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FINAL
Document Decision (DD) for Q-Area Drum Storage Yard Norfolk Naval Base Norfolk, Virginia

Prepared for:
Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia

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ESE Project No. 4921150-0900-2100

Declaration
Selected Remedial Alternative for the QADSY

Site Name and Location

This Document Decision (DD) has been prepared for the Q Area Drum Storage Yard (QADSY) located at the Norfolk Naval Base in Norfolk, Virginia. The QADSY is located in the northwest corner of the complex, within 1200 feet of both the Elizabeth River (to the west) and Willoughby Bay (to the northeast). Tens of thousands of drums containing solvents, oils, lubricants, paint thinners, pesticides, and acids have been stored at the QADSY. The site has not been used for drum storage since 1987.

Statement and Basis of Purpose

This DD presents the selected response actions for the QADSY that were chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This DD explains the factual and legal basis for selecting the response actions for the QADSY. The information supporting this remedial action decision is contained in the Administrative Record for the QADSY.

The content of this DD is based on recommendations in the US Environmental Protection Agency (USEPA)'s Interim Final Guidance on Preparing Superfund Decision Documents (USEPA, 1989).

Assessment of the Site

The investigations addressed in this DD began with an initial assessment study (IAS) in 1982 and ended with the comprehensive Remedial Investigation/Feasibility Study (RI/FS) performed in 1996.

During the IAS, recommendations were made to install and sample (quarterly) three monitor wells for oil and grease, volatile organic compounds (VOCs), pesticides, and polychlorinated biphenyls (PCBs). The IAS report published by Naval Energy and Environmental Support Activity (NEESA, February 1983) suggested that the wells be located downgradient of the QADSY, with specific attention to the leaking drum area.

Subsequent to the IAS, the Navy Assessment and Control of Installation Pollutants (NACIP) Program was redesigned as the Installation Restoration Program (IRP). The terminology and structure of the IRP were changed to conform to that of SARA. The RI Interim Report (LANTNAVFACENGCOM, March 1988) was designed to verify the existence of contamination, satisfying the site investigation requirements of SARA, but it does not meet the full requirements of an RI. The objective was to incorporate the RI Interim Report into a completed RI/FS document at a later date.

The initial site investigation for the interim RI was conducted in November and December of 1983. Four monitor wells were installed at that time, and 12 soil samples were analyzed from four hand borings. A second round of groundwater sampling was performed in August 1984. Groundwater samples from the existing wells and 21 soil samples from seven locations were analyzed as part of the third round of sampling, performed in April 1986. The Navy analyzed eight soil samples in April 1986 following the groundwater event; this effort resulted in plans to remove the most contaminated soil as part of a 1989 military construction project. Finally, a fourth round of groundwater sampling occurred in June 1986.

Following the interim RI, the Navy excavated 750 cubic yards of soil in 1987. That portion of the QADSY is presently paved and used for fleet parking.

A RI/FS was conducted from 1990 to 1995. The RI Field Investigation included soil, groundwater, surface water, and sediment sampling, aquifer testing, groundwater modeling, and a quantitative risk assessment.

The results of the Risk Assessment (RA) in Section 6 of the RI concluded that conditions at the QADSY do not pose an unacceptable potential risk to human health and the environment for the current worker. There is a potential risk to human health and the environment for the future worker and residential scenario because of inhalation if a building is constructed onsite.

The QADSY is located in a highly industrial area at the Norfolk Naval Base in Norfolk, Virginia. The future plan at the QADSY is to increase the fleet ship parking by paving the current 5-acre gravel area. There are no future building plans, although the recommended remedial action objectives are for the future worker. The future resident scenario is highly unlikely because of the location of the QADSY (refer to Section 4.0 of this document for a description of this RA). This RA showed that under a worker exposure scenario, potential risks to human health are within the acceptable range. The future commercial scenario will be used to determine the preferred alternative selection.

Additionally, potential ecological risks associated with exposure due to ingestion of fish are all less than 1, suggesting that there is low potential for adverse effects to the terrestrial animals due to site-related chemicals in fish caught near the site. The ecotoxicity quotients (EQs) for water- and sediment-dwelling aquatic organisms at QADSY are all below the EQ of less than 1, indicating that there is low potential for adverse effects to these aquatic organisms.

Description of the Selected Remedy

This DD addresses the final remedy for QADSY. The following remedial actions are determined to be necessary at the QADSY:

- No action for soil is necessary at the QADSY because:
  - Inorganic compounds (IOC) contamination appears to be inherited from the dredged material
  - The QADSY is not conducive to an ecological environment because it is in a highly industrial area and is mostly a paved parking lot
  - The present plans are for the unpaved area to be paved, which will subsequently eliminate this ecologic risk pathway
- Air sparging/soil vapor extraction (AS/SVE) remedial action is determined to be necessary for groundwater

- Groundwater monitoring
- A 5-year review to assess site conditions

Statutory Determinations

The selected remedy for the QADSY is protective of human health and the environment, complies with federal and state environmental requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost effective. This remedy uses permanent solutions to the maximum extent practicable for the QADSY. No further remedial action is determined to be necessary for the soil. AS/SVE remedial action is determined to be necessary for groundwater.

Remedial action objectives include protecting the groundwater and preventing inhalation of VOCs from impacted groundwater. The studies undertaken at the QADSY have shown that future worker potential for human health and environmental risks are associated with the groundwater.

Based on the careful consideration of the technical, environmental, institutional, public health, and cost criteria as presented in Section 6.0, and in keeping with the overall response strategy, the recommended remedial action for the QADSY at Norfolk Naval Base is AS/SVE.

[signature]	11-19-96
Commander, Naval Base, Norfolk	Date

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List of Acronyms and Abbreviations

ARARs	applicable or relevant and appropriate requirements
AS	air sparging
AWQC	ambient water quality criteria
AWS	air-water separator
BDL	below detection limit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeters
cm/sec	centimeters per second
COCs	chemicals of concern
COPCs	chemicals of potential concern
CSF	carcinogenic slope factor
CTV	critical toxicity value
cy	cubic yard
DCA	1,2-Dichloroethane
DCE	1,2-Dichloroethene
EQ	ecotoxicity quotient
ERA	Ecological Risk Assessment
ESE	Environmental Science & Engineering, Inc.
FS	Feasibility Study
HI	hazard index
HRA	Human Risk Assessment
IAS	Initial Assessment Study
IOCs	inorganic compounds
IRP	Installation Restoration Program
IWTP	Industrial Waste Treatment Plant
LOAEL	lowest-observed-adverse-effect level
mg/kg	milligrams per kilogram
mg/kg/day	milligram per kilogram day
mg/L	milligrams per liter
mm	millimeter
msl	mean sea level
MTV	mobility, toxicity, and volume
NACIP	Navy Assessment and Control of Installation Pollutants
NCP	National Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effect level
NPDES	National Pollutant Discharge Elimination Stream
NPL	National Priorities List
NWR	National Wildlife Refuge
NWRSA	National Wildlife Refuge System Act
O&M	operation and maintenance

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List of Acronyms (continued)

OSHA	Occupational Safety and Health Administration
PAHs	Polynuclear Aromatic Halogens
PCA	1,1,2,2-Tetrachloroethane
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethene
ppm	parts per million
PRAP	Proposed Remedial Action Plan
PQL	Practical Quantitation Limit
QADSY	Q-Area Drum Storage Yard
RA	Risk Assessment
RAE	reasonable average exposure
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RGOs	remedial goal objectives
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RME	reasonable maximum exposure
SARA	Superfund Amendments and Reauthorization Act
SF	slope factors
sq ft	square foot
SVE	soil vapor extraction
SVOCs	semi-volatiles organic compounds
TBC	To be considered
TCE	trichloroethene
TCLP	toxic characteristic leachate procedure
TPH	Total Petroleum Hydrocarbon
TRV	toxicity reference value
μg/l	micrograms per liter
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
VDEQ	Virginia Department of Environmental Quality
VOCs	volatile organic compounds
WQSs	Water Quality Standards

1.0 Site Name, Location, and Description

The QADSY is located on the Norfolk Naval Base and is part of the Sewells Point Naval Complex (Figure 1). It is located in the northwest corner of the complex, within 1200 feet of both the Elizabeth River (to the west) and Willoughby Bay (to the northeast). The site is currently a relatively flat fenced area, paved with crushed gravel, and bounded by asphalt parking lots to the north and west.

The QADSY was created by a fill operation in the early 1950s and was used as a disposal area for the dredged materials from Willoughby Bay. Tens of thousands of drums containing solvents, oils, lubricants, paint thinners, pesticides, and acids have been stored at the QADSY. The site has not been used for drum storage since 1987.

Since 1982, a number of investigations and reports have been conducted and prepared under various Navy programs to assess the nature and extent of contamination and contaminant migration.

1.1 Topography

The topography of the area is relatively uniform, characterized by flat sloping areas. The QADSY is located in the northernmost portion of the Norfolk Naval Base (Figure 1). The surrounding terrain is flat and even, characteristic of the whole region. The southern portion of the site (south of well SW-3) slopes gently from north to south. The average elevation of the site is about 10 feet above mean sea level (msl).

Two large water bodies are located adjacent to the QADSY. Elizabeth River borders the western boundary of the site; Willoughby Bay borders the northern and eastern boundary of the site.

Drainage of the site and surrounding area is controlled by man-made structures and features. Much of the area is paved, and surface runoff is directed into numerous open storm drains that presumably lead directly to the open waters of the Elizabeth River to the west or to Willoughby Bay to the north. No natural drainage features (creeks, marshes, etc.) were found on or near the site.

1.2 Geology/Hydrology

The QADSY is located in the outer Coastal Plain Physiographic Province, characterized by low elevations and relief, sloping gently eastward. The Coastal Plain is defined to the east by the Atlantic Ocean and to the west by the Fall Line near Emporia, Virginia (Frye, 1986). The Coastal Plain is characterized by unconsolidated sediments of Cretaceous, Tertiary, and Quaternary ages that dip gently eastward and rest on pre-Cretaceous aged bedrock at a depth of approximately 2200 feet. The Coastal Plain of Virginia consists of an eastward thickening sedimentary wedge composed principally of unconsolidated gravels, sands, silts, and clays with variable amounts of shells. Coastal Plain deposits cover the length of the Virginia coastline, extending westward to the "fall line," where the pre-Cretaceous basement complex reaches the surface approximately 80 miles westward (Meng and Harsh, 1988).

QADSY is underlain by approximately 15 feet of fill. The edge of the fill is located approximately 2500 feet south of the site (Barker and Bjorken, 1978). Below the fill, the QADSY is underlain by the Upper Pleistocene Lynnhaven Member within the Tabb Formation. The strata consist of fine to coarse sand grading upward to sandy and clayey silt. Locally, the base of the unit includes cross-bedded sand and clayey silt containing plant material. The member constitutes surficial deposits of broad swales and extensive lowlands. The average thickness of the Lynnhaven Member is 20 feet (Mixon, et al., 1989).

The QADSY is underlain by yellow-brown, gray, and black silty sand with shell fragments indicative of the fill material that created the site; brown to black clay lenses are rare from 20 to 30 feet below ground surface. The water table is approximately 8 feet below ground surface, and water table elevations range from 2 to 5 feet above msl.

Throughout the Coastal Plain, groundwater occurs in the unconsolidated, layered sediments. The depositional strata encountered at the site are part of the undifferentiated quaternary sediments of the Columbia aquifer. These sediments are primarily Pleistocene and Holocene in age, but also include sandy Pliocene sediments along the contact with the underlying Yorktown confining unit. The Columbia aquifer is generally unconfined; however, clayey sediments within the aquifer may produce local confined or semi-confined conditions. The sediments composing the Columbia aquifer consist mostly of a series of formations resulting from Pleistocene marine transgressions (Meng and Harsh, 1988).

According to Siudyla, et al. (1981), the aquifer can be used only for lawn watering and other similar uses due to water quality limitations. The groundwater commonly has a low pH and a high iron content. Regionally, the aquifer has typically been contaminated by:

- Waste lagoons
- Landfills
- Septic tanks below the water table
- Municipal sludge application sites

The City of Norfolk Health Department prohibits the use of the water table aquifer for public or private potable water supplies under law ordinance Chapter 46.1, Reference 46.1-5. All potable water in the City of Norfolk is supplied by the City of Norfolk.

The Yorktown Formation underlies the Tabb Formation and is Miocene in age. The unit is characterized by coarse sand and gravel beds, and abundant, thick shell beds; the formation thickness ranges from 300 to 400 feet.

The Yorktown aquifer is generally encountered under confined (artesian) conditions; the major water-bearing zones are found at depths from 50 to 150 feet (Siudyla, et al., 1981). The aquifer is generally separated from the overlying water table aquifer by 20- to 40-foot thick confining beds of silt, clay, and sandy clay. Leaky confined conditions are encountered in places, and Yorktown recharge commonly occurs through downward leakage from the water table aquifer.

Domestic, public, commercial, and industrial supply wells tap the Yorktown aquifer throughout the region; the water quality is generally suitable for potable and most other uses. However, high iron concentrations are occasionally noted, and brackish water problems (i.e., high chloride content) have also occurred locally. No drinking water wells are used in the vicinity of the site. The Yorktown aquifer at the site adjacent to the Elizabeth River and/or Willoughby Bay is brackish and not used for potable water (Siudyla, et al., 1981). The Yorktown aquifer discharges into the Elizabeth River and Willoughby Bay. The Elizabeth River and Willoughby Bay water is not used for domestic, public, commercial, or industrial supply because the surface water is brackish.

Available water supplies at the QADSY site and surrounding area consist of that stored in the pore space of the underlying sediments. As mentioned earlier, literature confirms the presence of two major aquifer systems in the area. The lower system (Yorktown Formation) is not confined at the QADSY. Clay was intercepted at the base (20 feet) at boring SW-4 but not in any of the deeper borings, including wells DW-1 through DW-8 (Figure 2). The confining bed between the Columbia and Yorktown aquifers does not exist at the site; it appears to be eroded from channelization and meandering of the Elizabeth River. The Yorktown aquifer is not hydraulically separated from the Columbia aquifer at the site.

The Yorktown aquifer in the area of the site is only used for lawn irrigation. The discharge flows to either the Elizabeth River or Willoughby Bay. This aquifer is not used for public water supply because the downgradient surface waters (Willoughby Bay and Elizabeth River) are brackish and contain high metal concentrations.

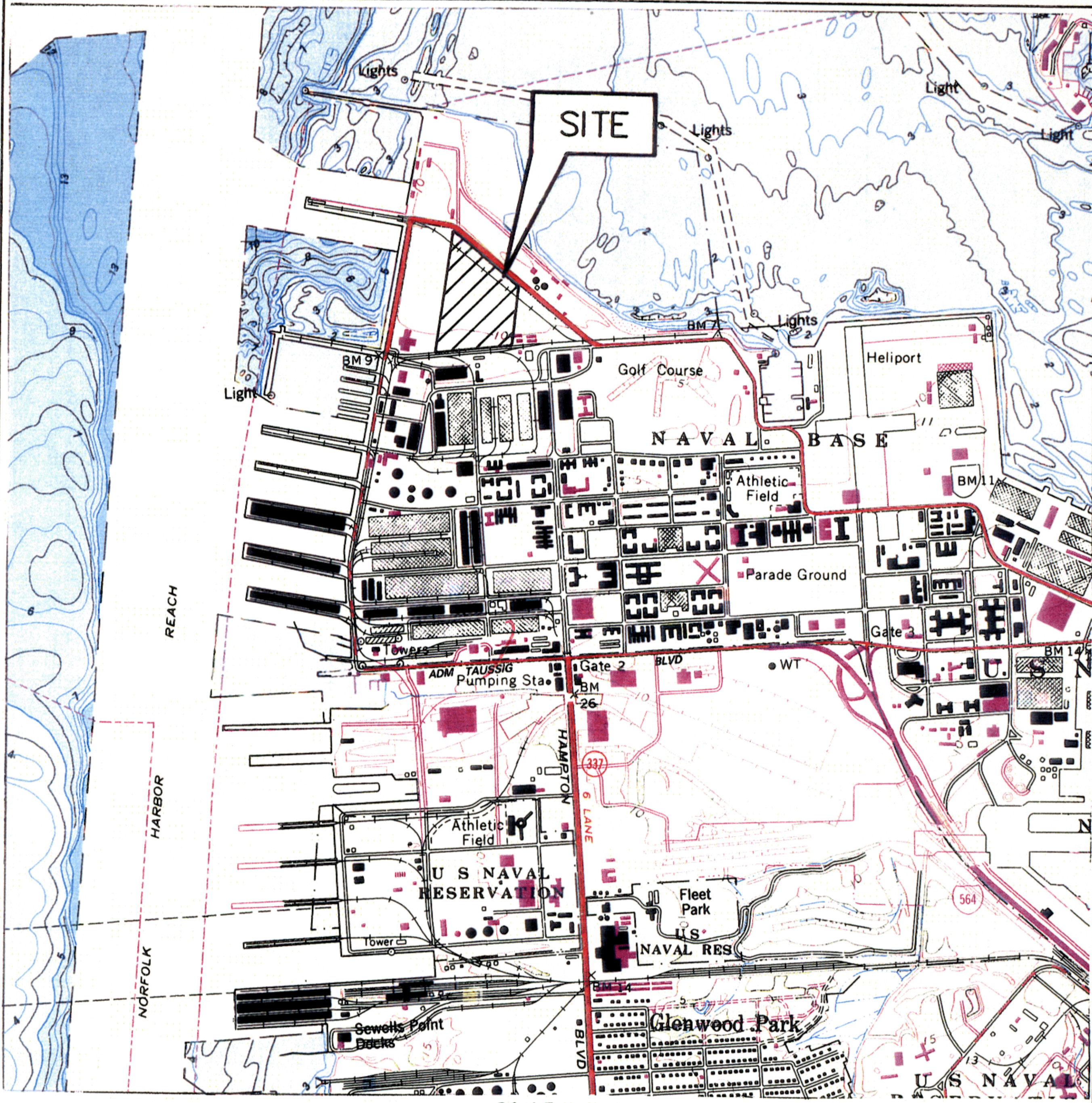
The Yorktown and Columbia aquifers are hydraulically connected at the site, producing an unconfined aquifer. Aquifer thickness has not been determined at the site, but appears to be between 85 to 140 feet by incorporating the fill (15 to 20 feet), Tabb (20 feet), and Yorktown (50 to 100 feet) formations (Meng and Harsh, 1988).

Groundwater in the study area is sustained by precipitation, which infiltrates the land surface, and by regional flow. Broadly speaking, the unconfined aquifer is recharged by infiltration.

Recharge by infiltration at the site and surrounding areas is limited to unpaved areas; extensive paved areas and man-made drains and culverts control much of the surface runoff. The construction and placement of the drainage network may also have profound effects on the localized flow in the area: they may be partially permeable and intercept the groundwater surface.

Annual precipitation averages 47 inches; however, much may be lost as runoff to man-made drainage ways. Additionally, evapotranspiration may result in a significant loss, despite the lack of vegetation at the site. The annual recharge to the water table aquifer is not precisely known, but is estimated to be between 12 and 20 inches.

Groundwater discharge from the unconfined aquifer is thought to be primarily into Elizabeth River to the west and Willoughby Bay to the east. However, significant control on groundwater discharge and flow patterns may be exercised by man-made drainage culverts that may intercept the water table.



SCALE 1:24000

1 — 1/2 — 0 — 1 MILE

1000 — 0 — 1000 — 2000 — 3000 — 4000 — 5000 — 6000 — 7000 FEET

1 — .5 — 0 — 1 KILOMETER

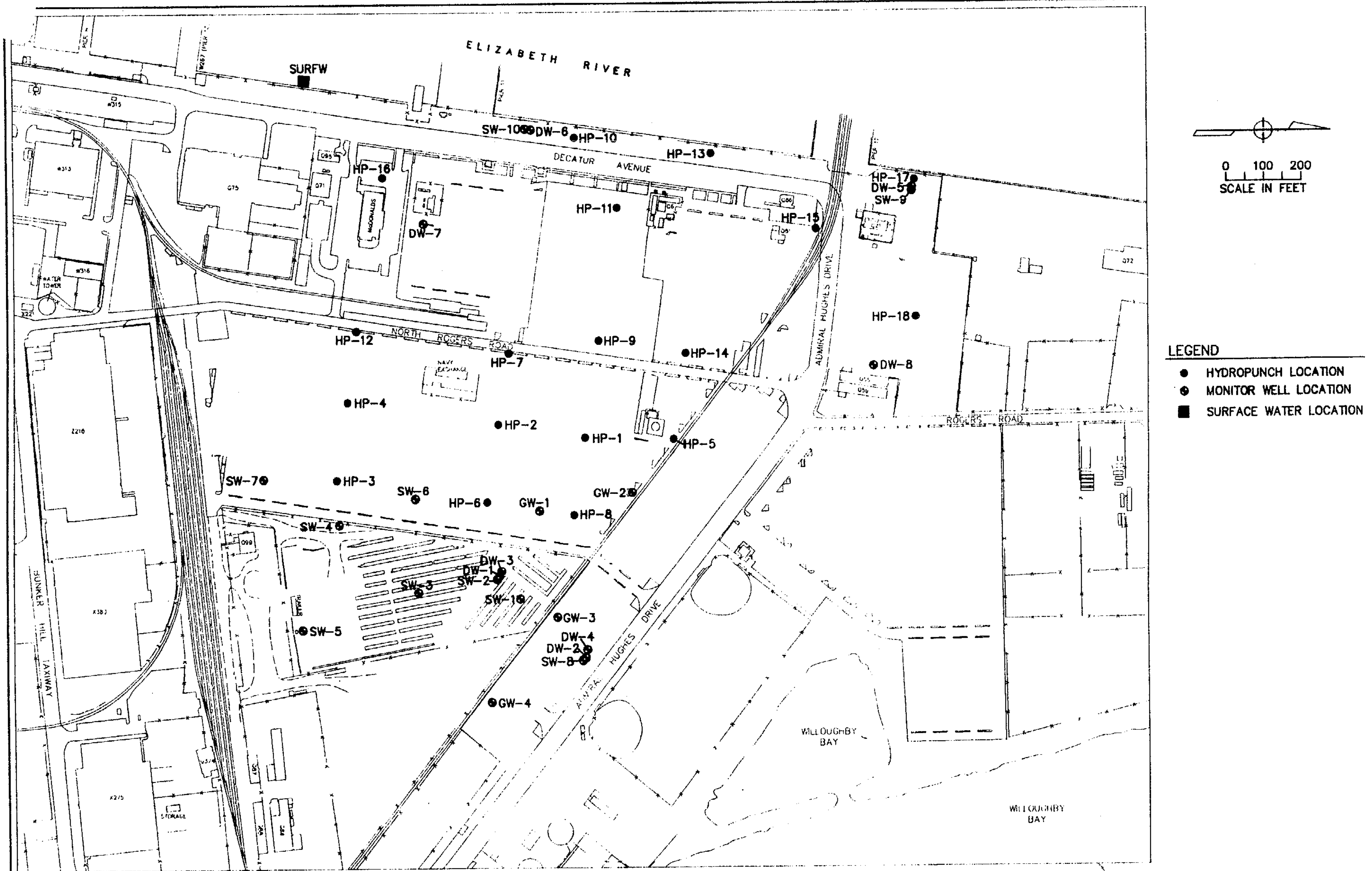
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

MN GN
9° 160 MILS
1°22' 24 MILS

UTM GRID AND 1984 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SOURCE: USGS NORFOLK NORTH, VA. QUADRANGLE

ESE Environmental Science & Engineering	DATE 6-3-91	SCALE SHOWN	TITLE Site Location Map — Q Area Drum Storage Yard — Norfolk Naval Base — Norfolk, Virginia
	DRAWN BY LAF	APPROVED BY	
	JOB NO. 4901107	DWG. NO./ REV. NO. 1 —	CLIENT NAVFAC LANTDIV — Q AREA · FIGURE 1



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DATE	SCALE	TITLE
3-16-94	SHOWN	MONITOR WELL, HYDROPUNCH, AND WATER LOCATIONS Q AREA DRUM STORAGE YARD NORFOLK, VIRGINIA
DRAWN BY LAL/DN	APPROVED BY	
JOB NO. 4921150	DWG. NO./ REV. NO. QDB / -	CLIENT NAVFAC - Q AREA

FIGURE 2

2.0 Site History and Enforcement Activities

The QADSY has been in use since its creation in the 1950s, and tens of thousands of drums have been stored at the site since that time (LANTNAVFACENGCOM, 1988). A variety of materials were stored in 55-gallon steel drums, including petroleum products (such as oil lubricants), various organic solvents, paint thinners, some pesticides, formaldehyde, and acids. Throughout the site's history, the northern portion of the yard was used to store damaged and leaking drums. The site has not been used for drum storage since 1987.

Since 1982, a number of investigations and reports have been conducted and prepared under various Navy programs to assess the nature and extent of contamination and contaminant migration.

The investigations addressed in this Proposed Plan began with an IAS in 1982 and ended with the comprehensive RI/FS performed in 1996.

During the IAS, evidence of considerable liquid leakage and spillage was noted throughout the site. In particular, the northern portion of the site was used to store damaged and leaking drums. Recommendations were made to install and sample (quarterly) three monitor wells; recommended analytes included oil and grease, VOCs, pesticides, and PCBs. The IAS report (NEESA, February 1983) suggested that the wells be located downgradient of the QADSY, with specific attention to the leaking drum area.

Subsequent to the IAS, the NACIP Program was redesigned as the IRP. The terminology and structure of the IRP were changed to conform to that of SARA. The RI Interim Report (LANTNAVFACENGCOM, March 1988) was designed to verify the existence of contamination, satisfying the site investigation requirement of SARA, but it does not meet the full requirements of an RI. The objective was to incorporate the RI Interim Report into a completed RI/FS document at a later date.

The initial site investigation for the interim RI was conducted in November and December of 1983. Four monitor wells were installed at that time, and 12 soil samples were analyzed from four hand borings. A second round of groundwater sampling was performed in August 1984. Groundwater samples from the existing wells and 21 soil samples from seven locations were analyzed as part of the third round of sampling, performed in April 1986. The Navy analyzed eight soil samples in April 1986 following the groundwater event; this effort resulted in plans to remove the most contaminated soil as part of a 1989 military construction project. Finally, a fourth round of groundwater sampling occurred in June 1986.

Following the interim RI, the Navy excavated 750 cubic yards of soil in 1987 as shown in Figure 1-5 of the RI (ESE, 1996). That portion of the QADSY is now paved and used for fleet parking.

3.0 Highlights of Community Participation

The RI/FS and Proposed Remedial Action Plan (PRAP) Reports for the QADSY were released to the public in May and June 1996. These two document are available to the public as part of the Administrative Record and in the information repositories maintained at the following location:

Kirn Library City of Norfolk Main Library 301 City Hall Avenue Norfolk, VA	(757) 664-7323
Larchmont Public Library 6525 Hampton Blvd. Norfolk, VA	(804) 441-5335
Mary Pretlow Public Library 9640 Granby Street Norfolk, VA	(804) 441-1750
Naval Station Library Building C-9, Bacon Street Naval Station Norfolk, VA 23511	(804) 445-2740 (804) 444-2880

The notice of availability of these documents was published in the 15 July 1996 Virginia Pilot newspaper. A public comment period was held between 15 July and 15 August 1996. In addition, a public availability session and meeting was held on 14 August 1996. At this meeting, representatives from the Navy, USEPA, City of Norfolk, Elizabeth River Project, and Virginia Department of Environmental Quality (VDEQ) addressed questions and received comments about the remedial alternatives under consideration.

This DD presents the selected remedial action for the QADSY. The selected remedy presented in this DD was chosen in accordance with CERCLA, as amended by SARA, and the NCP. The decision for this site is based on the QADSY Administrative Record.

4.0 Scope and Role of the Response Action

This DD addresses the selected remedy for the QADSY, the construction and operation of an AS/SVE system. This remedial action was determined to be necessary due to the identified potential human health risks to the future worker at the QADSY. Studies undertaken at the QADSY identified these potential human health risks being associated with the volatilization of the VOC-impacted groundwater at the site into a future building located above the contaminate plume. The remedial objective of the QADSY is to minimize any threat of these potential human health risks from the VOC-impacted groundwater.

Incorporated into the design of this system is the positioning of AS and SVE wells along the downgradient edge of the contaminate plume that parallels the waterfront. This well arrangement will provide a remediation zone prior to groundwater discharge to the Elizabeth River. Semi-annual groundwater monitoring and a 5-year review to assess site conditions will also be conducted.

5.0 Summary of Site Characteristics

The objective of the RI was to determine the nature and extent of contamination at the site, as well as locate and characterize the groundwater contamination both onsite and offsite. The complete results of the RI are presented in this document.

The RI field investigation was performed in two stages: (1) a 1990 groundwater and soil sampling event; and (2) 1992-1993 groundwater, 1992 soil, 1992 surface water, 1993 sediment, and 1995 soil and groundwater sampling events (Figure 2).

To fulfill the objectives of the RI, ESE performed the following tasks:

- A total of 18 monitor wells were installed. Ten of the wells comprise four well clusters. Each cluster consists of two or three wells that monitor the shallow and deep portions of the aquifer beneath the site. Subsurface soil samples were collected from wells SW-1 through SW-5.
- Surface soil samples were collected from 36 locations from the four study areas during the 1990 sampling event. Samples were collected from two intervals in 24 of the borings: 0 to 18 inches and 18 to 36 inches. A composite sample was taken from 0 to 36 inches in the remaining 12 borings.
- Subsurface samples were collected from eight locations during the 1992 sampling event to further delineate the extent of total petroleum hydrocarbon (TPH) contamination. Samples were collected from two intervals in the borings: 3 to 5 feet and 5 to 7 feet.
- During the May 1995 sampling event, surface soil samples were collected at 19 locations. Fifteen of these were analyzed to further delineate the extent of TPH contamination. The remaining four were analyzed for VOCs, semi-volatile organic compounds (SVOCs), pesticides, PCBs, IOCs, and cyanide.
- Two sediment samples were collected from onsite storm drains.
- During the 1990 sampling event, groundwater samples were collected from the ten new wells and from three existing wells installed as part of the IAS. During the 1992-1993 sampling event, groundwater was collected from five of the wells installed in 1990 and from the eight new wells installed in 1992. Groundwater samples were collected from the eight new wells in May 1995.
- Collection of 66 groundwater samples from 18 locations was completed using the hydropunch sampling technique in December 1992. The samples were analyzed for Trichloroethene (TCE), Tetrachloroethene (PCE), and 1,2-Dichloroethane (DCA) using a Photovac field gas chromatograph. At least two hydropunch samples were collected at each location. Groundwater samples were collected at 10-foot intervals beginning at 15 feet below ground surface. Hydropunch samples were collected until the contamination was below detection limits (BDL) or two consecutive samples were detected at or below 5 micrograms per liter (μg/l).

- One surface water sample was collected from the Elizabeth River adjacent to the piers.
- Rising and falling head slug tests were used to determine the hydraulic conductivity of the aquifer. Continuous water level monitoring was conducted on one shallow and one deep well to determine tidal and recharge influences on the aquifer.
- The vertical flow regime between the aquifer and the Elizabeth River was determined by installing a piezometer at the end of one of the piers.
- A 72-hour drawdown test was performed to evaluate aquifer characteristics including specific capacity, transmissivity, storativity, and area of influence.
- Following the 1992 field investigation, MODFLOW®, a three-dimensional groundwater flow model, was used to determine groundwater flow lines at the site.
- Monitor well locations were surveyed to determine the elevation of each well; additional surveys were performed to develop accurate site maps.
- Two AS/SVE pilot studies were performed in May 1995 to test the feasibility of a remediation system.

5.1 RI Results

A variety of contaminants have been identified at the site. A list of compounds of concern (target compounds) was created from the contaminants identified and is located in Section 4 of the RI report.

The following factors were considered when identifying the target compounds:

- Relation to known or suspected site activity
- Frequency of detection above background levels and/or relevant standards/criteria
- Frequency of detection above those mandated by NEESA Level C Protocols
- Compound presence in laboratory or field blanks

Several compounds identified at the site are recognized laboratory contaminants. These compounds are not the focus of the FS and therefore are not relevant. In addition, the treatment proposed for PCE and TCE will also eliminate these compounds if they are present at low levels.

A brief summary follows of the sample results from each media investigated during the RI. Figures 2-1 and 2-2 of the RI report show the locations sampled during the investigation. Media included groundwater, surface soils, subsurface soils, sediment, and surface water. Figures 5-6 through 5-38 of the RI report show the location of the monitor wells and interpreted contaminant plumes. Additional details regarding the site can be found in Sections 3.0 through 8.0 of the RI Report.

Surface Soils:

- Fifty percent of the 0- to 3-foot samples from the QADSY were contaminated by petroleum hydrocarbons above the 100 parts per million (ppm) of VDEQ action level. Two-thirds of the samples exceeded the 50 ppm VDEQ guideline for disposal of the soil as clean fill. Concentrations ranged from not detected to 4400 ppm. A hydrocarbon that closely matched the reference standard for compressor oil was the most common; other oils were less common. All of the 3- to 7-foot samples were below the 50 ppm VDEQ guideline.

- Soil VOC contamination is limited. Only the sample from location HM-9-2, at 32,000 micrograms per kilogram (μg/kg) PCE, exceeded the range for all other samples of 1000 μg/kg total VOCs. Other VOCs detected at much lower levels included: acetone, xylenes, 1,1-DCA, toluene, methylene chloride, 1,2-Dichloroethene (DCE), 1,1,1-Trichloroethane (TCA), TCE, 4-methyl-2-pentanone, and 1,1,2,2-Tetrachloroethane (PCA).

- All detected toxic characteristic leachate procedure (TCLP) organics and IOCs were well below federal standards.

- Many of the compounds detected in the surface soils were also detected in the groundwater samples, including VOCs, TPH, and IOCs.

Groundwater:

- The contaminants present in the saturated zone were comparable to those observed in the soils and are typical of the type of contaminants stored at the site except for TPH.

- Contamination appears to affect the upper 60 feet of the aquifer.

- The main groundwater contaminants of concern are the following chlorinated organics: PCE, TCE, 1,1,1-TCA, 1,1,-DCA, 1,1-DCE, 1,2-DCE, and acetone. Locally, some IOC concentrations were elevated (e.g., cadmium).

6.0 Summary of Risks

6.1 Human Health Risks

6.1.1 Identification of Constituents of Concern

A Risk Assessment is a procedure that uses a combination of facts and assumptions to estimate the potential for adverse effects on human health and the environment from exposure to chemicals found at a site. The RA process for the QADSY involved consideration of chemicals of concern (COCs) in air, soil, sediment, surface water, and groundwater and how humans and animals can be exposed to these COCs.

In the RA, potential carcinogenic risks and non-carcinogenic health risks were calculated using EPA standards, protocols, and specific EPA Region III guidelines. Conservative assumptions were used in calculating potential risks that weigh in favor of protecting human health and the environment.

Potential risks to human health and the environment were then evaluated with respect to carcinogenic and non-carcinogenic effects. USEPA's acceptable increased cancer risk range is 1.0×10^{-4} to 1.0×10^{-6} (one individual in 10,000 to one individual in 1,000,000) as established in the NCP. The number 1.0×10^{-4} corresponds to a probability of one additional individual in 10,000 developing cancer from a lifetime (70 years) of exposure to chemicals on the installation.

A hazard index (HI) is used to determine whether individuals in a population could be adversely affected by non-carcinogenic chemicals. An HI exceeding 1.0 indicates a potential unacceptable risk and a possible concern for potential toxic effects.

The ecological RA was conducted to determine if there were any potential/current or future adverse effects on plants and animals due to the presence of chemicals at the study areas. Potential risks were determined by evaluating the toxicity of the study area COCs and the potential exposure to those COCs.

The Risk Assessment was generated in accordance with EPA Risk Assessment Guidance (RAGS) for Superfund and Region III guidance to assess the potential current and future human and ecological health risks associated with potential onsite exposures at the QADSY, assuming no remedial action is implemented at the site. The risk results are then used to develop remedial goal objectives (RGOs), goals that remedial alternatives strive to achieve considering other factors such as feasibility and achievability.

The RA identified the primary site-related chemicals of potential concern (COPCs) at the QADSY. Based on past operations at the site, the COPCs evaluated in the Human RA (HRA) and Ecological RA (ERA) include a subset of VOCs and IOCs. The data used in the RA are taken from ESE sampling events (1990-1993) and sampling events from different contractors (Malcolm Pirnie, 1983-1986 and Baker Environmental, 1995). The most recent and/or reliable data are used in the calculation of the exposure concentrations for the RA. The number of chemicals to be evaluated in the RAs was reduced using 1) EPA Region III methodology for risk-based concentration screening, 2) comparison of site and background soil concentrations, and 3) a screening for nutritionally essential chemicals.

TPH was also detected at the site. Although this group of chemicals is useful for determining the extent of petroleum-based contamination, a quantitative risk evaluation was not performed, as TPH represents a large group of chemicals, typically composed of long, straight-chain hydrocarbons of relatively low toxicity. However, to provide a conservative risk evaluation, the carcinogenic polynuclear aromatic halogens (PAHs) were used as a surrogate to evaluate TPH.

Potential human health risks were characterized based on the detected constituents of concern present in the relevant medium at the QADSY. Based on the results of the RA, the constituents of concern that pose the greatest potential risk to human health were identified. The constituents of concern are VOCs in the soil and groundwater.

6.1.2 Human Health Exposure Assessment

The exposure assessment identifies significant human and ecological exposure pathways and population(s) based on the environmental fate/transport analysis; determines the exposure concentrations to potential receptors; and estimates the magnitude, duration, and frequency of exposure for each receptor (or receptor group). The primary exposure pathways evaluated in the HRA and ERA are as follows:

<u>Human Exposure Pathways</u>
Current Worker -- incidental ingestion and direct contact with site soils; inhalation of vapors volatilized from groundwater into indoor air
Future Worker -- incidental ingestion and direct contact with site soils; inhalation of vapors volatilized from groundwater into indoor air
Future Residential -- incidental ingestion and direct contact with site soils; inhalation of vapors volatilized from groundwater into indoor air

Domestic groundwater consumption is an incomplete human exposure pathway as the water below the QADSY site is not potable due to the high salinity of the water. Thus, this pathway, under the guidance of state and federal regulatory agencies, is not further evaluated in the RA. However, due to the presence of VOCs in groundwater beneath the site, inhalation of VOCs volatilized from groundwater into indoor air is evaluated.

The primary sources of toxicological data were from EPA-verified references. When an appropriate toxicological constant was not identified, current literature was reviewed to find appropriate toxicological data, which were used to calculate dose-response values using the methodologies outlined in EPA guidance documents.

For each human exposure pathway evaluated, carcinogenic and non-carcinogenic health risks were characterized for the reasonable maximum exposure (RME), and the reasonable average exposure (RAE) scenarios. The standard and default exposure assumptions recommended by RAG's were used, as well as conservative assumptions and professional judgement. The methods and assumptions used in the exposure assessment are presented in Section 6.0 of the RI/FS Report (ESE, 1996).

6.1.3 Human Health Toxicity Assessment

Available toxicity factors of carcinogenic and noncarcinogenic COPCs are discussed and presented in Section 5.0 of the RI/FS Report (ESE, 1996). The COPCs selected for the RA for the site have a wide range of carcinogenic and noncarcinogenic effects associated with them. The reference dose (RfD) values and slope factors (SF) were key dose-response variables used in the RA. The RfD, expressed in units of milligrams per kilogram per day (mg/kg/day), for a specific chemical is an estimated daily intake rate that appears to pose no risk over a lifetime of exposure. The RfD value is used to assess noncarcinogenic effects. The SF, expressed in units of $(mg/kg/day)^{-1}$, provides a conservative estimate of the probability of cancer development from a lifetime of exposure to a particular level of a potential carcinogen. Brief toxicity summaries of the COPCs that may present the greatest carcinogenic risks and are present at the highest concentrations at the site are presented in Section 6.0 of the RI Report.

6.1.4 Human Health Risk Characterization

Potential excess carcinogenic risks were calculated for individual constituents by multiplying exposure levels of each constituent by the appropriate carcinogenic slope factor (CSF). The total combined potential health risks were also evaluated for each pathway by summing estimates derived for each constituent of concern for that pathway. The additive approach is in accordance with USEPA guidelines (USEPA, 1989) on chemical mixtures in which potential risks associated with carcinogens are considered additive. Risks from inhalation, skin absorption, and oral exposures can be added to estimate total overall potential risk to human receptors.

The site-specific potential carcinogenic risk estimates were based on the RME and RAE scenarios. The potential cancer risks associated with the known or suspected carcinogens detected at the QADSY were compared to the USEPA acceptable cancer risk range of 1.0E-4 to 1.0E-06.

The potential for noncarcinogenic effects was evaluated by comparing an exposure level over a specified time period (e.g., the daily dose in mg/kg/day for a long period up to a lifetime) with an RfD derived for a similar period (USEPA, 1989a). This ratio of exposure to toxicity is called a noncarcinogenic HI. The noncarcinogenic HI assumes that there is a level of exposure below which it is unlikely for even sensitive populations to experience adverse health effects (USEPA, 1989). If the exposure level exceeds the threshold level (i.e., if the HI exceeds unity), there may be concern for potential noncarcinogenic effects. Total pathway HIs were calculated by summing estimates derived for each constituent of concern. This additive approach assumes that multiple subthreshold-exposures could result in an adverse effect and that the magnitude of the effect is proportional to the sum of the ratios of the exposure to acceptable exposures. The possible effects of multimedia exposures were evaluated by summing the HI values for the relevant exposure routes.

The results of the HRA indicate that the following scenarios exceed either a cumulative risk of 10^{-4} or an HI of 1:

Human Health Exposure Summary Table

Exposure Scenario	Medium	Exceedance	COCs	Risk/ HI Values
Future Worker	Indoor air	Risk $>1x10^{-4}$	carbon tetrachloride,	$4.4x10^{-5}$
			chloroform,	$5.4x10^{-6}$
			1,1-dichloroethene,	$3.7x10^{-4}$
			tetrachloroethene,	$2.6x10^{-6}$
			trichloroethene,	$2.8x10^{-5}$
			and vinyl chloride	$4.4x10^{-4}$
		HI >1	carbon tetrachloride	4.1
Future Residential (Lifetime)	Indoor air	Risk $>1x10^{-4}$	carbon tetrachloride,	$6.6x10^{-5}$
			chloroform,	$8.1x10^{-6}$
			1,1-dichloroethane,	$5.5x10^{-4}$
			1,1-dichloroethene,	$1.3x10^{-4}$
			tetrachloroethene,	$4.0x10^{-6}$
			1,1,1-trichloroethane,	$6.4x10^{-5}$
			trichloroethene,	$4.2x10^{-5}$
			vinyl chloride	$6.6x10^{-4}$
(Child)	Indoor air	HI >1	carbon tetrachloride,	21
			1,1-dichloroethane,	0.10
			1,1,1-trichloroethane	0.29
	Soil	HI >1	thallium	2.2

6.2 Ecological Risk Summary

6.2.1 Identification of Constituents of Concern

Constituents at the QADSY were identified from soil, groundwater, surface water, and sediment samples. In addition, constituents were also identified through small mammal trapping and tissue sample collection conducted at the QADSY. Over 40 constituents (including volatile organics, semi-volatile organics, and inorganics) were detected in these media.

Potential ecological risks were characterized based on the detected constituents of concern present in the relevant medium at the QADSY. Information about the specific constituents of concern detected at each site and in each medium is presented in Section 5.0 of this DD.

6.2.2 Ecological Exposure Assessment

The exposure assessment in the RA identified potential receptors and complete exposure pathways, and estimated chemical intakes for potentially exposed populations. Terrestrial, aquatic, and vegetative ecological receptor groups were evaluated for quantitative evaluation in the RA.

Exposures to potential ecological receptors, including a number of terrestrial, aquatic, and vegetative receptors, were evaluated for soil, groundwater, surface water, and sediment. The groundwater pathway was evaluated in the ecological RA in terms of potential groundwater discharge to surface water causing potential risks to aquatic species through exposure to affected surface water and sediment. The food chain (bioaccumulation) pathway was also evaluated for ecological receptors. Future ecological exposure scenarios are expected to remain unchanged from the current scenarios at the QADSY.

Current ecological exposure scenarios at the QADSY sites included a number of terrestrial and aquatic receptors. Because of the large number of different species of wildlife that are known or suspected of inhabiting the QADSY sites, it was not possible to evaluate all ecological receptors. The ecological receptors were screened based on the analysis of the ecological setting and site characteristics, and a determination of those communities/species critical to the ecological RA. A detailed analysis of the ecological receptors is presented in Section 6.0 of the RI/FS (ESE, 1996). After the analysis of the ecological receptors was conducted, indicator species were selected. These indicator species were chosen from the list of potential ecological receptors and are those species that appeared to be at greatest risk from exposure to potential constituents of concern.

The QADSY is located in an industrial area with limited vegetative cover, which would provide habitat for terrestrial wildlife. Potential exposure of terrestrial animals to contaminated surficial soils was evaluated in Section 6.3.3.1 of the RI/FS (ESE, 1996) and, due to the lack of exposed soil, was found to be incomplete. Therefore, no terrestrial receptors are considered applicable at the QADSY.

To evaluate potential bioaccumulative effects of site contaminants on surface water organisms, one species of wading bird, the great blue heron, is found in Mid-Atlantic habitats and was chosen as the indicator avian species for this ERA. The great blue heron (*Ardea herodias*) is the only species of wading bird that is found during the winter in the northern parts of the Atlantic coast [US Fish and Wildlife Service (USFWS, 1984)]. The great blue heron is one of the larger wading birds, eating fish as small as minnows or as large as 20 to 25 centimeters (cm) in length. Other items in the great blue heron's diet include crayfish, snails, frogs, lizards, and snakes (USFWS, 1984). The potential for bioaccumulation of IOCs into fish in the Elizabeth River and the subsequent ingestion of these fish by the heron is evaluated in the RA.

The selected representative ecological receptors are the following:

Ecological Exposure Pathways

Terrestrial -- ingestion of contaminated fish by great blue heron

Aquatic -- exposure to surrounding surface water and sediment by aquatic and benthic organisms

6.2.3 Ecological Toxicity Assessment

The toxicities of the constituents of concern were assessed for effects on vegetation, aquatic life, and terrestrial wildlife, including birds. Risks to ecological receptors are quantitatively evaluated by comparing the chemical intake (for terrestrial receptors) to a toxicity reference value (TRV) for that chemical in the specific receptor.

Selected ecotoxicity benchmarks for the surface water COPCs at QADSY were obtained from the available literature and are presented in Table 6-17 in the RI (ESE, 1996). Ecotoxicity benchmarks were chosen based on the following considerations:

- Including acute and chronic effects
- Choosing results of tests using organisms as closely related taxonomically to representative receptors as possible
- Choosing tests with ecologically relevant endpoints
- Choosing tests conducted with an ecologically relevant exposure pathway

The preferred value sought was a chronic no-observed-adverse-effect level (NOAEL) in the indicator species or related organism. For chemicals with no available chronic NOAEL, other values [e.g., a lowest-observed-adverse-effect level (LOAEL) or the dose/concentration lethal to 50 percent of a study population (LD_{50}/LC_{50})] were used to derive a TRV. In the absence of US Navy guidance on the evaluation of ecotoxicity data, the ecotoxicity benchmarks were adjusted to account for extrapolation uncertainties according to guidance provided by the US Army (USA, 1994). The Army's methodology for applying uncertainty factors to ecotoxicity benchmark values is presented in Figure 6-1 in the RI (ESE, 1996).

As discussed in Section 5.3.2, the great blue heron (*Ardea herodias*) was evaluated for ingestion of fish that may bioconcentrate contaminants from surface water. Potential ecotoxicity for this species is evaluated by comparing the intake of biota-borne chemicals during feeding to the species-specific TRVs presented in Tables 6-17 in the RI (ESE, 1996).

Due to few toxicity studies conducted on the heron, ecotoxicity benchmarks for the mouse and rat were predominantly used for the COPCs modeled into Elizabeth River surface water at QADSY. The following avian values were used for the surface water COPCs: an acute LD_{50} for arsenic and a chronic LD for selenium in mallard ducks (*Anas platyrhyncos*); an acute NOAEL for chromium in the black duck (*Anas rubripes*); an unknown chronic value for lead in the American kestrel (*Falco sparverius*); a chronic LOEL for cadmium and an acute LD_{50} for mercury in Japanese quail (*Coturnix coturnix japonica*); an acute LC_{50} for copper in an unknown species of pheasant; acute LC_{50}s for acetone in Japanese quail (*Coturnix coturnix japonica*) and ring-necked pheasant (*Phasianus colchicus*); and acute LC_{50}s for thallium in unspecified birds.

Aquatic receptors are continually in contact with the contaminated medium. Groundwater contaminants are assumed to be discharging to surface water adjacent to the site, resulting in potential bioaccumulation of certain contaminants in fish tissue and potential exposure to aquatic organisms. Instead of using receptor-specific TRVs, modeled surface water contaminant concentrations were compared to chronic federal and state ambient water quality criteria. Also, measured onsite groundwater concentrations were compared to acute water quality criteria to evaluate a worst-case scenario of toxicological effects at the groundwater-surface water interface. The level of contamination at the point of discharge is assumed to be equivalent to the level of contamination found in onsite groundwater. This assumption is considered very conservative, as it does not consider physical processes such as dilution, attenuation, or volatilization.

Similar to surface water receptors, organisms living in sediment are continually in contact with the contaminated medium. Instead of using receptor-specific TRVs, potential impacts to organisms inhabiting river sediments near the site were evaluated using the National Oceanic and Atmospheric Administration (NOAA) sediment benchmarks for LOAELs in marine organisms (1990). Sediment concentrations modelled from the groundwater concentrations at the groundwater-surface water interface were compared to the NOAA values.

The results of the RA indicated that, for the future commercial use scenario, groundwater at the QADSY poses an elevated carcinogenic (risk is 9E-04) and non-carcinogenic risks (HI of 4). The QADSY is located in a highly industrial area at the Norfolk Naval Base in Norfolk, Virginia. The future plan at the QADSY is to increase the fleet ship parking by paving the current 5-acre gravel area. There are no future building plans, although the recommended remedial action objectives are for the future worker. The future resident scenario is highly unlikely because of the location of the QADSY (refer to Section 4.0 of this document for a description of this RA). This RA showed that under a worker exposure scenario, potential risks to human health are within the acceptable range. The QADSY will use the future commercial scenario for its preferred alternative selection.

6.2.4 Ecological Risk Characterization

The objective of this risk characterization is to integrate information developed in the RI report (ESE, 1996) exposure assessment (Section 5.3.2) and the toxicity assessment (Section 5.3.3) into a complete evaluation of the potential worst-case ecological health risks associated with contaminants at QADSY. The ERA evaluates the nature and degree of risk to potential receptor populations described in Section 6.3.3. Wherever possible, risk estimates are derived for individual source areas as well as for the total contaminant contribution from the site to aid in developing priorities for remedial action planning.

The evaluation of potential health risks posed to wildlife is performed in a similar manner as the evaluation of health risks to humans. The main difference between evaluating ecological versus human health risks is that intra-species differences may significantly affect the amount that an animal ingests per body weight or the sensitivity of a species to adverse health effects. To evaluate potential risks to terrestrial receptors, the chemical intakes for a particular indicator species are compared to chemical-specific TRVs derived for that species. The ratio of chemical intake to TRV is calculated as the EQ.

Chemical intakes and TRVs are expressed in the same units. EQs less than 1 suggest that the benchmark effect is unlikely to occur in the individual; EQs greater than or equal to 1 require further evaluation. Although these EQs may indicate some potential for adverse effects to individuals, at this point, the potential for adverse effects to populations or ecosystems is qualified. Although the EQ method does not provide an estimate of uncertainty and is not an estimation of risk, it is commonly used for screening the potential for ecological effects from exposure to hazardous chemicals (EPA, 1988b).

Great Blue Heron--Diluted surface water concentrations were used to estimate the concentration of contaminants in fish. Health risks to a great blue heron ingesting fish from the river are estimated by comparing estimated chemical intakes (from fish ingestion) to TRVs to produce an EQ. An EQ equal to or exceeding unity ($\geq$ 1) suggests that the potential for adverse health effects may exist and indicates that further evaluation of the ecological exposure scenario should be performed. An EQ less than 1 indicates that it is unlikely for even sensitive populations to experience adverse health effects.

Surface Water Receptors--Groundwater contaminants are assumed to be discharging to surface water adjacent to the site, resulting in potential bioaccumulation of certain contaminants in fish tissue and potential exposure to aquatic organisms. Exposure of potential surface water receptors to site contaminants was evaluated using two methods. First, onsite groundwater concentrations were compared to acute federal Ambient Water Quality Criteria (AWQCs) and Commonwealth of Virginia Water Quality Standards (WQSs) to evaluate a worst-case scenario of toxicological effects at the groundwater-surface water interface. The level of contamination at the point of discharge is assumed to be equivalent to the level of contamination found in onsite groundwater. This assumption is considered very conservative, as it does not consider physical processes such as dilution, attenuation, or volatilization. A ratio greater than 1 indicates that the potential may exist for adverse effects to occur in an organism exposed to chemical concentrations at the groundwater-surface water interface.

Second, surface water contaminant concentrations that may be found in the open river were modeled from onsite groundwater concentrations using a dilution factor. These modeled concentrations were compared to chronic federal AWQCs and state WQSs to evaluate the potential exposure of aquatic organisms in the area. A ratio greater than 1 indicates that the potential may exist for adverse effects to occur in an organism exposed to diluted chemical concentrations in the river.

Benthic Organisms--Potential impacts to organisms inhabiting river sediments near the site are evaluated using the NOAA (1990) sediment benchmarks for LOAELs in aquatic organisms. Sediment concentrations modelled from the groundwater concentrations at the groundwater-surface water interface were compared to the NOAA values. A ratio greater than 1 indicates that the potential may exist for adverse effects in organisms exposed to sediments with the modelled chemical concentration.

Great Blue Heron
A summary of the potential risks associated with exposure of great blue heron to site contaminants due to ingestion of fish is presented in Table 6-18 in the RI (ESE, 1996). The EQs for this exposure pathway are less than 1 for all potential surface water contaminants, suggesting that

there is low potential for adverse effects to the great blue heron due to site-related chemicals in fish caught near the site.

Aquatic Receptors

Surface Water Organisms--A comparison of modeled surface water concentrations to federal and state ambient water quality criteria is presented in Table 6-19 in the RI (ESE, 1996). Acute surface water concentrations (i.e., groundwater concentrations assumed to be present at the groundwater-surface water interface) exceed federal AWQCs and/or Commonwealth of Virginia WQSs for arsenic, cadmium, chromium, copper, lead, nickel, selenium, silver, and zinc. Diluted surface water concentrations are less than the chronic federal AWQCs and Virginia WQSs for all chemicals evaluated. As groundwater chemical concentrations will be quickly diluted upon confluence with the Elizabeth River, acute impacts to surface water organisms in the river are not anticipated.

Benthic Organisms--A comparison of modeled sediment concentrations to NOAA sediment values is presented in Table 6-20 in the RI (ESE, 1996). Sediment IOC concentrations (i.e., concentrations modeled from site groundwater and present at the groundwater-sediment interface) exceed NOAA sediment benchmark values for antimony, arsenic, chromium, lead, and silver. Due to the industrialized nature of the site vicinity and the size of the Elizabeth River, the presence of significant benthic organisms and exposure of sediment organisms to significant amounts of site groundwater chemicals is not expected.

Terrestrial--The EQs associated with exposure of great blue heron to site contaminants due to ingestion of fish are all less than 1, suggesting that there is low potential for adverse effects to the great blue heron due to site-related chemicals in fish caught near the site.

Aquatic--The EQs for water- and sediment-dwelling aquatic organisms at QADSY are all less than 1, indicating that there is low potential for adverse effects to these aquatic organisms.

7.0 Description of Alternatives

No action for soil is necessary at the QADSY because:

- IOCs contamination appear to be inherited from the dredged material
- The QADSY is not conducive to an ecological environment because it is in a highly industrial area and is mostly a paved parking lot
- The present plans are for the unpaved area to be paved, which will subsequently eliminate this ecologic risk pathway

In the RA, potential carcinogenic risks and non-carcinogenic health risks were calculated. Conservative assumptions were used in calculating potential risks that weigh in favor of protecting human health and the environment.

Five alternatives were analyzed in the FS for their ability to protect human health and the environment, comply with legal requirements, and be cost effective.

The evaluations of capital costs, operation and maintenance (O&M) costs, net present worth costs, and implementation times presented below are estimates. Each alternative, except the No Action alternative, will include a provision for land use controls at the QADSY whether remedial activities take place or not. Implementation of land use controls will reduce the potential for future exposure to the remaining affected soil and restrict the construction of drinking water wells in the QADSY.

Under Alternatives 2 through 5, groundwater at the QADSY will be remediated to RGOs developed in the RA. Under Alternatives 2 through 5, groundwater monitoring will occur at the QADSY quarterly the first year, semi-annually the second and third years, annually the fourth and fifth years, then every 5 years thereafter until year 30. Monitoring well samples will be analyzed for VOCs.

7.1 Alternative 1 - No Action

The No Action alternative leaves the QADSY in its current condition. No remedial actions that result in the treatment, containment, or removal of affected soil are implemented under Alternative 1. The NCP requires the consideration of a No Action alternative. The No Action alternative is also used as a baseline for comparison with other remedial alternatives. This no remedial action alternative consists of implementing monitoring to determine access and exposure to contaminated groundwater. No remedial actions that result in the treatment, containment, or removal of the contaminated media will be implemented under this alternative. In addition, this alternative would require continuation of current water use restrictions.

The elements necessary to implement the no-action alternative follow:

- Installing two shallow and three deep monitor wells
- Collecting groundwater samples at 11 wells

- Additional contaminant transport modeling
- Periodically evaluating public health

Capital Costs	$ 35,000
Present Worth O&M	$ 28,500
Total Present Worth Costs	$884,200
Time to Construct	2 Months

7.2 Alternative 2 - Groundwater Collection, Treatment, and Onsite Discharge

Alternative 2 consists of the following elements:

- Locating and installing 33 extraction wells
- Constructing and operating a groundwater treatment system
- Locating and installing pressurized conveyance piping
- Locating a discharge point for treated water into Willoughby Bay
- Groundwater monitoring
- A detailed review of site conditions every 5 years

Capital Costs	$ 411,500
Present Worth O&M Costs	$ 136,250
Total Present Worth	$2,902,250
Time to Construct	6 months

7.3 Alternative 3 - Groundwater Collection, Pretreatment, and Offsite Treatment

Alternative 3 consists of the following elements:

- Locating and installing 33 extraction wells
- Constructing and operating a groundwater treatment system
- Locating and installing pressurized conveyance piping
- Pretreated by VOC volatilization by air stripping
- Effluent can be discharged to an Industrial Waste Treatment Plant (IWTP)
- Groundwater monitoring
- A detailed review of site conditions every 5 years

Capital Costs	$ 411,500
Present Worth O&M Costs	$ 318,400
Total Present Worth	$5,936,300
Time to Construct	9 months

This alternative consists of the same groundwater recovery and treatment system as Alternative 2. The contaminated groundwater will be pretreated by VOC volatilization by air stripping so that the effluent can be discharged to an IWTP, such as the Norfolk Naval Base Industrial IWTP, via pipeline. This alternative, therefore, eliminates the need for direct discharge to Willoughby Bay.

The contamination would be treated over a 3- to 12-year period, depending on the groundwater extraction rates. This estimate can vary significantly due to factors such as volume and velocity of groundwater flow, and extent and degree of contamination.

7.4 Alternative 4 - Collection/Onsite Treatment/Onsite Discharge/In-Situ Treatment

Alternative 4 consists of the following elements:

- Locating and installing 33 extraction wells
- Constructing and operating a groundwater treatment system
- Locating and installing pressurized conveyance piping
- Pretreated by VOC volatilization by air stripping
- Effluent can be discharged to an infiltration gallery
- Groundwater monitoring
- A detailed review of site conditions every 5 years

This alternative consists of the same groundwater recovery system (i.e., air stripping) as Alternative 2, but includes additional in-situ treatment by biological degradation to decrease remediation time. In addition to the recovery and treatment equipment outlined under Alternative 2, Alternative 4 will require installing and operating biologic nutrient and catalyst control units, infiltration gallery, and manifolds. As part of the design effort, a Biofeasibility study will be required. All treated water will be discharged into the surficial aquifer so that no water discharge to Willoughby Bay or Elizabeth River will occur.

Capital Costs	$ 503,750
Present Worth O&M Costs	$ 136,250
Total Present Worth	$2,963,700
Time to Construct	6 months

7.5 Alternative 5 - Air Sparging/Soil Vapor Extraction

Alternative 5 consists of the following elements:

- Locating and installing 30 AS wells
- Locating and installing 19 SVE wells
- Locating and installing pressurized conveyance piping
- Pretreated by VOC volatilization from the SVE wells to an air-water separator (AWS) (vapor removal) and then through an activated carbon vessel by air stripping
- Condensed water vapor removed by the AWS will be piped through an air stripper and an activated carbon vessel before it is discharged to a surface storm drain
- Groundwater monitoring
- A detailed review of site conditions every 5 years

An alternative discussed with LANTDIV will position the AS and SVE wells on the downgradient edge of the plume paralleling the waterfront. This arrangement will provide a remediation zone prior to groundwater discharge to the Elizabeth River. The system at the FP would consist of approximately 22 AS wells and 13 SVE wells. A total of 30 AS and 19 SVE wells will be required to effectively remediate the two existing plumes.

Capital Costs	$1,269,500
Present Worth O&M Costs	$ 264,400
Total Present Worth	$6,401,118
Time to Construct	6 months

8.0 Summary of the Comparative Analysis of Alternatives

In accordance with the provisions set forth in CERCLA, SARA, and the NCP, each of the alternatives was evaluated against nine established criteria. Overall protection of human health and the environment and attainment of applicable or relevant and appropriate requirements (ARARs) are threshold criteria and the primary objectives of a remedial action. In addition, the selected remedial alternative must reflect the best balance among criteria such as reduction of nitroaromatic compounds; short- and long-term effectiveness; implementability; and cost. Support agency and community acceptance are also considered during the evaluation. These nine criteria are as follows:

Threshold Criteria

- **Overall Protection of Human Health and the Environment** determines whether an alternative eliminates, reduces, or controls threats to human health and the environment.

- **Compliance with ARARs** evaluates whether the alternative meets federal and state environmental laws pertaining to the site.

Balancing Criteria

- **Long-term Effectiveness and Permanence** considers the ability of an alternative to protect human health and the environment over time.

- **Reduction of Toxicity, Mobility, or Volume Through Treatment** evaluates an alternative's use of treatment to reduce the harmful nature of contaminants, their ability to move in the environment, and the amount of contamination present.

- **Short-term Effectiveness** considers the length of time needed to implement an alternative and the risks it poses for workers, residents, and the environment during implementation.

- **Implementability** considers the technical and administrative feasibility of implementing an alternative.

- **Cost** evaluates estimated capital and O&M costs, as well as present-worth costs.

Modifying Criteria

- **State Acceptance** considers whether the state agrees with the recommendations as presented in the RI/FS and the Proposed Plan.

- **Community Acceptance** considers the public's response to the alternatives described in the FS and the Proposed Plan. Specific responses to public comments are contained in the Responsiveness Summary attached to this DD.

The five alternatives for groundwater are compared under the various evaluation criteria, profiling the performance of the alternatives against the nine criteria. A summary of this comparison is provided in Table 1.

8.1 Overall Protection of Human Health and the Environment

Alternatives 2, 3, 4, and 5 will provide adequate protection to human health and the environment following contaminated groundwater treatment. Once treatment is completed, the risk to human health will be the same as the risk associated with background levels that currently exist at the site. Contaminants will be completely destroyed, providing overall protection to the environment.

Alternative 1 will provide protection to human health by eliminating exposure to groundwater; however, the alternative will not be protective of the environment because contaminants will remain in place.

8.2 Compliance with ARARs

Alternatives 2 through 5 will all meet chemical-specific ARARs following completion of the treatment phase. Alternative 1, however, will not meet ARARs because no remediation of the contaminants will occur and VDEQ exceedances will still exist in the upper aquifer. Treated groundwater under Alternative 2 will be discharged into Willoughby Bay at levels below chemical-specific ARARs.

Action-specific ARARs will also be met by Alternatives 2 through 5. Alternatives 2 through 4 are not expected to exceed action-specific ARARs for air emissions from the air stripping towers. Alternative 5 is not expected to exceed action-specific ARARs for air emissions from the VES. Alternative 2 will meet ARARs for surface water discharges, and Alternative 4 should meet ARARs for treated groundwater infiltration.

8.3 Long-Term Effectiveness

The alternatives, except the no-action alternative, remove contaminants from the site and do not leave any untreated waste or residuals that require managing to ensure an adequate level of protection.

The no-action alternative will effectively reduce the potential for exposure to contaminants but will not eliminate exposure over the long term. This alternative leaves the contaminants in place and requires management beyond the implementation phase.

8.4 Reduction of Mobility, Toxicity, and Volume Through Treatment

Alternative 4 will provide the greatest degree of contaminant destruction and therefore the greatest degree of mobility, toxicity, and volume reduction. Alternatives 2 and 3 will also provide a similar reduction. However, Alternative 4 provides a greater degree of volume and mobility reduction due to the additional in-situ treatment of the VOCs in the area influenced by the extraction wells.

Alternatives 2 through 4 provide hydraulic control of the Aquifer.

Alternative 5, through the removal of contaminants, vapors, and extraction of air will provide a quick reduction in contaminant volume and therefore provide control of mobility, toxicity, and volume of contaminated groundwater.

Alternative 1 does not consist of any containment, collection, or treatment actions and will not reduce the mobility, toxicity, or volume of contaminants in the groundwater.

8.5 Short-Term Effectiveness

Alternatives 2 through 5 are more effective in reducing aquifer contamination than the no remedial action alternative. In alternatives 2 through 4, this is because contaminated groundwater is extracted from the surficial aquifer, treated, and discharged by three different means: surface water, WTP, and infiltration gallery. Alternative 5 effectively treats the contamination from the groundwater prior to discharge to the atmosphere. However, the no-action alternative may be equally effective in reducing exposure to contaminants if current water and land use restrictions are maintained.

Alternatives 2 through 4 will have onsite emissions from air stripping and/or onsite discharge of treated water. Alternative 5 will have onsite emissions from vapor extractions. Alternative 1 will not affect the current exposure to workers and the community because no contaminated groundwater extraction will occur.

Alternative 4 will achieve remedial objectives quicker than Alternatives 2 and 3. The relative remedial rates cannot be determined until the completion of a Bioremediation/biological degradation/biological feasibility study is conducted.

Alternative 5 does not include extraction of groundwater and has the least likelihood of uncontrolled contaminant release.

Alternative 1 will not meet the remedial response objectives over time.

8.6 Implementation

All of the remediation alternatives for groundwater are technically feasible. Each alternative can be constructed and operated on reliable technologies that are both effective and proven. Alternatives 2 through 4 involve standard extraction and wastewater treatment processes with monitored discharge or disposal. The exception is Alternative 4, infiltration gallery with microbial degradation. However, until a biological treatability study is performed, the actual degradation rate and system parameters are unknown. Further, the operational permit process for the infiltration gallery is not well defined.

The no-action alternative for groundwater is easiest to implement because water and land use restrictions are already in place, and long-term groundwater monitoring and surface water runoff monitoring are easy to put in operation.

Implementation of the remediation alternatives from an administrative standpoint is not estimated to be a major concern because the QADSY is on Navy property. It is also surrounded by Navy property so rights-of-way and easements should not be a problem. Permits from the Virginia regulatory agencies will be required for any air emissions from stripping towers.

8.7 Cost

Present worth cost is provided in Table 12-3 in the FS (ESE, 1996). Alternative 5 has the highest capital cost and the highest present worth.

The present worth costs were calculated by considering the replacement of the capital expenditure items at half the performance period for those alternatives that have performance periods greater than one year. Alternative 5 demonstrates the greatest sensitivity to the replacement cost because the capital expenditures are a greater portion of the alternative's present worth cost. There are no additional costs associated with implementing No Further Action. Alternatives 1 is the least costly of the alternatives. However, Alternative 1 provides no active remediation processes.

Active remedial processes associated with Alternative 2 consist of groundwater pumping and treating of VOCs and discharging to the storm drain. Alternative 3 and 4 discharges the treated water to IWTP and a infiltration gallery, respectively. Of the remaining alternatives that do provide for active remediation processes (Alternatives 2 through 4), Alternatives 2 and 4 are similar in cost ranging from $2.9 million for Alternative 2 and $2.96 million for Alternative 4. Alternative 3 is the most costly of the alternatives at $5.9 million.

Each of the Alternatives 2 through 4 meet the criteria for protection of human health and the environment, and are accepted by the state as viable treatment alternatives. In addition, each of these alternatives also meet the requirements for compliance with ARARs; long- and short-term effectiveness; implementability; and the reduction of mobility, toxicity, and volume (MTV) for the VOCs. Based on this evaluation, Alternative 5 is the most cost effective of the alternatives that meet the seven threshold criteria.

8.8 State Acceptance

USEPA and VDEQ concur with the implementation of AS/SVE of groundwater at the QADSY.

8.9 Community Acceptance

The community concurs with the implementation of AS/SVE of groundwater at the QADSY.

Table 1. Remedial Alternative Evaluation Summary

	No Further Action 1	Groundwater Collection, Treatment, and Onsite Discharge 2	Groundwater Collection, Pretreatment, and Offsite Treatment 3	Groundwater Collection/ Offsite Treatment, Onsite Discharge, In-Situ Treatment 4	Air Sparging/Soil Vapor Extraction 5
Protective of Human Health and Environment			✓	✓	✓
Complies with ARARs			✓	✓	✓
Long-Term Effectiveness			✓	✓	✓
Reduction of Mobility			✓	✓	✓
Reduction of Toxicity			✓	✓	✓
Reduction of Volume			✓	✓	✓
Short-Term Effectiveness		✓	✓	✓	✓
Implementability	✓	✓	✓	✓	✓
Cost ($M)	0.8	2.9	5.9	2.95	6.4
Public Acceptance		✓	✓	✓	✓
State Acceptance			✓	✓	✓

9.0 Selected Remedy

Based on careful consideration of the technical, environmental, institutional, public health, and cost criteria, and in keeping with the overall response strategy, the preferred alternative is Alternative 5. Alternative 5 consists of implementing an AS/SVE system, performing periodic groundwater monitoring, and a review of site conditions every 5 years.

9.1 Remediation Goals

SARA requires that remedial actions attain a degree of contaminant cleanup that ensures protection of public health and the environment. Thus, the risk characterization results are used to identify whether site COPCs need to be reduced to acceptable health-based levels. The acceptable health-based levels are referred to as RGOs, which are chemical-specific concentration goals for individual chemicals for specific medium and reasonable land use combinations.

Based on the results of the risk characterization, future worker exposure to indoor air and future residential exposure to indoor air and soil resulted in a cumulative risk exceeding 10^{-4} and/or an HI exceeding 1. However, to provide a complete site analysis, RGOs are developed for all chemicals contributing an individual risk of at least 10^{-6} to a total of greater than 10^{-4} or on HI of at least 0.1 to a total HI of greater than 1. Ecological risk characterization results indicated that several IOCs in soil produced an excess EQ in mice and raccoon; therefore, RGOs were developed for these IOCs in soil based on these two receptors. In summary, RGOs are developed for the following chemicals to provide risk managers with the maximum risk-related media level options on which to develop remediation aspects of the FS:

Medium Scenario RGO	RGOs COCs
Groundwater	
Future Worker	
Carbon tetrachloride	2.7 µg/l
chloroform	11.1 µg/l
1,1-dichloroethene	0.38 µg/l
tetrachloroethene	59.6 µg/l
trichloroethene	48.9 µg/l
vinyl chloride	0.08 µg/l
Future Resident	
Carbon tetrachloride	1.8 µg/l
chloroform	7.4 µg/l
1,1-dichloroethane	540 µg/l
1,1-dichloroethene	0.26 µg/l
tetrachloroethene	38.9 µg/l
1,1,1-trichloroethane	3790 µg/l
trichloroethene	32.6 µg/l
vinyl chloride	0.05 µg/l
Soil	
Future Resident	
Thallium	12.5 mg/kg

The QADSY is located in a highly industrial area at the Norfolk Naval Base in Norfolk, Virginia. The future plan at the QADSY is to increase the fleet ship parking by paving the current 5-acre gravel area. There are no future building plans although the recommended remedial action objectives are for the future worker. The future resident scenario is highly unlikely because of the location of the QADSY.

9.2 Detailed Description of the Selected Remedy

AS/SVE address VOC-impacted groundwater via in-situ remediation. AS acts as a subsurface air stripper to volatilized dissolved VOCs in the groundwater. The AS system include AS wells and an air compressor. The SVE will collect the vapors as they migrate to the vadose zone. A minimal amount of groundwater is entrained and collected with the vapor. The collected water and vapor will be separated and treated via carbon adsorption technology. The primary components of the SVE system will include SVE wells, an AWS, a liquid-phase carbon unit, and a vacuum pump. A building may be required to house the various mechanical/electrical components of the system.

9.2.1 AS

The AS process involves injection of air into the water table (Columbia) aquifer to create a subsurface air stripper that will volatilize the dissolved impacted groundwater. The natural aerobic biodegradation process will be enhanced by the AS process due to the addition of air and oxygen to the aquifer.

The AS system will utilize a network of air injection points constructed of horizontal and/or vertical wells installed below the impacted groundwater. The AS wells will be spaced to have overlapping zones of influence. Air will be injected in the wells and exits through the well screen, moving outward and upward through the saturated zone. The AS wells will be connected to a compressor or blower that will supply the air.

9.2.2 SVE

SVE involves a vacuum applied to soil extraction wells that are installed in the vadose zone. The vacuum creates a pressure gradient that induces volatile contaminants in the vadose zone to be volatilized and transported through the soil to the SVE wells. SVE also promotes in-situ biodegradation of contaminants.

Groundwater monitoring will be conducted using 20 monitor wells on the following schedule: quarterly during the first year, semiannually during the second and third years, annually during the fourth and fifth years, and every fifth year thereafter.

The estimated capital cost of the selected remedy is $1,269,500. The estimated present worth O&M cost is $4,278,890, and the estimated net present worth cost is $6,401,118. These costs are detailed in Table 2.

9.3 Rationale for Selection

After careful consideration of the technical, environmental, institutional, public health, and cost criteria, the recommended remedial action alternative for the QADSY is Alternative 5 (AS/SVE). Implementation of Alternative 5 will achieve the remedial action objective for the QADSY by minimizing the potential human health and ecological risks associated with site contaminants present in the groundwater above remediation goals.

All of the remediation alternatives for groundwater are technically feasible. The actual degradation rate and system parameters are unknown until a biologic treatability study is performed for Alternatives 4 and 5.

AS and SVE wells will be placed on the downgradient edge of the plume paralleling the waterfront. This arrangement will provide a remediation zone prior to groundwater discharge to the Elizabeth River. A small-scale pilot test will be conducted to develop design parameters for a full-scale AS/SVE system.

Given the installation-specific conditions discussed above, AS/SVE will be protective of human health and the environment. Therefore, AS/SVE is the recommended remedial alternative for the QADSY.

Although not the least costly alternative, Alternative 5 provides sufficient protection of public health and the environment and substantially complies with federal and state environmental statutes. This alternative provides for active treatment of affected groundwater. This alternative also provides comparable environmental and public health protection as the other alternatives considered through elimination of potential risks associated with direct contact by humans and animals. This alternative meets USEPA's statutory preference for treatment, and is also acceptable to VDEQ.

CERCLA Section 120(h)(3)(B) requires that, if the property is sold or transferred, each deed contain language stating that action to protect human health and the environment has been taken before the date of property transfer.

Table 2. Estimated Costs of Selected Remedy - Alternative 5

	Estimated Cost
Treatment Component	
Mobilization	$30,000
AS/SVE Well Installation	$240,000
Treatment System	$930,700
Indirect Costs (e.g., Survey, Well Locating)	$8,800
Subtotal Capital Costs	$1,209,500
Engineering	$60,000
Total Capital Cost	$1,269,500
Operations and Maintenance Costs	
Groundwater monitoring (quarterly first year, through third year, biannually fourth and fifth year, annually after five years thereafter)	$17,800
Treatment System Maintenance	$4,278,890
Contingency	$834,928
Total Costs	**$6,401,118**
Net present worth using a 5 percent discount value for 30 years	$6,081,062

10.0 Statutory Determinations

To comply with the requirements of Section 121 of CERCLA, as amended by SARA, the selected remedy must satisfy the following statutory requirements:

- Protect human health and the environment
- Comply with ARARs
- Be cost effective
- Utilize permanent solutions and alternative treatment or resource recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment as a principal element, or provide an explanation as to why this preference is not satisfied

The implementation of Alternative 5 satisfies the requirements of CERCLA, as amended by SARA, as detailed below.

10.1 Overall Protection of Human Health and the Environment

Implementation of Alternative 5 will provide for the overall protection of human health and the environment at the QADSY. The results of the RA indicated that, for the future commercial use scenario, groundwater at the QADSY poses an elevated carcinogenic (risk is 9E-04) and non-carcinogenic risks (HI of 4). The QADSY is located in a highly industrial area at the Norfolk Naval Base in Norfolk, Virginia. The future plan at the QADSY is to increase the fleet ship parking by paving the current 5-acre gravel area. There are no future building plans although the recommended remedial action objectives are for the future worker. The future resident scenario is highly unlikely because of the location of the QADSY (refer to Section 4.0 of this document for a description of this RA). This RA showed that under a worker exposure scenario, potential risks to human health are within the acceptable range. The QADSY will use the future commercial scenario for its preferred alternative selection.

Of those complete exposure pathways evaluated in the RA (ESE, 1996), groundwater treatment will eliminate the human exposure pathways of inhalation from a future building located at the QADSY. Therefore, by remediating groundwater above remediation goals, any potential unacceptable risks from the affected groundwater to human health and the environment will be mitigated, thus attaining the protective benchmarks of 1.0E-06 and HI/ERI $<$ 1.

10.2 Compliance with ARARs

The selected alternative will comply with federal and state ARARs. A listing of ARARs associated with the selected alternative is found in Appendix O of the RI/FS (ESE, 1996). The following ARARs will be attained.

Chemical-specific--Shallow groundwater at the QADSY is not currently used for drinking water nor will it be used in the foreseeable future because of a City of Norfolk Ordinance that prohibits water table wells for potable water.

Location-specific--The Endangered Species Act and Migratory Bird Treaty will be met under this alternative by implementing proper procedures to protect wildlife during remediation of groundwater. Efforts will be made during excavation and construction of the soil staging area to minimize any adverse effects on potential wetlands to comply with Executive Order 11990-Protection of Wetlands and Section 404 of the Clean Water Act. This alternative will be compatible with the major purposes for which the refuge was established under the National Wildlife Refuge System Act (NWRSA) including development and disposition consistent with the needs of agriculture, industry, recreation, and wildlife conservation.

Action-specific--Active remediation of groundwater will be implemented through AS/SVE to RGOs calculated in the RA. This alternative will be designed to fulfill action-specific ARARs for the site and for the future worker.

10.3 Cost Effectiveness

Although not the least costly alternative, Alternative 5 provides sufficient protection of public health and the environment and substantially complies with federal and state environmental statutes. This alternative provides comparable environmental and public health protection as the other alternatives considered through elimination of potential risks associated potential future plans for a building. The risks are from incidental ingestion and direct contact with site soils; inhalation of vapors volatilized from groundwater into indoor air.

10.4 Use of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

Alternative 5 represents the maximum extent to which permanent solutions can be utilized at the QADSY and still remain cost effective. Although Alternatives 2 through 4 each are protective of human health and the environment and comply with ARARs, Alternative 5 was selected as the remedy that will provide the greater balance of long-term effectiveness; implementability; reduction of toxicity, mobility, or volume; and cost.

An AS/SVE pilot study will be conducted during the initial installation of the system. The AS/SVE pilot study will calculate the actual zone of influence for AS/SVE well placement.

10.5 Preference for Treatment as a Principal Element

AS/SVE is considered a reliable treatment method to remediate VOC-impacted groundwater. In-situ air stripping by AS/SVE of VOCs under Alternative 5 meets the statutory requirement for treatment as a principal element.

In summary, the selected remedy for the QADSY is protective of human health and the environment, complies with federal and state environmental requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost effective. This remedy uses permanent solutions, to the maximum extent practicable. The statutory preference for treatment as a principal element of the remedy will be met. Because the remedy will result in hazardous substances remaining onsite, a review will be conducted within 5 years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

11.0 References

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Appendix A

Glossary of Terms

GLOSSARY OF TERMS

Administrative Record: A file that contains the information used to make a decision on the selection of a response action under CERCLA. The file is established at or near a site and is available for public review.

Ambient Water Quality Criteria (AWQC): USEPA designated limits for toxic chemicals in surface waters. The levels are set to protect plant, fish, and animal habitats in the areas surrounding the surface waters.

Applicable or Relevant and Appropriate Requirements (ARARs): Any state or federal law or regulation that pertains to the protection of human health and the environment in addressing certain site conditions or using a particular cleanup technology at a site.

Background Concentrations: Naturally occurring chemicals present in air, water, or soil in concentrations which would normally be expected.

Base/Neutral Acid Extractable Compounds (BNAs): Chemicals detected using a laboratory procedure designed to determine the concentration of semi-volatile organic compounds.

Berm: An earthen, concrete, or other man-made barrier used to keep liquids from flowing into or out of an enclosure.

Bioaccumulation: The build-up of toxic chemicals in living things.

Carcinogenic: Term used to describe chemicals or substances that are known or suspected to cause cancer in humans based on observed health effects in humans or existing data from animal laboratory tests.

Characteristically Hazardous Waste: A waste material that exhibits certain potentially hazardous characteristics such as flammability, toxicity, corrosivity, and reactivity or contains levels of certain chemicals, as designated by federal regulations.

Constituents of Concern or Contaminants of Concern: Site-related chemicals that pose critical health concerns to human or environmental receptors because of their toxicity and potential for exposure. Although many chemicals at a site may pose a potential risk to human health and the environment, constituents of concern represent those chemicals that contribute the majority of potential risk.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): A federal law enacted in 1980 and subsequently modified by the Superfund Amendments and Reauthorization Act of 1986 (SARA). This act resulted in the creation of a trust fund, commonly known as "Superfund," which provides money to investigate and clean up abandoned or uncontrolled hazardous waste sites.

Critical Toxicity Values (CTVs): A term used to describe the level of toxicity to ecological receptors in terms of acceptable daily intake.

Detection Limits: The lowest concentration of a chemical that laboratory instruments or methods can detect.

Dose-Response: The concept in that the physiological affect (the response) is directly related to the level of chemical intake (the dose) by a living thing.

Ecological Risk Index (ERI): A calculated value used to quantify potential risks to plants and animals due to the presence of constituents of concern. The index value is calculated by dividing the estimated chemical exposure concentrations with the critical toxicity values (CTV). An ERI greater than 1.0 is considered to represent an potential unacceptable risk.

Exposure Pathways: The routes by which chemicals reach receptors. These routes may include (for example) drinking groundwater or inhaling windblown dust.

Feasibility Study (FS): A study that selects a remedial action at a site. through a series of evaluation steps. The FS identifies, develops, and evaluates several alternatives for addressing contamination.

Groundwater: Water that is present in the open spaces between soil particles (silt, sand, gravel) and/or rock fractures below the ground surface.

Hazard Index (HI): An indicator of the potential for a hazardous substance to cause noncancerous health effects in humans. The HI is calculated by dividing estimated human exposure concentrations by exposure levels that USEPA has determined to be acceptable. Any result of this calculation that is greater than 1.0 is considered to represent a potential unacceptable risk.

Hydrogeology: The study of groundwater and aquifers.

Indicator Species: Those species from the list of potential ecological receptors that appear to be at greatest risk from exposure to potential constituents of concern.

Information Repository: A location where documents and data related to a site investigation and response actions are maintained to allow the public access to this material.

Land Use Controls: Management of a property in a manner that minimizes the potential exposure of hazardous substances to the public. For example, placing restrictions on the use of groundwater at a site.

Lowest-Observed-Effect Level (LOEL): The lowest concentration of a constituent of concern at which an adverse effect is observable.

Milligrams per Kilogram (mg/kg): A unit of measure used to show concentrations of chemicals in dry materials such as soil, sediment, or sludge. This unit (mg/kg) is equal to parts per million. As a conceptual example, 1 mg/kg is equivalent to one dollar in a stack of one million dollars.

Milligrams per Liter (mg/L): A unit of measure used to show concentrations of chemicals in liquid materials such as groundwater and surface water.

Mobility, Toxicity, and Volume (MTV): Three indicators of chemical presence and movement in the environment. These indicators are used to assess the current and future concentrations of chemicals in the environment and determine how harmful these chemicals may be to human health and the environment.

Monitoring Well: A well installed for the purpose of collecting samples of groundwater to be analyzed for chemicals. A monitoring well is a permanent structure that can be sampled repeatedly over an extended period to track chemical concentrations.

National Oil and Hazardous Substances Pollution Contingency Plan (NCP): A federal regulation that outlines the procedures that must be followed under the Superfund Program. The NCP was most recently revised in 1990.

National Priorities List (NPL): USEPA's list of the most serious uncontrolled or abandoned waste sites identified for possible long-term remedial response actions.

Non-carcinogenic: The term used to describe chemicals or substances that are not known or suspected to cause cancer in humans. This term generally refers to chemicals that may not cause cancer, but potentially produce other unwanted health effects.

No-Observed-Effect Level (NOEL): The concentration of a constituent of concern that results in no observable effect on an ecological system.

Organic Constituents: Chemical compounds composed primarily of carbon, including materials such as solvents, oils, and pesticides.

Polychlorinated Biphenyls (PCBs): A group of organic compounds related by their basic chemical structure. They are highly resistant to degradation, but have a tendency to be retained in body tissue. Due to their efficient electrical conductivity properties, they were widely used in capacitors, transformers, and other products in the U.S. before 1980.

Practical Quantitation Limits (PQLs): A value equal to 10 times the detection limit that reflects the value above which a chemical can be quantified with acceptable confidence.

Preferred Alternative: The remedial alternative initially proposed for implementation as a result of the screening process conducted during the FS.

Present Worth Cost: An economic term used to describe today's cost for a Superfund cleanup and reflect the discounted value of future costs. A present value cost estimate includes construction and future operation and maintenance costs.

Receptor: A human, animal, or plant that could potentially receive exposure to chemicals migrating from or present at hazardous waste sites.

Record of Decision (ROD): A legal document that describes in detail the remedy selected for an entire NPL site or a particular operable unit. The DD summarizes the results of the RI/FS and includes a formal response to comments supplied by the public.

Reference Dose (RfD): The daily acceptable level of constituents of concern intake. This number is used to estimate potential for non-carcinogenic effects.

Remediation Goals: Remedial action objectives and remediation goals are the target cleanup levels for chemicals at a contaminated site.

Remedial Investigation (RI): A study that supports the selection of a remedial action at a Superfund site. The RI identifies the nature, magnitude and extent of contamination associated with a Superfund site.

Resource Conservation and Recovery Act of 1976 (RCRA): The federal law that establishes a regulatory system that governs procedures to be used in generating, storing, transporting, treating, and disposing of hazardous waste.

Responsiveness Summary: Comments presented during the public meeting and received during the public comment period that are considered and addressed by the lead agency.

Risk Assessment (RA): The process whereby risks to human health and the environment are quantitatively evaluated. This information is used to determine whether remedial actions are necessary. The BRA is conducted during the Remedial Investigation/Feasibility Study.

Risk Assessment Guidance for Superfund (RAGS): A document produced by the USEPA as a guide for conducting risk assessments under Superfund.

Sediment: Soil and other material that settles to the bottom of a stream, creek, or lake.

Semi-Volatile Organic Compounds (VOCs): Semi-VOCs are organic chemicals that vaporize less readily than VOCs. These compounds include many polynuclear aromatic hydrocarbons and pesticides.

Slope Factor (SF): A number used to estimate the probability of potential carcinogenic effects.

Superfund Amendments and Reauthorization Act of 1986 (SARA): This act modified specific provisions in CERCLA.

Surface Water: Water on the earth's surface such as streams, ponds, and lakes.

To Be Considered (TBC) Value - State advisories, guidance, non-binding guidelines, or other standards that are not legally binding that may be considered when fashioning a protective remedy for a site.

Toxicity Characteristic Leaching Procedure (TCLP): USEPA approved laboratory procedure used to determine if a waste material is characteristically hazardous.

Toxicity Value: Used to indicate the level of toxicity of the constituents of concern at the site.

Uncertainty Factor: A measure of the uncertainty inherent in assumptions made in risk assessments.

Volatile Organic Compounds (VOCs): Organic liquids that readily evaporate under atmospheric conditions and exhibit varying degrees of solubility in water. Examples of VOCs include benzene and xylenes.