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SUMMARY OF TREATABILITY TESTING OPTIONS TO EVALUATE TECHNOLOGIES FOR IN-SITU TREATMENT OF VANADIUM IN GROUNDWATER AT SITE 45 STEAM GENERATING PLANT NAS CECIL FIELD FL

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TETRA TECH NUS INC

SUMMARY OF TREATABILITY TESTING OPTIONS TO EVALUATE TECHNOLOGIES FOR THE IN-SITU TREATMENT OF VANADIUM IN GROUNDWATER SITE 45 – STEAM GENERATING PLANT NAS CECIL FIELD, JACKSONVILLE, FLORIDA

1.0 INTRODUCTION

Tetra Tech NUS Corporation (TtNUS) is currently preparing a Feasibility Study (FS) for Site 45 – Steam Generating Plant at Naval Air Station (NAS) Cecil Field in Jacksonville, Florida. This FS is being prepared for Southern Division Naval Facilities Engineering Command (SOUTHDIVNAVFACENGCOM) under the Navy Comprehensive Long-Term Environmental Action Navy (CLEAN) Program, Contract Number N62467-94-D-0888, Contract Task Order (CTO) 0078.

The main focus of this FS is the evaluation of groundwater containing relatively low concentrations (maximum 240 µg/L) of vanadium that are, however, in excess of the Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Level (GCTL) of 49 µg/L

This brief technical memorandum was prepared as a result of a decision reached by the Base Realignment Cleanup Team (BCT) during the May 15, 2001 meeting (Minute No. 1472). The purpose of this memrandum is to present a brief survey of the current state-of-the-art for the in-situ treatment of vanadium in groundwater and to outline an approach for the evaluation of one or more of the most promising remedial technologies through treatability testing.

The two following important assumptions were made for the preparation of this technical memorandum:

- Because of the very slow rate of vanadium migration predicted by the FS modeling and because of the small size (28,600 ft^2) of the vanadium plume, it was assumed that in-situ technologies that treat the vanadium in place would be more timely and cost-effective than extraction and ex-situ treatment (pump-and-treat) or technologies that depend on groundwater and contaminant movement, such as permeable reactive barriers (PRBs).

- Although the oxidation state of the vanadium in the Site 45 groundwater is unknown and would not be simple to determine, it was assumed that this vanadium would be present in one of its higher oxidation states, either as vanadium (IV) or vanadium (V), because it resulted from emissions of fuel combustion that is an oxidative process.

2.0 TECHNOLOGY SURVEY METHODOLOGY

Remedial technologies were surveyed through a literature review and Internet search. In particular, a number of documents were downloaded from the Groundwater Remediation Technologies Analysis Center (GWRTAC) site and the U.S. EPA REACHIT search engine.

The documents that were reviewed are referenced in section 5.0 of this memorandum.

3.0 POTENTIAL IN-SITU TREATMENT TECHNOLOGIES

The technology survey identified very few vanadium-specific treatment technologies. Work at only one United States Department of Energy (U.S. DOE) site (Rifle, Colorado, see first two references in Section 5.0) was vanadium-related. However, it was assumed that technologies proven to be effective for the treatment of other heavy metals, such as hexavalent chromium in particular, would also have the potential to be effective for the treatment of vanadium (IV or V).

Taking into consideration the above assumption as well as the two assumptions presented in Section 1.0, the technology survey showed that the most promising approach for the in-situ treatment of vanadium in groundwater at Site 45 would be to create a "reactive zone" within the contaminant plume. This "reactive zone" would result in immobilization of the vanadium, either through reduction and precipitation, or through adsorption, or through a combination of both processes.

The technology survey also identified the injection of reductive chemical reagents as the most likely type of technology to create such a "reactive zone." According to the information downloaded from the GWRTAC site, several such reagents have been successfully used, at least on a pilot-scale, including sodium or potassium dithionite (S_2O_4) solutions and colloidal suspensions [nano meter (E-09) particle size] of zero-valent iron (ZVI). According to the U.S. EPA REACHIT search engine, yet another reagent is a polythiocarbonate, marketed by ETUS under the name of TR-DETOX, and which is reportedly capable of both reducing and precipitating heavy metals, such as vanadium.

All of the above reagents have been proven to be effective on either a pilot- or full-scale for the treatment of hexavalent chromium. However, only ZVI, used in a PRB, has actually been proven effective on a pilot-scale for the treatment of vanadium (V) at the previously-mentioned U.S. DOE site (Rifle, Colorado).

Besides chemical injection, another type of technology that might be used for the creation of a reactive zone would be electrokinetics, as offered by such companies as Geokinetics International, Inc. and Electro Petroleum Inc. Electrokinetics would consist of installing a network of electrodes within the contaminant plume. These electrodes are reportedly capable of capturing such ionic contaminants as

vanadium in a much more effective manner than pump-and-treat. However, a review of some of the existing literature showed that electrokinetics is best suited to the treatment of highly-contaminated aquifers, which is not the case at Site 45. Also, once captured at the electrode sites, contaminants must still be extracted and treated as they would be in a conventional pump-and-treat system. Therefore, electrokinetics was not retained for further evaluation at Site 45.

4.0 TREATABILITY TESTING

The effectiveness of all of the above technologies should be verified through treatability testing.

Conceptually, this testing could be conducted as a multi-tiered process consisting of the four steps described below. The first three of these four steps would be performed on a bench-scale in a laboratory and the fourth would be performed on a pilot-scale in the field. In practice, however, it may not be necessary to perform all four steps and the availability of sufficient previous testing data may allow the by-passing of the first two, or even the first three steps.

The first laboratory bench-scale step would consist of a jar test type screening study in water. The objective of this first step would be to verify the ability of a particular reagent to reduce and precipitate vanadium and to establish chemical usage rates and other reaction parameters (e.g., ORP, pH, temperature, etc..) under optimal controlled conditions. Depending on knowledge derived from literature and/or prior work, this step might not always be necessary. The typical timeframe and cost for this first step of bench-scale testing would be approximately two to four weeks and $5,000 to $10,000, respectively. Management and oversight of testing activities, including procurement of a treatability contractor in accordance to Federal Acquisition Regulations (FAR) would typically add approximately 2 months and $15,000 to these timeframes and costs.

The second laboratory bench-scale step would consist of a batch study with a mixture of groundwater and natural matrices (soil). The objective of this second step would to evaluate the effect of natural matrices upon the effectiveness of the tested chemical and the reaction parameters, as established by the first step testing. The typical timeframe and cost for this second step of bench-scale testing would be approximately four to six weeks and $10,000 to $20,000, respectively. Management and oversight of testing activities would require an additional 2 months and $17,000.

The third laboratory bench-scale step would consist of a column study with site-specific natural matrices. The objective of this third step would be to get as close as possible to actual field conditions and to determine the impact of dynamic rather than batch testing upon the removal effectiveness and reaction parameters established by the first two steps of testing. The typical timeframe and cost for this third step

of bench-scale testing would be approximately six to eight weeks and $30,000 to $50,000, respectively. Management and oversight of testing activities would require an additional 2 months and $20,000.

Field pilot-scale testing would consist of injecting a reagent at one or two locations of the site to be tested and monitoring remediation through the collection and analysis of samples from monitoring wells strategically located around the injection point(s). The objective of this fourth step is to verify that a given technology would be effective under actual site-specific field conditions and to establish design parameters for a full-scale application. At Site 45, because of the relatively small size of the groundwater contaminant plume, field pilot-scale testing could in fact constitute a significant portion of the full-scale remedial action and be used to cleanup the area of highest vanadium contamination in the vicinity of monitoring wells CEF-F11-1Sa and CEF-007-01Sa. The typical timeframe and cost for pilot-scale testing would be approximately three to four months and $150,000 to $300,000, respectively. Management and oversight of testing activities would require an additional 2 months and $25,000.

The following table summarizes the time requirements and costs for each of the above treatability testing steps:

Step	Testing		Management & Oversight		Total	
	Duration (months)	Cost ($1,000)	Duration (months)	Cost ($1,000)	Duration (months)	Cost ($1,000)
1st Stage Lab Bench-Scale	0.5 – 1	5 – 10	2	15	2.5 - 3	20 – 25
2nd Stage Lab Bench-Scale	1 – 1.5	10 - 20	2	20	3 – 3.5	30 – 40
3rd Stage Lab Bench-Scale	1.5 – 2	30 - 50	2	25	3.5 - 4	55 – 75
Field Pilot-Scale	3 – 4	150 - 300	2	30	5 - 6	180 – 330
Totals	**6 – 8.5**	**195 - 380**	**8**	**90**	**13 – 16.5**	**285 - 470**

5.0 REFERENCES

The following document were downloaded and reviewed from an Internet search (Yahoo.com search engine, "vanadium removal"):

Title: Rifle, Colorado, Pilot Study Begins for Vanadium Removal
Publication: U.S. Department of Energy, Grand Junction Office, Perspective, Winter/Spring 2001

Title: Final Site Observational Work Plan for the UMTRA Project New Rifle Site
Publication: U.S. Department of Energy, Grand Junction Office, Document U0058601, December 1999

Title: In Situ Redox Manipulation, Subsurface Contaminants Focus Area
Publication: U.S. Department of Energy Innovative Technology Summary Report DOE/EM-0499, January 2000

Title: Innovative Technology Evaluation Repory, Dynaphore, Inc., Forager™ Sponge Technology

Publication: U.S. EPA Environmental Agency EPA/540/R-94/552, June 1995

The following documents were downloaded for review from the GWRTAC web site at http://www.gwrtac.org:

Title: An Overview of R&D Addressing In Situ Treatment of Heavy Metal Contaminants in Soil and Groundwater
Author: Edgar Berkey
Reference: Presentation for Workshop on Heavy Metal Contaminants in Water, Snowbird, Utah, August 2-4, 1999

Title: In Situ Chemical Treatment
Authors: Yujun Yin and Herbert Allen
Reference: Technology Evaluation Report TE-99-01, July 1999

Title: Remediation of Metals-Contaminated Soils and Groundwater
Authors: Cynthia Evanko and David Dzombak
Reference: Technology Evaluation Report TE-97-01, October 1997

Title: Electrokinetics
Author: Liesbet Van Cauwenberghe
Reference: Technology Overview Report TO-97-03, July 1997

The following technologies were identified and reviewed using the U.S. EPA REACHIT http://www.epareachit.org search engine:

Type: In-Situ Chemical treatment
Trade Name: TR-DETOX
Vendor: ETUS, Inc.

Type: In-Situ Chemical treatment
Trade Name: MAECTITE
Vendor: Sevenson Environmental Services, Inc.

Type: In-Situ Electrokinetic Treatment
Trade Name: Pool Process™
Vendor: Geokinetics International, Inc..

Type: In-Situ Stabilization
Vendor: AGEC

Type : In-Situ Adsorption
Trade Name: Forager™ Sponge
Vendor: Dynaphore, Inc.

Type: Delivery/Extraction System for In-Situ Injection
Trade Name: Mectool
Vendor: Hayward Baker, Inc.