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NWS YORKTOWN
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EMAIL AND ATTACHED U S EPA REGION III COMMENTS ON THE SITE 22 RECORD OF DECISION NWS YORKTOWN VA
08/28/2012
U S EPA REGION III PHILADELPHIA PA

Marrow, Monica/VBO

From: Frank Fritz <Fritz.Frank@epamail.epa.gov>
Sent: Tuesday, August 28, 2012 11:38 AM
To: Moshood Oduwole
Cc: Gravette, James CIV NAVFAC MIDLANT, IPTNE; Forshey, Adam/VBO; Caldwell, Donna J CIV NAVFAC LANT, EV; Will, Katherine CIV NAVFAC MIDLANT, Counsel; Sawyer, Stephanie/VBO; Friedmann, William/VBO; wmsmith@deq.virginia.gov
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments
Attachments: Site 22 ROD.082812.no figures.EPA ORC manager comments.docx

My manager's comments are tiny: delete the word "regular" before "groundwater" on two pages. A redline is attached.

We can expect concurrence from ORC with these changes.

Frank A. Fritz III
Assistant Regional Counsel
U.S. EPA Region III (3RC44)
1650 Arch St
Philadelphia, PA 19103
215-814-2664
215-814-2603 fax

From: Moshood Oduwole/R3/USEPA/US
To: Frank Fritz/R3/USEPA/US@EPA
Cc: "Gravette, James CIV NAVFAC MIDLANT, IPTNE" <james.gravette@navy.mil>, Adam.Forshey@CH2M.com, "Caldwell, Donna J CIV NAVFAC LANT, EV" <donna.caldwell@navy.mil>, "Will, Katherine CIV NAVFAC MIDLANT, Counsel" <katherine.will@navy.mil>, Stephanie.Sawyer@CH2M.com, William.Friedmann@CH2M.com, wmsmith@deq.virginia.gov
Date: 08/27/2012 02:19 PM
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

Frank:

I just received Ron's comment and they are very minor and pretty insignificant. We will be waiting on your green light on the suggested language so that we can proceed with finalizing the ROD and moving onto concurrence and signature.

Nice work everyone!

From: Frank Fritz/R3/USEPA/US
To: "Gravette, James CIV NAVFAC MIDLANT, IPTNE" <james.gravette@navy.mil>
Cc: Adam.Forshey@CH2M.com, "Caldwell, Donna J CIV NAVFAC LANT, EV" <donna.caldwell@navy.mil>, "Will, Katherine CIV NAVFAC MIDLANT, Counsel" <katherine.will@navy.mil>, Moshood Oduwole/R3/USEPA/US@EPA, Stephanie.Sawyer@CH2M.com, William.Friedmann@CH2M.com, wmsmith@deq.virginia.gov
Date: 08/27/2012 08:32 AM
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

I've given my suggested changes (which Jim G OK'ed) on Thursday. Waiting to hear back. I'll send them an email.

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From: "Gravette, James CIV NAVFAC MIDLANT, IPTNE" <james.gravette@navy.mil>
To: Moshood Oduwole/R3/USEPA/US@EPA, Frank Fritz/R3/USEPA/US@EPA
Cc: "Will, Katherine CIV NAVFAC MIDLANT, Counsel" <katherine.will@navy.mil>, <wmsmith@deq.virginia.gov>, "Caldwell, Donna J CIV NAVFAC LANT, EV" <donna.caldwell@navy.mil>, <William.Friedmann@CH2M.com>, <Adam.Forshey@CH2M.com>, <Stephanie.Sawyer@CH2M.com>
Date: 08/27/2012 08:16 AM
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

Moshood and Frank,

Not pushing - just checking back in. Can we get an update sometime today on the status/progress with the internal EPA review of the Site 22 draft final ROD.

Thanks.

Jim

-----Original Message-----
From: Will, Katherine CIV NAVFAC MIDLANT, Counsel
Sent: Thursday, August 23, 2012 9:42
To: Gravette, James CIV NAVFAC MIDLANT, IPTNE
Cc: 'Moshood Oduwole'; 'Frank Fritz'; 'wmsmith@deq.virginia.gov'; Caldwell, Donna J CIV NAVFAC LANT, EV; 'William.Friedmann@CH2M.com'; 'Adam.Forshey@CH2M.com'; 'Stephanie.Sawyer@CH2M.com'
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

Thank you Jim.

Frank/Moshood - Anything you can do to help keep this one on track would be great.

Thanks again to everyone for all the work on this.

V/r,
Katherine
Katherine D. Will
Assistant Counsel
NAVFAC MIDLANT
9742 Maryland Avenue
Norfolk, Virginia 23511
757-341-2106

-----Original Message-----
From: Gravette, James CIV NAVFAC MIDLANT, IPTNE
Sent: Thursday, August 23, 2012 9:38 AM
To: Will, Katherine CIV NAVFAC MIDLANT, Counsel
Cc: 'Moshood Oduwole'; 'Frank Fritz'; 'wmsmith@deq.virginia.gov'; Caldwell, Donna J CIV

NAVFAC LANT, EV; 'William.Friedmann@CH2M.com'; 'Adam.Forshey@CH2M.com';
'Stephanie.Sawyer@CH2M.com'
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

Katherine,

Yes - we are really running out of time. At partnering last week we discussed having EPA's approval of the draft final by the end of this week. However, it seems we are up against a few more comments - so hopefully we can get EPA's suggested redline changes by mid-next week. Bottom line - once we get the ROD straight - I will need to get on the COs calendar to brief him and get it signed in early September so the State and EPA have time to work the ROD through their systems for concurrence and signature by the end of September.

Jim

-----Original Message-----
From: Will, Katherine CIV NAVFAC MIDLANT, Counsel
Sent: Thursday, August 23, 2012 9:27
To: Gravette, James CIV NAVFAC MIDLANT, IPTNE; 'Frank Fritz'
Cc: 'Moshood Oduwole'; 'wmsmith@deq.virginia.gov'; Caldwell, Donna J CIV NAVFAC LANT, EV;
'William.Friedmann@CH2M.com'; 'Adam.Forshey@CH2M.com'; 'Stephanie.Sawyer@CH2M.com'
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

Jim,

What is the scheduled date for getting this ROD signed? Just wondering if we're pushing up against any target dates or deadlines either on our part or EPA's. Thanks.

V/r,
Kate

-----Original Message-----
From: Gravette, James CIV NAVFAC MIDLANT, IPTNE
Sent: Thursday, August 23, 2012 9:10 AM
To: Frank Fritz
Cc: Moshood Oduwole; wmsmith@deq.virginia.gov; Will, Katherine CIV NAVFAC MIDLANT,
Counsel; Caldwell, Donna J CIV NAVFAC LANT, EV; William.Friedmann@CH2M.com;
Adam.Forshey@CH2M.com; Stephanie.Sawyer@CH2M.com
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

Frank,

You are correct - these monitoring activities are all very similar. However, what really distinguishes them is the timing. As you know - the selected remedy includes injections to knock down the RDX concentrations with associated "performance" monitoring to confirm that the injections worked; then, only after the team agrees no further injections (or other tweaks) are needed - we move into "LTM" monitoring. "MNA" monitoring is something we plan to do in all phases. In the pre-design - we plan to collect MNA data to confirm it is occurring; and will continue to collect this type data during the performance and LTM monitoring phases.

Therefore - I tweaked the monitoring definitions that Bill sent yesterday to further explain these differences:

Performance Monitoring - a relatively brief monitoring period (~2 years) associated with the injections to evaluate the effectiveness of reducing RDX concentrations in groundwater to levels that would allow natural process to achieve cleanup goals in a timely manner; groundwater data collected during this phase would be used to confirm that the injected material was distributed into the aquifer as intended, RDX concentrations were reduced below 100 ppb, and natural processes remain in place to reduce RDX

concentrations; this phase is expected to extend one year out from the last injection

Long-Term Monitoring - monitoring that occurs after the team confirms injections successfully reduced RDX concentrations in groundwater to levels that allow natural processes to achieve cleanup goals in a timely manner; groundwater data collected during this phase includes COC data (RDX, TCE, and TCE daughter products) and natural attenuation parameters; the data will be used to show that natural process are in place that are effectively and in a timely manner reducing the concentration of COCs (RDX, TCE, and VC); this phase will continue until COCs meet cleanup goals

Let me know if we need a call today to wrap this up.

(Bill - Please let us know if I missed something in re-writing the definitions. Thanks.)

Thanks.

Jim

-----Original Message-----
From: Frank Fritz [mailto:Fritz.Frank@epamail.epa.gov]
Sent: Wednesday, August 22, 2012 16:28
To: William.Friedmann@CH2M.com
Cc: Adam.Forshey@CH2M.com; Caldwell, Donna J CIV NAVFAC LANT, EV; Gravette, James CIV NAVFAC MIDLANT, IPTNE; Will, Katherine CIV NAVFAC MIDLANT, Counsel; Moshood Oduwole; Stephanie.Sawyer@CH2M.com; wmsmith@deq.virginia.gov
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

From the definitions below, I don't see much difference between performance monitoring and long-term monitoring. The definitions use different words, but seem to amount to basically the same thing. Am I missing something? Why not delete the words "performance monitoring" from the ROD and just use long-term monitoring?

Monitored natural attenuation seems to be a part or subset of long-term monitoring.

These definitions seem a bit long and very technical. Is there a way to write them more briefly, in plainer English?

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From: <William.Friedmann@CH2M.com>
To: <james.gravette@navy.mil>, Frank Fritz/R3/USEPA/US@EPA
Cc: Moshood Oduwole/R3/USEPA/US@EPA, <wmsmith@deq.virginia.gov>, <katherine.will@navy.mil>, <donna.caldwell@navy.mil>, <Stephanie.Sawyer@CH2M.com>, <Adam.Forshey@CH2M.com>
Date: 08/22/2012 02:50 PM
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

Some basic definitions that may work.

Natural Attenuation Monitoring - the measuring of the groundwater's self ability (without human intervention) to reduce the mass, toxicity, mobility, volume, or concentration of contaminants through physical, chemical or biological processes until cleanup levels are met.

Performance Monitoring - the use of periodically collected groundwater data to evaluate the effectiveness of a remedy with respect to; horizontal and vertical extent of contamination gradients, rate and direction of contaminant migration, changes in concentrations or distribution, impacts on the remedial design, and other environmental impacts.

Long-Term Monitoring - an agreed upon strategy of the frequency and duration of groundwater data collection for both contaminants and monitored attenuation parameters. Long-term monitoring plans are developed among the regulatory agencies and portion of the plan (frequency, duration, chemicals) may be modified over time based upon the results of the monitoring data.

-----Original Message-----
From: Gravette, James CIV NAVFAC MIDLANT, IPTNE [mailto:james.gravette@navy.mil <mailto:james.gravette@navy.mil>]
Sent: Wednesday, August 22, 2012 1:26 PM
To: Friedmann, William/VBO; Frank Fritz
Cc: Moshood Oduwole; wmsmith@deq.virginia.gov; Will, Katherine CIV NAVFAC MIDLANT, Counsel; Caldwell, Donna J CIV NAVFAC LANT, EV; Sawyer, Stephanie/VBO; Forshey, Adam/VBO
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

Bill - Please provide us (all copied here) a few sentences at most that describes the differences between the three types of monitoring discussed in the ROD (i.e., performance monitoring, MNA Monitoring, and LTM monitoring). Thanks.

Frank - Bill will provide the requested information. However, not sure why there is need to dive any deeper than what is in the ROD already? Performance monitoring is simply a general way of indicating we intend to evaluate the performance of the injections, and the terms MNA and LTM are basic CERCLA terms.

Jim

-----Original Message-----
From: Frank Fritz [mailto:Fritz.Frank@epamail.epa.gov <mailto:Fritz.Frank@epamail.epa.gov>]
Sent: Wednesday, August 22, 2012 13:12
To: Moshood Oduwole
Cc: Gravette, James CIV NAVFAC MIDLANT, IPTNE; Adam.Forshey@ch2m.com; Caldwell, Donna J CIV NAVFAC LANT, EV; Will, Katherine CIV NAVFAC MIDLANT, Counsel; Stephanie.Sawyer@CH2M.com; William.Friedmann@CH2M.com; wmsmith@deq.virginia.gov
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

I agree with Moshood. Can we briefly describe, in plain English, performance monitoring, long-term monitoring and how they relate to monitoring of natural attenuation?

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From: Moshood Oduwole/R3/USEPA/US
To: "Gravette, James CIV NAVFAC MIDLANT, IPTNE" <james.gravette@navy.mil>
Cc: Adam.Forshey@ch2m.com, "Caldwell, Donna J CIV NAVFAC LANT, EV" <donna.caldwell@navy.mil>, Frank Fritz/R3/USEPA/US@EPA, "Will, Katherine CIV NAVFAC MIDLANT, Counsel" <katherine.will@navy.mil>, Stephanie.Sawyer@CH2M.com, William.Friedmann@CH2M.com, wmsmith@deq.virginia.gov
Date: 08/22/2012 01:05 PM
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

I think the lawyers are rather concern on the public understanding of these terms but I agree we should hold on until Ron's review. I'll suggest we do the best we can to better simplify the language as much as it can be done and leave the rest to the Work Plans.

Moshood

From: "Gravette, James CIV NAVFAC MIDLANT, IPTNE" <james.gravette@navy.mil>
To: Moshood Oduwole/R3/USEPA/US@EPA
Cc: <wmsmith@deq.virginia.gov>, Frank Fritz/R3/USEPA/US@EPA, "Will, Katherine CIV NAVFAC MIDLANT, Counsel" <katherine.will@navy.mil>, "Caldwell, Donna J CIV NAVFAC LANT, EV" <donna.caldwell@navy.mil>, <William.Friedmann@CH2M.com>, <Adam.Forshey@ch2m.com>, <Stephanie.Sawyer@CH2M.com>
Date: 08/22/2012 12:57 PM
Subject: RE: Yorktown Site 22 ROD - EPA ORC manager comments

Moshood,

I see from the comments that Frank passes along (below and attached) that there appears to be concern from EPA legal with better defining what is meant in the ROD by terms such as performance, MNA, and LTM monitoring. I really don't think we need to tweak the ROD based on these latest comments since the details will be worked out in work plans, as identified in the ROD, that will come after this ROD. Specifically, a pre-design work plan will include, among other things, discussion of MNA monitoring; a remedial action work plan will include details regarding the selected remedy including performance monitoring and MNA monitoring; and a LTM work plan will include LTM details. Furthermore, as you know, each of these work plans will be provided to EPA and the State for review and approval before they are finalized.

We will sit tight with the comments Frank passed along until we hear back from you regarding how/when you suggest we address these latest legal comments. My understanding from our previous email is that you will bring up these latest legal comments when you brief Ron and at that time will either indicate no further ROD changes are required or will specifically provide suggested language we can consider before the ROD is final.

Did I capture the next steps as you see it?

Jim

-----Original Message-----
From: Frank Fritz [mailto:Fritz.Frank@epamail.epa.gov
<mailto:Fritz.Frank@epamail.epa.gov> <mailto:Fritz.Frank@epamail.epa.gov

<mailto:Fritz.Frank@epamail.epa.gov> >]
Sent: Wednesday, August 22, 2012 11:51
To: Moshood Oduwole
Cc: William.Friedmann@CH2M.com; Caldwell, Donna J CIV NAVFAC LANT, EV; Gravette, James CIV NAVFAC MIDLANT, IPTNE; Will, Katherine CIV NAVFAC MIDLANT, Counsel; Stephanie.Sawyer@CH2M.com; wmsmith@deq.virginia.gov
Subject: Yorktown Site 22 ROD - EPA ORC manager comments

Here some (not very many) line edits and more comments about performance monitoring, long-term monitoring and MNA.

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Dear People,

I've just gotten back comments from my manager, Suzanne Parent, and her manager, Cecil Rodrigues. I'll send a track change markup as soon as I can.

However, both noted the same problem about how the ROD describes monitoring (see section 1.4 remedy bullets and section 2.11.2 selected remedy bullets and following sections on pre-design investigation, monitored natural attenuation and performance monitoring and long-term monitoring).

The essence of this portion of their comments are:

* What is performance monitoring? What is its purpose?
*
* What is long-term monitoring? What is its purpose? How is it different from performance monitoring?
*
* What is the monitoring that we'll do for natural attenuation of RDX and VOCs? What is its purpose? How is it different from, or the same as, performance monitoring or long-term monitoring?
*

For example, is performance monitoring only for vegetable oil injections? Is it only for RDX? Is it for VOCs, too?

The language in the ROD about monitoring confused them. They couldn't tell if the different words (performance, long-term, MNA) actually described different things. They felt the ROD did not consistently describe or distinguish three different kinds of monitoring.

They had more comments as well, which I'll pass along as soon as I can.

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[attachment "Site 22 ROD.082212.no figures.EPA ORC manager comments.docx" deleted by Moshood Oduwole/R3/USEPA/US]

Draft

Record of Decision

Site 22 Groundwater – Burn Pad

Naval Weapons Station Yorktown, Yorktown, Virginia

June 2012

1 Declaration

1.1 Site Name and Location

This Record of Decision (ROD) presents the selected remedy for groundwater at Environmental Restoration Program (ERP) Site 22, Burn Pad, at Naval Weapons Station (WPNSTA) Yorktown, Yorktown, Virginia. WPNSTA Yorktown was placed on the United States Environmental Protection Agency (USEPA) National Priorities List effective October 15, 1992 (USEPA Identification [ID]: VA8170024170).

1.2 Statement of Basis and Purpose

This remedy was selected in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended. This decision is based on information contained in the Administrative Record (AR) file for the site. Information not specifically summarized in this ROD or its references[1], but contained in the AR, has been considered and is relevant to the selection of the remedy at Site 22. Thus, the ROD is based upon and relies upon the entire AR file for the site remedy selection decision.

The United States Department of the Navy (Navy) is the lead agency and provides funding for ERP activities at Site 22. The Navy and USEPA Region 3, the lead regulatory agency, issue this ROD jointly. The Commonwealth of Virginia, Virginia Department of Environmental Quality (VDEQ), the support regulatory agency, concurs with the selected remedy.

1.3 Assessment of the Site

Groundwater is the only remaining environmental medium to be addressed at Site 22. A no further action ROD was signed for soil at Site 22 in 2003, and a no further action ROD for sediment and surface water at Site 22 was signed in 2011. Therefore, this ROD serves as the final ROD for Site 22.

Previous investigations concerning groundwater at Site 22 did not identify any potential ecological risks, but did identify the presence of chemicals of concern (COCs) at concentrations that pose a potential threat to human health. Trichloroethene (TCE) in shallow groundwater (Yorktown-Eastover aquifer) was identified as posing a potential risk under the future construction worker exposure scenario. Vinyl chloride (VC) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) in shallow groundwater (Yorktown-Eastover aquifer) were identified as posing a potential risk under the future residential use exposure scenario.

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 into the environment.

[1] Reference phrases, presented as ***Bold Italicized Text***, are followed by a corresponding number from the References Section.

1.4 Description of Selected Remedy

The selected remedy for Site 22 groundwater is comprised of the following components:

- Implementing Enhanced In Situ Bioremediation of RDX using emulsified vegetable oil bio-barriers perpendicular to groundwater flow in the target treatment area (with RDX above 100 micrograms per liter [µg/L]) to reduce the total time for achieving cleanup levels
- Using monitored natural attenuation (MNA) to address the dissolved TCE and VC plumes and the remaining dissolved RDX plume (less than 100 µg/L) following active treatment
- ~~Regular g~~Groundwater monitoring to collect data about COC concentrations and natural attenuation parameters
- Land Use Controls in the form of groundwater use restrictions to prevent contact with and use of groundwater until cleanup levels are met

The selected remedy will address COCs in groundwater at Site 22. Before completing the engineering design of the remedy, an investigation will collect additional data about natural attenuation and the extent of the RDX, TCE and VC plumes. This investigation will help to design or, if necessary, enhance or change the remedy. The effectiveness of the selected remedy will be evaluated following a second in situ treatment event to determine if remedy enhancement (such as additional injections) or a different remedy is warranted.

The primary source of contamination was the release of chemicals that occurred during waste handling and the burning of materials on the ground surface. The contaminants that were released to the ground surface leached into the soil as a result of infiltration of rain water, causing downward migration of contamination into subsurface soil and ultimately creating a dissolved phase groundwater plume. The contaminated soil at Site 22 was excavated and disposed of offsite in 2002 resulting in conditions that allow unlimited use and unrestricted exposure to soil at Site 22. Groundwater at Site 22 is not a principal threat waste.

1.5 Statutory Determinations

The selected groundwater 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. This remedy also satisfies the statutory preference for treatment as a principal element of the remedy (i.e., reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment). Because the remedy will result in hazardous substances, pollutants or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the groundwater remedy is, or will be, protective of human health and the environment.

1.6 ROD Data Certification Checklist

The following information is included in the Decision Summary section of this ROD. Additional information related to Site 22 can be found in the AR.

COCs and their respective concentrations (Section 2.5, **Table 2**)

Current and reasonably anticipated future land use assumptions and current and potential future uses of groundwater (Section 2.6)

Baseline risk represented by the COCs (Section 2.7, **Table 4**)

Cleanup levels established for COCs and the basis for these levels (Section 2.8, **Table 5**)

Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (Section 2.9, **Table 6**)

How source materials constituting principal threats will be addressed (Section 2.10)

Key factor(s) that led to selecting the remedy (such as a description of how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision) (Section 2.11.1)

Potential land and groundwater use that will be available at the site as a result of the selected remedy (Section 2.11.4, **Table 9**)

1.7 Authorizing Signatures

Captain Lowell D. Crow Commanding Officer Naval Weapons Station Yorktown	Date
Ronald J. Borsellino Director Hazardous Site Cleanup Division USEPA (Region 3)	Date

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2 Decision Summary

2.1 Site Name, Location, and Description

Site 22 (Burn Pad)
Naval Weapons Station Yorktown
Yorktown, Virginia
USEPA ID: VA8170024170

WPNSTA Yorktown is a 10,624-acre installation located on the Virginia Peninsula between the York River and the James River in Virginia (**Figure 1**). WPNSTA Yorktown is bounded on the northwest by WPNSTA Yorktown Cheatham Annex and the King's Creek Commerce Center; on the northeast by the York River and the Colonial National Historic Parkway; on the southwest by Route 143 and Interstate 64; and on the southeast by Route 238 and the town of Lackey.

Site 22, the Burn Pad, encompasses a 9-acre area, located in the northeastern portion of WPNSTA Yorktown (**Figure 1**). An access road runs north-south and provides vehicle access to the site from the north (**Figure 2**). Site 22 consists of a grassy field surrounded by woods, situated on a flat, elevated area, with its ground surface sloping steeply to the east, south, and southwest toward the Eastern Branch of Felgates Creek and its unnamed tributary.

FIGURE 1
Regional Location Map

FIGURE 2
Site Map

2.2 Site History and Enforcement Activities

Originally named the United States Mine Depot, WPNSTA Yorktown was established in 1918 to support the laying of mines in the North Sea during World War I. For 20 years after World War I, the depot continued to receive, reclaim, store, and issue mines, depth charges, and related materials. During World War II, the facility was expanded to include three trinitrotoluene loading plants and new torpedo overhaul facilities. A research and development laboratory for experimentation with high explosives was established in 1944. In 1947, a quality evaluation laboratory was developed to monitor special tasks assigned to the facility, which included the design and development of depth charges and advanced underwater weapons. On August 7, 1959, the depot was renamed the United States Naval Weapons Station. Today, the primary mission of WPNSTA Yorktown is to provide ordnance, technical support, and related services to sustain the war-fighting capability of the armed forces in support of national military strategy.

Site 22 was used for burning waste explosives and spent solvents generated from loading operations from the early 1940s until 1995. The ash from the burned solvents and explosives was transported to the Burning Pad Residue Landfill.

Site 22 once contained a 150-foot-diameter, circular array of 11 steel burning pans that were used for burning waste plastic explosives and spent solvents. A historical photograph taken in 1983 is included as **Figure 3**, and shows the numerous burn pads in a circular formation in the central and southern portion of Site 22.

FIGURE 3
Site 22 Historical Aerial Photograph

In 1996, a 153-foot by 86-foot biocell was constructed at Site 22 and used for the treatment of nitramine-contaminated soils and trinitrotoluene-contaminated soils from WPNSTA Yorktown Sites 7 and 19 (**Figure 2**). Use of the biocell ended in 1999, and it was subsequently removed.

In 2002, a removal action was completed to remove contaminated soils from Site 22 (**Figure 2**). The COCs included the following: carcinogenic polynuclear aromatic hydrocarbons, octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine, cadmium, copper, and lead. Contaminated soil was excavated to a depth of 2 feet, and confirmation samples were collected. Approximately 3,450 cubic yards of soil were removed. A ***ROD*** (Ref. 1) was signed in 2003 documenting that no further action for unlimited use and unrestricted exposure was necessary for soil at Site 22. In addition, a ***ROD*** (Ref. 2) documenting that no further action was necessary for sediment and surface water at Site 22 was signed in 2011.

Groundwater at Site 22 has been characterized during several investigations. **Table 1** provides a chronological list and brief summary of previous groundwater investigations conducted at Site 22. The respective investigation documents are a part of the AR and can be referenced for further details for specific sampling strategies, media investigations, and when and where the sampling was performed. The documents listed are available in the AR and provide detailed information used to support remedy selection at Site 22.

TABLE 1
Summary of Previous Groundwater Studies and Investigations at Site 22

Previous Study / Investigation* (Document and Document Date)	Sites	Investigation Activities
Round Two Remedial Investigation Report, Sites 4, 21, and 22 Baker, 2001	Sites 4, 21, and 22	From August to November 1996, groundwater, surface water, and surface/subsurface sediment samples were collected to evaluate potential risks to human health and the environment (**Figure 4**). Samples were analyzed for Target Compound List (TCL) volatile organic compounds (VOCs), TCL semivolatile organic compounds, TCL pesticides/polychlorinated biphenyls, explosives and Target Analyte List metals and cyanide. The ***analytical results*** (Ref. 3) of six groundwater samples at Site 22 were used to complete a Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA). The HHRA indicated no unacceptable non-cancer hazards or cancer risks to current or future receptors under a beneficial use scenario for groundwater. The ERA, which was based on a screening of groundwater concentrations at Site 22 against marine surface water screening levels, indicated aquatic receptors would potentially be at risk from exposure to 1,1-dichloroethene, TCE, di-n-butylphthalate, aldrin, and several explosives and metals if groundwater contaminants from Site 22 were to discharge to a surface water body without dilution or natural attenuation. The ***analytical results*** (Ref. 4) of six co-located surface water and sediment samples at Site 22 were used to complete an HHRA and an ERA. The HHRA indicated no unacceptable non-cancer hazards or cancer risks to current or future receptors from exposure to surface water and sediment. The ERA indicated potential risk to ecological receptors from exposure to several pesticides, explosives, and metals in sediment.
Remedial Investigation Report for Groundwater at Sites 4, 21, and 22 CH2M HILL, 2009	Sites 4, 21, and 22	From March 2007 to April 2008, groundwater, groundwater seep, surface water, and surface and subsurface sediment samples were collected to evaluate potential risks to human health and the environment. Upstream surface water and sediment samples were also collected to assess site-specific background conditions (Figure 4). Samples were analyzed for TCL VOCs, TCL semivolatile organic compounds, TCL pesticides and polychlorinated biphenyls, explosives, and Target Analyte List metals and cyanide. The analytical results (Ref. 5) of 12 groundwater samples at Site 22 were used to complete an HHRA and ERA. The HHRA indicated potential cancer risks to future residents due to exposure to VC, RDX, and arsenic, as well as non-cancer hazards to future residents from exposure to RDX, arsenic, and heptachlor epoxide, and to construction workers due to exposure to TCE. TCE, heptachlor epoxide, VC, RDX, and arsenic were identified as human health COCs within the Yorktown-Eastover aquifer at Site 22 under a future exposure scenario. However, based on the final results of the remedial investigation (RI), the COCs in groundwater at Site 22 identified for action were TCE, VC, and RDX (refer to Section 2.5.1 of this ROD). The RI concluded that development of a Feasibility Study (FS) for Site 22 groundwater was warranted. The ERA indicated no COCs were identified for seep exposures at Site 22. Similarly, no COCs were identified for food web exposures. Thus, risks to ecological receptors were considered acceptable. Groundwater is generally considered only as a transport medium since there are no ecological exposures to groundwater until it discharges to a water body or surfaces as a seep. The analytical results (Ref 6) of 11 co-located surface water and sediment samples, two independently located sediment samples, and six co-located background surface water and sediment samples were used to complete a HHRA and ERA. The ERA was completed to reevaluate conditions in surface water and sediment following the soil removal action. The HHRA and ERA identified no unacceptable risk to human health or the environment. Based on the results of the HHRA and ERA, the RI concluded that no unacceptable risk to human health or the environment from exposure to surface water or sediment is present at Site 22; therefore, no additional action was recommended to address surface water and sediment adjacent to the site.
Feasibility Study Report for Groundwater at Site 22 CH2M HILL, 2011	Site 22	An FS was generated to evaluate alternatives (Ref. 7) for remediation of TCE, VC, and RDX present at unacceptable levels in the groundwater. The preferred alternative as presented in the FS was Alternative 2 - Hot Spot Treatment of RDX using Enhanced In Situ Bioremediation and Associated Performance Monitoring; MNA of TCE, VC and RDX; and Land Use Controls.

FIGURE 4
Historical Sample Layout

***Figure 4** illustrates the most recent activities conducted at each sampling location at Site 22 (sample locations associated with adjacent Sites 4 and 21 are included for completeness). In instances of samples collected in the same location across multiple reports, the most recent sampling event is shown.

2.3 Community Participation

Community participation at WPNSTA Yorktown includes a Restoration Advisory Board (RAB), public meetings, a public information repository, newsletters, fact sheets, public notices, and an ERP Website. The Community Involvement Plan for WPNSTA Yorktown, updated in 2009, provides detailed information on community participation for the ERP. The RAB was formed in 1994 and consists of community members and representatives from USEPA Region 3, VDEQ, and the Navy. RAB meetings are held twice a year and are open to the public to provide opportunity for public comment and input.

The investigations conducted at Site 22, the findings, and the documents in the AR form the basis for this ROD. A Proposed Plan (PP) was developed and made available for public review to request public input on the selected remedy for groundwater. In accordance with 40 Code of Federal Regulations 300.430(f)(3)(i)(A), a notice of availability of the PP was published in *The Virginia Gazette* and the *Daily Press* on May 12 and 13, 2012, respectively. The PP was available for review during the public comment period in accordance with Section 117(a) of CERCLA at the York County Public Library – Yorktown (8500 George Washington Memorial Highway, Yorktown, Virginia 23692, 757-890-3376). The public comment period ran from May 14 through June 28, 2012, and included a public meeting to present the PP, which was held on May 24, 2012 at the York County Public Library – Yorktown. No comments were received during the public comment period.

This ROD, the PP, and all other information that supports the selected remedy for groundwater at Site 22 are available in the AR. The AR is accessible through the WPNSTA Yorktown ERP public website at http://go.usa.gov/yFb or by contacting the WPNSTA Yorktown Public Affairs Officer at:

Public Affairs Office
P.O. Drawer 160
Yorktown, VA 23691-0160
Phone: (757) 887-4939

2.4 Scope and Role of Operable Unit

Comprehensive environmental restoration activities at WPNSTA Yorktown began in 1984 under the Navy Assessment and Control of Installation Pollutants program, prior to state and federal regulatory oversight of environmental activities at the installation. The Navy Assessment and Control of Installation Pollutants program was modified to become the ERP in 1986 (then known as the Installation Restoration Program) to meet the requirements of CERCLA, as amended. WPNSTA Yorktown was added to the National Priorities List on October 15, 1992 (USEPA ID: VA8170024170). A Federal Facilities Agreement (FFA) between the Navy and USEPA Region 3 was signed in 1994. This FFA identified CERCLA sites, Site Screening Areas, and areas of concern for investigation and possible cleanup, and provided the framework and a schedule to accomplish this work. Subsequent to the FFA, additional sites, Site Screening Areas, and areas of concern were added to the ERP. Site 22 was evaluated in accordance with CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan under the Navy's ERP, the status of which can be found in the current version of the Site Management Plan in the AR file for WPNSTA Yorktown.

This ROD presents the selected remedy for groundwater at Site 22. The selected remedy documented in this ROD for groundwater at Site 22 does not include or affect any other media at Site 22 or any other sites at WPNSTA Yorktown. The WPNSTA Yorktown ERP consists of 31 sites including Site 22 as detailed below:

There are 28 Installation Restoration Program sites at various phased of investigation or cleanup. Although RODs are in place for select media at some sites, below is a summary based on the last media being addressed at each site:

- Fifteen (15) sites under investigation (Sites 1, 3, 6, 7, 8, 9, 19, 23, 24, 25, 26, 31, 32, 33, and 34)
- One (1) site at the remedy decision stage (Site 22)

- Two (2) sites in long-term management (Sites 12 and 16)
- Ten (10) closed sites (Sites 4, 5, 11, 17, 18, 21, 27, 28, 29, and 30)

There are 3 Munitions Response Program sites at various phases of investigation and cleanup. Below is a summary based on the last media being addressed at each site:

- Two (2) sites under investigation (UXO 2 and 3)
- One (1) closed site (UXO 1)

2.5 Site Characteristics

Site 22 consists primarily of a flat, grass-covered open area surrounded by woods; elevations for the site range from 20 to 32 feet above mean sea level. The southern and eastern edges of the site slope steeply toward the east, south, and southwest, toward the Eastern Branch of Felgates Creek and its unnamed tributary (**Figure 2**). Felgates Creek is a tidally influenced tributary to the York River. A gravel road runs north-south and provides vehicle access to Site 22 from the north. The site is currently unused except for periodic recreational hunting, and is located within a restricted area of WPNSTA Yorktown.

The hydrogeology at Site 22 consists of unsaturated soils at the ground surface, which are lithologically consistent with the Yorktown confining unit (gray silt and clay). The uppermost saturated unit in the Site 22 area is the Yorktown-Eastover aquifer, which lies below the 10- to 30-foot-thick Yorktown confining unit. The Yorktown-Eastover aquifer consists of coarse, shelly, gray sand, and is approximately 25 to 50 feet thick in the vicinity of Site 22. This aquifer overlies the Eastover-Calvert confining unit. There is no current or expected future use for groundwater at Site 22; drinking water is supplied to WPNSTA Yorktown and the surrounding area by the City of Newport News Waterworks.

Groundwater at Site 22 ranges from 5 to 20 feet bgs and flows to the south toward drainage channels and the Eastern Branch of Felgates Creek (**Figure 5**).

A ***conceptual site model*** (Ref. 8) was developed to summarize site conditions, contaminant distribution, transport pathways, potential receptors, exposure pathways, and land use for Site 22 (**Figure 6**). The sources of contamination were releases of chemicals that occurred during waste handling and burning of materials on the ground surface. No subsurface burial of materials at Site 22 is known to have occurred. Some of the contaminants that were released to the ground surface leached into the soil as a result of infiltration of stormwater, causing downward migration of contamination into subsurface soil and ultimately creating a dissolved-phase groundwater plume. Much of the contamination remained relatively close to the land surface due to adsorption to soil. The contaminated soil at Site 22 was excavated and disposed of offsite and a no further action ROD which allows unlimited use of and unrestricted exposure to soil was signed in 2003. Contaminant concentrations in the groundwater of the Yorktown-Eastover aquifer at Site 22 are likely to decrease in the future because the source is no longer present and there is no ongoing release mechanism.

FIGURE 5
Yorktown-Eastover Aquifer Potentiometric Surface Map

FIGURE 6
Conceptual Site Model

2.5.1 Nature and Extent of Contamination in Groundwater

Numerous investigations (Ref. 9) have been conducted to characterize potential impacts at Site 22 (**Table 1**). Based on the results of these investigations, the COCs in groundwater at Site 22 are TCE, VC, and RDX. Sampling locations from previous investigations are depicted on **Figure 4**, and the nature and extent of contamination is discussed as follows. Maximum concentrations of chemicals identified as site COCs detected in Site 22 groundwater are presented in **Table 2**.

TABLE 2
Maximum Detected Concentrations of Site 22 Chemicals of Concern in Groundwater

VOCs	Concentration (µg/L)	MCL (µg/L)
TCE	650	5
VC	17	2
Explosives	**Concentration (µg/L)**	**RSL (µg/L)**
RDX	150	0.61

The ***results*** (Ref. 10) of the investigations at Site 22 indicated that TCE, VC, and RDX concentrations exceeded their respective Maximum Contamination Level (MCL) or Regional Screening Level (RSL) in shallow groundwater. TCE was detected at concentrations exceeding the MCL (5 µg/L) in five shallow monitoring wells, VC was detected at concentrations exceeding the MCL (2 µg/L) in two shallow monitoring wells, and RDX was detected at concentrations exceeding the RSL (0.61 µg/L) in 10 shallow monitoring wells.

The TCE, VC, and RDX groundwater contamination is present in a "corridor" that runs through the middle of Site 22 from north to south (**Figure 7**). Analytical results indicated the VOCs and RDX detected in groundwater were within the upper portion of the Yorktown-Eastover aquifer. The highest concentrations of TCE, VC, and RDX were detected between 10 and 50 feet bgs along the central portion of the site in sand containing a number of silt and clay stringers that may be retarding the downward mobility of the contaminants. No COCs were identified in samples taken from the base of the Yorktown-Eastover aquifer, which lies above the Eastover Calvert confining unit. Contaminant discharge to surface water via groundwater was not found to exceed any risk screening values (adjusted RSLs or ecological screening values) at Site 22; groundwater is therefore not a significant continuing source of contaminants to the aquatic habitats adjacent to the site.

2.5.2 Fate and Transport of COCs in Groundwater

The lateral groundwater seepage velocity at Site 22 is approximately 0.128 feet per day. However, contaminants are not expected to migrate as rapidly as groundwater because of a tendency for sorption to soil particles (retardation). Contaminants may also be migrating in groundwater through dispersion, which may slowly increase the size of the contaminant plume in groundwater. Volatilization of some contaminants from the groundwater into the air is also a possible migration pathway where elevated concentrations of chlorinated solvents are present.

TCE and VC

The source of TCE and its degradation product, VC, are likely releases from burn activities previously conducted at Site 22. Chlorinated VOC concentrations such as TCE and VC can change over time due to dilution and dispersion, but the primary mechanism for reductions under naturally occurring conditions is ***biodegradation*** (Ref. 11). Historical groundwater data for monitoring well YS22-GW04 demonstrates a trend of decreasing contaminant mass and/or concentration over time (**Table 3**). In addition, other sites at WPNSTA Yorktown, which share similar contaminants and aquifer characteristics, have demonstrated that the MNA process is a viable

TABLE 3
TCE and Associated Degradation Products in Monitoring Well YS22-GW04 at Site 22

VOCs (µg/L)	11/12/1996	10/25/2007
TCE	1200	69
1,1-Dichloroethene	1700	37
cis-1,2-Dichloroethene	Not Analyzed	22
trans-1,2-Dichloroethene	Not Analyzed	10U
Total 1,2-Dichloroethene	*370*	*32*
VC	Not Detected	10U

U - The material was analyzed for, but not detected.

component of the selected groundwater remedy.

FIGURE 7
Remedial Goal Exceedances TCE and RDX

Note: Remedial goals are detailed in Section 2.8.

Biodegradation of chlorinated ethenes (such as TCE and VC) occurs through two primary mechanisms: co-metabolism and reductive dechlorination. Co-metabolism occurs as a fortuitous destruction of contaminants by organisms intending to metabolize other organic compounds. Reductive dechlorination occurs as part of a microbial respiratory process called halorespiration. As halorespiring organisms make energy, each chlorine ion on the chlorinated VOC molecule is sequentially replaced with hydrogen. Once all chlorine ions have been replaced, only innocuous end-products, such as chloride, ethene, and ethane remain. *Dehalococcoides sp.* is the primary organism known to be capable of completely degrading contaminants like TCE to innocuous end products. This organism thrives under oxygen depleted (reducing) conditions. The reductive dechlorination type of biodegradation is currently occurring at Site 22. This is evidenced by the presence of the *Dehalococcoides sp.* and partially degraded TCE. TCE contains three chlorine ions. Cis-1,2-DCE contains two chlorine ions and VC contains only one. The presence of these less-chlorinated compounds indicates that halorespiring organisms are removing the chlorines through their respiratory process. .

Geochemical and microbial samples were collected from two wells (YS22-GW01 and YS22-GW04) at Site 22. Results from these two locations suggest the site is characterized by low concentrations of native and/or anthropogenic carbon (0.5U and 1.0 milligram per liter, respectively). Since microbial utilization of a carbon source drives reductive dechlorination, Enhanced In Situ Bioremediation at Site 22 will create enhanced bioremediation conditions. In addition to the geochemical data, the presence of the *Dehalococcoides sp.* bacterial species (0.134J and 0.493 cells per milliliter, in monitoring wells YS220GW01 and YS22-GW04,respectively), which is the only microbe identified to be capable of degrading chlorinated ethenes completely to ethane, was identified at Site 22.

RDX

The likely source of RDX is releases from burn activities previously conducted at Site 22. RDX can be biodegraded under most redox conditions and by a variety of microorganisms. Three mechanisms for the biodegradation of RDX have been identified: two-electron reduction, single-electron reduction/denitration, and direct enzymatic cleavage. The denitration pathway is considered the major pathway for biodegradation in the natural environment, resulting in the formation of products such as nitrite, ammonia, formaldehyde, and formic acid. Under ideal (laboratory) conditions, the biodegradation rate for RDX is exponential, and could decay as much as 1 to 5 times in a day (that is, a half-life of 0.2 to 1 day). RDX is not volatile and not very mobile; therefore, biodegradation is believed to be the primary attenuation mechanism for this chemical.

2.6 Current and Potential Future Land and Resource Uses

Site 22 is currently unused except for periodic recreational hunting, and is predominantly characterized by vegetated fields within a locked wire gate. Site 22 is located inside an area encumbered by the Explosive Safety Quantity Distance, which limits the activities that can be performed to explosives-related functions; therefore, the site cannot be developed for real estate purposes. It is anticipated that WPNSTA Yorktown will remain a military installation for the foreseeable future, and use of Site 22 will remain the same.

Groundwater from the Yorktown-Eastover aquifer in the vicinity of Site 22 is not a current or anticipated future source of drinking water at WPNSTA Yorktown due to generally low natural water quality and yield and a more readily available potable water source. Potable water at WPNSTA Yorktown is currently supplied by the City of Newport News Waterworks. However, the Commonwealth of Virginia considers all aquifer groundwater of potential beneficial use as potable water.

2.7 Summary of Site Risks

The baseline risk assessment estimates what risks the site poses if no action was taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of the baseline risk assessment for this site.

Potential human health and ecological risks at Site 22 were evaluated for groundwater and documented in the 2009 RI report (**Appendix A**). The following subsections and **Table 4** briefly summarize the findings of the risk assessments.

2.7.1 Summary of Human Health Risk Assessment

As part of the 2009 RI report for Site 22, an HHRA was completed. Based on the human health conceptual site model (**Appendix B**), risks were quantitatively evaluated for future adult construction workers and future adult/child residents exposed to shallow groundwater using reasonable maximum exposure (RME) and central tendency exposure (CTE) scenarios. Exposure pathways that were quantified included inhalation/ingestion of and dermal contact with groundwater for hypothetical future lifetime adult and child residents and ingestion and dermal contact with groundwater for hypothetical future construction workers. Based on current site use and conditions, there are no ***complete exposure pathways*** (Ref. 12) for groundwater at Site 22. The vapor intrusion pathway was not evaluated as part of this RI (the pathway is incomplete; there are no buildings); potential future risk for the vapor intrusion pathway will be addressed in the LUC RD.

The RME calculation determines risk based on the highest level of human exposure that could reasonably be expected to occur, whereas the CTE level reflects human exposure to average concentrations across the site. The potential non-cancer hazards, expressed as the hazard index (HI), and cancer risk estimates were calculated using RME concentrations. For non-cancer effects, an HI represents the ratio between the reference dose and the dose for a person in contact with site chemicals of potential concern. An HI exceeding 1.0 indicates that potential health effects may occur. For known or suspected carcinogens, acceptable exposure levels generally are concentration levels that represent an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} (a 1 in 10,000 chance of developing cancer) and 10^{-6} (a 1 in 1,000,000 chance of developing cancer) using information on the relationship between dose and response.

Potential unacceptable human health risks (Ref. 13) were identified under a future resident and/or construction worker exposure scenario due to exposure to TCE, heptachlor epoxide, VC, RDX, and arsenic within the Yorktown-Eastover aquifer (**Table 4**).

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TABLE 4

Summary of Potential Human Health Risks for Site 22 COCs

Receptor	Exposure Pathway	COC	Exposure Point Concentration	RME Cancer Risk	RME Non-Cancer Risk (HI)	CTE Cancer Risk	CTE Non-Cancer Risk (HI)	Cancer Toxicity Factor (Cancer Slope Factor) milligrams per kilogram per day^{-1}	Non-Cancer Toxicity Factor (Reference Dose) milligrams per kilograms per day
Future Resident Adult	Ingestion	VC	17	N/A	0.16	Not Applicable (N/A)	0.016	0.72	0.003
		Heptachlor epoxide	0.142	N/A	0.3	N/A	0.089	9.1	0.000013
		RDX	94.17	N/A	0.86	N/A	0.076	0.11	0.003
		Arsenic	6.96	N/A	0.64	N/A	0.21	1.5	0.0003
		Total*	--	--	**2.9[1]**	--	0.62	--	--
	Dermal Contact	VC	17	N/A	0.0083	N/A	0.00077	0.72	0.003
		Heptachlor epoxide	0.142	N/A	0.62	N/A	0.17	9.1	0.000013
		RDX	94.17	N/A	0.0077	N/A	0.00064	0.11	0.003
		Arsenic	6.96	N/A	0.0033	N/A	0.00068	1.5	0.0003
		Total*	--	--	0.8	--	0.21	--	--
	Inhalation/Shower	TCE	315	1.6 x 10-5	0.039	4.0×10^{-6}	0.026	0.007	0.17
		VC	17	2.7 x 10-6	0.018	6.8×10^{-7}	0.012	0.015	0.029
		Total*	--	3.3 x 10-5	0.1	8.2×10^{-6}	0.9	--	--
	Total Across All Exposure Routes	--	--	3.3 x 10-5	**3.8[1]**	8.2×10^{-6}	0.07	--	--
Future Resident Child	Ingestion	VC	17	N/A	0.36	N/A	0.053	0.72	0.003
		Heptachlor epoxide	0.142	N/A	0.70	N/A	0.30	9.1	0.000013
		RDX	94.17	N/A	**2.0**	N/A	0.25	0.11	0.003
		Arsenic	6.96	N/A	**1.5**	N/A	0.70	1.5	0.0003
		Total*	--	--	**6.8**	--	**2.1**	--	--
	Dermal Contact	VC	17	N/A	0.020	N/A	0.0015	0.72	0.003
		Heptachlor epoxide	0.142	N/A	**1.4**	N/A	0.34	9.1	0.000013
		RDX	94.17	N/A	0.017	N/A	0.0013	0.11	0.003
		Arsenic	6.96	N/A	0.0098	N/A	0.0015	1.5	0.0003
		Total*	--	--	**1.8**	--	0.41	--	--
	Total Across All Exposure Routes	--	--	N/A	**8.7**	N/A	**2.5**	--	--
Future Lifetime Resident (Adult/Child)	Ingestion	TCE	315	6.1 x 10-5	N/A	5.3×10^{-6}	N/A	0.013	N/A
		VC	17	**1.8 x 10-4**	N/A	1.4×10^{-5}	N/A	0.72	0.003
		Heptachlor epoxide	0.142	1.0 x 10-5	N/A	4.4×10^{-6}	N/A	9.1	0.000013
		RDX	94.17	**1.5 x 10-4**	N/A	1.0×10^{-5}	N/A	0.11	0.003
		Arsenic	6.96	**1.6 x 10-4**	N/A	3.9×10^{-5}	N/A	1.5	0.0003
		Total*	--	**6.4 x 10-4**	N/A	8.7×10^{-5}	N/A	--	--
	Dermal Contact	TCE	315	1.0 x 10-5	N/A	6.0×10^{-7}	N/A	0.013	N/A
		VC	17	9.8 x 10-6	N/A	4.9×10^{-7}	N/A	0.72	0.003
		Heptachlor epoxide	0.142	4.0 x 10-5	N/A	6.1×10^{-6}	N/A	9.1	0.000013
		RDX	94.17	1.4 x 10-6	N/A	6.2×10^{-8}	N/A	0.11	0.003
		Arsenic	6.96	8.9 x 10-7	N/A	9.8×10^{-8}	N/A	1.5	0.0003
		Total*	--	8.4 x 10-5	N/A	1.1×10^{-5}	N/A	--	--
	Inhalation/Shower	TCE	315	1.6 x 10-5	N/A	4.0×10^{-6}	N/A	0.007	0.17
		VC	17	2.7 x 10-6	N/A	6.8×10^{-7}	N/A	0.015	0.029
		Total*	--	3.3 x 10-5	N/A	8.2×10^{-6}	N/A	--	--
	Total Across All Exposure Routes	--	--	**7.6 x 10-4**	N/A	**1.1 x 10-4**	N/A	--	--
Future Construction Worker - Adult	Dermal Contact	TCE	315	1.7 x 10-7	N/A	2.3×10^{-8}	N/A	0.013	N/A
		VC	17	2.3 x 10-7	0.0074	2.6×10^{-8}	0.00085	0.72	0.003
		Heptachlor epoxide	0.142	4.4 x 10-7	0.26	2.0×10^{-7}	0.12	9.1	0.000013
		RDX	94.17	1.7 x 10-8	0.0036	2.1×10^{-9}	0.00044	0.11	0.003
		Arsenic	6.96	4.4 x 10-8	0.0068	1.7×10^{-8}	0.0026	1.5	0.0003
		Total*	--	1.2 x 10-6	0.47	4.0×10^{-7}	0.17	--	--
	Inhalation	TCE	315	2.2 x 10-5	**1.3**	1.3×10^{-6}	0.077	0.007	0.17
		VC	17	3.9 x 10-6	0.61	2.0×10^{-7}	0.032	0.015	0.029
		Total*	--	4.8 x 10-5	**3.3**	3.7×10^{-6}	0.28	--	--
	Total Across All Exposure Routes	--	--	4.9 x 10-5	**3.7**	4.1×10^{-6}	0.45	--	--

*Exposure pathway totals are additive and include all chemicals that contribute to potential risk

1 = No COCs identified with an HI >1

Bold/Yellow Shaded text indicates potential unacceptable human health risk

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Although arsenic and heptachlor epoxide contributed to the total RME cancer risk for the future lifetime resident (adult/child) scenario, the Navy, in partnership with USEPA and VDEQ, agree that no additional action is required for these chemicals for the following reasons:

- Although arsenic was considered a human health COC under the RME scenario, concentrations of arsenic did not pose risk under the CTE scenario
- Dissolved arsenic concentrations did not exceed the MCL (10 µg/L)
- Arsenic concentrations are consistent with natural background concentrations rather than a site-related CERCLA source
- Heptachlor epoxide (YS22-GW03 at 0.21 µg/L) only slightly exceeded the MCL (0.2 µg/L) in 1 out of 13 samples
- The low concentrations of heptachlor epoxide suggest its presence is attributable to routine pesticide treatment activities by the base

The HHRA concluded TCE and VC in groundwater exceed MCLs and contribute to potential risk under hypothetical future exposure scenarios in the upper portion of the Yorktown-Eastover aquifer. No MCL exists for RDX, but concentrations were found to pose potential risk under hypothetical future exposure scenarios. COCs were not detected above MCLs or RSLs in the deep portion of the Yorktown-Eastover aquifer. The Navy, in partnership with USEPA and VDEQ, agree that remedial action for groundwater is necessary to address TCE, VC, and RDX in the upper portion of the Yorktown-Eastover aquifer.

2.7.2 Summary of Ecological Risk Assessment

As part of the 2009 RI report for Site 22, an ERA was completed. Complete pathways for ecological receptors were limited to exposure to surface water, surface sediment, and surface soil. Surface soil was not evaluated in the ERA because risks associated with this medium were addressed during the previous remedial action. Groundwater was considered only as a transport medium since there were no ecological exposures to groundwater until it discharged to a water body or surfaced as a seep. Based on the results of the ERA, the Navy, USEPA Region 3, and VDEQ agree that groundwater at Site 22 does not pose unacceptable ecological risks to current receptors based on the following:

- No ecological COCs were identified for surface water, sediment, or seep exposures (no further action - ROD signed in 2011)
- Source areas were removed during previous site activities
- Groundwater is not a significant continuing source of contaminants to the aquatic habitats adjacent to the site

The ERA concluded there is ***no potentially unacceptable risk*** (Ref. 14) due to exposure to groundwater seeps, surface water, or sediment at Site 22. The Navy, in partnership with the USEPA and VDEQ agree that no further action for groundwater is necessary to prevent exposure to ecological receptors.

2.7.3 Basis for Response Action

The selected groundwater remedy in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

While there are no potential ecological risks from exposure to site groundwater, there are potential future human health risks from TCE, VC, and RDX. TCE in shallow groundwater (Yorktown-Eastover aquifer) was identified as posing a potential risk under the future construction worker exposure scenario, and VC and RDX in shallow groundwater (Yorktown-Eastover aquifer) were identified as posing a potential risk under the future residential use exposure scenario (**Table 4**).

2.8 Remedial Action Objectives

The site-specific remedial action objectives (RAOs) for Site 22 groundwater are as follows:

- Reduce TCE, VC, and RDX concentrations in groundwater to established risk-based cleanup levels.
- Prevent human (residential and construction worker) exposure to groundwater until cleanup levels are met.

Cleanup levels for groundwater were developed for site-related COCs (TCE, VC, and RDX) with cancer risks exceeding 1 in 10,000 or with concentrations exceeding the established MCLs (**Table 5**). MCLs were used to establish the groundwater cleanup levels for TCE and VC (5 µg/L and 2 µg/L, respectively). Attainment of MCLs is considered to be protective and suitable for unlimited use and unrestricted exposure. Because no MCL has been established for RDX, a risk-based cleanup level of 6 µg/L was calculated. Cleanup level exceedances for TCE and RDX are spatially shown on **Figure 7**; VC exceeded the MCL in two wells located within the TCE plume (22GW09 and 22GW11) and fall within the footprint of the TCE plume, and therefore is not shown. The cleanup level for RDX was determined based on Remedial Goal Option calculations, which incorporate pathways for the ingestion, dermal absorption, and inhalation of volatiles and particulates for future residents using the same exposure assumptions as the HHRA.

TABLE 5
Remediation Goals (Cleanup Levels) for COCs at Site 22

COC	Remediation Goal (µg/L)
TCE	5 µg/L
VC	2 µg/L
RDX	6 µg/L

2.9 Description of Remedial Alternatives

The objective of this section is to provide a brief explanation of the remedial alternatives developed for Site 22 groundwater.

2.9.1 Description of Remedy Components

Remedial alternatives were ***developed and evaluated*** (Ref. 15) to address COCs in groundwater at Site 22, as detailed in the 2011 FS Report. Following the initial screening of groundwater remediation technologies, the following remedial alternatives were selected for detailed evaluation and comparative analysis:

- **Alternative 1** – No Action
- **Alternative 2** – Hot Spot Treatment of RDX using Enhanced In Situ Bioremediation and Associated Performance Monitoring; MNA of TCE, VC, and RDX; and Land Use Controls
- **Alternative 3** – Hot Spot Treatment of RDX, TCE, and VC using In situ Chemical Oxidation (ISCO) and Associated Performance Monitoring; MNA of TCE, VC and RDX; and Land Use Controls
- **Alternative 4** – Hot Spot Treatment of TCE, VC, and RDX using Enhanced In Situ Bioremediation and Associated Performance Monitoring; MNA of TCE, RDX, and VC; and Land Use Controls

Based on the results of the alternatives evaluation, Hot Spot Treatment of RDX using Enhanced In Situ Bioremediation and Associated Performance Monitoring; MNA of TCE, VC, and RDX; and Land Use Controls (Alternative 2) was selected as the Preferred Alternative. With the exception of the No Action alternative (Alternative 1), each of the alternatives includes monitoring and implementation of Land Use Controls to prevent exposure and control changes in site use. A No Action alternative is required by the National Oil and Hazardous Substances Pollution Contingency Plan and serves as the baseline against which the other alternatives are compared. For Alternatives 2, 3, and 4, monitoring and Land Use Controls would be maintained until the RAOs are

met, with 5-year statutory reviews to ensure protection of human health and the environment. A description of each remedial alternative is provided in **Table 6**.

TABLE 6
Description of Remedial Alternatives for Site 22

Alternative	Components	Details	Cost
1-No Action	None	Allow the COCs to breakdown naturally over time.	Capital Cost: $0 O&M Present Value: $0 Total Present Value: $0 Cost Estimate Timeframe: 0 years
2-Hot Spot Treatment of RDX using Enhanced In Situ Bioremediation and Associated Performance Monitoring, MNA of TCE, VC, and RDX; and Land Use Controls	• Implementing Enhanced In Situ Bioremediation using emulisified vegetable oil bio-barriers in areas where RDX concentrations exceed 100 µg/L • MNA for dissolved TCE and VC plumes and the remaining RDX plume (less than100 µg/L) following active treatment • Regular groundwater monitoring to collect data about COC concentrations and natural attenuation parameters • Land Use Controls	Injecting a suitable insoluble substrate to the subsurface providing a carbon source for microorganisms to enhance the biodegradation of RDX. Regular, long-term monitoring performed to demonstrate that: • COC concentrations continue to decrease • Potentially toxic transformation products are not created at levels that are a threat to human health • Impacted area is not expanding • There are no changes in hydrogeologic, geochemical, or microbiological parameters that might reduce the effectiveness of the Remedial Action Land Use Controls to prevent contact with and use of groundwater until cleanup levels are met. 5-year reviews	Capital Cost: $708,026 O&M Present Value:$1,028,565 Total Present Value:$1,907,000 Cost Estimate Timeframe: 34 years
3-Hot Spot Treatment of RDX, TCE and VC using ISCO and Associated Performance Monitoring; MNA of TCE, VC, and RDX; and Land Use Controls	• ISCO using permanganate (MN04) in active target treatment areas where TCE, VC, and RDX concentrations exceed100 µg/L • MNA for dissolved TCE, VC, and RDX plumes where concentrations are less than100 µg/L • Regular groundwater monitoring to collect data about COC concentrations and natural attenuation parameters • Land Use Controls	Injection of oxidizing agent to promote abiotic, in situ oxidation of COCs through reaction of oxidants with COCs to produce innocuous substances such as carbon dioxide, water, and chloride. Electron donor source is provided to enhance naturally occurring reductive dechlorination process. Regular, long-term monitoring performed to demonstrate that: • COC concentrations continue to decrease • Potentially toxic transformation products are not created at levels that are a threat to human health • Impacted area is not expanding • There are no changes in hydrogeologic, geochemical, or microbiological parameters that might reduce the effectiveness of the Remedial Action Land Use Controls to prevent contact with and use of groundwater until cleanup levels are met 5-year reviews	Capital Cost:$1,228,931 O&M Present Value:$833,902 Total Present Value:$2,482,000 Cost Estimate Timeframe: 25 years
4-Hot Spot Treatment of TCE, VC, and RDX using Enhanced In Situ Bioremediation and Associated Performance Monitoring; MNA of TCE, RDX, and VC; and Land Use Controls	• Enhanced In Situ Bioremediation of RDX, TCE, and VC using emulsified vegetable oil bio-barriers in areas with TCE, VC, and RDX concentrations greater than 100 µg/L • MNA for dissolved RDX, TCE, and VC plumes where concentrations are less than100 µg/L • Regular groundwater monitoring to collect data about COC concentrations and natural attenuation parameters • Land Use Controls	Injection of substrates into groundwater to facilitate reductive chlorination, thereby producing an electron donor source for biodegradation. Regular, long-term monitoring performed to demonstrate that: • COC concentrations continue to decrease • Potentially toxic transformation products are not created at levels that are a threat to human health • Impacted area is not expanding • There are no changes in hydrogeologic, geochemical, or microbiological parameters that might reduce the effectiveness of the Remedial Action Land Use Controls to prevent contact with and use of groundwater until cleanup levels are met 5-year reviews	Capital Costs: $1,024,061 O&M Present Value: $994,759 Total Present Value: $2,718,000 Cost Estimate Timeframe: 29 years

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2.9.2 Summary of Comparative Analysis of Alternatives

This section summarizes a comparison and analysis of the four alternatives with respect to the National Contingency Plan's nine evaluation criteria. The nine criteria are summarized in **Table 7**. It is Navy policy to evaluate and optimize remedy efficiencies; therefore, each alternative includes an optimization effort for development of a plan for remedy enhancement (such as additional plume treatment) or development of a different remedy if the Navy, USEPA, and VDEQ determine through monitoring that the alternative is not performing as anticipated. **Table 8** depicts a comparison of the alternatives to the criteria. Alternative 1 (No Action) does not achieve RAOs designed to protect human health and the environment; therefore, it fails the first threshold criterion and is not considered further in this ROD.

TABLE 7
Evaluation Criteria for Remedial Alternative Analysis

CERCLA Criteria	Definition
Threshold Criteria	
Protection Of Human Health And The Environment	Addresses whether an alternative provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.
Compliance with Applicable Or Relevant And Appropriate Requirements (ARARs)	Addresses whether an alternative will meet all of the ARARs or justifies a waiver of the requirements.
Primary Balancing Criteria	
Long-Term Effectiveness And Permanence	Addresses the expected residual risk and the ability of an alternative to maintain reliable protection of human health and the environment over time, once clean-up goals have been met.
Reduction In Toxicity, Mobility, Or Volume Through Treatment	Discusses the anticipated performance of the treatment technologies an alternative may employ.
Short-Term Effectiveness	Considers the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period, until cleanup goals are achieved.
Implementability	Evaluates the technical and administrative feasibility of an alternative, including the availability of materials and services needed to implement an option.
Present-Worth Cost	Compares the estimated initial, O&M, and present-worth costs.
Modifying Criteria	
State Acceptance	Considers the state agency response to the remedial alternative described in the Proposed Plan.
Community Acceptance	Provides the public's general response to the remedial alternatives described in the Proposed Plan. The specific responses to the public comments are addressed in the "responsiveness summary" section of the ROD.

TABLE 8
Relative-Ranking of Remedial Alternatives

CERCLA Criteria	No Action (ALT 1)	Enhanced In Situ Bioremediation and Performance Monitoring of RDX with MNA of TCE, VC, and RDX and Land Use Controls (ALT 2)	ISCO, Performance Monitoring and MNA of TCE, VC, and RDX and Land Use Controls (ALT 3)	Enhanced In Situ Bioremediation, Performance Monitoring, and MNA of TCE, VC, and RDX and Land Use Controls (ALT 4)
Threshold Criteria				
Protection of human health and the environment	❍	●	●	●
Compliance with ARARs	N/A	●	●	●
Primary Balancing Criteria				
Long-term effectiveness and permanence	❍	●	●	●
Reduction in toxicity, mobility, or volume through treatment	❍	●	●	●
Short-term effectiveness	❍	◉	◉	◉
Implementability	●	◉	◉	◉
Cost	N/A	● $1,907,000	◉ $2,482,000	◉ $2,718,000
Modifying Criteria				
State Acceptance	NC	C	NC	NC
Community Acceptance	NC	C	NC	NC

Ranking: ● High ◉ Moderate ❍ Low N/A=Not Applicable

Rankings are provided as qualitative descriptions of the relative compliance of each alternative with the criteria.

NC = No significant comments were received from State or Community Members on the Proposed Plan.

C = Concurrence received from the State and Community Members on the with the preferred alternative

Threshold Criteria

Overall Protection of Human Health and the Environment

With the exception of Alternative 1 (No Action), each alternative protects human health and the environment by reducing or controlling risks posed by the site through treatment and/or Land Use Controls. Alternative 2 employs treatment to reduce RDX concentrations in a faster timeframe than would occur naturally. Alternatives 3 and 4 employ treatment to reduce concentrations in the RDX, TCE, and VC target areas to reduce the remedial timeframe. Monitoring will be conducted to confirm that the remedies are functioning and protective, and that Land Use Controls have been implemented and maintained to provide adequate protection of human health and the environment by controlling exposure to contaminated groundwater and potential vapor intrusion until cleanup levels are met.

Compliance with Applicable or Relevant and Appropriate Requirements

The ARARs for the selected remedy at Site 22 are listed in **Appendix C**. Alternatives 2, 3, and 4 are expected to comply with the federal and state ARARs. All of these alternatives would also require additional measures to ensure compliance with ARARs related to the injections of reagents into the subsurface.

Primary Balancing Criteria

Long-Term Effectiveness and Permanence

Each alternative with the exception of Alternative 1 is expected to achieve long-term effectiveness and permanence at the conclusion of remedial activities in reducing concentrations of TCE, VC, and RDX. Once RAOs are achieved, all alternatives, except Alternative 1, are expected to be effective in the long-term, as active treatment is intended to treat the contamination (treatment for RDX using Enhanced In Situ Bioremediation for Alternative 2, treatment for RDX, TCE, and VC using ISCO for Alternative 3, and treatment for RDX, TCE, and VC using Enhanced In Situ Bioremediation for Alternative 4) and allow natural attenuation to reduce groundwater contaminant concentration to below cleanup levels.

Reduction in Toxicity, Mobility, or Volume through Treatment

Alternatives 2 (treatment of RDX), 3 (treatment of RDX, TCE, and VC), and 4 (treatment of RDX, TCE, and VC) are each expected to reduce toxicity, mobility, and volume by treating the groundwater, which is a statutory preference. For Alternative 2, some active treatment of TCE and VC is assumed to occur where the VOC plumes overlap with the RDX treatment area. Also, while MNA is not considered a treatment, the natural reduction of contaminant concentrations through a variety of physical, chemical, or biological activities is expected to occur over time for Alternatives 2, 3, and 4.

Short-Term Effectiveness

The short-term effectiveness associated with Alternatives 2, 3, and 4 are similar with regard to how they affect the community and the local environment. Alternatives 2, 3, and 4 all rely on direct injection technology for implementation. The community would be impacted due to the transportation of injection materials and the generated investigation-derived waste.

While the relative-rankings of the remedial alternatives provided in **Table 8** show similar short term effectiveness between Alternatives 2, 3, and 4, minor distinctions for comparative analysis are discussed below.

Alternative 2 would least impact the environment due to a lower amount of construction or intrusive activities and environmental impacts (fewer injection points and Enhanced In Situ Bioremediation injections and a limited extent of treatment area). RAOs are estimated to be achieved in 34 years.

Alternative 3 has the highest impact on workers and the community due to the high use of heavy machinery, handling of chemical oxidants, and transportation of chemical oxidant on public roads and highways. This alternative has the highest greenhouse gas emissions and energy consumption primarily due to oxidant and polyvinyl chloride manufacturing. RAOs are estimated to be achieved in 25 years.

Alternative 4 will have a moderate impact on workers and the community due to the highest amount of intrusive activities (greater number of injection points and Enhanced In Situ Bioremediation injections) and the high volume of heavy machinery traffic and frequency of site visits. This alternative has the highest sulfur oxide emissions, nitrogen oxide, particulate matter less than 10 micrometers in aerodynamic diameter, and emissions due to fuel consumption. RAOs are estimated to be achieved in 29 years.

Alternative 2 provides the greatest short-term effectiveness due to its minimization of intrusive activities compared to Alternatives 3 and 4.

Implementability

Alternatives 2, 3, and 4 can each be implemented using standard and widely available technologies. All materials and services needed for implementation are readily and commercially available. These three alternatives (2, 3, and 4) require engineering and construction services, and each alternative requires thorough monitoring to ensure they continue to operate on a path toward achieving RAOs. Each of the three alternatives (2, 3 and 4) is reliable provided they are designed and implemented correctly.

Cost

An order of magnitude cost for each alternative has been estimated based on a variety of key assumptions, including an assumed 35-year project life. The estimated timeframe required to achieve the cleanup levels varies by alternative (**Table 6**). The estimated capital cost for implementation of Alternative 2 ($700,000) is less than that of Alternative 3 ($1.2 million) or Alternative 4 ($1.0 million). The estimated present value cost for Alternative 2 is $1.9 million, less than for Alternative 3 ($2.5 million) and Alternative 4 ($2.7 million). Alternative 2 has a lower capital cost due to the type and quantity of injection materials.

Table 6 provides details of the cost summaries, and **Table 8** provides a relative ranking of the four alternatives.

Modifying Criteria

State Acceptance

State involvement has been solicited throughout the CERCLA and remedy selection process. VDEQ, as the designated state support agency in Virginia, has reviewed this ROD and has given concurrence on the selected remedy for groundwater at Site 22. The selected remedy, Alternative 2 (Hot Spot treatment of the RDX target area [concentrations above 100 µg/L] using Enhanced In Situ Bioremediation and associated performance monitoring; MNA of TCE, VC, and RDX; and Land Use Controls), is consistent with the VDEQ's preference for active treatment of high-concentration target areas.

Community Acceptance

The public meeting was held on May 24, 2012, to present the Proposed Plan and answer community questions regarding the proposed remedial action at Site 22. The questions and concerns raised at the meeting were general inquiries for informational purposes only; but no comments were received requiring amendment to the Proposed Plan, and no additional written comments, concerns, or questions were received from community members during the public comment period.

2.10 Principal Threat Wastes

Principal threat wastes are 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 an exposure occur. Although no "threshold level" of risk has been established to identify principal threat waste, a general guideline is to consider a principal threat to be those source materials with toxicity and mobility characteristics that combine to pose a potential risk several orders of magnitude greater than the risk level that is acceptable for the current or reasonably anticipated future land use, given realistic exposure scenarios. Contaminated groundwater is generally not considered to be a source material, and VOC concentrations are below 1 percent of the aqueous solubility of each COC, indicating that groundwater contamination likely consists of a dissolved phase plume with no dense non-aqueous phase liquid present. Therefore, the groundwater at Site 22 is not considered to be a principal threat waste. However, the selected remedy includes a treatment technology that will be used to permanently reduce TCE, VC, and RDX concentrations in groundwater to established risk-based cleanup levels.

2.11 Selected Remedy

Based on the ***comparative analysis*** (Ref. 16), the selected remedy to address risk associated with groundwater at Site 22 is Alternative 2, consisting of three components: (1) Hot Spot Treatment of RDX using Enhanced In Situ Bioremediation and Associated Performance Monitoring; (2) MNA of RDX, TCE, and VC; and (3) Land Use Controls.

2.11.1 Summary of the Rationale for the Selected Remedy

Based on the evaluation of the data and information currently available, the Navy, in partnership with USEPA, has determined that the selected remedy meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria. The Navy expects the Preferred Alternative to satisfy the following statutory requirements of CERCLA §121(b): 1) be protective of human health and the environment; 2) comply with ARARs; 3) be cost-effective; 4) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and 5) satisfy the preference for treatment as a principal element. Alternative 2 is the selected remedy for remediation of groundwater contamination at Site 22. Alternative 2 was chosen over Alternatives 3 and 4 (not including the No Action alternative) because the nine criteria analysis indicated that although Alternative 2 takes longer to reach RAOs, it is protective, more cost-effective and results in less short term risk during implementation. Targeting areas using Enhanced In Situ Bioremediation where RDX concentrations exceed 100 µg/L decreases the environmental impacts of construction or intrusive activities by reducing the extent of the treatment area. Although no active treatment process would be employed specifically for VOCs, some active treatment of TCE and VC would occur where the VOC plumes overlap with the RDX target treatment area. Outside the influence of the RDX treatment area, natural biodegradation and other attenuation processes would be occurring.

2.11.2 Description of the Selected Remedy

The selected remedy (Alternative 2) for groundwater at Site 22 consists of the following elements:

- Implementing Enhanced In Situ Bioremediation of RDX using emulsified vegetable oil bio-barriers perpendicular to groundwater flow in the target treatment area (with RDX above 100 µg/L) to reduce the total time for achieving cleanup levels
- Monitored natural attenuation to address the dissolved TCE and VC plumes and the remaining dissolved RDX plume (less than 100 µg/L) following active treatment
- ~~Regular g~~Groundwater monitoring to collect data about COC concentrations and natural attenuation parameters
- Land Use Controls in the form of land and groundwater use restrictions to prevent contact with and use of groundwater until cleanup levels are met

Figure 8 presents a conceptual illustration of the potential implementation of the selected remedy (Alternative 2).

The Navy will implement the selected remedy in phases to optimize treatment in groundwater at Site 22. Prior to completing the Remedial Design (RD) of Alternative 2, a pre-design investigation will be performed to refine the CSM. The remedy implementation approach will be finalized during RD.

FIGURE 8
Alternative 2 - Hot Spot Treatment of RDX using Enhanced In Situ Bioremediation and Associated Performance Monitoring; MNA of TCE, VC, and RDX; and Land Use Controls

Pre-Design Investigation

Prior to the final design of the selected remedy (Alternative 2), a pre-design investigation will be implemented for greater resolution of the lateral and vertical extent of TCE, VC, and RDX, to collect additional data about natural attenuation of VOCs at the site, and to identify the precise areas, depths, and lithologic units requiring RDX treatment. Based on historical data, the only monitoring well with RDX concentrations above 100 μg/L in groundwater is YS22-GW04 (at 150 μg/L in 2007). This investigation is expected to include installation of at least three new monitoring wells, one round of groundwater samples from new and select existing monitoring wells for TCE, VC, RDX and MNA parameters (**Figure 8**), and groundwater samples from 30 direct-push technology (DPT) points to pinpoint the RDX treatment area. Additional lines (or transects) of DPT points will be added if RDX concentrations at the edge of each transect exceeds 100 μg/L. The details of this pre-design investigation, including a schedule and criteria for evaluating natural attenuation of VOCs, will be presented in a pre-design workplan for review and approval by USEPA and VDEQ. Following the pre-design investigation, if it is determined that a different remedy for the VOCs should be considered, the Navy, USEPA, and VDEQ will evaluate remedy enhancements or other remedial alternatives on a schedule set forth in the Site Management Plan for WPNSTA Yorktown.

Enhanced In Situ Bioremediation of RDX Using emulsified vegetable oil Bio-barriers

Enhanced In Situ Bioremediation of RDX using bio-barriers will be implemented in the target treatment area, defined as where RDX concentrations exceed 100 μg/L, through direct injection of a suitable insoluble substrate (such as, but not limited to, emulsified oil substrate or 3D microemulsion) to the shallow groundwater. The introduced substrate will create conditions favorable for degradation for both RDX and the chlorinated ethene compounds at the site. Additionally, a pH buffer (either as a pre-buffered substrate, such as sodium bicarbonate, or as an additional injection) may be required to raise the existing groundwater pH. Based on the observed effectiveness of Enhanced In Situ Bioremediation during field investigations for other Navy projects with similar subsurface conditions, it is assumed that no laboratory treatability studies or field pilot studies are warranted prior to full-scale implementation of Alternative 2.

Before this alternative is implemented, baseline groundwater samples will be collected to confirm assumptions made in the conceptual design and to modify as necessary the application locations, substrate, and the corresponding monitoring locations. Based on current site conditions, conceptual design elements for implementation of Enhanced In Situ Bioremediation are presented in **Figure 8**.

Upon completion of the pre-design investigation, an injection method will be determined (pneumatic fracturing, direct-push, or permanent injection wells). One bio-barrier is anticipated to be placed directly upgradient of the area with the highest RDX concentrations as determined during the pre-design investigation. Two additional bio-barriers are assumed, one to the north and one to the south of this primary line. The southernmost bio-barrier will help prevent further migration of the RDX plume. Within each bio-barrier, or transect line, the injection wells will be spaced approximately 20 feet apart. The radius of influence of each injection point is assumed to be 10 feet. As shown on **Figure 8**, approximately 15 permanent injection locations are estimated for the target treatment area. The vertical target interval will be determined during the design. For cost-estimating purposes, it was assumed that each location will have two co-located permanent injection wells, each with 10-foot screens to more effectively distribute emulsified vegetable oil to units with lower permeability across a 20-foot-depth interval. It was also assumed that two injections would be completed within a 2-year interval. If necessary, as treatment progresses and the concentrations of COCs and their daughter products change, the type and quantity of substrate, frequency of injection, and the location of injection may be revised.

Monitored Natural Attenuation of VOCs and RDX

MNA refers to the reliance on natural processes to achieve cleanup levels. Natural attenuation processes include a variety of physical, chemical, or biological processes that under favorable conditions act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These processes include biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants. Biodegradation pathways for chlorinated VOCs were discussed in Section 2.5.

MNA will be implemented in the area outside the target treatment area and will rely on natural attenuation processes to achieve the cleanup levels for TCE (5 µg/L), VC (2 µg/L), and RDX (6 µg/L). Reducing conditions predominantly present at the site are favorable for biological degradation of the chlorinated VOCs and RDX. In addition, the RDX target treatment area may overlap with a portion of the TCE and VC plumes, resulting in enhanced biodegradation of these chemicals within this area. Natural attenuation will continue under this alternative until the COC concentrations decline to below cleanup levels.

Groundwater Monitoring

Following substrate injection, groundwater monitoring will begin with a brief (estimated 2 year) period of performance monitoring, during which the Navy will collect data about (1) the effect of the injections on COC concentrations and (2) natural attenuation parameters. Effectiveness of the remedial technology (emulsified vegetable oil bio-barriers and MNA) will be evaluated through one year of quarterly groundwater monitoring following each of the two rounds of substrate injections. Following performance monitoring and optimization review of remedy efficiency, remedy enhancements (such as additional injections) may be implemented or, if it is determined that a different remedy should be considered, the Navy, USEPA, and VDEQ will evaluate other remedial alternatives. Any implementation of remedy enhancements or evaluation of other remedial alternatives shall be done on a schedule, which shall be set forth in the Site Management Plan for WPNSTA Yorktown.

Following performance monitoring and any remedy enhancements or changes, the Navy shall conduct long-term monitoring, which will regularly collect data about COC concentrations and natural attenuation parameters until cleanup levels are met.

The Navy shall submit to USEPA and VDEQ for review and approval performance monitoring and long-term monitoring plans, which shall identify criteria for remedy performance and the estimated schedule of remedy implementation. Based on current site conditions, it was assumed for cost-estimating purposes that any new monitoring wells plus the 12 existing shallow monitoring wells and one existing deep monitoring well will be included in the performance and long-term monitoring plans.

Land Use Controls

Throughout implementation of the remedy, the Navy will implement Land Use Controls in the area shown on Figure [X] to prevent unacceptable risks to humans from exposure to COCs in groundwater. Under Alternative 2, the site will be designated as a “restricted use” area in the base geographic information system. This designation will place controls on groundwater at Site 22.

The associated Land Use Controls will meet the following objectives:

- Prohibit activities that would result in contact with groundwater except for environmental monitoring
- Prohibit the withdrawal of groundwater except for environmental monitoring

- Prohibit construction and occupation of any future buildings in the area shown on Figure [x] unless (1) an investigation, concurred upon by the Navy, EPA and VDEQ, shows that risks to human health from vapor intrusion are within acceptable limits or (2) the Navy, EPA and VDEQ concur on the design of a vapor mitigation system for the building, and the vapor mitigation system is installed and operating properly and successfully
- Maintain the integrity of any current or future remedial or monitoring system

The Land Use Controls shall be maintained until concentrations of RDX, TCE and its breakdown-products (including VC) in groundwater have been reduced to levels that allow for unlimited use and unrestricted exposure. The Navy will develop and submit to USEPA and VDEQ, for review, a LUC RD within 90 days following the signature of this ROD. The LUC RD will provide for implementation and maintenance actions, including periodic inspections and reporting. The Navy will implement, maintain, monitor, report on, and enforce the Land Use Controls according to the approved LUC RD and this ROD.

Although the Navy may transfer these responsibilities to another party by contract, property transfer agreement, or through other means, the Navy will remain ultimately responsible for remedy integrity and will: 1) perform CERCLA Section 121(c) 5-year reviews; 2) notify the appropriate regulators and/or local government representatives of any known land use control deficiencies or violations; 3) provide access to the property to conduct any necessary response; 4) retain the ability to change, modify, or terminate Land Use Controls; and 5) ensure that the LUC objectives are met to maintain remedy protectiveness.

2.11.3 Summary of the Estimated Remedy Costs

Table 6 presents a cost estimate summary for implementation of the selected remedy. ***Detailed cost estimates*** (Ref. 17) are provided in the 2011 FS report. The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost.

2.11.4 Expected Outcomes of the Selected Remedy

Site 22 is currently only being used for periodic hunting activities. This use is expected to continue, and there are no other planned land uses in the foreseeable future. Cleanup levels for the selected remedy are based on established risk-based cleanup levels suitable for unlimited use and unrestricted exposure. Exposure will be controlled through Land Use Controls until COCs in groundwater (TCE, VC, and RDX) are reduced to the cleanup levels. Remedial activities at Site 22 will consist of Hot Spot treatment of RDX using Enhanced In Situ Bioremediation and associated performance monitoring; MNA of RDX, TCE, and VC; and Land Use Controls. **Table 9** identifies the potential unacceptable human health risks (there are no potential unacceptable ecological risks), the RAOs established to address these unacceptable risks, the remedy component(s) that will be implemented to achieve each RAO, what metrics will be used to confirm the RAOs are met, and the expected outcome from implementation of the remedy components.

TABLE 9
Expected Outcomes

Risk		RAO	Remedy Component	Metric	Expected Outcomes	
Human Health	Ecological					
Groundwater						
Ingestion of, dermal contact with, and inhalation of TCE, VC, and RDX in groundwater for hypothetical future lifetime adult and child residents; ingestion of and dermal contact with groundwater for hypothetical future construction workers	No exposure pathway	To reduce TCE, VC, and RDX concentrations in groundwater to established risk-based cleanup levels	Hot Spot treatment of RDX using Enhanced In Situ Bioremediation bio-barriers in areas where concentrations exceed 100 µg/L and associated performance monitoring	Monitor shallow groundwater concentrations to confirm reduction of RDX concentrations to cleanup levels	Reduction of RDX concentrations to cleanup levels	No further treatment or monitoring after achieving cleanup goals that allow for unlimited use and unrestricted exposure or groundwater
			MNA for TCE, VC, and RDX	Monitor groundwater COC concentrations and their degradation products, geochemical parameters, and sensitive metals to confirm the natural degradation process is occurring until concentrations are at or below cleanup levels	Reduction of RDX, TCE, and VC concentrations to cleanup levels	
				Monitor shallow groundwater COC concentrations and their degradation products for potential toxic transformation products to confirm concentrations are not created at levels that threaten human health		
		To maintain Land Use Controls to prevent human (residential and construction worker) exposure to groundwater until cleanup levels are met.	Land Use Controls	Annual LUC inspections until cleanup levels are met for groundwater COCs	Elimination of groundwater exposure pathway	Removal of groundwater Land Use Controls

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2.11.5 Statutory Determinations

In accordance with CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan, the selected remedy meets the following statutory requirements:

Protection of Human Health and the Environment— The selected remedy will protect human health (there are no potential ecological risks) from known site risks to future receptors through groundwater treatment and monitoring to reduce COC concentrations, and through Land Use Controls to restrict the use of and exposure to shallow groundwater and shallow groundwater emissions until concentrations are reduced to established risk-based cleanup levels that allow for unrestricted use and unlimited exposure.

Compliance with ARARs—The selected remedy will meet all identified ARARs. Federal and state ARARs for Site 22, summarized by classification, are presented in **Appendix C**. The classification of ARARs identified includes chemical-specific, location-specific, and action-specific requirements.

Cost-Effectiveness—The selected remedy provides the most reasonable value relative to the cost through the use of active treatment in the high-concentration target area, while allowing for MNA in the low-concentration target areas.

Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable—The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be used in a practicable manner at Site 22. The selected remedy provides treatment through substrate injection that enhances biologically mediated degradation of the chlorinated COCs and RDX through natural microbial degradation processes to reduce contaminant mass. Because the long-term effectiveness and permanence, as well as reduction of toxicity and volume, are achieved through the selected remedy, the Navy, USEPA, and VDEQ concur that the selected remedy provides the best balance of tradeoffs in terms of the balancing criteria, while also considering the statutory preference for treatment as a principal element and considering state and community acceptance.

Preference for Treatment as a Principal Element—The selected remedy uses treatment of the high-concentration target area as a principal element, and therefore satisfies the statutory preference for treatment.

Five-Year Review Requirements—Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

2.12 Documentation of Significant Changes

The Proposed Plan for Site 22 was released for public comment on May 14, 2012. The public comment period ran from May 14 to June 28, 2012 with the public meeting to discuss the plan on May 24, 2012. General inquiries were received during the public meeting on May 24, 2012, but no comments were received requiring amendment to the Proposed Plan, and no additional written comments, concerns, or questions were received from community members 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.

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3 Responsiveness Summary

The participants in the public meeting held on May 24, 2012, included representatives of the Navy and VDEQ. Two community members attended the meeting. Questions received during the public meeting were general inquiries and are included in the ***meeting transcript*** (Ref. 18 and **Appendix D**). There were no comments received at the public meeting requiring amendment to the PP, and no additional written comments, concerns, or questions were received from community members during the public comment period.

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References

Reference Number	Reference Phrase in ROD	Location in ROD	Identification of Referenced Document Available in the AR
1	***ROD***	Section 2.2	Baker Environmental, Inc. (Baker). 2003. Record of Decision Site 22 Burn Pad, Naval Weapons Station, Yorktown, Virginia. September. AR No. 01375.
2	***ROD***	Section 2.2	CH2M HILL. 2011. Record of Decision, Site 4 – Burning Pad Residue Landfill, Site 21 – Battery and Drum Disposal Area & Site 22 – Burn Pad, Naval Weapons Station, Yorktown, Virginia. August. AR No. 000262.
3	***analytical results***	Table 1	Baker. 2001. Round Two Remedial Investigation Report, Sites 4, 21, and 22, Naval Weapons Station, Yorktown, Virginia. January. Tables 4-36 through 4-38. AR No. 01296, 01297, and 01298.
4	***analytical results***	Table 1	Baker. 2001. Round Two Remedial Investigation Report, Sites 4, 21, and 22, Naval Weapons Station, Yorktown, Virginia. January. Tables 4-15 through 4-20 and Tables 4-39 through 4-41. AR No. 01296, 01297, and 01298.
5	***analytical results***	Table 1	CH2M HILL. 2009. Remedial Investigation Report for Groundwater, Sites 4, 21, and 22, Naval Weapons Station, Yorktown, Virginia. November. Table 6-3. AR No. 000024.
6	***analytical results***	Table 1	CH2M HILL. 2009. Remedial Investigation Report for Groundwater, Sites 4, 21, and 22, Naval Weapons Station, Yorktown, Virginia. November. Tables 7-1 and 7-7. AR No. 000024.
7	***evaluate alternatives***	Table 1	CH2M HILL. 2011. Feasibility Study Report for Groundwater at Site 22, Naval Weapons Station, Yorktown, Virginia. November. Section 6. AR No. 000181.
8	***CSM***	Section 2.5	CH2M HILL. 2011. Feasibility Study Report for Groundwater at Site 22, Naval Weapons Station, Yorktown, Virginia. November. Section 2.2.3. AR No. 000181.
9	***Numerous investigations***	Section 2.5.1	CH2M HILL. 2011. Feasibility Study Report for Groundwater at Site 22, Naval Weapons Station, Yorktown, Virginia. November. Sections 2.1 and 2.2. AR No. 000181.
10	***results***	Section 2.5.1	CH2M HILL. 2011. Feasibility Study Report for Groundwater at Site 22, Naval Weapons Station, Yorktown, Virginia. November. Sections 2.2.1. AR No. 000181.

Reference Number	Reference Phrase in ROD	Location in ROD	Identification of Referenced Document Available in the AR
11	***biodegradation***	Section 2.5.2	CH2M HILL. 2009. Remedial Investigation Report for Groundwater, Sites 4, 21, and 22, Naval Weapons Station, Yorktown, Virginia. November. Section 10.5.3. AR No. 000024.
12	***complete exposure pathways***	Section 2.7.1	CH2M HILL. 2009. Remedial Investigation Report for Groundwater, Sites 4, 21, and 22, Naval Weapons Station, Yorktown, Virginia. November. Section 8.4.2. AR No. 000024.
13	***Potential unacceptable human health risks***	Section 2.7.1	CH2M HILL. 2009. Remedial Investigation Report for Groundwater, Sites 4, 21, and 22, Naval Weapons Station, Yorktown, Virginia. November. Tables 8-14 and 8-15. AR No. 000024.
14	***no potentially unacceptable risk***	Section 2.7.2	CH2M HILL. 2009. Remedial Investigation Report for Groundwater, Sites 4, 21, and 22, Naval Weapons Station, Yorktown, Virginia. November. Section 9.5.4. AR No. 000024.
15	***developed and evaluated***	Section 2.9.1	CH2M HILL. 2011. Feasibility Study Report for Groundwater at Site 22, Naval Weapons Station, Yorktown, Virginia. November. Section 4.2. AR No. 000181.
16	***comparative analysis***	Section 2.11	CH2M HILL. 2011. Feasibility Study Report for Groundwater at Site 22, Naval Weapons Station, Yorktown, Virginia. November. Section 6. AR No. 000181.
17	***Detailed cost estimates***	Section 2.11.3	CH2M HILL. 2011. Feasibility Study Report for Groundwater at Site 22, Naval Weapons Station, Yorktown, Virginia. November. Appendix C. AR No. 000181.
18	***meeting transcript***	Section 3	CH2M HILL. 2009. Proposed Plan, Site 1: Landfill Near Incinerator, Naval Weapons Station Yorktown, Cheatham Annex. January. AR No. Pending.

Detailed site information reference in this ROD in bold blue text is contained in the AR.

For access to information contained in the AR for WPNSTA Yorktown please contact:

Public Affairs Office
P.O. Drawer 160
Yorktown, VA 23691-0160
Phone: (757) 887-4939

Appendix A

Appendix B

Appendix C