not applicable	No remedial activities conducted to address contamination. Long-term monitoring program to monitor groundwater levels.	Retained for baseline comparison purposes in accordance with NCP 40CFR Section 300.430(e).
Limited Action	Institutional controls	Deed restrictions and notices	Administrative action used to restrict future and current activities at site and at individual properties. Installation of private wells and use of untreated groundwater in the area of contamination may be restricted using property deeds.	Retain - Prevent potential human exposures to contaminated groundwater, protective of human health.
		Local ordinances	Administrative actions enacted by municipalities to limit property use or activities and installation of water supply wells.	Eliminate - Plume has not moved off site; difficult to implement and enforce. Deed restrictions and notices provide same level of protection.
	Monitoring	Sampling and analysis of groundwater	Periodic sampling and analysis of groundwater and other media to assess extent and nature of contaminant plume.	Retain - Groundwater monitoring is effective and implementable. Protective of human health and the environment.
Natural Attenuation	Natural Attenuation	Naturally occurring biodegradation and dilution	Monitoring of groundwater to assess contaminant dilution or degradation.	Retain - Natural attenuation appears to be happening in site groundwater and functioning to limit growth of the plume. Protective of human health and the environment.

TABLE 2-6
PRELIMINARY IDENTIFICATION, SCREENING AND EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR CONTAMINATED GROUNWATER - SITE 5
NAS JRB WILLOW GROVE, PENNSYLVANIA
SHEET 2 OF 6

General Response Action	Technology	Process Options	Description	Screening Comment
Containment	Vertical barriers	Slurry wall	Low-permeability subsurface wall used to restrict horizontal migration of contaminants and groundwater.	Eliminate - Dissolved contaminant plume is too large and groundwater contamination in residual zone extends beyond conventional equipment depth (>100 feet).
		Grout curtain	Pressure injection of low-permeability grout to form a continuous subsurface wall to restrict horizontal migration of groundwater.	Eliminate - Dissolved contaminant plume is too large and groundwater contamination in residual zone extends beyond conventional equipment depth where the installation would be impractical.
		Sheet piling	Metal sheet piling driven into the ground to restrict horizontal migration of groundwater.	Eliminate - Dissolved contaminant plume is too large and groundwater contamination in residual zone extends beyond conventional equipment depth where the installation would be too expensive and impractical.
		Hydraulic barrier	Use of injection and extraction wells within or around the contaminant plume to restrict horizontal migration of groundwater.	Retain - Use of extraction wells within and around the contaminant plume may effectively restrict its migration and may reduce its volume and/or area. Protective of human health and the environment.
	Horizontal barriers	Physical barrier	Injection of bottom sealing slurry beneath the source to minimize vertical migration of groundwater.	Eliminate - Source of contamination has been dispersed naturally over time.

TABLE 2-6
PRELIMINARY IDENTIFICATION, SCREENING AND EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR CONTAMINATED GROUNWATER - SITE 5
NAS JRB WILLOW GROVE, PENNSYLVANIA
SHEET 3 OF 6

General Response Action	Technology	Process Options	Description	Screening Comment
Extraction	Groundwater extraction	Extraction wells	Series of conventional pumping wells used to remove contaminated groundwater.	Retain - Use of extraction wells within and around a portion of the dissolved contaminant plume to withdraw groundwater may restrict its migration. Protective of human health and the environment.
		Collection trench	A permeable trench used to intercept and collect groundwater.	Eliminate - Groundwater contamination in residual zone extends to a depth beyond where the installation of such trenches would be practical.
In-Situ Treatment	Biological	Aerobic	Biodegradation of organics in an aerobic (oxygen-rich) environment by addition of electron donors with or w/o supplemental microbial cultures.	Eliminate - Not proven effective in a subsurface environment which appears to be anaerobic. Full-scale use may form different microbial culture or more toxic substances.
		Anaerobic	Biodegradation of organics in an anaerobic (oxygen-deficient) environment by addition of electron donors with or w/o supplemental microbial cultures.	Retain - Proven effective and implementable for large-scale uses in subsurface environment which is already anaerobic. Pilot studies should be conducted to confirm degradation of site-specific contaminants without formation of more toxic substances or microbial cultures. Protective of human health and the environment.

TABLE 2-6
PRELIMINARY IDENTIFICATION, SCREENING AND EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR CONTAMINATED GROUNWATER - SITE 5
NAS JRB WILLOW GROVE, PENNSYLVANIA
SHEET 4 OF 6

General Response Action	Technology	Process Options	Description	Screening Comment
In-Situ Treatment (continued)	Physical	Air sparging/ vapor extraction (AS/VE)	Volatilization of organics by injection of air in the groundwater and vacuum-extraction and treatment of volatilized compounds.	Eliminate - Mostly applicable for treatment of higher contaminant concentrations in residual zone or isolated areas in dissolved plume. Subsurface conditions and proximity to structures and residential areas are of concern.
		Permeable reactive barriers (PRBs)	Use of permeable barriers filled with a reactive medium (zero-valent iron) that allow the passage of groundwater and reacts with the contaminants.	Eliminate - Dissolved contaminant plume is too large and groundwater contamination in residual zone extends to a depth beyond conventional equipment limits. May also produce levels of other compounds that effects groundwater quality.
		Dynamic underground stripping	Vaporization of organics by injection of steam in the groundwater and vacuum extraction and treatment of volatilized compounds.	Eliminate - Only applicable to area of extremely high contaminant concentrations, which have not been encountered at this site.
	Chemical	Chemical oxidation	Degradation of organic contaminants by addition of strong oxidizing agents, including hydrogen peroxide and potassium permanganate.	Retain - Proven technology for treatment of higher contaminant concentrations in residual zone or isolated areas in dissolved plume. Pilot studies should be conducted to confirm effectiveness and implementability for site-specific contaminants and subsurface conditions. Protective of human health and the environment.
Ex-situ Treatment	Physical	Air stripping	Contact of water with forced air to strip off volatile and semi-volatile organics.	Retain - Proven technology for removal of VOCs and SVOCs from dissolved and residual groundwater plumes.
		Activated carbon adsorption	Removal of contaminants via vapor- or liquid-phase adsorption onto granular activated carbon (GAC) or other media.	Retain - Proven technology for removal of a wide range of organics from dissolved and residual groundwater plumes. Protective of human health and the environment.

TABLE 2-6
PRELIMINARY IDENTIFICATION, SCREENING AND EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR CONTAMINATED GROUNWATER - SITE 5
NAS JRB WILLOW GROVE, PENNSYLVANIA
SHEET 5 OF 6

General Response Action	Technology	Process Options	Description	Screening Comment
Ex-situ Treatment (continued)	Physical (continued)	Sedimentation	Separation of solids from water via gravity settling.	Retain - Proven technology as a pre- and/or post-treatment step for removing certain organics and may be used as a means of dewatering treatment residues. Protective of human health and the environment.
		Filtration	Separation of suspended solids from water via entrapment in a bed of granular media or membrane.	Retain - Proven technology as a pre- and/or post-treatment step for removing certain organics and may be used as a means of dewatering treatment residues. Protective of human health and the environment.
		Equalization	Providing a storage and blending tank in the treatment train to accommodate surges in flow and blend multiple streams of different composition for consistency of feed to downstream processes.	Retain - Proven technology as a pre-treatment step to prevent surges in flow and/or concentrations. Protective of human health and the environment.
	Chemical	Oxidation	Use of oxidizers such as air, UV ozone, peroxide, chlorine, or permanganate to oxidize organic compounds and precipitate inorganic compounds.	Eliminate - Mostly effective and applicable to extremely high level of contaminants, i.e., DNAPL, which have not been encountered at this site.
		Ion exchange	Process in which ions, held by electrostatic forces to charged functional groups on the resin surface, are exchanged for ions of similar charge in a water stream.	Eliminate - Mostly applicable to removal of dissolved inorganic compounds, which are not site chemical of concern (COC).
		Coagulation/ flocculation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	Retain - Proven technology as a pretreatment step prior to certain organics removal processes. Protective of human health and the environment.

TABLE 2-6
PRELIMINARY IDENTIFICATION, SCREENING AND EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR CONTAMINATED GROUNWATER - SITE 5
NAS JRB WILLOW GROVE, PENNSYLVANIA
SHEET 6 OF 6

General Response Action	Technology	Process Options	Description	Screening Comment
Ex-situ Treatment (continued)	Chemical (continued)	Neutralization/pH Adjustment	Use of acids or bases to counteract excess pHs.	Retain - Proven technology as a possible pretreatment step or final step prior to discharge. Protective of human health and the environment.
	Biological	Aerobic	Degradation of organic contaminants by a culture of microorganisms in an aerobic environment.	Eliminate - Mostly effective to removal of organic compounds in a large flow, which the quantity of site groundwater does not support.
		Anaerobic	Degradation of organic contaminants by a culture of microorganisms in an anaerobic environment.	Eliminate - Mostly effective to removal of organic compounds in a large flow, which the quantity of site groundwater does not support.
Disposal	On-site discharge	Reinjection	Use of injection wells and/or infiltration gallery to discharge collected and treated water underground.	Retain - Proven technology as a viable post-treatment step or final step to discharge treated water. Protective of human health and the environment.
		Spray irrigation	Use of spraying device to discharge collected and treated water.	Eliminate - Technology is not suitable in wet weather and winter time.
	Off-site discharge	Treatment facility	Treatment and disposal of water at an off site (near-by) treatment works.	Retain - NASJRB Willow Grove operates a treatment facility on property with significant capacity to accept the flow from Site 5 remedial action.

- Ex-Situ Treatment
  - Physical treatment
    - Air stripping
    - Activated carbon adsorption
    - Sedimentation
    - Filtration
    - Equalization
  - Chemical treatment
    - Coagulation/flocculation
    - Neutralization/pH adjustment
- Discharge
  - On-site discharge
    - Reinjection (injection wells and/or infiltration gallery)
  - Off-site discharge
    - Treatment facility

3.0 DEVELOPMENT AND SCREENING OF REMEDIAL ACTION ALTERNATIVES

The purpose of the alternative development and screening process is to assemble an appropriate range of possible remedial options to achieve the RAOs identified for the site. In this process, technically feasible technologies retained for further evaluation in Section 2 are combined to form remedial alternatives that provide varying levels of risk reduction.

3.1 DEVELOPMENT OF REMEDIAL ALTERNATIVES FOR SITE 5 GROUNDWATER

The section provides rationale for development of remedial alternatives, the assembled alternatives, and screening of these alternatives for Site 5 groundwater. Detailed evaluations and costing of the retained alternatives are presented in Section 4.0.

3.1.1 Rationale for Development of Remedial Alternatives

Factors considered in formulating the remedial alternatives to address the RAOs for Site 5 groundwater are discussed below:

Protection of Human Health Considerations - The RAO for protection of human health specifies preventing human exposure to contaminated groundwater. This objective has been addressed in the formulation of remedial alternatives.

Protection of the Environment Considerations - The RAO for protection of the environment specifies mitigating migration of VOC contaminants in groundwater to areas with potential receptors. This objective has been addressed in the formulation of remedial alternatives.

Navy/Marine Corps policy (as stated in the Installation Restoration Manual) dictates that the procedures outlined in the National Oil and Hazardous Substances Contingency Plan (NCP, 40 CFR 300.430) be followed for all IR sites. In accordance with this policy, alternatives development for Site 5 was conducted in compliance with statutory requirements of the NCP and in consideration of the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (Interim Final) (RI/FS Guidance), OSWER Directive No. 9355.3-01, EPA/540/G-89/004, October 1988.

The NCP and the EPA RI/FS guidance present a broad framework for the formulation, evaluation, and selection of remedial alternatives for uncontrolled hazardous waste sites. The NCP encourages development of a range of treatment alternatives, including one or more engineering control alternatives (such as containment), one or more innovative treatment alternatives, and the baseline no-action

alternative. Treatment technologies are favored to address principal threats and engineering controls are favored to address relatively low long-term threats.

3.1.2 Description of the Assembled Remedial Alternatives

Groundwater remediation alternatives that have been developed for the site on the basis of identification and screening of technology types and process options discussed in this section. The remedial alternatives identified for further evaluation include the following:

- Alternative 1: No action.
- Alternative 2: Monitored natural attenuation.
- Alternative 3A: Groundwater pump and treatment of entire plume and discharge to on-site sewer.
- Alternative 3B: Groundwater pump and treatment of plume source zone and discharge to on-site sewer.
- Alternative 4: In-situ treatment of groundwater by anaerobic enhanced biological reductive dehalogenation, groundwater recirculating, monitored natural attenuation.
- Alternative 5: In-situ treatment of groundwater by chemical oxidation process, groundwater recirculating, institutional control, long-term monitoring.

This section presents detailed descriptions of the remedial alternatives for Site 5. The key components of Alternatives 1 through 5 are identified on Table 3-1.

3.1.2.1 Alternative 1: No Action

The no-action alternative is developed as a baseline case, as required by the NCP. No remedial actions would be taken to protect human health or the environment. The purpose of the alternative is to evaluate the overall human health and environmental protection provided by the site in its present state for a comparison to the remedial alternatives developed. There would be no activities conducted under this alternative.

Under this alternative, no measures would be implemented to remove or contain the groundwater VOC plume, to prevent potential human exposure to site groundwater, or to mitigate contaminant migration in the environment. Key components of Alternative 1 are summarized on Table 3-1 and described below:

Existing Features - Currently, site features offer limited protection of human health and the environment. The primary protective feature is that underlying groundwater at Site 5 is not used as a potable water supply. As a result, there is currently no pathway for human exposure to VOC-contaminated groundwater. However, potable water supply wells are situated elsewhere in the vicinity of Site 5 (within approximately 1,700 feet of the plume boundary) and site groundwater could conceivably be used as a potable water supply in the future, posing a potential excess human health risk.

Discharge of contaminants to site media ceased when fire training operations were shut down at the site. Under Alternative 1, no actions would be taken to mitigate contaminant migration into the groundwater.

Costs - For the purpose of cost comparison, the No Action Alternative would have no costs.

Five-Year Reviews - Although contaminants remain on the site, a review of site conditions and risks would not be conducted every 5 years, as required by CERCLA.

3.1.2.2 Alternative 2: Monitored Natural Attenuation

Alternative 2 was developed as an alternative that involves little or no treatment but relies on natural processes to achieve groundwater PRGs. Under Alternative 2, the groundwater quality would be expected to gradually return to acceptable levels (i.e., eventually meet federal and state standards) through natural attenuation processes. Alternative 2 would attempt to limit human exposure through the establishment of land use controls. Monitoring would be conducted on a proposed frequency of quarterly in Years 1 through 3, and semi-annually in Years 4 through 30 to provide the monitoring of Site conditions required by federal ARARs.

NA relies on natural processes to achieve site-specific remedial objectives within a timeframe that is comparable to that offered by engineered alternatives. The natural processes consist of a variety of physical, chemical, or biological processes that act to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater.

TABLE 3-1
COMPONENTS OF REMEDIAL ALTERNATIVES
SITE 5 GROUNDWATER (OU 2) REMEDIATION
NAS JRB WILLOW GROVE, PENNSYLVANIA

	ALTERNATIVE	KEY COMPONENTS OF ALTERNATIVE
1	No Action	• None.
2	Monitored Natural Attenuation	• Institutional Controls (land use restrictions on the Base Master Plan). • Long-term monitoring of natural attenuation progress. • Predictive modeling. • Five-year reviews.
3A	Groundwater Pump and Treatment of Entire Plume and Discharge to On-Site Sewer	• Pre-design investigation, groundwater modeling, and extraction/treatment system design. • Installation of groundwater extraction well network for plume containment. • On-site treatment of VOC-contaminated groundwater (i.e., by air stripping and activated carbon polishing). • Monitoring of treatment system performance. • Discharge of treated water through the sanitary sewer to the NAS JRB Willow Grove's wastewater treatment plant. • Institutional controls. • Long-term monitoring. • Five-year reviews.
3B	Groundwater Pump and Treatment of Plume Source Zone and Discharge to On-Site Sewer	• Pre-design investigation, groundwater modeling, and extraction/treatment system design. • Installation of groundwater extraction well network for plume source zone only. • On-site treatment of VOC-contaminated groundwater (i.e., by air stripping and activated carbon polishing). • Monitoring of treatment system performance. • Discharge of treated water through the sanitary sewer to the NAS JRB Willow Grove's wastewater treatment plant. • Institutional controls. • Long-term monitoring. • Five-year reviews.

TABLE 3-1 (continued)
REMEDIAL ALTERNATIVES COMPONENTS
SITE 5 GROUNDWATER (OU 2)
NAS JRB WILLOW GROVE, PENNSYLVANIA
Page 2 of 2

	ALTERNATIVE	KEY COMPONENTS OF ALTERNATIVE
4	In-Situ Treatment of Groundwater by Anaerobic Reductive Dehalogenation, Groundwater Recirculating, Monitored Natural Attenuation	• Pre-design subsurface investigation, treatability studies, and pilot/field-scale testing. • Treatment system design and installation of recirculating (extraction and injection) well network and other equipment for addition of electron donor and microbial cultures. • Monitoring of treatment progress via existing monitoring wells. • Operation and maintenance of the in-situ treatment system. • Institutional Controls (land use restrictions/notices). • Long-term monitoring. • Predictive modeling. • Five-year reviews.
5	In-Situ Treatment of Groundwater by Chemical Oxidation Process, Institutional Control, Long-Term Monitoring	• Pre-design subsurface investigation, treatability studies, and pilot/field-scale testing. • Treatment system design and installation of injection wells for addition of oxidants and catalysts. • Monitoring of treatment progress via existing monitoring wells. • Operation and maintenance of the in-situ treatment system. • Institutional Controls (land use restrictions/notices). • Long-term monitoring. • Five-year reviews.

These processes include volatilization, dilution, sorption, biodegradation, dispersion, chemical or biological stabilization, transformation, or destruction of contaminants. Some natural attenuation processes may result in the creation of transformation products that are more toxic than the original parent. For example, reductive dehalogenation transforms TCE to 1,2-dichloroethene, which in turn degrades to vinyl chloride, which is more toxic than TCE. Vinyl chloride will further degrade to ethene and carbon dioxide.

A decision to support NA as a remedy or as a component of an engineered remedy needs to be adequately supported with site-specific characterization data and analysis. Site characterization for NA requires a quantitative understanding of contaminant phase distribution; partitioning between soil, soil gas, and groundwater; contaminant migration rates and pathways; and rates of biological and non-biological transformation and an understanding of how these factors vary with time and are supported within the local geological formation.

Screening analysis of historical TCE data based on concentrations observed at 05MW01 and 05MW10 using the BIOCHLOR model indicates a downward trend in TCE mass. This model, which has only moderate prediction accuracy, predicted the date for attainment of the PRGs. For purposes of planning and costing, it was assumed that the groundwater quality standard would be attained in 30 years. Appendix B presents the BIOCHLOR model results.

The monitoring program would be designed to accomplish the following:

- Demonstrate that TCE groundwater concentrations are attenuating as projected.
- Identify any potentially toxic transformation products resulting from biodegradation.
- Ensure no impact to downgradient receptors.
- Detect changes in environmental conditions that may reduce the efficacy of the natural attenuation processes.
- Verify attainment of clean-up goals.

The activities that would be conducted under this alternative include the development and maintenance of a predictive attenuation model, the installation of five new monitoring wells, long-term monitoring of groundwater to evaluate contaminant status and migration, and a review of site conditions and risks every 5 years. Key components of Alternative 2 are identified in Table 3-1. The cost estimate for Alternative 2 is provided in Appendix C.

Institutional Controls - Land use restrictions would be incorporated into the Base Master Plan to restrict the use of site groundwater until remediation is complete. Use of untreated groundwater for drinking would be prohibited during the remediation period.

Long-Term Monitoring - Groundwater would be sampled periodically to monitor the quality of groundwater and the potential for contaminant migration. It is assumed that samples would be collected from five new wells and five existing monitoring wells and would be analyzed for VOCs. The frequency of monitoring may be adjusted based on findings of the 5-year reviews.

Predictive Modeling - NA would rely on naturally occurring processes to reduce the concentrations of VOCs in the plume without human intervention. Implementation of monitored natural attenuation includes a comprehensive evaluation of historical analytical and current site data and incorporating that data into a predictive model. Predictive modeling to determine the efficacy of natural attenuation will require analytical or numerical simulation of a number of complex in-situ attenuation processes including biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants.

Five-Year Reviews - Since contaminants remain on site, a review of site conditions and risks would be conducted every 5 years, as required by CERCLA.

3.1.2.3 Alternative 3A: Pump and Treat Groundwater from Entire Plume and Discharge via Sewer Line to NAS JRB Willow Grove's Wastewater Treatment Plant

Under Alternative 3A, VOC-contaminated groundwater would be extracted from the entire plume and a groundwater treatment system would be installed. Extracted groundwater would be treated in a treatment plant constructed nearby. Effluent from the groundwater treatment plant would be discharged to the NAS JRB Willow Grove's sanitary sewer system. Institutional controls would be implemented to prevent exposure to untreated groundwater for the duration of the groundwater treatment period, until PRGs are achieved. Long-term monitoring would be conducted for the duration of the remediation period to assess the effectiveness of the remedial action and to determine when remediation is complete. Site conditions and risks would be reviewed every 5 years until remediation is complete. Key components of Alternative 3A are summarized on Table 3-1 and described below:

Pre-Design Investigation, Groundwater Modeling, and Extraction/Treatment System Design - Pre-design investigations, consisting of a hydrogeologic evaluation and sampling and analysis of groundwater and aquifer materials, would be required to support the design of the groundwater extraction and treatment systems. The hydrogeologic investigation would be used to better define steady-state aquifer characteristics (i.e., hydraulic conductivity, transmissivity, and hydraulic gradient) in order to determine the sizing, placement, and design of the extraction system. The investigation would include a single well aquifer pump test, groundwater elevation monitoring, and physical analysis of aquifer materials.

To aid in the design of an effective groundwater treatment system, extracted groundwater, representative of that which would ultimately be pumped into the treatment system, would be collected during the pump test and analyzed for chemical constituents. Groundwater collected from site monitoring wells or comparable sample locations would also be analyzed to better delineate the extent of contamination and optimize placement of the groundwater extraction system.

Installation of Groundwater Extraction Well Network - A groundwater containment (extraction) system would be installed to depths of approximately 30 to 150 feet in the overburden aquifer to capture the VOC contaminant plume. A groundwater containment system consisting of groundwater extraction wells would be placed near the downgradient edge of the plume. The leading plume edge extraction system would be situated just downgradient of the highest levels of contamination in order to maximize contaminant recovery and minimize the capture of uncontaminated groundwater. Extracted groundwater would be pumped to a groundwater treatment system. The actual pumping rate and number and location of extraction wells would be determined based on the results of the pre-design investigations. The proposed location of the extraction system is shown on Figure 3-1.

On-Site Groundwater Treatment System - Extracted groundwater would be treated in a plant on the surface of Site 5, using technology selected during the design phase. For the purpose of this FS, it is assumed that the groundwater treatment system would consist of an air stripper for removal of the majority of VOCs and aqueous phase activated carbon treatment unit for final polishing of VOCs to attain PRGs. Air stripping and activated carbon are widely used and effective technologies for the removal of VOCs from groundwater. If necessary to prevent fouling of the air stripper or to meet discharge requirements, pre-treatment of the groundwater for removal of metals and suspended solids would be conducted. Pre-treatment may include sedimentation and filtration. Exhaust air from the air stripper may require treatment to remove VOCs prior to discharge to the atmosphere. If necessary, activated carbon would be used to remove VOCs from the air stream. The final system design would be determined based on chemical characterization of groundwater extracted during the pump tests. A typical process flow diagram of the proposed treatment process is presented on Figure 3-2.

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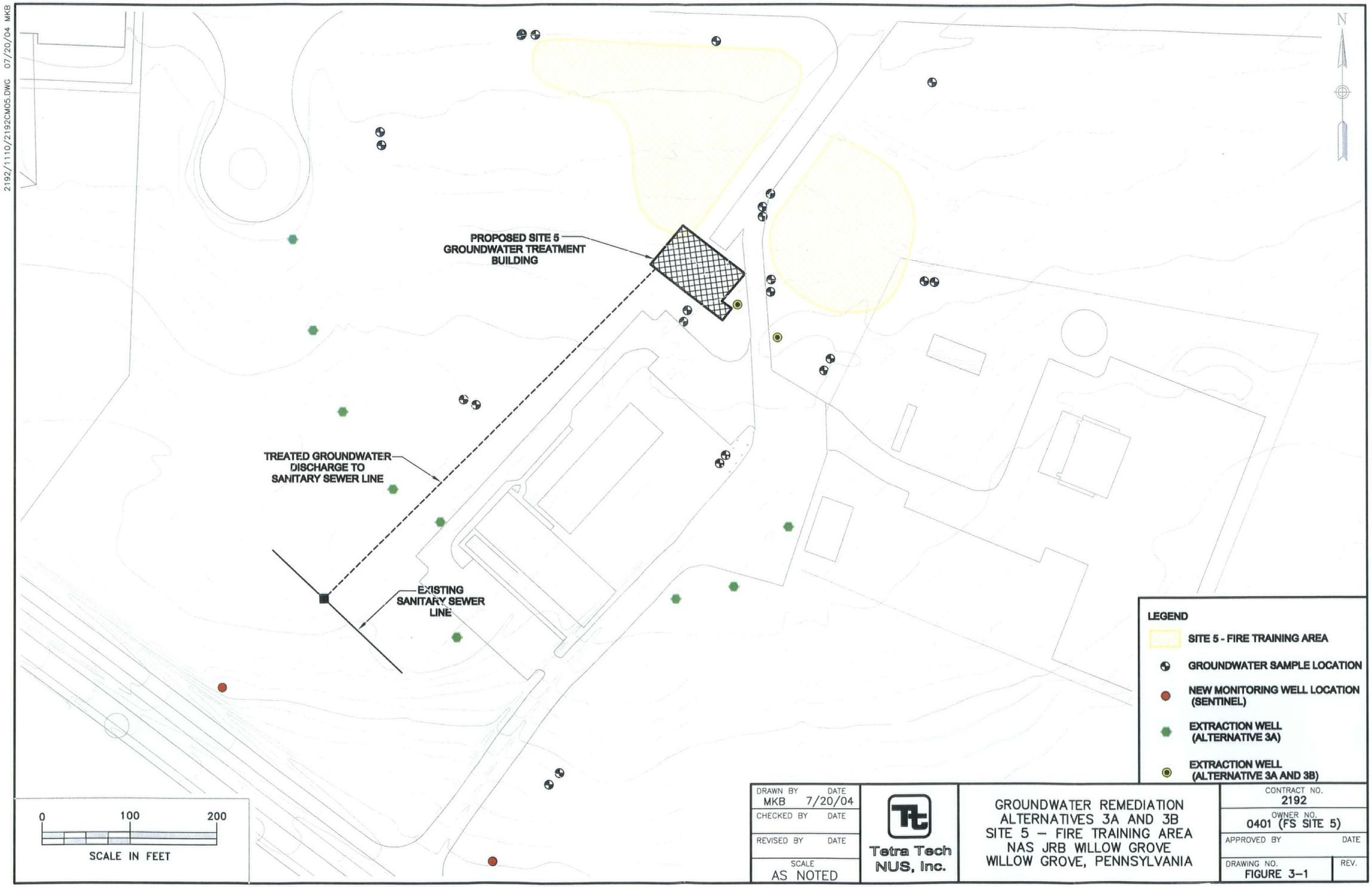
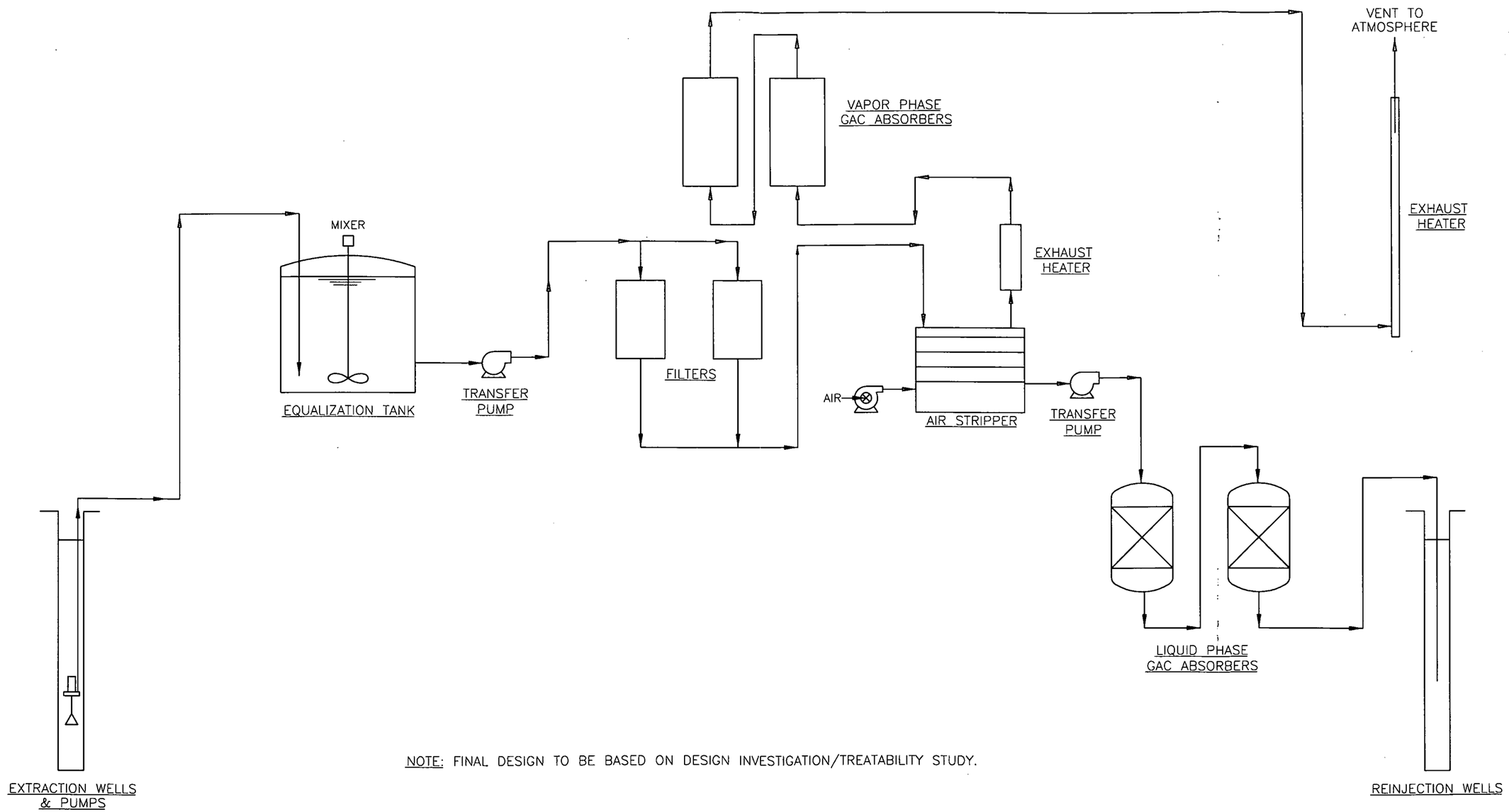


DRAWN BY MKB DATE 7/20/04	Tetra Tech NUS, Inc.	GROUNDWATER REMEDIATION ALTERNATIVES 3A AND 3B SITE 5 – FIRE TRAINING AREA NAS JRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	CONTRACT NO. 2192
CHECKED BY DATE			OWNER NO. 0401 (FS SITE 5)
REVISED BY DATE			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 3–1 REV.

2192/1110/2192FP01.DWG 07/20/04 MKB



NOTE: FINAL DESIGN TO BE BASED ON DESIGN INVESTIGATION/TREATABILITY STUDY.

DRAWN BY MKB DATE 7/20/04	Tetra Tech NUS, Inc.	PROCESS FLOW DIAGRAM TYPICAL GROUNDWATER TREATMENT SYSTEM ALTERNATIVES 3A AND 3B SITE 5 – FIRE TRAINING AREA NAS JRB WILLOW GROVE WILLOW GROVE, PENNSYLVANIA	CONTRACT NO. 2192
CHECKED BY DATE			OWNER NO. 0401 (FS SITE 5)
REVISED BY DATE			APPROVED BY DATE
SCALE NONE			DRAWING NO. FIGURE 3–2 REV.

Discharge of Treated Water to the NASJRB Willow Grove's Wastewater Treatment Plant - The treated (clean) water will be tested regularly to demonstrate that it meets the discharge criteria set by NAS JRB Willow Grove's wastewater treatment facility and could then be discharged to it through the sanitary sewer.

Monitoring of Treatment System Performance - The performance of the on-site treatment system will be assessed regularly (monthly, quarterly, and/or annually) by sampling and analysis of the system influent, effluent, system operations, and a network of groundwater monitoring wells.

Institutional Controls - Under Alternative 3A, land use restrictions would be incorporated into the Base Master Plan to restrict the use of site groundwater until remediation is complete. Use of untreated groundwater for drinking would be prohibited during the remediation period.

Long-term Monitoring - Under Alternative 3A, groundwater elevation monitoring would be conducted monthly for the first year of system operation to monitor the effectiveness of the groundwater extraction system. Periodic (beginning as semi-annual) groundwater monitoring and chemical analysis would be conducted to monitor the effectiveness of the remedial action. The data would be used to determine the need for additional actions and to determine when remediation goals have been achieved.

For the purpose of costing, it is assumed that groundwater samples would be collected from 10 existing monitoring wells. Three of the 10 monitoring wells would be located near the highest concentration of TCE in the plume, and the remaining seven would be located downgradient of the currently delineated plume. All samples would be analyzed for site-specific contaminants (VOCs).

Five-Year Reviews - Since contaminants would remain in groundwater, a review of site conditions and risks would be conducted every 5 years until remediation goals have been achieved, as required by CERCLA. The reviews would consist of evaluating analytical and hydrogeologic data, assessing whether contaminant migration has increased, and determining whether human receptors or natural resources are at risk.

3.1.2.4 Alternative 3B: Pump and Treat Groundwater from Plume Source Zone and Discharg via Sewer Line to NAS JRB Willow Grove's Wastewater Treatment Plant

Under Alternative 3B, VOC-contaminated groundwater would be extracted from the plume source zone and a groundwater treatment system would be installed. Extracted groundwater would be treated in a treatment plant constructed nearby. Effluent from the groundwater treatment plant would be discharged to the NAS JRB Willow Grove's sanitary sewer system. Institutional controls would be implemented to prevent exposure to untreated groundwater for the duration of the groundwater treatment period, until

PRGs are achieved. Long-term monitoring would be conducted for the duration of the remediation period to assess the effectiveness of the remedial action and to determine when remediation is complete. Site conditions and risks would be reviewed every 5 years until remediation is complete. Key components of Alternative 3B are summarized on Table 3-1 and described below:

Pre-Design Investigation, Groundwater Modeling, and Extraction/Treatment System Design - Pre-design investigations, consisting of a hydrogeologic evaluation and sampling and analysis of groundwater and aquifer materials, would be required to support the design of the groundwater extraction and treatment systems. The hydrogeologic investigation would be used to better define steady-state aquifer characteristics (i.e., hydraulic conductivity, transmissivity, and hydraulic gradient) in order to determine the sizing, placement, and design of the extraction system. The investigation would include a single well aquifer pump test, groundwater elevation monitoring, and physical analysis of aquifer materials.

To aid in the design of an effective groundwater treatment system, extracted groundwater, representative of that which would ultimately be pumped into the treatment system, would be collected during the pump test and analyzed for chemical constituents. Groundwater collected from site monitoring wells or comparable sample locations would also be analyzed to better delineate the extent of contamination and optimize placement of the groundwater extraction system.

Installation of Groundwater Extraction Well Network - A groundwater containment (extraction) system would be installed to a depth of approximately 30 to 150 feet in the overburden aquifer to capture the VOC contaminant plume. A groundwater containment system consisting of groundwater extraction wells would be placed near the more concentrated plume source zone. Extracted groundwater would be pumped to a treatment system. The actual pumping rate and number and location of extraction wells would be determined based on the results of the pre-design investigations. The proposed location of the extraction system is shown on Figure 3-1.

On-Site Groundwater Treatment System - Extracted groundwater would be treated in a plant on the surface of Site 5, using technology selected during the design phase. For the purpose of this FS, it is assumed that the groundwater treatment system would consist of an air stripper for removal of the majority of VOCs and aqueous phase activated carbon treatment unit for final polishing of VOCs to attain PRGs. Air stripping and activated carbon are both widely used and effective technologies for the removal of VOCs from groundwater. If necessary to prevent fouling of the air stripper or to meet discharge requirements, pre-treatment of the groundwater for removal of metals and suspended solids would be conducted. Pre-treatment may include sedimentation and filtration. Exhaust air from the air stripper may require treatment to remove VOCs prior to discharge to the atmosphere. If necessary, activated carbon would be used to remove VOCs from the air stream. The final system design would be determined based on chemical characterization of groundwater extracted during the pump tests. A typical process flow

diagram of the proposed treatment process is presented on Figure 3-2. The treated (clean) groundwater would then be discharged to the NAS JRB Willow Grove wastewater treatment plant.

Monitoring of Treatment System Performance - The performance of the on-site treatment system will be assessed regularly (monthly, quarterly, and/or annually) by sampling and analysis of the system influent, effluent, system operations, and a network of groundwater monitoring wells.

Discharge of Treated Water to the NASJRB Willow Grove's Wastewater Treatment Plant - The treated (clean) water will be tested regularly to demonstrate that it meets the discharge criteria set by NAS JRB Willow Grove's wastewater treatment facility and could then be discharged to it through the sanitary sewer.

Institutional Controls - Under Alternative 3B, land use restrictions would be incorporated into the Base Master Plan to restrict the use of site groundwater until remediation is complete. Use of untreated groundwater for drinking would be prohibited during the remediation period.

Long-term Monitoring - Under Alternative 3B, groundwater elevation monitoring would be conducted monthly for the first year of system operation to monitor the effectiveness of the groundwater extraction system. Periodic (beginning as semi-annual) groundwater monitoring and chemical analysis would be conducted to monitor the effectiveness of the remedial action. The data would be used to determine the need for additional actions and to determine when remediation goals have been achieved.

For the purpose of costing, it is assumed that groundwater samples would be collected from 10 existing monitoring wells. Three of the 10 monitoring wells would be located near the highest concentration of TCE in the plume, and the remaining seven would be located downgradient of the currently delineated plume. All samples would be analyzed for site-specific contaminants (VOCs).

Five-Year Reviews - Since contaminants remain in groundwater, a review of site conditions and risks would be conducted every 5 years until remediation goals have been achieved, as required by CERCLA. The reviews would consist of evaluating analytical and hydrogeologic data, assessing whether contaminant migration has increased, and determining whether human receptors or natural resources are at risk.

3.1.2.5 Alternative 4: In-Situ Treatment of Groundwater by Enhanced Biological Anaerobic Reductive Dehalogenation, and Monitored Natural Attenuation

Alternative 4 utilizes in-situ enhanced biological anaerobic reductive dehalogenation treatment and monitored natural attenuation (MNA) to promote remediation of the VOC-contaminated groundwater.

Under anaerobic conditions, a variety of naturally occurring bacteria can convert PCE and TCE to cis-1,2-dichloroethylene (cis-1,2-DCE). While less common, other naturally occurring bacteria can transform TCE and cis-1,2-DCE to vinyl chloride (VC) and then ethene/ethane or complete mineralization (i.e., CO_2, H_2O, and chlorine). At Site 5, ethene, ethane and CO_2 are elevated above background at a number of sampling locations, indicating that intrinsic anaerobic biodegradation of the VOCs in groundwater is occurring. However, the concentrations of these end-products are low relative to the concentrations of the parent compounds (e.g. TCE and 1,1,1-TCA) indicating that this process is proceeding at a low rate, and rather incompletely in some areas of the Site. The predominance of cis-1,2-DCE over trans-1,2-dichloroethylene (trans-1,2-DCE), a manufactured VOC product, indicates that cis-1,2-DCE is the product of anaerobic degradation of TCE rather than a VOC introduced to the subsurface.

A laboratory treatability study and/or field pilot test are recommended to test the effectiveness of several different electron donors with the site aquifer materials, including soils and groundwater. If electron donor addition alone does not result in rapid degradation of VOCs, bioaugmentation can be considered to accelerate the degradation process. Specific dehalorespiring microorganisms, such as *dehalcoccoides ethenogenes*, can be used to augment the natural-occurring microorganisms.

When the majority of site VOCs has been biodegraded, treatment of Site 5 groundwater may be continued by NA processes to achieve groundwater PRGs. Similar to Alternative 2, the NA process consists of a variety of physical, chemical, or biological processes that act to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These processes include volatilization, dilution, sorption, biodegradation, dispersion, chemical or biological stabilization, transformation, or destruction of contaminants. Institutional controls would be implemented to prevent exposure to untreated groundwater for the duration of the groundwater treatment period, until PRGs are achieved. Long-term monitoring would be conducted for the duration of the remediation period to assess the effectiveness of the remedial action and to determine when remediation is complete. Site conditions and risks would be reviewed every 5 years until remediation is complete. Key components of Alternative 4 are summarized on Table 3-1 and described below:

<u>Pre-Design Subsurface Investigation, Treatability Studies, and Pilot/Field-Scale Testing</u> - Pre-design investigations, consisting of a hydrogeologic evaluation, and sampling and analysis of groundwater and aquifer materials, would be required to provide current conditions of the subsurface and site groundwater. The investigation would include a single well aquifer injection test, groundwater elevation monitoring, and physical analysis of aquifer materials. Groundwater collected from site monitoring wells or comparable sample locations would be analyzed to delineate the extent of contamination and select the locations of the injection, extraction, and monitoring well networks.

The hydrogeologic investigation will be used to define steady-state aquifer characteristics (i.e., hydraulic conductivity, soil porosity, and hydraulic gradient) for the subsequent treatability/pilot studies regarding electron donors and/or microbial cultures injection/delivery systems. The location, sizing and design of the extraction and injection (recirculating) well network for this remedial alternative will be determined by the results of pilot/field testing. Other physical and chemical parameters, such as soil organic and moisture contents, organic and inorganic matters in groundwater, oxygen content, and redox potential, will be acquired as well.

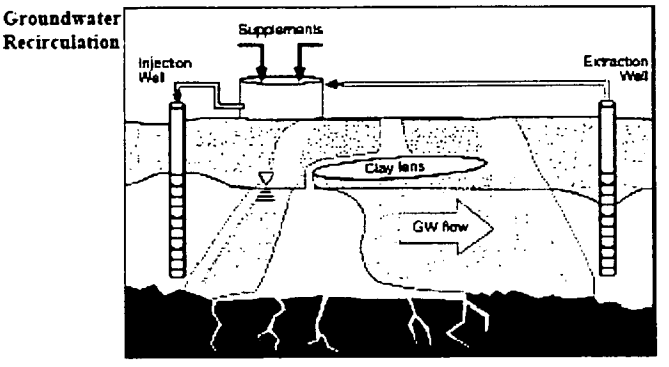
Treatability (bench- or laboratory-scale) testing may be conducted to evaluate the effectiveness of candidate degradation mechanisms and remediation processes that are being considered for the site. For example, results of treatability testing can be used to determine the conditions under which degradation products are produced, the rates of degradation, and the paths of degradation. Examples of treatability tests for in-situ bioremediation of VOCs include microcosm bottle studies and soil column studies. Data from treatability testing can help identify the parameters to be used for field-scale testing and implementation.

Pilot- or field-scale testing may be used to aid in the design and installation of an extraction and/or injection system at a site, and operation of that system over time. Existing monitoring wells that are located between the injection and extraction wells will be utilized to monitor the pilot testing progress. It is assumed that a small pilot-scale test of a groundwater recirculating system will include a system with two 2-inch injection wells spaced along 12-inch centers, one 2-inch extraction well down-gradient from the injection wells, and one 4-inch extraction well further down-gradient. This design requires that the system be oriented parallel to the natural flow direction, and that the spacing between injection and extraction wells be the distance that groundwater would travel in 30+ days under natural flow conditions.

Treatment System Design and Installation - In the system design stage, a system configuration such as groundwater recirculation or direct injection that is appropriate for site conditions and remedial goals is paired with one or more enhanced biological remediation technology. Major considerations for system design include the type and size of extraction and injection systems, the arrangement of plumbing and other infrastructure, the method and schedule for addition of amendments, monitoring system equipment, and monitoring schedule. Considerations include design of components such as storage containers, pumps, mixers, and flow meters.

In general, for a groundwater recirculating system, well spacing is designed to be at a distance sufficient to observe measurable changes in contaminant concentrations between two or more wells. Residence time or period is the amount of time required for a pollutant molecule to pass through the contaminated area.

For Site 5 OU 2 groundwater remediation, a full-scale design is assumed to be 3 times of the field-scale recirculating well network and permanent equipment for storage and mixing purposes. A typical in-situ bioremediation system configuration with groundwater recirculation is illustrated in Figure 3-3.



Source: Modified from USAF 1998

Figure 3-3 Conceptual Diagram of In-Situ Bioremediation System with Recirculating

Monitoring of Treatment Progress via Existing Monitoring Wells - Two important aspects of a remedial action are the monitoring of the treatment progress and evaluation of the results to determine system effectiveness. At Site 5, it is assumed that treatment system monitoring will be accomplished by the existing monitoring well network. Evidence for treatment system performance includes:

- Reduction in contaminant mass - this includes temporal and spatial reductions in concentrations; integration of extrapolated concentration measurements for the system; comparison of concentrations through multiple recirculating cycles and addition of amendments; and comparison of mass leaving injection points and arriving at extraction points.

- Microbiological activity linked to degradation - this includes microcosm or column studies which demonstrate metabolic activity; demonstrations showing that calculated field degradation rates are consistent with microcosm or column studies; and correlation of biomass in the field with zones of contaminant depletion.

In-Situ Treatment System Operation and Maintenance - Treatment system start-up activity will be carried out to ensure microbial populations are acclimatized to the added amendments. After start-up, routine operation and maintenance will be performed, in addition to monitoring of system performance. The types of data gathered and evaluated will include information about reductions in contaminant mass and microbiological activity linked to degradation.

Clogging of injection and extraction wells is a typical problem for in-situ bioremediation systems. Clogging occurs when there is a buildup of biomass on or near the well screens, making it difficult to inject or extract fluids from the subsurface. Techniques that have been used to reduce the impacts from clogging include pulsed addition of substrates, use of reduced concentrations of substrates, and routine well cleaning.

Institutional Controls (Land Use Restrictions/Notices) - Under Alternative 4, land use restrictions would be incorporated into the Base Master Plan to restrict the use of site groundwater until remediation is complete. Consumption of untreated groundwater would be prohibited during the duration of the remediation period.

Long-Term Monitoring - Under Alternative 4, groundwater elevation monitoring will be conducted continuously by transducers in the injection wells and advanced warnings will be provided to system operators to prevent overflowing situations. For extraction wells and monitoring wells, monthly monitoring of the groundwater elevations will be performed by the system operators for the first year of system operation to monitor the effectiveness of the groundwater recirculating system. Periodic (quarterly and then semi-annually) groundwater monitoring and chemical analysis will be conducted to monitor the effectiveness of the remedial action. The data will be used to determine the need for additional actions and to determine when remediation goals have been achieved.

For the purpose of costing, it is assumed that groundwater samples would be collected from 6 injection/extraction wells and 6 existing monitoring wells. There are 3 injection wells to be located up gradient of the plume source area and 3 extraction well at the downgradient edge of the plume. Two of the 6 monitoring wells would be located near the highest concentration of TCE in the plume, and the remaining 4 monitoring wells would be located further downgradient of the currently delineated plume. All samples would be analyzed for site-specific contaminants (VOCs) and parameters that will demonstrate biodegradation and natural attenuation activities in the subsurface.

Predictive Modeling - NA would rely on naturally occurring processes to reduce the concentrations of VOCs in the plume without human intervention. Implementation of monitored NA includes a comprehensive evaluation of historical analytical and current site data and incorporating that data into a predictive model. Predictive modeling to determine the efficacy of NA will require analytical or numerical simulation of a number of complex in-situ attenuation processes including biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants.

Five-Year Reviews - Since contaminants remain in the subsurface for a period of time, a review of site conditions and risks would be conducted every 5 years until remediation goals have been achieved, as

required by CERCLA. The reviews would consist of evaluating analytical and hydrogeologic data, assessing whether contaminant migration has increased, and determining whether human receptors or natural resources are at risk.

3.1.2.6 Alternative 5: In-Situ Treatment of Groundwater by Chemical Oxidation

Chemical oxidation processes involve oxidation-reduction (redox) reactions, which are essentially an exchange of electrons between chemical species. This exchange of electrons affects the oxidation state (valence) of the chemical species involved. The carbon bonds are broken as a result and the organic compounds are either completely destroyed or converted to smaller and typically less hazardous compounds. Recent advances in the development of this technology include systems that effectively deliver and distribute reagents into soil and groundwater so that in-situ chemical oxidation (ISCO) may be favorable. ISCO technologies are somewhat selective with regard to target compounds and have been shown to be generally effective on halogenated and nonhalogenated volatiles and certain semivolatiles, PCBs, pesticides, and cyanides. The rate of reaction is highly variable, depending on the compound being treated. Many of the most common contaminants, such as halogenated hydrocarbons, saturated aliphatic hydrocarbons, and benzene, have relatively low rates of reactivity. Remediation success using ISCO is heavily dependent on the ability to deliver the oxidant to the contaminated area. As is the case with other in-situ treatment technologies, low soil permeability and heterogeneity can be problematic for ISCO systems. Potential delivery methods include soil mixing, direct injection, and oxidant recirculating. This alternative assumes that direct injection to groundwater is to be used. Nevertheless, other types of delivery system configurations and dosing rates will be considered during design process in order to optimize remediation.

Institutional controls would be implemented to prevent exposure to untreated groundwater for the duration of the groundwater treatment period, until PRGs are achieved. Site groundwater monitoring would be conducted for the duration of the remediation period to assess the effectiveness of the remedial action and may be required for long-term in order to verify that remediation is complete. Site conditions and risks would be reviewed every 5 years until remediation is complete. Key components of Alternative 5 are summarized on Table 3-1 and described below:

Pre-Design Subsurface Investigation, Treatability Studies, and Pilot/Field-Scale Testing - The success of in-situ chemical oxidation (ISCO) technology to remediate Site 5 groundwater is heavily contingent upon the ability to deliver the oxidant(s) to the contaminated zone(s) and the appropriate oxidant(s) for the site-specific contaminants. Similar to Alternative 4, pre-design investigations for subsurface conditions would consist of a hydrogeologic evaluation, investigation, and sampling and analysis of groundwater and aquifer materials. The investigation would typically utilize a single- or multi-well aquifer injection test, groundwater elevation monitoring, and physical analysis of aquifer materials. Groundwater collected from site

monitoring wells or comparable sample locations would be analyzed to delineate the extent of contamination and select the locations of the injection and monitoring well networks. Also, the hydrogeologic investigation will be used to define steady-state aquifer characteristics (i.e., hydraulic conductivity, soil porosity, and hydraulic gradient) for subsequent treatability/pilot studies. Other physical and chemical parameters, such as soil organic and moisture contents, organic and inorganic matters in groundwater, redox potential, etc., need to be acquired as well.

Treatability (bench- or laboratory-scale) testing is generally conducted after site characteristics, contaminant oxidation mechanisms, and potential enhancements have been identified. Treatability testing will be used to evaluate the effectiveness of oxidation mechanisms and enhancements that may be applicable or under consideration for the site groundwater remediation. Data from treatability testing can help identify the parameters to be used for pilot-or field-scale testing and full-scale implementation.

Pilot- or field-scale testing is used to aid in the design and installation of an injection system at a site, and operation of the system over time. Existing monitoring wells that are located between the injection and downgradient receptors are assumed to be utilized for monitoring the progress of pilot testing. A small pilot-scale test of a groundwater injection system utilizes two 2-inch injection wells in two groundwater zones in the source areas and two tiers of monitoring wells down-gradient from the injection wells. The spacing between injection and monitoring wells will be the distance that groundwater would be treated by chemical oxidation based on the treatability testing.

Treatment System Design and Installation of Injection Wells for Addition of Oxidants and Catalysts - The primary considerations associated with design of an ISCO system include the mass of site contaminants to treat, the type and quantity of reagent needed for complete oxidation, design of an effective delivery system, and installation of delivery or injection system. Three of the most common in situ chemical oxidation technologies are potassium permanganate ($KMnO_4$), hydrogen peroxide (H_2O_2) or Fenton's Reagent, and ozone (O_3). Site-specific information is needed for field application. Some basic considerations for ISCO are provided below:

- Treatable compounds: Chlorinated alkenes, PAHs, and petroleum products. Not effective for chlorinated alkanes and saturated aliphatic hydrocarbons.

- Natural organic matter and other reduced species: Any reduced species in the system can exert a demand for oxidant. Of particular importance are the natural organic matter, anthropogenic organic matter, and reduced inorganics.

- Permeability: Prefer high permeability, but feasible for low permeability with use of advanced oxidant delivery techniques, such as deep soil mixing and soil fracturing.

- Depth of Application: With use of the advanced delivery techniques, depth is generally not a serious limitation.

- Potential Detrimental Effects: Gas evolution, toxic byproducts, resolubilization of metals and reduction of natural biomass.

- Optimal pH for representative oxidants:
  - Permanganate - Prefer neutral pH of 7 to 8, but effective over a wide range.
  - Fenton's Reagent - Prefer low pH of 2 to 4, but feasible up to near neutral pH.
  - Ozone - Effective at natural soil pH.

- Degradation characteristics:
  - Permanganate - The oxidant is very stable.
  - Fenton's Reagent - Easily degraded in contact with soil/groundwater.
  - Ozone - Ozone degradation in soils is limited.

Monitoring of Treatment Progress via Existing Monitoring Wells - As a remediation plan is implemented, the remediation process will be monitored to confirm that the specific ISCO technology and remediation design are in fact addressing the following basic concerns:

- Technology applicability
- Remediation design
- Safety
- Technical performance

Process monitoring is done as a quality control measure before, during and immediately after the injection operation. Process monitoring consists primarily of the following:

- Confirmation of oxidant injection concentrations, volumes, and flow rates.
- Measurement of oxidant concentrations in groundwater or soil gas samples.
- Measurement of oxidant persistence.

Performance monitoring is done primarily after the injection operations, although preinjection data must be gathered to establish a baseline.

At Site 5, it is assumed that treatment system monitoring will be accomplished by the existing monitoring well network. Evidence for treatment system performance includes:

- Reduction in contaminant mass - this includes temporal and spatial reductions in concentrations; integration of extrapolated concentration measurements for the system; comparison of concentrations through addition of oxidants and catalysts; and comparison of mass leaving injection points and arriving at monitoring points.

- Distribution and usage of oxidants - this includes studies of spatial concentrations of oxidants which demonstrate delivery of chemicals and oxidative activities; and correlation of oxidants in the subsurface with zones of contaminant depletion.

Common field monitoring parameters and analytical methods or instruments are:

- Site contaminants - EPA SW 846 8260B
- Oxidant - Field test kit
- Metals - EPA Method 200.7 (ICP), SM 3120B
- Major ions (Na, K, Ca, Mg, Fe) - EPA Method 200.7 (ICP) SM 3120B
- Nitrate, sulfate, and chloride - EPA Method 300 – Ion chromatography
- Alkalinity, as $CaCO_3$ - EPA Method 310.1, SM 2320B
- ORP (Eh) - Field measurement SM 18th ED 2580B
- pH, hydrogen ion - Field measurement EPA Method 150.1, 18th ED
- Temperature - Field measurement EPA Method 170.1, 18th ED
- Specific conductance - Field measurement EPA Method 120.1, 18th ED

To determine the effectiveness of treatment and to evaluate if the desired degree of oxidation is achieved, oxidant level, contaminant level, and geochemical conditions will be monitored. Due to adsorption and desorption equilibrium, contaminant concentrations often rebound. Therefore, monitoring will be conducted for at least a few years to evaluate the final level of treatment obtained.

Operation and Maintenance of the In-Situ Treatment System - Potassium permanganate (KMnO4) can be readily mixed in concentrations of about 3–4%. The actual concentration obtained may vary depending on temperature and the dissolved solids in the make-up water. Sodium permanganate (NaMnO4) is available in liquid form at a 40% (by weight concentration. Typical concentrations for injection range up to approximately 25%. The permanganate concentration needed at the site can be determined by dividing

the required total permanganate dose (either estimated or based on bench or pilot tests) into the appropriate injection volume (based on site hydrogeology and other constraints).

For delivery of aqueous solutions of permanganate, selection of the solution injection concentration and volume are key to the resulting subsurface oxidant delivery. Injection of higher concentrations of permanganate can promote greater diffusion and can result in greater permanganate persistence. However, injection of greater permanganate concentrations can also result in lower treatment efficiency because the matrix demand is generally greater at larger oxidant concentrations.

Oxidants would be applied at a number of injection wells and in several phases to obtain optimum results for a full-scale treatment system. Such an approach offers both technical and cost advantages.

Institutional Controls (Land Use Restrictions/Notices) - Under Alternative 5, land use restrictions would be incorporated into the Base Master Plan to restrict the use of site groundwater until remediation is complete. Consumption of groundwater would be prohibited during the duration of the remediation period.

Long-Term Monitoring - Under Alternative 5, groundwater elevation monitoring would be conducted continuously by transducers in the injection wells and advanced warnings will be provided to system operators to prevent overflowing situations. For monitoring wells, monthly monitoring of the groundwater elevations will be performed by the system operators for the first year of system operation to monitor the effectiveness of the groundwater remedial action. Periodic (quarterly and then semi-annually) groundwater monitoring and chemical analysis will be conducted to monitor the effectiveness of the remedial action. The data will be used to determine the need for additional actions and to determine when remediation goals have been achieved.

For the purpose of costing, it is assumed that groundwater samples would be collected from 10 existing monitoring wells. There are 2 monitoring wells located upgradient of the plume source area and 8 monitoring wells in 2 rows in the downgradient direction of the plume. All samples would be analyzed for site-specific contaminants (VOCs) and parameters that will verify chemical oxidation is occurring in the subsurface.

Five-Year Reviews - Since contaminants remain in the subsurface for a period of time, a review of site conditions and risks would be conducted every 5 years until remediation goals have been achieved, as required by CERCLA. The reviews would consist of evaluating analytical and hydrogeologic data, assessing whether contaminant migration has increased, and determining whether human receptors or the environment are at risk.

3.2 SCREENING OF REMEDIAL ALTERNATIVES FOR SITE 5 GROUNDWATER

3.2.1 Screening Criteria for Remedial Alternatives

In the screening process, alternatives are evaluated generally with regard to effectiveness, implementability, and cost. The purpose of the evaluation is to control the number of alternatives that will undergo a more thorough and extensive analysis so that the detailed evaluation in Section 4 focuses on the most plausible array of remedial alternatives. If possible, the alternatives carried forward for detailed evaluation should include the full range of alternatives recommended in the NCP and EPA RI/FS Guidance: no action, treatment, and containment.

3.2.2 Screening Results

The alternative screening process for Site 5 resulted in five of the six identified alternatives being retained for further evaluation in order to preserve a full range of representative and plausible remedial actions. Alternative 1 is retained as a baseline alternative for comparison purposes per NCP. Although Alternative 2 (MNA) offers only limited short-term protection of human health and the environment by itself, it is retained because it has potential to remediate Site 5 groundwater over the long term and it represents a major component of other alternatives. Alternative 3A (Groundwater Pump and Treatment of Entire Plume) will provide adequate protection of human health and the environment over the long-term and it provides contaminant containment. Alternative 3B (Groundwater Pump and Treatment of Plume Source Zone) is eliminated primarily due to the concerns of short-term effectiveness and timeliness for protection of human health and the environment. Both Alternative 4 (In-Situ Treatment of Groundwater by Enhanced Biological Degradation) and Alternative 5 (In-Situ Treatment of Groundwater by Chemical Oxidation) are retained because they have been demonstrated to provide adequate protection of human health and the environment over a relatively short period of time, although costs are moderate to high. Long-term effectiveness of ISCO (Alternative 5) is generally of concern, as ISCO would be more suitable to treat higher concentrations of contaminants and frequently contaminants rebound after perceived completion of treatment.

The complete results of the alternatives screening evaluation for Site 5 groundwater are presented in Table 3-2.

TABLE 3-2
SCREENING SUMMARY OF REMEDIAL ALTERNATIVES
SITE 5 GROUNDWATER (OU 2) REMEDIATION
NAS JRB WILLOW GROVE, PENNSYLVANIA

	Alternative	Effectiveness	Implementability	COST	COMMENTS
1	No Action and Long-Term Monitoring	Provides no additional protection of human health and the environment. No measures would be implemented to remove or contain the groundwater VOC plume, or to prevent potential human exposure to site groundwater. Does not comply with ARARs.	Readily implementable. No technical or administrative difficulties.	Capital: none O&M: none	**Retained** - Retained as a baseline alternative in accordance with NCP.
2	Monitored Natural Attenuation, Institutional Controls, and Long-Term Monitoring	Provides protection of human health and the environment through natural attenuation, institutional control, monitoring, and regulatory agency review. Provides added protection of human health through predictive modeling. Groundwater use would be restricted. Complies with ARARs during and upon completion of remediation.	Proven technology and readily implementable. No technical or administrative difficulties.	Capital: low O&M: low	**Retained** - Provides limited adequate short-term protection of human health and the environment by itself. Long-term effectiveness is achievable at relatively low cost.
3A	Groundwater Pump and Treatment of Entire Plume, Institutional Controls, and Long-Term Monitoring	Provides protection of human health and the environment through pump and treat, institutional control, periodic monitoring and regulatory agency review. Concentration or volume of contaminants in groundwater would be decreased through extraction and active treatment. Reduces contaminant migration to the environment. Groundwater use would be restricted. Complies with ARARs during and upon completion of remediation.	Proven technology and readily implementable. No technical or administrative difficulties. Personnel and materials necessary to implement alternative are widely available.	Capital: high O&M: high	**Retained** - Provides adequate protection of human health and the environment over short- and long-term. Provides containment. Cost is high.
3B	Groundwater Pump and Treatment of Plume Source Zone, Institutional Controls, and Long-Term Monitoring	Provides protection of human health and the environment through pump and treat, institutional control, periodic monitoring and regulatory agency review. Concentration or volume of contaminants in groundwater would be decreased gradually through extraction and active treatment. Eventually reduces contaminant migration to the environment. Groundwater use would be restricted. Complies with ARARs during and upon completion of remediation.	Proven technology and readily implementable. No technical or administrative difficulties. Personnel and materials necessary to implement alternative are widely available.	Capital: high O&M: moderate	**Eliminated** - Provides adequate protection of human health and the environment over long-term. Does not provide containment. Cost is relatively high. Short-term effectiveness and timeliness are of concern.
4	In-Situ Treatment of Groundwater by Enhanced Biological Anaerobic Reductive Dehalogenation and Monitored Natural Attenuation, Institutional Controls, and Long-Term Monitoring	Provides protection of human health and the environment through in-situ biological treatment, natural attenuation, institutional control, monitoring, and regulatory agency review. Also provides added protection of human health through predictive modeling. Concentration or volume of contaminants in groundwater would be decreased relatively quickly and permanently through in-situ biological treatment. Provides both short- and long-term effectiveness. Groundwater use would be restricted. Complies with ARARs during and upon completion of remediation.	Proven technology. Implementation requires specialized personnel, material and equipment.	Capital: moderate O&M: moderate	**Retained** - Provides adequate protection of human health and the environment over relatively short-term. Provides long-term effectiveness as well. Cost is typically lower than pump and treat process.
5	In-Situ Treatment of Groundwater by Chemical Oxidation Process, Institutional Control, Long-Term Monitoring	Provides protection of human health and the environment through in-situ chemical treatment, institutional control, monitoring, and regulatory agency review. Concentration or volume of contaminants in groundwater would be decreased rapidly through in-situ chemical treatment. Provides short-term effectiveness. Long-term effectiveness may be questionable. Contaminants rebounding are common. Groundwater use would be restricted. Complies with ARARs during and upon completion of remediation.	Proven technology. Implementation requires specialized personnel, material and equipment.	Capital: high O&M: moderate	**Retained** – Provides adequate protection of human health and the environment over short-term. Contaminant concentrations may rebound. Long-term effectiveness may be questionable. More suitable to higher contaminant concentrations. Cost is relatively higher than in-situ biological treatment.

4.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The remedial alternatives retained from the screening in Section 3.0 are subject to detailed analysis in this section in accordance with the NCP and EPA guidance. The criteria for detailed analysis, according to the NCP, are as follows:

- Overall protection of human health and the environment
- Compliance with ARARs and TBCs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

Under the NCP, the selection of the remedy is based on the nine evaluation criteria, which are categorized into three groups:

- Threshold Criteria - These criteria must be satisfied in order for an alternative to be eligible for selection. The threshold criteria are overall protection of human health and the environment and compliance with ARARs.

- Primary Balancing Criteria - The balancing criteria are used to weigh the relative merits of alternatives. The five criteria that are included are long-term effectiveness and permanence, the reduction of toxicity, mobility, or volume through treatment, short-term effectiveness, implementability, and cost.

- Modifying Criteria - State acceptance and community acceptance are considered to be modifying criteria that must be considered during remedy selection. These last two criteria cannot be evaluated until a preferred remedy has been presented.

Brief, general discussions of the evaluation criteria are presented in the following text. Detailed analyses of the remedial alternatives using seven of the evaluation criteria and a comparative analysis of the remedial alternatives are presented in this section.

4.1 EVALUATION CRITERIA

The first seven criteria are addressed in this FS. The last two criteria will be addressed in the Record of Decision (ROD). The following sections define and detail each of the nine criteria:

Overall Protection of Human Health and the Environment

Alternatives must be assessed for adequate protection of human health and the environment. Overall protection draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. The evaluation focuses on whether a specific alternative achieves adequate protection, how risks are eliminated, reduced, or controlled, and whether remedial action objectives would be achieved.

Compliance with ARARs AND TBCs

Alternatives must be assessed to determine whether they attain applicable and appropriate requirements under federal and state environmental laws or facility siting laws. If one or more regulations that are applicable cannot be complied with, then a waiver must be invoked. Grounds for invoking a waiver would depend on the following circumstances:

- The alternative is an interim measure and will become part of a total remedial action that will attain the ARAR.
- Compliance will result in greater risk to human health and the environment.
- Compliance is technically impracticable from an engineering perspective.
- The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach.
- A state requirement has not been consistently applied or the state has not demonstrated the intention to consistently apply the promulgated requirement in similar circumstances at other remedial actions within the state.

Long-Term Effectiveness and Permanence

Alternatives must be assessed for the long-term effectiveness and permanence they offer, along with the degree of certainty that the alternative will prove successful. Factors that will be considered as appropriate are as below:

- Magnitude of Residual Risk - Assesses the risk posed by untreated waste or treatment residuals at the conclusion of the remedial activities. The characteristics of residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

- Adequacy and Reliability of Controls - Assesses controls such as containment systems and institutional controls that are necessary to manage treatment residuals or remaining untreated wastes and their reliability, in particular the uncertainties associated with land disposal for providing long-term protection from residuals, the assessment for the potential need to replace technical components of the alternative, and the potential exposure pathways and risks posed should the remedial action need replacement.

Reduction of Toxicity, Mobility, or Volume through Treatment

The degree to which the alternative employs recycling or treatment that reduces the toxicity, mobility, or volume will be assessed, including how treatment is used to address the principal threats posed by the site. Factors that are considered, as appropriate, include the following:

- The treatment processes that the alternative employs, the media they would treat, and threats addressed.

- The amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled.

- The degree of expected reduction in toxicity, mobility, or volume as a result of treatment.

- The degree to which the treatment is irreversible.

- The type and quantity of residuals that would remain following treatment, considering the persistence, toxicity, mobility, and bioaccumulation capacity of the contaminants of concern and impacted media.

- The degree to which treatment reduces the inherent hazards posed by principal threats at the site.

Short-Term Effectiveness

The assessment of short-term effectiveness during construction or implementation until the RAOs are met includes consideration of the following factors:

- Short-term risks that might be posed to the community during implementation.

- Potential impacts to and protection of the workers during remedial actions.

- Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation.

- Time until the RAOs are achieved.

Implementability

The ease or difficulty of implementing the alternatives will be assessed by considering the following types of factors, as appropriate:

- Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy.

- Administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-site actions).

- Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, disposal capacity and services, the availability of necessary equipment and specialists, provisions to ensure any necessary additional resources, and availability of prospective technologies.

Cost

For the detailed cost analysis of alternatives, the expenditures required to complete each measure are estimated in terms both of capital and annual operation and maintenance (O&M) costs. Given these values, a present-worth calculation for each alternative can be made for comparison. Capital costs consist of direct and indirect costs. Direct costs include the cost of construction, equipment, land and site development, treatment, transportation, and disposal. Indirect costs include engineering expenses, license or permit costs, and contingency allowances. Annual O&M costs are the post-construction costs required to ensure the continued effectiveness of the remedial action. Components of annual O&M cost include the cost of operating labor, maintenance materials and labor, auxiliary materials and energy, residue disposal, purchased services, administration, insurance, taxes, licensing, maintenance reserve and contingency funds, rehabilitation, monitoring, and periodic site reviews. Expenditures that occur over different time periods were analyzed using present worth, which discounts all future costs to a common base year. Present-worth analysis allows the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in the base year and disbursed

as needed, would be sufficient to cover all costs associated with the life of the remedial project. Assumptions associated with the present-worth calculations include a discount rate of 7 percent before taxes and after inflation, cost estimates in the planning years in constant dollars, and a period of performance that would vary depending on the activity, but would not exceed 30 years. The cost estimates for this section are provided to an accuracy of +50 percent to -30 percent. The alternative cost estimates are in the fiscal year dollars as indicated and are based on conceptual design from information available at the time of this study. The actual cost of the project would depend on the final scope and design of the selected remedial action, the schedule of implementation, competitive market conditions, and other variables. Most of these factors are not expected to affect the relative cost differences between alternatives.

State Acceptance

PADEP has been providing input during the RI phase and will continue during the FS and public comment period. The state's concerns that must be assessed include the following:

- The state's position and key concerns related to the preferred alternative and other alternatives.

- State comments on ARARs or the proposed use of waivers.

These concerns cannot be evaluated at this time in the FS until the Navy issues the Proposed Plan and the state has reviewed and commented on the RI/FS. State concerns may be discussed, to the extent possible, in the Proposed Plan to be issued for public comment.

Community Acceptance

This criterion refers to the community's comments on the remedial alternatives under consideration. NAS JRB Willow Grove has an active Restoration Board (RAB) that consists partly of community representatives, that meets regularly to review developments of the Installation Restoration (IR) Program. RAB members have the opportunity to review documents and presentations from Navy and regulatory representatives during the EPA-prescribed RI/FS process. Comments from community RAB members are encouraged and these comments are considered in the development of RI/FS documents. In addition, general public community concerns or comments will be addressed after the public comment period, which follows the release of the RI/FS report and the Proposed Plan. As a result, this FS does not provide any discussion regarding the community acceptance of any of the remedial alternatives.

4.2 INDIVIDUAL ANALYSIS OF SITE 5 GROUNDWATER REMEDIAL ALTERNATIVES

Detailed evaluations of the five Site 5 remedial alternatives retained for further evaluation are presented in this section. Detailed cost estimates and assumptions for each alternative are presented in Appendix C.

4.2.1 Alternative 1: No Action

The no-action alternative was developed as a baseline case, as required by the NCP. No activities are to be conducted under this alternative.

Overall Protection of Human Health and the Environment

The no-action alternative would provide only limited protection of human health and the environment. Contaminants within the groundwater would not be remediated or isolated and would continue to pose risk and adversely impact the environment.

Contaminants beneath the site would continue to migrate with groundwater, potentially affecting downgradient portions of the aquifer. Under a future residential land use scenario, exposure to contaminated groundwater beneath the site would pose potential carcinogenic and non-carcinogenic risks exceeding EPA's target risk range (carcinogenic risk greater than 1 E-04 and HI greater than 1.0). Alternative 1 does not include implementation of institutional controls to restrict use of contaminated groundwater in the event of future change in land or groundwater use.

Compliance with ARARs and TBCs

This alternative would not comply with chemical-specific ARARs or TBCs because no action would be taken to reduce contaminant concentrations. Groundwater contaminant levels beneath the site would continue to exceed federal and state drinking water criteria and no actions would be taken to restrict use or obtain a waiver for technical impracticability of groundwater restoration. No action- or location-specific ARARs or TBCs are applicable because no remedial actions would be taken.

Long-Term Effectiveness and Permanence

This alternative would have limited long-term effectiveness or permanence since it would not remedy the underlying aquifer or prevent on-site exposure to contaminated groundwater. Since no remedial actions would occur under Alternative 1, the current and future threats to human health and the environment would remain.

Because no actions would be taken to reduce contaminant migration to groundwater and no institutional controls would be implemented to prohibit use of untreated contaminated groundwater, the risk to potential future residential users of the groundwater would remain. The groundwater underlying Site 5 is not

currently used as a potable water supply and there are no existing plans for its use; however, public non-community wells and domestic wells are situated nearby (within approximately a ½ mile downgradient of the site).

Under ambient conditions, NA and degradation of some of the contaminants in site groundwater may occur; however, the process is likely to take many years. No reviews would be planned to assess whether threats or risks are increasing or abating with time in light of future land use or changes in the conditions at the site.

No controls would be used to manage Site 5 groundwater under the no-action alternative; therefore, the evaluation of the adequacy and reliability of controls is not applicable.

Reduction of Toxicity, Mobility, or Volume through Treatment

The no-action alternative would not reduce the toxicity, mobility, or volume of contamination through treatment, since no treatment is used to address the contaminated groundwater. This alternative would not satisfy the statutory preference for treatment to reduce the risks posed by contaminated groundwater.

Short-Term Effectiveness

Short-term effectiveness is not relevant to this alternative since no remedial action would be performed that could create additional short-term risks to the community or future on-site workers. Current risks would remain unchanged. The RAOs would not be met.

Implementability

Since no response activities would occur, the no-action alternative is readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not relevant to this alternative. Additional actions could be easily implemented in the future, if warranted.

Permits would not be required under Alternative 1.

Cost

No costs are associated with the no action alternative.

4.2.2 Alternative 2: Monitored Natural Attenuation

Alternative 2 is a low-cost remedial alternative that aims to protect human health primarily through land use restrictions and long-term groundwater monitoring. Under this alternative, five new monitoring wells would be installed, data would be evaluated, and a predictive attenuation model would be developed and maintained. Land use restrictions would be placed on the Base Master Plan to preclude consumption of site groundwater. Groundwater would be sampled periodically to monitor the quality of groundwater.

Monitoring data would be evaluated to confirm the efficacy of the attenuation processes and to evaluate the need for additional response actions if deemed necessary.

Because contaminants remain on site, a review of site conditions and risks would be conducted every 5 years, as required by the NCP.

Overall Protection of Human Health and the Environment

For this alternative, the natural attenuation of contaminants would eventually reduce contaminant concentrations to PRGs for groundwater. Preliminary modeling indicates that the groundwater at the site may attain the PRG for TCE around the year 2030. Land use restrictions precluding consumption of groundwater from the site will protect human health and the environment.

Compliance with ARARs

In the long term, this alternative would comply with chemical-specific ARARs and TBCs. Relevant and appropriate sections of federal and state groundwater guidelines would be attained because NA gradually causes contaminant levels to decline. In the short term, Alternative 2 would not comply with chemical-specific ARARs and TBCs.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of Alternative 2 are similar to those of Alternative 1. Although no remedial actions would occur under Alternative 2, preliminary modeling indicates that reduction in contaminant concentrations would occur over time due to NA processes. The estimated rate of attenuation is slow and the attainment of MCLs would take more than 30 years. Until that time, risks associated with groundwater contamination would remain.

Because contaminants would remain in groundwater, 5-year reviews would be required to assess contaminant migration, changes in site conditions, and changes in risks.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 would gradually reduce the toxicity, mobility, or volume of contamination through NA process. However, because treatment is not employed, no hazardous substances would be specifically treated, recycled, or destroyed.

Alternative 2 would not satisfy the statutory preference for remedies that employ treatment as a principal element.

Short-Term Effectiveness

Implementation of Alternative 2 would not pose additional risks to the local community or to workers. Workers performing periodic sampling of groundwater for analysis would be protected from risks (e.g., exposure to contaminated groundwater, VOC vapors, etc.) through the use of appropriate PPE. No adverse impact to the environment would be anticipated during groundwater monitoring activities.

This alternative could be implemented shortly after signing the Record of Decision (ROD). Institutional controls could be implemented almost immediately and would effectively protect human health and the environment.

Implementability

Alternative 2 is implementable. There would be no anticipated technical difficulties or uncertainties in conducting long-term periodic monitoring. No technical problems would be anticipated that would impede the schedule.

Additional actions can be easily implemented in the future, if warranted. Because groundwater monitoring and predictive modeling are included under Alternative 2, contaminant status or migration could be assessed.

There is ample availability of companies with the trained personnel, equipment, and materials to implement long-term groundwater monitoring and laboratories to perform chemical analyses. Regulatory personnel and environmental specialists are readily available to perform predictive modeling and effective 5-year reviews.

Cost

The capital costs for implementing Alternative 2 total an estimated $189,800. Average annual monitoring and O&M costs are $91,300 (first 3 years) and $45,600 (following years), and 5-year reviews are estimated at $20,000 per event. Over an estimated 30-year period, the net present-worth cost is estimated to be $919,000 (at a 7 percent discount rate).

4.2.3 Alternative 3A: Groundwater Pump and Treatment of Entire Plume and Discharge to On-Site Sewer

Alternative 3A employs groundwater pumping and treatment, long-term monitoring, institutional controls, and 5-year reviews to protect human health and the environment. After pre-design studies, a groundwater containment system consisting of groundwater extraction wells would be placed near the downgradient edge of the plume, and the groundwater would be extracted and treated above ground by air stripping.

Additional groundwater extraction wells would be placed in the vicinity of the high-concentration plume center, for groundwater pumping and above-ground treatment. Because of the relatively low concentration and diffuse nature of VOCs in groundwater, a portion of the groundwater contaminants would be difficult to capture using the groundwater extraction system. Institutional controls would be implemented to prevent exposure to contaminated groundwater for the duration of the groundwater treatment period, until PRGs are achieved. Long-term monitoring would be conducted for the duration of the remediation period to assess the effectiveness of the remedial action and to determine when the remediation is complete. Site conditions and risks would be reviewed every 5 years until the groundwater remediation is complete.

Overall Protection of Human Health and the Environment

The implementation of Alternative 3A would result in the overall protection of human health and the environment for site groundwater contaminated with VOCs. Although contamination would remain in the bedrock fractures within the residual area, extraction and treatment of contaminated groundwater along the leading edge and the concentrated center of the plume would result in a measurable level of protection to human health and the environment. It would prevent further expansion of the center of the plume and eventually achieve the PRGs along the leading edge. This would significantly reduce risk from exposure to contaminated groundwater and provide protection to downgradient private or municipal wells. However, potential users of contaminated groundwater beneath Site 5 would not be protected by Alternative 3A until groundwater remediation goals are achieved throughout the plume. It is not known how long it may take to achieve remediation goals in the bedrock aquifer, but groundwater flow is expected to be very slow in competent bedrock. The use of pump and treat should be effective for the reduction of VOC concentrations in the fractures, but reduction of concentrations in the competent bedrock may be very slow using this technique. It is anticipated that long-term, permanent protection would be achieved after a treatment duration of less than 30 years. During this period, groundwater contaminants would be removed both by the extraction system and through natural attenuation and dissipation.

In the interim period, until remediation goals for site groundwater have been achieved, human health would be protected through use of institutional controls that would restrict use of untreated contaminated groundwater as drinking water. The effectiveness of this interim protection would depend entirely upon adequate enforcement. If groundwater use restrictions were not adequately enforced, existing health risks would remain until groundwater contaminant concentrations decreased to acceptable levels.

The groundwater underlying Site 5 is not currently used as a potable water supply and there are no existing plans for its use; however, public community wells and domestic wells are situated nearby (within approximately a ½ mile cross-gradient of the site).

Extraction and treatment of groundwater would provide permanent long-term protection by removing contaminants from site groundwater. The proposed institutional controls would provide additional assurance of the long-term protection by restricting use of contaminated groundwater.

Long-term monitoring of groundwater for the duration of the remediation period would make it possible to evaluate site conditions and risks in order to determine when remedial actions are complete. The proposed periodic monitoring would allow adequate time to act in the event that additional actions are needed to protect human health or the environment.

Compliance with ARARs

Alternative 3A would eventually comply with chemical-specific ARARs, such as MCLs throughout the plume, although, initially, groundwater contaminated with TCE at levels above PRGs would continue to migrate from the concentrated plume center. Alternative 3A would also comply with location- and action-specific ARARs because operation of the treatment system would be conducted in a regulatory-approved manner.

Long-Term Effectiveness and Permanence

Alternative 3A would be effective in minimizing the migration of VOCs from Site 5. During clean-up, protection of human health would depend on adequate enforcement of the groundwater use restrictions.

The groundwater underlying Site 5 is not currently used as a potable water supply and there are no existing plans for its use. If site land and groundwater usage changes in the future, potential residential and industrial users of groundwater would not be protected if institutional controls were not enforced.

The reliability of the pump-and-treat system is expected to be high. Groundwater extraction and ex-situ treatment by air stripping are widely used and are effective technologies for remediation of VOC-contaminated groundwater. The process would be easily monitored and maintained. Routine maintenance and replacement of system components could be accomplished with little interruption of system operation and no adverse impact to human health or the environment.

Long-term monitoring of groundwater for the duration of the remediation period would allow the responsible agency to monitor the quality of groundwater beneath the site, assess potential impacts to downgradient receptors, determine whether additional remedial actions are necessary, and determine when remedial actions are complete. The proposed periodic monitoring should allow adequate time to act in the event that additional actions are needed to protect human health or the environment.

Five-year reviews would be required for the duration of the groundwater remediation period to assess whether human health risks are increasing or abating with time in light of future land use or changes in

conditions at the site. These reviews would be based in large part on analytical data collected during periodic monitoring events. Review of the effectiveness of land use restrictions would also be required.

No difficulties or uncertainties are anticipated in performing the long-term monitoring. Groundwater monitoring wells would require replacement if sedimentation or vandalism were to occur; the wells would be readily replaceable.

Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative would reduce the toxicity, mobility, and volume of contamination through extraction and treatment of contaminated groundwater. The treatment system and NA of residual levels of contaminants would remove TCE and the other chlorinated VOCs present in site groundwater to meet the remediation goals.

The proposed groundwater containment system would be designed to address the entire groundwater contaminant plume exceeding PRGs. Approximately 270,000 gallons per day (190 gallons per minute) of contaminated groundwater would be treated by the air stripper system. NA and dissipation would supplement VOC removal by the pump-and-treat system.

Spent carbon and any other air stripping treatment residuals would be disposed off site at approved, regulated facilities. Adsorbed contaminants would be destroyed off site.

Short-Term Effectiveness

The implementation of Alternative 3A would have minimal short-term effectiveness concerns. Exposure of workers to contaminants during the well installation and during construction, start-up, and operation of the on-site treatment system would be minimized by wearing appropriate PPE and complying with site-specific health and safety procedures. Treatment of the air-stripping off-gases with granular activated carbon (GAC) adsorption would reduce the risk to human receptors and workers by eliminating organic vapors from the emissions.

Alternative 3A would require approximately 18 months to put in place, including treatability studies, pre-design, and design activities. Upon start-up of the groundwater extraction and treatment systems, Alternative 3A would achieve the RAO for minimizing migration of groundwater contamination. The RAO for protection of human health by preventing exposure to contaminated groundwater would be achieved upon implementation of land use restrictions.

Implementability

Alternative 3A is implementable. There are no technical difficulties or uncertainties anticipated in constructing and operating the groundwater extraction and treatment systems. The proposed treatment

technologies are proven and have been widely used in full-scale application. Common construction techniques and equipment would be required for construction and operation of the treatment system.

If warranted, additional actions could be easily implemented in the future while the groundwater treatment system is operating. Contaminant migration and exposure pathways and treatment effectiveness would be adequately assessed during implementation of Alternative 3A by monitoring groundwater quality. Long-term monitoring of groundwater would be effective for monitoring the progress of groundwater remediation and identifying potential impacts to downgradient receptors and the need for additional actions.

Permits (manifests) would be required and obtainable for off-base transportation and disposal of contaminated materials from the source area. Permits would not be required for on-site activities. Coordination with other agencies may be required as part of the long-term monitoring and 5-year review processes.

The proposed low-profile, modular air stripping units are widely available and easily installed. Routine maintenance, including periodic cleaning of the stripping trays, would be easily implemented. Maintenance of the carbon polishing and air treatment systems would require only periodic replacement of spent carbon canisters. Extraction system equipment (pumps, valves, controls) would require periodic service or replacement. Well screens and pumps may require periodic cleaning to remove mineral deposit buildup.

Long-term monitoring (sampling and analysis) only requires readily available resources. Incorporating land use restrictions into the Base Master Plan should not be difficult to implement and enforce, since the site is part of an active Navy facility and coordination with other agencies and property owners would not be necessary.

Many companies exist with the trained personnel, equipment, and materials necessary to design, install, and operate extraction and treatment systems and implement long-term groundwater monitoring. There is ample availability of companies with the trained personnel, equipment, and materials to perform long-term monitoring. Regulatory personnel and environmental specialists are readily available to perform 5-year reviews.

Cost

The capital costs for Alternative 3A total $1,424,000. The average annual O&M costs would be $230,000 for the first 3 years and $188,000 for the following years. Five-year reviews cost $20,000 per event. Over a 30-year period, the net present-worth cost is estimated to be $4,756,000 (at a 7 percent discount rate).

4.2.4 Alt rnativ 4: In-Situ Tr atm nt of Groundwater by Enhanced Biological Anaerobic Reductive Dehalogenation, and Monitored Natural Attenuation

Alternative 4 employs in-situ treatment by enhanced biological anaerobic reductive dehalogenation process with groundwater recirculation followed by MNA for the remediation of VOC-contaminated groundwater, implementation of land use controls, long-term monitoring, and periodic reviews.

After pre-design studies, a laboratory treatability study and a pilot- or field-scale test are to be conducted to evaluate and verify the effectiveness of several different electron donors with the site aquifer materials, including soils and groundwater. If electron donor addition alone is not resulting in rapid degradation of VOCs, a process called bioaugmentation (addition of facultative bacteria and nutrition supplement) will be utilized to accelerate the degradation process.

When the majority of site VOCs have been biodegraded (i.e., biological treatment efficacy has leveled off), treatment of Site 5 groundwater may be continued by NA process to achieve groundwater PRGs. Similar to Alternative 2, the NA processes consist of a variety of physical, chemical, or biological processes that act to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater.

This alternative also utilizes institutional controls to prevent exposure to contaminated groundwater for the duration of the groundwater remediation period, until PRGs are achieved. Long-term monitoring would be conducted for the duration of the remediation period to assess the effectiveness of the remedial action and to determine when the remediation is complete. Site conditions and risks would be reviewed every 5 years until the groundwater remediation is complete.

Overall Protection of Human Health and the Environment

Implementation of Alternative 4 would result in a long-term overall protection of human health and the environment for site groundwater contaminated with VOCs. The enhanced biological anaerobic biological treatment processes would facilitate continuing biodegradation of VOCs in the groundwater and flush residual constituents present in the subsurface by recirculating a portion or entire extracted volume of groundwater after biostimulation and/or bioaugmentation processes. Groundwater extraction and biostimulation and/or bioaugmentation processes will be conducted in enclosed equipment to maintain an anaerobic environment and to minimize or eliminate risk from exposure to contaminated groundwater by the workers. This would also provide additional protection to downgradient private or municipal wells. It is not known until pre-design investigation activities, including treatability study and pilot-/field-scale testing, are complete, how long it would take to achieve PRGs in the groundwater. It is assumed that long-term, permanent protection would be achieved after approximately 5 years of active biological treatment and 10 years of NA for the groundwater. In the interim period, until remediation goals for site groundwater have been achieved, human health would be protected through the use of institutional controls that would restrict

use of untreated contaminated groundwater as drinking water. The groundwater underlying Site 5 is not currently used as a potable water supply and there are no existing plans for its use. However, public community wells and domestic wells are situated nearby (within approximately a ½ mile cross-gradient of the site).

In-situ biological treatment coupled with MNA of groundwater would provide permanent long-term protection by destroying contaminants from site groundwater. The proposed institutional controls would provide additional assurance of the long-term protection by restricting use of contaminated groundwater.

Long-term monitoring of groundwater for the duration of the remediation period would make it possible to evaluate site conditions and risks in order to determine when remedial actions are complete. The proposed periodic monitoring and 5-year reviews would allow adequate time to act in the event that additional actions are needed to protect human health or the environment.

Compliance with ARARs

Alternative 4 would eventually comply with chemical-specific ARARs, such as MCLs, although, initially, groundwater contaminated with VOCs at levels above PRGs would continue to migrate through the plume. Alternative 4 would also comply with location- and action-specific ARARs because the operation of the treatment system would be conducted in a manner consistent with all applicable rules and regulations.

Long-Term Effectiveness and Permanence

Alternative 4 would be effective in minimizing the migration of VOCs from Site 5. During remediation, protection of human health would depend on adequate enforcement of the groundwater use restrictions. The groundwater underlying Site 5 is not currently used as a potable water supply and there are no existing plans for its use. If site land and/or groundwater usage are to change in the future, potential residential and industrial users of groundwater will not be protected if institutional controls were not enforced.

In-situ bioremediation is a relatively uncomplicated remedial technology to apply, requiring little major infrastructure other than standard wells and piping, and equipment that may include pumps and programmable logical controls to regulate flow rates associated with nutrient injection or recirculation of groundwater to aid in distribution of any amendments. In-situ bioremediation has been demonstrated to degrade the site contaminants, and bioaugmentation with halo-respiring microorganisms will ensure meeting required process efficiencies or performance specifications. In-situ bioremediation for removing residual sources may take several years to complete, and will therefore require long-term operation and maintenance of the in-situ bioremediation systems. This will require routine monitoring to ensure that an adequate supply of nutrients is available, process efficiencies are being met, occasional or preventative well rehabilitation to address any biofouling that may occur, and periodic examination and replacement of

pumps. Over time the in-situ bioremediation will result in the buildup of a complex biomass within the aquifer which will buffer against system upsets.

Long-term monitoring of groundwater for the duration of the remediation period would allow the responsible agency to monitor the quality of groundwater beneath the site, assess potential impacts to downgradient receptors, determine whether additional remedial actions are necessary, and determine when remedial actions are complete. Routine maintenance and replacement of system components could be accomplished with little interruption of system operation and no adverse impact to human health or the environment. The proposed periodic monitoring should allow adequate time to act in the event that additional actions are needed to protect human health or the environment.

Five-year reviews would be required for the duration of the groundwater remediation period to assess whether human health risks are increasing or abating with time in light of future land use or changes in conditions at the site. These reviews would be based in large part on analytical data collected during periodic monitoring events. Review of the effectiveness of land use restrictions would also be required.

No difficulties or uncertainties are anticipated in performing the long-term monitoring. Groundwater monitoring wells may require replacement if sedimentation or vandalism occurs; the wells would be readily replaceable.

Reduction of Toxicity, Mobility, or Volume through Treatment

In-situ bioremediation reduces the toxicity, mobility and volume of the VOCs in the site groundwater. These reductions are achieved by converting site contaminants to innocuous, non-toxic end products at a rate that prevents their further migration. Reducing the aqueous phase concentrations enhances the dissolution rate of the residual VOCs that may exist in bedrock, which results in their continuous removal at a rate that ultimately achieves a timely clean-up for the site groundwater. The NA processes would eventually remove TCE and the other VOCs present in site groundwater to meet the remediation goals.

Short-Term Effectiveness

The implementation of Alternative 4 would have minimal concerns of short-term effectiveness. Exposure to workers of contaminants during the well installation and during construction, start-up, and operation of the on-site feed preparation and delivery systems (for nutrient and/or biomass addition, mixing and delivery) would be minimized by wearing appropriate PPE and complying with site-specific health and safety procedures. The on-site feed preparation and delivery will be conducted in a self-contained and enclosed system.

Alternative 4 would require approximately 24 months to put in place, including treatability studies, pre-design activities, pilot-/field-scale testing, and design activities. Upon start-up of the in-situ biological treatment, the

reaction occurs in-situ and therefore there is no exposure to the community or workers to site contaminants during the remedy, except when sampling groundwater and operating the feed systems where adequate health and safety protocols will be used. Several potential nutrients that may be used are flammable, and require appropriate handling and storage. The risk of fire could be mitigated by diluting the nutrients in water for storage and delivery. There are no environmental impacts associated with in-situ treatment during its construction and operation other than soil disturbance during well installation, and vehicular traffic. Well replacement or additional wells may be required under some conditions (i.e., more wells are needed if permeability is significantly low).

Alternative 4 would achieve the RAO for minimizing migration of groundwater contamination. The RAO for protection of human health would be achieved upon implementation of land use restrictions by preventing exposure to contaminated groundwater.

Implementability

Alternative 4 utilizes proven technologies that are easily constructed using standard wells, pipes, plumbing, pumps etc, and should not lead to schedule delays. Design of the treatment train may require specialized technical expertise. Biological feeds require little specialized expertise in the terms of operations, which require only nutrient addition and delivery that can be manually or automatically added on pre-defined schedules. In-situ biological treatment is not likely to require additional future remedial actions, other than MNA, after its' application. Standard procedures are used to monitor the system performance and will identify if there is system failure (e.g., shifts in microbial populations, loss of key microbial species, changes in VOC concentrations). Regular monitoring permits timely response to optimize system operation through the addition rate or type of nutrients or microorganisms. Groundwater extraction and feed delivery system equipment (pumps, valves, and controls) would require periodic service or replacement. Well screens may require periodic cleaning to remove mineral deposit or biological buildup.

Permits would not be required for on-site activities. Coordination with other agencies may be required as part of the long-term monitoring and 5-year review processes. Long-term monitoring (sampling and analyses) only requires readily available resources. Incorporating land use restrictions into the Base Master Plan should not be difficult to implement and enforce, since the site is part of an active Navy facility and coordination with other agencies and property owners would not be necessary.

Many companies exist with the trained personnel, equipment, and materials needed to design, install, and operate extraction, treatment and delivery systems and implement long-term groundwater monitoring. There is ample availability of companies with the trained personnel, equipment, and materials to perform long-term monitoring. Regulatory personnel and environmental specialists are readily available to perform 5-year reviews.

Cost

The capital costs for Alternative 4 total $609,000. During the first year of operation, O&M and monitoring costs would total $122,000. During years 2 through 5 the average annual O&M costs would be $85,300. In Year 6 O&M costs would total $51,600. For the remaining years, O&M costs would be $35,000 per year. Five-year reviews cost $20,000 per event. Over a 15-year remediation period, the net present-worth cost is estimated to be $1,211,000 (at a 7 percent discount rate).

4.2.5 Alternative 5: In-Situ Treatment of Groundwater by Chemical Oxidation

Alternative 5 employs in-situ treatment of VOC-contaminated site groundwater by chemical oxidation process. The effectiveness of this technology is highly dependent on the injection delivery and distribution technology, the subsurface hydrogeology of the site, the nature and extent of contamination, and other site-specific conditions such as presence of total organic carbon (TOC), which can competitively interfere with target contaminants for available oxidants.

A bench-scale treatability study is used to investigate the site-specific effectiveness of in-situ chemical oxidation (ISCO) for mitigating contaminant concentrations in both dissolved and sorbed-phase conditions. Additionally, the ISCO bench-scale treatability study will provide design data for subsequent pilot- or field-scale ISCO injection programs. To complete the bench-scale treatability study, saturated zone soil and groundwater samples would be collected from several locations within the remedial target area (sorbed-phase concentrations in excess of 500 mg/kg). During the bench-scale test, several oxidizer/catalyst blends would be evaluated to determine which blend could achieve the targeted removal efficiencies with respect to the RAOs upon application. The bench-scale study would also serve to assess the potential for competitive interference of TOC (including naturally occurring compounds and TPH) to reduce the effective removal of COCs. Data generated during the bench-scale test provides an indication of the expected number and duration of injection events required to achieve target remedial goals, and the concentration profile of both oxidants and chelating solutions that provide the most cost-effective treatment of site-specific contaminants.

Following completion of the bench-scale ISCO study (i.e., with positive results indicating that ISCO would be effective for treatment of the chlorinated VOC at the site), a pilot test would be conducted to obtain additional site-specific design information, to confirm and evaluate the performance of the delivery system and vertical well injection techniques, to evaluate the in-situ effectiveness of the treatment, and to obtain additional site hydrogeologic and chemical characteristics. Data generated during the pilot test would also be used to refine the expected number and duration of injection events required to achieve target remedial goals. Any inefficiencies identified as part of the pilot-scale testing event for ISCO treatment would be addressed and the remedial approach optimized (if deemed practicable), prior to the implementation of the full-scale ISCO program.

Following the bench-scale and pilot studies, the full-scale ISCO treatment(s) would be implemented by injecting the oxidant blend through the vertical injection wells converted from the existing monitoring wells in the source areas (where the highest concentrations of contaminants were observed).

Monitoring would be conducted during the treatment process to confirm the presence of chemical oxidation indicators throughout the remedial target areas, to maintain an effective remediation zone, and to monitor for treatment effectiveness with respect to the RAOs. Contaminant concentrations, as well as ISCO indicator parameters, pH, total dissolved solids, and temperature would be monitored on a regular basis. These parameters provide a direct indication of the presence of the ISCO solution at radial locations from the injection point. The pH and temperature would both be measured with water quality parameter instrumentation. Fluctuations in pH and/or increases in temperature due to exothermic reactions are both indications of ISCO activity. Similarly, the total dissolved solids concentration would be measured with water quality parameter instrumentation. An increase in total dissolved solids provides an indication of ISCO due to the presence of dissolved matter in the reagents. Typically, a 30-40 percent fluctuation compared to the baseline concentration indicates radial influence due to chemical oxidation. Existing monitoring wells in two tiers down-gradient from the injection wells would be used to collect aqueous ISCO monitoring samples. Number and spacing of monitoring wells between the injection and compliance wells or receptors will be determined by the pre-design investigations and treatability and /or pilot studies. Some previous ISCO treatment sites indicated that the ISCO treatment would take approximately 1-2 years to achieve the RAOs. Continued monitoring for 10 additional years would be needed to monitor the water quality to assure no rebound or dissolution of site contaminants.

This alternative also utilizes institutional controls to prevent exposure to contaminated groundwater for the duration of the groundwater remediation period, until PRGs are achieved. Long-term monitoring would be conducted for the duration of the remediation period to assess the effectiveness of the remedial action and to confirm the remediation is complete. Site conditions and risks would be reviewed every 5 years until the groundwater remediation is complete.

Overall Protection of Human Health and the Environment

Alternative 5 may be low in overall protection of human health and the environment for site groundwater contaminated with VOCs, due to the inability of ISCO in removing or eliminating the sorbed-phase contaminant mass with few applications. Multiple applications of ISCO are typically required. Neither the ISCO would be effective to mitigate residual dissolved-phase concentrations that are observed at the site.

The time period to achieve PRGS cannot be accurately estimated until pre-design investigation activities, consisting of a treatability study and pilot-/field-scale testing, are completed. For purposes of this FS it is assumed that long-term, permanent protection would be achieved following 2 years of active ISCO treatment

and an additional 10 years of groundwater monitoring. In the interim period, until remediation goals for site groundwater have been achieved, human health would be protected through the use of institutional controls that would restrict use of untreated contaminated groundwater as drinking water. The groundwater underlying Site 5 is not currently used as a potable water supply and there are no existing plans for its use. However, public community wells and domestic wells are situated nearby (within approximately a ½ mile cross-gradient of the site).

Long-term monitoring of groundwater for the duration of the remediation period would make it possible to evaluate site conditions and risks in order to determine when remedial actions are complete. The proposed periodic monitoring and 5-year reviews would allow adequate time to act in the event that additional actions are needed to protect human health or the environment.

Compliance with ARARs

Alternative 5 would comply with chemical-specific ARARs, such as MCLs, although, initially, groundwater contaminated with VOCs at levels above PRGs would continue to migrate through the downgradient plume edge. Alternative 5 would also comply with location- and action-specific ARARs because the operation of the treatment system would be conducted in a manner consistent with all applicable rules and regulations.

Long-Term Effectiveness and Permanence

Alternative 5 would be effective in long-term reduction of VOCs migrating from Site 5. Active remediation of sorbed-phase contamination in Site 5 groundwater using ISCO would reduce VOCs in Site 5 groundwater, but may not eliminate the exceedances of the PRGs until multiple applications of ISCO have been implemented. Failure to eliminate or reduce the sorbed-phase sources of VOCs would likely result in continued impacts to groundwater, and residual dissolved-phase concentrations in excess of the RAOs.

During the remediation period protection of human health would depend on adequate enforcement of the groundwater use restrictions. If site land and groundwater usage are to change in the future, potential residential and industrial users of groundwater will not be protected if institutional controls were not enforced.

ISCO is a well demonstrated remedial technology to apply, requiring little major infrastructure other than standard wells and piping, and equipment that may include pumps and programmable logical controls to regulate flow rates associated with mixing and injection. ISCO may take multiple applications to complete and require long-term monitoring to ensure that destruction of contaminants is complete. Long-term monitoring of groundwater for the duration of the remediation period would allow the responsible agency to monitor the quality of groundwater beneath the site, assess potential impacts to downgradient receptors, determine whether additional remedial actions are necessary, and determine when remedial actions are

complete. Routine maintenance and replacement of system components could be accomplished with little interruption of system operation and no adverse impact to human health or the environment. The proposed periodic monitoring (10 years) should allow adequate time to act in the event that additional actions are needed to protect human health or the environment.

Five-year reviews would be required for the duration of the groundwater remediation period to assess whether human health risks are increasing or abating with time in light of future land use or changes in conditions at the site. These reviews would be based in large part on analytical data collected during periodic monitoring events. Review of the effectiveness of land use restrictions would also be required.

No difficulties or uncertainties are anticipated in performing the long-term monitoring. Groundwater monitoring wells may require replacement if sedimentation or vandalism occurs; the wells would be readily replaceable.

Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative includes a form of active remediation (ISCO) that potentially will reduce the toxicity, mobility, volume of the sorbed-phase, and ultimately, the dissolved-phase residual contamination in the Site 5 groundwater. ISCO, however, may not reduce the toxicity, mobility, and volume of certain contaminants. The treatability study and pilot-/field-scale testing would have to be performed before the full-scale remediation is implemented. As shown by other studies and site remediation, ISCO applications have resulted in the partial mobilization of previously sorbed-phase contaminants, increasing the dissolved-phase contaminants rather than treating the contaminants in their entirety.

Short-Term Effectiveness

Alternative 5 may provide short-term effectiveness in reducing human health risks through the use of ISCO. However, possible short-term risks to operation and maintenance workers include the handling and injection of oxidizing/reducing agents during chemical injections. These risks would be minimized by appropriate PPE and safe work practices. Furthermore, ISCO may present an inherent short-term safety and health risk because the chemical processes associated with the ISCO treatment will result in exothermic reactions in the shallow aquifer and the release of pressurized gases, and may pose a risk to near-by structures.

Alternative 4 would achieve short-term effectiveness by restricting land and groundwater usage via institutional controls.

Implementability

ISCO is a proven technology that can be constructed using standard wells, pipes, plumbing, pumps etc, and should not lead to schedule delays. Design of the treatment train may require specialized technical

expertise. The application of ISCO also requires specialized personnel, but many are available. As indicated before, ISCO may require multiple injection events and excessive volumes. Handling and scheduling of the applications may be challenging. ISCO would likely result in additional mobilization of sorbed-phase contaminants and alterations to the subsurface geochemistry such that subsequent ISCO injection events would be progressively less effective.

Standard procedures are used to monitor the system performance and will identify if there will be a potential system failure. Chemical delivery system equipment (pumps, valves, controls) would require periodic service or replacement. Well screens may require periodic cleaning to remove mineral deposit buildup. The long-term monitoring programs associated with Alternative 5 could be conducted without difficulty. Permits would not be required for on-site activities. Coordination with other agencies may be required as part of the long-term monitoring and 5-year review processes. Incorporating land use restrictions into the Base Master Plan should not be difficult to implement and enforce, since the site is part of an active Navy facility and coordination with other agencies and property owners would not be necessary.

Cost

The capital costs for Alternative 5 total $757,800. The average annual O&M costs (including monitoring) would be $206,600 for the 2-year period of ISCO applications followed by ten years of monitoring. O&M and monitoring costs for Years 3 through 5 would be $131, 2000 per year. For Years 6 through 12 the yearly O&M costs including monitoring would be $62,000. Five-year reviews cost $20,000 per event. Over a total 12-year period, the net present-worth cost is estimated to be $1,704,752 (at a 7 percent discount rate).

4.3 COMPARATIVE ANALYSIS OF SITE 5 ALTERNATIVES

Comparative analysis of the five remedial alternatives for the Site 5 groundwater is performed to identify differences among the alternatives with respect to the evaluation process, remedial goals, and associated costs. A summary of the comparative analysis is presented in Table 4-1.

TABLE 4-1
COMPARATIVE ANALYSIS OF REMEDIAL ACTION ALTERNATIVES
SITE 5 GROUNDWATER REMEDIATION
NAS JRB WILLOW GROVE, PENNSYLVANIA

CRITERION:	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: MONITORED NATURAL ATTENUATION	ALTERNATIVE 3A: PUMP AND TREAT ENTIRE PLUME	ALTERNATIVE 4: IN-SITU BIOLOGICAL TREATMENT MONITORED NATURAL ATTENUATION	ALTERNATIVE 5: IN-SITU CHEMICAL OXIDATION
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT					
Prevent Human Exposure to Contaminated Groundwater	Would provide no additional protection against human exposure to contaminated groundwater. Carcinogenic and non-carcinogenic risks exceeding EPA's target risk range would remain. No institutional controls implemented to restrict use of untreated contaminated groundwater for drinking water. Lack of long-term periodic monitoring and review would not provide the Navy and regulatory agencies the opportunity to review site conditions and perform additional remedial actions if they become warranted.	Over a long period of time, contaminant concentrations would reach levels that would not pose excess risk. Institutional controls would minimize potential exposure to site groundwater by prohibiting its use as drinking water. Long-term periodic monitoring and review, combined with predictive modeling, would provide the Navy and regulatory agencies the opportunity to review site conditions and perform additional remedial actions if they become warranted. Time required for natural attenuation to reduce contaminants to levels that would not pose risk may be longer than for other alternatives, except Alternative 1.	Would provide collection and ex-situ treatment of the advancing contaminant plume. Upon completion of construction, the proposed remediation would prevent exposure to potential downgradient receptors by treating the advancing plume. Institutional controls would minimize potential exposure to site groundwater during the remediation period by prohibiting its use as drinking water. Long-term periodic monitoring and review would provide the Navy and regulatory agencies the opportunity to review site conditions and perform additional remedial actions if they become warranted. Time required to meet PRGs would be the longest of the 3 alternatives (3A, 4, and 5) that employ active treatment.	Would provide in-situ treatment of the contaminant plume. Upon completion of construction, the proposed remediation would begin to reduce exposure to potential downgradient receptors by treating the source of the contaminant plume. Enhanced natural attenuation ultimately would reduce groundwater contaminant concentrations to levels that would not pose excess risk. Institutional controls would minimize potential exposure to site groundwater during the remediation period by prohibiting its use as drinking water. Long-term periodic monitoring and review would provide the Navy and regulatory agencies the opportunity to review site conditions and perform additional remedial actions if they become warranted. Time required to meet PRGs would be the medium of the 3 alternatives (3A, 4, and 5) that employ active treatment.	Would provide in-situ treatment of the contaminant plume. Would provide active reduction of contaminant concentration and volume in the concentrated source. The plume may enlarge initially due to contaminants dissolution and partial degradation. Contaminant rebound may occur in the interim. Multiple applications of ISCO are usually needed. Institutional controls would minimize potential exposure to site groundwater during the remediation period by prohibiting its use as drinking water. Long-term periodic monitoring and review would provide the Navy and regulatory agencies the opportunity to review site conditions and perform additional remedial actions if they become warranted. Time required to meet PRGs would be the shortest of the 3 alternatives (3A, 4, and 5) that employ active treatment.
Mitigate Migration of VOC Contaminated Groundwater	No actions taken to reduce migration of contaminated groundwater. Relies on natural attenuation.	No actions taken to reduce migration of contaminated groundwater. Relies on natural attenuation.	The groundwater extraction and treatment system, installed immediately downgradient of the contaminant plume, would prevent further migration of contaminated groundwater.	The groundwater would be extracted from downgradient locations, mixed with electron donors and biomass, and recirculated to injection wells. This alternative would prevent some or all migration of contaminated groundwater.	The groundwater treatment system would enlarge the plume initially due to contaminants dissolution and partial degradation. Would eventually prevent migration of contaminated groundwater.

TABLE 4-1
COMPARATIVE ANALYSIS OF REMEDIAL ACTION ALTERNATIVES
SITE 5 GROUNDWATER REMEDIATION
NAS JRB WILLOW GROVE, PENNSYLVANIA

CRITERION:	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: MONITORED NATURAL ATTENUATION	ALTERNATIVE 3A: PUMP AND TREAT ENTIRE PLUME	ALTERNATIVE 4: IN-SITU BIOLOGICAL TREATMENT MONITORED NATURAL ATTENUATION	ALTERNATIVE 5: IN-SITU CHEMICAL OXIDATION
COMPLIANCE WITH ARARS					
Chemical-Specific ARARs	Would not comply with state or federal groundwater quality standards or statutory requirements. No institutional controls to protect potential (future) receptors would be implemented.	Groundwater contaminant concentrations would initially exceed PRGs. Over time, PRGs would be achieved by natural attenuation. Institutional controls to protect potential receptors would be implemented.	Groundwater contaminant concentrations would initially exceed PRGs. Over time, active treatment would reduce contaminant levels below PRGs. Institutional controls to protect potential receptors would be implemented.	Groundwater contaminant concentrations would initially exceed PRGs. Over time, active treatment and natural attenuation would reduce contaminant levels below PRGs. Institutional controls to protect potential receptors would be implemented.	Groundwater contaminant concentrations would initially exceed PRGs. Contaminant rebounding may occur. After multiple applications, contaminant levels would be reduced below PRGs. Institutional controls to protect potential receptors would be implemented.
Location-Specific ARARs	Not applicable.	Not applicable.	The on-site treatment facility would be constructed in accordance with applicable federal and state storm water regulations.	The on-site facility for in-situ treatment would be constructed in accordance with applicable federal and state storm water regulations.	The on-site facility for in-situ treatment would be constructed in accordance with applicable federal and state storm water regulations.
Action-Specific ARARs	Not applicable.	Not applicable.	The on-site treatment facility would be constructed and operated in accordance with federal and state regulations. Treatment residues determined to be hazardous would be handled by approved RCRA facilities according to applicable transportation, storage, and disposal regulations. Materials disposed off site would comply with RCRA Land Disposal Restrictions.	The on-site facility for in-situ treatment would be constructed and operated in accordance with applicable federal and state hazardous TSD facility regulations. Federal and state regulatory requirements related to injection will be complied with.	The on-site facility for in-situ treatment would be constructed and operated in accordance with applicable federal and state hazardous TSD facility regulations. Federal and state regulatory requirements related to injection will be complied with.

TABLE 4-1
COMPARATIVE ANALYSIS OF REMEDIAL ACTION ALTERNATIVES
SITE 5 GROUNDWATER REMEDIATION
NAS JRB WILLOW GROVE, PENNSYLVANIA
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CRITERION:	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: MONITORED NATURAL ATTENUATION	ALTERNATIVE 3A: PUMP AND TREAT ENTIRE PLUME	ALTERNATIVE 4: IN-SITU BIOLOGICAL TREATMENT MONITORED NATURAL ATTENUATION	ALTERNATIVE 5: IN-SITU CHEMICAL OXIDATION
LONG-TERM EFFECTIVENESS AND PERMANENCE					
Magnitude of Residual Risk	Existing risks would remain. Future residential receptor of site groundwater would remain exposed to potential 8 x 10^{-4} (RME) carcinogenic risk and potential non-carcinogenic risks greater than 1.	Implementation and enforcement of institutional controls would reduce risks from exposure to site groundwater to less than 1 x 10^{-6} and HI would remain greater than 1.0. Over time, natural attenuation would result in permanently reduced risks.	Groundwater treatment would result in a permanent reduction of potential risks from exposure to site groundwater to less than 1 x 10^{-6} and an HI less than 1.0. In the interim, until groundwater remediation goals are achieved, implementation and enforcement of institutional controls would reduce risks from exposure to site groundwater to less than 1 x 10^{-6} and an HI less than 1.0.	Groundwater treatment would result in a permanent reduction of potential risks from exposure to site groundwater to less than 1 x 10^{-6} and an HI less than 1.0. In the interim, until groundwater remediation goals are achieved, implementation and enforcement of institutional controls would reduce risks from exposure to site groundwater to less than 1 x 10^{-6} and an HI less than 1.0.	Groundwater treatment would result in permanent reduction of potential risks from exposure to site groundwater to less than 1 x 10^{-6} and an HI less than 1.0. In the interim, until groundwater remediation goals are achieved, implementation and enforcement of institutional controls would reduce risks from exposure to site groundwater to less than 1 x 10^{-6} and an HI less then 1.0.
Adequacy and Reliability of Controls	No new controls implemented.	Long-term enforcement of institutional controls would be required to ensure their effectiveness for preventing use of contaminated groundwater.	Groundwater extraction and air stripping are widely used, effective technologies for the remediation of VOC-contaminated groundwater. There are some uncertainties associated with long-term effectiveness and reliability of the system because the rate of contaminant capture may be very slow. The process would be easily monitored and maintained. Routine maintenance and replacement of system components could be accomplished with little interruption of system operation. Long-term enforcement of institutional controls would be required to ensure their effectiveness for preventing use of contaminated groundwater.	In-situ biological treatment is a proven technology and has been field demonstrated for the remediation of VOC-contaminated groundwater. There is little uncertainty associated with long-term effectiveness and reliability of the system. Treatability study and pilot-/field-scale testing are used before full-scale application. The process would be easily monitored and maintained. Routine maintenance and replacement of system components could be accomplished with little interruption of system operation. Long-term enforcement of institutional controls would be required to ensure their effectiveness for preventing use of contaminated groundwater.	In-situ chemical oxidation is a proven technology and has been field demonstrated for the remediation of VOC-contaminated groundwater. Rebound of contaminants is of concern. Otherwise, there is little uncertainty associated with long-term effectiveness and reliability of the system. Treatability study and pilot-/field-scale testing are used before full-scale application. The process would be easily monitored and maintained. Routine maintenance and replacement of system components could be accomplished with little interruption of system operation. Long-term enforcement of institutional controls would be required to ensure their effectiveness for preventing use of contaminated groundwater.
Need for 5-Year Review	None.	Review would be required since groundwater contaminants would be left in place and institutional controls would be implemented.	Review would be required for the duration of the groundwater remediation period since groundwater contaminants would remain above remediation goals and institutional controls would be implemented.	Review would be required for the duration of the groundwater remediation period since groundwater contaminants would remain above remediation goals and institutional controls would be implemented.	Review would be required for the duration of the groundwater remediation period since groundwater contaminants would remain above remediation goals and institutional controls would be implemented.

TABLE 4-1
COMPARATIVE ANALYSIS OF REMEDIAL ACTION ALTERNATIVES
SITE 5 GROUNDWATER REMEDIATION
NAS JRB WILLOW GROVE, PENNSYLVANIA

CRITERION:	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: MONITORED NATURAL ATTENUATION	ALTERNATIVE 3A: PUMP AND TREAT ENTIRE PLUME	ALTERNATIVE 4: IN-SITU BIOLOGICAL TREATMENT MONITORED NATURAL ATTENUATION	ALTERNATIVE 5: IN-SITU CHEMICAL OXIDATION
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT					
Treatment Process Used	None.	None.	Air stripping with activated carbon polishing.	In-situ biological treatment by anaerobic reductive dehalogenation and monitored natural attenuation	In-situ chemical oxidation treatment.
Amount Treated or Destroyed	None.	None.	100 million gallons of contaminated groundwater, containing approximately 181 pounds of VOCs, remediated per year for up to 30 years.	Majority of sorbed- and dissolved-phase contaminants would be treated or destroyed in an estimated 15 years.	Majority of sorbed- and dissolved-phase contaminants would be treated or destroyed in an estimated 12 years.
Reduction of Toxicity, Mobility, or Volume Through Treatment	No reduction, since no treatment would be employed.	Slow reduction through passive treatment by natural attenuation.	The groundwater extraction and treatment system would contain the contaminant plume and remove the VOCs to reduce the toxicity, mobility, and volume of contaminated groundwater. Over a period of less than 30 years, the contaminants of concern in site groundwater would be reduced to PRG levels.	The in-situ groundwater treatment system would treat the contaminant plume, destroy the VOCs, and reduce the toxicity, mobility, and volume of contaminated groundwater. Over a period of 15 years, the contaminants of concern in site groundwater would be reduced to PRG levels.	The in-situ groundwater treatment system would treat the contaminant plume, destroy the VOCs, and reduce the toxicity, mobility, and volume of contaminated groundwater. Over a period of 12 years, the contaminants of concern in site groundwater would be reduced to PRG levels.
Irreversible Treatment	Not applicable.	Passive treatment.	Contaminants would be removed for off site treatment and disposal.	Irreversible treatment is applied, contaminants would be destroyed.	Irreversible treatment is applied, contaminants would be destroyed.
Statutory Preference for Treatment	No.	No.	Complies with statutory preference for treatment.	Complies with statutory preference for treatment.	Complies with statutory preference for treatment.

TABLE 4-1
COMPARATIVE ANALYSIS OF REMEDIAL ACTION ALTERNATIVES
SITE 5 GROUNDWATER REMEDIATION
NAS JRB WILLOW GROVE, PENNSYLVANIA

CRITERION:	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: MONITORED NATURAL ATTENUATION	ALTERNATIVE 3A: PUMP AND TREAT ENTIRE PLUME	ALTERNATIVE 4: IN-SITU BIOLOGICAL TREATMENT MONITORED NATURAL ATTENUATION	ALTERNATIVE 5: IN-SITU CHEMICAL OXIDATION
SHORT-TERM EFFECTIVENESS					
Community Protection	No additional risk to the community or the environment.	No significant risk to community anticipated. Engineering controls would be used during implementation to mitigate risks.	No significant risk to community anticipated. Engineering controls would be used during implementation to mitigate risks.	In-situ treatment pose no risk to community. Engineering controls would be used during implementation to mitigate risks.	In-situ treatment pose no risk to community. Engineering controls would be used during implementation to mitigate risks.
Worker Protection	No risk to workers anticipated.	No risk to workers anticipated if proper PPE is used during long-term monitoring.	No significant risk to workers anticipated if proper PPE and safe work practice are used during installation of the treatment facilities, operation and maintenance, and long-term monitoring.	No significant risk to workers anticipated if proper PPE and safe work practice are used during installation of the treatment facilities, operation and maintenance, and long-term monitoring.	Minimal risk to workers anticipated if proper PPE and safe work practice are used during operation and maintenance of the system. Installation and long-term monitoring carry no significant risks.
Environmental Impacts	No additional adverse impacts to the environment anticipated.	No adverse impacts to the environment anticipated.	No adverse impacts to the environment anticipated, if properly operated. Engineering controls would be used during construction and operations to mitigate risks.	No adverse impacts to the environment anticipated, if properly operated. Engineering controls would be used during construction and operations to mitigate risks.	No adverse impacts to the environment anticipated, if properly operated. Engineering controls would be used during construction and operations to mitigate risks.
Time Until Action is Complete	Not applicable.	More than 30 years are estimated until contaminants would be reduced to acceptable concentrations by natural attenuation.	Less than 30 years until RAO for mitigating migration of VOC contaminated groundwater would be achieved. Less than approximately 30 years until contaminants would be reduced to PRGs by groundwater treatment.	5 years until RAO for mitigating migration of VOC contaminated groundwater would be achieved. Approximately 15 years until contaminants would be reduced to PRGs by active treatment and monitored natural attenuation.	2 years until RAO for mitigating migration of VOC contaminated groundwater would be achieved. Approximately 12 years until contaminants would be reduced to PRGs by active treatment and verified by monitoring.

TABLE 4-1
SITE 5 COMPARATIVE ANALYSIS OF REMEDIAL ACTION ALTERNATIVES
NAS JRB WILLOW GROVE, PENNSYLVANIA

CRITERION:	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: MONITORED NATURAL ATTENUATION	ALTERNATIVE 3A: PUMP AND TREAT ENTIRE PLUME	ALTERNATIVE 4: IN-SITU BIOLOGICAL TREATMENT MONITORED NATURAL ATTENUATION	ALTERNATIVE 5: IN-SITU CHEMICAL OXIDATION
IMPLEMENTABILITY					
Ability to Construct and Operate	No construction or operation involved.	No construction or operational difficulties anticipated.	No significant construction or operational difficulties anticipated. Common construction equipment and construction techniques used for installation of groundwater extraction and treatment system.	No significant construction or operational difficulties anticipated. Common construction equipment and construction techniques used for installation of groundwater in-situ treatment system.	No significant construction or operational difficulties anticipated. Common construction equipment and construction techniques used for installation of groundwater in-situ treatment system.
Ease of Doing More Action if Needed	Additional actions would be easily implemented if required.	Additional actions would be easily implemented if required.	Additional actions would be easily implemented if required.	Additional actions would be easily implemented if required.	Additional actions would be easily implemented if required.
Ability to Monitor Effectiveness	Not applicable.	Groundwater monitoring would provide assessment of contaminant presence, migration, and changes in site conditions.	Groundwater monitoring would provide assessment of contaminant presence, migration, and changes in site conditions.	Groundwater monitoring would provide assessment of contaminant presence, migration, and changes in site conditions.	Groundwater monitoring would provide assessment of contaminant presence, migration, and changes in site conditions.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable..	Coordination for 5-year reviews may be required and would be obtainable.	Coordination with the state would be required for NPDES discharge permit revision.	Coordination with the state would be required for discharge limitations revision and underground injection control.	Coordination with the state would be required for discharge limitations revision and underground injection control.
Availability of Treatment, Storage Capacities, and Disposal Services	None required.	None required.	Sufficient commercial transportation, treatment and disposal capacity is available for materials requiring disposal.	Sufficient commercial transportation, treatment and disposal capacity is available for materials requiring disposal.	Sufficient commercial transportation, treatment and disposal capacity is available for materials requiring disposal.
Availability of Equipment, Specialists, and Materials	None required.	Ample availability of companies with trained personnel, equipment, and materials to perform natural attenuation modeling, long-term monitoring, and 5-year reviews.	Ample availability of companies with trained personnel, equipment, and materials to perform treatment system installation and operation, long-term monitoring, and 5-year reviews.	Ample availability of specialty companies with trained personnel, equipment, and materials to perform treatment system installation and operation, long-term monitoring, and 5-year reviews.	Ample availability of specialty companies with trained personnel, equipment, and materials to perform treatment system installation and operation, long-term monitoring, and 5-year reviews.
Availability of Technology	Not required.	Not required.	Groundwater extraction and air stripping are widely used, conventional technologies available from a variety of companies.	Treatment technology is proven and well-demonstrated, technologies available from a variety of companies.	Treatment technology is proven and well-demonstrated, technologies available from a variety of companies.

TABLE 4-1
SITE 5 COMPARATIVE ANALYSIS OF REMEDIAL ACTION ALTERNATIVES
NAS JRB WILLOW GROVE, PENNSYLVANIA

CRITERION:	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: MONITORED NATURAL ATTENUATION	ALTERNATIVE 3A: PUMP AND TREAT ENTIRE PLUME	ALTERNATIVE 4: IN-SITU BIOLOGICAL TREATMENT MONITORED NATURAL ATTENUATION	ALTERNATIVE 5: IN-SITU CHEMICAL OXIDATION
COST					
Capital Cost (including preliminary and final designs)	$0	$189,800	$1,423,800	$609,400	$757,800
Annual O&M and Monitoring Costs During Active Treatment	$0	$91,300 (Years 1 through 3)	$342,700 (Years 1 through 3)	$122,100 (Year 1) $85,300 (Years 2 through 5)	$206,600 (Years 1 through 2) $131,200 (Years 3 through 5)
Annual O&M and Monitoring Costs During Passive Treatment	$0	$45,600 (Yr 4 through 30)	$244,300 (Years 4 through 30)	$51,600 (Year 6) $35,000 (Years 7 through 15)	$62,000 (Years 6 through 12)
Five-Year Reviews (per event)	$0	$20,000	$20,000	$20,000	$15, 000 to $20,000
Present Worth Cost*	$0	$919,000	$4,756,000	$1,211,000	$1;705,000

*Present worth cost is based on discount rate of 7% per OSWER Directive No. 9355.3-20, June 1993.

Following a review of the comparative summary and detailed evaluations, Alternative 4 (In-Situ Treatment of Groundwater by Anaerobic Reductive Dehalogenation, Groundwater Recirculating, and Monitored Natural Attenuation) appears to be the most effective, most implementable, and least expensive alternative that will provide aggressive treatment for the Site 5 groundwater at NAS JRB Willow Grove.

4.3.1 Overall Protection of Human Health and the Environment

Alternative one would provide little additional protection of human health or the environment because no actions would be taken to prevent human exposure to groundwater or to mitigate migration of contaminated groundwater. Monitoring of VOC concentrations in existing site monitoring wells would provide the Navy and regulatory agencies limited notice if site conditions were to change over time.

Alternative 2 would provide protection of human health through implementation of groundwater use restrictions. No actions would be taken to mitigate migration of contaminated groundwater. Remediation of the groundwater contamination through NA and dissipation would eventually result in achievement of PRGs. The effectiveness of this alternative for interim protection of human health would be dependent on enforcement of institutional controls.

Alternatives 3A would provide protection of both human health and the environment through treatment of contaminated groundwater and implementation of institutional controls. Active removal of the VOC groundwater contamination through above-ground treatment should facilitate the natural attenuation and remediation of contaminated groundwater. The effectiveness of this alternative for interim protection of human health (until groundwater remediation is complete) would be dependent on enforcement of institutional controls.

Alternatives 4 and 5 would provide overall protection of human health and the environment through active treatment of contaminated groundwater and implementation of institutional controls. Active removal or destruction of the VOC groundwater contamination by in-situ treatment would minimize exposure to the site contaminants. The enhanced natural attenuation that is incorporated in Alternative 4 should provide further remediation of contaminated groundwater. The in-situ chemical oxidation that is employed by Alternative 5 may result in COC levels rebounding as a result of contaminant dissolution and/or partial degradation. Time required to complete the active treatment would be medium (estimated 5 years) and the shortest (estimated 2 years) for Alternative 4 and Alternative 5, respectively. The effectiveness of these alternatives for interim protection of human health (until groundwater remediation is complete) would be dependent on enforcement of institutional controls.

4.3.2 Compliance with ARARs

Implementation of Alternatives 3A, 4 and 5 would eventually comply with all ARARs and TBCs identified in Tables 2-1 through 2-3. None of the alternatives would initially comply with the ARARs for attainment of groundwater quality criteria; however, Alternatives 2, 3A, 4 and 5 would include a provision to implement institutional controls on the use of groundwater from Site 5 until the PRGs are achieved through NA and active treatment in-situ or above-ground. Alternative 1 would not comply with these standards or include a provision to seek temporary exemption.

Because no wetlands, floodplains, water bodies, or other sensitive receptors are believed to be present at Site 5, no location-specific ARARs were identified for this site. If any such receptors are identified during pre-design investigations, the corresponding location-specific ARARs would be identified during the remedial design and all necessary measures would be taken to comply with the federal and state location-specific ARARs. Any treatment facilities erected for Alternatives 3a, 4 and 5 would comply with applicable storm water management requirements in federal and state rules and regulations.

Because no actions would be implemented, no action-specific ARARs were identified for Alternatives 1 and 2. Alternatives 3A, 4, and 5 may require National Pollution Discharge Elimination System (NPDES) permit consideration or underground injection control (UIC) review by EPA and PADEP for the effluent disposal components in these alternatives.

If treatment residues or off-spec materials from the active treatment alternatives (Alternatives 3A, 4, and 5) are determined to be hazardous, their transport and disposal would comply with RCRA hazardous waste generator and transporter requirements [40 CFR parts 262 and 263]. Materials disposed off site would also comply with RCRA Land Disposal Restrictions [40 CFR 268]. Non-hazardous materials would be handled and managed in accordance with appropriate federal and state regulations,

The on-site treatment facilities proposed under Alternatives 3A, 4 and 5 would be constructed and operated in compliance with all ARARs identified in Tables 2-1 through 2-4.

4.3.3 Long-Term Effectiveness and Permanence

Alternatives 2, 3A, 4, and 5 offer long-term protection of both human health and the environment. Alternative 2 would not include actions to actively remediate VOCs but would provide protection of human health through the use of institutional controls. Alternative 1 would provide little additional protection of human health or the environment.

Alternatives 3A, 4, and 5 would employ active groundwater treatment, institutional controls, and removal or destruction of the groundwater contaminants to protect human health and the environment. All three would result in permanent reduction in risks from exposure to site groundwater to less than $1x10^{-6}$ carcinogenic risk and HI less than 1.0.

Downgradient receptors and the environment would be protected immediately upon installation and start-up of the treatment system under Alternative 3A. Under Alternatives 4 and 5, concentrations at the leading edge of the plume would be expected to decrease over time as the contaminants in the concentrated plume source area are degraded. Because all active treatment systems (3A, 4, and 5) would be designed to treat the contaminated groundwater in- or above-ground, the groundwater treatment systems would eventually decrease contaminant concentrations in site groundwater to acceptable levels, providing permanent protection of human health and the environment. Institutional controls would be used to prevent exposure to contaminated groundwater in the interim period until remediation goals have been achieved. Under these alternatives, the effectiveness of the interim protection would depend upon enforcement of institutional controls. If groundwater use restrictions were not enforced, protection of human health would not be achieved until the groundwater remediation is complete.

Under Alternative 2, protection of human health (for on-site and downgradient receptors) would be provided by institutional controls that place limitations on use of contaminated groundwater as drinking water. As with Alternatives 3A, 4 and 5, the effectiveness of these controls depends on enforcement. If groundwater use restrictions were not enforced, protection of human health would not be achieved until the groundwater contaminant concentrations decreased to acceptable levels through treatment and/or NA.

Some uncertainties are associated with the long-term effectiveness and reliability of Alternative 3A, which employs groundwater capture to collect contaminated groundwater. The rate of contaminant capture from the competent bedrock portion of the aquifer may be very slow. Pre-design investigations, treatability studies, and predictive modeling are included under Alternative 3A to aid in the design of the treatment system and to gauge the potential for progress toward remediation goals. However, the treatment reliability of Alternative 3A is expected to be high; because it employs unit treatment systems that have been widely demonstrated for remediation of VOC-contaminated groundwater. The long-term effectiveness and reliability of Alternatives 4 and 5 are generally high. In order to minimize uncertainties associated with the long-term effectiveness and reliability, treatability study and pilot-/field-scale testing are to be used before full-scale applications for these alternatives.

Long-term monitoring and 5-year reviews would be required for all five alternatives until groundwater contaminant concentrations decrease to acceptable levels through treatment or natural attenuation and dissipation. Regular monitoring would allow the responsible agency to assess changes in contaminant status and identify potential impacts to downgradient receptors.

4.3.4 Reduction of Toxicity, Mobility, or Volume Through Tr atm nt

Alternatives 3A, 4 and 5 would reduce the toxicity, mobility, and volume of contaminants through active treatment of contaminated groundwater and through treatment and disposal of treatment residues at approved facilities off site. All three treatment alternatives would be designed to address the same mass of contaminants, i.e., the entire groundwater contaminant plume and any source area materials requiring treatment.

Alternative 2 would reduce groundwater contamination through passive treatment of NA. Alternative 1 would not reduce the toxicity, mobility, or volume of contaminants, because no treatment is included.

Depending on VOC concentrations in air from the air stripper, Alternative 3A may generate spent carbon as a treatment residual from the vapor-phase carbon polishing unit. The aqueous carbon in Alternative 3A may also generate spent carbon for disposal.

4.3.5 Short-Term Effectiveness

The short-term effectiveness of Alternatives 1 through 5 would be similar since the use of appropriate engineering controls and PPE would be expected to minimize adverse impacts to base residents and personnel, the local community, and workers during implementation.

Long-term monitoring, the only on-site action proposed under Alternative 1, would provide little opportunity for short-term impact to the local community or the environment.

Alternative 2 would present a somewhat greater opportunity for short-term impacts to human health and the environment due only to the greater number of samples and field parameters collected to monitor natural attenuation in groundwater.
Alternatives 3A, 4 and 5 would present the greatest opportunity for short-term impacts due to installation and operation of the groundwater treatment systems. In all cases, short-term risks posed to base personnel, site workers, and the environment would be mitigated through use of engineering controls, transportation planning, appropriate PPE, and safe work practices. No permanent adverse impacts to the human health or the environment would be anticipated to result from implementation of Alternatives 3A, 4 and 5.

4.3.6 Implementability

Each of the alternatives would be implementable. Alternative 1 is the most easily implemented since the only activities proposed are long-term monitoring and 5-year reviews.

Alternative 2 would be the next easiest to implement because it involves only the marginal additional tasks of field personnel collecting additional samples and field parameters, as well as additional professional services needed to implement the institutional controls and for evaluation of raw data. There is a sufficient number of companies available with the trained personnel, equipment, and materials to perform field sample collection, office evaluation, and long-term monitoring tasks. Sufficient commercial laboratory capacity is available to handle the volume of analytical samples for analysis.

Alternatives 3A, 4 and 5 would be somewhat more difficult to implement because all would require installation and operation of an on-site treatment and delivery system. However, no difficulties are anticipated in implementing these alternative because they utilize well demonstrated technologies that employ relatively common equipment and materials. Several vendors in the specialized fields are available that could provide the necessary equipment, materials, and services. If additional actions are warranted, they could be easily implemented under any of the Alternatives.

4.3.7 Cost

The costs associated with each alternative are provided in Table 4-1. Alternative 1, No Action, would be the least expensive to implement, and Alternative 4, In-Situ Treatment of Groundwater by Enhanced Biological Anaerobic Reductive Dehalogenation, Groundwater Recirculating, and Monitored Natural Attenuation, would be the least expensive alternative that includes active treatment for the VOC-contaminated site groundwater.

4.3.8 Recommended Remedial Alternative

Alternative 4 (in-situ enhanced biological treatment and monitored natural attenuation) would provide aggressive and cost-effective treatment of sorbed- and dissolved-phase contamination in the source area and plume, as well as effectively protect human health and the environment over the short and long-term. Both treatability study and pilot- or field-scale testing would be required to determine in-situ treatment efficiencies and to verify the treatment effectiveness of anaerobic reductive dehalogenation process prior to designing a full scale remedial program. Active remediation of the saturated zone sorbed-phase contamination at the NAS JRB Willow Grove using enhanced biological anaerobic reductive dehalogenation will eliminate the most significant exceedances of the dissolved-phase COCs. NA processes will eventually eliminate or reduce the toxicity and volume of sorbed-phase sources of VOC contamination, thus limiting contaminant mobility and continued impacts to groundwater and residual dissolved-phase contaminant concentrations in excess of the RAOs.

Alternative 4 is readily implementable. The treatment and long-term monitoring programs associated with Alternative 4 could be conducted without difficulty. The implementation of Alternative 4 would not

limit future remedial actions, if needed, and would not interfere with the active facility operations at NAS JRB Willow Grove.

EXCERPTS FROM
CULTURAL RESOURCES SURVEY
NAVAL AIR STATION WILLOW GROVE PENNSYLVANIA
DRAFT 1996

The entire Cultural Resources Survey is available in the Administrative Record for NASJRB Willow Grove - Located at the Horsham Township Building.

CULTURAL RESOURCES SURVEY

NAVAL AIR STATION
WILLOW GROVE, PENNSYLVANIA

Prepared By

The Cultural Resource Group
Louis Berger & Associates, Inc.

For

Smith Environmental Technologies Corporation
NAVFAC Contract N62472-94-D-1397
Appendix U

Submitted To

Northern Division
Naval Facilities Engineering Command
Lester, Pennsylvania

Prepared For

Naval Air Station Willow Grove
Willow Grove, Pennsylvania

Draft
April 1996

Executive Summary

A cultural resources survey was conducted by Louis Berger & Associates, Inc. (LBA), at Naval Air Station Willow Grove (NAS Willow Grove), Pennsylvania, in 1996. The objectives of the study were to (1) inventory the station's buildings and structures and evaluate their significance in terms of the National Register of Historic Places Criteria for Evaluation; and (2) assess the potential of Navy property at NAS Willow Grove to contain prehistoric and historic-period archaeological resources.

The findings of this study are as follows:

(1) NAS Willow Grove contains no concentration of buildings or structures meeting National Register Criteria as a historic district.

(2) None of the buildings or structures at NAS Willow Grove erected prior to 1945 meet National Register Criteria as individual cultural resources, due to lack of historical significance and/or loss of physical integrity.

(3) Of the buildings and structures constructed since 1945 at NAS Willow Grove, none demonstrate qualities of exceptional significance necessary to meet National Register Criteria Consideration G governing properties less than 50 years of age.

(4) The vast majority of the land surface within the boundaries of NAS Willow Grove has been subjected to severe disturbance resulting from construction activities that have occurred since 1944. As a result, the potential for intact historic or prehistoric archaeological remains at the station are limited. In regard to historic archaeological site potential, 15 locations of historically-documented occupation were examined. Of these, four appear to have either moderate or high potential for intact historic archaeological remains. The remaining 11 locations possess low or extremely low potential for such remains. In terms of prehistoric site sensitivity, only one circumscribed area within the station boundaries appears to possess even moderate potential for prehistoric archaeological resources.

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Introduction

This document presents the results of a cultural resource study conducted in 1995 and 1996 at NAS Willow Grove, Montgomery County, Pennsylvania. Pursuant to Section 110 of the National Historic Preservation Act (as amended), the Department of the Navy commissioned this study in order to identify historic properties within its jurisdiction at NAS Willow Grove. Results of this study will be utilized by the Navy in meeting its obligations under Section 106 of the National Historic Preservation Act, and in accordance with 36 CFR 800 and with OPNAVINST 50901B, the Environmental and Natural Resources Program Manual.

The cultural resources survey for NAS Willow Grove included a Phase 1A archaeological investigation and an architectural resource survey. The general purpose of the Phase 1A archaeological investigation was to assess the potential of Navy property to contain prehistoric and/or historic archaeological resources. The objective of the architectural resource survey was to develop an inventory and assessment of buildings and structures with respect to the National Register of Historic Places Criteria for Evaluation (36 CFR 60.4).

APPENDIX B

BIOCHLOR MODEL RESULTS

BIOCHLOR Natural Attenuation Decision Support System

Version 1.1

Site 5, 00R1A
Willow Grove PA
Run Name

Data Input Instructions:
115 → 1. Enter value directly ... or
or 2. Calculate by filling in gray cells. Press Enter, then
0.02 ↗ (To restore formulas, hit "Restore Formulas" button.)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes / Ethanes

1. ADVECTION

Seepage Velocity*	Vs	43.3	(ft/yr)
or			
Hydraulic Conductivity	K	2.5E-03	(cm/sec)
Hydraulic Gradient	i	0.00335	(ft/ft)
Effective Porosity	n	0.2	(-)

2. DISPERSION

Alpha x Calc. Method	50	(ft)
(Alpha y) / (Alpha x)	0.1	(-)
(Alpha z) / (Alpha x)	5.1E-02	(-)

Change Alpha x Calc. Method

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	2	(kg/L)		
FractionOrganicCarbon, foc	2.0E-3	(-)		
Partition Coefficient	Koc			
PCE	210	(L/kg)	5.2	(-)
TCE	90	(L/kg)	2.8	(-)
DCE	70	(L/kg)	2.4	(-)
VC	20	(L/kg)	1.4	(-)
ETH	302	(L/kg)	7.0	(-)
Common R (used in model)* =			2.4	

4. BIOTRANSFORMATION — 1st Order Decay Coef*

Zone 1	λ (1/yr)	half-life (yrs)	Yield*
PCE → TCE	0.140		0.79
TCE → DCE	0.100		0.74
DCE → VC	0.360		0.64
VC → ETH	0.240		0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	
ETH → Ethane		

5. GENERAL

Simulation Time*	23	(yr)
Modeled Area Width*	300	(ft)
Modeled Area Length*	1000	(ft)
Zone 1 Length*	1000	(ft)
Zone 2 Length*	0	(ft)

L, W

Zone 2 = L - Zone 1

6. SOURCE DATA

Source Options

TYPE: Single Planar

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations

Source Thickness in Sat. Zone* 50 (ft)

Width* (ft) 50

Conc. (mg/L)*	C1
PCE	.03
TCE	.3
DCE	.4
VC	
ETH	

View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)											
DCE Conc. (mg/L)											
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Dist. from Source (ft)											

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example | Unprotect Sheet

1:00

BIOCHLOR DATAINPUT SCREEN

H-1. Parameters for Preliminary Screening for Anaerobic Biodegradation Processes

	H	CO2	O	Nitrate	Methane	Ethane	Ethene	pH*
Well	(nM/L)	(mg/L	mg/L	as N (mg/L)	(mg/L)	(mg/L)	(mg/L)	
05MW01S	6.4	128.4	1.09	10.4	15.8	0.03	0.05	5.2
05MW01SI	8.8	71.9	0.75	13.6	0.3	nd	0.02	6
05MW07S	S**	119.1	0.64	9.4		0.01	0.01	4.9
05MW07I	S	21.8	1.95	13.3	1.5	nd	nd	6.4
05MW08S	S	122	0.86	10.8	nd	nd	nd	5.4
05MW08SI	S	67.2	0.82	11.7	nd	nd	nd	5.8
05MW08I	S	16.1	2.33	10.9	nd	nd	nd	6.2
05MW09S	11.1	174.9	0.36	11.5	0.8	0.01	0.05	4.9
05MW09SI	6.6	90.5	0.73	12.5	nd	nd	0.02	5.4
05MW09I	7	21.8	1.92	12.8	nd	0.01	0.01	6
05MW10S	S	192.9	0.52	9.7	2.8	nd	0.01	5.4
05MW10SI	S	58.2	1.06	11.4	nd	0.01	0.01	6
05MW10I	S	6.5	3.89	16.8	nd	0.01	0.02	6.8
05MW11S	1.8	100.4	0.21	11.3	nd	nd	0.01	
05MW11SI	2.5	83.5	3.05	8.5	nd	nd	nd	
05MW11I	S	1.7	1.09	13	1.3	nd	nd	

Criteria (US EPA, 1998)

Tolerated	> 1	> 2 x backgr	< 0.5	< 1	> 0.5	> 0.1	> 0.01	5<pH<9
Score	3	1	3	2	3	3	2	0
not tolerated	< 1		> 5	> 1	< 0.5			5>pH>9
Score	VC oxid.		-3	0	VC oxid.			-2

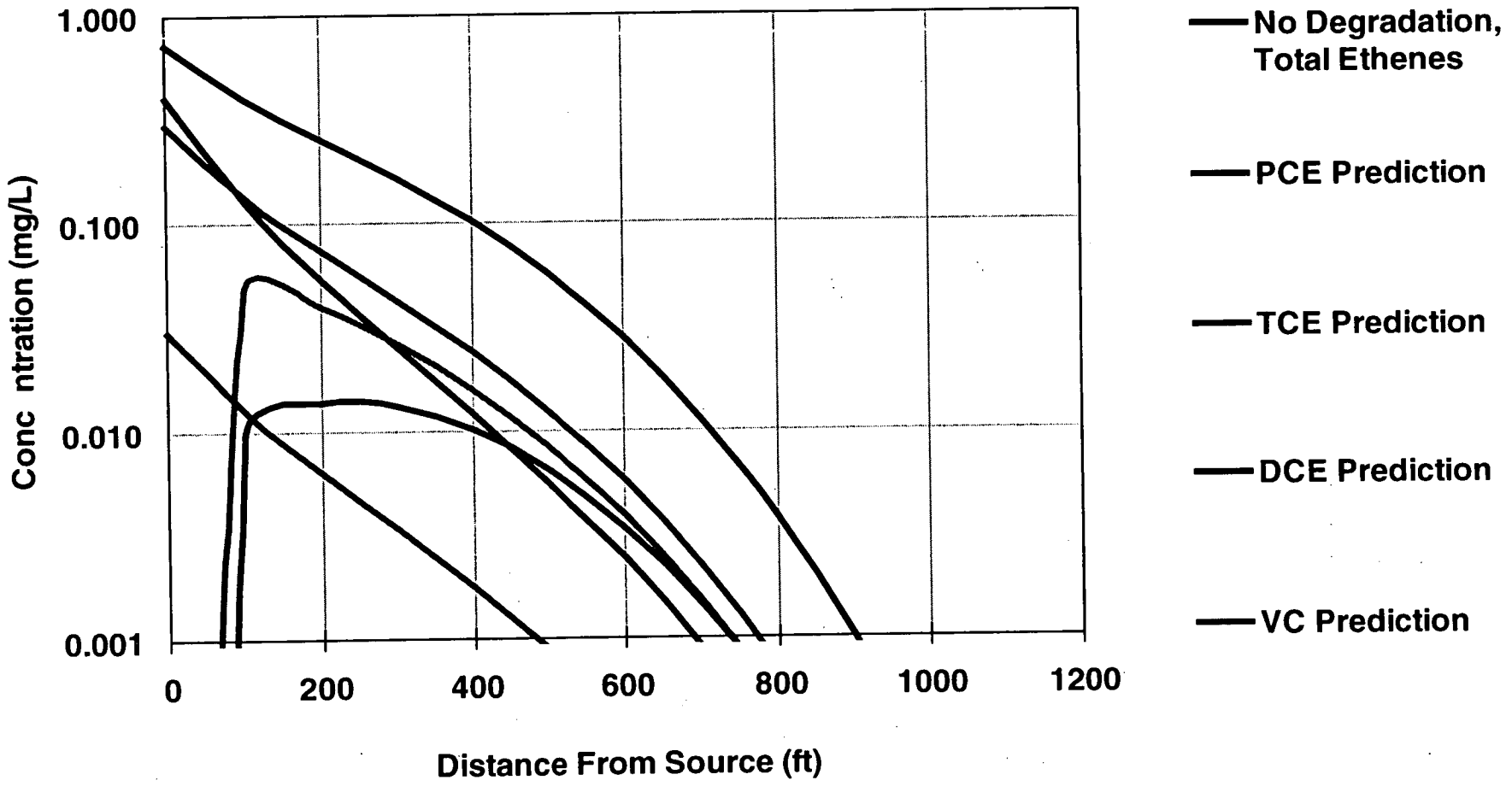
*pH data from Groundwater Sample Log Sheet (Phase II RIR, April 1998)

**S Compaund saturated detector, actual result > 50 nM/L

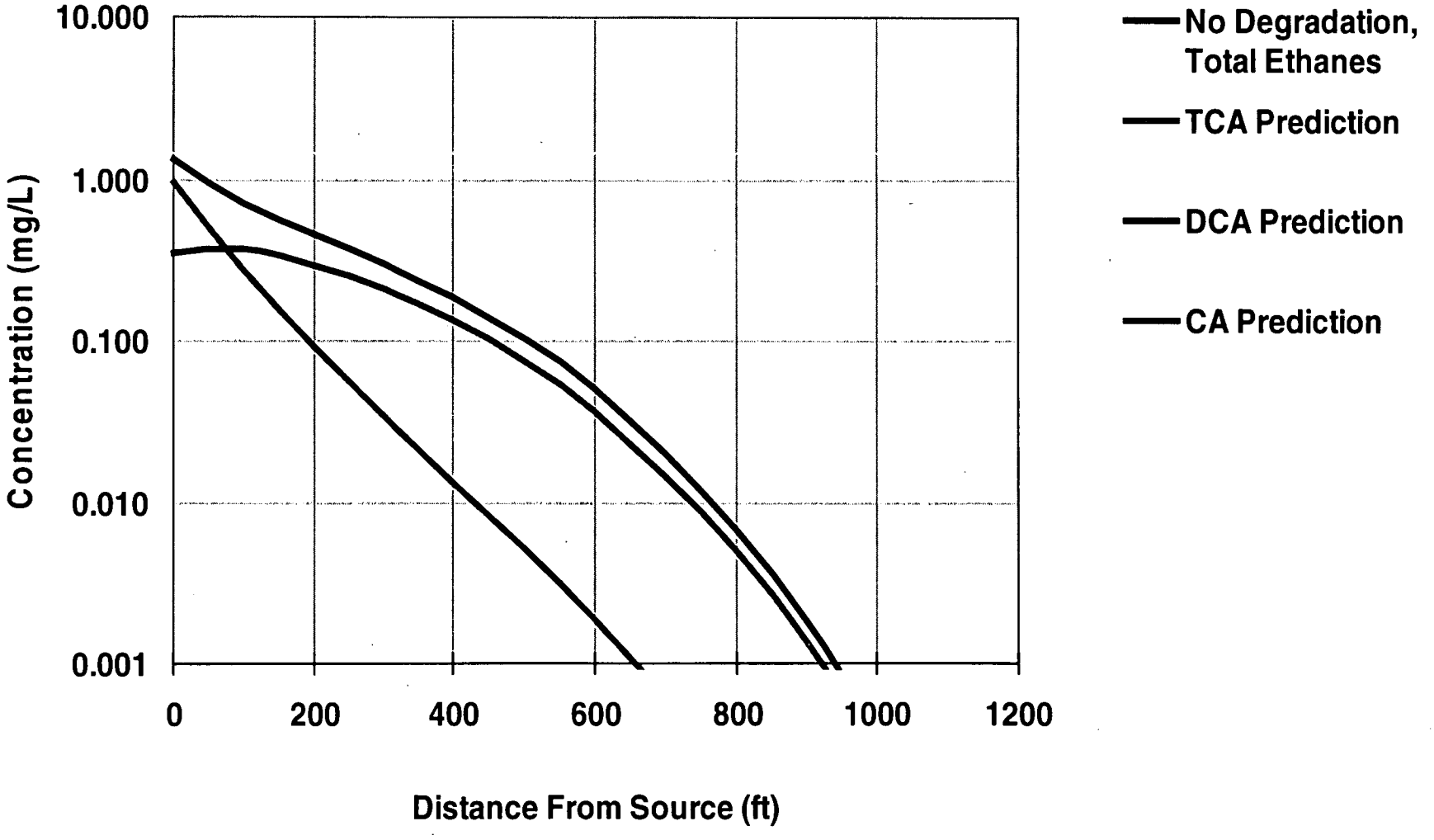
nd - not detected

NASJRB, Site 5, Willow Grove PA

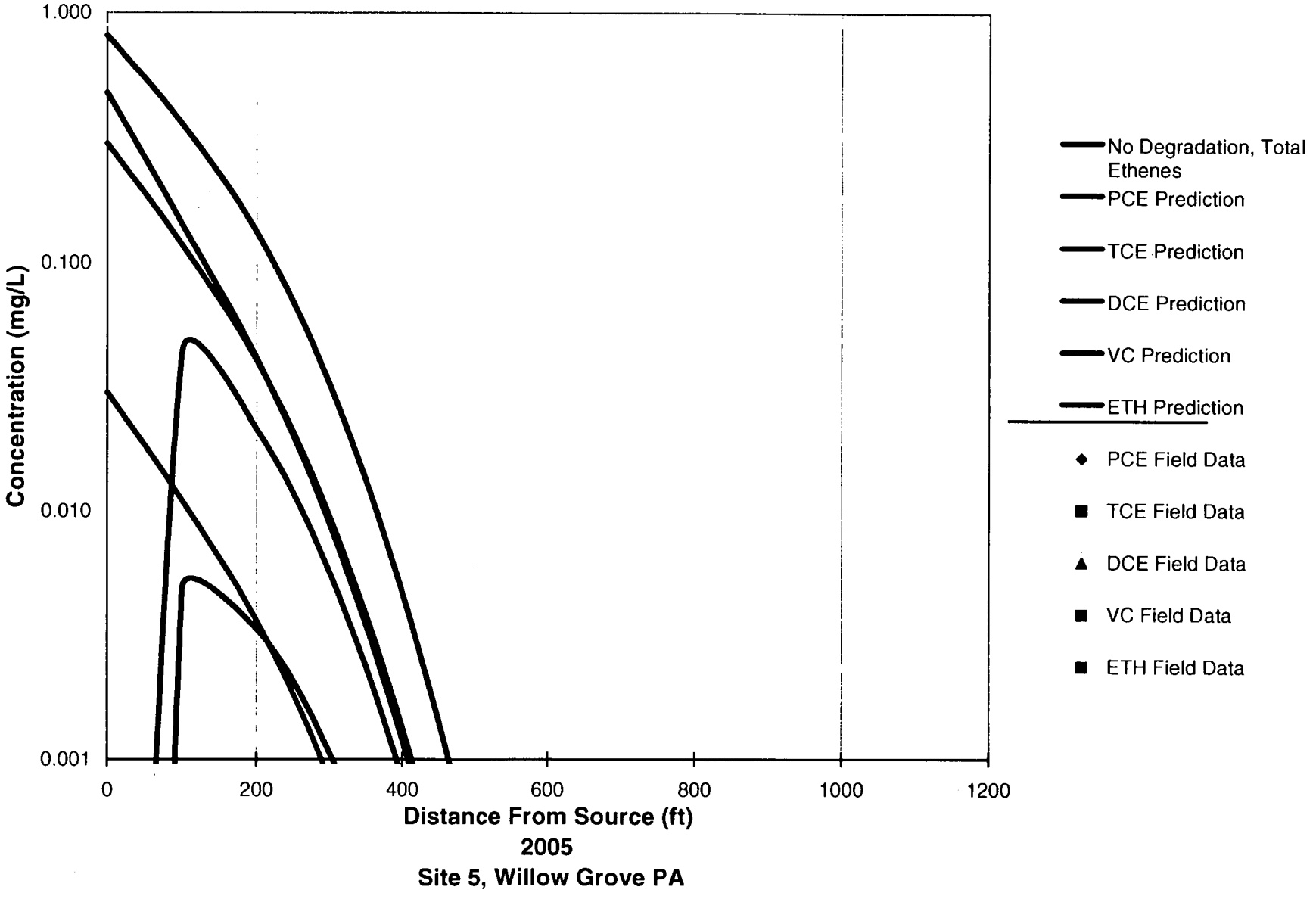
Predicted Concentrations and Migration of Ethenes for year 2020



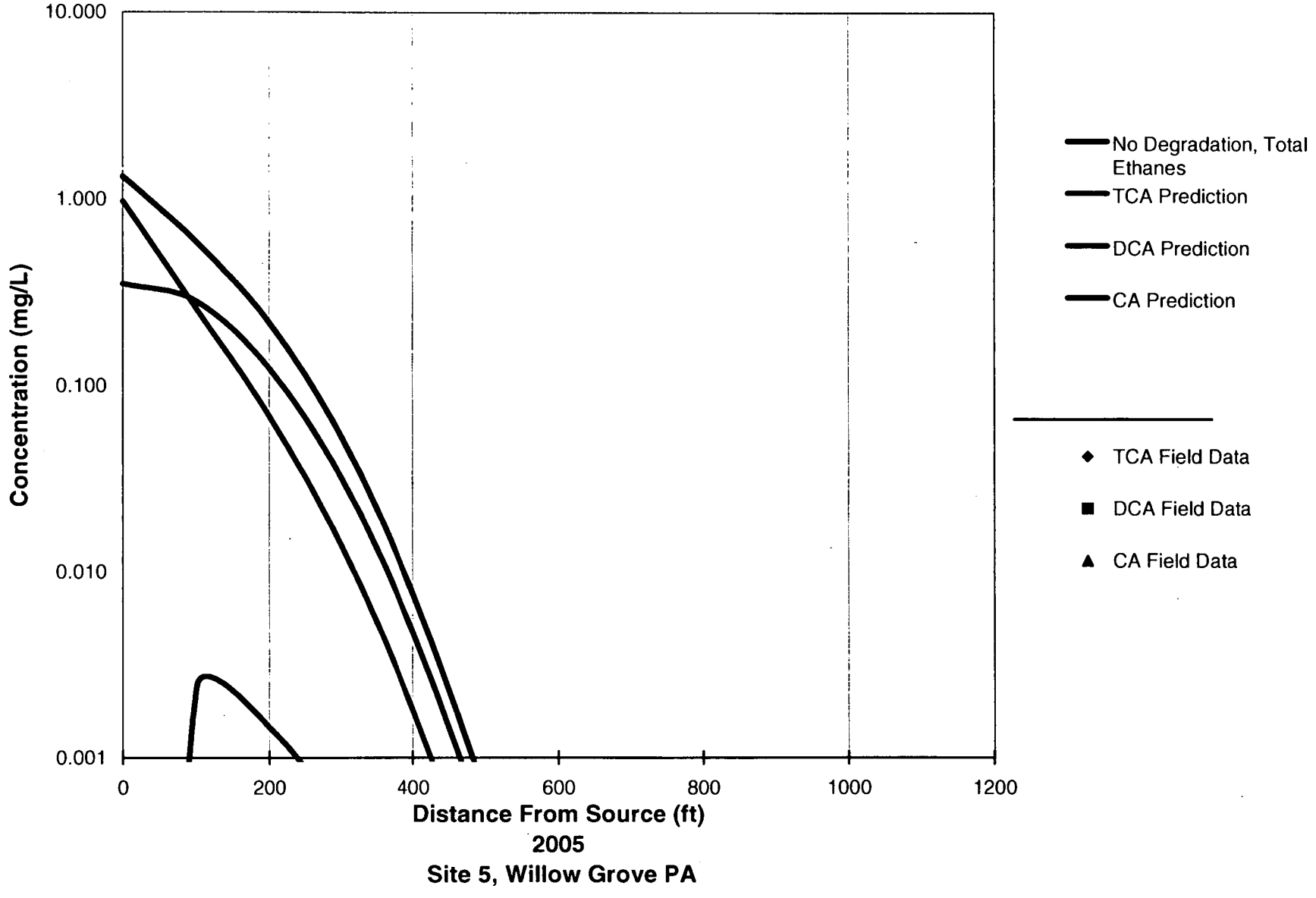
NASJRB, Site 5, Willow Grove PA Predicted Concentrations and Migration of Ethanes for year 2020

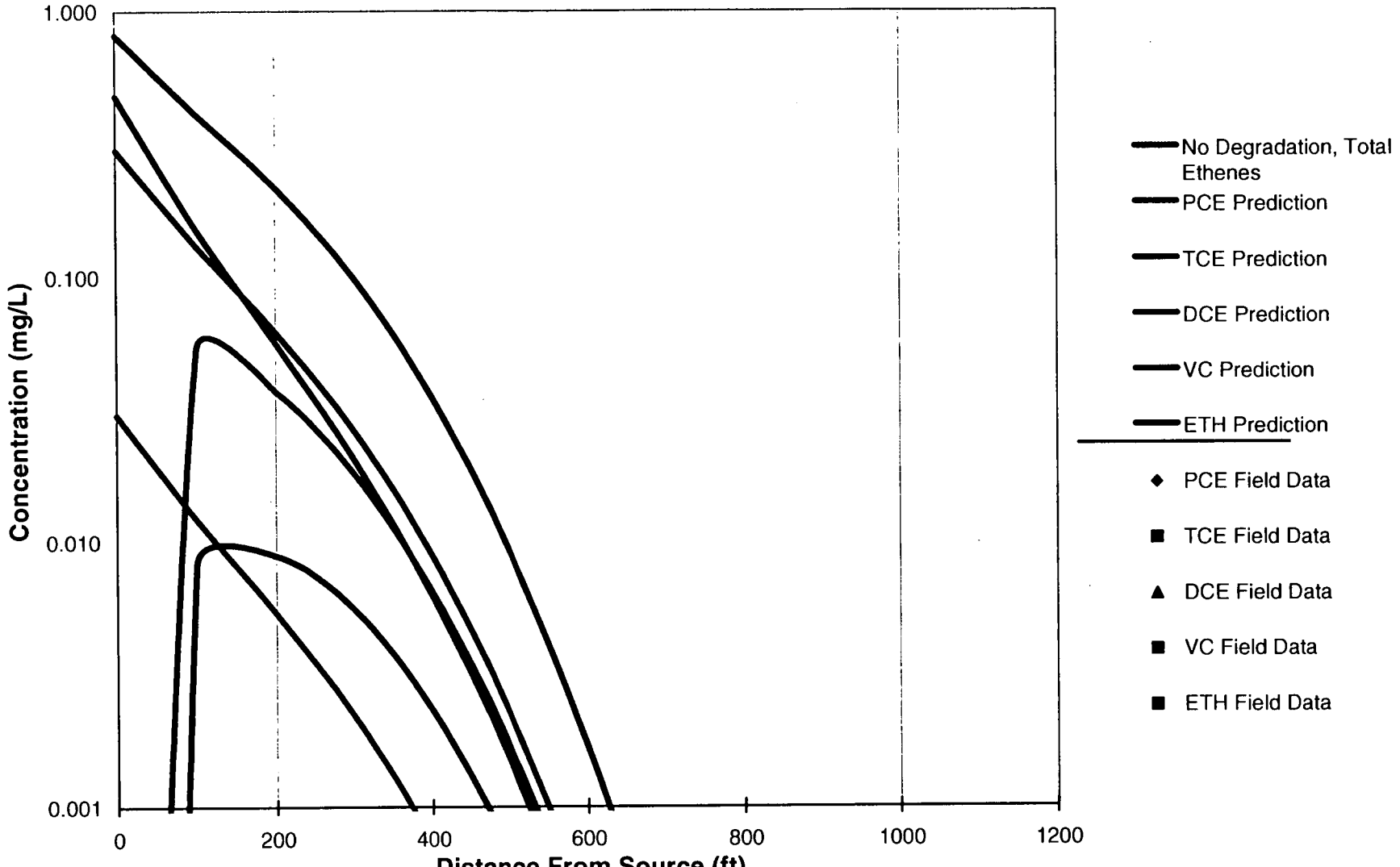


Centerline Output Chart 3



Centerline Output Chart 3

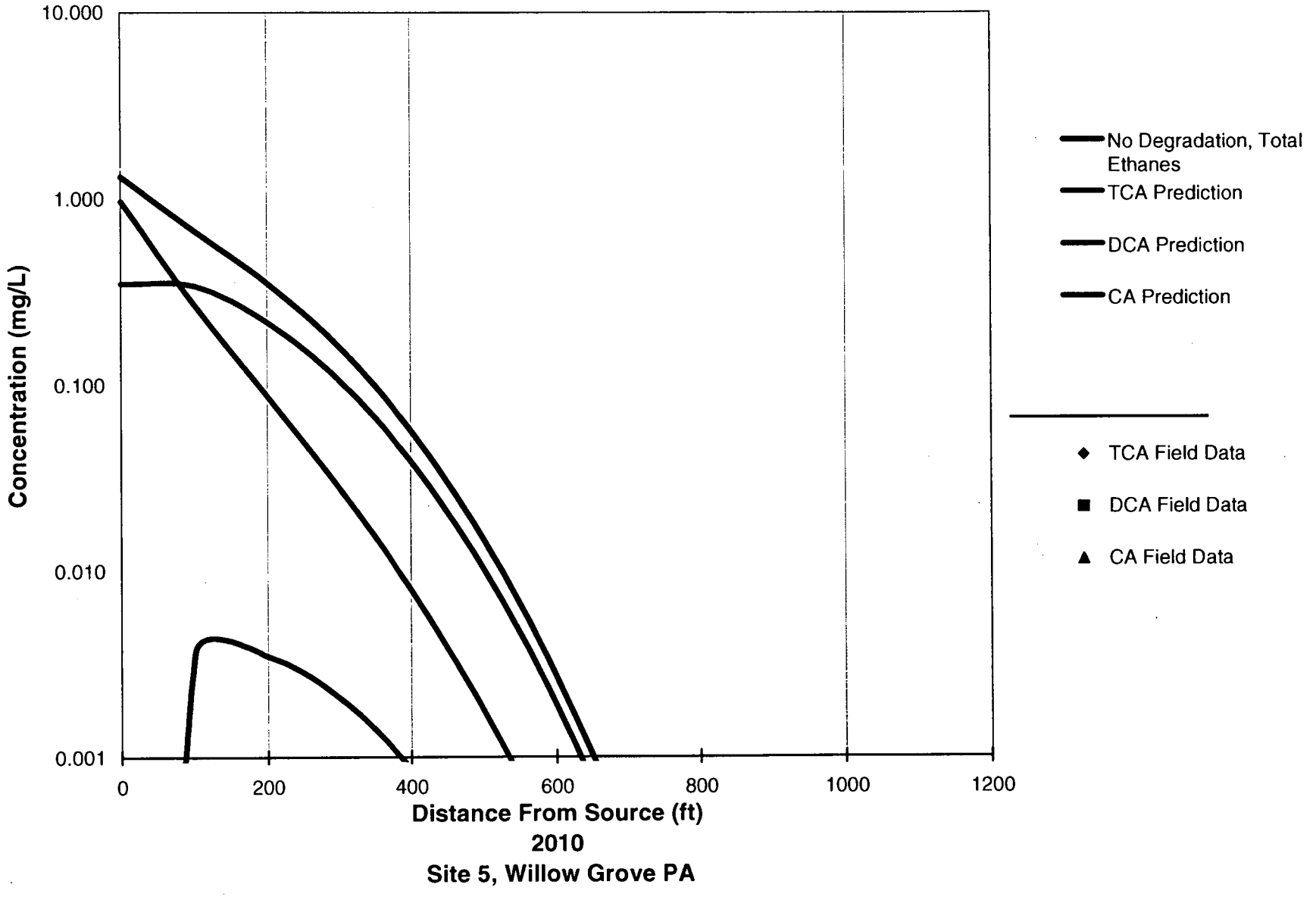




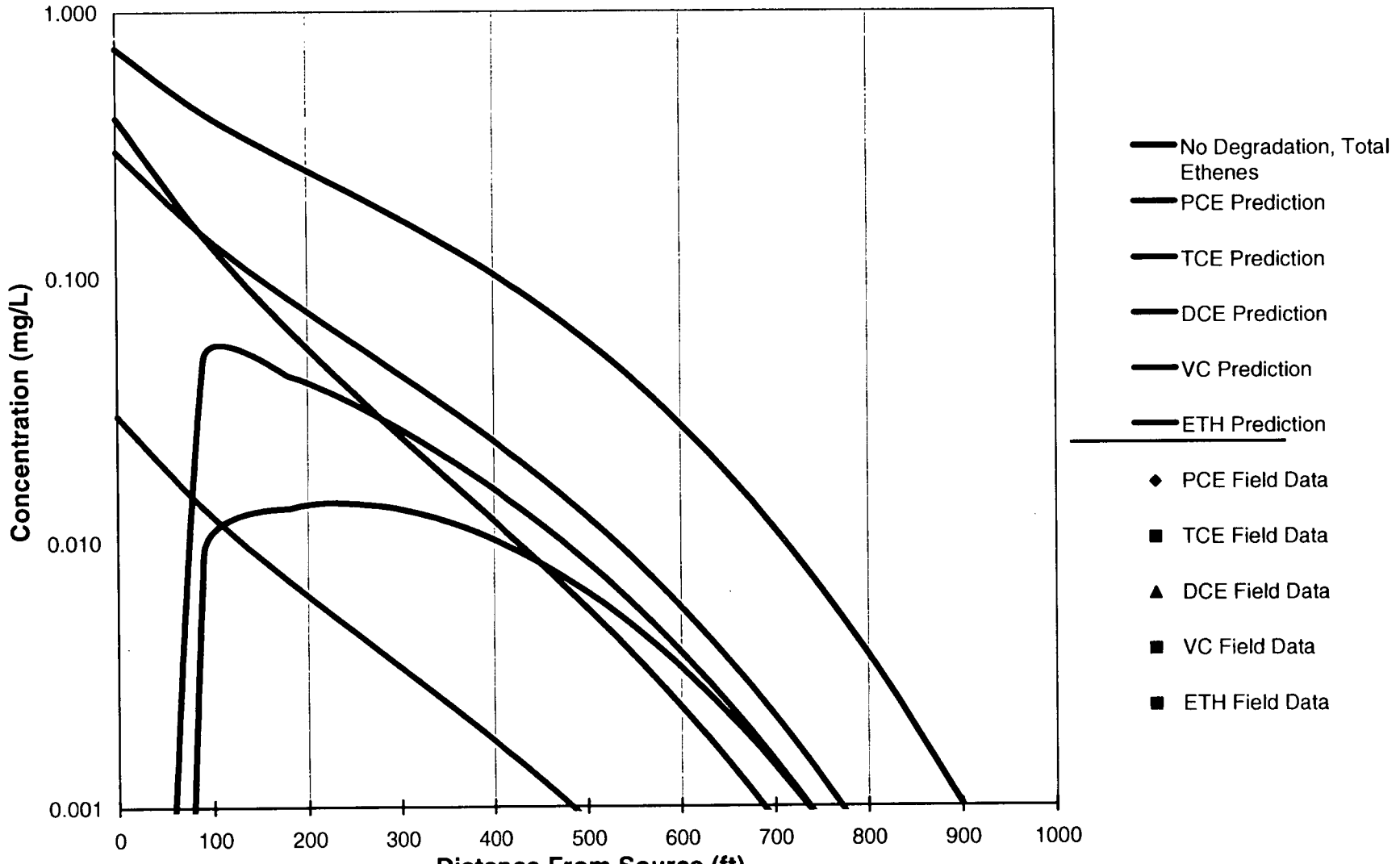
2010

Site 5, Willow Grove PA

Centerline Output Chart 3



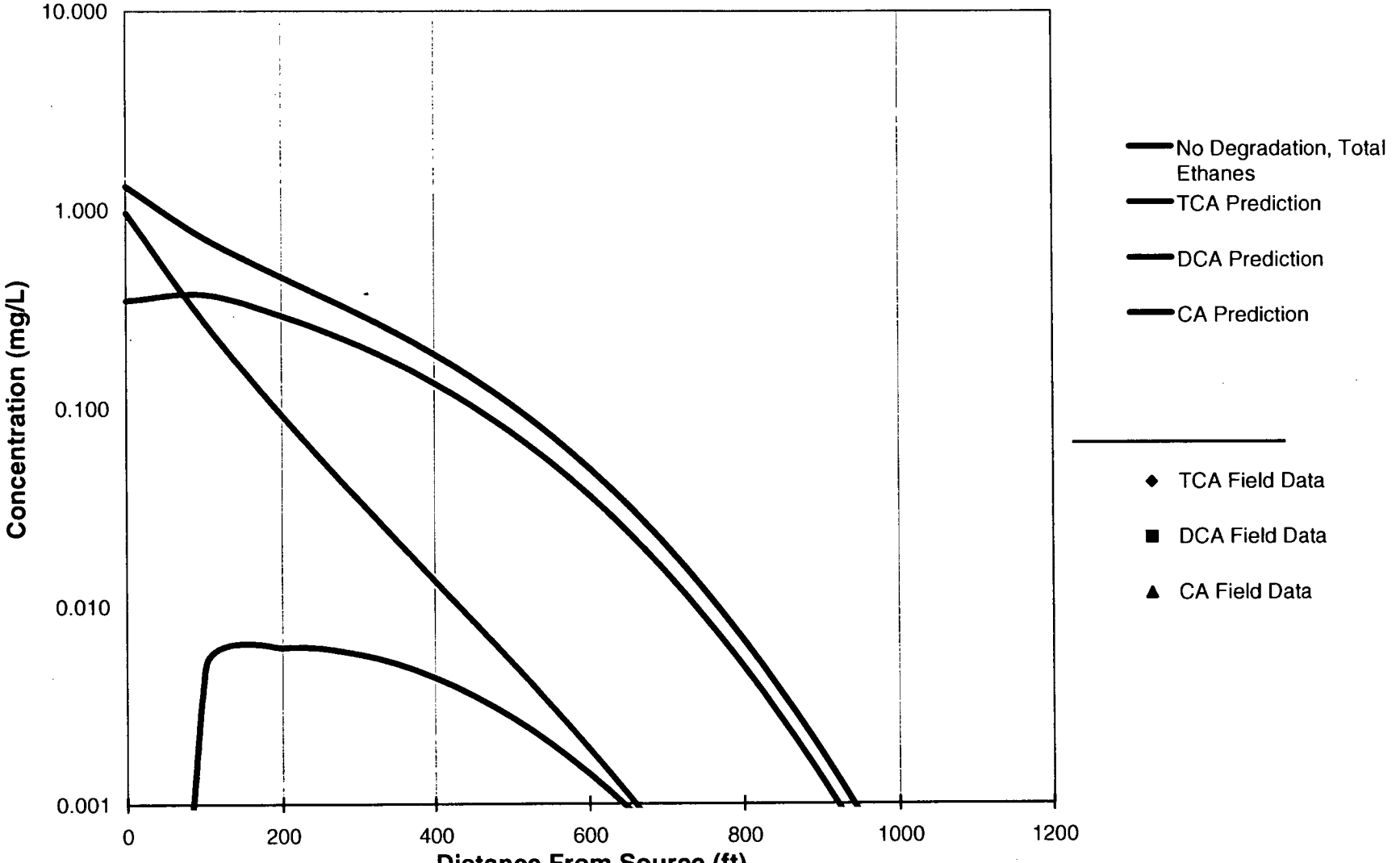
Centerline Output Chart 3



2020

Site 5, Willow Grove PA

Centerline Output Chart 3



2020

Site 5, Willow Grove PA

APPENDIX C

REMEDIATION ALTERNATIVE COST ESTIMATES

CALCULATION WORKSHEET

PAGE _____ OF _____

CLIENT NASJRB Willow Grove		JOB NUMBER 5466	
SUBJECT Site 5 FS - AH2			
BASED ON		DRAWING NUMBER	
BY MES	CHECKED BY	APPROVED BY	DATE

Assumptions

For MNA - 5 new monitoring wells will be required. Each well will be 150ft deep

- A total of 10 monitoring wells will comprise the monitoring program

Land use controls will be required on-base and off-base to limit ground water use.

PRESENT WORTH ANALYSIS
ALTERNATIVE 2 - MONITORED NATURAL ATTENUATION
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

YEAR	PRESENT WORTH FACTOR	CAPITAL COSTS	O & M COSTS	5-YEAR REVIEWS	PRESENT WORTH
0	1.000	$189,753			$189,753
1	0.935		$91,252		$85,283
2	0.873		$91,252		$79,703
3	0.816		$91,252		$74,489
4	0.763		$45,626		$34,808
5	0.713		$45,626	$20,000	$46,791
6	0.666		$45,626		$30,403
7	0.623		$45,626		$28,414
8	0.582		$45,626		$26,555
9	0.544		$45,626		$24,818
10	0.508		$45,626	$20,000	$33,361
11	0.475		$45,626		$21,677
12	0.444		$45,626		$20,259
13	0.415		$45,626		$18,933
14	0.388		$45,626		$17,695
15	0.362		$45,626	$20,000	$23,786
16	0.339		$45,626		$15,455
17	0.317		$45,626		$14,444
18	0.296		$45,626		$13,499
19	0.277		$45,626		$12,616
20	0.258		$45,626	$20,000	$16,959
21	0.242		$45,626		$11,019
22	0.226		$45,626		$10,298
23	0.211		$45,626		$9,625
24	0.197		$45,626		$8,995
25	0.184		$45,626	$20,000	$12,092
26	0.172		$45,626		$7,857
27	0.161		$45,626		$7,343
28	0.150		$45,626		$6,862
29	0.141		$45,626		$6,413
30	0.131		$45,626	$20,000	$8,621

TOTAL PRESENT WORTH = $918,824

Discount rate of 7% per OSWER Directive No. 9355.3-20, June 1993

ALTERNATIVE 2 - MONITORED NATURAL ATTENUATION
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments
1 MONITORING												
YEARS 1,2, and 3, Quarterly Monitoring												
1.01 Analytical 15 samples/event	60	amples	$285.00				$17,100	$0	$0	$0	$17,100	
1.02 Per Diem 5 days/event/2 people	40	days	$120.00				$4,800	$0	$0	$0	$4,800	
1.03 Vehicle	20	days	$75.00				$1,500	$0	$0	$0	$1,500	
1.04 Field labor 5 days/event/2 people	400	hours			$25.00		$0	$0	$10,000	$0	$10,000	
1.05 Data Validation (QA\QC) 24 hr/event	96	hours			$30.00		$0	$0	$2,880	$0	$2,880	
1.06 Prepare Report, Update Model 40 hr./event	160	hours			$30.00		$0	$0	$4,800	$0	$4,800	
1.07 IDW	2	events		$1,550.00			$0	$3,100	$0	$0	$3,100	
1.08 ODC's @$500/event	4	events		$500.00			$0	$2,000	$0	$0	$2,000	
1.09 Equipment Rental @$2500/event	4	events				$2,500.00	$0	$0	$0	$10,000	$10,000	
1.10 Project Management 10hr./event	40	hrs			$35.00		$0	$0	$1,400	$0	$1,400	
Subtotal							$23,400	$5,100	$19,080	$10,000	$57,580	
Overhead on Labor Cost @ 30%									$5,724		$5,724	
G & A on Labor Cost @ 10%									$1,908		$1,908	
Sales Tax on Material 6%: 6%								$306			$306	
G & A on Material Cost @ 10%								$541			$541	
G & A on Subcontract Cost @ 10%							$2,340				$2,340	
Total Direct Cost							$25,740	$5,947	$26,712	$10,000	$88,399	
Indirects on Total Direct Labor Cost @ 50%									$13,356		$13,356	
Profit on Total Direct Cost @ 10%											$8,840	
Subtotal											$88,594	
Health & Safety Monitoring @ 3%											$2,658	
Total Monitoring Cost											$91,252	
2 YEARS 4 through 30, Semi-annual monitoring												
2.01 Analytical 15 samples/event	30	amples	$285.00				$8,550	$0	$0	$0	$8,550	
2.02 Per Diem 5 days/event/2 people	20	days	$120.00				$2,400	$0	$0	$0	$2,400	
2.03 Vehicle	10	days	$75.00				$750	$0	$0	$0	$750	
2.04 Field labor 5 days/event/2 people	200	hours			$25.00		$0	$0	$5,000	$0	$5,000	
2.05 Data Validation (QA\QC) 24 hr/event	48	hours			$30.00		$0	$0	$1,440	$0	$1,440	
2.06 Prepare Report, Update Model 40 hr./event	80	hours			$30.00		$0	$0	$2,400	$0	$2,400	
2.07 IDW	1	events		$1,550.00			$0	$1,550	$0	$0	$1,550	
2.08 ODC's @$500/event	2	events		$500.00			$0	$1,000	$0	$0	$1,000	
2.09 Equipment Rental @$2500/event	2	events				$2,500.00	$0	$0	$0	$5,000	$5,000	
2.10 Project Management 10hr./event	20	hrs			$35.00		$0	$0	$700	$0	$700	
Subtotal							$11,700	$2,550	$9,540	$5,000	$28,790	
Overhead on Labor Cost @ 30%									$2,862		$2,862	
G & A on Labor Cost @ 10%									$954		$954	
Sales Tax on Material 6%: 6%								$153			$153	
G & A on Material Cost @ 10%								$270			$270	
G & A on Subcontract Cost @ 10%							$1,170				$1,170	
Total Direct Cost							$12,870	$2,973	$13,356	$5,000	$34,199	
Indirects on Total Direct Labor Cost @ 50%									$6,678		$6,678	
Profit on Total Direct Cost @ 10%											$3,420	
Subtotal											$44,297	
Health & Safety Monitoring @ 3%											$1,329	
Total Monitoring Cost											$45,626	

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ALTERNATIVE 2 - MONITORED NATURAL ATTENUATION
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments
NATURAL ATTENUATION											
1 SUBCONTRACTED COSTS											
1.01 Drilling (five wells @ 150 ft. each)	750	ft	$60.00			$45,000	$0	$0	$0	$45,000	
1.02 Analytical	20	ea	$285.00			$5,700	$0	$0	$0	$5,700	
1.03 Travel & Living	15	day	$150.00			$2,250	$0	$0	$0	$2,250	
1.04 Surveyor	1	ls	$1,700.00			$1,700	$0	$0	$0	$1,700	
1.05 IDW	10	dm	$550.00			$5,500	$0	$0	$0	$5,500	
1.06 Equipment Rental	1	ls	$4,500.00			$4,500	$0	$0	$0	$4,500	
Subtotal						$64,650	$0	$0	$0	$64,650	
Overhead on Labor Cost @ 30%								$0		$0	
G & A on Labor Cost @ 10%								$0		$0	
Sales Tax on Material 8%							$0			$0	
G & A on Material Cost @ 10%							$0			$0	
G & A on Subcontract Cost @ 10%						$8,465				$8,465	
Total Direct Cost						$135,765	$0	$0	$0	$135,765	
Indirects on Total Direct Labor Cost @ 75%								$0		$0	
Profit on Total Direct Cost @ 10%										$13,577	
Total Field Cost										$149,342	
			Level of Effort (Hours)								
2 PROFESSIONAL LABOR	P4	P3	P2	P1	T2						
2.01 Preparatory (WP, SAP, HASP, Procure Sub)	15	20	40	40	24			$3,138		$3,138	
2.02 Monitoring Well Installation	0	15	120	120				$4,830		$4,830	
2.03 Data Reduction/Validation	5	40	24					$1,911		$1,911	
2.04 Reporting	5	40	24		32			$2,479		$2,479	
2.05 Project Management	20							$877		$877	
						$0.00		$13,235		$13,235	
Overhead on Labor Cost @ 30%										$3,971	
G & A on Labor Cost @ 10%										$1,324	
Indirects on Total Prof. Labor Cost @ 25%										$3,309	
Profit on Total Cost @ 10%										$1,323.51	
Total Prof. Labor Cost										$23,161	
Total Field Cost + Prof. Labor										$172,503	
Contingency @ 10%										$17,250	
ESTIMATED CAPITAL COSTS FOR NATURAL ATTENUATION										**$189,753**	

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CALCULATION WORKSHEET PAGE _____ OF _____

CLIENT NASJRB Willow Grove		JOB NUMBER 5466	
SUBJECT Site 5 FS - Alt 3A			
BASED ON		DRAWING NUMBER	
BY MES	CHECKED BY	APPROVED BY	DATE

Pump & Treat Source Zone & Plume

Install two extraction wells @ Source zone 200 ft ea
Contaminants flow rates etc. as in Alt 3
Install two monitoring wells 200 ft ea.
Install nine extraction wells downgradient of source zone, extract gw @ 20 gpm per well.

Avg. concentration:

Downgradient Wells		Avg. Total Conc. (Source & Down)
Benzene	16 ug/L	15
TCE	69 ug/L	112
PCE	– ug/L	12
1,1-DCE	120 ug/L	166
1,1,1-TCA	260 ug/L	394

From QED Air Stripper Model
for an EZ Tray model 24.x operating @ 1300 cfm

Total air concentration 2.8268 ppmV mass flux = 0.0694 lb/hr

From Calgon for air between 1 and 10 ppmV
removal capacity is ≈10% by wieght – use 5%

$0.07\ lb/hr \times \frac{1}{0.05} \times 24\ hr = 33.6\ lb/day$ carbon

for 2000 lb units 2000 lb / 33.6 lb/d = 60 day

2000 lb units acceptable, bi-monthly changeouts.

Model 1. Alt 4

QED Air Stripper Model ver. c1.00	4/2/2001

Site Data

Name: Mike Snyder
e-mail: snyderm@ttnus.com
Project: Willow Grove
Units: English
Altitude: 360 ft
Air Temp: 55 F
Flow: 190 gpm
Water Temp: 52 F
Stripper: EZ-Tray 24.x - Click for details
Stripper Air Flow: 1300 cfm
Stripper Max Flow: 200 gpm

Water Results

Contaminant	Influent (ppb)	Target (ppb)	4-Tray Results (ppb)	4-Tray % Removal	6-Tray Results (ppb)	6-Tray % Removal
benzene	15	0	< 1	100.000	< 1	100.000
trichloroethylene (TCE)	112	0	< 1	100.000	< 1	100.000
tetrachloroethylene (PCE)	12	0	< 1	100.000	< 1	100.000
1,1-dichloroethylene	166	0	< 1	100.000	< 1	100.000
1,1,1-trichloroethane	394	0	< 1	100.000	< 1	100.000
1,1-dichloroethane	31	0	< 1	100.000	< 1	100.000

Air Results

Contaminant	4-Tray (ppmV)	4-Tray (lb/hr)	6-Tray (ppmV)	6-Tray (lb/hr)
benzene	0.0890	0.00143	0.0891	0.00143
trichloroethylene (TCE)	0.3952	0.01065	0.3955	0.01065
tetrachloroethylene (PCE)	0.0336	0.00114	0.0336	0.00114
1,1-dichloroethylene	0.7945	0.01579	0.7945	0.01579
1,1,1-trichloroethane	1.3704	0.03748	1.3704	0.03748
1,1-dichloroethane	0.1441	0.00292	0.1453	0.00295
Total	2.8268	0.06941		

Notes

Copyright -- QED Treatment Equipment, PO Box 3726, Ann Arbor, MI 48106.

PH-> 1-800-624-2026 or 1-734-995-2547, FX-> 1-734-995-1170. E-mail->info@qedenv.com. WEB->www.qedenv.com.

The QED modeler estimates unit performance for the listed contaminants. ***Results assume -***

1. *dissolved-phase contaminant within a water matrix*
2. *clean stripper air*
3. *no surfactants, oil, grease or other immiscible phase(s) in the influent*
4. *unit operated within the given parameters and as instructed in the O&M manual*

Stripper performance shall meet or exceed either the required effluent concentration(s) or effluent estimates, whichever is greater, for the conditions supplied and assumes the influent concentrations of each contaminant are less than 25% solubility in water. QED makes no claim of the model's accuracy beyond the 25% solubility in water limit.

Save Data

PRESENT WORTH ANALYSIS
ALTERNATIVE 3A - PUMP AND TREAT SOURCE & PLUME
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

YEAR	PRESENT WORTH FACTOR	CAPITAL COSTS	O & M COSTS	MONITORING COSTS	5-YEAR REVIEWS	PRESENT WORTH
0	1.000	$1,423,830				$1,423,830
1	0.935		$230,062	$112,564		$320,211
2	0.873		$230,062	$112,564		$299,263
3	0.816		$230,062	$112,564		$279,685
4	0.763		$187,984	$56,282		$186,350
5	0.713		$187,984	$56,282	$20,000	$188,418
6	0.666		$187,984	$56,282		$162,765
7	0.623		$187,984	$56,282		$152,117
8	0.582		$187,984	$56,282		$142,165
9	0.544		$187,984	$56,282		$132,865
10	0.508		$187,984	$56,282	$20,000	$134,340
11	0.475		$187,984	$56,282		$116,049
12	0.444		$187,984	$56,282		$108,457
13	0.415		$187,984	$56,282		$101,362
14	0.388		$187,984	$56,282		$94,731
15	0.362		$187,984	$56,282	$20,000	$95,782
16	0.339		$187,984	$56,282		$82,741
17	0.317		$187,984	$56,282		$77,328
18	0.296		$187,984	$56,282		$72,270
19	0.277		$187,984	$56,282		$67,542
20	0.258		$187,984	$56,282	$20,000	$68,291
21	0.242		$187,984	$56,282		$58,994
22	0.226		$187,984	$56,282		$55,134
23	0.211		$187,984	$56,282		$51,527
24	0.197		$187,984	$56,282		$48,156
25	0.184		$187,984	$56,282	$20,000	$48,691
26	0.172		$187,984	$56,282		$42,062
27	0.161		$187,984	$56,282		$39,310
28	0.150		$187,984	$56,282		$36,738
29	0.141		$187,984	$56,282		$34,335
30	0.131		$187,984	$56,282	$20,000	$34,716

TOTAL PRESENT WORTH = $4,756,224

Discount rate of 7% per OSWER Directive No. 9355.3-20, June 1993

ALTERNATIVE 3A - PUMP AND TREAT SOURCE & PLUME
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost
ATER INTERCEPTION CAPITAL COST											
IZATION/DEMOBILIZATION											
Mobilize/Demobilize Equipment	1	ls				$10,000.00	$0	$0	$0	$10,000	$10,000
Office Trailer	4	mo				$225.00	$0	$0	$0	$900	$900
Sanitary Facilities	4	mo				$120.00	$0	$0	$0	$480	$480
Construction Survey	3	days			$410.00		$0	$0	$1,230	$0	$1,230
Electric/Phone Hookups	1	ls	$2,000.00				$2,000	$0	$0	$0	$2,000
Utilities (Electric + Phone)	4	mo	$450.00				$1,800	$0	$0	$0	$1,800
REPARATION											
Strip top soil	16	hr			$27.00	$60.97	$0	$0	$432	$976	$1,408
NG											
Driller Mobilization\Demobilization	1	ls	$10,000.00				$10,000	$0	$0	$0	$10,000
Source Zone Extraction Wells (2- 4" wells @ 200 ft. each)	400	ft	$40.00				$16,000	$0	$0	$0	$16,000
Plume Extraction Wells (9- 4" wells @ 200 ft. each)	1800	ft	$40.00				$72,000	$0	$0	$0	$72,000
Monitoring Wells (2 - 4" wells @200 ft. each)	400	ft	$40.00				$16,000	$0	$0	$0	$16,000
Well Development @ 4 hours/well	52	ea	$150.00				$7,800	$0	$0	$0	$7,800
Standby Time	12	hrs	$150.00				$1,800	$0	$0	$0	$1,800
Well Vault	11	each		$1,500.00	$750.00	$250.00	$0	$16,500	$8,250	$2,750	$27,500
Sampling/Analysis of Drill Cuttings	2	ea	$1,500.00		$100.00		$3,000	$0	$200	$0	$3,200
T&D of Drill Cuttings - 4 tons	28	tons	$250.00				$7,000	$0	$0	$0	$7,000
Decon Drilling Equipment	13	events	$250.00				$3,250	$0	$0	$0	$3,250
Sampling/Analysis of Waste Water	4	ea	$1,500.00				$6,000	$0	$0	$0	$6,000
Frac Tank Drop Off/Pickup	2	ea	$800.00				$1,600	$0	$0	$0	$1,600
Frac tank rental	4	weeks	$350.00				$1,400	$0	$0	$0	$1,400
OnSite Carbon Treatment, Prefilter / Fittings	1	ea	$2,000.00				$2,000	$0	$0	$0	$2,000
Cleanout & dispose of sediment	2	ea	$1,500.00				$3,000	$0	$0	$0	$3,000
T&D of Carbon Drums	2	drums	$1,000.00				$2,000	$0	$0	$0	$2,000
ATION & STRUCTURAL											
Treatment Building	400	sf	$85.00				$34,000	$0	$0	$0	$34,000
Earthwork	30	cy			$4.75	$4.99	$0	$0	$143	$150	$292
Form-work	80	sfca		$1.49	$4.41		$0	$119	$353	$0	$472
Reinforcment (WWF)	8	csf		$6.90	$13.90		$0	$55	$111	$0	$166
Spread footings	12	cy		$89.50	$77.00	$0.97	$0	$1,074	$924	$12	$2,010
8-inch Slab-on-Grade	400	sf		$2.74	$4.17	$6.91	$0	$1,096	$1,668	$2,764	$5,528
Foundation Walls	80	lf		$22.00	$48.00		$0	$1,760	$3,840	$0	$5,600
Foundation Damp Proofing and Underdrain	80	lf		$6.38	$6.10		$0	$510	$488	$0	$998
HING & PIPING											
Trench and Backfill, extraction piping	1150	lf		$0.00	$4.29	$2.48	$0	$0	$4,934	$2,852	$7,786
Pipe Bedding, extraction piping	1150	lf		$0.58	$1.32	$0.00	$0	$667	$1,518	$0	$2,185
3"/6" Double-Wall HDPE influent piping w/fittings	800	lf		$15.53	$21.27	$1.32	$0	$12,424	$17,016	$1,056	$30,496
4"/6" Double-Wall HDPE influent piping w/fittings	300	lf		$15.53	$21.27	$1.32	$0	$4,659	$6,381	$396	$11,436
1" PE downhole piping	400	lf		$0.25	$3.45	$0.00	$0	$100	$1,380	$0	$1,480
2" PE downhole piping	3600	lf		$0.37	$4.13	$0.00	$0	$1,332	$14,868	$0	$16,200
Trench and Backfill, discharge piping	500	lf		$0.00	$4.29	$2.48	$0	$0	$2,145	$1,240	$3,385
Pipe Bedding,discharge piping	500	lf		$0.58	$1.32		$0	$290	$660	$0	$950
Discharge Piping	500	lf		$2.68	$2.45	$0.66	$0	$1,340	$1,225	$330	$2,895
Sewer Improvements at discharge (manhole w/frame and cover	1	ea		$642.00	$452.00	$130.00	$1,500	$642	$452	$130	$2,724
Leak Detection System	1	ls	$12,500.00				$12,500	$0	$0	$0	$12,500
MENT											
Extraction well pump	11	ea		$2,345.00	$340.25	$0.00	$0	$25,795	$3,743	$0	$29,538
Receptacle	11	ea		$200.00	$75.00	$25.00	$0	$2,200	$825	$275	$3,300
Pump Probes	22	ea		$20.00	$100.00	$55.00	$0	$440	$2,200	$1,210	$3,850
Suspension	4000	lf		$1.72	$1.25	$0.50	$0	$6,880	$5,000	$2,000	$13,880
Cable Reel	11	ea		$20.10	$75.00	$30.00	$0	$221	$825	$330	$1,376
Equalization Tank	1	ea		$12,500.00	$450.00	$200.00					
Influent Pump	2	ea		$4,897.00	$976.00		$0	$9,794	$1,952	$0	$11,746
Prefabricated low-profile air stripper w/controls	1	ea		$37,005.00	$3,600.00	$2,500.00	$0	$37,005	$3,600	$2,500	$43,105
Vapor Phase Activated Carbon (Vessel) 2,000 lb. Carbon	2	ea		$11,200.00	$2,500.00	$1,500.00	$0	$22,400	$5,000	$3,000	$30,400

ALTERNATIVE 3A - PUMP AND TREAT SOURCE & PLUME
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost
Discharge Pump	2	ea		$4,897.00	$976.00		$0	$9,794	$1,952	$0	$11,746
Telemetry (includ. sensors)	1	system		$10,000.00	$2,500.00		$0	$10,000	$2,500	$0	$12,500
Freight	1	ls		$10,000.00			$0	$10,000	$0	$0	$10,000
RICAL											
Three Phase Service	1	ls	$25,000.00				$25,000	$0	$0	$0	$25,000
Well Pump Feeder cable w/conduit (3 ea.)	3830	lf		$3.95	$8.67	$0.35	$0	$15,129	$33,206	$1,341	$49,675
Motor Starter	16	ea		$1,800.00	$864.00		$0	$28,800	$13,824	$0	$42,624
Safety Switch, 30 amp	16	ea		$102.00	$80.00		$0	$1,632	$1,280	$0	$2,912
Control Panel/Miscellaneous wiring	1	ls		$7,500.00	$5,000.00	$750.00	$0	$7,500	$5,000	$750	$13,250
Heating	1	ls		$3,000.00	$5,000.00		$0	$3,000	$5,000	$0	$8,000
Lighting	1	ls		$7,200.00	$3,500.00		$0	$7,200	$3,500	$0	$10,700
Grounding System	1	ls		$5,000.00	$2,000.00						
RUCTION MANAGEMENT							$0	$0	$0	$0	$0
Field Engineer	688	hrs			$27.00		$0	$0	$18,576	$0	$18,576
Field Geologist	300	hrs			$27.00		$0	$0	$8,100	$0	$8,100
Health & Safety Officer	40	hrs			$18.00		$0	$0	$720	$0	$720
Senior Geologist	40	hrs			$35.00		$0	$0	$1,400	$0	$1,400
Project Manager	100	hrs			$35.00		$0	$0	$3,500	$0	$3,500
Per Diem	150	days	$105.00				$15,750	$0	$0	$0	$15,750
Vehicle	150	days				$75.00	$0	$0	$0	$11,250	$11,250
H&S Equipment	1	ls				$5,000.00	$0	$0	$0	$5,000	$5,000
Subcontractor Procurement (Includ. Pre-Bid Conferences)	240	hrs			$25.00		$0	$0	$6,000	$0	$6,000
P											
System Operator	160	hrs			$27.00		$0	$0	$4,320	$0	$4,320
Technician	160	hrs			$18.00		$0	$0	$2,880	$0	$2,880
Project Manager	24	hrs			$35.00		$0	$0	$840	$0	$840
Per Diem	20	days	$105.00				$2,100	$0	$0	$0	$2,100
Vehicle	24	days				$75.00	$0	$0	$0	$1,800	$1,800
O&M Manual	1	ls	$8,500.00				$8,500	$0	$0	$0	$8,500
As-Builts	1	ls			$7,800.00		$0	$0	$7,800	$0	$7,800
Analytical	70	samples	$500.00				$35,000	$0	$0	$0	$35,000
ESIGN INVESTIGATION DIRECT COSTS											
Analytical	1	ls	$3,900.00				$3,900	$0	$0	$0	$3,900
Subtotal							$294,900	$240,358	$211,760	$53,490	$800,509
Overhead on Labor Cost @ 30%									$63,528		$63,528
G & A on Labor Cost @ 10%									$21,176		$21,176
Sales Tax on Material 6%								$14,422			$14,422
G & A on Material Cost @ 10%								$25,478			$25,478
G & A on Subcontract Cost @ 10%							$29,490				$29,490
Total Direct Cost							$324,390	$280,258	$296,464	$53,490	$954,602
Indirects on Total Direct Labor Cost @ 75%									$222,348		$222,348
Profit on Total Direct Cost @ 10%											$95,460
Total Field Cost											$1,272,410
				Level of Effort (Hours)							
	P4	P3	P2	P1	T2						
Pre-Design Investigation	4	20	20	40	40				$2,518		$2,518
Equipment Design	5	17	85	45	14				$3,459		$3,459
Hydraulic Calculations	0	10	45	25	0				$1,632		$1,632
Layout of Pre-Fabricated Building	5	17	85	45	40				$3,920		$3,920
Site Work Detail	5	20	80	45	20				$3,549		$3,549
							$0.00		$12,560.46		$12,560
Overhead on Labor Cost @ 30%											$3,768

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ALTERNATIVE 3A - PUMP AND TREAT SOURCE & PLUME
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost
G & A on Labor Cost @ 10%											$1,256
Indirects on Total Design Labor Cost @ 25%											$3,140
Profit on Total Design Cost @ 10%											$1,256.05
Total Design Cost											$21,981
Total Field Cost + Design											$1,294,391
Contingency @ 10%											$129,439
ESTIMATED CAPITAL COSTS											**$1,423,830**

ALTERNATIVE 3A - PUMP AND TREAT SOURCE & PLUME
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments
1 GROUNDWATER INTERCEPTION O&M												
YEARS 1 through 3												
1.01 Subcontractor (O&M Specialty Contractor)	12	months	$5,500.00				$66,000	$0	$0	$0	$66,000	
1.02 Analyze effluent samples samples (1 sample/month)	12	months	$655.00		$80.00		$7,860	$0	$960	$0	$8,820	
1.03 Analyze Vapor Samples	12	samples	$200.00				$2,400	$0	$0	$0	$2,400	2 per month (GACeffluent)
1.04 Data Validation (QA\QC)	12	reviews			$200.00		$0	$0	$2,400	$0	$2,400	
1.05 Report Preparation	4	reports		$150.00	$3,000.00	$250.00	$0	$600	$12,000	$1,000	$13,600	
1.06 Vapor Phase Carbon Change Out	6	events	$7,500.00				$45,000	$0	$0	$0	$45,000	
1.07 Electrical consumption	314,892	kW-hr	$0.08				$25,191	$0	$0	$0	$25,191	68 kW
1.08 Telephone	12	months	$125.00				$1,500	$0	$0	$0	$1,500	
1.09 Project Management	120	hrs			$30.00		$0	$0	$3,600	$0	$3,600	
Subtotal							$147,951	$600	$18,960	$1,000	$168,511	
Overhead on Labor Cost @ 30%									$5,688		$5,688	
G & A on Labor Cost @ 10%									$1,896		$1,896	
Sales Tax on Material: 6%								$36			$36	
G & A on Material Cost @ 10%								$64			$64	
G & A on Subcontract Cost @ 10%							$14,795				$14,795	
Total Direct Cost							$162,746	$700	$26,544	$1,000	$190,990	
Indirects on Total Direct Labor Cost @ 50%									$13,272		$13,272	
Profit on Total Direct Cost @ 10%											$19,099	
Subtotal											$223,361	
Health & Safety Monitoring @ 3%											$6,701	
Total O&M Cost											$230,062	
2 YEARS 4 through 30												
2.01 Subcontractor (O&M Specialty Contractor)	12	months	$5,500.00				$66,000	$0	$0	$0	$66,000	
2.02 Analyze effluent samples samples (1 sample/month)	12	months	$655.00		$80.00		$7,860	$0	$960	$0	$8,820	
2.03 Analyze Vapor Samples	8	samples	$200.00				$1,600	$0	$0	$0	$1,600	2 per month (GACeffluent)
2.04 Data Validation (QA\QC)	4	reviews			$200.00		$0	$0	$800	$0	$800	
2.05 Report Preparation	4	reports		$150.00	$3,000.00	$250.00	$0	$600	$12,000	$1,000	$13,600	
2.06 Vapor Phase Carbon Change Out	2	events	$7,500.00				$15,000	$0	$0	$0	$15,000	
2.07 Electrical consumption	314,892	kW-hr	$0.08				$25,191	$0	$0	$0	$25,191	
2.08 Telephone	12	months	$125.00				$1,500	$0	$0	$0	$1,500	
2.09 Project Management	120	hrs			$30.00		$0	$0	$3,600	$0	$3,600	
Subtotal							$117,151	$600	$17,360	$1,000	$138,111	
Overhead on Labor Cost @ 30%									$5,208		$5,208	
G & A on Labor Cost @ 10%									$1,736		$1,736	
Sales Tax on Material @ 6%								$36			$36	
G & A on Material Cost @ 10%								$64			$64	
G & A on Subcontract Cost @ 10%							$11,715				$11,715	
Total Direct Cost							$128,866	$700	$24,304	$1,000	$154,870	
Indirects on Total Direct Labor Cost @ 50%									$12,152		$12,152	
Profit on Total Direct Cost @ 10%											$15,487	
Subtotal											$182,509	
Health & Safety Monitoring @ 3%											$5,475	
Total O&M Cost											$187,984	

ALTERNATIVE 3A - PUMP AND TREAT SOURCE & PLUME
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments
1 MONITORING												
YEARS 1,2, and 3, Quarterly Monitoring												
1.01 Analytical 30 samples/event	120	amples	$285.00				$34,200	$0	$0	$0	$34,200	
1.02 Per Diem 5 days/event/2 people	40	days	$120.00				$4,800	$0	$0	$0	$4,800	
1.03 Vehicle	20	days	$75.00				$1,500	$0	$0	$0	$1,500	
1.04 Field labor 5 days/event/2 people	400	hours			$25.00		$0	$0	$10,000	$0	$10,000	
1.05 Data Validation (QA\QC) 24 hr/event	96	hours			$30.00		$0	$0	$2,880	$0	$2,880	
1.06 Prepare Report, Update Model 40 hr./event	160	hours			$30.00		$0	$0	$4,800	$0	$4,800	
1.07 IDW	2	events		$1,550.00			$0	$3,100	$0	$0	$3,100	
1.08 ODC's @$500/event	4	events		$500.00			$0	$2,000	$0	$0	$2,000	
1.09 Equipment Rental @$2500/event	4	events				$2,500.00	$0	$0	$0	$10,000	$10,000	
1.10 Project Management 10hr./event	40	hrs			$35.00		$0	$0	$1,400	$0	$1,400	
Subtotal							$40,500	$5,100	$19,080	$10,000	$74,680	
Overhead on Labor Cost @ 30%									$5,724		$5,724	
G & A on Labor Cost @ 10%									$1,908		$1,908	
Sales Tax on Material 6%: 6%								$306			$306	
G & A on Material Cost @ 10%								$541			$541	
G & A on Subcontract Cost @ 10%							$4,050				$4,050	
Total Direct Cost							$44,550	$5,947	$26,712	$10,000	$87,209	
Indirects on Total Direct Labor Cost @ 50%									$13,356		$13,356	
Profit on Total Direct Cost @ 10%											$8,721	
Subtotal											$109,285	
Health & Safety Monitoring @ 3%											$3,279	
Total Monitoring Cost											$112,564	
2 YEARS 4 through 30, Semi-annual monitoring												
2.01 Analytical 30 samples/event	60	amples	$285.00				$17,100	$0	$0	$0	$17,100	
2.02 Per Diem 5 days/event/2 people	20	days	$120.00				$2,400	$0	$0	$0	$2,400	
2.03 Vehicle	10	days	$75.00				$750	$0	$0	$0	$750	
2.04 Field labor 5 days/event/2 people	200	hours			$25.00		$0	$0	$5,000	$0	$5,000	
2.05 Data Validation (QA\QC) 24 hr/event	48	hours			$30.00		$0	$0	$1,440	$0	$1,440	
2.06 Prepare Report, Update Model 40 hr./event	80	hours			$30.00		$0	$0	$2,400	$0	$2,400	
2.07 IDW	1	events		$1,550.00			$0	$1,550	$0	$0	$1,550	
2.08 ODC's @$500/event	2	events		$500.00			$0	$1,000	$0	$0	$1,000	
2.09 Equipment Rental @$2500/event	2	events				$2,500.00	$0	$0	$0	$5,000	$5,000	
2.10 Project Management 10hr./event	20	hrs			$35.00		$0	$0	$700	$0	$700	
Subtotal							$20,250	$2,550	$9,540	$5,000	$37,340	
Overhead on Labor Cost @ 30%									$2,862		$2,862	
G & A on Labor Cost @ 10%									$954		$954	
Sales Tax on Material 6%: 6%								$153			$153	
G & A on Material Cost @ 10%								$270			$270	
G & A on Subcontract Cost @ 10%							$2,025				$2,025	
Total Direct Cost							$22,275	$2,973	$13,356	$5,000	$43,604	
Indirects on Total Direct Labor Cost @ 50%									$6,678		$6,678	
Profit on Total Direct Cost @ 10%											$4,360	
Subtotal											$54,643	
Health & Safety Monitoring @ 3%											$1,639	
Total Monitoring Cost											$56,282	

CALCULATION WORKSHEET

CLIENT: JOB NUMBER: 5466

SUBJECT:

BY: CHECKED BY: DATE:

Calculate electrical cost for Years 1 through 4

FIRST: Summarize electric motors:

Motor Description	*Quantity*	*Hp*	*Subtotal Hp*
Submersible GW pumps	11	1.5	16.5
Induced Draft Blowers	1	15	15
Feed Pumps	1	5	5
Discharge Pumps	1	5	5

Total Electrical Hp (EHp): 41.5 EHp

SECOND: Estimate power consumption (kilo-watts) based on motor Hp:
KiloWatt Power = (0.7457) X EHp

31 kW

THIRD: Add any other power requirements from other electrical devices:
Examples - Lighting, receptacles, heating, air conditioning, etc..

INPUT [5] kW

36 Total kW consumption

FOURTH: Estimate daily power usage:
Input the number of hours per day equipment is operational.

INPUT [24] Hours per day

863 kW-Hr/day

FIFTH: Estimate annual power usage:
kW-Hr/year = kW-Hr/day X 365 days/year

314,892 kW-Hr/year

SIXTH: Estimate annual power costs:
Annual Electrical Costs = kW-Hr/year X $PRICE/kW-Hr

INPUT [$0.08] Price per kW-Hr

$25,191 per year

CALCULATION WORKSHEET PAGE _____ OF _____

CLIENT NASJRB Willow Grove		JOB NUMBER 5466	
SUBJECT Site 5 FS - Alt 3B			
BASED ON		DRAWING NUMBER	
BY MES	CHECKED BY	APPROVED BY	DATE

Pump and treat source zone

- Install two extraction wells @ 200 ft ea.
- Install two monitoring wells @ 200 ft ea.

System Flow average = 10 gpm

Contaminant Concentrations

111-TCE	2800 ug/L
11 DCA	600 ug/L
11 DCE	1000 ug/L
PCE	80 ug/L
TCE	890 ug/L

- From QED Air Stripper Model. Air Results

for an EZ-Tray 4.x stripper operating @ 210 cfm

Total air conc. ≈ 6 ppmV mass flux ≈ 0.0268 lb/hr.

- From Carbtrol for air between 1 an 10 ppmV removal capacity is ≈ 10% by wt. - use 5%

$$0.03\ lb/hr \times \frac{1}{0.05} \times 24\ hr = 14.4\ lb/day\ carbon$$

for 2000 lb units 2000/14.4 = 140 days

∴ 2000 lb units acceptable, quarterly changeouts.

Model #1 – Alt 3

QED Air Stripper Model ver. c1.00

3/28/2001

Site Data

Name: Michael Snyder
e-mail: snyderm@ttnus.com
Project: Willow Grove
Units: English
Altitude: 360 ft
Air Temp: 55 F
Flow: 10 gpm
Water Temp: 55 F
Stripper: EZ-Tray 4.x - Click for details
Stripper Air Flow: 210 cfm
Stripper Max Flow: 25 gpm

Water Results

Contaminant	Influent (ppb)	Target (ppb)	4-Tray Results (ppb)	4-Tray % Removal	6-Tray Results (ppb)	6-Tray % Removal
1,1,1-trichloroethane	2800	0	< 1	100.000	< 1	100.000
1,1-dichloroethane	600	0	< 1	100.000	< 1	100.000
1,1-dichloroethylene	1000	0	< 1	100.000	< 1	100.000
tetrachloroethylene (PCE)	80	0	< 1	100.000	< 1	100.000
trichloroethylene (TCE)	890	0	< 1	100.000	< 1	100.000

Air Results

Contaminant	4-Tray (ppmV)	4-Tray (lb/hr)	6-Tray (ppmV)	6-Tray (lb/hr)
1,1,1-trichloroethane	3.1730	0.01402	3.1730	0.01402
1,1-dichloroethane	0.9165	0.00300	0.9166	0.00300
1,1-dichloroethylene	1.5594	0.00501	1.5594	0.00501
tetrachloroethylene (PCE)	0.0729	0.00040	0.0729	0.00040
trichloroethylene (TCE)	1.0240	0.00446	1.0240	0.00446

≈ 6 0.02688 lb/hr

Notes

Copyright -- QED Treatment Equipment, PO Box 3726, Ann Arbor, MI 48106.

PH-> 1-800-624-2026 or 1-734-995-2547, FX-> 1-734-995-1170. E-mail->info@qedenv.com. WEB->www.qedenv.com.

The QED modeler estimates unit performance for the listed contaminants. ***Results assume -***

1. *dissolved-phase contaminant within a water matrix*
2. *clean stripper air*
3. *no surfactants, oil, grease or other immiscible phase(s) in the influent*
4. *unit operated within the given parameters and as instructed in the O&M manual*

Stripper performance shall meet or exceed either the required effluent concentration(s) or effluent estimates, whichever is greater, for the conditions supplied and assumes the influent concentrations of each contaminant are less than 25% solubility in water. QED makes no claim of the model's accuracy beyond the 25% solubility in water limit.

Save Data

PRESENT WORTH ANALYSIS
ALTERNATIVE 3B - PUMP AND TREAT SOURCE ZONE
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

YEAR	PRESENT WORTH FACTOR	CAPITAL COSTS	O & M COSTS	MONITORING COSTS	5-YEAR REVIEWS	PRESENT WORTH
0	1.000	$691,574				$691,574
1	0.935		$206,941	$91,252		$278,685
2	0.873		$206,941	$91,252		$260,453
3	0.816		$206,941	$91,252		$243,414
4	0.763		$164,863	$45,626		$160,581
5	0.713		$164,863	$45,626	$20,000	$164,336
6	0.666		$164,863	$45,626		$140,258
7	0.623		$164,863	$45,626		$131,082
8	0.582		$164,863	$45,626		$122,507
9	0.544		$164,863	$45,626		$114,492
10	0.508		$164,863	$45,626	$20,000	$117,169
11	0.475		$164,863	$45,626		$100,002
12	0.444		$164,863	$45,626		$93,460
13	0.415		$164,863	$45,626		$87,346
14	0.388		$164,863	$45,626		$81,631
15	0.362		$164,863	$45,626	$20,000	$83,540
16	0.339		$164,863	$45,626		$71,300
17	0.317		$164,863	$45,626		$66,636
18	0.296		$164,863	$45,626		$62,276
19	0.277		$164,863	$45,626		$58,202
20	0.258		$164,863	$45,626	$20,000	$59,563
21	0.242		$164,863	$45,626		$50,836
22	0.226		$164,863	$45,626		$47,510
23	0.211		$164,863	$45,626		$44,402
24	0.197		$164,863	$45,626		$41,497
25	0.184		$164,863	$45,626	$20,000	$42,467
26	0.172		$164,863	$45,626		$36,245
27	0.161		$164,863	$45,626		$33,874
28	0.150		$164,863	$45,626		$31,658
29	0.141		$164,863	$45,626		$29,587
30	0.131		$164,863	$45,626	$20,000	$30,279

TOTAL PRESENT WORTH = $3,576,863

Discount rate of 7% per OSWER Directive No. 9355.3-20, June 1993

691,574
5,683,203
894,579
120,000
7,389,356

ALTERNATIVE 3B - PUMP AND TREAT SOURCE ZONE
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost
GROUNDWATER INTERCEPTION CAPITAL COST											
1 MOBILIZATION/DEMOBILIZATION											
1.01 Mobilize/Demobilize Equipment	1	ls				$10,000.00	$0	$0	$0	$10,000	$10,000
1.02 Office Trailer	3	mo				$225.00	$0	$0	$0	$675	$675
1.03 Sanitary Facilities	3	mo				$120.00	$0	$0	$0	$360	$360
1.04 Construction Survey	2	days			$410.00		$0	$0	$820	$0	$820
1.05 Electric/Phone Hookups	1	ls	$2,000.00				$2,000	$0	$0	$0	$2,000
1.06 Utilities (Electric + Phone)	3	mo	$450.00				$1,350	$0	$0	$0	$1,350
2 SITE PREPARATION											
2.01 Strip top soil	8	hr			$27.00	$60.97	$0	$0	$216	$488	$704
3 DRILLING											
3.01 Driller Mobilization\Demobilization	1	ls	$10,000.00				$10,000	$0	$0	$0	$10,000
3.02 Extraction Wells (2- 4" wells @ 200 ft. each)	400	ft	$40.00				$16,000	$0	$0	$0	$16,000
3.03 Monitoring Wells (2 - 4" wells @200 ft. each)	400	ft	$40.00				$16,000	$0	$0	$0	$16,000
3.04 Well Development @ 4 hours/well	12	ea	$150.00				$1,800	$0	$0	$0	$1,800
3.05 Standby Time	6	hrs	$150.00				$900	$0	$0	$0	$900
3.06 Well Vault	2	each		$1,500.00	$750.00	$250.00	$0	$3,000	$1,500	$500	$5,000
3.07 Sampling/Analysis of Drill Cuttings	1	ea	$1,500.00		$100.00		$1,500	$0	$100	$0	$1,600
3.08 T&D of Drill Cuttings - 4 tons	4	tons	$250.00				$1,000	$0	$0	$0	$1,000
3.09 Decon Drilling Equipment	4	events	$250.00				$1,000	$0	$0	$0	$1,000
3.10 Sampling/Analysis of Waste Water	3	ea	$1,500.00				$4,500	$0	$0	$0	$4,500
3.11 Frac Tank Drop Off/Pickup	2	ea	$800.00				$1,600	$0	$0	$0	$1,600
3.12 Frac tank rental	2	weeks	$350.00				$700	$0	$0	$0	$700
3.13 OnSite Carbon Treatment, Prefilter / Fittings	1	ea	$2,000.00				$2,000	$0	$0	$0	$2,000
3.14 Cleanout & dispose of sediment	2	ea	$1,500.00				$3,000	$0	$0	$0	$3,000
3.15 T&D of Carbon Drums	2	drums	$1,000.00				$2,000	$0	$0	$0	$2,000
4 FOUNDATION & STRUCTURAL											
4.01 Treatment Building	400	sf	$85.00				$34,000	$0	$0	$0	$34,000
4.02 Earthwork	30	cy			$4.75	$4.99	$0	$0	$143	$150	$292
4.03 Form-work	80	sfca		$1.49	$4.41		$0	$119	$353	$0	$472
4.04 Reinforcment (WWF)	8	csf		$6.90	$13.90		$0	$55	$111	$0	$166
4.05 Spread footings	12	cy		$89.50	$77.00	$0.97	$0	$1,074	$924	$12	$2,010
4.06 8-inch Slab-on-Grade	400	sf		$2.74	$4.17	$6.91	$0	$1,096	$1,668	$2,764	$5,528
4.07 Foundation Walls	80	lf		$22.00	$48.00		$0	$1,760	$3,840	$0	$5,600
4.08 Foundation Damp Proofing and Underdrain	80	lf		$6.38	$6.10		$0	$510	$488	$0	$998
5 TRENCHING & PIPING											
5.01 Trench and Backfill, extraction piping	75	lf		$0.00	$4.29	$2.48	$0	$0	$322	$186	$508
5.02 Pipe Bedding, extraction piping	75	lf		$0.58	$1.32		$0	$44	$99	$0	$143
5.03 2"/6" Double-Wall HDPE influent piping w/fittings	75	lf		$30.55	$20.37	$0.00	$0	$2,291	$1,528	$0	$3,819
5.04 1" PE downhole piping	400	lf		$0.25	$3.45	$0.00	$0	$100	$1,380	$0	$1,480
5.05 Trench and Backfill, discharge piping	500	lf		$0.00	$4.29	$2.48	$0	$0	$2,145	$1,240	$3,385
5.06 Pipe Bedding,discharge piping	500	lf		$0.58	$1.32		$0	$290	$660	$0	$950
5.07 Discharge Piping	500	lf		$2.68	$2.45	$0.66	$0	$1,340	$1,225	$330	$2,895
5.07 Sewer Improvements at discharge (manhole w/frame and cover	1	ea		$642.00	$452.00	$130.00	$1,500	$642	$452	$130	$2,724
5.08 Leak Detection System	1	ls	$7,500.00				$7,500	$0	$0	$0	$7,500
6 EQUIPMENT											
6.01 Extraction well pump	2	ea		$2,050.00	$340.25	$0.00	$0	$4,100	$681	$0	$4,781
6.02 Receptacle	2	ea		$200.00	$75.00	$25.00	$0	$400	$150	$50	$600

ALTERNATIVE 3B - PUMP AND TREAT SOURCE ZONE
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

	Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost
	6.03 Pump Probes	2	ea		$20.00	$100.00	$55.00	$0	$40	$200	$110	$350
	6.04 Suspension	700	lf		$1.72	$1.25	$0.50	$0	$1,204	$875	$350	$2,429
	6.05 Cable Reel	2	ea		$20.10	$75.00	$30.00	$0	$40	$150	$60	$250
	6.06 Equalization Tank											
	6.07 Prefabricated low-profile air stripper w/controls	1	ea		$15,000.00	$2,700.00	$1,300.00	$0	$15,000	$2,700	$1,300	$19,000
	6.08 Vapor Phase Activated Carbon (Vessel) 2,000 lb. Carbon	2	ea		$11,200.00	$2,500.00	$1,500.00	$0	$22,400	$5,000	$3,000	$30,400
	6.09 Discharge Pump	2	ea		$700.00	$309.49		$0	$1,400	$619	$0	$2,019
	6.10 Telemetry (includ. sensors)	1	system		$10,000.00	$2,500.00		$0	$10,000	$2,500	$0	$12,500
	6.11 Freight	1	ls		$10,000.00			$0	$10,000	$0	$0	$10,000
7	ELECTRICAL											
	7.01 Three Phase Service	1	ls	$25,000.00				$25,000	$0	$0	$0	$25,000
	7.02 Well Pump Service cable w/conduit (3/well)	100	lf		$3.95	$8.67	$0.35	$0	$395	$867	$35	$1,297
	7.03 Motor Starter	4	ea		$1,800.00	$864.00		$0	$7,200	$3,456	$0	$10,656
	7.04 Safety Switch, 30 amp	4	ea		$63.00	$80.00		$0	$252	$320	$0	$572
	7.05 Control Panel/Miscellaneous wiring	1	ls		$2,500.00	$5,000.00		$0	$2,500	$5,000	$0	$7,500
	7.06 Heating	1	ls		$6,000.00	$5,000.00		$0	$6,000	$5,000	$0	$11,000
	7.07 Lighting	1	ls		$7,200.00	$3,500.00		$0	$7,200	$3,500	$0	$10,700
	7.08 Grounding System	1	ls		$5,000.00	$2,000.00						
8	CONSTRUCTION MANAGEMENT							$0	$0	$0	$0	$0
	8.01 Field Engineer	516	hrs			$27.00		$0	$0	$13,932	$0	$13,932
	8.02 Field Geologist	100	hrs			$27.00		$0	$0	$2,700	$0	$2,700
	8.03 Health & Safety Officer	20	hrs			$18.00		$0	$0	$360	$0	$360
	8.04 Senior Geologist	20	hrs			$35.00		$0	$0	$700	$0	$700
	8.05 Project Manager	100	hrs			$35.00		$0	$0	$3,500	$0	$3,500
	8.06 Per Diem	100	days	$105.00				$10,500	$0	$0	$0	$10,500
	8.07 Vehicle	102	days				$75.00	$0	$0	$0	$7,650	$7,650
	8.08 H&S Equipment	1	ls				$5,000.00	$0	$0	$0	$5,000	$5,000
	8.09 Subcontractor Procurement (Includ. Pre-Bid Conferences)	240	hrs			$25.00		$0	$0	$6,000	$0	$6,000
9	Start-up											
	9.01 System Operator	100	hrs			$27.00		$0	$0	$2,700	$0	$2,700
	9.02 Technician	100	hrs			$18.00		$0	$0	$1,800	$0	$1,800
	9.03 Project Manager	24	hrs			$35.00		$0	$0	$840	$0	$840
	9.04 Per Diem	20	days	$105.00				$2,100	$0	$0	$0	$2,100
	9.05 Vehicle	24	days				$75.00	$0	$0	$0	$1,800	$1,800
	9.06 O&M Manual	1	ls	$8,500.00				$8,500	$0	$0	$0	$8,500
	9.07 As-Builts	1	ls			$7,800.00		$0	$0	$7,800	$0	$7,800
	9.08 Analytical	25	samples	$500.00				$12,500	$0	$0	$0	$12,500
10	PRE-DESIGN INVESTIGATION DIRECT COSTS											
	10.01 Analytical	1	ls	$3,900.00				$3,900	$0	$0	$0	$3,900
	Subtotal							$170,850	$100,453	$89,322	$36,189	$396,814
	Overhead on Labor Cost @ 30%									$26,797		$26,797
	G & A on Labor Cost @ 10%									$8,932		$8,932
	Sales Tax on Material 6%								$6,027			$6,027
	G & A on Material Cost @ 10%								$10,648			$10,648
	G & A on Subcontract Cost @ 10%							$17,085				$17,085
	Total Direct Cost							$187,935	$117,128	$125,051	$36,189	$466,303

ALTERNATIVE 3B - PUMP AND TREAT SOURCE ZONE
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

Item	Quantity	Unit	Subcontract	Unit Cost Material	Labor	Equipment	Extended Cost Subcontract	Material	Labor	Equipment	Subtotal Direct Cost
Indirects on Total Direct Labor Cost @ 75%									$93,789		$93,789
Profit on Total Direct Cost @ 10%											$46,630
Total Field Cost											$606,722
				Level of Effort (Hours)							
12 Design	P4	P3	P2	P1	T2						
12.01 Pre-Design Investigation	4	20	20	40	40				$2,518		$2,518
12.02 Equipment Design	5	17	85	45	14				$3,459		$3,459
12.03 Hydraulic Calculations	0	10	45	25	0				$1,632		$1,632
12.04 Layout of Pre-Fabricated Building	5	17	85	45	40				$3,920		$3,920
12.05 Site Work Detail	5	20	80	45	20				$3,549		$3,549
							$0.00		$12,560.46		$12,560
Overhead on Labor Cost @ 30%											$3,768
G & A on Labor Cost @ 10%											$1,256
Indirects on Total Design Labor Cost @ 25%											$3,140
Profit on Total Design Cost @ 10%											$1,256.05
Total Design Cost											$21,981
Total Field Cost + Design											$628,703
Contingency @ 10%											$62,870
ESTIMATED CAPITAL COSTS											**$691,574**

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ALTERNATIVE 3B - PUMP AND TREAT SOURCE ZONE
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments
1 GROUNDWATER INTERCEPTION O&M												
YEARS 1 through 3												
1.01 Subcontractor (O&M Specialty Contractor)	12	months	$5,500.00				$66,000	$0	$0	$0	$66,000	
1.02 Analyze effluent samples samples (1 sample/month)	12	months	$655.00		$80.00		$7,860	$0	$960	$0	$8,820	
1.03 Analyze Vapor Samples	12	samples	$200.00				$2,400	$0	$0	$0	$2,400	
1.04 Data Validation (QA\QC)	12	reviews			$200.00		$0	$0	$2,400	$0	$2,400	
1.05 Report Preparation	4	reports		$150.00	$3,000.00	$250.00	$0	$600	$12,000	$1,000	$13,600	
1.06 Vapor Phase Carbon Change Out	6	events	$7,500.00				$45,000	$0	$0	$0	$45,000	
1.07 Electrical consumption	82,994	kW-hr	$0.08				$6,640	$0	$0	$0	$6,640	
1.08 Telephone	12	months	$125.00				$1,500	$0	$0	$0	$1,500	
1.09 Project Management	120	hrs			$30.00		$0	$0	$3,600	$0	$3,600	
Subtotal							$129,400	$600	$18,960	$1,000	$149,960	
Overhead on Labor Cost @ 30%									$5,688		$5,688	
G & A on Labor Cost @ 10%									$1,896		$1,896	
Sales Tax on Material: 6%								$36			$36	
G & A on Material Cost @ 10%								$64			$64	
G & A on Subcontract Cost @ 10%							$12,940				$12,940	
Total Direct Cost							$142,339	$700	$26,544	$1,000	$170,583	
Indirects on Total Direct Labor Cost @ 50%									$13,272		$13,272	
Profit on Total Direct Cost @ 10%											$17,058	
Subtotal											$200,913	
Health & Safety Monitoring @ 3%											$6,027	
Total O&M Cost											$206,941	
2 YEARS 4 through 30												
2.01 Subcontractor (O&M Specialty Contractor)	12	months	$5,500.00				$66,000	$0	$0	$0	$66,000	
2.02 Analyze effluent samples samples (1 sample/month)	12	months	$655.00		$80.00		$7,860	$0	$960	$0	$8,820	
2.03 Analyze Vapor Samples	8	samples	$200.00				$1,600	$0	$0	$0	$1,600	
2.04 Data Validation (QA\QC)	4	reviews			$200.00		$0	$0	$800	$0	$800	
2.05 Report Preparation	4	reports		$150.00	$3,000.00	$250.00	$0	$600	$12,000	$1,000	$13,600	
2.06 Vapor Phase Carbon Change Out	2	events	$7,500.00				$15,000	$0	$0	$0	$15,000	
2.07 Electrical consumption	82,994	kW-hr	$0.08				$6,640	$0	$0	$0	$6,640	
2.08 Telephone	12	months	$125.00				$1,500	$0	$0	$0	$1,500	
2.09 Project Management	120	hrs			$30.00		$0	$0	$3,600	$0	$3,600	
Subtotal							$98,600	$600	$17,360	$1,000	$117,560	
Overhead on Labor Cost @ 30%									$5,208		$5,208	
G & A on Labor Cost @ 10%									$1,736		$1,736	
Sales Tax on Material @ 6%								$36			$36	
G & A on Material Cost @ 10%								$64			$64	
G & A on Subcontract Cost @ 10%							$9,860				$9,860	
Total Direct Cost							$108,459	$700	$24,304	$1,000	$134,463	
Indirects on Total Direct Labor Cost @ 50%									$12,152		$12,152	
Profit on Total Direct Cost @ 10%											$13,446	
Subtotal											$160,061	
Health & Safety Monitoring @ 3%											$4,802	
Total O&M Cost											$164,863	

ALTERNATIVE 3B - PUMP AND TREAT SOURCE ZONE
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments
1 MONITORING												
YEARS 1,2, and 3, Quarterly Monitoring												
1.01 Analytical 15 samples/event	60	amples	$285.00				$17,100	$0	$0	$0	$17,100	
1.02 Per Diem 5 days/event/2 people	40	days	$120.00				$4,800	$0	$0	$0	$4,800	
1.03 Vehicle	20	days	$75.00				$1,500	$0	$0	$0	$1,500	
1.04 Field labor 5 days/event/2 people	400	hours			$25.00		$0	$0	$10,000	$0	$10,000	
1.05 Data Validation (QA\QC) 24 hr/event	96	hours			$30.00		$0	$0	$2,880	$0	$2,880	
1.06 Prepare Report, Update Model 40 hr./event	160	hours			$30.00		$0	$0	$4,800	$0	$4,800	
1.07 IDW	2	events		$1,550.00			$0	$3,100	$0	$0	$3,100	
1.08 ODC's @$500/event	4	events		$500.00			$0	$2,000	$0	$0	$2,000	
1.09 Equipment Rental @$2500/event	4	events				$2,500.00	$0	$0	$0	$10,000	$10,000	
1.10 Project Management 10hr./event	40	hrs			$35.00		$0	$0	$1,400	$0	$1,400	
Subtotal							$23,400	$5,100	$19,080	$10,000	$57,580	
Overhead on Labor Cost @ 30%									$5,724		$5,724	
G & A on Labor Cost @ 10%									$1,908		$1,908	
Sales Tax on Material 6%: 6%								$306			$306	
G & A on Material Cost @ 10%								$541			$541	
G & A on Subcontract Cost @ 10%							$2,340				$2,340	
Total Direct Cost							$25,740	$5,947	$26,712	$10,000	$68,399	
Indirects on Total Direct Labor Cost @ 50%									$13,356		$13,356	
Profit on Total Direct Cost @ 10%											$6,840	
Subtotal											$88,594	
Health & Safety Monitoring @ 3%											$2,658	
Total Monitoring Cost											$91,252	
2 YEARS 4 through 30, Semi-annual monitoring												
2.01 Analytical 15 samples/event	30	amples	$285.00				$8,550	$0	$0	$0	$8,550	
2.02 Per Diem 5 days/event/2 people	20	days	$120.00				$2,400	$0	$0	$0	$2,400	
2.03 Vehicle	10	days	$75.00				$750	$0	$0	$0	$750	
2.04 Field labor 5 days/event/2 people	200	hours			$25.00		$0	$0	$5,000	$0	$5,000	
2.05 Data Validation (QA\QC) 24 hr/event	48	hours			$30.00		$0	$0	$1,440	$0	$1,440	
2.06 Prepare Report, Update Model 40 hr./event	80	hours			$30.00		$0	$0	$2,400	$0	$2,400	
2.07 IDW	1	events		$1,550.00			$0	$1,550	$0	$0	$1,550	
2.08 ODC's @$500/event	2	events		$500.00			$0	$1,000	$0	$0	$1,000	
2.09 Equipment Rental @$2500/event	2	events				$2,500.00	$0	$0	$0	$5,000	$5,000	
2.10 Project Management 10hr./event	20	hrs			$35.00		$0	$0	$700	$0	$700	
Subtotal							$11,700	$2,550	$9,540	$5,000	$28,790	
Overhead on Labor Cost @ 30%									$2,862		$2,862	
G & A on Labor Cost @ 10%									$954		$954	
Sales Tax on Material 6%: 6%								$153			$153	
G & A on Material Cost @ 10%								$270			$270	
G & A on Subcontract Cost @ 10%							$1,170				$1,170	
Total Direct Cost							$12,870	$2,973	$13,356	$5,000	$34,199	
Indirects on Total Direct Labor Cost @ 50%									$6,678		$6,678	
Profit on Total Direct Cost @ 10%											$3,420	
Subtotal											$44,297	
Health & Safety Monitoring @ 3%											$1,329	
Total Monitoring Cost											$45,626	

ALTERNATIVE 3B - PUMP AND TREAT SOURCE ZONE
SITE 5 FEASIBILITY STUDY
NASJRB WILLOW GROVE, PENNSYLVANIA

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments
1 MONITORING												
YEARS 1,2, and 3, Quarterly Monitoring												
1.01 Analytical 15 samples/event	60	amples	$285.00				$17,100	$0	$0	$0	$17,100	
1.02 Per Diem 5 days/event/2 people	40	days	$120.00				$4,800	$0	$0	$0	$4,800	
1.03 Vehicle	20	days	$75.00				$1,500	$0	$0	$0	$1,500	
1.04 Field labor 5 days/event/2 people	400	hours			$25.00		$0	$0	$10,000	$0	$10,000	
1.05 Data Validation (QA\QC) 24 hr/event	96	hours			$30.00		$0	$0	$2,880	$0	$2,880	
1.06 Prepare Report, Update Model 40 hr./event	160	hours			$30.00		$0	$0	$4,800	$0	$4,800	
1.07 IDW	2	events		$1,550.00			$0	$3,100	$0	$0	$3,100	
1.08 ODC's @$500/event	4	events		$500.00			$0	$2,000	$0	$0	$2,000	
1.09 Equipment Rental @$2500/event	4	events				$2,500.00	$0	$0	$0	$10,000	$10,000	
1.10 Project Management 10hr./event	40	hrs			$35.00		$0	$0	$1,400	$0	$1,400	
Subtotal							$23,400	$5,100	$19,080	$10,000	$57,580	
Overhead on Labor Cost @ 30%									$5,724		$5,724	
G & A on Labor Cost @ 10%									$1,908		$1,908	
Sales Tax on Material 6%: 6%								$306			$306	
G & A on Material Cost @ 10%								$541			$541	
G & A on Subcontract Cost @ 10%							$2,340				$2,340	
Total Direct Cost							$25,740	$5,947	$26,712	$10,000	$68,399	
Indirects on Total Direct Labor Cost @ 50%									$13,356		$13,356	
Profit on Total Direct Cost @ 10%											$6,840	
Subtotal											$88,594	
Health & Safety Monitoring @ 3%											$2,658	
Total Monitoring Cost											$91,252	
2 YEARS 4 through 30, Semi-annual monitoring												
2.01 Analytical 15 samples/event	30	amples	$285.00				$8,550	$0	$0	$0	$8,550	
2.02 Per Diem 5 days/event/2 people	20	days	$120.00				$2,400	$0	$0	$0	$2,400	
2.03 Vehicle	10	days	$75.00				$750	$0	$0	$0	$750	
2.04 Field labor 5 days/event/2 people	200	hours			$25.00		$0	$0	$5,000	$0	$5,000	
2.05 Data Validation (QA\QC) 24 hr/event	48	hours			$30.00		$0	$0	$1,440	$0	$1,440	
2.06 Prepare Report, Update Model 40 hr./event	80	hours			$30.00		$0	$0	$2,400	$0	$2,400	
2.07 IDW	1	events		$1,550.00			$0	$1,550	$0	$0	$1,550	
2.08 ODC's @$500/event	2	events		$500.00			$0	$1,000	$0	$0	$1,000	
2.09 Equipment Rental @$2500/event	2	events				$2,500.00	$0	$0	$0	$5,000	$5,000	
2.10 Project Management 10hr./event	20	hrs			$35.00		$0	$0	$700	$0	$700	
Subtotal							$11,700	$2,550	$9,540	$5,000	$28,790	
Overhead on Labor Cost @ 30%									$2,862		$2,862	
G & A on Labor Cost @ 10%									$954		$954	
Sales Tax on Material 6%: 6%								$153			$153	
G & A on Material Cost @ 10%								$270			$270	
G & A on Subcontract Cost @ 10%							$1,170				$1,170	
Total Direct Cost							$12,870	$2,973	$13,356	$5,000	$34,199	
Indirects on Total Direct Labor Cost @ 50%									$6,678		$6,678	
Profit on Total Direct Cost @ 10%											$3,420	
Subtotal											$44,297	
Health & Safety Monitoring @ 3%											$1,329	
Total Monitoring Cost											$45,626	

C-24

CALCULATION WORKSHEET

CLIENT: JOB NUMBER: 5466

SUBJECT:

BY: CHECKED BY: DATE:

Calculate electrical cost for Years 1 through 4

FIRST: Summarize electric motors:

Motor Description	*Quantity*	*Hp*	*Subtotal Hp*
Submersible GW pumps	2	0.5	1
Induced Draft Blowers	1	5	5
Feed Pumps	0	7.5	0
Discharge Pumps	0	7.5	0

Total Electrical Hp (EHp): 6 EHp

SECOND: Estimate power consumption (kilo-watts) based on motor Hp:
KiloWatt Power = (0.7457) X EHp

4 kW

THIRD: Add any other power requirements from other electrical devices:
Examples - Lighting, receptacles, heating, air conditioning, etc..

INPUT [5] kW

9 Total kW consumption

FOURTH: Estimate daily power usage:
Input the number of hours per day equipment is operational.

INPUT [24] Hours per day

227 kW-Hr/day

FIFTH: Estimate annual power usage:
kW-Hr/year = kW-Hr/day X 365 days/year

82,994 kW-Hr/year

SIXTH: Estimate annual power costs:
Annual Electrical Costs = kW-Hr/year X $PRICE/kW-Hr

INPUT [$0.08] Price per kW-Hr

$6,640 per year