RECORD OF DECISION

WASTE OIL DUMP

NASA Wallops Flight Facility
Wallops Island, Virginia

National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility

March 2008

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ACRONYMS AND ABBREVIATIONS

µg/L	microgram per liter
AAOC	Administrative Agreement on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
AS	air sparging
bgs	below ground surface
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	CERCLA Information System
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	chemical of potential concern
CSM	Conceptual Site Model
DEQ	Department of Environmental Quality
EPA	United States Environmental Protection Agency
ERA	ecological risk assessment
ESD	Explanation of Significant Differences
FS	Feasibility Study
GSFC	Goddard Space Flight Center
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
LUC	land use control
MCL	Maximum Contaminant Level
MTBE	methyl tert-butyl ether
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
O&M	operation and maintenance
ORC	oxygen release compound
ORP	oxidation reduction potential
PA	Preliminary Assessment
PCB	polychlorinated biphenyl
RAO	remedial action objective
RfC	reference concentration
RfD	reference dose
RI	Remedial Investigation

ACRONYMS AND ABBREVIATIONS (Continued)

ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SF	slope factor
SI	Site Inspection
SVOC	semivolatile organic compound
TAL	Target Analyte List
TCL	Target Compound List
TOC	total organic carbon
TPH	total petroleum hydrocarbons
UCL	upper confidence limit
VAC	Virginia Administrative Code
VOC	volatile organic compound
WFF	Wallops Flight Facility
WOD	Waste Oil Dump

1.0 DECLARATION

1.1 SITE NAME AND LOCATION

Waste Oil Dump
NASA Wallops Flight Facility
Wallops Island, Virginia
CERCLIS ID No. VA8800010763

1.2 STATEMENT OF BASIS AND PURPOSE

This decision document presents the Selected Remedy for the Waste Oil Dump (WOD or Site) at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) Wallops Flight Facility (WFF) in Accomack County, Virginia. The Selected Remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, 42 U.S.C. Section 9601 et seq., and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300. This decision is based on the Administrative Record file for this Site.

NASA and the United States Environmental Protection Agency (EPA) jointly selected the remedy, and the Virginia Department of Environmental Quality (DEQ) concurs with the Selected Remedy.

1.3 ASSESSMENT OF THE SITE

The response action selected in this Record of Decision (ROD) is necessary to protect the public health and welfare and the environment from actual or threatened releases of hazardous substances into the environment.

1.4 DESCRIPTION OF SELECTED REMEDY

The WOD is one of the sites currently subject to the EPA/NASA Administrative Agreement on Consent (AAOC) (EPA Docket No. RCRA-03-2004-0201TH). Separate investigations and assessments are being conducted for other sites in accordance with the AAOC and CERCLA. Therefore, this ROD only applies to the WOD.

The Selected Remedy for the WOD consists of in-situ biological treatment (biostimulation), institutional controls, and monitoring. The Selected Remedy consists of the following major components:

- Injecting oxygen-releasing compounds into the groundwater contaminant plume to promote in-situ biological treatment (biostimulation).

- Implementing institutional controls to prevent the use of groundwater for drinking purposes until clean-up levels have been met.

- Monitoring groundwater to confirm the effectiveness of treatment and evaluate potential contaminant migration.

1.5 STATUTORY DETERMINATIONS

The Selected Remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action, is cost-effective, and utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable.

The remedy also satisfies the statutory preference for treatment as a principal element of the remedy (i.e., reduces toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment).

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on Site above levels that allow for unlimited use and unrestricted exposure, 5-year reviews will be required for this remedial action, until clean-up levels are achieved.

1.6 ROD CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD:

- Chemicals of concern (COCs) and their respective concentrations.

- Baseline risk represented by the COCs.

- Clean-up levels established for COCs and the basis for these levels.

- How source materials constituting principal threats are addressed.

- Current and reasonably anticipated future land use assumptions and current and beneficial uses of groundwater used in the baseline risk assessment and ROD.

- Potential land and groundwater use that will be available at the Site as a result of the Selected Remedy.

- Estimated capital, annual operation and maintenance (O&M), and total present-worth costs, discount rate, and number of years over which the remedy cost estimates are projected.

- Key factor(s) that led to selecting the remedy (i.e., how the Selected Remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision).

Additional information can be found in the Administrative Record file for this Site.

1.7 AUTHORIZING SIGNATURES

John H. Campbell ______________________ 3/30/08 ______________

Dr. John H. Campbell — Date

Director Wallops Flight Facility

Abraham Ferdas ______________________ 4/28/08 ______________

Abraham Ferdas, Director — Date

Waste and Chemicals Management Division

U.S. EPA Region 3

James Burke ______________________ 4/30/08 ______________

James Burke, Director — Date

Hazardous Site Cleanup Division

U.S. EPA Region 3

2.0 DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND DESCRIPTION

WFF is located in Accomack County on the eastern shore of Virginia (Figure 2-1). The WFF is comprised of three separate areas: the Main Base, the Mainland, and Wallops Island. The Main Base is the most heavily developed area. The Main Base is bordered to the east by extensive marshland and creeks that drain to the Chincoteague Bay and inlet. Little Mosquito Creek, which eventually flows eastward into the inlet and the Atlantic Ocean, borders the Main Base to the north and west. State Routes 175 and 798 form the southern and southeastern borders of the WFF (Figure 2-2). The Mainland and Wallops Island are located several miles south of and are not contiguous with, the Main Base. The EPA identification number for the WFF is VA8800010763.

NASA is the lead agency for site activities at the WFF. EPA is the lead regulatory agency, and DEQ is the support agency. Funding is provided by NASA.

The WOD, the Site for which this ROD is being issued, is an open area located on the north side of the WFF Main Base at the northern end of Runway 17-35 on a peninsula-like feature adjacent to Little Mosquito Creek (Figure 2-3). The southern portion of the Site is relatively flat and grass-covered. The northern portion of the Site is covered with brush and tall grass and slopes to the north and east, with slopes ranging from 1 to 3 percent. The northern, eastern, and western boundaries of the Site are steeply sloped.

2.2 SITE HISTORY AND ENFORCEMENT ACTIONS

2.2.1 <u>Site History</u>

The WOD was reportedly used for disposal of waste oils and possibly solvents from the 1940s through the 1950s. Reportedly, the Site was used for disposal of excess waste oil that could not be used for fire fighting training activities. No records are available to determine the types and quantities of materials disposed or the duration of this activity at the Site. A review of aerial photographs from 1943 through 1994 indicated the presence of ground scarring and possible excavation at the WOD from 1943 to 1961.

2.2.2 Previous Investigations, Removal Actions, and Enforcement Actions

Environmental actions began at the WOD in 1986 when the Commonwealth of Virginia conducted an inspection and identified the presence of waste (reported as waste oil) on the surface of the Site. NASA removed approximately 180 cubic yards of contaminated soil from four separate areas of the Site in November and December 1986.

A Preliminary Assessment (PA) consisting of interviews, review of historical records, and a site visit was conducted in 1988.

A Site Inspection (SI) was conducted from 1989 through 1992. Field activities included soil-gas surveys, monitoring well installation, and sampling and analysis of soil, groundwater, and sediment.

In 1997, a monitoring well was installed in the WOD and sampled as a background well for investigations being conducted at Site 15, which is located west of the WOD.

A Remedial Investigation (RI) was conducted from 1998 through 2000 and included a review of historical data, a geophysical survey, installation of temporary and permanent monitoring wells, and sampling and analysis of soil and groundwater.

A Supplemental RI field investigation was conducted in 2003. Field activities included monitoring well installation and sampling and analysis of soil and groundwater.

No other enforcement activities, removal actions, or remediation activities have been initiated at the WOD.

2.3 COMMUNITY PARTICIPATION

The Supplemental RI Report, Feasibility Study (FS) Report, and Proposed Plan for the WOD at the NASA WFF were made available to the public. The Supplemental RI Report was made available in June 2004, the FS Report was made available in October 2005, and the Proposed Plan was made available in February 2007. These documents can be found in the Administrative Record file and the Information Repositories maintained at the Eastern Shore Public Library (23610 Front Street, Accomack, Virginia 23301) and Island Library (4077 Main Street, Chincoteague, Virginia 23336). The notice of availability of these documents was placed in the Chincoteague Beacon and Eastern Shore News on February 8 and 14, 2007, respectively. A public comment period on the Proposed Plan was held from February 14, 2007 to March 15, 2007. In addition, a public meeting was held on March 01, 2007 to present the Proposed

Plan to a broader community audience than those who had already been involved at the Site. At this meeting, representatives from NASA, EPA, and DEQ were present to answer questions about the Site and the remedial alternatives. No comments were received during the comment period as noted in the Responsiveness Summary section of this ROD.

2.4 SCOPE AND ROLE OF RESPONSE ACTION

The WOD is one of the sites currently included in the NASA/EPA AAOC. The Selected Remedy is the final remedial action for the WOD under CERCLA. The function of the remedy is to reduce risks to human health and the environment associated with exposure to contaminated groundwater. There were no unacceptable risks to human health or the environment associated with exposure to soil, surface water, or sediment.

The potential exposure to shallow groundwater contamination under a hypothetical future residential exposure scenario constitutes the principal risk to human health. The lifetime carcinogenic risk is estimated to be 3.8E-04. There are no unacceptable risks to ecological receptors. Although shallow groundwater is contaminated, the contamination is not affecting public drinking water supplies or nearby surface water. The purpose of the remedial action is to prevent future potential exposure to contaminated shallow groundwater.

Separate investigations and assessments are being conducted for the other sites at the WFF in accordance with CERCLA and the AAOC. Therefore, this ROD only applies to the WOD. Separate RODs or other CERCLA decision documents have been or will be prepared for the other sites subject to the AAOC.

2.5 SITE CHARACTERISTICS

2.5.1 <u>Physical Setting</u>

Site features are shown on Figure 2-3. The WOD is located at the northern end of Runway 17-35 on a peninsula-like feature adjacent to Little Mosquito Creek. The southern half of the Site is grass covered and relatively flat. The central portion of the Site slopes slightly to the north and east. A large stand of conifer trees was recently removed from the northern portion of the Site. Vegetation currently consists of brush and grass. The northern, eastern, and western boundaries of the Site are steeply sloped. These slopes direct surface water runoff into low-lying marshes that border an unnamed tributary of Little Mosquito Creek. There are no surface water bodies within or adjacent to the disposal area of the WOD. An unnamed tributary of Mosquito Creek is located approximately 160 feet west of the Site, and approximately 300 feet of marshland to the north and east separates the WOD from Little Mosquito Creek.

The WOD is bordered to the west and southwest by two other suspected disposal sites used by the Navy prior to NASA operations. These sites are Debris Pile – Site 15 and Abandoned Drum Field – Site 9 and are under investigation by the United States Army Corps of Engineers as part of the Formerly Used Defense Sites program.

The lithologic unit called the Columbia Group underlies the study area. Regionally, the Columbia Group is approximately 50 feet thick and is underlain by a 20- to 40-foot thick clay and silt aquitard that isolates the Columbia Group from the underlying Yorktown aquifer. Geologic materials encountered at the Site consist of fine- to medium-grained quartz sand with some silt. A sandy clay layer was consistently encountered at depths ranging from 10 to 27 feet below ground surface (bgs) at an elevation near sea level. The thickness of this clay is reported to be as much as 5 feet. This clay is suspected to be a localized lens within the Columbia Group. It is not believed to represent the upper Yorktown aquitard that was encountered at an elevation of approximately 25 feet below sea level at the nearby Former Fire Training Area.

The depth to groundwater in the southern portion of the Site, in areas of higher elevations, is approximately 23 feet bgs and decreases in depth to approximately 6 feet bgs at the northern edge of the open field. Groundwater is encountered immediately below the ground surface in surrounding areas adjacent to the marsh. The WOD is bisected by a groundwater divide that trends to the north-northeast. Groundwater to the west of the divide generally flows in a western to northwestern direction and discharges to the unnamed tributary of Little Mosquito Creek. Groundwater east of the divide generally flows in an eastern to northeastern direction and discharges to Little Mosquito Creek and its adjacent wetlands. Groundwater from the Columbia aquifer in the vicinity of the Site is not currently used as a potable water supply. The Town of Chincoteague owns three supply wells screened within the Columbia aquifer. These wells are located about 4,000 feet to the southeast, upgradient, of the Site and are operated on an as-needed seasonal bases. Drinking water at the WFF is obtained from the Yorktown aquifer. There is no known hydrogeologic connection or communication between the surficial Columbia aquifer and the deeper Yorktown aquifer used for drinking water.

There are no known areas of archeological or historical importance at the WOD.

2.5.2 Conceptual Site Model

Figure 2-4 is the Conceptual Site Model (CSM) for human and ecological receptors. The CSM graphically integrates information regarding the physical characteristics of the Site, exposed populations, sources of contamination, and contaminant mobility (fate and transport) to identify potential exposure routes and receptors evaluated in the risk assessments. A well-defined CSM allows for a better understanding of the risks at a site and aids in the identification of the potential need for remediation.

2.5.3 Sampling Strategy

Waste oil disposed on the ground surface and/or in excavations is the likely source of contamination.

During the SI, two separate soil-gas surveys were conducted at the WOD. In 1989, nine soil-gas samples were collected at 100-foot intervals and analyzed using a field instrument. One of the samples indicated elevated levels of volatile organic compounds (VOCs). In 1990, 37 soil-gas samples were collected throughout and between the areas where soil was removed in 1986 and analyzed using a field instrument. Additional soil and groundwater sampling was recommended.

Additional sampling was conducted during the SI in 1990 and 1992. In 1990, two surface soil, one subsurface soil, two groundwater, and two sediment samples were collected and analyzed for Target Compound List (TCL) VOCs, semivolatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs) and Target Analyte List (TAL) metals. In 1992, five soil borings were installed in and around areas that had previously been excavated. Soil samples collected from borings were analyzed for total petroleum hydrocarbons (TPH). The analytical results were compared to action levels, background concentrations, and EPA guidance criteria, and no further action was recommended.

In 1997, monitoring well WFF15-GW7 was installed in the WOD as a background well for investigations being conducted at Site 15 located west of the WOD. Samples from this well collected in 1997 and 1998 as part of the Site 15 RI, indicated the presence of solvent and petroleum compounds. As a result, NASA conducted an inspection of the WOD and identified an area of stained soil and stressed vegetation. The stained soil was west of the area that was excavated in 1986 and was suspected to consist of weathered petroleum-based materials.

An RI was conducted from 1998 through 2000. A geophysical survey conducted over an area of 200,000 square feet indicated that the WOD did not contain large areas of buried material or a large burial area but did identify two small areas of possible buried metal debris. The survey findings were confirmed through the advancement of 31 soil borings throughout the area. Borings were extended to the water table and ranged in depth from 12 to 30 feet bgs. Twenty-seven of the borings were converted to temporary monitoring wells, and groundwater samples were collected and analyzed for VOCs and TPH using an on-site mobile laboratory and arsenic using an off-site laboratory. Based on the analytical results, six permanent monitoring wells were installed. Groundwater samples were collected from new wells and existing wells on four occasions and analyzed for TCL organics, TAL metals, and TPH. Soil investigations included collection of 21 surface soil and four subsurface soil samples from within and around the area of stained soil and stressed vegetation. Soil samples were analyzed for TCL organics, TAL metals, and TPH.

The Supplemental RI field investigation conducted in 2003 included installation of three new monitoring wells and soil and groundwater sampling to better define the extent of soil and groundwater contamination, groundwater flow direction, and contaminant migration pathways. A total of 27 surface and subsurface soil samples were collected from throughout the WOD and analyzed for TCL VOCs, SVOCs, and PCBs and TAL metals. Surface soil samples were also analyzed for pH, total organic carbon (TOC), and grain size. Twelve surface soil samples were collected from the marsh surrounding the WOD and analyzed for the same parameters. Groundwater samples were collected from new and existing monitoring wells and analyzed for TCL VOCs plus methyl tert-butyl ether (MTBE), SVOCs, and PCBs, TAL metals (total and dissolved), and natural attenuation indicator parameters.

2.5.4 <u>Nature and Extent of Contamination</u>

Contaminants of Concern were identified based on the analytical data, risk drivers from the human health and ecological risk assessments (discussed in Section 2.7), and exceedances of regulatory standards and criteria. The concentrations of the groundwater COCs, benzene and arsenic, are provided in Table 2-1. Past disposal operations at the WOD are the likely source of groundwater contamination. The 1986 removal action conducted at the WOD addressed on-site soil contamination; therefore, there are no COCs for soil. The removal action also removed a significant portion of the contaminant source material and reduced the impact on groundwater.

Groundwater contamination at the WOD is very localized and centered in the vicinity of monitoring well WFF15-GW7. Groundwater samples collected from this area contained high levels of petroleum-related compounds as well as benzene and arsenic. In addition, a floating layer of petroleum product (0.4 foot thick) was measured in this well at the start of the Supplemental RI field activities. The presence of a free-phase product and high contaminant concentrations detected in the dissolved phase within the groundwater indicate that the contaminant source occurs at or near the water table in the immediate vicinity of WFF15-GW7. The contaminated groundwater associated with well WFF15-GW7 has not migrated for a significant distance, and COC concentrations detected during the Supplemental RI are within the same order of magnitude as seen in historical samples. The groundwater contaminant plume covers approximately 8,400 square feet (0.19 acre). Figure 2-5 shows COC concentrations detected during the Supplemental RI in 2003 and compares them to preliminary remediation goals identified in the FS Report.

During the Supplemental RI, the highest concentration of benzene was detected at 11 micrograms per liter (µg/L) in a sample from well WFF15-GW7. The only other sample in which benzene was detected was from well WFF16-GW2D (8 µg/L). The only concentration of arsenic detected was at well WFF16-GW2D (21.4 µg/L).

A sample from well WFF15-GW-7 also had the only concentrations of 1,2,4-trimethylbenzene (170 µg/L), tetrachloroethene (5 µg/L), total xylenes (540 µg/L), and naphthalene (130 µg/L). A sample from well WFF15-GW2 had the only concentration of 4-methylphenol (42 µg/L) detected. These chemicals were detected at concentrations above risk-based screening levels but did not result in an unacceptable risk to human health. Nonetheless, these chemicals will be included in future groundwater monitoring programs to evaluate their impact on achieving the remedial action objectives (RAOs) discussed in Section 2.8 of this ROD.

Additional details on the spatial distribution and concentrations of chemicals detected in all Site media and site investigations conducted to date are contained in the Supplemental RI Report (TtNUS, 2004) and FS Report (TtNUS, 2005).

2.6 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

The WOD is currently an open field covered with brush and grass and is no longer used for waste disposal. The WOD is not used for any specific purpose, and there are no plans for residential development of the Site. No change in the use of the Site is likely as it is located at the end of an active runway that is an important part of the future facility plan for the WOD. Shallow groundwater is not used by NASA for any purpose other than environmental monitoring and restoration and there are no plans for the development of this resource for potable use in the future. However, upgradient and approximately 4,000 feet from the Site the Town of Chincoteague operates 2 shallow Columbia aquifer wells that are used to augment its public water supply, as needed, on a seasonal basis. The Town owns a third well that is in disrepair and is currently not used but is in the vicinity of the 2 operating wells. The shallow Columbia aquifer is not as productive as the deeper, hydraulically unconnected, Yorktown aquifer also present in the area. The Yorktown aquifer is the source of the majority of the Town’s and all of NASA’s potable water. Nonetheless, the potential use of the groundwater from the Columbia aquifer as a potable water supply represents a potential future use of the resource.

An unnamed tributary of Little Mosquito Creek is located approximately 160 feet west of the Site, and approximately 300 feet of marshland to the north and east separates the WOD from Little Mosquito Creek. The tributary is entirely within the NASA Wallops property boundary and offers little recreational or commercial use now and is not expected to in the future.

2.7 SUMMARY OF SITE RISKS

2.7.1 Summary of Human Health Risk Assessment

The baseline human health risk assessment estimates the risks that the Site poses if no further action is taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of the baseline risk assessment that was conducted for the Supplemental RI Report. The primary focus of this summary is on those exposure pathways and chemicals found to pose actual or potential risks to human health. The risk assessment in the Supplemental RI Report contains an evaluation of all chemicals of potential concern (COPCs) and exposure pathways, including those that do not pose unacceptable risks to human health. COPCs are those chemicals that are identified as potential threats to human health and are evaluated further in the baseline risk assessment. COCs are a subset of COPCs that are identified in the RI/FS as needing to be addressed by the response action selected in this ROD.

2.7.1.1 Identification of Chemicals of Concern

Table 2-1 presents the COCs and exposure point concentrations for each of the COCs detected in groundwater based on the risk assessment in the Supplemental RI Report. There are no COCs for soil, surface water, or sediment. COCs either result in an unacceptable risk or exceed a regulatory standard. The exposure point concentration is the concentration that was used to estimate the exposure and risk from each COC. Table 2-1 contains the concentration range of each COC in groundwater, the frequency of detection, the exposure point concentration, and how the exposure point concentration was derived.

The groundwater COCs posing unacceptable risks to human health include arsenic and benzene. The contaminant contributing the majority of the risk is arsenic. Detected concentrations of benzene and arsenic are greater than federal Maximum Contaminant Levels (MCLs) promulgated at 40 C.F.R. Part 141 pursuant to Section 1412 of the Safe Drinking Water Act, 42 U.S.C. Section 300g-1, for drinking water. Therefore, benzene is also a COC for groundwater.

2.7.1.2 Exposure Assessment

This section presents a summary of the exposure assessment detailed in the Supplemental RI Report. The exposure assessment defines and evaluates the type and magnitude of human exposure to the chemicals present at or migrating from a site. The exposure assessment is designed to depict the physical setting of the site, to identify potentially exposed populations, and to estimate chemical intakes under the identified exposure scenarios. Actual or potential exposures are based on the most likely pathways of contaminant release and transport, as well as human activity patterns. A complete exposure pathway has the following three components: a source of chemicals that can be released into the environment, a route of contaminant transport through an environmental medium, and an exposure or contact point for a human receptor.

The compilation of contaminant sources, likely exposure pathways, and receptors at the WOD is depicted in the CSM (Figure 2-4). Potential receptors include current and future industrial workers, future construction workers, and hypothetical future residents. Examples of activities for the industrial worker include groundskeeping, installation and maintenance of airfield equipment, and utility or road work. Construction workers can be involved in any type of excavation activity. Future residential use is not a reasonably anticipated land use but was evaluated to determine whether unrestricted land use could be permitted. Potential exposure pathways evaluated in the risk assessment include direct contact with and ingestion of soils, direct contact with and ingestion of shallow groundwater, and inhalation of vapors from groundwater either through direct exposure or through intrusion or migration into a hypothetical building.

Major assumptions about exposure frequency (days per year), exposure duration (years), and other exposure factors (e.g., body surface area for dermal exposure, ingestion rates) that were included in the exposure assessment can be found in the Supplemental RI Report (TtNUS, 2004).

2.7.1.3 Toxicity Assessment

Table 2-2 provides carcinogenic risk information for COCs in shallow groundwater. Both of the COCs have toxicity data indicating their potential for carcinogenic effects in humans.

Table 2-3 provides noncarcinogenic risk information for COCs in shallow groundwater. Both of the COCs have toxicity data indicating their potential for adverse noncarcinogenic effects in humans. At this time inhalation reference concentrations are only available for benzene.

2.7.1.4 Risk Characterization

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

$$Risk = CDI \times SF$$

Where: Risk = a probability (e.g., 2.0E-05) of an individual developing cancer (unitless)
CDI = chronic daily intake averaged over 70 years (mg/kg-day)
SF = slope factor, expressed as $(mg/kg\text{-}day)^{-1}$

These risks are probabilities that are usually expressed in scientific notation (e.g., 1.0E-06). An excess lifetime cancer risk of 1.0E-06 indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This risk is referred to as an “excess lifetime cancer risk” because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes has been estimated to be as high as one in three. The EPA’s generally acceptable risk range for site-related exposure is 1.0E-04 to 1.0E-06, or an excess lifetime cancer risk of 1 in 10,000 to 1 in 1,000,000.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ of less than one indicates that a receptor’s dose of a single contaminant is less than the RfD and that toxic noncarcinogenic effects from that chemical are unlikely. The hazard index (HI) is generated by adding the HQs for all COCs that affect the same target organ (e.g., liver). An HI of less than one indicates that, based on the sum of all HQs from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI greater than one indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

$$Noncancer\ HQ = CDI/RfD$$

Where: CDI = chronic daily intake

RfD = reference dose

CDI and RfD are expressed in the same units (e.g., mg-kg/day) and represent the same exposure period (i.e., chronic, subchronic, or short-term).

Carcinogenic Risks

The only unacceptable carcinogenic risk at the Site was for the future lifetime resident. The total lifetime risk for a hypothetical resident exposed to contaminated ground water is estimated to be 3.8E-04. Carcinogenic effects for all other evaluated receptors were within or less than the EPA acceptable risk range (1.0E-04 to 1.0E-06). The major contributing factors to the estimated lifetime carcinogenic risk are presented in Table 2-4 and summarized below.

Table 2-4 provides risk estimates for the hypothetical future child resident for exposure to shallow groundwater. These risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of a child's exposure to shallow groundwater. The risk estimates were based on the toxicity of the COCs (benzene and arsenic). The total risk from direct exposure to shallow groundwater at the WOD for a future child resident is estimated to be 1.7E-04. The COC contributing most to this risk level is arsenic. This risk level indicates that, if no clean-up action is taken, an individual child resident would have an increased probability of about 2 in 10,000 of developing cancer as a result of Site-related exposure to the COCs in shallow groundwater.

Table 2-4 provides risk estimates for the hypothetical future adult resident for exposure to shallow groundwater. These risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of an adult's exposure to shallow groundwater. The risk estimates were based on the toxicity of the COCs (benzene and arsenic). The total risk from direct exposure to shallow groundwater at the WOD for a future adult resident is estimated to be 2.1E-04. The COC contributing most to this risk level is arsenic. This risk level indicates that, if no clean-up action is taken, an individual adult resident would have an increased probability of about 2 in 10,000 of developing cancer as a result of Site-related exposure to the COCs in shallow groundwater.

Noncarcinogenic Risks

The only unacceptable noncarcinogenic risks were for the future child resident and future adult resident. Noncarcinogenic risks for all other evaluated receptors have an HI of less than one.

Table 2-5 provides the HQs for the hypothetical future child resident for exposure to shallow groundwater and the HI for all COCs. The estimated HI of 4.5 indicates the potential for adverse noncarcinogenic health effects from exposure. The COC contributing most to the groundwater HI is arsenic.

Table 2-6 provides the HQs for the hypothetical future adult resident for exposure to shallow groundwater and the HI for all COCs. The estimated HI of 1.5 indicates the potential for adverse noncarcinogenic health effects from exposure. The COC contributing most to the groundwater HI is arsenic.

Uncertainty Analysis

At the WOD, arsenic is the major contributor to the carcinogenic risks for the groundwater pathway for the hypothetical future resident. Although the accepted basis for evaluating risk associated with exposure to arsenic is to assume it is a carcinogen, there is uncertainty whether carcinogenic effects are the primary health effects expected to be manifested upon exposure to arsenic. There is some scientific information to indicate that humans are capable of metabolizing arsenic to expedite its elimination from the body. On the other hand, arsenic has been associated with a variety of cancers in epidemiological studies. This adds to uncertainty regarding carcinogenic risks associated with arsenic exposure. However, arsenic is also a major contributor to the noncarcinogenic risks.

2.7.2 Summary of Ecological Risk Assessment

The ecological risk assessment (ERA) was performed to characterize potential risks to ecological receptors from Site-related contaminants. Details may be found in the Supplemental RI Report (TtNUS, 2004). The ERA for the WOD included the following steps of the eight-step ERA process:

- Step 1 – Preliminary Problem Formulation and Ecological Effects Evaluation
- Step 2 – Preliminary Exposure Assessment and Risk Calculation
- Step 3A – Refinement of COPCs
- Step 8 – Risk Management

The habitat, contaminants present, migration pathways, and the routes by which receptors may be exposed to chemicals were defined and evaluated as part of the ERA. The WOD is a terrestrial habitat, and the receptors evaluated for the terrestrial environment were plants, soil invertebrates, and herbivorous and insectivorous birds and mammals. The ERA also evaluated the risks to benthic invertebrates (aquatic life) that may be exposed to chemicals that migrated from the WOD to marsh soil/sediment in the surrounding area. The chemical concentrations, occurrence, and distribution and potential effects data were evaluated to determine whether adverse effects to growth, survival, and reproduction were likely to occur in these receptors. Overall, risks to plants, terrestrial wildlife, and terrestrial and benthic invertebrates from chemicals detected at the WOD in surface soil were found to be low to negligible.

2.7.3 Risk Assessment Conclusions

The only unacceptable risks to human health are for the hypothetical child and adult residents who use shallow groundwater from the Columbia aquifer as a source of potable water. There are no unacceptable risks to other human receptors under current land use and reasonably anticipated future land use. The surface and subsurface soil, surface water, sediment and vapor exposure pathways were considered. Surface water and sediment are not present on site and no COCs were identified for surface or subsurface soils. The main risk driver for groundwater is arsenic. In addition, the detected concentrations of benzene and arsenic exceed their respective federal MCLs.

There are no unacceptable risks to ecological receptors.

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment.

2.8 REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives (RAOs) provide a general description of what the cleanup will accomplish. These levels typically serve as the design basis for many of the remedial alternatives that are discussed in Section 2.9. The RAOs provide the basis for evaluation of clean-up options for the Site and an understanding of how the risks identified in the previous section will be addressed by the response action.

Based on the recommendations in the Supplemental RI Report, the only medium of concern at the WOD is shallow groundwater.

The RAOs for remedial action at the WOD are summarized as follows:

- Prevent exposure to and use of WOD-contaminated groundwater which presents an unacceptable risk associated with hypothetical future residential use of shallow groundwater.

- Restore WOD-impacted groundwater to drinking water standards (MCLs). The drinking water standards for arsenic and benzene are 10 µg/l, respectively.

RAOs were not developed for soil. There are no unacceptable risks to human health under a residential land use scenario or to ecological receptors from exposure to soil.

2.9 DESCRIPTION OF ALTERNATIVES

Remedial alternatives evaluated for the WOD are presented below. More detailed descriptions of the alternatives can be found in the FS Report (TtNUS, 2005).

2.9.1 Description of Remedy Components

This section provides a list of the major components of each alternative as they occur in the remediation process. Each list includes treatment components and the materials they will address, institutional controls, operation and maintenance (O&M) activities requirements to maintain the integrity of the remedy, and monitoring requirements. In addition, the Applicable or Relevant and Appropriate Requirements (ARARs) are listed and summarized in Table 2-11 of this ROD.

2.9.1.1 Alternative 1: No Action

There are no remedy components for the no-action alternative. This alternative is required under CERCLA to establish a basis for comparison with other alternatives. No remedial actions would be implemented, and the shallow groundwater would be available for unrestricted use because no institutional controls would be implemented. Because hazardous substances, pollutants or contaminants would remain at the Site, policy reviews would be conducted every 5 years.

2.9.1.2 Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring

Alternative 2 consists of the following major components: natural attenuation, institutional controls, and monitoring.

<u>Natural Attenuation</u>
Natural attenuation would rely on naturally occurring processes within the Columbia aquifer to reduce concentrations of benzene and other organic chemicals. These processes include a combination of breakdown by natural microbes, dispersion, dilution, and the binding of contaminants onto the surface of particles in the aquifer. The arsenic contamination is most likely associated with a low dissolved oxygen, or reducing environment, created by degradation of contaminants by microorganisms. Arsenic contamination is limited to one monitoring well that is on the downgradient edge of the area exhibiting the highly reduced environment. When natural attenuation processes complete biodegradation of benzene

and other organic chemicals, the conditions at the Site will return to an aerobic environment with higher levels of oxygen that should cause arsenic to transform to insoluble oxidized compounds, which do not readily dissolve in the groundwater.

Institutional Controls

Institutional controls would consist of prohibiting use of groundwater from the Columbia aquifer for domestic purposes until clean-up levels are met. Land use control (LUC) plans would be prepared and would prohibit installation of drinking water wells that would draw water from the Columbia aquifer and require EPA concurrence and NASA approval of all Colombia aquifer wells installed for non-drinking water purposes. Use of groundwater would be controlled through restrictions documented in the Facility Master Plan. Regular site inspections would be performed to verify implementation of institutional controls until clean-up levels are met.

Monitoring

Monitoring would consist of regularly collecting and analyzing groundwater samples from within the contaminant plume to assess the performance of natural attenuation processes and downgradient of the leading edge of the contaminant plume to verify that COCs are not migrating. The FS assumed that monitoring would consist of collecting groundwater samples from nine monitoring wells (7 existing and 2 new). Samples would be analyzed for VOCs (benzene, tetrachloroethene, xylenes, 1,2,4-trimethylbenzene, and any associated degradation compounds identified to be appropriate), SVOCs (4-methylphenol and naphthalene), and total arsenic. It was also assumed that samples would be analyzed, as needed, for natural attenuation indicator parameters such as oxidation reduction potential (ORP), dissolved oxygen, pH, alkalinity, temperature, conductivity, total organic carbon (TOC), ferrous and total iron, sulfur compounds (sulfates, hydrogen sulfide, and sulfides), orthophosphates, chloride, metabolic gases produced by microbial transformation of contaminants such as methane, ethane and ethene, and carbon dioxide. A long-term monitoring plan would need to be developed with EPA and DEQ concurrence.

Reviews would be performed every 5 years to evaluate Site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary. The need for Five-Year reviews would be terminated after clean-up levels are attained.

2.9.1.3 Alternative 3: In-Situ Biological Treatment (Biostimulation), Institutional Controls, and Monitoring

Alternative 3 consists of the following major components: in-situ biological treatment (biostimulation), institutional controls, and monitoring.

In-Situ Biological Treatment (Biostimulation)

In-situ biostimulation treatment would consist of using an oxygen release compound (ORC) to encourage the growth of native microorganisms to increase the rate of biodegradation and create favorable conditions to break down benzene and other organic chemicals into nontoxic forms. An ORC is a mixture which contains magnesium peroxide which reacts with the groundwater to produce an insoluble magnesium solid and releases oxygen over the course of several months. For purposes of the FS, it was assumed that the groundwater plume that consists of benzene would be treated with ORC. The treatment would consist of 12 ORC injection points, or temporary wells, spaced 30 feet apart across the portion of the Site that contains benzene. The final locations would be determined after completion of the treatability study. The injection points would be 30 feet deep. It was assumed that no repeat applications of ORC would be required.

The arsenic contamination is most likely associated with the reduced environment created by the natural degradation of organic compounds in the aquifer. Arsenic contamination is not widespread and is found in one monitoring well that exhibits the highly reduced, low oxygen, environment. In-situ aerobic treatment would change the groundwater into an oxygen-rich environment that should cause arsenic to transform from soluble compounds to insoluble oxidized compounds, which do not readily dissolve in the groundwater.

Institutional Controls

Institutional controls would consist of prohibiting use of groundwater from the Columbia aquifer for domestic purposes until clean-up levels are met. LUC plans would be prepared and would prohibit installation of drinking water wells that would draw water from the Columbia aquifer and require EPA concurrence and NASA approval of all Columbia aquifer wells installed for non-drinking water purposes. Use of groundwater would be controlled through restrictions documented in the Facility Master Plan. Regular Site inspections would be performed to verify the implementation of the institutional controls until clean-up levels are met.

Monitoring

Monitoring would consist of regularly collecting and analyzing groundwater samples from within the contaminant plume to assess the performance of treatment and downgradient of the leading edge of the contaminant plume to verify that COCs are not migrating. The FS assumed that monitoring would consist of collecting groundwater samples from nine wells (seven existing and two new). Samples would be analyzed for VOCs (benzene, tetrachloroethene, xylenes, 1,2,4-trimethylbenzene, and any associated degradation compounds identified to be appropriate), SVOCs (4-methylphenol and naphthalene), and total and dissolved arsenic. It was also assumed that samples would be analyzed for biodegradation indicator parameters such as ORP, dissolved oxygen, pH, alkalinity, temperature, conductivity, TOC, ferrous and total iron, sulfur compounds (sulfates, hydrogen sulfide, and sulfides), orthophosphates, chloride, metabolic gases produced by microbial transformation of contaminants such as methane, ethane and ethane, and carbon dioxide. A long-term monitoring plan would need to be developed with EPA and DEQ concurrence.

Five-Year Reviews would be conducted to evaluate Site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary.

2.9.1.4 Alternative 4: In-Situ Biological Treatment (Bioaugmentation), Institutional Controls, and Monitoring

Alternative 4 consists of the following major components: in-situ biological treatment (bioaugmentation), institutional controls, and monitoring.

In-situ Biological Treatment (Bioaugmentation)

In-situ bioaugmentation would consist of injecting a solution of aerobic microbes and nutrients to augment natural biodegradation processes to break down benzene and other organic chemicals into nontoxic forms. For purposes of the FS, it was assumed that treatment would consist of 12 injection points, or temporary wells, spaced 30 feet apart across the portion of the Site that contains benzene. The final locations would be determined after completion of the treatability study. Each of the injection points would be 30 feet deep. It was assumed that no repeat applications would be required.

The arsenic contamination is most likely associated with the reduced environment created by the natural degradation of organic compounds in groundwater. Arsenic contamination is not widespread and is found in one monitoring well that exhibits the highly reduced, low oxygen environment. When the in-situ bioaugmentation process to biodegrade the benzene and other organic compounds has been completed, conditions at the Site will return to an aerobic environment that should cause arsenic to transform from soluble compounds to insoluble oxidized compounds that do not readily dissolve in the groundwater.

Institutional Controls

Institutional controls would consist of prohibiting use of groundwater from the Columbia aquifer for drinking purposes until clean-up levels are met. Use of groundwater would be controlled through restrictions documented in the Facility Master Plan. LUC plans would be prepared and would prohibit installation of drinking water wells that would draw water from the Columbia aquifer and require EPA concurrence and NASA approval of all Columbia aquifer wells installed for non-drinking water purposes. Regular site inspections would be performed to verify the implementation of the institutional controls until clean-up levels are met.

Monitoring

Monitoring would consist of regularly collecting and analyzing groundwater samples from within the contaminant plume to assess the performance of treatment and downgradient of the leading edge of the contaminant plume to verify that COCs are not migrating. The FS assumed that monitoring would consist of collecting groundwater samples from nine wells (seven existing and two new). Samples would be analyzed for VOCs (benzene, tetrachloroethene, xylenes, 1,2,4-trimethylbenzene, and any associated degradation compounds identified to be appropriate), SVOCs (4-methylphenol and naphthalene), and total and dissolved arsenic. It was also assumed that the samples would be analyzed for biodegradation indicator parameters such as ORP, dissolved oxygen, pH, alkalinity, temperature, conductivity, TOC, ferrous and total iron, sulfur compounds (sulfates, hydrogen sulfide, and sulfides), orthophosphates, chloride, metabolic gases produced by microbial transformation of contaminants such as methane, ethane and ethane, and carbon dioxide. A long-term monitoring plan would need to be developed with EPA and DEQ concurrence.

Five-Year Reviews would be conducted to evaluate Site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary.

2.9.1.5 Alternative 5: In-Situ Air Sparging Treatment, Institutional Controls, and Monitoring

Alternative 5 includes the following major components: in-situ air sparging (AS) treatment, institutional controls, and monitoring.

In-Situ Air Sparging Treatment

Air sparging (AS) involves pumping air into injection wells which causes the volatile contaminants to be transformed into vapors which evaporate from the groundwater. The vapors then move through the soil and discharge to the air where they are destroyed through exposure to sunlight or are dispersed. In addition, a portion of the organic contaminants are degraded in the groundwater and soil through the same microbial process discussed under Alternative 2.

The AS system would consist of a blower connected to a series of AS wells screened to a specific depth. The FS assumed that the AS system would consist of a blower providing 150 cubic feet of air per minute and 12 wells spaced approximately 15 feet apart and screened from 15 to 20 feet below the water table (35 to 40 feet bgs) across the portion of the Site containing benzene. Based on site contaminant levels and air injection rates, fugitive emissions would be well below regulatory limits and would not require treatment.

The arsenic contamination is most likely associated with the reduced environment created by the natural degradation of organic compounds in groundwater. Arsenic contamination is not widespread and is found in one monitoring well that exhibits the highly reduced, low oxygen environment. AS treatment would change the groundwater to an aerobic environment with higher dissolved oxygen that should cause arsenic to transform from soluble compounds to insoluble oxidized compounds that do not readily dissolve in the groundwater.

Institutional Controls

Institutional controls would consist of prohibiting use of groundwater from the Columbia aquifer for domestic purposes until clean-up levels are met. LUC plans would be prepared and would prohibit installation of drinking water wells that would draw water from the Columbia aquifer and require EPA concurrence and NASA approval of all Columbia aquifer wells installed for non-drinking water purposes. Use of groundwater would be controlled through restrictions documented in the Facility Master Plan. Regular Site inspections would be performed to verify the implementation of the institutional controls until clean-up levels are met.

Monitoring

Monitoring would consist of regularly collecting and analyzing groundwater samples from within the contaminant plume to assess the performance of treatment and downgradient of the leading edge of the contaminant plume to verify that COCs are not migrating. The FS assumed that monitoring would consist of collecting groundwater samples from nine wells (seven existing and two new). Samples would be analyzed for VOCs (benzene, tetrachloroethene, xylenes, 1,2,4-trimethylbenzene, and any associated degradation compounds identified to be appropriate), SVOCs (4-methylphenol and naphthalene), and total and dissolved arsenic. A long-term monitoring plan would need to be developed with EPA and DEQ concurrence. Fugitive emissions or air monitoring would not be required.

Five-Year Reviews would be conducted to evaluate Site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary.

2.9.2 Common Elements and Distinguishing Features of Each Alternative

No response actions would be implemented under Alternative 1, the no-action alternative.

Alternative 2 includes natural attenuation to reduce COC concentrations in shallow groundwater. Alternatives 3, 4, and 5 include various forms of in-situ treatment to reduce COC concentrations in shallow groundwater. Alternative 3 uses in-situ biostimulation, Alternative 4 uses in-situ bioaugmentation, and Alternative 5 uses in-situ AS.

Institutional controls are a component of Alternatives 2, 3, 4, and 5. Use of groundwater from the Columbia aquifer as a source of domestic water would not be permitted until clean-up levels are met and the installation of wells for non-domestic water use purposes would require NASA approval and EPA concurrence.

Alternatives 2, 3, 4, and 5 include collection of shallow groundwater samples on a regular basis with analysis for VOCs (benzene, tetrachloroethene, xylenes, 1,2,4-trimethylbenzene, and any associated degradation compounds identified to be appropriate), SVOCs (4-methylphenol and naphthalene), and total and dissolved arsenic. Alternatives 2, 3, and 4 include analysis for natural attenuation and biodegradation indicator parameters.

Five-Year Reviews would be required for Alternatives 1, 2, 3, 4 and 5 until clean-up levels are attained. Once the clean-up levels are attained, Alternatives 2, 3, 4, and 5 will not result in hazardous substances, pollutants, or contaminant remaining on site above levels that allow for unlimited use and unrestricted exposure. For Alternatives 3, 4, and 5, the FS assumed that clean-up levels would be attained in less than 5 years; however, for costing purposes, Five-Year Reviews to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary are included.

Under Alternative 2, it would take less than 1 month to install additional monitoring wells and 5 years to attain all RAOs. Under Alternatives 3 and 4 it would take approximately 1 month to install treatment systems and 3 years to attain all RAOs. Under Alternative 5, it would take approximately 2 months to implement the treatment system and 3 years to attain all RAOs. Alternative 5 would also require coordination of construction activities for the installation of semi-permanent structures/features at the end of an active runway.

The present-worth costs of Alternatives 2, 3, 4, and 5 are based on 5 years of annual costs and a 3.5 percent discount factor. The estimated present-worth costs are as follows:

- Alternative 1: $12,600
- Alternative 2: $224,000
- Alternative 3: $397,000
- Alternative 4: $530,000
- Alternative 5: $493,000

2.9.3 Expected Outcome of Each Alternative

For Alternative 1, no institutional controls would be implemented, thereby resulting in unacceptable risks to human health and the environment from exposure to contaminated groundwater.

For Alternatives 2, 3, 4, and 5, use of groundwater from the Columbia aquifer as a source of domestic water use would not be permitted, and the installation of Columbia aquifer wells for non-drinking water purposes would require EPA concurrence and NASA approval. Use of groundwater would be controlled through restrictions documented in the Facility Master Plan until clean-up levels are achieved. Groundwater would be suitable for unlimited use and unrestricted exposure after clean-up levels are achieved.

2.10 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The objective of the comparative analysis of alternatives is to evaluate the relative performance of the alternatives with respect to the nine evaluation criteria established in the NCP, 40 C.F.R. Section 300.430(e)(9)(iii), so that the advantages and disadvantages of each are clearly understood. The first two evaluation criteria, Overall Protection of Human Health and the Environment and Compliance with Applicable or Relevant and Appropriate Requirements (ARARs), are threshold criteria that must be satisfied by a remedial alternative chosen for a site. Table 2-7 contains a summary of the comparative analysis of alternatives.

2.10.1 Overall Protection of Human Health and the Environment

All the alternatives, except the no-action alternative, protect human health and the environment by eliminating, reducing, or controlling risks posed by the Site through removal of contaminants and institutional controls. Therefore, Alternative 1 (no action) will not be considered further in this analysis because it does not satisfy this threshold criterion.

Alternative 2 would be protective of human health and the environment because natural attenuation would reduce COC concentrations to clean-up levels over time given the proper site conditions. Institutional controls and monitoring would provide immediate protection until the clean-up levels are met by prohibiting the use of groundwater from the Columbia aquifer as a source of drinking water, controlling the installation of wells, and monitoring potential contaminant migration.

Alternatives 3, 4, and 5 would be more protective than Alternative 2 because, in addition to the same institutional control and monitoring components, these alternatives would also include an active treatment component to remove groundwater COCs.

2.10.2 Compliance with ARARs

As listed and summarized in Table 2-11 of this ROD, Alternatives 2, 3, 4, and 5 have common chemical-specific ARARs associated with clean-up levels for shallow groundwater. These include MCLs for benzene and arsenic. These alternatives would eventually attain compliance as they attain clean-up levels through natural attenuation (Alternative 2) or active treatment (Alternatives 3, 4, and 5). Alternatives 3, 4, and 5 are expected to attain clean-up levels more quickly than Alternative 2.

Alternatives 2, 3, 4, and 5 would also comply with location- and action-specific ARARs.

2.10.3 Long-Term Effectiveness and Permanence

Alternatives 2, 3, 4, and 5 would provide long-term effectiveness and permanence.

Given that source control activities have been implemented, the natural attenuation component of Alternative 2 would effectively and permanently reduce concentrations of groundwater COCs to clean-up levels. The institutional controls component of Alternative 2 would effectively prevent use of the Columbia aquifer as a drinking water source until clean-up levels have been achieved. The long-term monitoring component of Alternative 2 would provide an effective means of evaluating the progress of remediation and verifying that no migration of COCs is occurring.

Alternatives 3, 4, and 5 would be more effective than Alternative 2 because, in addition to the same institutional controls and monitoring components, these alternatives would also include an active treatment component that would accelerate removal of COCs. Alternatives 3 and 4 would be slightly less effective than Alternative 5 because the in-situ biological treatment technologies would require treatability testing to confirm long-term effectiveness.

Reviews would be conducted at least every 5 years, as required, to evaluate the effectiveness of Alternatives 2, 3 4 and 5. Reviews would be required as long as hazardous substances remain in shallow groundwater at concentrations greater than health-based levels that allow for unlimited use and unrestricted exposure. Alternatives 3, 4, and 5 are expected to attain clean-up levels in less than 5 years.

2.10.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 3 and 4 include in-situ biological treatment and Alternative 5 includes in-situ AS treatment to reduce the toxicity of hazardous substances in shallow groundwater. Alternative 2 does not include active treatment to reduce the toxicity, mobility, or volume of hazardous substances.

2.10.5 Short-Term Effectiveness

Implementation of Alternatives 2, 3, 4, and 5 would not adversely affect the surrounding community or the environment. There may be minor short-term risks to remediation workers exposed to contaminated groundwater. These risks would be effectively controlled by wearing appropriate personal protective equipment and compliance with proper site-specific health and safety procedures.

Alternatives 2, 3, 4, and 5 would achieve the first RAO immediately upon implementation of institutional controls. The estimated time to achieve clean-up levels is 5 years for Alternative 2 and 3 years for Alternatives 3, 4, and 5.

2.10.6 Implementability

Technical implementation of the various components of Alternative 2 would be relatively simple. The resources, equipment, and materials required for the activities associated with these components are readily available.

Technical implementation of Alternatives 3, 4, and 5 would be somewhat more difficult than for Alternative 2 because these three alternatives would require installation of a groundwater treatment system. Of these three alternatives, Alternatives 3 and 4 would be easiest to implement because they would only require installation of small-diameter injection points and feeding of chemicals without installation of permanent equipment. Alternative 5 would be more difficult to implement than Alternatives 3 and 4 because it would require construction of an AS system with numerous sparging wells, interconnecting piping, and a blower system near the active runway. However, the resources, equipment, and materials necessary to implement Alternatives 3, 4, and 5 are readily available.

Administrative implementation of the institutional controls component of Alternative 2 would be relatively simple because LUCs and a Facility Master Plan, including land and groundwater use restrictions, would be formulated and implemented to prevent the use of groundwater from the shallow Columbia aquifer. Administrative implementation of the monitoring component of Alternative 2 would also be relatively simple and would not require permits.

The administrative implementation of Alternatives 3, 4, and 5 would be slightly more difficult than for Alternative 2. In addition to the same requirements as Alternative 2, Alternatives 3 and 4 may include a construction permit for installation of injection points. Alternative 5 may include a construction permit and an erosion and sediment control plan for installation of the AS system. These permits should be relatively easy to obtain.

2.10.7 <u>Cost</u>

The estimated present-worth costs for Alternatives 1, 2, 3, 4, and 5 range from $12,600 for Alternative 1 to $530,000 for Alternative 4. Capital, annual O&M, and present-worth costs are provided in Table 2-7. Present-worth costs are listed below:

- Alternative 1: $12,600
- Alternative 2: $224,000
- Alternative 3: $397,000
- Alternative 4: $530,000
- Alternative 5: $493,000

2.10.8 <u>State Acceptance</u>

The Commonwealth of Virginia has expressed its support of Alternatives 2, 3, 4, and 5 and agrees with the Selected Remedy described in Section 2.12 below.

2.10.9 <u>Community Acceptance</u>

Because no comments were expressed at the public meeting, and no comments were received during the public comment period, it appears that the community generally agrees with the Selected Remedy. Specific details regarding the public comment period can be found in the Responsiveness Summary section of this ROD.

2.11 PRINCIPAL THREAT WASTES

The NCP establishes an expectation that treatment will be used to address the principal threats posed by a site wherever practicable [40 C.F.R. Section 300.430(a)(1)(iii)(A)]. Based on the results of the investigations, studies, and sampling conducted, the contaminated groundwater at the WOD does not constitute a principal threat waste as defined by the NCP. Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. Contaminated groundwater is generally not considered to be a source material.

2.12 SELECTED REMEDY

2.12.1 Summary of Rationale for the Selected Remedy

The Selected Remedy for the WOD is Alternative 3: In-Situ Biological Treatment (Biostimulation), Institutional Controls, and Monitoring. This alternative meets the RAOs, provides adequate protection of human health and the environment, attains ARARs, and provides the best balance of tradeoffs with respect to the balancing and modifying criteria. Alternative 3 includes active treatment as a principal element and is expected to attain all RAOs in less time than Alternative 2. Although Alternatives 4 and 5 also include treatment, Alternative 3 is equally as effective as these alternatives at a lower cost. Alternative 3 would be easier to implement than Alternative 5.

2.12.2 Description of Selected Remedy

2.12.2.1 In-Situ Biological Treatment (Biostimulation)

An ORC will be injected into the Columbia aquifer to create an aerobic treatment zone suitable for biodegradation of benzene and other organic chemicals. The conceptual design in the FS assumed that the ORC will be injected in a grid pattern within the contaminant plume. The injection scheme will consist of 12 injection points with a spacing of 30 feet. The ORC will be injected at a rate of 450 pounds per injection point in the upper 10 feet of the aquifer (approximately 20 to 30 feet bgs). The conceptual design assumed that only one injection event will be needed.

The arsenic contamination is most likely associated with the reduced environment created by the natural degradation of organic chemicals in the aquifer. In-situ biological treatment will change the groundwater to an aerobic environment that is expected to cause the arsenic to transform from soluble compounds to insoluble oxidized compounds.

2.12.2.2 Institutional Controls

Use of groundwater will be controlled through restrictions documented in the Facility Master Plan and deed notices, if the property is transferred. The following institutional controls for the WOD will be implemented:

- No use of shallow groundwater (Columbia aquifer) for domestic purposes.

- No installation of new drinking water wells.
- All other uses of groundwater require NASA approval. The acceptability of such use will be evaluated based on chemical concentrations present in groundwater at the time of such use.

- Maintain the integrity and protectiveness of any current or future remediation or monitoring systems.

The institutional controls will be maintained until concentrations of hazardous substances in shallow groundwater are at such levels to allow for unlimited use and unrestricted exposure.

A LUC Plan will be prepared as the land use component of the Remedial Design. Within 90 days of ROD signature, NASA will be required to prepare and submit to EPA for approval a LUC Plan that shall contain implementation and maintenance actions, including periodic inspections. NASA will implement, maintain, monitor, report on, and enforce the institutional controls in accordance with the LUC Plan. If some or all of the Site property is transferred, NASA will notify EPA ninety (90) days prior to transfer, or within 7 days of the decision to transfer the property if 90 days notice is not possible. Deed notices notifying subsequent owners that groundwater is not potable until the clean-up levels are met will be prepared and recorded prior to transfer.

2.12.2.3 Monitoring

Monitoring will involve shallow groundwater sampling as described in Section 2.9.1.3. A monitoring plan will be developed with EPA and DEQ concurrence to detail the frequency, analysis, and locations of the monitoring samples and the criteria for cessation of monitoring.

Five-Year Reviews will be conducted to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary.

2.12.3 Summary of Estimated Remedy Costs

Cost estimate summaries for the Selected Remedy are provided in Table 2-8 (capital cost), Table 2-9 (annual costs), and Table 2-10 (present-worth analysis). The information in these cost estimate summary tables is based on the best available information regarding the anticipated scope of the remedial alternative. The estimated present-worth of the selected remedy is $397,000. Changes in the cost elements may occur because of new information or data collected during the engineering design of the selected remedy. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Differences (ESD), or a ROD amendment depending on the scope of the change. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost. These estimates are refined as the remedy is designed and implemented. Even after the remedial action is constructed, the total project cost is still reported as an estimate because of the uncertainty associated with annual O&M expenditures.

2.12.4 Expected Outcomes of the Selected Remedy

After the Selected Remedy has been implemented, use of shallow groundwater (Columbia aquifer) as a source of drinking water at the WOD will be prohibited until clean-up levels are attained. Groundwater can possibly be used for non-domestic purposes depending on contaminant concentrations at the time of the proposed use. Shallow groundwater will be available for unlimited use and unrestricted exposure after the clean-up levels are attained enhancing the value of the WOD Site should it be developed in the future. The estimated time to achieve clean-up levels is 3 years.

2.12.5 Performance Standards

Clean-up levels for the COCs and the basis for each are as follows:

- Benzene – 5 µg/L (MCL)
- Arsenic (total) – 10 µg/L (MCL)

NASA will prepare a series of Treatability Testing, Remedial Design, Remedial Action and Remedial Action Monitoring Work Plans and Reports for EPA and DEQ review and EPA approval. These documents will detail the requirements of the remedial action including the specific wells and parameters that will be monitored during the implementation of the Selected Remedy. At a minimum the Remedial Action Monitoring Plan will include the sampling of wells located within and immediately upgradient and downgradient of the contaminant plume. Monitoring wells WFF15-MW3R, WFF15-GW7, WFF15-GW1, WFF15-GW2, WFF16-GW2S, WFF16-GW2D, and WFF16-GW5 will be included in the monitoring plan unless substitution and/or elimination is approved by EPA. Up to 2 additional monitoring wells will be installed as necessary, to ensure an adequate groundwater monitoring network. Groundwater samples will be analyzed for benzene and dissolved and total arsenic. In addition, the monitoring program will include analysis of groundwater samples for tetrachloroethene, xylenes, 1,2,4-trimethylbenzene, 4-methylphenol, and naphthalene to confirm that the presence and/or concentrations of these compounds does not significantly contribute to Site risks. Groundwater samples will also be analyzed for indicator compounds necessary to monitor the performance and effectiveness of the remedial action. Monitoring and reporting will be required until clean-up levels are attained, as addressed in the approved plans listed above. The monitoring frequency will include, at a minimum, the collection and analysis of quarterly samples for the first year after completion of injection activities, and semi-annual samples for the second and third year after completion of injection activities. Monitoring will continue until 4 consecutive monitoring events confirm that the clean-up levels have been attained in Site monitoring wells included in the Remedial Action Monitoring Plan. The monitoring frequency and program may be modified, with EPA concurrence, after initial sample results reach the clean-up levels or during the remedial action monitoring phase.

2.13 STATUTORY DETERMINATIONS

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

2.13.1 Protection of Human Health and the Environment

The Selected Remedy, Alternative 3, will protect human health and the environment using a combination of in-situ biological treatment to reduce COC concentrations in shallow groundwater and institutional controls to prohibit use of contaminated shallow groundwater as a source of drinking water until the clean-up levels have been attained. Exposure concentrations for each COC will be reduced to attain MCLs.

There are no short-term threats associated with the Selected Remedy that cannot be readily controlled. In addition, no cross-media impacts are expected from the Selected Remedy. Monitoring will be conducted to ensure that shallow groundwater contaminants are not migrating offsite at unacceptable concentrations.

2.13.2 Compliance with ARARs

The Selected Remedy will meet all identified ARARs. Federal and state ARARs and TBCs for the Selected Remedy are identified and summarized by classification in Tables 2-11 and 2-12.

2.13.3 Cost-Effectiveness

In NASA and EPA's judgment, the Selected Remedy is cost effective. In making this determination, the following definition was used [40 C.F.R. Section 300.430(f)(1)(ii)(D)]: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." NASA first evaluated the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and in compliance with ARARs). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, or volume through treatment; and short-term effectiveness). The overall effectiveness of all the alternatives was considered and then compared to each of their costs.

The estimated present-worth cost of the Selected Remedy (Alternative 3) is $397,000. Although Alternative 2 is approximately $173,000 less expensive, it does not include treatment and is expected to take longer to attain clean-up levels. Present-worth costs for Alternatives 4 and 5 are approximately $133,000 and $96,000 higher, respectively, than for Alternative 3 but are considered equally effective at attaining the clean-up levels in the same time frame.

2.13.4 Utilization of Permanent Solutions and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Practicable

NASA and EPA, with DEQ concurrence, have determined that the Selected Remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the Site. Of those alternatives that are protective of human health and the environment and comply with ARARs, NASA and EPA have determined that the Selected Remedy provides the best balance of trade-offs in terms of the five balancing criteria. NASA and EPA also considered the statutory preference for treatment as a principal element and state and community acceptance.

The Selected Remedy uses in-situ biological treatment to remove benzene from the entire contaminant plume. Although biological treatment does not specifically target arsenic, the addition of oxygen is expected to transform arsenic from soluble compounds into insoluble oxidized compounds. The Selected Remedy does not present short-term risks different than the other treatment alternatives. There are no special implementability issues that set the Selected Remedy apart from any of the other alternatives evaluated.

2.13.5 Treatment as a Principal Element

The Selected Remedy includes in-situ biological treatment of the entire contaminant plume where COC concentrations are greater than clean-up levels. By utilizing treatment as a significant portion of the remedy, the statutory preference for remedies that employ treatment as a principal element is satisfied.

2.13.6 Five-Year Review Requirement

Five-Year Reviews will be conducted for the Site until clean-up levels are attained.

2.14 DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for the WOD at NASA WFF, Wallops Island, Virginia was released for public comments February 14, 2007. The Proposed Plan identified Alternative 3, In-Situ Biological Treatment (Biostimulation), Institutional Controls, and Monitoring, as the preferred alternative. No written or verbal comments were submitted during the public comment period. It was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

3.0 RESPONSIVENESS SUMMARY

In accordance with Sections 113 and 117 of CERCLA, NASA provided a public comment period from February 14, 2007 to March 15, 2007 for the proposed remedial action described in the Proposed Plan for the WOD. Public input is a key element in the decision-making process.

The Proposed Plan is available to the public in the Administrative Record. The Supplemental RI and FS Reports are also available in the Administrative Record. The Information Repositories for the Administrative Record are maintained by the Eastern Shore Public Library (23610 Front Street, Accomack, Virginia 23301) and the Island Library (4077 Main Street, Chincoteague, Virginia 23336). The Proposed Plan was made available on February 14, 2007.

A public meeting to present the Proposed Plan for the WOD was held at the NASA WFF Visitor Center on March 1, 2007. Public notice of the meeting and availability of documents was placed in the Chincoteague Beacon and Eastern Shore News on February 8 and 14, 2007, respectively.

No comments were received by NASA, EPA, or DEQ during the public comment period. Representatives of NASA, EPA, and DEQ were available at the public meeting to present the Proposed Plan for the WOD and to answer questions on the proposed remedy.

REFERENCES

TtNUS (Tetra Tech NUS, Inc.), 2004. Supplemental Remedial Investigation, Waste Oil Dump, NASA Wallops Flight Facility, Wallops Island, Virginia. Prepared for National Aeronautics and Space Administration Goddard Space Flight Center Wallops Flight Facility, Wallops Island, Virginia under a contract issued by the Engineering Field Activity Northeast of the Naval Facilities Engineering Command. King of Prussia, Pennsylvania.

TtNUS, 2005. Feasibility Study, Waste Oil Dump, NASA Wallops Flight Facility, Wallops Island, Virginia. Prepared for National Aeronautics and Space Administration Goddard Space Flight Center Wallops Flight Facility, Wallops Island, Virginia under a contract issued by the Engineering Field Activity Northeast of the Naval Facilities Engineering Command. King of Prussia, Pennsylvania.

TABLES

TABLE 2-1

SUMMARY OF CHEMICALS OF CONCERN AND MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATIONS
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

Exposure Point	Chemical of Concern	Concentration Detected (µg/L)	Frequency of Detection	Exposure Point Concentration (µg/L)	Statistical Measure
Groundwater – ingestion, dermal contact, inhalation	Benzene	8 - 11	2/12	8.5	97.5% UCL
	Arsenic (total)	21.4	1/8	15.1	95% UCL

UCL: Upper confidence limit.

This table presents the chemicals of concern (COCs) and exposure point concentrations (i.e., the concentration that will be used to estimate the exposure and risk) for each of the COCs detected in groundwater.

TABLE 2-2

CANCER TOXICITY DATA SUMMARY
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

Pathway: Ingestion, Dermal

Chemical of Concern	Oral Cancer Slope Factor	Dermal Cancer Slope Factor	Slope Factor Units	Weight of Evidence	Source	Date
Benzene	5.5E-02	5.5E-02	$(mg/kg/day)^{-1}$	A	IRIS	7/24/03
Arsenic	1.5E+00	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	7/24/03

Pathway: Inhalation

Chemical of Concern	Unit Risk	Units	Inhalation Cancer Slope Factor	Units	Weight of Evidence	Source	Date
Benzene	7.7E-03	$(mg/m^3)^{-1}$	2.7E-02	$(mg/kg/day)^{-1}$	A	IRIS	7/24/03
Arsenic	4.3E+00	$(mg/m^3)^{-1}$	1.51E+01	$(mg/kg/day)^{-1}$	A	IRIS	7/24/03

--: No information available.
IRIS: Integrated Risk Information System.

Weight of Evidence
A: Human carcinogen.

Cancer slope factors are not available for the dermal route of exposure; the dermal slope factors used in the assessment have been extrapolated from oral values. An adjustment factor is applied and is dependent on how well the chemical is absorbed via the oral route. Adjustments are particularly important for chemicals with less than 50 percent absorption via the ingestion route. However, no adjustments were necessary. Benzene and arsenic are also considered carcinogenic via the inhalation route of exposure.

TABLE 2-3

NONCANCER TOXICITY DATA SUMMARY
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

Pathway: Ingestion, Dermal

Chemical of Concern	Chronic/ Subchronic	Oral RfD	Dermal RfD	Units	Target Organ(s)	Uncertainty Factor	Source	Date
Benzene	Chronic	4.0E-03	4.0E-03	mg/kg-day	Blood, Immune	300	IRIS	7/24/03
Arsenic	Chronic	3.0E-04	3.0E-04	mg/kg-day	Skin, Vascular	3	IRIS	7/24/03

Pathway: Inhalation

Chemical of Concern	Chronic/ Subchronic	Inhalation RfC	Units	Inhalation RfD	Units	Primary Target Organ	Uncertainty Factor	Source	Date
Benzene	Chronic	3.0E-02	mg/m^3	8.6E-03	mg/kg-day	Blood, Immune	1,000	IRIS	7/24/03
Arsenic	--	--	--	--	--	--	--	--	--

--: No information available.
IRIS: Integrated Risk Information System.
RfC: Reference concentration.
RfD: Reference dose.

The chronic toxicity data available for oral exposures have been used to develop oral RfDs. As was the case with carcinogenic data, dermal RfDs can be extrapolated from oral values by applying an adjustment factor as appropriate. However, no adjustments were necessary, and the oral values were used as the dermal RfDs. The uncertainty factor is used to account for uncertainty when deriving the RfD from experimental data.

TABLE 2-4

FUTURE LIFETIME RESIDENT RISK CHARACTERIZATION SUMMARY – CARCINOGENS
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

CHILD RESIDENT

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Dermal	Inhalation	Exposure Route Total
Groundwater	Groundwater	Tap Water	Benzene	3.4E-06	4.1E-07	NA	3.8E-06
		Tap Water	Arsenic	1.7E-04	8.5E-07	NA	1.7E-04
						Groundwater risk total =	**1.7E-04**

ADULT RESIDENT

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Dermal	Inhalation	Exposure Route Total
Groundwater	Groundwater	Tap Water	Benzene	4.4E-06	2.25E-07	NA	4.6E-06
		Tap Water	Arsenic	2.1E-04	4.8E-07	NA	2.1E-04
	Air	Inhalation of Volatiles	Benzene	NA	NA	2.6E-06	2.6E-06
		Inhalation of Volatiles	Arsenic	NA	NA	NT	NT
						Groundwater risk total =	**2.1E-04**

LIFETIME RESIDENT INCREMENTAL CARCINOGENIC RISK	**3.8E-04**

NA: Route of exposure is not applicable to this medium.
NT: Toxicity criteria are not available to quantitatively address this route of exposure.

TABLE 2-5

FUTURE CHILD RESIDENT RISK CHARACTERIZATION SUMMARY – NONCARCINOGENS
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Noncarcinogenic Hazard Quotient			
					Ingestion	Dermal	Inhalation	Exposure Route Total
Groundwater	Groundwater	Tap Water	Benzene	Blood, Immune	1.8E-01	2.2E-02	NA	0.2
		Tap Water	Arsenic	Skin, Vascular	4.3E+00	2.2E-02	NA	4.3
							Groundwater Hazard Index Total =	**4.5**
							Blood Hazard Index =	**0.2**
							Immune System Hazard Index =	**0.2**
							Skin Hazard Index =	**4.3**
							Vascular System Hazard Index =	**4.3**

NA: Route of exposure is not applicable to this medium.

TABLE 2-6

FUTURE ADULT RESIDENT RISK CHARACTERIZATION SUMMARY – NONCARCINOGENS
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Noncarcinogenic Hazard Quotient			
					Ingestion	Dermal	Inhalation	Exposure Route Total
Groundwater	Groundwater	Tap Water	Benzene	Blood, Immune	5.8E-02	3.0E-03	NA	0.06
		Tap Water	Arsenic	Skin, Vascular	1.4E+00	3.1E-03	NA	1.4
	Air	Inhalation of Volatiles	Benzene	Blood, Immune	NA	NA	3.3E-02	0.03
		Inhalation of Volatiles	Arsenic	Skin, Vascular	NA	NA	NT	NT
Groundwater Hazard Index Total =								**1.5**
Blood Hazard Index =								**0.09**
Immune System Hazard Index =								**0.09**
Skin Hazard Index =								**1.4**
Vascular System Hazard Index =								**1.4**

NA: Route of exposure is not applicable to this medium.
NT: Toxicity criteria are not available to quantitatively address this route of exposure.

TABLE 2-7

SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

Evaluation Criterion	Alternative 1 – No Action	Alternative 2 –Natural Attenuation, Institutional Controls and Monitoring	Alternative 3 – In-Situ Bioremediation (Biostimulation), Institutional Controls, and Monitoring
Threshold Criteria			
Overall Protection of Human Health and the Environment	No reduction in potential risks.	Groundwater use restrictions and monitoring would reduce risks to human health and the environment.	Groundwater treatment, use restrictions, and monitoring would reduce risks to human health and the environment.
Compliance with ARARs	Alternative 1 would not comply with ARARs. Specifically,		
Chemical-specific	Would allow ingestion of groundwater exceeding MCLs.	Groundwater would meet MCLs in 5 years.	Groundwater would meet MCLs within 5 years.
Location-specific	No measures would be taken to prevent the use of private wells at the Site.	Would prevent the use of private wells at the Site.	Same as Alternative 2.
Action-specific	Not applicable.	Not applicable.	Would comply with the UIC Program drinking water protection standards.
Primary Balancing Criteria			
Long-Term Effectiveness and Permanence	Allows uncontrolled risks to remain.	Natural attenuation would be expected to be effective. Groundwater use restrictions would reduce risks to human health. Monitoring and use restrictions would provide adequate and reliable controls.	Treatment would be expected to be effective over the long term. Treatability studies needed to confirm effectiveness. Monitoring and use restrictions would provide adequate and reliable controls.
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment.	No treatment.	In-situ biostimulation would reduce toxicity of hazardous substances in groundwater.

TABLE 2-7

**SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA
PAGE 2 OF 4**

Evaluation Criterion	Alternative 1 – No Action	Alternative 2 –Natural Attenuation, Institutional Controls and Monitoring	Alternative 3 – In-Situ Bioremediation (Biostimulation), Institutional Controls, and Monitoring
Primary Balancing Criteria (continued)			
Short-Term Effectiveness	Not applicable.	No impacts to community or environment. Potential impacts to workers can be adequately controlled. Five years to attain clean-up levels.	No impacts to community or environment. Potential impacts to workers can be adequately controlled. One month to construct. Three years to attain clean-up levels.
Implementability	Not applicable.	Groundwater use restrictions could be implemented through LUCs and a Facility Master Plan.	Alternative consists of common remediation practices that are readily available and implementable. Permits may be obtained for installation of injection points and chemical injection.
Cost			
Capital	$0	$37,000	$240,000
Annual O&M	$15,000 Five-Year Review	$73,000 (Year 1), $38,000 (Years 2 and 3), $20,000 (Year 4), $35,000 (Year 5)	$78,000 (Year 1), $38,000 (Years 2 and 3), $15,000 (Year 5)
Present worth	$12,600	$224,000	$397,000
Modifying Criteria			
State Acceptance	Not applicable.	Acceptable.	Acceptable.
Community Acceptance	Not applicable.	Acceptable.	Acceptable.

TABLE 2-7

SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

Evaluation Criterion	Alternative 4 – In-Situ Bioremediation (Bioaugmentation), Institutional Controls, and Monitoring	Alternative 5 – In-Situ Air Sparging Treatment, Institutional Controls, and Monitoring
Threshold Criteria		
Overall Protection of Human Health and the Environment	Groundwater treatment, use restrictions, and monitoring would reduce risks to human health and the environment.	Groundwater treatment, use restrictions, and monitoring would reduce risks to human health and the environment.
Compliance with ARARs		
Chemical-specific	Same as Alternative 3.	Groundwater would meet MCLs within 5 years.
Location-specific	Same as Alternative 2.	Same as Alternative 2.
Action-specific	Same as Alternative 3.	
Primary Balancing Criteria		
Long-Term Effectiveness and Permanence	Treatment would be expected to be effective over the long term. Treatability studies needed to confirm effectiveness. Monitoring and use restrictions would provide adequate and reliable controls.	Treatment would be expected to be effective over the long term. Monitoring and use restrictions would provide adequate and reliable controls.
Reduction of Toxicity, Mobility, or Volume through Treatment	In-situ bioaugmentation would reduce toxicity of hazardous substances in groundwater.	In-situ air sparging would reduce toxicity of hazardous substances in groundwater.
Short-Term Effectiveness	No impacts to community or environment. Short-term impacts to workers can be adequately controlled. One month to construct. Three years to attain clean-up levels.	No impacts to community or environment. Short-term impacts workers can be adequately controlled. Two months to construct. Three years to attain clean-up levels
Implementability	Alternative consists of common remediation practices that are readily available and implementable. Permits may be obtained for installation of injection points and chemical injection.	Alternative consists of common remediation practices that are readily available and implementable. Permits may be needed for installation of air sparging system.

TABLE 2-7

SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

Evaluation Criterion	Alternative 4 – In-Situ Bioremediation (Bioaugmentation), Institutional Controls, and Monitoring	Alternative 5 – In-Situ Air Sparging Treatment, Institutional Controls, and Monitoring
Primary Balancing Criteria (continued)		
Cost		
Capital	$175,000	$307,000
Annual O&M	$180,000 (Year 1), $144,000 (Year 2), $38,000 (Year 3), $15,000 (Year 5)	$90,000 (Year 1), $64,000 (Year 2), $29,000 (Year 3), $15,000 (Year 5)
Present worth	$530,000	$493,000
Modifying Criteria		
State Acceptance	Acceptable.	Acceptable.
Community Acceptance	Acceptable.	Acceptable.

ARARs Applicable or Relevant and Appropriate Requirements.
COCs Chemicals of concern.
O&M Operation and maintenance.

TABLE 2-8

CAPITAL COST ESTIMATE SUMMARY FOR THE SELECTED REMEDY
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

Item	Quantity	Unit	Unit Cost				Extended Cost				Subtotal
			Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS											
1.1 Prepare Documents & Plans including Permits	150	hr			$35.00		$0	$0	$5,250	$0	$5,250
1.2 Prepare Land Use Control (LUC)	200	hr			$35.00		$0	$0	$7,000	$0	$7,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer	1	mo				$286.00	$0	$0	$0	$286	$286
2.2 Office Trailer Mob/Demo	1	ea				$225.00	$0	$0	$0	$225	$225
2.3 Field Office Support	1	mo		$143.00			$0	$143	$0	$0	$143
2.4 Utility Connection/Disconnection (phone/electric)	1	ls	$1,500.00				$1,500	$0	$0	$0	$1,500
2.5 Site Utilities (phone & electric)	1	mo		$302.00			$0	$302	$0	$0	$302
2.6 Drill Rig Mobilization/Demobilization	1	ls	$3,000.00				$3,000	$0	$0	$0	$3,000
2.7 Professional Oversight (2p * 5 days/week)	3	wk			$1,600.00		$0	$0	$4,800	$0	$4,800
3 DECONTAMINATION											
3.1 Decontamination Services	1	mo		$375.00	$1,200.00	$900.00	$0	$375	$1,200	$900	$2,475
3.2 Pressure Washer	1	mo				$1,100.00	$0	$0	$0	$1,100	$1,100
3.3 Equipment Decon Pad	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105
3.4 Decon Water	1	kgal		$200.00			$0	$200	$0	$0	$200
3.5 Decon Water Storage Tank, 6,000 gallon	1	mo				$645.00	$645	$0	$0	$645	$1,290
3.6 Clean Water Storage Tank, 4,000 gallon	1	mo				$580.00	$580	$0	$0	$580	$1,160
3.7 Disposal of Decon Waste (liquid & solid)	1	mo	$900.00				$900	$0	$0	$0	$900
4 MONITORING WELL INSTALLATION											
4.1 Install Monitoring Well	45	lf	$30.00				$1,350	$0	$0	$0	$1,350
4.2 Well Development	8	hr	$35.00				$280	$0	$0	$0	$280
4.3 Collect/Containerize IDW	2	ea	$50.00				$100	$0	$0	$0	$100
4.4 Transport/Dispose IDW Off Site	2	drum	$150.00				$300	$0	$0	$0	$300
5 BIOREMEDIATION											
5.1 Bench-Scale Treatability Study	1	ls	$10,000.00				$10,000	$0	$0	$0	$10,000
5.2 Drill 12 1-inch DPT Points to 30' bgs	360	ft	$30.00				$10,800	$0	$0	$0	$10,800
5.3 ORC Materials (5430 lbs. + 5%)	5,700	lbs		$9.30			$0	$53,010	$0	$0	$53,010
5.4 Supplier Technical Oversight	1	ls	$2,000.00				$2,000	$0	$0	$0	$2,000
6 SITE RESTORATION											
6.1 Vegetate Disturbed Areas	1	ls		$300.00	$500.00	$200.00	$0	$300	$500	$200	$1,000
Subtotal							$31,455	$54,830	$19,200	$4,091	$109,576
Local Area Adjustments							100.0%	104.8%	85.6%	85.6%	
							$31,455	$57,462	$16,435	$3,502	$108,854
Overhead on Labor Cost @ 30%									$4,931		$4,931
G & A on Labor Cost @ 10%									$1,644		$1,644
G & A on Material Cost @ 10%								$5,746			$5,746
G & A on Equipment Cost @ 10%										$350	$350
G & A on Subcontract Cost @ 10%							$3,146				$3,146
Total Direct Cost							$34,601	$63,208	$23,009	$3,852	$124,670

TABLE 2-8

CAPITAL COST ESTIMATE SUMMARY FOR THE SELECTED REMEDY
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

Item	Quantity	Unit	Unit Cost				Extended Cost				Subtotal
			Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	
Indirects on Total Direct Cost @	35%										$43,634
Profit on Total Direct Cost @	10%										$12,467
Subtotal											$180,771
Health & Safety Monitoring @	2%										$3,615
Total Field Cost											$184,387
Contingency on Total Field Costs @	20%										$36,877
Engineering on Total Field Cost @	10%										$18,439
TOTAL COST											**$239,703**

TABLE 2-9

ANNUAL COST ESTIMATE SUMMARY FOR THE SELECTED REMEDY
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

Item	Item Cost Year 1	Item Cost Years 2 and 3	Item Cost Year 5	Notes
Site Inspection and Report	$2,570	$2,570		One-day land use control inspection with 2 people
3-Month Monitoring	$5,090			Monitoring oxygen and carbon dioxide in treatment area 3 months following injection.
Sampling	$16,080	$8,040		Labor and field supplies (local
Analysis	$17,136	$8,568		Analyze 9 water samples for volatile organics, semivolatile organics, and arsenic. Quarterly - Year 1; Semi-annually - Years 2 and 3
Analysis	$17,136	$8,568		Analyze 9 water samples for bioremediation indicator parameters. Quarterly - Year 1; Semi-annually - Years 2 and 3
Sampling and Analysis Report	$20,000	$10,000		Document sampling events and results
Site Review			$15,000	Perform 5-year review
TOTALS	$78,012	$37,746	$15,000	

TABLE 2-10

PRESENT-WORTH ANALYSIS FOR THE SELECTED REMEDY
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

Year	Capital Cost	Annual Cost	Annual Discount Rate at 3.5%	Present Worth
0	$239,703		1.000	$239,703
1		$78,012	0.966	$75,360
2		$37,746	0.934	$35,255
3		$37,746	0.902	$34,047
4			0.871	$0
5		$15,000	0.842	$12,630
			TOTAL PRESENT WORTH	**$396,994**

TABLE 2-11

DESCRIPTION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
FOR THE SELECTED REMEDY
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

ARAR or TBC	Citation	Classification	Summary of Requirement	Applicability to Selected Remedy
A. State				
1. Virginia Department of Health Private Well Regulations, 12 VAC 5-630				
a. Well Location	12 VAC 5-630-380	Applicable	Prohibits private wells in locations where a source of contamination could adversely affect the well and preventive measures are not available to protect the groundwater.	The selected remedy will comply with this regulation by restricting the use of the Columbia aquifer at the Site as a source of drinking water until clean-up levels are attained.
b. Monitoring and Observation Well Construction and Abandonment	12 VAC 5-630-420 and -450	Relevant and Appropriate	Establishes monitoring well construction requirements if monitoring wells are to remain in place after completion of a groundwater study. Also establishes requirements and procedures for abandoning monitoring wells.	The selected remedy will comply with these regulations by requiring that monitoring wells be abandoned after confirming groundwater has reached clean-up goals.
B. Federal				
1. Safe Drinking Water Act, 42, U.S.C. Section 300f et seq.				
a. Maximum Contaminant Levels	40 C.F.R. Sections 141.23 and 141.24	Relevant and Appropriate	Enforceable standards for public drinking water supply systems. The NCP requires that MCLs shall be attained by remedial actions for groundwater that is a current or potential source of drinking water.	These standards apply to: Arsenic and Benzene. The Selected Remedy will comply with these regulations through in-situ bioremediation.

TABLE 2-11

**DESCRIPTION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
FOR THE SELECTED REMEDY
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA**

ARAR or TBC	Citation	Classification	Summary of Requirement	Applicability to Selected Remedy
2. Solid Waste Disposal Act Underground Injection Control Program, 40 C.F.R. 144				
a. Underground Injection Control Regulations	40 C.F.R. Section 144.12	Applicable	Establishes minimum program and performance standards for underground injection programs. Requires protection of underground sources of drinking water.	The Selected Remedy will comply with the substantive requirements of the regulation by assuring that injection of bioremediation chemicals is accomplished in accordance with these standards.

Note: Refer to FS (TtNUS, 2005) for ARARs for other alternatives.

CFR: Code of Federal Regulations.
COCs: Chemicals of concern.
MCLs: Maximum Contaminant Levels.
VAC: Virginia Administrative Code

TABLE 2-12

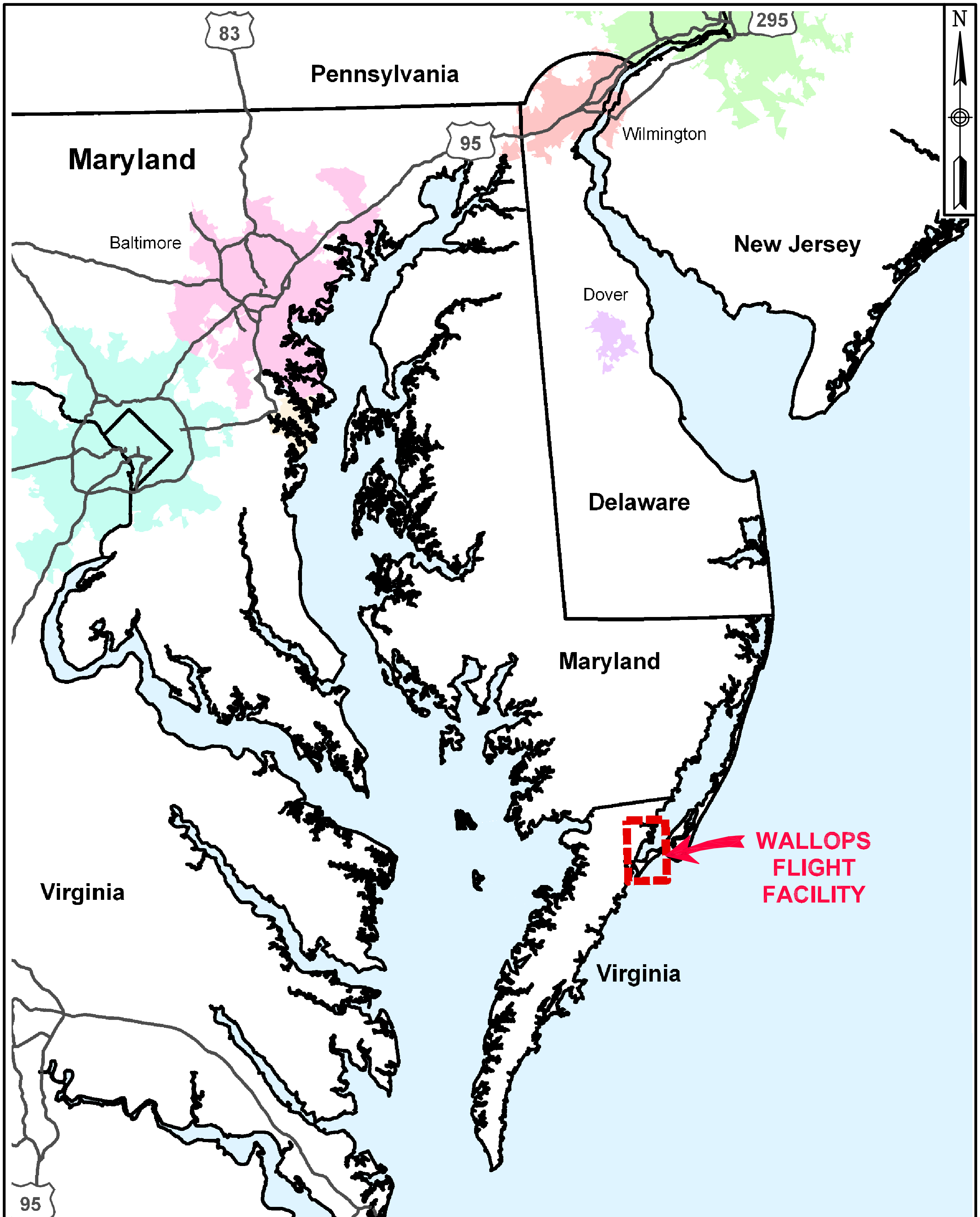
**DESCRIPTION OF TO BE CONSIDERED (TBC) REQUIREMENTS
FOR THE SELECTED REMEDY
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA**

TBC	Citation	Classification	Summary of Requirement	Applicability to Selected Remedy
A. State				
1. State Water Control Board, 9 VAC 25-280 Groundwater Standards; § 62.1-44.15(3a) Code of Virginia				
a. Groundwater Standards	9 VAC 24-280-20 through -50	To Be Considered	Provides general requirements, the anti-degradation policy for groundwater, statewide groundwater standards, and groundwater standards by physiographic province.	The selected remedy will comply with these standards and policies by restoring the groundwater quality to levels that support and protect anticipated uses.

Note: Refer to FS (TtNUS, 2005) for ARARs for other alternatives.

VAC: Virginia Administrative Code

FIGURES

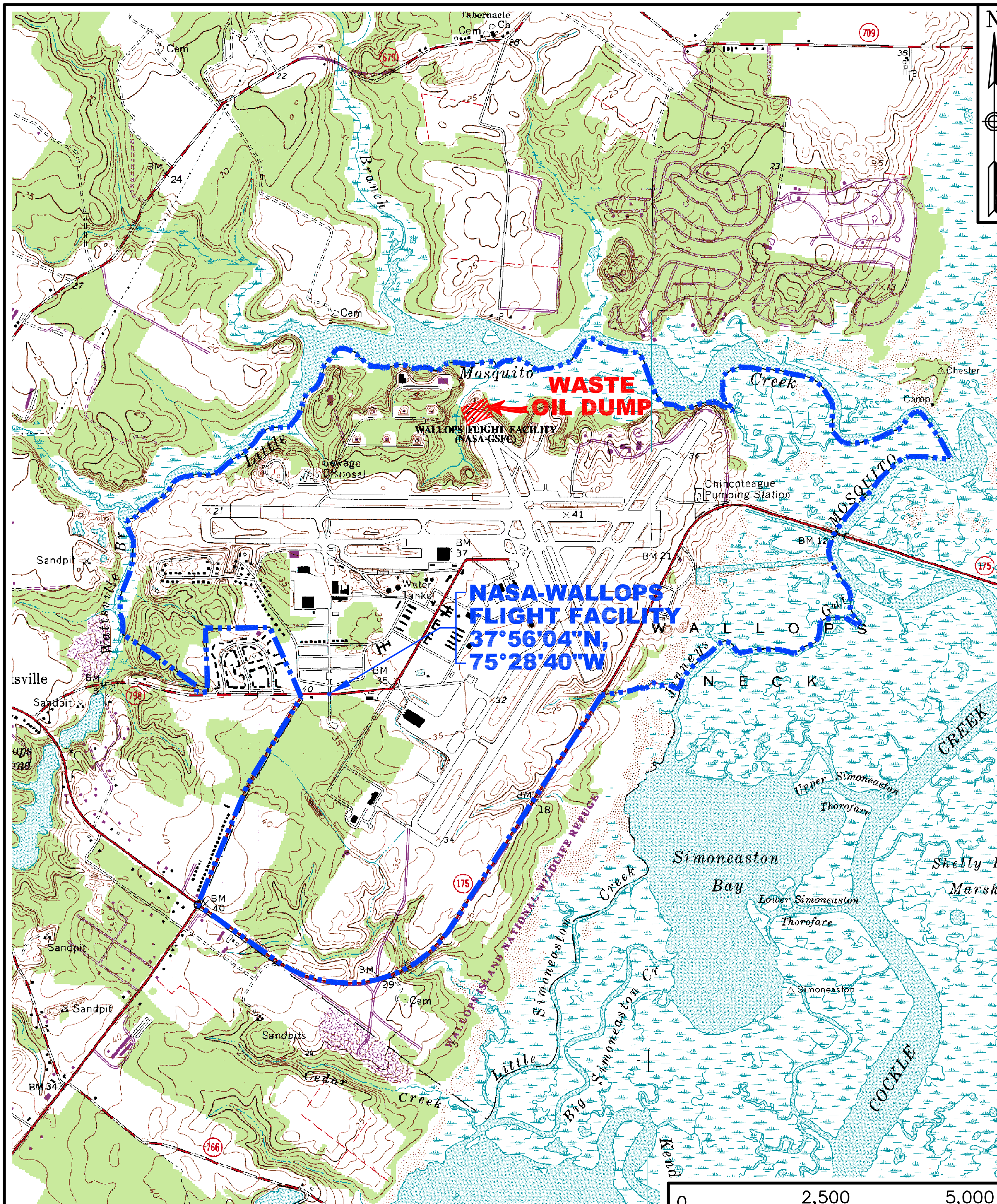


112GN1612\1240\1612BM02.DWG 09/10/07 MKB

TETRA TECH NUS, INC.

SITE LOCATION MAP
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

SCALE	AS NOTED
FILE	1612BM02.DWG
REV 0	DATE 09/10/07
FIGURE NUMBER	FIGURE 2–1



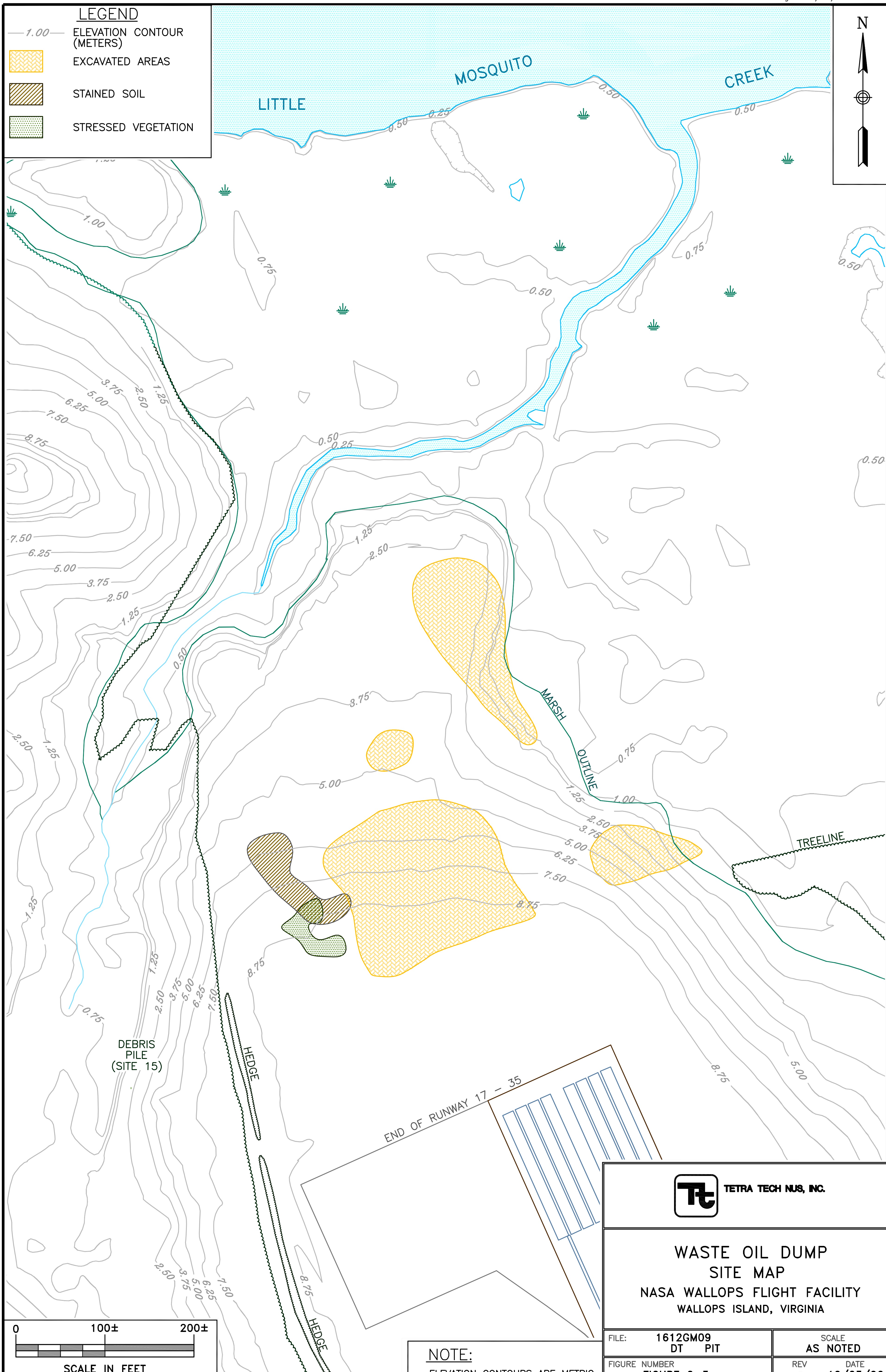
SOURCE: U.S.G.S. 7.5' QUADRANGLE MAP, CHINCOTEAGUE WEST, VA., (37075–H4–TF–024) PHOTOINSPECTED 1989.

112GN1612/1240/1612BM01.DWG 10/23/2006 MKB

TETRA TECH NUS, INC.

STUDY AREA LOCATION MAP OF NASA WALLOPS FLIGHT FACILITY WALLOPS ISLAND, VIRGINIA

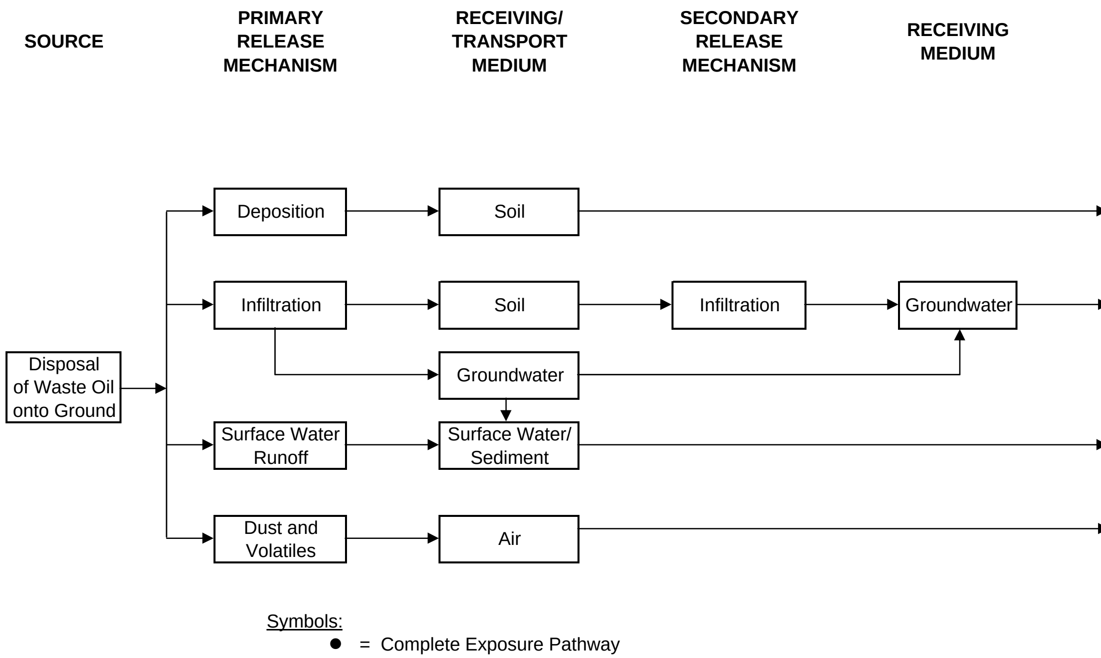
SCALE	AS NOTED
FILE	1612BM01.DWG
REV 0	DATE 10/23/06
FIGURE NUMBER	FIGURE 2–2



TETRA TECH NUS, INC.

WASTE OIL DUMP
SITE MAP
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

FILE:	1612GM09 DT PIT	SCALE	AS NOTED
FIGURE NUMBER	FIGURE 2–3	REV	DATE 10/23/06



RECEPTORS

Medium	Exposure Route	Human: Current/Future Industrial Worker	Human: Future Construction Worker	Human: Hypothetical Future Resident	Ecological: Soil Invertebrates	Ecological: Terrestrial Vegetation	Ecological: Terrestrial Vertebrates	Ecological: Aquatic Organisms
Soil	Direct/dermal contact	●		●	●	●	●	
Soil	Ingestion of soil	●		●	●		●	
Soil	Ingestion of food						●	
Groundwater	Direct/dermal contact		●	●				
Groundwater	Ingestion of water			●				
Groundwater	Inhalation		●	●				
Surface Water/Sediment	Direct/dermal contact						●	●
Surface Water/Sediment	Ingestion of water/sediment						●	●
Surface Water/Sediment	Ingestion of food						●	●
Air	Inhalation	●		●			●	

Blank space indicates incomplete exposure pathway or relatively insignificant, or not applicable, potential exposure.

FIGURE 2-4

CONCEPTUAL SITE MODEL
WASTE OIL DUMP
NASA WFF, WALLOPS ISLAND, VIRGINIA

ACAD:1612GP04.dwg 10/23/06 DT PIT