N00158.AR.000422
NASJRB WILLOW GROVE
5090.3a

FINAL RECORD OF DECISION SITE 5 FORMER FIRE TRAINING AREA GROUNDWATER OPERABLE UNIT 2 (OU2) NASJRB WILLOW GROVE PA

9/1/2012

TETRA TECH

Record of Decision
Site 5 Groundwater
Operable Unit 2 (OU 2)

Naval Air Station
Joint Reserve Base (NAS JRB)
Willow Grove, Pennsylvania

Naval Facilities Engineering Command
Mid-Atlantic

September 2012

1.0 DECLARATION

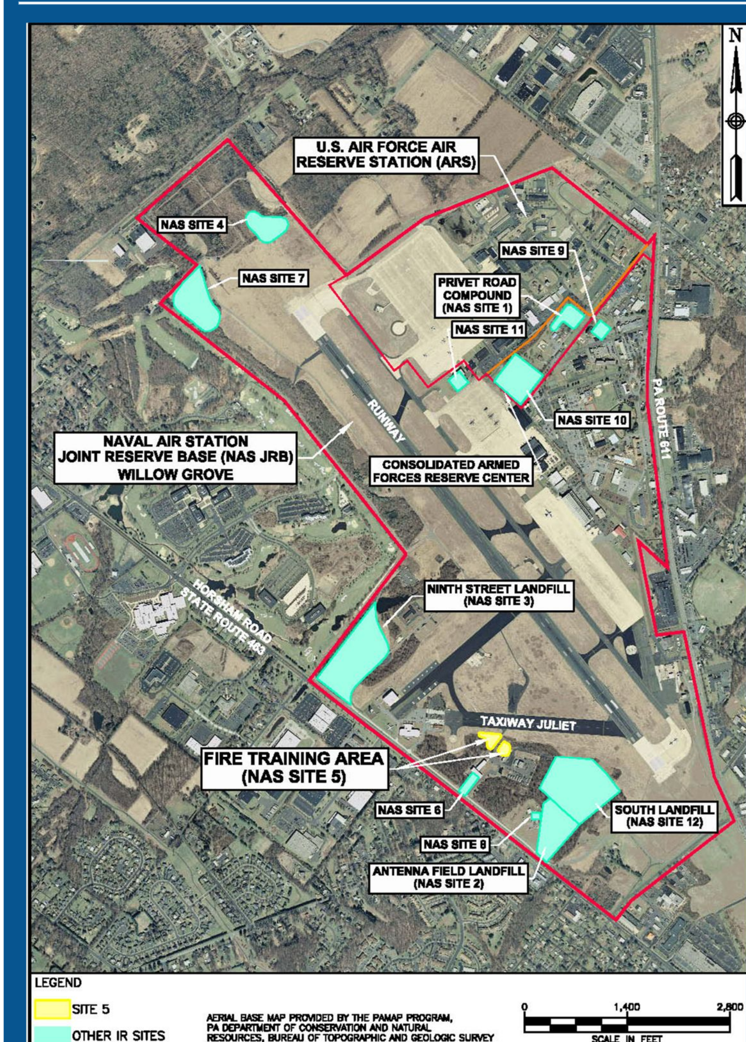
1.1 SITE NAME AND LOCATION

Site 5 – Former Fire Training Area (FFTA) at the former Naval Air Station Joint Reserve Base (NAS JRB) Willow Grove, Horsham Township, Montgomery County, Pennsylvania; United States Environmental Protection Agency (EPA) ID number PAD987277837.

1.2 STATEMENT OF BASIS AND PURPOSE

The Department of the Navy (Navy), the lead agency for site activities, and the U.S. Environmental Protection Agency Region III (EPA), in consultation with the Pennsylvania Department of Environmental Protection (PADEP), selected the remedy detailed in this Record of Decision (ROD). This ROD is issued jointly by the Navy and EPA in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [Part 300, Title 40, of the Code of Federal Regulations (CFR)], presents the Selected Remedy for groundwater at Site 5 (see Figure 1-1), designated as Operable Unit (OU) 2. This decision is based on information contained in the Administrative Record File for the site. The Pennsylvania Department of Environmental Protection (PADEP) concurs with the Selected Remedy.

FIGURE 1-1. SITE 5 LOCATION MAP



1.3 ASSESSMENT OF SITE

The response action selected in this ROD is necessary to protect the public health or the environment from actual or threatened releases of hazardous substances into the environment. A CERCLA action is required because concentrations of volatile organic compounds (VOCs) in groundwater pose unacceptable risk to human health under a hypothetical future residential land use scenario. The site does not pose unacceptable ecological risk because groundwater from the site does not discharge to the surface in the vicinity of the site or interact with any surface water bodies; consequently, there are no ecological receptors exposed to Site 5 groundwater.

1.4 DESCRIPTION OF SELECTED REMEDY

The major components of the Selected Remedy for Site 5 groundwater include the following:

- In-situ anaerobic bioremediation of contaminated groundwater within the source area until VOC concentrations meet established cleanup levels (i.e., remedial goals).
- Monitored Natural Attenuation (MNA) of the groundwater plume downgradient of the source area.
- Implementation of land use controls (LUCs) to prohibit the use of untreated OU 2 groundwater, mitigate the potential for vapor intrusion from the subsurface into future structures, and require that existing buildings install a system to mitigate potential intrusion of VOCs from subsurface into the structure or be subject to a vapor intrusion investigation that documents an unacceptable risk to future occupants is not present at the structure, until contaminants in groundwater are at levels that allow for unlimited use and unrestricted exposure. The use of treated groundwater must be approved by the Navy, EPA, and PADEP.
- Long-term groundwater monitoring until the plume has attenuated to concentrations that meet the established cleanup levels [i.e., remedial goals as defined on Table 2-3).

The Selected Remedy eliminates potential unacceptable human exposure to hazardous substances in the untreated groundwater and vapors by reducing VOC concentrations in groundwater to concentrations that permit unlimited use and unrestricted exposure and by implementing LUCs to prohibit current and future potable use of untreated OU 2 groundwater, require that future structures are built to mitigate the potential for vapor intrusion, and require a vapor intrusion investigation or installation of a vapor mitigating system prior to reuse of existing buildings. The Selected Remedy is expected to achieve substantial long-term risk reduction and allow the property to be used for the reasonably anticipated future land uses, which, is currently planned for open space, recreational, and non-residential (e.g., office space) use. This ROD documents the final remedial action for Site 5 groundwater (OU 2) and concludes the evaluation of all Site 5 media, and does not include or affect any other sites at the facility.

Implementation of this remedy will allow industrial/commercial or residential reuse of the site, which is consistent with the former use and potential reuse of the property. In 2005, NAS JRB Willow Grove was designated for closure under the authority of the Defense Base Realignment and Closure Act (BRAC) of 1990, Public Law 101-510, as amended. Under BRAC, as amended, the Navy is required to dispose of NAS JRB Willow Grove in accordance with the laws and regulations governing the disposal of property made available as a result of the closure or realignment of a military installation. On March 21, 2012, the Horsham Township Authority for NAS JRB Willow Grove (HLRA) approved the proposed NAS JRB Willow Grove Redevelopment Plan and Homeless Assistance Submission. This document indicates that land use in the area encompassing and surrounding Site 5 will be developed for use as open space, a golf course, and office space.

1.5 STATUTORY DETERMINATIONS

The Selected Remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action, is cost-effective, and utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable. The Selected Remedy satisfies the statutory preference for remedies that use treatment as a principal element to reduce the toxicity, mobility, or volume of hazardous substances, pollutants, and contaminants. The VOCs in the Site 5 source area groundwater will be reduced over time by bioremediation, during which treatment the toxic halogenated compounds will be destroyed through the process of dechlorination. The lower concentrations of VOCs in the downgradient portion of the dissolved-phase plume will be monitored to establish that contaminant concentrations are naturally attenuating.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on site in excess of levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years of initiation of the remedial action and every 5 years thereafter until contaminants present at the site are at levels that allow for unlimited use and unrestricted exposure to the site to ensure that the remedy is, or will be, protective of human health and the environment.

1.6 ROD Data Certification Checklist

The locations in Section 2.0, Decision Summary, of the information required to be included in the ROD are summarized in Table 1-1. Additional information can be found in the Administrative Record file for NAS JRB Willow Grove.

Table 1-1. ROD Data Certification Checklist

Data	Location in ROD
Chemicals of concern (COCs) and their respective concentrations	Sections 2.5 and 2.7
Baseline risk represented by the COCs	Section 2.7
Cleanup levels established for COCs and the basis for these levels	Section 2.7 and 2.8
How source materials constituting principal threats are addressed	Section 2.11
Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the risk assessment	Section 2.6
Potential land and groundwater uses that will be available at the site as a result of the Selected Remedy	Section 2.12.3
Estimated capital, operating and maintenance (O&M), and total net present worth (NPW) costs; discount rate; and number of years over which the remedy costs are projected	Appendix B
Key factors that led to the selection of the remedy	Section 2.12.1

1.7 Authorizing Signatures

9/18/2012

Willington Lin
BRAC Environmental Coordinator
BRAC Program Management Office Northeast

Date

9/25/2012

Ronald Borsellino, Director
Hazardous Site Cleanup Division
EPA Region 3

Date

2.0 DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND BRIEF DESCRIPTION

The former NAS JRB Willow Grove, EPA ID number PAD987277837, is located in Horsham Township in Montgomery County, Pennsylvania. NAS JRB Willow Grove occupied approximately 900 acres of the 1,100 acres the Department of Defense (DoD) maintained at the Air Station. The primary mission of NAS JRB Willow Grove was to provide support for operations involving aviation training activities and to train Navy reservists. NAS JRB Willow Grove supported other DoD tenants such as the Marine Reserve and the Army Reserve and shared facilities and services with the Air Force Reserve. The former NAS JRB Willow Grove was selected in 2005 by the BRAC Commission for closure and was officially disestablished on March 30, 2011.

Site 5 originated from a fire-fighting training area (FFTA) located on the southern side of the former NAS JRB Willow Grove (see Figure 2-1) that covered an irregularly shaped area of approximately 1.25 acres. Fire training operations included the temporary staging and subsequent burning of flammable liquid wastes from 1942 through 1975, when burning operations ceased.

NAS JRB Willow Grove was designated for closure in 2005 under the BRAC of 1990, Public Law 101-510, as amended. BRAC requires that base closure be in full compliance with the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). Section 2 (Definitions) of the NAS JRB Federal Facilities Agreement (FFA) identifies Navy Engineering Field Activity Northeast (EFANE) as the primary Navy local contact entity. Because the EFANE office was designated for closure under the 2005 round of BRAC, EFANE has been replaced by BRAC Program Management Office (PMO) Northeast as the primary local Navy contact office.

In May 2007, Special Legislation was enacted that stated, “The Secretary of the Navy shall, notwithstanding any other provision of law, transfer to the Secretary of the Air Force, at no cost, all lands, easements, Air Installation Compatible Use Zones, and facilities at NAS JRB Willow Grove designated for operation as a Joint Interagency Installation (JII) for use by the Pennsylvania National Guard and other Department of Defense components, government agencies, and associated users to perform national defense, homeland security, and emergency preparedness missions.” Subsequent legislation in 2008 authorized the Secretary of the Air Force to convey all transferred Navy property to the Commonwealth of Pennsylvania at no cost for operating the Horsham Joint Interagency Installation (HJII).

In September 2009, the Navy transferred 18.25 acres to the Air Force as part of the BRAC 2005 requirement to construct a consolidated Armed Forces Reserve Center. The transfer obligates the Air Force to comply with all provisions of the FFA between the Navy, EPA, and PADEP dated June 27, 2005 and all associated CERCLA actions and requirements related to the FFA for this property.

In November 2009, the Governor of Pennsylvania announced that the Commonwealth had withdrawn its plan to own, operate, and maintain the Horsham Joint Interagency Installation (JII) proposed for NAS JRB Willow Grove. As a result, the Under Secretary of Defense advised all parties that the Navy would then dispose of the former NAS JRB Willow Grove in accordance with the laws and regulations governing the disposal of property made available as a result of the closure or realignment of a military installation under BRAC, as amended.

NAS JRB Willow Grove was officially disestablished on March 30, 2011. The base continued to provide services and facilities, on a limited basis, until September 2011, at which time it was transferred to BRAC PMO and entered caretaker status. The former NAS JRB Willow Grove is an inactive facility, and environmental investigations and remediation at the base are funded under the BRAC program. The Navy is the lead agency for CERCLA activities at the facility and EPA is the lead regulatory agency. PADEP also reviews and provides comments on environmental site activities. Decisions regarding the future use of the land are coordinated by the HLRA; all HLRA reuse decisions ultimately require federal approval. The planned future use of the Site 5 area is for open space, a public golf course, and office space.

2.2 Site History and Enforcement Activities

Suspected sources of contamination at Site 5 include the spillage of waste VOCs temporarily staged along the access road before transfer to the former burn ring (see Figure 2-1), and minor amounts of polynuclear aromatic hydrocarbons (PAHs) in waste liquids that were spilled in the immediate vicinity of the burn ring during their burning. When excavated, the burn ring was found to have a competent steel bottom, which accounts for the lack of VOC contamination in the vicinity of the ring. Table 2-1 provides brief summaries of previous investigations at Site 5.

There have been no cited violations under federal or state environmental law or any past or pending enforcement actions pertaining to the cleanup of Site 5.

Table 2-1. Previous Investigations and Site Documentation

Investigation	Date	Activities
Initial Assessment Study (IAS)	1986	Included reviews of historical records and aerial photographs, interviews with site personnel, and field inspections. Identified Site 5 as a potential source of soil and groundwater contamination through evaluation of potential contaminants, migration pathways, and potential receptors for these contaminants. Recommended that a Site Inspection (SI) be performed.
SI	1989	Included performance of soil vapor investigation, collection of one soil sample from each of four soil borings with analysis for TCL VOCs, and installation and sampling of four groundwater monitoring wells with analysis for TCL VOCs and total petroleum hydrocarbons. Based on the levels of VOCs detected in soil and groundwater, a Remedial Investigation (RI) was recommended.
RI	1993	During the Phase I RI, 12 soil borings were drilled and 58 samples were collected for subsurface soil characterization. Six additional monitoring wells were installed to further delineate the nature and extent of groundwater contamination detected during the SI. Soil and groundwater samples were analyzed for Target Compound List (TCL) VOCs only based on the results of the SI. The RI documented halogenated VOC contaminants in the groundwater at and downgradient of the former drum storage area. The subsurface soils were analyzed for VOCs only, and found only inconsistent detections at very low concentrations throughout the site. The RI concluded that further investigation was required to fully document the nature and extent of media contamination.
	2002	During the Phase II RI, 17 additional monitoring wells were installed to further characterize the horizontal and vertical extent of the groundwater plume. New and existing wells were sampled multiple times for parameters including TCL VOCs, semivolatile organic compounds (SVOCs), pesticides and polychlorinated biphenyls (PCBs), Target Analyte List (TAL) metals, and monitored natural attenuation (MNA) parameters. Eighteen surface soil and 16 subsurface soil samples were collected and analyzed for a wider suite of parameters including TCL VOCs and SVOCs and TAL metals. Selected samples were also analyzed for PCBs and dioxin. Two surface water and two sediment samples collected from the ephemeral ponds located just south of the drum staging area were analyzed for TCL VOCs and SVOCs, TAL metals, and PCBs and pesticides. A baseline human health risk assessment (HHRA) estimated unacceptable risk associated with exposure to site-wide groundwater and to surface soils in the immediate vicinity of the burn ring.
United States Geological Survey (USGS) Groundwater Flow Investigation	1999	Joint USGS and Navy investigation during the RI to identify regional groundwater flow patterns at and in the vicinity of the base. Identified the regional groundwater divide that underlies Site 5.

Table 2-1. Previous Investigations and Site Documentation

Investigation	Date	Activities
USGS Hydrogeological Investigation	2002	Included borehole geophysical logging of Site 5 wells and drilling of a rock core in the source area to determine the nature and concentrations of VOCs in the rock matrix. Conducted a water level study to determine the pumping effects of the nearby public supply well (Horsham Water and Sewer Authority Well No. 26) and concluded that the Site 5 plume is not affected by the pumping.
Soil Removal Action (OU 4)	2005 2006	The Navy submitted an Action Memorandum for Site 5 – Fire Training Area Soil Removal to deal with the limited area of surface soil contaminated with PAHs in the vicinity of the burn ring. Soil was excavated and removed to a depth of approximately 2 feet. A total of 513 tons of soil was removed and backfilled with clean fill.
Site 5 RI Addendum 2, Soil Investigation for Volatile Organic Compound Soil to Groundwater Impact	2006	Submitted in response to regulatory concerns that existing soil data were generated through now-obsolete sampling methods. Six soil borings were drilled and 12 samples were obtained through EPA-approved sampling methods and analyzed for TCL VOCs. The analytical data confirmed the validity of previous soil analyses.
RI Addendum 5 for Site 5 Groundwater (OU 2)	2006	Documented the additional work performed to fill data gaps concerning groundwater quality at several locations, to determine whether 1,4-dioxane was present, and to obtain additional chemical data needed to evaluate MNA. Six additional monitoring wells were installed and sampled for TCL VOCs and 1,4-dioxane. The results indicated that 1,4-dioxane was present only in shallow groundwater near the former drum storage area.
RI Addendum 3, Technical Memorandum of Risk Assessment Evaluation for Site 5 Groundwater (OU 2)	2007	Included a limited update of the HHRA for groundwater in response to changes in risk assessment methodology. The revised HHRA estimated unacceptable risk for future child and adult residents and future lifelong residents exposed to untreated groundwater. A risk screening for vapor intrusion indicated that this migration pathway did not present unacceptable risk.
RI Addendum 6, for Site 5 Soil (OU 4)	2007	Submitted to address concerns regarding low concentrations of dioxin in post-removal confirmation samples that were a significant contributor to residual risk. Five additional soil samples were collected from the 2006 excavation area, and a residual risk evaluation was performed that concluded that the total residual risk was within the acceptable carcinogenic risk range.
Feasibility Study (FS) for Groundwater (OU 2)	2008	Identified and evaluated five remedial alternatives for Site 5 groundwater to address unacceptable risks identified during the RI.
Pilot Test for Bioremediation of Site 5 Groundwater (OU 2)	2011	Reported the results of the pilot test for in-situ anaerobic bioremediation of VOCs in Site 5 groundwater. Seven additional monitoring wells and four recirculation (injection and extraction) wells were installed for the test. The test included three biostimulation events, one bioaugmentation event, and eight rounds of groundwater sampling for TCL VOCs and various bioremediation parameters. The pilot test was considered successful due to the significant reduction in VOCs in source area groundwater.
Groundwater Proposed Remedial Action Plan	2011	Presented the Navy's preferred remedial alternative for OU 2 as in-situ, anaerobic bioremediation, monitored natural attenuation, LUCs, and long-term groundwater monitoring.
Report of Results for PFOA/PFOS for Site 5 Groundwater (OU 2)	2011	Presented results of sampling for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). Results indicate levels of these compounds above EPA's provisional health advisory concentration levels in wells near the burn ring and source area. Samples also were analyzed for 1,4-dioxane and showed levels exceeding remedial goals.

FIGURE 2-1. SITE LOCATION

2.3 COMMUNITY PARTICIPATION

The Navy performs public participation activities in accordance with CERCLA and the NCP throughout the site cleanup process at the former NAS JRB Willow Grove. The Navy has a comprehensive community relations program for NAS JRB Willow Grove, and community relations activities are conducted in accordance with the NAS JRB Willow Grove Community Relations Plan (Brown & Root Environmental, 1997). These activities include regular technical and Restoration Advisory Board (RAB) meetings with local officials and community members and the establishment of an Information Repository at the local library for dissemination of information to the community.

The Navy organized a Technical Review Committee (TRC) for the base in 1990, which transitioned into a Restoration Advisory Board (RAB) in 1995, to review and discuss NAS JRB Willow Grove environmental issues with local community officials and concerned citizens. The RAB consists of representatives of the Navy, EPA, PADEP, and members of the community. The RAB has met quarterly since its inception. Site 5 groundwater investigation activities, results, and associated remedial decisions have been discussed frequently at RAB meetings, and a Site 5 pilot test for anaerobic bioremediation was performed largely in response to the community's preference for this remedial technology.

The NAS JRB Willow Grove Information Repository is located at the Horsham Township Public Library, 435 Babylon Road, Horsham, Pennsylvania. Documents and relevant information are available for public review at the Information Repository (including a copy of the Administrative Record), or can be accessed via the library's web site at www.horshamlibrary.org/WillowGroveNASAdminRecord.html. For additional information concerning the Installation Restoration (IR) Program at the former NAS JRB Willow Grove, contact Willington Lin, BRAC Environmental Coordinator, BRAC PMO Northeast, 4911 South Broad Street, Philadelphia, PA 19112, 215-897-4900.

In accordance with Sections 113 and 117 of CERCLA, the Navy provided a public comment period from June 15 to August 1, 2011, for the proposed remedial action described in the Proposed Remedial Action Plan for Site 5 Groundwater (OU 2). A public meeting to present the Proposed Plan was held on June 22, 2011, at the Horsham Township Municipal Building. Public notice of the meeting and availability of documents were published in The Intelligencer newspaper on June 15, 2011.

2.4 SCOPE AND ROLE OF OPERABLE UNIT

Site 5 is part of a comprehensive environmental investigation and cleanup program currently being performed at the former NAS JRB Willow Grove under CERCLA authority pursuant to the FFA dated June 27, 2005. IR Program cleanup activities are performed under CERCLA except at those sites subject to the PADEP Underground Storage Tank (UST) Program or the Pennsylvania Land Recycling Program (Act 2). Eleven IR sites and ten OUs have been identified at NAS JRB Willow Grove. A No Further Action ROD for Site 1 soil (OU 1) was signed September 2006, and an Interim ROD for Site 1 groundwater (OU 3) was signed September 2008. A No Action ROD for Site 2 soil (OU 5) and groundwater (OU 9) was signed June 2010. Record of Consensus Agreement No Action decisions were reached between the Navy, EPA, and PADEP for Site 4 (January 2009), Site 6 (December 2007), and Site 7 (August 2008). EPA issued a letter of concurrence under CERCLA with the PADEP notice of agreement with the Navy for No Further Action at Site 8 and Site 9 (October 2006). Site 11 was investigated and eliminated from further consideration before being designated an IR site by a PADEP letter for No Further Action (April 2004) and an EPA letter of concurrence for No Further Action (February 2007). Site 10 was deferred to the PADEP UST Program, and currently holds a status of No Further Action at This Time, under the Air Station land use scenario as of April 2004. Site 10 was transferred to the Air Force in September 2009 as part of an 18.25 acre parcel for the construction of a new Armed Forces Reserve Center. The Army Reserves conducted additional investigation of this Site prior to construction of the reserve center. A No Further Action ROD for Site 5 soil (OU 4) was signed September 2007. Site 3 soil (OU 6) and groundwater (OU 10), and Site 12 are currently in the CERCLA RI/FS phase. The Site Management Plan (SMP) for NAS JRB Willow Grove further details the schedule for CERCLA activities and is updated annually.

Investigations at Site 5 indicated that groundwater contamination from past operating practices poses unacceptable risk to potential future human receptors under a residential land use scenario. Previous actions taken in response to the contamination at Site 5 are summarized in Table 2-1. The remedy documented in this ROD will achieve the Remedial Action Objectives (RAOs) for Site 5, as listed in Section 2.8. Implementation of this remedy will allow future residential reuse of the site, which is being considered as a reasonably anticipated future use of the property by the HLRA.

2.5 SITE CHARACTERISTICS

Figure 2-2 presents the Site 5 conceptual site model (CSM), which identifies contaminant sources, contaminant release mechanisms, transport routes, and receptors under current and future land use scenarios. The VOC source area is the former drum staging area, where the drums of spent solvents were temporarily staged prior to being burned. The results of the RI indicate that small and isolated areas of VOCs remain in soil at low concentrations and do not serve as a major source of groundwater contamination. The majority of the VOCs that serve as the source of the groundwater plume exist within the matrix and secondary porosity (including fractures) of the shallow bedrock. The groundwater plume is created by both the downward infiltration of precipitation and the flow of upgradient groundwater that migrates through the residual source in the weathered bedrock. Due to the downward hydraulic gradient, the plume migrates downward within the bedrock as it migrates laterally away from the source area, until it is dominantly confined to open fractures within the unweathered bedrock. Human receptors are discussed in Section 2.7.1. As discussed in Section 2.7.2, there are no ecological receptors because Site 5 groundwater does not discharge to the surface anywhere in the vicinity of the site or interact with any surface water bodies.

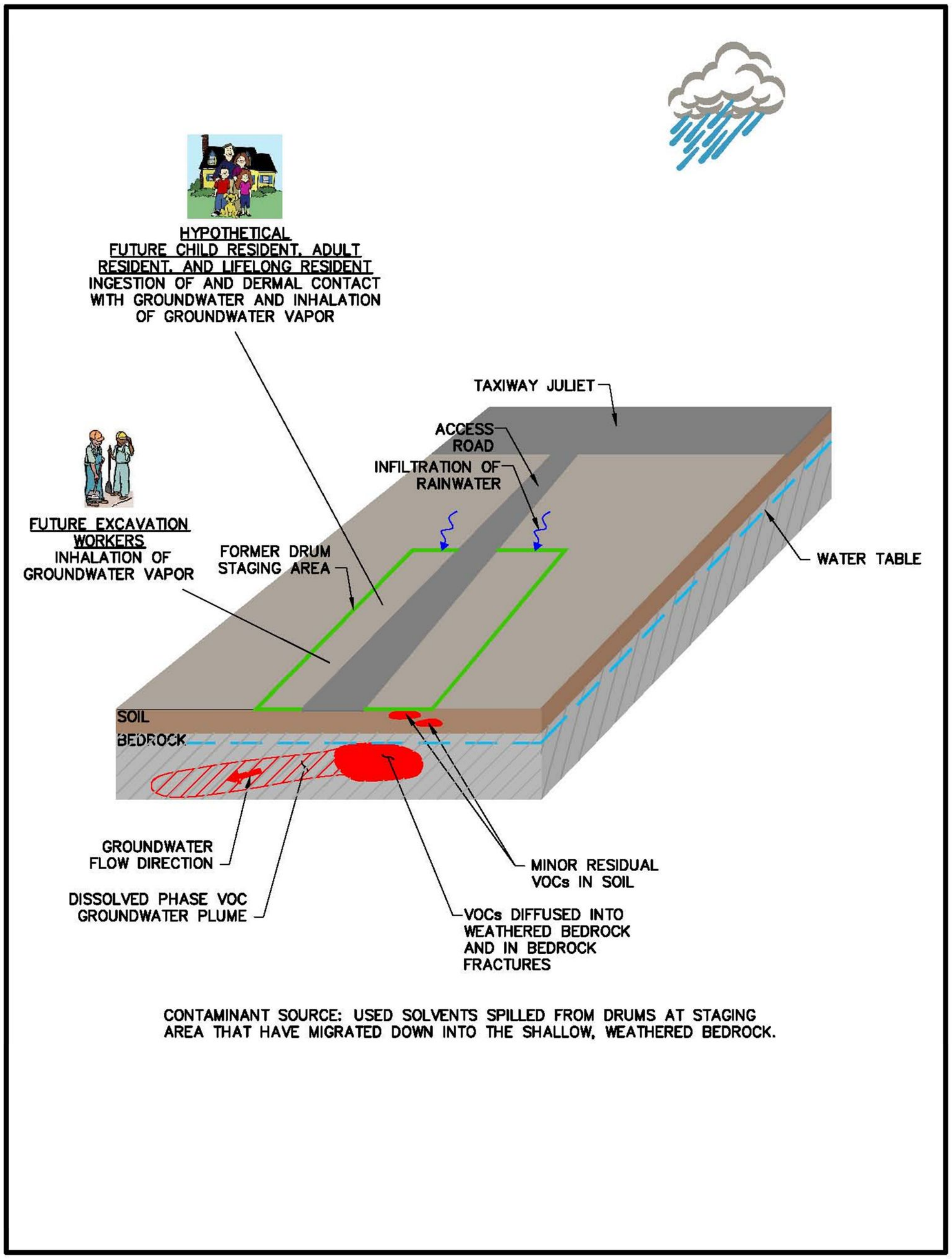
2.5.1 Physical Characteristics

Site 5 is primarily covered by grasses, with some woody and brushy vegetation in the southern portion of the area. The ground surface in the vicinity of the former drum storage area is partially covered by a paved access road that extends northward to Taxiway Juliet. The ground surface slopes toward the south at a grade of approximately 2 percent. Runoff during normal precipitation events is minimized by the relatively gentle slope and abundant vegetation, which serve to decrease runoff velocity and increase infiltration.

Soil borings drilled at Site 5 encountered a variably thick overburden layer underlain by weathered siltstone and sandstone. The overburden consists of approximately 7 to 19 feet of silty clay to clayey silt with minor amounts of silty sand. The bedrock beneath Site 5 belongs to the Stockton Formation, which to the total depth of investigation of 261 feet consists of a generally coarse-grained lithology of alternating sequences of siltstone and sandstone. Thin but laterally persistent beds of finer-grained mudstone are located within the lower portion of the monitored section. The bedrock strikes southwest to northeast and dips to the northwest at a rate of about 7 degrees.

The overburden beneath Site 5 typically does not contain groundwater. The water table occurs within the bedrock at depths of about 20 to 25 feet, and the nature of groundwater flow within the bedrock is complex. The site is underlain by two groundwater divides that do not coincide in position or orientation. A local groundwater divide within the shallow groundwater zone is oriented east-west and generally coincides with the location and orientation of the base runway, which is the highest local topographic feature. A deeper regional groundwater divide identified during the USGS investigation (1999) is oriented southwest-northeast, generally bisects the site, and closely coincides with the regional surface water divide for the Little Neshaminy Creek and Pennypack Creek watersheds.

FIGURE 2-2. CONCEPTUAL SITE MODEL



The horizontal hydraulic gradients throughout the site are very low under ambient conditions, reflecting the relatively flat local topography. Consistent with its position on a regional groundwater divide, the overall vertical hydraulic gradient at Site 5 is oriented downward. The construction of horizontal flow maps (and consequently the interpretation of groundwater flow directions) is difficult because of the very low natural horizontal gradient, whose effects may be masked by the head differences resulting from the vertical hydraulic gradient. Site 5 is located south of the local shallow groundwater divide, so groundwater at the water table and in the shallowest (most highly contaminated) groundwater zone flows in a generally southward direction. Site 5 is also located just west of the regional groundwater divide, so groundwater in the deeper groundwater zones flows in a generally northwestward direction; the general directions of groundwater flow are illustrated on a hydrogeologic cross-section constructed perpendicular to the axis of the groundwater plume, which is included as Appendix D.

Groundwater flow within the Stockton Formation is markedly anisotropic, with the main direction of anisotropy oriented parallel to the strike of the bedrock. Under stressed (pumping or injection) conditions, the aquifer exhibits preferential drawdown or mounding along strike, so the cones of depression (or recharge mounds) typically resemble elongated ellipses with the long axis oriented parallel to the strike of the bedrock. The pilot test for bioremediation was able to use this anisotropy, along with the low natural hydraulic gradient, to establish an efficient groundwater recirculation cell at relatively low [1.5 gallons per minute (gpm)] pumping rates.

2.5.2 Nature and Extent and Fate and Transport of Contamination

As stated above, the VOCs in the Site 5 groundwater are a result of the spillage of spent solvents from drums that were temporarily placed at the drum staging area west of the burn ring. VOC concentrations are greatest at the water table immediately below the staging area and decrease with both lateral distance away from and vertical depth below this zone of highest contamination.

The distributions and concentrations of COCs in Site 5 groundwater are illustrated on Figure 2-3 and 2-4. Figure 2-3, which presents results from summer 2005 prior to implementation of the bioremediation pilot test, shows that the groundwater plume with COC concentrations exceeding the proposed cleanup levels exists for a distance of about 1,200 feet northwest and downgradient of the former drum staging area. The hydrogeologic cross-section constructed along the axis plume (Appendix D) also indicates that as VOCs migrate laterally away from the site, they also move vertically downward within the aquifer, consistent with the directions of groundwater flow. The deepest detection of a VOC at a concentration exceeding its proposed cleanup level is 1,1-dichloroethane (DCA) in monitoring well 03MW08D, which is 173 feet deep and represents the approximate downgradient boundary of the plume.

Figure 2-4 illustrates the results from fall 2010, approximately 19 months after the first injection of amendments in the pilot test. Only the wells in the immediate vicinity of the pilot test were sampled during this round. During the reductive dechlorination process, tetrachloroethene (PCE), trichloroethene (TCE), and 1,1,1-trichloroethane (1,1,1-TCA) are transformed into breakdown compounds by the sequential removal of chlorine atoms from their molecules, creating intermediate VOCs such as 1,1-dichloroethene (DCE), cis-1,2-DCE (c-1,2-DCE), and vinyl chloride (VC). These intermediate compounds are eventually reduced by the same reductive process into end-stage non-toxic compounds such as ethene and ethane. Therefore, the bioremediation process will cause an immediate reduction in some COCs (parent compounds), a temporary increase in some COCs (such as 1,1-DCE), and the temporary creation of a COC (VC) that was not present at the site prior to the pilot test because the natural chemistry of the groundwater did not permit the dechlorination process to continue through completion. Consequently, the creation or increased concentrations of some COCs early in the remedial action is expected and should not be interpreted as a failure in the bioremediation process.

Due to their high vapor pressures and aqueous solubilities and low potential for adsorption to soils, VOCs released to soil will be readily lost by volatilization and transported to groundwater by dissolution in infiltrating precipitation. Once in the groundwater, VOC compounds will be transported with groundwater movement through advection and dispersion.

Because of the use of aqueous film-forming foam (AFFF) for fire suppression training at the site, EPA requested sampling for PFOA and PFOS in monitoring wells near the burn ring (well cluster 05MW06) and the most impacted wells (well cluster 05MW01) in the pilot test area. PFOA and PFOS are constituents of AFFF and EPA has published non-enforceable provisional health advisory concentration levels for drinking water of 0.4 ug/L and 0.2 ug/L, respectively, for these compounds. PFOA (up to 33 ug/L) and PFOS (up to 4.6 ug/L) were detected in the shallow and intermediate depth wells at both well clusters. LUCs will be implemented to control exposure to groundwater containing these contaminants. Changes to toxicity and regulatory status for PFOA and PFOS will be evaluated during Five-Year Reviews to determine if any additional remedial measures are required specifically for these compounds.

2.6 Current and Potential Future Site and Resource Uses

The former NAS JRB Willow Grove is an inactive military facility that is currently in caretaker status under the Navy BRAC PMO. Future land use decisions are coordinated by the HLRA. Land use in the area surrounding the former NAS JRB Willow Grove is mixed. The United States Air Force Air Reserve Station (ARS) and Consolidated Armed Forces Reserve Center occupy the northeastern portion of the former base. The surrounding area is predominantly residential, with a mix of commercial and light industrial use concentrated along PA Route 611 (Easton Road) to the east and State Route 463 (Horsham Road) to the west. Site 5 is located in the southwestern portion of the former NAS JRB Willow Grove, immediately adjacent to former Taxiway Juliet and about midway between IR Program Site 3 to the northwest and Sites 2 and 12 to the southeast. On March 21, 2012, the HLRA approved the land use plan for the former NAS JRB Willow Grove to include mixed use of residential, commercial, and open space. The area including and surrounding Site 5 is proposed for use as open space, a portion of a golf course, and office space. All buildings in the vicinity of Site 5 are currently unoccupied and the future use has not been determined.

The former NAS JRB Willow Grove is situated within an upland area that forms a local drainage divide between the Little Neshaminy Creek drainage basin to the north and the Pennypack Creek drainage basin to the south. As discussed above, Site 5 straddles this local drainage divide. Both of the local drainage basins lie within the regional drainage basin of the Delaware River. Surface water from most of the base drains toward the north through several unnamed ephemeral, intermittent, and perennial drainageways into Park Creek, which is a tributary of Little Neshaminy Creek. The extreme southern portion of the base, including the southeastern portion of Site 5, lies within the Pennypack Creek drainage basin. There are no flowing or perennial streams within the NAS JRB Willow Grove boundaries. During heavy rainfall, very local flooding conditions are associated with various swales and man-made drainage ditches. Enclosed swales, including several at Site 5, typically contain standing surface water throughout the spring and after a heavy rainfall. The swales dry out during the summer and fall because they are not connected to the aquifer system and do not receive groundwater discharge. Runoff from surface areas is primarily channeled through open drainage swales and enclosed storm sewers to one of five primary outfall areas. Three of these outfalls drain to Park Creek. The fourth outfall is an intermittent stream that flows into Pennypack Creek. The fifth outfall is a direct connection to the Northern Storm Sewer System.

Groundwater underlying the former NAS JRB Willow Grove was used for drinking water. The Navy operated two deep extraction wells in the vicinity of Site 1 that were contaminated by VOCs that flowed onto the base from an off-base source. The Navy treated the water via air stripping before sending the water into the base supply line. These wells are currently operated by the Air Force and are on land that has been transferred to the Air Force to support the Horsham Air Reserve Station. The Public Water Supply permit for these wells was transferred from the Navy to the PA Air National Guard on September 14, 2011. The Horsham Water and Sewer Authority operates several public supply wells in the vicinity of the former NAS JRB Willow Grove, the closest of which to the base (Well No. 26) is located approximately 1,700 feet south of Site 5. The multiple groundwater investigations conducted at Site 5 concluded that the groundwater plume originating at the site flows to the northwest and does not impact the public supply well, nor does the pumping of the supply well impact the migration direction of the plume. The Selected Remedy documented in this ROD includes LUCs that will prevent the future use of untreated groundwater extracted from Site 5.

FIGURE 2-3. VOCs EXCEEDING REMEDIAL GOALS – 2005 (PRE-PILOT TEST)

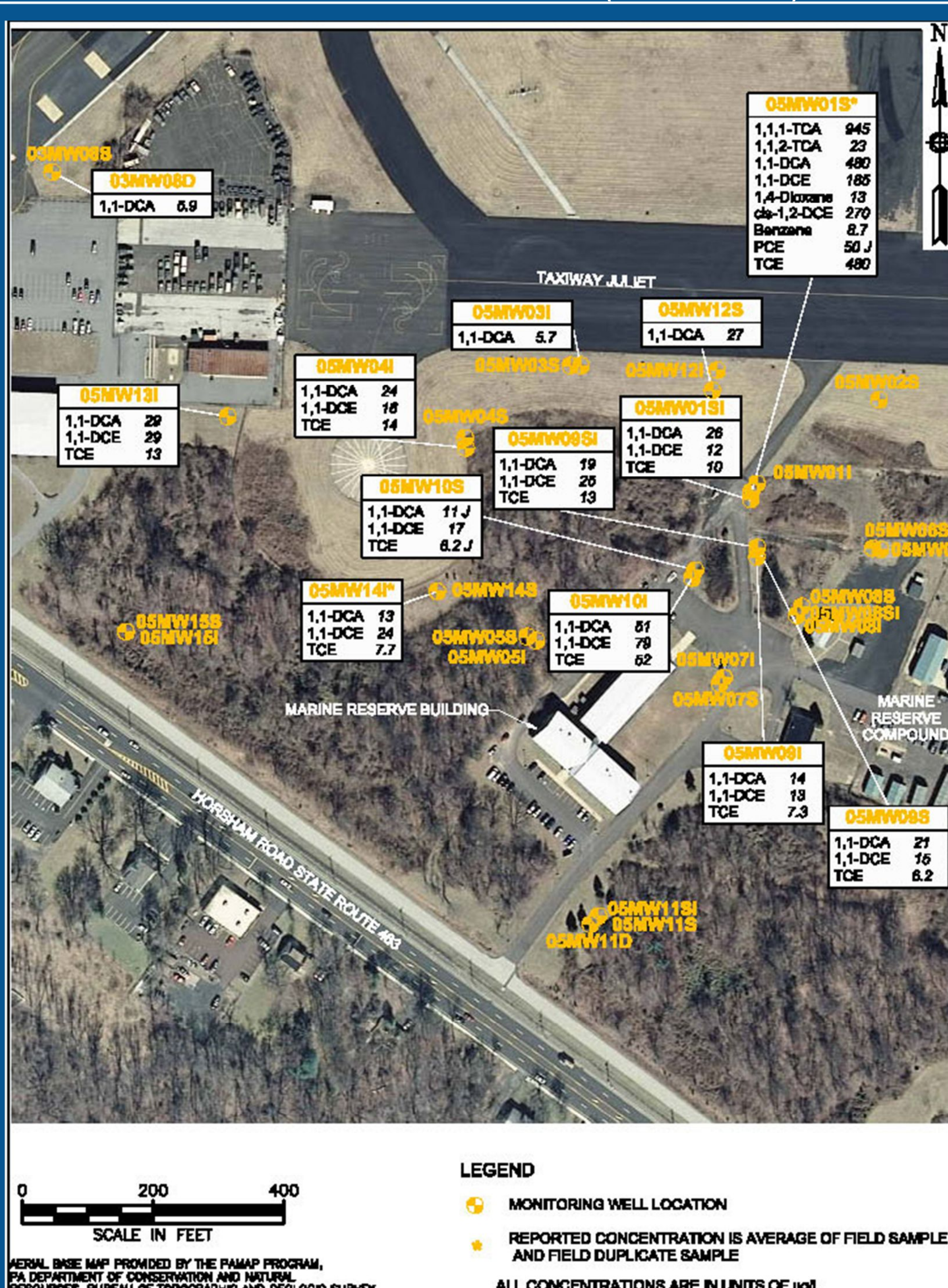
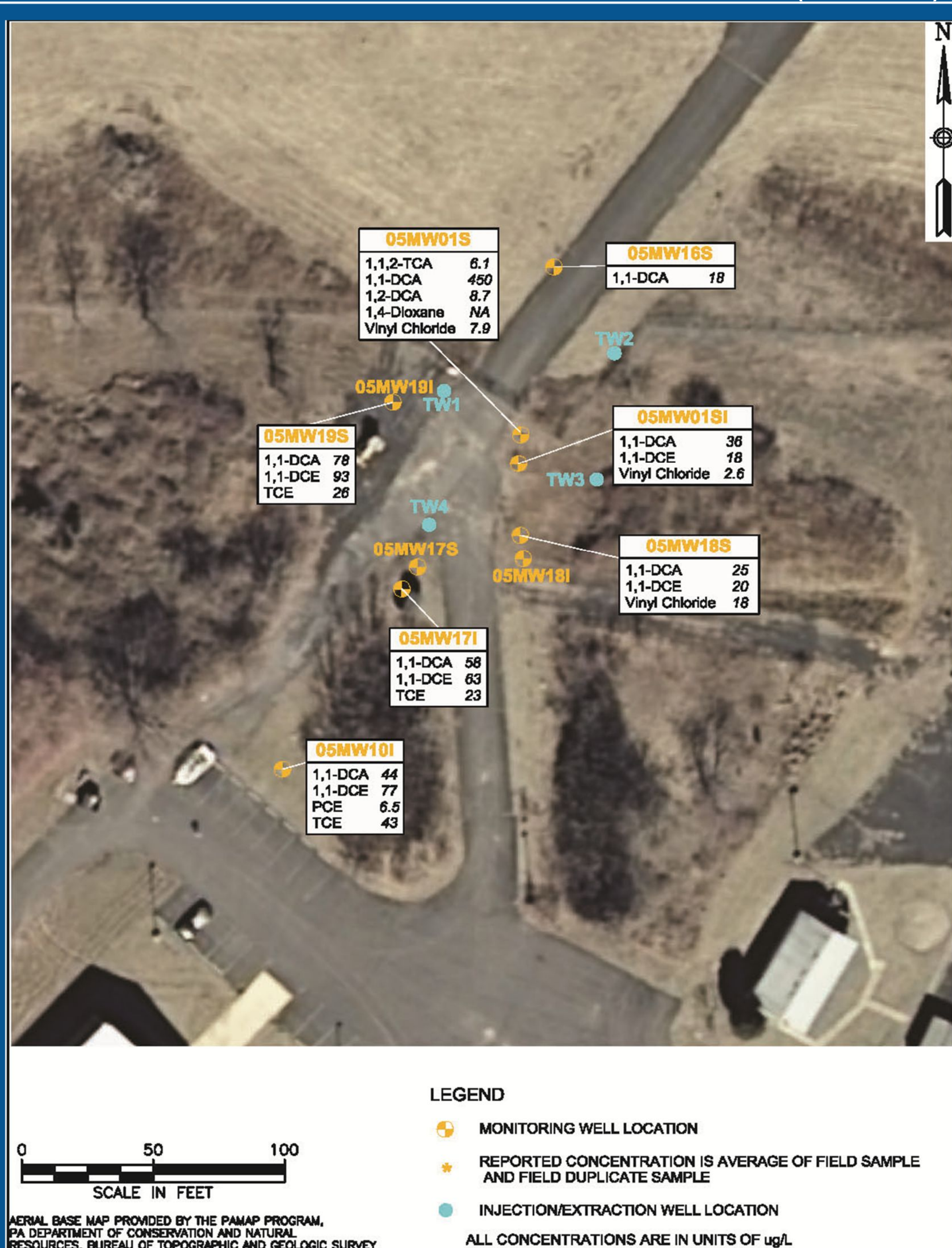


FIGURE 2-4. VOCS EXCEEDING REMEDIAL GOALS IN SOURCE AREA – 2010 (PILOT TEST)



2.7 SUMMARY OF SITE RISKS

The baseline risk assessment estimates what risks the site would pose if no action was taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. A baseline HHRA and a screening-level ecological risk assessment for site groundwater were conducted as part of the Phase II RI (Tetra Tech, 2002). An update of the HHRA was conducted in 2007 (Tetra Tech, 2007) to evaluate the effects of recent changes in risk assessment methodology, particularly regarding exposure assessment calculations and significant changes to toxicity criteria for multiple compounds. The updated HHRA also included additional groundwater VOC data obtained during subsequent investigative work documented in the Site 5 RI, Addendum 5 (Tetra Tech, 2006). The updated HHRA evaluated changes in risks only to hypothetical future residents because they had been identified as the receptors presented with unacceptable risk in the original HHRA.

2.7.1 Summary of Human Health Risk

The quantitative HHRA was conducted using chemical concentrations detected in groundwater samples. Key steps in the risk assessment process included exposure assessment, toxicity assessment, and risk characterization and identification of COCs.

Identification of COPCs

Chemicals of Potential Concern (COPCs) were initially identified by comparing groundwater concentrations to EPA MCLs and EPA Region 3 Risk-Based Concentrations (RBCs) for tap water to conservatively be protective of all receptors that could be exposed to groundwater. A chemical was eliminated from consideration if the maximum detected concentration did not exceed the lesser of the MCL and RBC determined at a cancer risk level of 1×10^{-6} or a non-cancer Hazard Quotient (HQ) of 0.1. Table 7 from the updated HHRA (Tetra Tech, 2007) (included in Appendix C) presents the original and updated exposure point concentrations (EPCs) for the COCs identified for Site 5. EPCs are the concentrations used in the risk assessment to estimate exposure and risk from each COPC. The footnotes in the table also explain the statistical method from which the EPC was calculated.

The baseline HHRA (Tetra Tech, 2002) determined that maximum detected concentrations of eight metals exceeded RBCs, but were less than EPA MCLs. Because metals were not used or disposed at Site 5 and were less than the MCLs and not considered a human health risk, they were determined not to be site related. Therefore, the data used for the updated HHRA included only VOCs and 1,4-dioxane (for which data had not been available during the baseline HHRA). At the request of EPA, the metals results from the baseline HHRA were retained in the updated HHRA for the purpose of identifying all original groundwater COPCs.

Exposure Assessment

During the exposure assessment, current and potential future exposure pathways through which humans might come into contact with the COPCs for groundwater were evaluated. The results of the exposure assessment for Site 5 were used to refine the CSM (Figure 2-2), which identifies potential contaminant sources, contaminant release mechanisms, transport routes, and receptors under current and future land use scenarios. Potential exposure routes for groundwater include ingestion (swallowing), dermal contact (skin exposure), and inhalation (breathing of VOC vapors). Potential receptors evaluated by the initial HHRA included future excavation workers and future residents. The risk estimates for hypothetical future residents were recalculated in the updated HHRA because they were identified as the receptors exposed to unacceptable risk in the initial HHRA. Exposure pathways and receptors at Site 5 are summarized in Table 2-2.

TABLE 2-2. RECEPTORS AND EXPOSURE ROUTES EVALUATED IN HHRAS	
RECEPTOR (SCENARIO)	EXPOSURE ROUTE
2002 HHRA	
Excavation workers (future)	inhalation of groundwater vapor
Residents (future)	Ingestion, dermal contact, and inhalation
2007 Updated HHRA	
Residents (future child, adult, lifelong)	Ingestion, dermal contact, and inhalation

Toxicity Assessment

Toxicity assessment involves identifying the types of adverse health effects caused by exposure to site COPCs and determining the relationship between the magnitude of exposure and the severity of adverse effects (i.e., dose-response relationship) for each COC. Based on the quantitative dose-response relationships determined, toxicity values for both cancer (cancer slope factor [CSF]) and non-cancer (reference dose [RfD]) effects were derived and used to estimate the potential for adverse effects.

Table 6 in Appendix C (from the 2007 updated HHRA) provides carcinogenic risk information relevant to the Site 5 COPCs for oral, dermal, and inhalation exposure. At this time, CSFs are not available for the dermal route of exposure; therefore, dermal slope factors were extrapolated from oral values.

Table 5 in Appendix C (from the 2007 updated HHRA) provides non-carcinogenic hazard information relevant to the Site 5 COPCs for oral, dermal, and inhalation routes of exposure. As is the case for carcinogenic data, dermal RfDs were extrapolated from oral RfDs.

Risk Characterization

During the risk characterization, the outputs of the exposure and toxicity assessments are combined to characterize the baseline risk (cancer risks and non-cancer hazards) at the site if no action is taken to address the contamination. Potential cancer risks and non-cancer hazards were calculated based on reasonable maximum exposure (RME) and central tendency exposure (CTE) assumptions. The RME scenario assumes the maximum level of human exposure that could reasonably be expected to occur, and the CTE scenario assumes a median or average level of human exposure.

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

$$\text{Risk} = \text{CDI} \times \text{SF}$$

where: risk = a unitless probability (e.g., 2×10^{-5}) of an individual developing cancer
CDI = chronic daily intake averaged over 70 years (in mg/kg-day)
SF = slope factor (in mg/kg-day^{-1})

These calculated risks are probabilities that are usually expressed in scientific notation (e.g., 1×10^{-6}). An excess lifetime cancer risk of 1×10^{-6} under an RME scenario indicates that an individual experiencing the reasonable maximum exposure estimate has an “excess lifetime cancer risk” because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes has been estimated to be as high as one in three. EPA’s generally acceptable risk range for site-related exposures is 1×10^{-4} to 1×10^{-6}.

Tables 9.1, 9.2, and 9.3 in Appendix C provide RME cancer risk estimates for future child, adult, and lifelong residents, respectively, and the routes of exposure developed by taking into account various

conservative assumptions about the frequency and duration of exposure for each receptor and also about the toxicity of the COCs.
The results of the 2007 updated HHRA indicate that the estimated RME incremental lifetime cancer risk (ILCR) for future child residents (2×10^{-4}), adult residents (3×10^{-4}), and lifelong residents (5×10^{-4}) exceed the target risk range. PCE and TCE are the major contributors under both scenarios, with TCE displaying ILCRs of 1×10^{-4} and 2×10^{-4} for adult and lifelong residents, respectively, and PCE displaying ILCRs of 1×10^{-4} for future adult residents and 2×10^{-4} for lifelong residents. These risk levels indicate that if no cleanup action was taken, the increased probabilities of developing cancer as a result of site-related exposure would be approximately 5 in 10,000. Tables 9.1, 9.2, and 9.3 in Appendix C provide the CTE cancer risk estimates for future child, adult, and lifelong residents, respectively. The ILCR for future adult resident (5×10^{-5}) and lifelong resident (8×10^{-5}) under the CTE scenario are within EPA's target risk range.

The potential for non-carcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., a lifetime) to an RfD derived for a similar exposure period. An RfD represents a level to which an individual may be exposed that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called an HQ. An HQ less than 1 indicates that a receptor's dose of a single contaminant is less than the RfD and that toxic non-carcinogenic effects from that chemical are unlikely. The hazard index (HI) is generated by adding the HQs for all chemicals that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may be reasonably exposed. An HI less than 1 indicates that, based on the sum of all HQs from different contaminants and exposure routes, toxic non-carcinogenic effects from all contaminants are unlikely. An HI greater than 1 indicates that site-related exposures may present a risk to human health. The HQ is calculated as follows:

$$\text{Non-cancer HQ} = \text{CDI} / \text{RfD}$$

where: CDI = chronic daily intake
RfD = reference dose

CDIs and RFDs are expressed in the same units and represent the same exposure period (i.e., chronic, sub-chronic, or short-term).

Tables 9.1, 9.2, and 9.3 in Appendix C also provide RME non-cancer HQs for each receptor and route of exposure and total HIs for all routes of exposure. Non-carcinogenic HIs for the child residents and adult residents exceeded acceptable levels based on toxicity contributions from TCE associated with a HQ of 24 for the future child resident and 15 for the future adult resident.

For Site 5 groundwater, unacceptable cancer risk was identified under the RME scenario for future adult resident and lifelong (child and adult) residents due to exposure to VOCs (primarily PCE) via ingestion, dermal contact, and inhalation. Unacceptable non-cancer hazards were identified for the future child (RME HI=28) and adult (HI=17) residents, and individual target organ HIs were also greater than 1.0. Under the CTE scenario, no unacceptable cancer risk was identified. For non-cancer risk, CTE HIs for future child (HI=19) and adult (HI=10) residents similarly greater than 1.0.

In the baseline HHRA, lead was detected in 1 of 21 groundwater samples at a concentration of 18.1 µg/L, which exceeds the Safe Water Drinking Act action level of 15 µg/L. Hypothetical future residential exposures to lead were evaluated using EPA's Integrated Exposure Uptake Biokinetic (IEUBK) lead model, Version 1, Build 263 (1994). The calculations are included in the updated 2007 HHRA. The model estimated that 0.08 percent of future on-site child residents would have a blood-lead level greater than 10 µg/dL and resulted in a geometric mean blood lead level of 2.3 µg/dL. This percentage is less than the EPA goal, as described in the 1994 Office of Solid Waste and Emergency Response (OSWER) Directive, of no more than 5 percent of children exceeding a 10 µg/dL blood-lead level.

Potential future exposures to COCs from vapor intrusion, or vapors that migrate from groundwater into indoor air, were evaluated using EPA's Johnson and Ettinger volatilization model (2003). The two scenarios evaluated included a current industrial use scenario and a future residential scenario. The calculations are included in the updated 2007 HHRA. HIs for industrial workers (0.001) and hypothetical residents (0.01) for indoor air exposure are less than unity, indicating that adverse non-cancer effects are not anticipated for these receptors. The ILCRs for the industrial workers (7×10^{-7}) and residents (1×10^{-6}) for the indoor air exposure are within EPA's target risk range of 10^{-4} to 10^{-6}. The Johnson and Ettinger model was applicable for use in evaluating vapor intrusion exposure when the risk assessment was performed. EPA guidance has since been updated; thereby creating some uncertainty of potential risk. Therefore, LUCs will be implemented to conduct a vapor intrusion investigation or install a vapor mitigation system in existing buildings prior to reuse and occupancy of the buildings. LUCs will also be implemented requiring the installation of vapor mitigation systems in any new buildings constructed at the site.

One source of uncertainty in the HHRA that has been reduced concerns the toxicity criteria for TCE. The toxicity criteria for this compound were recently revised and published on the EPA's Integrated Risk Information System (IRIS) database. Therefore, the TCE risks presented in Attachment C are now based on consensus toxicity values.

Based on the results of the HHRAs, RME cancer risks were identified for groundwater that, if not addressed by remedial measures, may present a potential threat to public health, welfare, or the environment and therefore require a response action. Unacceptable cancer risks were identified for future adult residents and future lifelong (child and adult) residents.

2.7.2 Summary of Ecological Risk

An ecological risk screening was performed to characterize the potential risks from site-related contaminants to potential ecological receptors (flora and fauna) that inhabit the site. The risk assessment is included in the Site 5 RI (Tetra Tech, 2002). For Site 5 groundwater, the assessment concluded that there are no ecological risks because the Site 5 groundwater does not discharge to the surface in the vicinity of the site or interact with any surface water bodies. Because there are no ecological receptors exposed to Site 5 groundwater, there is no unacceptable ecological risk presented by the groundwater contaminants.

2.7.3 Basis for Action

Unacceptable human health risks were estimated for potential future residential exposure to groundwater at Site 5 due to VOCs, including cancer risks for future adult and lifelong (child and adult) residents. Because risks were identified for potential future residential receptors, a response action is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

2.8 Remedial Action Objectives

RAOs are medium-specific goals that define the objective of conducting remedial actions to protect human health and the environment. RAOs specify the COCs, potential exposure routes and receptors, and acceptable concentrations (i.e., cleanup levels) for a site and provide a general description of what the cleanup will accomplish. RAOs typically serve as the design basis for the remedial alternatives described in Section 2.9. The RAOs for Site 5 groundwater are as follows:

- Prevent potential human exposures to contaminated groundwater.
- Restore concentrations of COCs in groundwater to MCLs.
- Prevent further degradation of groundwater.

These RAOs are based on currently undetermined but reasonably anticipated future residential site use. Data from the RI and HHRAs and the Applicable or Relevant and Appropriate Requirements (ARARs) were reviewed to identify the Site 5 groundwater COCs that would be used to determine the appropriate remediation goals (RGs). The Site 5 groundwater RGs are presented in Table 2-3, along with the basis for their selection.

TABLE 2-3. SITE 5 GROUNDWATER REMEDIATION GOALS

COC	Range of Detected Concentrations(1) (µg/L)	Exceeds MCL?	Remedial Goal (µg/L)	Rationale for Remedial Goal
1,1,1-Trichloroethane (TCA)	2 - 960	Yes	200	MCL
1,1,2-TCA	10	Yes	5	MCL
1,1-DCA	3 - 350	NC	31	MSC
1,1-DCE	6 - 300	Yes	7	MCL
1,2-DCA(2)	3 - 4	No	5	MCL
c-1,2-DCE	0.51 - 270	Yes	70	MCL
1,4- Dioxane	12 - 21 (3)	NC	6.4	MSC
Benzene	3 - 28	Yes	5	MCL
PCE	1 - 35	Yes	5	MCL
TCE	5 - 300	Yes	5	MCL
VC(2)	ND	No	2	MCL

MSC - Medium Specific Concentration for Groundwater, Residential Used Aquifers, PA Code 250, Table 1. (see Appendix A, Table A-1 for rationale for selecting MSC in lieu of EPA Regional Screening Level for Tap Water)
1 Summer 2005 results, prior to bioremediation pilot test.
2 Breakdown products of parent compounds 1,1,1-TCA, PCE, and TCE that either currently exist in Site 5 groundwater or are expected to be temporarily created (or increase in concentration) as byproducts of the reductive dechlorination process before they are in turn reduced through the same bioremediation process.
3 September 2011 results
ND – Not detected.
NC – No MCL.

2.9 DESCRIPTION OF ALTERNATIVES

To address potential unacceptable human health risks associated with groundwater at Site 5, a preliminary technology screening evaluation was conducted in the FS. The general response actions that were retained after the FS preliminary screening are presented in Table 2-4.

TABLE 2-4. GENERAL RESPONSE ACTIONS

General Response Action	Technology	Process Options
No Action	None	Not applicable
Natural Attenuation	Natural Attenuation	Naturally occurring biodegradation and dilution
Institutional Controls (Limited Action)	LUCs	Administrative controls: deeds and site use restrictions
Containment	Vertical Barrier	Hydraulic barrier (injection and extraction wells)
Collection, ex-situ treatment, and discharge	Groundwater Extraction	Extraction wells with air stripping
In-Situ Treatment	Biological	Anaerobic bioremediation
	Chemical	Chemical oxidation

These technologies and process options were assembled into five alternatives. Consistent with the NCP, the no action alternative was evaluated as a baseline for comparison with other alternatives during the comparative analysis. Table 2-5 describes the major components and provides estimated costs for each remedial alternative identified for Site 5 groundwater.

TABLE 2-5. SUMMARY OF REMEDIAL ALTERNATIVES EVALUATED

ALTERNATIVE	COMPONENTS	DETAILS	COST
1. No Action *No action to address contaminated groundwater and no use restrictions*	None	No action. Site conditions and risks would require review every 5 years.	**Capital**: $0 **Average Annual O&M Cost**: $0 **Average Annual O&M Cost After Active Treatment**: N/A **30-Year NPW**: $32,400 **Discount Rate**: 7% **Time Frame**: N/A
2. MNA, Institutional Controls, and Long-Term Groundwater Monitoring	MNA	Natural physical, chemical, and biological processes reduce contaminant concentrations in groundwater.	**Capital**: $63,000 **Average Annual O&M Cost**: $20,000 **Average Annual O&M Cost After Active Treatment**: N/A **30-Year NPW**: $358,500 **Discount Rate**: 7% **Time Frame**: 30 years
	LUCs	LUCs would prohibit future use of untreated groundwater and require that future buildings and /or reuse of existing buildings protect against vapor intrusion until contaminants in groundwater are at levels that allow for unlimited use and unrestricted exposure.	
	Monitoring	Periodic groundwater sampling and analysis would be performed to assess the status of the plume.	
3A. Pump and Treat Groundwater from Entire Plume and Discharge	Groundwater Extraction	Contaminated groundwater would be extracted from the entire length of the plume.	**Capital**: $1,524,000 **Average Annual O&M Cost**: $268,000 **Average Annual O&M Cost After Active Treatment**: N/A **30-Year NPW**: $5,057,000 **Discount Rate**: 7% **Time Frame**: 30 years
	Groundwater Treatment	Groundwater would be treated by air stripping in a treatment plant to be constructed near the site. Effluent would be discharged to the sanitary sewer system.	
	LUCs	LUCs would prohibit future use of untreated groundwater and require that future buildings and/or reuse of existing buildings protect against vapor intrusion until contaminants in groundwater are at levels that allow for unlimited use and unrestricted exposure. .	
	Monitoring	Long-term monitoring would be conducted to assess the effectiveness of the remedial action and to determine when remediation is complete.	

TABLE 2-5. SUMMARY OF REMEDIAL ALTERNATIVES EVALUATED			
ALTERNATIVE	**COMPONENTS**	**DETAILS**	**COST**
4. In-Situ Treatment of Groundwater by Anaerobic Bioremediation and MNA	Anaerobic Bioremediation	The most highly contaminated groundwater within the source area would be treated to promote the growth of bacteria within the aquifer to degrade site contaminants via reductive dechlorination Additional bacteria would be added if the natural population was too low.	**Capital**: $307,000 **Average Annual O&M Cost**: $91,000 **Average Annual O&M Cost After Active Treatment**: $18,000 **30-Year NPW**: $819,000 **Discount Rate**: 7% **Time Frame**: 15 years
	Groundwater Recirculation	Groundwater would be recirculated within the source area to distribute the biological amendments.	
	MNA	With the source area remediated, the less contaminated downgradient segment of the plume would attenuate through natural physical, chemical, and biological processes.	
	LUCs	LUCs would prohibit future use of untreated groundwater and require future buildings and/or reuse of existing buildings protect against vapor intrusion until contaminants in groundwater are at levels that allow for unlimited use and unrestricted exposure.	
	Monitoring	Long-term monitoring would be conducted to assess the effectiveness of the remedial action and to determine when remediation is complete.	
5. In-Situ Treatment of Groundwater by Chemical Oxidation	Chemical Oxidation	A chemical oxidant would be injected into the most highly contaminated groundwater within the source area to destroy the COC via chemical oxidation.	**Capital**: $620,000 **Average Annual O&M Cost**: $99,000 **Average Annual O&M Cost After Active Treatment**: $28,000 **30-Year NPW**: $1,176,000 **Discount Rate**: 7% **Time Frame**: 12 years
	LUCs	LUCs would prohibit future use of untreated groundwater and require future buildings and/or reuse of existing protect against vapor intrusion until contaminants in groundwater are at levels that allow for unlimited use and unrestricted exposure.	
	Monitoring	Long-term monitoring would be conducted to assess the effectiveness of the remedial action and to determine when remediation is complete.	

2.10 COMPARATIVE ANALYSIS OF ALTERNATIVES

Table 2-6 and subsequent text in this section summarize the comparison of the remedial alternatives with respect to the nine CERCLA evaluation criteria outlined in the NCP at 40 Code of Federal Regulations (CFR) 300.430(e)(9)(iii) and categorized as threshold, primary balancing, and modifying criteria. Further information on the detailed comparison of remedial alternatives is presented in the Site 5 FS.

TABLE 2-6. COMPARATIVE ANALYSIS OF THRESHOLD AND BALANCING CRITERIA

CRITERION	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3A	ALTERNATIVE 4	ALTERNATIVE 5
Overall Protectiveness of Human Health and the Environment	○	◉	●	●	●
Compliance with ARARs	○	◉	●	●	●
Long-Term Effectiveness and Permanence	○	◉	●	●	●
Reduction of Toxicity, Mobility, or Volume through Treatment	○	○	●	●	●
Short-Term Effectiveness	◉	◉	◉	◉	◉
Implementability	●	●	◉	◉	◉
Cost (Present Net Worth)	$32,400	$358,500	$5,057,000	$819,000	$1,176,000

Ranking: ● Satisfies criterion well ◉ Moderately satisfies criterion ○ Poorly satisfies criterion

Threshold Criteria

Overall Protection of Human Health and the Environment. Alternative 1 would not achieve the RAOs and therefore does not protect human health and the environment. It will therefore not be considered further in this ROD. Alternatives 2, 3A, 4, and 5 are all protective of human health and the environment. Alternative 2 is considered to be less protective than Alternatives 3A, 4, and 5 because it relies on natural degradation, which adds a higher degree of uncertainty for the rate of contaminant reduction and length of time to achieve the RAOs. Alternatives 3A, 4, and 5 would provide similar protection of human health and the environment through active treatment of contaminated groundwater to reduce contaminant concentrations and implementation of institutional controls to protect human health and the environment by preventing exposure to OU 2 groundwater until RAOs are achieved.

Compliance with ARARs. ARARs include any federal or state environmental standards, requirements, criteria, or limitations determined to be legally applicable or relevant and appropriate to the site or remedial action. Alternatives 2, 3A, 4, and 5 would eventually comply with all chemical-specific ARARs, and Alternatives 3A, 4, and 5 would also comply with all action-specific and location-specific ARARs. None of the alternatives would initially comply with ARARs for attainment of groundwater quality criteria; however, Alternatives 2, 3A, 4, and 5 would include a provision to implement LUCS preventing use of groundwater until the RGs are achieved.

Primary Balancing Criteria

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 LUCs that would prohibit the use of contaminated groundwater. 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.

Reduction in Toxicity, Mobility, or Volume Through Treatment. Although Alternative 2 is expected to reduce the toxicity, mobility, or volume of contaminants through natural attenuation processes over an extended period of time; there is no treatment associated with this alternative. Alternatives 4 and 5 would permanently reduce the contaminants through on-site treatment, with no off-site disposal required. Alternative 3A would treat contaminated groundwater using activated carbon; disposal of spent carbon would transfer contaminants off site.. Alternatives 3A, 4, and 5 would also generate small amounts of waste material for disposal such as empty nutrient or chemical additive containers, used personal protective equipment, and used filters. Depending on VOC concentrations in air from the air stripper, Alternative 3A may generate spent carbon as a treatment residual from a vapor-phase or aqueous-phase carbon polishing unit.

Short-Term Effectiveness. Short-term effectiveness evaluates the length of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved. Alternative 2 would take the least amount of time to implement and presents a limited opportunity for short-term impacts to human health and the environment related to the one-time monitoring well installation activities and collection of samples and field parameters 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 groundwater treatment systems. In all cases, short-term risks would be mitigated through use of engineering controls, transportation planning, appropriate personal protective equipment, and safe work practices. No permanent adverse impacts to human health or the environment would be anticipated to result from implementation of Alternatives 2, 3A, 4, and 5.

Implementability. Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Each of the alternatives would be implementable. Alternative 2 would be the easiest to implement because it involves the relatively simple additional tasks of adding new monitoring wells, the collection and analysis of groundwater samples, and additional professional services required for the evaluation of the data and the implementation of the institutional controls. Alternatives 3A, 4, and 5 would be somewhat more difficult to implement because all would require installation and operation of an on-site treatment system. However, no difficulties are anticipated in implementing these alternatives because they include proven technologies that employ relatively common equipment and materials. If additional actions are warranted, they could easily be implemented under any of the alternatives.

Cost. The costs are summarized in Table 2-6. Alternative 4 would be the least expensive alternative that includes active treatment for the VOC-contaminated site. The most expensive alternative, Alternative 3A, includes extraction of groundwater for treatment at a facility to be constructed near the site. The least expensive alternative, other than the No Action alternative, is Alternative 2; however, active treatment is not included in this alternative.

Modifying Criteria

State Acceptance. State involvement has been solicited throughout the CERCLA process. PADEP, as the designated state support agency in Pennsylvania, concurs with the Selected Remedy.

Community Acceptance. One comment letter containing multiple comments was received during the formal public comment period for the Proposed Plan. The questions raised at the public meeting on July 22, 2009, were general inquiries for informational purposes only; no objections to the proposed alternative were voiced. These comments and Navy responses are discussed in Section 3.0. The preferred alternative was presented during a public meeting on June 22, 2011. Only one written comment was received and is addressed in the responsiveness summary. The selected remedy has been discussed in subsequent RAB meetings (August 17, 2011; December 7, 2011; March 7, 2012; and June 6, 2012).

2.11 PRINCIPAL THREAT WASTE

The NCP at 40 CFR 300.430(a)(1)(iii)(A) establishes an expectation that treatment will be used to address the principal threats posed by a site wherever practicable. Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or that would present a significant risk to human health or the environment should exposure occur. A source material is a material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air, or acts as a source for direct exposure. EPA generally does not consider contaminated groundwater a source material unless non-aqueous-phase liquids (NAPLs) are present (EPA, 1991). NAPL does not exist at Site 5.

2.12 SELECTED REMEDY

2.12.1 Rationale for Selected Remedy

The Selected Remedy for OU 2 is in-situ anaerobic bioremediation combined with MNA for remediation of VOC-contaminated groundwater within the source area, MNA with long-term monitoring for the diffuse portion of the plume, and LUCs to prevent human contact with COCs until contaminants in the groundwater are at levels that allow for unlimited use and unrestricted exposure. This remedy was selected because it provides the best balance of tradeoffs with respect to the nine evaluation criteria and will allow for unlimited future reuse of the property once remediation is complete. The remedy will meet the RAOs through in-situ bioremediation and MNA of groundwater by reducing the VOC concentrations to levels that are at or below the established remediation goals and by implementing LUCs to prohibit use of untreated groundwater, require that construction of future structures integrate measures to mitigate the potential for vapor intrusion of VOCs from the subsurface into the structure, and require that existing buildings install a system to mitigate potential intrusion of VOCs from the subsurface into the structure or be subject to a vapor intrusion investigation that documents that an unacceptable risk to future occupants is not present at that structure. The use of treated groundwater must be approved by the Navy, EPA, and PADEP.

The principal factors in the selection of this remedy included the following:

- The remedy will permit future residential or non-residential use of the property and support any future land use decisions made by the HLRA.
- The efficacy of the remedy has already been proven through the performance of the bioremediation pilot test.
- The cost is lowest among the remedies that meet the threshold criteria, and most of the capital costs have already been expended through the construction of the pilot test.

2.12.2 Description of Selected Remedy

The Selected Remedy includes four major components: (1) in-situ anaerobic bioremediation combined with MNA for VOC-contaminated groundwater in the source area, (2) MNA of the diffuse plume downgradient of the source area, (3) long-term monitoring to assess the effectiveness of the remedial action and to determine when remediation is complete, and (4) LUCs to prohibit the use of untreated groundwater and to require construction of future buildings to integrate measures to mitigate the potential for vapor intrusion of VOCs from the subsurface into the building until contaminants in the groundwater are at levels that allow for unlimited use and unrestricted exposure.

Implementation of in-situ bioremediation will largely consist of the continued operation of the successful pilot test treatment system. Periodic biostimulation events consisting of the injection of organic substrate will be performed to maintain the geochemical conditions necessary for efficient bioremediation. In addition, the pilot test results indicated that remediation of the source area would be accelerated by the installation of several additional shallow injection wells to augment the existing injection operation and to ensure that a larger portion of the site's most highly impacted groundwater is most efficiently addressed.

The segment of the groundwater plume located downgradient of the source area will not immediately be impacted by bioremediation and will initially contain contaminants at concentrations exceeding remediation goals. Because bioremediation of the diffuse plume outside of the source area is not practical, this segment of the plume will attenuate under natural physical, chemical, and biological processes as the source of the plume is removed through bioremediation.

Long-term groundwater monitoring will be conducted to evaluate and maintain the proper geochemical conditions within the source area, to assess the effectiveness and rate of bioremediation in the source area, to assess the effectiveness and rate of attenuation of VOCs in the source area and downgradient segment of the plume, and to determine when remediation is complete through the reduction of VOC concentrations throughout the entire extent of the plume to levels at or below the remediation goals for the respective compounds. Long-term groundwater monitoring will also be conducted to evaluate the PFOA and PFOS concentrations in groundwater for the Five-Year Review process.

LUCs will be implemented within the Site 5 boundaries to prohibit the use of untreated groundwater and to require that future buildings are constructed to mitigate the potential for vapor intrusion of VOCs from the subsurface into the buildings, and require that existing buildings install a system to mitigate potential intrusion of VOCs from the subsurface into the structure or be subject to a vapor intrusion investigation that documents that an unacceptable risk to future occupants is not present at that structure. When the Site 5 property is transferred to a non-federal entity, the LUCs will consist of deed restrictions to prohibit the use of untreated groundwater and requirements for incorporating vapor intrusion mitigation in buildings until contaminants in the groundwater are at levels that allow for unlimited use and unrestricted exposure. The use of treated groundwater must be approved by the Navy, EPA, and PADEP. The Site 5 LUC boundary encompasses the entire extent of the groundwater plume, as shown on Figure 2-5. The LUCs will be implemented and maintained by the Navy until concentrations of hazardous substances in groundwater are at levels that allow for unrestricted use and unlimited exposure. The Navy is responsible for implementing, maintaining, reporting on, and enforcing the LUCs described in this ROD. Although the Navy may later transfer these procedural responsibilities to another party by contract, property transfer agreement, or through other means, the Navy shall retain ultimate responsibility for the remedy integrity.

The LUC implementation actions including monitoring and enforcement requirements will be provided in a LUC Remedial Design (RD) that will be prepared by the Navy as the LUC component of the overall RD. Within 90 days of ROD signature, the Navy shall prepare and submit to EPA and PADEP for review and comment (pursuant to those Primary Document review procedures stipulated in the FFA) the LUC RD for Site 5 that shall contain implementation and maintenance actions, including periodic inspections. The Navy will maintain, monitor, and enforce the LUCs according to the LUC RD. Implementation of this remedy will therefore require annual visual inspections and a five-year review with report preparation. A survey of the LUC boundary will be conducted prior to property transfer.

2.12.3 Expected Outcomes of Selected Remedy

The current non-residential land use and potential future residential land reuse are both supported by the Selected Remedy. Groundwater at the site is not currently used, and the future use of untreated groundwater will be restricted through LUCs. Use of treated groundwater must be approved by the Navy, EPA, and PADEP. There are no significant socio-economic, community revitalization, and economic impacts or benefits associated with implementation of the Selected Remedy because it does not impact any potential land reuse determinations to be reached by the HLRA. It is estimated that the RAOs for OU 2 will be achieved within approximately 15 years of implementation of the remedy. Table 2-7 describes how the Selected Remedy mitigates risk and achieves RAOs for Site 5.

FIGURE 2-5. SITE 5 REMEDY COMPONENTS BOUNDARIES

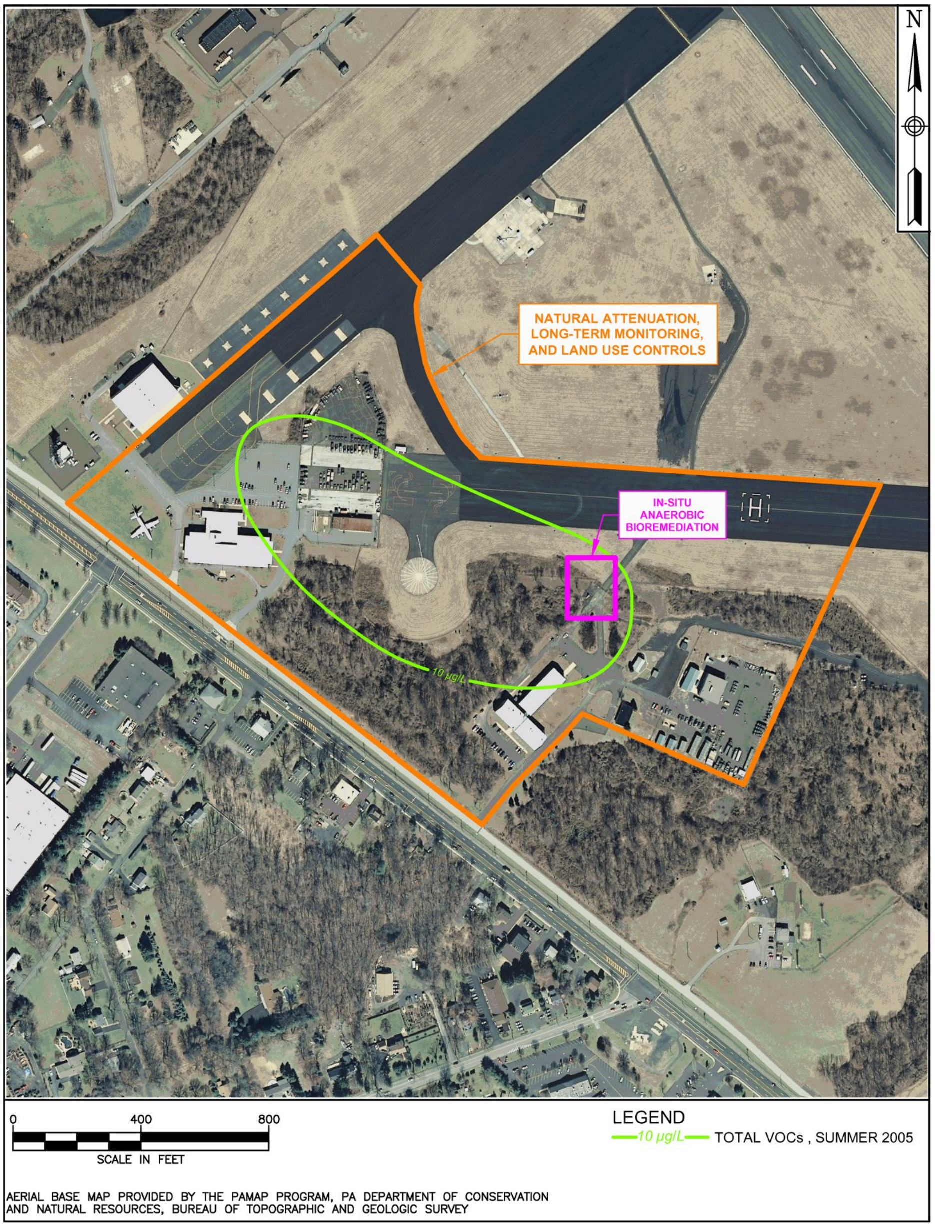


TABLE 2-7. HOW SELECTED REMEDY MITIGATES RISK AND ACHIEVES RAOS

RISK	RAO	COMMENTS
Exposure to contaminated groundwater through ingestion, inhalation, or dermal contact.	Prevent human exposure to contaminated groundwater	LUCs will prohibit the use of untreated groundwater and therefore prevent human exposures via ingestion, inhalation, or dermal contact. The use of treated groundwater must be approved by the Navy, EPA, and PADEP.
	Restore groundwater to MCLs or below	In-situ anaerobic bioremediation will destroy the VOCs in the source area through reductive dechlorination. MNA will eliminate the VOCs downgradient of the source area through natural physical, chemical, and biological processes after the most highly contaminated groundwater has been treated.
	Prevent further degradation of groundwater	Elimination of the most highly contaminated groundwater in the source area will stop the continuous generation of the plume, which will then contract and dissipate through MNA processes.

Because the LUCs are protective of the most conservative (future residential) potential land reuse scenarios, it is not expected that modification of the LUCs will be required by future HLRA decisions. If required, however, any modifications to LUCs will be conducted in accordance with provisions in the Site 5 LUC RD, CERCLA, and the NCP.

2.13 STATUTORY DETERMINATIONS

Under CERCLA § 121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with applicable or relevant and appropriate requirements (unless a statutory waiver is justified), are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. Following is a discussion of how the Selected Remedy meets these statutory requirements.

- **Protection of Human Health and the Environment** – The Selected Remedy is needed to prevent estimated potential future risks associated with residential exposure to contaminated groundwater. Bioremediation and MNA of the groundwater will be conducted to achieve the VOC remediation goals, and LUCs will be implemented to ensure protectiveness until contaminants at the site are at levels that allow for unlimited use and unrestricted exposure to the site.
- **Compliance with ARARs** – The Selected Remedy will attain all identified federal and state ARARs, as presented in Appendix A.
- **Cost-Effectiveness** – The Selected Remedy is the most cost-effective alternative that allows for future residential use of the property and represents the most reasonable value for the money. The costs are proportional to overall effectiveness by achieving an adequate amount of long-term effectiveness and permanence within a reasonable time frame. Detailed costs for the Selected Remedy are presented in Appendix B.
- **Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable** – The Selected Remedy represents the maximum extent to which permanent solutions and alternative treatment technologies can be used in a practical manner at Site 5.

- **Preference for Treatment as a Principal Element** – Treatment is a principal element of the Selected Remedy for groundwater at Site 5. Treatment includes in-situ anaerobic bioremediation to treat VOCs by reductive dechlorination.
- **Five-Year Review Requirement** – Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on site in excess of levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of remedial action and every 5 years thereafter to ensure that the remedy is, or will be, protective of human health and the environment. Five-Year Reviews will be performed until contaminants present at the site are at levels that allow for unlimited use and unrestricted exposure to the site.

2.14 DOCUMENTATION OF SIGNIFICANT CHANGES

CERCLA Section 117(b) requires an explanation of significant changes from the selected remedy presented in the Proposed Remedial Action Plan that was published for public comment. Several general questions were asked during the public meeting held on June 22, 2011, and formal comments were received from one citizen during the comment period. No significant changes to the remedy, as originally identified in the Proposed Remedial Action Plan, were necessary or appropriate. The questions raised at the public meeting, written formal comments, and responses are provided in Section 3.0, Responsiveness Summary.

3.0 RESPONSIVENESS SUMMARY

3.1 STAKEHOLDER COMMENTS AND LEAD AGENCY RESPONSES

Participants in the public meeting held on June 22, 2011, included RAB members, the HLRA, and representatives of the Navy, EPA, and PADEP. Questions and concerns raised at the meeting were addressed at the meeting, as summarized in Table 3-1. Written comments were received by the Navy from one citizen (a RAB member) during the public comment period, and are summarized in Table 3-2.

TABLE 3-1. SUMMARY OF COMMENTS FROM PUBLIC MEETING

COMMENT	RESPONSE
A RAB member asked if the various bacteria responsible for the reductive dechlorination all work at the same rate of speed.	Jeff Dale (Navy) explained that overall, the reductive dechlorination process works quickly, but the reduction of the various VOCs and creation of the subsequent breakdown products (and their subsequent reduction) do not all occur at the same rate.
A RAB member asked about the time frame of the remediation.	Jeff Dale replied that the Navy expects the active bioremediation operation to take approximately 5 years or less, and that it will take between 10 to 20 years for the downgradient segment of the plume to naturally attenuate.
A RAB member asked if the LUCs would inhibit the redevelopment of this area of the base.	Jeff Dale explained that the land could be developed for any use, including a building or a playground, and that the HLRA had not yet made any decision. Any building would have to be constructed to mitigate the potential for vapor intrusion. Robert Lewandowski pointed out that the land could not be redeveloped until the Navy has completed the active bioremediation operation and removed the remediation equipment.
An HLRA member asked if the frequency of the groundwater monitoring is included in the Proposed Plan.	Jeff Dale explained that it is not included. The Navy currently conducts monitoring about three times per year, based on the data needs of the pilot test. Robert Lewandowski explained that the requirement for long-term monitoring would be included in the ROD and that the subsequent RD written by the Navy would include the sampling plan and frequency.
An HLRA member asked if a Work Plan would be developed after the ROD is signed, and if there were any legal requirements regarding how soon it had to be submitted.	Robert Lewandowski (Navy) replied that the RD would serve as the Work Plan and that it had to be submitted within 15 months of ROD signature. A Draft LUC RD will be prepared within 90 days of ROD signature.

3.2 TECHNICAL AND LEGAL ISSUES

No technical or legal issues associated with the Site 5 ROD were identified.

TABLE 3-2. SUMMARY OF WRITTEN COMMENTS FROM A RAB MEMBER

COMMENT	RESPONSE
Benzene and 1,4-dioxane are not reduced through anaerobic bioremediation. Are these compounds currently above their remedial goals and will their remediation be through NA.	These compounds are expected to be reduced through NA. Benzene has historically exceeded its RG at well cluster 05MW01, which is located within the former drum staging area. However, two baseline bioremediation sampling rounds conducted in 2008 and 2009 indicated that even at this location, benzene concentrations were less than their RG, suggesting that this compound may have undergone significant aerobic degradation before the environment was driven to anaerobic conditions by the pilot test. In addition, many wells within the pilot test area that had historically not contained benzene now contain benzene at trace levels less than the RG, which suggests that groundwater recirculation within the treatment cell is distributing benzene within the cell but is at the same time lowering its concentration through dilution. 1,4-Dioxane was analyzed for during the summer 2008 sampling round, where it was detected in one well (the shallow well at the same 05MW01 well cluster) and at a concentration exceeding its RG. Sampling was conducted at well cluster 05MW01 in September 2011 with results showing 1,4-dioxane at levels above the RG in both the shallow and intermediate well. The Navy expects that, similar to benzene, the 1,4-dioxane has probably been distributed by groundwater recirculation but at the same time had its concentration decreased through dilution. The Navy will periodically analyze for 1,4-dioxane to ensure the concentration is attenuating and will eventually meet the RG.
The oxidation-reduction potential (ORP) measured during the pilot test indicates that the first injection of amendments was not successful, but the second injection was successful.	The Navy believes that, overall, favorable conditions were marginally created by the first injection but agrees that these conditions were not sustained. The first injection contained 606 pounds of sodium lactate, and the second injection contained 2,160 pounds of sodium lactate. The optimization of the injection volume and additive dosing rates was one of the pilot test's earliest primary objectives.
The biostimulation program was not able to drive the ORP to less than -200 millivolts (mV) in most of the wells, primarily indicating the additive's inability to create and sustain the required geochemical conditions.	Although the ORP in most wells was not less than -200 mV, the large reduction in concentrations of the parent VOCs, the temporary increase and subsequent reductions in the concentrations of intermediate VOCs, and the creation of multiple end-stage compounds all indicate that the environment required for bioremediation to be successful has been created.
The genus Dehalococcoides (Dhc) increased after bioaugmentation but was also present before this event. It is possible that the bioaugmentation may not have been required if the proper geochemical conditions had been created by the biostimulation.	Per the previous statement, the Navy believes that the required geochemical conditions have been created, as also witnessed by the continued population growth of Dhc throughout most of the cell and the reductions in VOC concentrations. In addition, bioaugmentation would have still been required for two important reasons. First, the genetic analysis of the native DHC indicated that it did not contain the critical VC-reductase gene, which means the bioremediation would have stalled at VC. Second, the native bacterial population did not contain the genus Dehalobacter (Dhb), whose presence is required to effectively reduce the chlorinated ethanes.
The low concentrations of VC and the corresponding increases in the concentration of ethene indicate the bioremediation program is effective.	The Navy agrees that the pilot test results indicate that bioremediation will be a successful remedial alternative.
Although the pilot test indicates that bioremediation was successful, the overall results indicate that sodium lactate may not be the optimum organic additive, and it may be prudent to evaluate additional options.	The Navy agrees that although it successfully created the required geochemical conditions, sodium lactate is not the optimum carbon source because the pilot test indicated that it is consumed too quickly by the microbial population. The Navy recently injected lactate contained within an emulsified oil, which is expected to be slower releasing and longer lasting. The results of a recently conducted sampling event will be used to evaluate the effectiveness of this new additive. The Navy is not committed to any particular additive at this point and may continue to evaluate additional options throughout the remedial process, including the particular commercial product mentioned in the written comment.

ACRONYMS

AFFF	Aqueous Film-Forming Foam
ARAR	Applicable or Relevant and Appropriate Requirement
ARS	Air Reserve Station
BRAC	Base Realignment and Closure Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	chemical of potential concern
CSF	cancer slope factor
CSM	conceptual site model
CTE	central tendency exposure
DCA	dichloroethane
DCE	dichloroethene
Dhb	*Dehalobacter*
Dhc	*Dehalococcoides*
DoD	Department of Defense
EFANE	Navy Engineering Field Activity Northeast
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
FFA	Federal Facility Agreement
FFTA	Former Fire Training Area
FS	Feasibility Study
gpm	gallons per minute
HEAST	Health Effects Assessment Summary Tables
HHRA	human health risk assessment
HI	hazard index
HJII	Horsham Joint Interagency Installation
HLRA	Horsham Township Authority for NAS JRB Willow Grove
HQ	Hazard Quotient
IAS	Initial Assessment Study
IEUBK	Integrated Exposure Uptake Biokinetic
ILCR	incremental lifetime cancer risk
IR	Installation Restoration
IRIS	Integrated Risk Information System
ISAB	In Situ Anaerobic Bioremediation
JII	Joint Interagency Installation

LUC	land use control
MCL	Maximum Contaminant Level
MNA	monitored natural attenuation
mV	millivolt
NA	natural attenuation
NAPL	non-aqueous-phase liquid
NAS JRB	Naval Air Station Joint Reserve Base
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPW	net present worth
O&M	operation and maintenance
ORP	oxidation reduction potential
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PADEP	Pennsylvania Department of Environmental Protection
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PMO	Program Management Office
RAB	Restoration Advisory Board
RAO	Remedial Action Objective
RBC	Risk-Based Concentration
RD	Remedial Design
RfD	reference dose
RG	Remedial Goal
RI	Remedial Investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RSL	Regional Screening Level
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	Site Inspection
SMP	Site Management Plan
SVOC	semivolatile organic compound
TCA	trichloroethane
TCE	trichloroethene
TCL	Target Compound List

TOC	total organic carbon
TRC	Technical Review Committee
USGS	United States Geological Survey
UST	Underground Storage Tank
VC	vinyl chloride
VOC	volatile organic compound

Appendix A
Applicable or Relevant and Appropriate Requirements

‘

TABLE A-1

SUMMARY OF CHEMICAL-SPECIFIC ARARs
SITE 5 NAS JRB WILLOW GROVE, PENNSYLVANIA

Table A-1 - Chemical-Specific ARARs to be Met by the Selected Remedy			
Requirement	**Status**	**Synopsis of Requirement**	**Action to be Taken to Attain Requirement**
Safe Drinking Water Act (SDWA) – Maximum Contaminant Levels - 40 CFR 141.61(a)	Relevant and Appropriate	Establishes maximum contaminant levels (MCLs) for common organic and inorganic contaminants applicable to public drinking water supplies. Used as relevant and appropriate cleanup standards for aquifers that are potential drinking water sources.	Site groundwater will attain MCLs through a combination of active treatment (bioremediation) and monitored natural attenuation. MCLs for site COCs are presented on Table 2-3.
Administration of Land Recycling Program - 25 Pennsylvania (PA) Code 250 Table 1; Medium-Specific Concentrations (MSCs) for Organic Regulated Substances in Groundwater for Residential Used Aquifers	Relevant and Appropriate	The Chapter provides remediation standards which shall be used whenever site remediation is voluntarily conducted or performed under other Pennsylvania acts. Table 1 provides remediation goals for groundwater.	MSCs were used for remedial goals for contaminants without MCLs. (1) The MSC has been used as the remedial goal for 1,1-dichloroethane and 1,4-dioxane.
Administration of Land Recycling Program - 25 Pennsylvania (PA) Code 250.312 for vapor intrusion.	Relevant and Appropriate	The Chapter provides remediation standards which shall be used whenever site remediation is voluntarily conducted or performed under other Pennsylvania acts. Section 250.312 requires the evaluation of vapor intrusion exposure pathway.	Land use controls (LUCs) will address exposure through the vapor intrusion pathway.

(1) The Proposed Plan indicated EPA Regional Screening Level (RSL) Tapwater Supporting Table (June 2011) would be used as remedial goals for contaminants of concern without MCLs. RSLs are screening values rather than cleanup goals as stated in EPA's Generic Table website. Risk-based PRGs were calculated for site contaminants without promulgated MCLs. Based on an increased carcinogenic risk of 1E-05, the risk-based PRGs were greater than those specified in The Land Recycling Program - 25 Pennsylvania (PA) Code 250 Table 1; Medium-Specific Concentrations (MSCs) for Organic Regulated Substances in Groundwater for Residential Used Aquifers. Therefore, MSCs have been substituted for the RSLs as remediation goals for contaminants without MCLs.

TABLE A-2

SUMMARY OF LOCATION-SPECIFIC ARARs
SITE 5 NAS JRB WILLOW GROVE, PENNSYLVANIA

Table A-2 – Location-Specific ARARs to be Met by the Selected Remedy			
Requirement	**Status**	**Synopsis of Requirement**	**Action to be Taken to Attain Requirement**

There are no location-specific ARARs.

TABLE A-3

SUMMARY OF ACTION-SPECIFIC ARARs
SITE 5 NAS JRB WILLOW GROVE, PENNSYLVANIA

Table A-3 – Action-Specific ARARs to be Met by the Selected Remedy

Requirement	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Clean Water Act, Underground Injection Control (UIC) Program – 40 CFR 144 Subpart G and 146.51	Relevant and Appropriate	Establishes requirements for owners and operators of and criteria and standards for Class V injection wells. (EPA administers the UIC Program in Pennsylvania)	Remedial actions involving underground injection of an electron donor for bioremediation would meet the requirements of these regulations.
Erosion and Sediment Control Regulations - 25 Pennsylvania (PA) Code 102.4(b), 102.11, and 102.22	Applicable	Identifies erosion and sediment control requirements and criteria for land clearing, grading, and other earth disturbance activities and establishes erosion and sediment control criteria.	Clearing for well installation and injection activities conducted as part of the Selected Remedy will be performed in accordance with an approved Erosion and Sediment Control Plan submitted as part of the remedial design.
Residual Waste Management , Chemical Analysis of Waste - 25 PA Code 287.54	Applicable	Describes the requirements for characterizing residual waste.	Sampling will be conducted in accordance with design documents to determine proper classification, handling, and disposal requirements for soil cuttings from new wells and purge water from monitoring well sampling. It is assumed that this waste will be classified as residual waste.
Storage of Residual Waste – Subchapter A, 25 PA Code 299.111 to 117 and 299.121	Applicable	Establishes standards for storage of residual waste.	Material classified as residual waste will be stored in containers in accordance with these requirements and the remedial design.
Identification and Listing of Hazardous Waste – Subchapter A, 25 PA Code 261a.1, 2., 3 [incorporating 40 CFR 261.11]	Applicable	Establishes hazardous waste determination requirements applicable to generators of hazardous waste.	Testing will be conducted to determine if any soil cuttings from new wells and purge water from monitoring well sampling will require disposal as hazardous waste. It is not anticipated that any of this waste will be classified as hazardous waste.
Standards Applicable to Generators of Hazardous Waste – Subchapters A and C, 25 PA Code 262a.10 [incorporating 40 CFR 262.11 and 262.34], 262a.11, and 262a.34	Applicable	Establishes standards for generators of hazardous waste.	Material classified as hazardous waste will be handled in accordance with these requirements and the remedial design.

Table A-3 – Action-Specific ARARs to be Met by the Selected Remedy

Requirement	Status	Synopsis of Requirement	Action to be Taken to Attain Requirement
Pennsylvania Drilling Water Wells – 17 PA Code 47	Applicable	Identifies the standards that must be followed for the installation or abandonment of wells.	Applies to wells installed for bioremediation and monitoring.

Appendix B
Cost Estimate

CLIENT: NAS JRB Willow Grove, PA		JOB NUMBER:	N2192
SUBJECT: Site 5 Feasibility Study - Alternative 4 Cost Estimate			
BASED ON:		DRAWING NUMBER:	
PREPARED BY: JC	CHECKED BY: VO	APPROVED BY: RT	DATE: 2/15/08

Purpose: Estimate costs for Alternative 4 - In-situ Anaerobic Bioremediation with recirculation followed by natural attenuation and long term monitoring (NA/LTM).

Assumptions

1. The remediation process consists of 3 stages: (1) permanent system design/modification, construction & start-up (after pilot/field testing are completed and evaluated) - year 0, (2) active treatment using EISB - Years 1 thru 5, (3) passive treatment using NA/LTM - Years 6 thru 15. PRGs will be achieved in 15 years.

2. The active remediation will utilize 4 new wells for injection of biomass and electron acceptors.

3. The pilot study/field scale testing is being conducted under separate funding. Therefore, all costs for subsurface investigation, treatability studies, system design and installation, pilot/field-scale testing are excluded from this cost analysis for Alternative No. 4.

4. Activities for O&M, evaluation, and reporting for active EISB remediation during Years 1 and 2 are assumed to be performed on a monthly basis. For Years 3 - 5, activities are assumed to be reduced to a quarterly basis.

5. Activities for monitoring, evaluation, and reporting for passive NA/LTM during Years 6 thru 10 are assumed to be performed on a semiannual basis. Activities during Years 11 thru 15 are assumed to be performed on an annual basis. The only utility required is communication.

6. Costs to prepare pre-RA site documents, plans, and permits are assumed to be $25,000. Costs to prepare deed notifications/restrictions are estimated to be $10,000. Costs to perform five-year review are estimated to be $20,000.

7. Other assumptions used to calculate the costs are presented in the attached spreadsheets.

Results:

Capital cost, Year 0 =	$306,663
Annual costs for O&M and monitoring for active treatment, Years 1 & 2 =	$130,421
Annual costs for O&M and monitoring for active treatment, Years 3 - 5 =	$65,285
Annual costs for O&M and monitoring for passive treatment, Years 6 thru 10 =	$23,465
Annual costs for O&M and monitoring for passive treatment, Years 11 thru 15 =	$12,931
Total Present Worth Costs (based on 7% discount rate) =	**$819,336**

PRESENT WORTH ANALYSIS - YEARS 0 THROUGH 15
Alternative 4 - In-Situ Treatment of Groundwater by Enhanced Anaerobic Reductive Dehalogenation, followed by NA/LTM
Site 5 Feasibility Study
NAS JRB Willow Grove, Pennsylvania

Year	Capital Cost	Annual Monitoring Cost	Active/Passive System Annual O&M Cost	5-yr Review Costs	Total Annual Cost	Present-Worth Factor (i = 7%)	Present Worth
0	$306,663				$306,663	1.000	$306,663
1		$78,821	$51,600		$130,421	0.935	$121,888
2		$78,821	$51,600		$130,421	0.873	$113,914
3		$29,685	$35,600		$65,285	0.816	$53,292
4		$29,685	$35,600		$65,285	0.763	$49,806
5		$29,685	$35,600	$20,000	$85,285	0.713	$60,807
6		$14,985	$8,480		$23,465	0.666	$15,635
7		$14,985	$8,480		$23,465	0.623	$14,613
8		$14,985	$8,480		$23,465	0.582	$13,657
9		$14,985	$8,480		$23,465	0.544	$12,763
10		$14,985	$8,480	$20,000	$43,465	0.508	$22,095
11		$7,651	$5,280		$12,931	0.475	$6,144
12		$7,651	$5,280		$12,931	0.444	$5,742
13		$7,651	$5,280		$12,931	0.415	$5,366
14		$7,651	$5,280		$12,931	0.388	$5,015
15		$7,651	$5,280	$20,000	$32,931	0.362	$11,936

TOTAL PRESENT WORTH Years 1 - 5 (EISB - active treatment) $399,707
TOTAL PRESENT WORTH Years 6 -15 (NA/LTM - passive treatment) $112,965

TOTAL PRESENT WORTH Years 0 -15 $819,336

Year 0 - Capital Costs
Alternative 4 - In-Situ Treatment of Groundwater by Anaerobic Reductive Dehalogenation, Groundwater Recirculating, and 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
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 Prepare Documents, Plans, and Permits	1	ea	$25,000				$25,000	$0	$0	$0	$25,000
1.2 Prepare Deed Notifications/Restrictions	1	ea	$10,000				$10,000	$0	$0	$0	$10,000
2 MOBILIZATION/DEMOBILIZATION, SITE PREPARATION, LAYOUT, AND FIELD SUPPORT											
2.1 Mobilize/Demobilize Equipment	1	ls				$1,000	$0	$0	$0	$1,000	$1,000
2.2 Office Trailer Rental	0	mo				$375	$0	$0	$0	$0	$0
2.3 Sanitary Facility Rental	0	mo				$50	$0	$0	$0	$0	$0
2.4 Construction Survey	2	days	$1,500				$3,000	$0	$0	$0	$3,000
2.5 Electric/Phone Hookup & Teardown	1	ls	$2,000				$2,000	$0	$0	$0	$2,000
2.6 Utilities (Electric + Phone) Usage	0	mo	$400				$0	$0	$0	$0	$0
2.7 Treatment Building/Shed for Permanent System	1	ls	$12,000				$12,000	$0	$0	$0	$12,000
2.8 Well Drilling	1	ls	$28,000				$28,000	$0	$4,620	$0	$32,620
3 TREATMENT EQUIPMENT AND MATERIAL											
3.1 Treatment Equipment (Mixers, Tanks, Pumps, Piping, etc.)	1	ls	$60,000				$60,000	$0		$0	$60,000
3.2 Material (nutrient, bacteria culture, carrier solution, etc.)	1	ls		$10,000			$0	$10,000	$0	$0	$10,000
4 START-UP											
4.1 System Operator	80	hrs			$36		$0	$0	$2,898	$0	$2,898
4.2 Technician	80	hrs			$31		$0	$0	$2,499	$0	$2,499
4.3 Project Manager	24	hrs			$59		$0	$0	$1,405	$0	$1,405
4.4 Per Diem	12	days	$105				$1,260	$0	$0	$0	$1,260
4.5 Vehicle	12	days				$75	$0	$0	$0	$900	$900
4.6 O&M Manual	1	ls	$4,500				$4,500	$0	$0	$0	$4,500
4.7 As-Builts	1	ls	$3,500				$3,500	$0	$3,500	$0	$7,000
4.8 Analytical	25	ea	$500				$12,500	$0	$0	$0	$12,500
Subtotal							$126,760	$10,000	$14,922	$1,900	$188,582
Overhead on Labor Cost @ 30%									$4,477		$4,477
G & A on Labor Cost @ 10%									$1,492		$1,492
Sales Tax on Material @ 6%								$600			$600
G & A on Material Cost @ 10%								$1,060			$1,060
G & A on Subcontract Cost @ 10%							$12,676				$12,676
Total Direct Cost							$139,436	$11,660	$20,891	$1,900	$208,887
Indirects on Total Direct Labor Cost @ 75%									$15,668		$15,668
Profit on Total Direct Cost @ 10%											$20,889
Total Field Cost											$245,444

5

Design	**P4**	**P3**	**P2**	**P1**	**S4**	**Subtotal**	Labor	Subtotal Direct Cost
	Level of Effort (Hours)							
5.01 Pre-Design Investigation	5	50	24	24	8	111	$3,601	$3,601
5.02 Equipment Design	8	20	20	40	16	104	$3,126	$3,126
5.03 Hydraulic Calculations	0	10	20	16	0	46	$1,408	$1,408
5.04 Layout of Pre-Fabricated Building	8	16	40	40	24	128	$3,784	$3,784
5.05 Site Work Detail	4	20	40	16	20	100	$3,024	$3,024
Total Design LOE	25	116	144	136	68	489		
							$14,943	$11,343
Overhead on Labor Cost @ 30%								$4,483
G & A on Labor Cost @ 10%								$1,494
Indirects on Total Design Labor Cost @ 75%								$12,990
Profit on Total Design Cost @ 10%								$3,031
Total Design Cost								$33,341
Total Field Cost + Design								$278,785
Contingency @ 10%								$27,878
ESTIMATED CAPITAL COSTS								**$306,663**

Years 1 thru 5 EISB - O&M and Monitoring Costs
Alternative 4 - In-Situ Treatment of Groundwater by Enhanced Anaerobic Reductive Dehalogenation, Groundwater Recirculating and NA/LTM Natural Attenuation
Site 5 Feasibility Study
NAS JRB Willow Grove, Pennsylvania

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
Monitoring for Years 1 thru 5 (including startup and subsequent testing)						
1	Hydrogeologist/Scientist (Monthly Sampling)	640	hrs	$80.00	$51,200	10 monitoring wells (2 people x 8 hrs/day at 3 wells/day x 12 events)
2	Hydrogeologist/Scientist (Quarterly Sampling)	220	hrs	$80.00	$17,600	10 monitoring wells (2 people x 8 hrs/day at 3 wells/day x 4 events)
3	Hydrogeologist/Scientist (Quarterly Water Level Measurement)	32	hrs	$80.00	$2,560	2 piezometrs (2 people x 8 hrs/day x 0.5 days x 4 events)
4	VOCs EPA Method 8260B (Monthly)	150	ea	$200.00	$26,667	21 day turn (Monthly)
5	VOCs EPA Method 8260B (Quarterly)	50	ea	$200.00	$8,889	21 day turn (Quarterly)
6	Shipping and handling					
	Shipping Sample Cooler & misc. (monthly)	12	ea	$79.50	$954	
	Shipping Sample Cooler & misc. (Quarterly)	8	ea	$79.50	$636	
Routine O&M for Permanent System for Years 1 thru 5						
	O&M Labor for Years 1 & 2	360	hrs	$80.00	$28,800	
	O&M Labor for Years 3 - 5	160	hrs	$80.00	$12,800	
	Material (nutrient, bacteria culture, carrier solution, etc.)	12	mo	$1,500	$18,000	
	Utilities (Electric + Phone) Usage	12	mo	$400	$4,800	
	Years 1 & 2 Monitoring				$78,821	Perform monitoring for monthly.
	Years 1 & 2 O&M				$51,600	Perform O&M, evaluation, and reporting for monthly events.
	Years 1 & 2 O&M and Monitoring				**$130,421**	
	Years 3 - 5 Monitoring				$29,685	Perform monitoring for quarterly . No monthly events.
	Years 3 - 5 O&M				$35,600	Perform O&M, evaluation, and reporting for quarterly. No monthly events.
	Years 3 - 5 O&M and Monitoring				**$65,285**	

Year 6 thru 15 - Monitoring Costs (MNA)
Alternative 4 - In-Situ Treatment of Groundwater by Enhanced Anaerobic Reductive Dehalogenation, Groundwater Recirculating, and NA/LTM
Site 5 Feasibility Study
NAS JRB Willow Grove, Pennsylvania

	Item	Qty	Unit	Unit Cost	Subtotal Cost	Notes
Annual Monitoring for MNA System						
1	Hydrogeologist/Geologist (semi-annual sampling)	130	hrs	$80.00	$10,400	10 monitoring wells (2 people x 8 hrs/day at 3 wells/day x 2 events)
2	Hydrogeologist/Geologist (annual sampling)	65	hrs	$80.00	$5,200	10 monitoring wells (2 people x 8 hrs/day at 3 wells/day x 1 event)
3	VOCs EPA Method 8260B (semi-annual sampling)	24	ea	$200.00	$4,267	semi-annual sampling
4	VOCs EPA Method 8260B (annual sampling)	12	ea	$200.00	$2,133	annual sampling
5	Shipping and handling					
	Shipping Sample Cooler (Semi-annually)	4	ea	$79.50	$318	
Routine O&M (Evaluation and Reporting) for MNA System						
	O&M Labor for Years 6-10	100	hrs	$80.00	$8,000	
	O&M Labor for Years 11-15	60	hrs	$80.00	$4,800	
	Utilities Usage (communication only)	12	mo	$40.00	$480	
	Years 6-10 Monitoring				$14,985	Perform semiannual monitoring
	Years 6-10 O&M				$8,480	Perform evaluation of site performance and prepare reports on a semiannual basis.
	Years 6 thru 10 O&M and Monitoring				**$23,465**	
	Years 11-15 Monitoring				$7,651	Perform annual monitoring
	Years 11-15 O&M				$5,280	Perform evaluation of site performance and prepare reports on an annual basis .
	Years 11 thru 15 O&M and Monitoring				**$12,931**	

Appendix C
Human Health Risk Tables

TABLE 9.1.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 5	1,1,1-Trichloroethane	- -	--	- -	--	- -	None Reported	0.07	- -	0.01	0.09
			1,1,2-Trichloroethane	2E-06	--	2E-07	--	3E-06	Blood	0.1	- -	0.01	0.1
			1,1-Dichloroethane	- -	--	- -	--	- -	Kidney	0.05	- -	0.004	0.06
			1,1-Dichloroethene	- -	--	- -	--	- -	Liver	0.09	- -	0.01	0.1
			1,2-Dichloroethane	1E-06	--	5E-08	--	1E-06	NA	--	- -	--	--
			1,4-Dichlorobenzene	3E-07	--	2E-07	--	6E-07	Liver	0.006	- -	0.004	0.009
			Benzene	9E-07	--	1E-07	--	1E-06	Blood	0.05	- -	0.007	0.06
			Chloroform	- -	--	- -	--	- -	Liver	0.002	- -	0.0002	0.002
			cis-1,2-Dichloroethene	- -	--	- -	--	- -	Blood	0.6	- -	0.07	0.7
			Tetrachloroethene	5E-05	--	3E-05	--	8E-05	Liver	0.1	- -	0.06	0.2
			Trichloroethene (mutagenic)	4E-05	--	7E-06	--	5E-05	N/A	--	- -	--	--
			Trichloroethene (nonmutagenic)	3E-05	--	6E-06	--	4E-05	CVS, Fetotoxicity, Immune	21	- -	3.5	24
			1,4-Dioxane	3E-07	--	1E-09	--	3E-07	NA	--	- -	--	--
			Arsenic	6E-06	--	4E-08	--	6E-06	Skin, CVS	0.1	- -	0.0010	0.1
			Barium	- -	--	- -	--	- -	Blood	0.1	- -	0.01	0.2
			Chromium	- -	--	- -	--	- -	Fetotoxicity, GS, Bone	0.3	- -	0.1	0.4
			Iron	- -	--	- -	--	- -	None Reported	0.9	- -	0.006	0.9
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.4	- -	0.06	0.4
			Nickel	- -	--	- -	--	- -	Body Weight	0.06	- -	0.002	0.06
			Vanadium	- -	--	- -	--	- -	Kidney	0.2	- -	0.05	0.2
			Chemical Total	1E-04	--	4E-05	--	2E-04		24	- -	3.9	28
		Exposure Point Total						2E-04					28
	Exposure Medium Total							2E-04					28
Medium Total								2E-04					28
Receptor Total							Receptor Risk Total	2E-04				Receptor HI Total	28

Note: Trichloroethene toxicity values were updated from IRIS as of 8/8/2012.

Total Blood HI	1.0
Total Body Weight HI	0.06
Total CNS HI	0.4
Total CVS HI	24
Total GS HI	0.4
Total Kidney HI	0.3
Total Liver HI	0.3
Total Skin HI	0.1
Total Fetotoxicity HI	25
Total Bone HI	0.4
Total Immune HI	24
Total None Reported HI	0.9

TABLE 9.2.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 5	1,1,1-Trichloroethane	- -	--	- -	--	- -	None Reported	0.03	- -	0.005	0.04
			1,1,2-Trichloroethane	4E-06	--	4E-07	--	4E-06	Blood	0.05	- -	0.005	0.06
			1,1-Dichloroethane	- -	--	- -	--	- -	Kidney	0.02	- -	0.002	0.02
			1,1-Dichloroethene	- -	--	- -	--	- -	Liver	0.04	- -	0.005	0.04
			1,2-Dichloroethane	2E-06	--	8E-08	--	2E-06	NA	--	- -	--	--
			1,4-Dichlorobenzene	6E-07	--	4E-07	--	1E-06	Liver	0.002	- -	0.002	0.004
			Benzene	2E-06	--	2E-07	--	2E-06	Blood	0.02	- -	0.003	0.02
			Chloroform	- -	--	- -	--	- -	Liver	0.0009	- -	0.00008	0.0010
			cis-1,2-Dichloroethene	- -	--	- -	--	- -	Blood	0.2	- -	0.03	0.3
			Tetrachloroethene	9E-05	--	5E-05	--	1E-04	Liver	0.05	- -	0.03	0.07
			Trichloroethene (mutagenic)	3E-05	--	4E-06	--	3E-05	N/A	--	- -	--	--
			Trichloroethene (nonmutagenic)	6E-05	--	8E-06	--	6E-05	CVS, Fetotoxicity, Immune	8.9	- -	1.3	10
			1,4-Dioxane	5E-07	--	2E-09	--	5E-07	NA	--	- -	--	--
			Arsenic	1E-05	--	4E-08	--	1E-05	Skin, CVS	0.06	- -	0.0003	0.06
			Barium	- -	--	- -	--	- -	Blood	0.06	- -	0.004	0.07
			Chromium	- -	--	- -	--	- -	Fetotoxicity, GS, Bone	0.1	- -	0.04	0.2
			Iron	- -	--	- -	--	- -	None Reported	0.4	- -	0.002	0.4
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.2	- -	0.02	0.2
			Nickel	- -	--	- -	--	- -	Body Weight	0.03	- -	0.0006	0.03
			Vanadium	- -	--	- -	--	- -	Kidney	0.08	- -	0.01	0.09
			Chemical Total	2E-04	--	6E-05	--	2E-04		10	- -	1.4	12
		Exposure Point Total						2E-04					12
	Exposure Medium Total							2E-04					12
	Groundwater	Site 5	1,1,1-Trichloroethane	--	- -	--	--	- -	NA	- -	--	- -	--
			1,1,2-Trichloroethane	--	1E-06	--	--	1E-06	NA	- -	--	- -	--
			1,1-Dichloroethane	--	- -	--	--	- -	Kidney	- -	0.02	- -	0.02
			1,1-Dichloroethene	--	- -	--	--	- -	Liver	- -	0.02	- -	0.02
			1,2-Dichloroethane	--	7E-07	--	--	7E-07	None Reported	- -	0.00003	- -	0.00003
			1,4-Dichlorobenzene	--	2E-07	--	--	2E-07	Liver	- -	0.0001	- -	0.0001
			Benzene	--	4E-07	--	--	4E-07	Blood	- -	0.005	- -	0.005
			Chloroform	--	1E-07	--	--	1E-07	Liver	- -	0.0003	- -	0.0003
			cis-1,2-Dichloroethene	--	- -	--	--	- -	NA	- -	--	- -	--
			Tetrachloroethene	--	1E-06	--	--	1E-06	Liver	- -	0.002	- -	0.002
			Trichloroethene (mutagenic)	--	6E-06	--	--	6E-06	N/A	- -	--	- -	--
			Trichloroethene (nonmutagenic)	--	1E-05	--	--	1E-05	CVS, Immune	- -	5.0	- -	5.0
			1,4-Dioxane	--	- -	--	--	- -	NA	- -	--	- -	--

TABLE 9.2.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 5	Arsenic	--	- -	--	--	- -	NA	- -	--	- -	--
			Barium	--	- -	--	--	- -	Fetotoxicity	- -	--	- -	--
			Chromium	--	- -	--	--	- -	Lungs	- -	--	- -	--
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	--	- -	--
			Nickel	--	- -	--	--	- -	NA	- -	--	- -	--
			Vanadium	--	- -	--	--	- -	NA	- -	--	- -	--
			Chemical Total	--	2E-05	--	--	2E-05		- -	5.08	- -	5.1
		Exposure Point Total						2E-05					5.1
	Exposure Medium Total							2E-05					5.1
Medium Total								3E-04					17
Receptor Total							Receptor Risk Total	3E-04				Receptor HI Total	17

Note: Trichloroethene toxicity values were updated from IRIS as of 8/8/2012.

Total Blood HI	0.4
Total Body Weight HI	0.03
Total CNS HI	0.2
Total CVS HI	15
Total GS HI	0.2
Total Kidney HI	0.1
Total Liver HI	0.1
Total Skin HI	0.06
Total Fetotoxicity HI	10
Total Bone HI	0.2
Total Immune HI	15
Total None Reported HI	0.4

TABLE 9.3.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Lifelong (Child and Adult)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 5	1,1,1-Trichloroethane	- -	--	- -	--	- -					
			1,1,2-Trichloroethane	6E-06	--	6E-07	--	7E-06					
			1,1-Dichloroethane	- -	--	- -	--	- -					
			1,1-Dichloroethene	- -	--	- -	--	- -					
			1,2-Dichloroethane	3E-06	--	1E-07	--	3E-06					
			1,4-Dichlorobenzene	9E-07	--	6E-07	--	2E-06					
			Benzene	2E-06	--	4E-07	--	3E-06					
			Chloroform	- -	--	- -	--	- -					
			cis-1,2-Dichloroethene	- -	--	- -	--	- -					
			Tetrachloroethene	1E-04	--	8E-05	--	2E-04					
			Trichloroethene (mutagenic)	7E-05	--	1E-05	--	8E-05					
			Trichloroethene (nonmutagenic)	9E-05	--	1E-05	--	1E-04					
			1,4-Dioxane	8E-07	--	3E-09	--	8E-07					
			Arsenic	2E-05	--	8E-08	--	2E-05					
			Barium	- -	--	- -	--	- -					
			Chromium	- -	--	- -	--	- -					
			Iron	- -	--	- -	--	- -					
			Lead	- -	--	- -	--	- -					
			Manganese	- -	--	- -	--	- -					
			Nickel	- -	--	- -	--	- -					
			Vanadium	- -	--	- -	--	- -					
			Chemical Total	3E-04	--	1E-04	--	4E-04					
		Exposure Point Total						4E-04					
	Exposure Medium Total							4E-04					
	Groundwater	Site 5	1,1,1-Trichloroethane	--	- -	--	--	- -					
			1,1,2-Trichloroethane	--	1E-06	--	--	1E-06					
			1,1-Dichloroethane	--	- -	--	--	- -					
			1,1-Dichloroethene	--	- -	--	--	- -					
			1,2-Dichloroethane	--	7E-07	--	--	7E-07					
			1,4-Dichlorobenzene	--	2E-07	--	--	2E-07					
			Benzene	--	4E-07	--	--	4E-07					
			Chloroform	--	1E-07	--	--	1E-07					
			cis-1,2-Dichloroethene	--	- -	--	--	- -					
			Tetrachloroethene	--	1E-06	--	--	1E-06					
			Trichloroethene (mutagenic)	--	6E-06	--	--	6E-06					
			Trichloroethene (nonmutagenic)	--	1E-05	--	--	1E-05					
			1,4-Dioxane	--	- -	--	--	- -					

TABLE 9.3.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURES

NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Lifelong (Child and Adult)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 5	Arsenic	--	- -	--	--	- -					
			Barium	--	- -	--	--	- -					
			Chromium	--	- -	--	--	- -					
			Iron	--	- -	--	--	- -					
			Lead	--	- -	--	--	- -					
			Manganese	--	- -	--	--	- -					
			Nickel	--	- -	--	--	- -					
			Vanadium	--	- -	--	--	- -					
			Chemical Total	--	2E-05	--	--	2E-05					
		Exposure Point Total						2E-05					
	Exposure Medium Total							2E-05					
Medium Total								5E-04					
Receptor Total							Receptor Risk Total	5E-04					

Note: Trichloroethene toxicity values were updated from IRIS as of 8/8/2012.

TABLE 9.1.CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 5	1,1,1-Trichloroethane	- -	--	- -	--	- -	None Reported	0.05	- -	0.007	0.06
			1,1,2-Trichloroethane	6E-07	--	4E-08	--	6E-07	Blood	0.09	- -	0.006	0.09
			1,1-Dichloroethane	- -	--	- -	--	- -	Kidney	0.04	- -	0.002	0.04
			1,1-Dichloroethene	- -	--	- -	--	- -	Liver	0.07	- -	0.007	0.07
			1,2-Dichloroethane	2E-07	--	9E-09	--	2E-07	NA	--	- -	--	--
			1,4-Dichlorobenzene	8E-08	--	4E-08	--	1E-07	Liver	0.004	- -	0.002	0.006
			Benzene	2E-07	--	3E-08	--	2E-07	Blood	0.03	- -	0.004	0.04
			Chloroform	- -	--	- -	--	- -	Liver	0.001	- -	0.0001	0.002
			cis-1,2-Dichloroethene	- -	--	- -	--	- -	Blood	0.4	- -	0.04	0.4
			Tetrachloroethene	1E-05	--	6E-06	--	2E-05	Liver	0.08	- -	0.04	0.1
			Trichloroethene (mutagenic)	6E-06	--	8E-07	--	7E-06	N/A	--	- -	--	--
			Trichloroethene (nonmutagenic)	8E-06	--	1E-06	--	9E-06	CVS, Fetotoxicity, Immune	15	--	2.0	17
			1,4-Dioxane	7E-08	--	2E-10	--	7E-08	NA	--	- -	--	--
			Arsenic	1E-06	--	4E-09	--	1E-06	Skin, CVS	0.1	- -	0.0003	0.1
			Barium	- -	--	- -	--	- -	Blood	0.1	- -	0.005	0.1
			Chromium	- -	--	- -	--	- -	Fetotoxicity, GS, Bone	0.2	- -	0.05	0.2
			Iron	- -	--	- -	--	- -	None Reported	0.6	- -	0.002	0.6
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.3	- -	0.02	0.3
			Nickel	- -	--	- -	--	- -	Body Weight	0.04	- -	0.0006	0.04
			Vanadium	- -	--	- -	--	- -	Kidney	0.1	- -	0.02	0.1
			Chemical Total	3E-05	--	8E-06	--	4E-05		17	- -	2.2	19
		Exposure Point Total						4E-05					19
	Exposure Medium Total							4E-05					19
Medium Total								4E-05					19
Receptor Total							Receptor Risk Total	4E-05				Receptor HI Total	19

Note: Trichloroethene toxicity values were updated from IRIS as of 8/8/2012.

Total Blood HI	0.7
Total Body Weight HI	0.04
Total CNS HI	0.3
Total CVS HI	17
Total GS HI	0.2
Total Kidney HI	0.2
Total Liver HI	0.2
Total Skin HI	0.1
Total Fetotoxicity HI	17
Total Bone HI	0.2
Total Immune HI	17
Total None Reported HI	0.7

TABLE 9.2.CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 5	1,1,1-Trichloroethane	- -	--	- -	--	- -	None Reported	0.02	- -	0.004	0.03
			1,1,2-Trichloroethane	8E-07	--	7E-08	--	9E-07	Blood	0.04	- -	0.003	0.04
			1,1-Dichloroethane	- -	--	- -	--	- -	Kidney	0.02	- -	0.001	0.02
			1,1-Dichloroethene	- -	--	- -	--	- -	Liver	0.03	- -	0.004	0.03
			1,2-Dichloroethane	3E-07	--	2E-08	--	4E-07	NA	--	- -	--	--
			1,4-Dichlorobenzene	1E-07	--	8E-08	--	2E-07	Liver	0.002	- -	0.001	0.003
			Benzene	3E-07	--	5E-08	--	4E-07	Blood	0.01	- -	0.002	0.02
			Chloroform	- -	--	- -	--	- -	Liver	0.0006	- -	0.00005	0.0007
			cis-1,2-Dichloroethene	- -	--	- -	--	- -	Blood	0.2	- -	0.02	0.2
			Tetrachloroethene	2E-05	--	1E-05	--	3E-05	Liver	0.03	- -	0.02	0.05
			Trichloroethene (mutagenic)	3E-06	--	4E-07	--	3E-06	N/A	--	- -	--	--
			Trichloroethene (nonmutagenic)	1E-05	--	2E-06	--	1E-05	CVS, Fetotoxicity, Immune	6.3	--	0.9	7.2
			1,4-Dioxane	1E-07	--	4E-10	--	1E-07	NA	--	- -	--	--
			Arsenic	2E-06	--	6E-09	--	2E-06	Skin, CVS	0.04	- -	0.0001	0.04
			Barium	- -	--	- -	--	- -	Blood	0.04	- -	0.002	0.05
			Chromium	- -	--	- -	--	- -	Fetotoxicity, GS, Bone	0.09	- -	0.02	0.1
			Iron	- -	--	- -	--	- -	None Reported	0.3	- -	0.0008	0.3
			Lead	- -	--	- -	--	- -	NA	--	- -	--	--
			Manganese	- -	--	- -	--	- -	CNS	0.1	- -	0.009	0.1
			Nickel	- -	--	- -	--	- -	Body Weight	0.02	- -	0.0003	0.02
			Vanadium	- -	--	- -	--	- -	Kidney	0.05	- -	0.007	0.06
			Chemical Total	4E-05	--	1E-05	--	5E-05		7.2	- -	1.0	8.2
		Exposure Point Total						5E-05					8.2
	Exposure Medium Total							5E-05					8.2
	Groundwater	Site 5	1,1,1-Trichloroethane	--	- -	--	--	- -	NA	- -	--	- -	--
			1,1,2-Trichloroethane	--	1E-07	--	--	1E-07	NA	- -	--	- -	--
			1,1-Dichloroethane	--	- -	--	--	- -	Kidney	- -	0.005	- -	0.005
			1,1-Dichloroethene	--	- -	--	--	- -	Liver	- -	0.006	- -	0.006
			1,2-Dichloroethane	--	6E-08	--	--	6E-08	None Reported	- -	0.00001	--	0.00001
			1,4-Dichlorobenzene	--	2E-08	--	--	2E-08	Liver	- -	0.00004	- -	0.00004
			Benzene	--	4E-08	--	--	4E-08	Blood	- -	0.002	- -	0.002
			Chloroform	--	1E-08	--	--	1E-08	Liver	- -	0.00009	- -	0.00009
			cis-1,2-Dichloroethene	--	- -	--	--	- -	NA	- -	--	- -	--
			Tetrachloroethene	--	1E-07	--	--	1E-07	Liver	- -	0.0007	- -	0.0007
			Trichloroethene (mutagenic)	--	3E-07	--	--	3E-07	N/A	- -	--	- -	--
			Trichloroethene (nonmutagenic)	--	9E-07	--	--	9E-07	CVS, Immune	- -	1.500	- -	1.500
			1,4-Dioxane	--	- -	--	--	- -	NA	- -	--	- -	--

TABLE 9.2.CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURES
NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 5	Arsenic	--	- -	--	--	- -	NA	- -	--	- -	--
			Barium	--	- -	--	--	- -	Fetotoxicity	- -	--	- -	--
			Chromium	--	- -	--	--	- -	Lungs	- -	--	- -	--
			Iron	--	- -	--	--	- -	NA	- -	--	- -	--
			Lead	--	- -	--	--	- -	NA	- -	--	- -	--
			Manganese	--	- -	--	--	- -	CNS	- -	--	- -	--
			Nickel	--	- -	--	--	- -	NA	- -	--	- -	--
			Vanadium	--	- -	--	--	- -	NA	- -	--	- -	--
			Chemical Total	--	2E-06	--	--	2E-06		- -	1.51	- -	1.5
		Exposure Point Total						2E-06					1.5
	Exposure Medium Total							2E-06					1.5
Medium Total								5E-05					10
Receptor Total							Receptor Risk Total	5E-05				Receptor HI Total	10

Note: Trichloroethene toxicity values were updated from IRIS as of 8/8/2012.

Total Blood HI	0.3
Total Body Weight HI	0.02
Total CNS HI	0.1
Total CVS HI	8.7
Total GS HI	0.1
Total Kidney HI	0.1
Total Liver HI	0.1
Total Skin HI	0.04
Total Fetotoxicity HI	7
Total Bone HI	0.1
Total Immune HI	8.7
Total None Reported HI	0.3

TABLE 9.3.CTE

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURES

NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Lifelong (Child and Adult)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 5	1,1,1-Trichloroethane	- -	--	- -	--	- -					
			1,1,2-Trichloroethane	1E-06	--	1E-07	--	2E-06					
			1,1-Dichloroethane	- -	--	- -	--	- -					
			1,1-Dichloroethene	- -	--	- -	--	- -					
			1,2-Dichloroethane	6E-07	--	2E-08	--	6E-07					
			1,4-Dichlorobenzene	2E-07	--	1E-07	--	3E-07					
			Benzene	5E-07	--	7E-08	--	6E-07					
			Chloroform	- -	--	- -	--	- -					
			cis-1,2-Dichloroethene	- -	--	- -	--	- -					
			Tetrachloroethene	3E-05	--	2E-05	--	4E-05					
			Trichloroethene (mutagenic)	9E-06	--	1E-06	--	1E-05					
			Trichloroethene (nonmutagenic)	2E-05	--	3E-06	--	2E-05					
			1,4-Dioxane	2E-07	--	6E-10	--	2E-07					
			Arsenic	3E-06	--	1E-08	--	3E-06					
			Barium	- -	--	- -	--	- -					
			Chromium	- -	--	- -	--	- -					
			Iron	- -	--	- -	--	- -					
			Lead	- -	--	- -	--	- -					
			Manganese	- -	--	- -	--	- -					
			Nickel	- -	--	- -	--	- -					
			Vanadium	- -	--	- -	--	- -					
			Chemical Total	6E-05	--	2E-05	--	8E-05					
		Exposure Point Total						8E-05					
	Exposure Medium Total							8E-05					
	Groundwater	Site 5	1,1,1-Trichloroethane	--	- -	--	--	- -					
			1,1,2-Trichloroethane	--	1E-07	--	--	1E-07					
			1,1-Dichloroethane	--	- -	--	--	- -					
			1,1-Dichloroethene	--	- -	--	--	- -					
			1,2-Dichloroethane	--	6E-08	--	--	6E-08					
			1,4-Dichlorobenzene	--	2E-08	--	--	2E-08					
			Benzene	--	4E-08	--	--	4E-08					
			Chloroform	--	1E-08	--	--	1E-08					
			cis-1,2-Dichloroethene	--	- -	--	--	- -					
			Tetrachloroethene	--	1E-07	--	--	1E-07					
			Trichloroethene (mutagenic)	--	3E-07	--	--	3E-07					
			Trichloroethene (nonmutagenic)	--	9E-07	--	--	9E-07					
			1,4-Dioxane	--	- -	--	--	- -					

TABLE 9.3.CTE

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURES

NASJRB WILLOW GROVE

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Lifelong (Child and Adult)

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk					Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Site 5	Arsenic	--	- -	--	--	- -					
			Barium	--	- -	--	--	- -					
			Chromium	--	- -	--	--	- -					
			Iron	--	- -	--	--	- -					
			Lead	--	- -	--	--	- -					
			Manganese	--	- -	--	--	- -					
			Nickel	--	- -	--	--	- -					
			Vanadium	--	- -	--	--	- -					
			Chemical Total	--	2E-06	--	--	2E-06					
		Exposure Point Total						2E-06					
	Exposure Medium Total							2E-06					
Medium Total								8E-05					
Receptor Total							Receptor Risk Total	8E-05					

Note: Trichloroethene toxicity values were updated from IRIS as of 8/8/2012.

TABLE 5
COMPARISON OF REFERENCE DOSES
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW, GROVE PENNSYLVANIA

Chemical of Potential Concern	Oral Absorption Efficiency for Dermal		Oral RfD		Dermal RfD[2]		Inhalation RfD	
	Old	New[1]	Old mg/kg/day	New mg/kg/day	Old mg/kg/day	New mg/kg/day	Old mg/kg/day	New mg/kg/day
Volatiles Organic Compounds								
1,1,1-Trichloroethane	1	1	3.5E-02 E	2.8E-01 E	3.5E-02	2.8E-01	2.9E-01 W	NA
1,1,2-Trichloroethane	1	1	4.0E-03 I	4.0E-03 I	4.0E-03	4.0E-03	NA	NA
1,1-Dichloroethane	1	1	1.0E-01 I	2.0E-01 P	1.0E-01	2.0E-01	1.4E-01 A	1.4E-01 A
1,1-Dichloroethene	1	1	9.0E-03 I	5.0E-02 I	9.0E-03	5.0E-02	NA	6.0E-02 I
1,2-Dichloroethane	1	1	NA	NA	NA	NA	2.9E-03 E	7.0E-01 M
Benzene	1	1	NA	4.0E-03 I	NA	4.0E-03	1.7E-03 E	8.6E-03 I
Tetrachloroethene	1	1	1.0E-02 I	1.0E-02 I	1.0E-02	1.0E-02	NA	8.0E-02 M
Trichloroethene	1	1	6.0E-03 E	5.0E-04 I**	6.0E-03	5.0E-04	NA	5.7E-04 I**
Pesticides/PCBs								
Dieldrin	0.5	1	5.0E-05 I	5.0E-05 I	1.0E-04 I	5.0E-05 I	NA	NA
Inorganics								
Aluminum	0.27	1	1.0E+00 E	NA	3.70E+00	NA	NA	NA
Arsenic	0.95	1	3.0E-04 I	3.0E-04 I	3.16E-04	3.0E-04	NA	NA
Barium	1	0.07	7.0E-02 I	2.0E-01 I	7.0E-02	1.4E-02	1.43E-04 A	1.4E-04 A
Beryllium	0.01	0.007	5.0E-03 I	2.0E-03 I	5.0E-01	1.4E-05	NA	5.7E-06 I
Chromium	0.01	0.025	5.0E-03 I	3.0E-03 I	5.0E-01	7.5E-05	NA	3.0E-05 I
Iron	1	1	3.0E-01 E	3.0E-01 E	3.0E-01	3.0E-01	NA	NA
Lead	1	1	NA	NA	NA	NA	NA	NA
Manganese (Water)	1	0.04	2.3E-02 I	2.4E-02 I	2.3E-02	9.6E-04	NA	NA
Manganese (Food)	1	0.04	1.4E-01 I	1.4E-01 I	1.4E-01	5.6E-03	1.43E-05 I	1.4E-05 I

Notes:
1 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.
2 - Adjusted dermal RfD = Oral RfD x Oral Absorption Efficiency for Dermal.
A= HEAST Alternative value.
CA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors, December 2002.
E = EPA-NCEA Provisional value.
I = Integrated Risk Information System (IRIS), December 2006.
I** = Integrated Risk Information System (IRIS), August 2012.
M = ATSDR MRL.
P = EPA Provisional Peer-Reviewed Value.
W = Withdrawn
Values that have changed from the previous HHRA are shaded.

TABLE 6
COMPARISON OF CANCER SLOPE FACTORS
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW, GROVE PENNSYLVANIA

Chemical of Potential Concern	Oral Absorption Efficiency for Dermal		Oral CSF		Dermal CSF[2]		Inhalation CSF	
	Old	New[1]	Old $(mg/kg/day)^{-1}$	New $(mg/kg/day)^{-1}$	Old $(mg/kg/day)^{-1}$	New $(mg/kg/day)^{-1}$	Old $(mg/kg/day)^{-1}$	New $(mg/kg/day)^{-1}$
Volatiles Organic Compounds								
1,1,1-Trichloroethane	1	1	NA	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	1	1	5.7E-02 I	5.7E-02 I	5.7E-02	5.7E-02	5.6E-02 I	5.6E-02 I
1,1-Dichloroethane	1	1	NA	NA	NA	NA	NA	NA
1,1-Dichloroethene	1	1	6.0E-01 I	NA	6.0E-01	NA	1.8E-01 I	NA
1,2-Dichloroethane	1	1	9.1E-02 I	9.1E-02 I	9.1E-02	9.1E-02	9.1E-02 I	9.1E-02 I
Benzene	1	1	2.9E-02 I	5.5E-02 I	2.9E-02	5.5E-02 I	2.9E-02 I	2.7E-02 I
Tetrachloroethene	1	1	5.2E-02 E	5.4E-01 O	5.2E-02	5.4E-01	2.0E-03 E	2.0E-02 O
Trichloroethene (mutagenic)	1	1	NA	9.3E-03 I**	NA	9.3E-03	NA	3.5E-03 I**
Trichloroethene (nonmutagenic)	1	1	1.1E-02 W	3.7E-02 I**	1.1E-02	3.7E-02	6.0E-03 E	1.1E-02 I**
Pesticides/PCBs								
Dieldrin	0.5	1	1.6E+01 I	1.6E+01 I	8.00E+00	1.6E+01	1.6E+01 I	1.6E+01 I
Inorganics								
Aluminum	1	1	NA	NA	NA	NA	NA	NA
Arsenic	0.95	1	1.5E+00 I	1.5E+00 I	1.43E+00	1.5E+00	1.5E+01 I	1.5E+01 I
Barium	1	0.7	NA	NA	NA	NA	NA	NA
Beryllium	0.01	0.007	4.3E+00 I	NA	4.3E-02	NA	8.4E+00 I	8.4E+00 I
Chromium	0.01	0.025	NA	NA	NA	NA	4.2E+01 I	4.2E+01 I
Lead	1	1	NA	NA	NA	NA	NA	NA
Iron	1	1	NA	NA	NA	NA	NA	NA
Manganese (Water)	1	0.04	NA	NA	NA	NA	NA	NA
Manganese (Food)	1	0.04	NA	NA	NA	NA	NA	NA

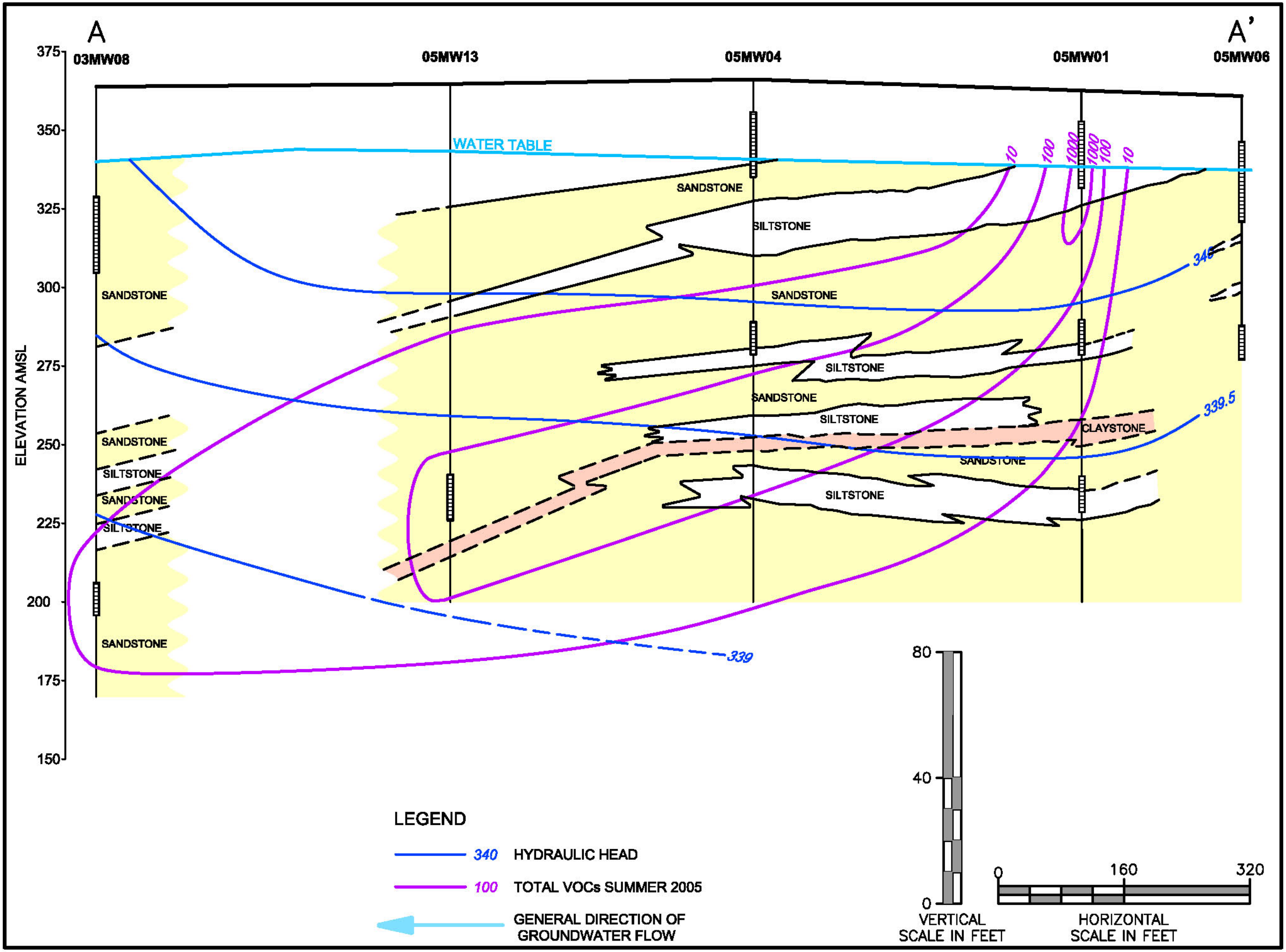
Notes:
1 - U.S. EPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.
2 - Adjusted cancer slope factor for dermal = Oral cancer slope factor / Oral Absorption Efficiency for Dermal.
CA = California EPA, Technical Support Document for Describing Available Cancer Potency Factors, December 2002.
E = NCEA Provisional value.
I = Integrated Risk Information System (IRIS), December 2006.
I** = Integrated Risk Information System (IRIS), August 2012.
O = Other, EPA Region 3 RBC Table, October 2006.
W = Withdrawn from IRIS or HEAST.
Values that have changed from the previous HHRA are shaded.

TABLE 7
COMPARISON OF EXPOSURE POINT CONCENTRATIONS
SITE 5 - FIRE TRAINING AREA
NASJRB WILLOW, GROVE PENNSYLVANIA

Chemical	**Exposure Point Concentrations**	
	Old Value[1]	**New Value[2]**
1,1,1-Trichloroethane	114[3]	319[5]
1,1,2-Trichloroethane	5.55[3]	7.66[5]
1,1-Dichloroethane	45.9[3]	169[5]
1,1-Dichloroethene	52.9[3]	72.8[5]
1,2-Dichloroethane	4[4]	1.96[5]
1,4-Dichlorobenzene	NA	2.66[5]
Benzene	6.79[3]	2.99[5]
Chloroform	NA	0.33[4]
cis-1,2-Dichloroethene	NA	90.8[5]
Tetrachloroethene	9.14[3]	17[5]
Trichloroethene	33.9[3]	163[5]
1,4-Dioxane	NA	4.96[5]
Aluminum	1300[3]	3700[5]
Arsenic	0.633[3]	0.695[6]
Barium	574[3]	454[7]
Beryllium	0.683[3]	0.798[6]
Chromium	7.32[3]	13.3[8]
Iron	853[3]	3990[5]
Lead	12.6[3]	2.24[9]
Manganese	356[3]	144[7]
Nickel	14.6[3]	18.3[6]

Notes:
All concentrations are in ug/L.
NA - This chemical was not identified as a COPC in the previous risk assessment.
1 - Old values are from the Remedial Investigation Report for Site 5 - Fire Training Area, February 2002, Appendix J.
2 - Calculated according to USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites.
3 - Land's H-UCL.
4 - Maximum detected concentration.
5 - 99% Chebyshev(Mean, Std) UCL.
6 - Student's-t UCL
7 - Approximate Gamma 95% UCL
8 - 95% Chebyshev(Mean, Std) UCL.
9 - Arithmetic mean
UCL = Upper Confidence Limit.
COPC = Chemical of Potential Concern.

Appendix D
Site 5 Hydrogeologic Cross-Section


A
A'
03MW08
05MW13
05MW04
05MW01
05MW06
375
350
325
300
275
250
225
200
175
150
ELEVATION AMSL
WATER TABLE
SANDSTONE
SILTSTONE
CLAYSTONE
10
100
1000
340
339.5
339
80
40
0
VERTICAL SCALE IN FEET
0
160
320
HORIZONTAL SCALE IN FEET
LEGEND
340 HYDRAULIC HEAD
100 TOTAL VOCs SUMMER 2005
GENERAL DIRECTION OF GROUNDWATER FLOW