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**FINAL**  
**Bench-Scale Test Workplan**  
**Data Gap Sampling Investigation**  
**Installation Restoration Site 28**

**Alameda Point**  
**Alameda, California**

Contract No. N68711-02-D-8213  
Task Order 0024  
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Prepared for:



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**October 2007**

**BENCH-SCALE TEST WORKPLAN**  
**DATA GAP SAMPLING INVESTIGATION**  
**INSTALLATION RESTORATION SITE 28**  
**ALAMEDA POINT, ALAMEDA, CALIFORNIA**

**FINAL**

Prepared For:

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**INSTALLATION RESTORATION SITE 28**  
**ALAMEDA POINT, ALAMEDA, CALIFORNIA**

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Contract Number N68711-02-D-8213  
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Comments:

The attached copies of the FINAL Workplan are provided for your information and records. Please note that the associated Sampling and Analysis Plan (SAP) is provided as an attachment to this Workplan.

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1	APPENDUM 1 TO THE Sampling and Analysis Plan
2	Potential for Mobilization of Arsenic Due to Remedial Treatment

## ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
BOD	biological oxygen demand
BEI	Bechtel Environmental, Inc.
bgs	below ground surface
CaS <sub>5</sub>	calcium polysulfide
CCC	Criterion continuous concentration
cm	centimeter
COD	chemical oxygen demand
Cr <sup>+6</sup>	chromium (VI)
CTR	California Toxics Rule
CuS	copper sulfide
DO	dissolved oxygen
DQO	Data Quality Objective(s)
EPA	United States Environmental Protection Agency
FS	Feasibility Study
g	grams
IR28	Installation Restoration Site 28
ITSI	Innovative Technical Solutions, Inc.
kg	kilogram(s)
kg/L	kilograms per liter
MCL	Maximum Contaminant Level
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mL	milliliters
MRC™	Metals Remediation Compound
mV	millivolts
Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub>	Sodium metabisulfite
ORP	oxidation-reduction potential
psi	pounds per square inch
PP	Proposed Plan

## ACRONYMS AND ABBREVIATIONS (Continued)

PVF	polyvinyl fluoride
RAO	Remedial Action Objective(s)
RD	Remedial Design
RI	Remedial Investigation
SAP	Sampling and Analysis Plan
SM	Standard Method
TOC	total organic carbon
USGS	United States Geological Survey
VOC	volatile organic compounds
WET	Waste Extraction Test
ZVI	zero-valent iron

## 1.0 PROJECT APPROACH AND OBJECTIVES

Innovative Technical Solutions, Inc. (ITSI) has prepared this Bench-Scale Test Workplan for Installation Restoration Site 28 (IR28) at Alameda Point, Alameda, California as part of a Data Gap Investigation at the site. A Remedial Investigation (RI) was conducted at IR28 in 2002 to characterize the nature and extent of contamination at the site (Bechtel Environmental, Inc. [BEI], 2004); a Feasibility Study (FS) was subsequently prepared to develop and evaluate remedial alternatives to address the identified contamination (BEI, 2005). The Navy's preferred remedial alternative for groundwater, as discussed in the Proposed Plan (Navy, 2006), recommends injection of a metals-reducing chemical into the subsurface to immobilize copper in order to prevent migration to the Bay, thereby protecting aquatic receptors. The Remedial Action Objective (RAO) for groundwater is stated in the Draft Record of Decision (Navy, 2007) as follows: "Prevent potential exposure of aquatic offshore receptors (in the Oakland Inner Harbor) to copper in surface water at the point of exposure exceeding the California Toxics Rule (CTR) criterion continuous concentration (CCC) of 3.1 micrograms per liter ( $\mu\text{g/L}$ )."

The Bench-scale testing described in this Workplan will be conducted to: validate the effectiveness of the selected remedy, compare the effectiveness of different chemical reagents for the precipitation and stabilization of copper, and select the optimal injection chemical(s) for site-specific conditions. An evaluation of the Data Quality Objectives (DQOs) for this Bench-Scale Test was conducted in accordance with Environmental Protection Agency (EPA) guidance (2006). These project-specific DQOs are described in Section 1.5 of the Sampling and Analysis Plan (SAP) included as Attachment 1 to this Workplan. The SAP for this Workplan was generated as Addendum 1 to the SAP originally produced for the Data Gap Sampling Investigation Workplan (ITSI, 2007). It describes the sampling and analysis protocol for the collection of the soil and groundwater samples needed for the bench-scale testing and consists only of sections which describe additions to the protocol included in the original Data Gap Investigation SAP.

This Workplan describes the batch testing activities that have been designed to evaluate the relative effectiveness of five different chemicals in immobilizing copper by binding it into stable, relatively insoluble sulfur or phosphate compounds. In addition, it describes control tests that

will be conducted to evaluate the effect of changing the Eh (a parameter which approximately represents redox conditions) and the pH conditions independent of the addition of reactive chemicals. The bench-scale test studies proposed in this Workplan will be conducted in a controlled laboratory setting using actual site soil and groundwater. This will allow the proposed treatment chemicals to be evaluated under geochemical conditions consistent with those at the site. Soil and groundwater contaminant concentrations and geochemical conditions will be compared before and after the addition of the treatment chemicals, as well as before and after the Eh and pH are altered for the control tests.

The Eh adjustment test will help determine the effectiveness of creating a reducing chemical environment on copper immobilization (without the addition of reactive chemicals), and also provide data on whether site soils yield significant quantities of iron and other metals under such conditions. Lactate, a non-toxic, reducing, non-sulfide-bearing chemical, will be added to the sample slurry in the laboratory to reduce the Eh to levels similar to those generated during the other bench tests using sulfide-bearing chemicals. The liberation of iron and other metals is a concern at IR28 because the availability of certain metals could alter the effectiveness of the treatment or produce unintended impacts; Attachment 2 describes the potential for mobilization of arsenic as a result of the treatment. If significant concentrations of dissolved iron are generated within the system during treatment, the sulfur in the treatment chemical could react with this iron rather than the copper, thus reducing the effectiveness of the treatment process.

The pH adjustment test (a pH increase by the addition of a base) will help determine whether pH adjustments alone might render copper immobile and thus achieve the same result as the addition of reagent chemicals. To understand whether the copper remains immobile, the pH adjustment will be followed by the addition of fresh site groundwater and the dissolved copper concentration will subsequently be re-analyzed.

The results of the bench-scale testing will provide data to assist in the selection of the most appropriate and effective of the five tested chemicals to use for site remediation, along with the optimal concentration and other parameters. These data will support the development of a Remedial Design (RD) document, which will describe in detail how to implement the selected remedy.

## 2.0 SAMPLE COLLECTION FOR BENCH-SCALE TESTING

Representative groundwater and saturated soil samples for use in the bench-scale testing will be collected from within the proposed treatment area to replicate actual site conditions expected during implementation of the remedy. The sample collection locations for the bench testing were selected based on an understanding of the nature and extent of contamination at the site, site geology, and groundwater characteristics. Procedures for the field sampling and laboratory analysis of these samples are described in greater detail in Attachment 1, the SAP Addendum. Soil samples will be collected from a soil boring to be installed as part of the data gap sampling investigation northeast of well 28SW03, where the highest concentrations of copper at IR28 have been detected during groundwater monitoring events. Saturated soil is expected to be encountered at a depth of approximately 8 feet below ground surface, based on observations documented during the installation of the well.

Historical sampling results that represent site conditions in the vicinity of the proposed treatment zone are summarized in the following table:

<b>TABLE 1: HISTORICAL SAMPLING RESULTS</b>
<b>Copper in IR28 Soil Highest Detected Concentrations (Bechtel, 2004)</b>
6,370 milligrams per kilogram (mg/kg) in the northeast part of IR28 (boring 28B25 at 3.5 feet below ground surface [bgs])
3,450 mg/kg in the northeast part of IR28 (boring 28B28 at 5.0 feet bgs)
<b>Copper in IR28 Groundwater Maximum Detected Concentration (ITSI, 2006)</b>
210 µg/L in the northeast part of IR28 (Well 28SW03; Summer 2005)
<b>Copper in Groundwater in the Same Well Most Recent Sampling Event</b>
95 µg/L at Well 28SW03 (Winter 2006)
<b>Additional data from the Same Well</b>
pH: 7.54 at Well 28SW03 (Fall 2006)
ORP: 132.3 at Well 28SW03 (Fall 2006)

Groundwater samples will be collected from two permanent IR28 well locations to represent different parts of the groundwater plume. Groundwater from well 28SW03, the well with the highest copper concentrations, will be collected for use in the initial bench-scale testing to

evaluate the ability of the immobilizing chemicals to reduce copper concentrations.

Groundwater from well 28SW04, located in an upgradient area, will be collected for use in a follow-up step of the bench test to represent the groundwater that will flow onto the site after the remedy has been implemented. This post-treatment step will be used to evaluate whether the copper remains immobilized over time as the treated area is subject to continued influx of upgradient groundwater.

Soil and groundwater sample collection is detailed in the Workplan for the Data Gap Sampling Investigation (ITSI, 2007), as well as in Attachment 1, the SAP Addendum. The soil sample collection for the Data Gap Investigation has been conducted concurrently with the sample collection for the bench testing. The total volumes of soil from the saturated zone, groundwater from the contaminated area, and groundwater from upgradient needed to conduct the five bench tests plus the two control tests are as follows:

- Soil: approximately 12 kilograms (kg) of soil, or about 18 6-inch long sections of 2-inch diameter soil cores (if large particles are prevalent in these cores, additional soil will be collected).
- Groundwater: 20 liters of groundwater will be collected from well 28SW03, and an additional 6 liters of groundwater will be collected from well 28SW04 for use in the follow-up testing.

The solid material from the field will be mixed in the laboratory to create a composite sample which will be used in the bench testing, as described in Section 5.0 of this Workplan.

### **3.0 RATIONALE AND SELECTION OF IMMOBILIZING CHEMICALS FOR BENCH-SCALE TESTS**

Technologies that are used to treat industrial effluents before they are released into the environment are also frequently used to remediate environmentally contaminated sites. These waste treatment and remediation technologies and products will be evaluated for their ability to stimulate the chemical precipitation processes identified in the Proposed Plan as the remediation strategy for IR28. The following five immobilizing chemicals will be evaluated for their ability to reduce copper concentrations at IR28, using laboratory bench-scale testing.

- Metals Remediation Compound (MRC™)

- EHC-M™
- Sodium metabisulfite (Na<sub>2</sub>S<sub>2</sub>O<sub>5</sub>)
- Calcium polysulfide (CaS<sub>5</sub>)
- Apatite II

MRC™, a proprietary Regenesis product, was the immobilizing chemical proposed in the FS (BEI, 2005). The alternative chemicals listed above will also be evaluated for their possible effectiveness and efficiency. These chemicals have been selected based on their availability and their ability to reduce metals, including copper, in contaminated soil, groundwater, or wastewater during applications at other sites. In these uses, immobilizing chemicals are added to the media of concern and typically react with the soluble metals present to create sulfides, phosphates, and other compounds such as hydroxides and carbonates. The sulfides are the most insoluble, as shown on the solubility graph (**Figure 1**) from the United States Environmental Protection Agency (EPA, 1981). This graph illustrates that copper sulfide (CuS) is able to precipitate at low concentrations at a pH of about 6.7. Due to the affinity of copper for sulfur, four of the immobilizing chemicals (MRC™, sodium metabisulfite, and calcium polysulfide, EHC-M™) selected for this bench test contain large quantities of chemically available sulfur that is expected to bond with the copper in the IR28 soil and groundwater to precipitate a very insoluble copper sulfide compound. Alternatively, Apatite II is expected to generate stable copper phosphate compounds.

Previous uses of sulfur-containing and phosphate-containing immobilizing chemicals to treat transition metals have been described by Thomasser and Rouse (2001), EPA (2000), Guertin, Jacobs, and Avakian (2005), Chen, Wright, Conca, and Peurrung (1997), and Stanforth and Chowdhury (1994). The immobilization of chromium (VI) (Cr<sup>+6</sup>) is the most common use of sulfur-containing treatment chemicals, while immobilization of lead is the most common use of phosphate-containing chemicals. The use of these chemicals to immobilize copper may not be as common, but similar, favorable chemistry is anticipated.

Eh and pH control tests will also be conducted during the bench testing to evaluate whether, in the absence of treatment reagent chemicals: (1) the creation of a reducing chemical environment

(Eh adjustment) will cause site soils to yield significant quantities of iron and other metals, and (2) changes in pH to more basic conditions might render copper immobile.

A brief description of the selected immobilizing chemicals to be evaluated in the bench-scale testing and the rationale for their use follows.

### 3.1 METALS REMEDIATION COMPOUND (MRC™)

MRC™ is a product manufactured by Regenesis ([www.regenesis.com](http://www.regenesis.com)) specifically for use in groundwater remediation. MRC™ directly affects biogeochemical processes to remove certain metals, such as Cr<sup>+6</sup>, from groundwater. MRC™ contains a polylactate polymer and a benign (nontoxic) organosulfur compound (which acts as a direct chemical reductant for soluble metals). According to the manufacturer, the MRC™ compound is formulated to allow a controlled, slow release of its active components over a long period of time. In addition, by providing lactic acid, which is rapidly metabolized by subsurface microbes, the aquifer will move toward more reducing conditions, creating ferrous iron and sulfide species that are known to chemically reduce many metals to insoluble compounds. Although copper should precipitate out of solution in a reducing environment in the presence of sulfide, the manufacturer does not claim copper contamination will be successfully treated with MRC™; therefore, bench testing using actual site soil and groundwater will be conducted to validate whether or not the use of MRC™ should be specified in the remedial design for IR28.

### 3.2 EHC-M™

EHC-M™ is a product manufactured by Adventus Americus, Inc. ([www.adventusgroup.com](http://www.adventusgroup.com)) for in-situ treatment of groundwater and saturated soil impacted by heavy metals. This metal remediation compound encourages the precipitation and adsorption of dissolved metals to limit their movement downstream of the treatment zone. The compound creates a strongly reducing environment in the subsurface (i.e., yields a redox potential in the -500 to -650 millivolt [mV] range) using a controlled-release, integrated carbon and zero-valent iron (ZVI) source, along with a source of sulfate and other additives. The controlled-release feature of the carbon is intended to provide extended longevity and assist in maintaining reducing conditions. Remediation methods for applying EHC-M™ include direct injection, hydraulic fracturing, pneumatic fracturing, soil mixing, and direct emplacement in trenches and excavations. For

injection applications, which are the most commonly used, the EHC-M™ is available from Adventus as a dry powder that can be mixed with water on site to produce a slurry.

### **3.3 SODIUM METABISULFITE (Na<sub>2</sub>S<sub>2</sub>O<sub>5</sub>)**

Sodium metabisulfite is an agent commonly used in industrial wastewater treatment and other industrial processes (such as treating process solutions from metal finishing and plating operations) to chemically reduce and immobilize metals. Sodium metabisulfite has also been used successfully for in-situ groundwater remediation of certain metals, as discussed further in Section 3.5, Case Studies. Sodium metabisulfite (a white or off-white, dry, finely crystalline granular powder with a faint sulfur dioxide odor) forms sodium bisulfite when added to water. It has a bulk density between 1.0 and 1.15 kilograms per liter (kg/L) and a density of 1.33 (for a 38% solution). Additional information on the physical properties and possible uses may be found at the manufacturer's web site (<http://www.basf.com/businesses/chemicals/pdfs/sodmeta.pdf>).

### **3.4 CALCIUM POLYSULFIDE (CaS<sub>5</sub>)**

Calcium polysulfide, known as Cascade™, is manufactured by Best Sulfur Products for fixating uranium and chromium in soils in-situ as well as for precipitating heavy metals and treating cyanide in water. The chemical has been used to stabilize metals in recirculated groundwater at a wood treating site, transforming hexavalent chromium to trivalent chromium at a rapid rate (HazTECH News, 1999). It has also been used to immobilize various other metals, including copper, lead, uranium, selenium, and arsenic (Jacobs, Hardison, and Rouse, 2001). Calcium polysulfide is water soluble and has a specific gravity of 1.273; it is commercially available as a 29% active ingredient solution with a pH of 11.3 to 11.5.

### **3.5 APATITE II**

Metals can be stabilized in place in a Phosphate-Induced Metal Stabilization (PIMS™) process using apatite minerals. An effective and inexpensive apatite, known as Apatite II [Ca<sub>10-x</sub>Na<sub>x</sub>(PO<sub>4</sub>)<sub>6-x</sub>(CO<sub>3</sub>)<sub>x</sub>(OH)<sub>2</sub>, where x < 1], has been developed for metals remediation by UFA Ventures. The remediation product is generated from fish bones from the commercial fishing industry (U.S. Patent #6,217,775).

The remediation technology stabilizes metals by chemically binding them into new stable phosphate phases (apatite minerals) and other relatively insoluble phases. Remediation treatment using apatites has been successful with contaminated range soils, groundwaters, and wastewaters for aluminum, cadmium, copper, lead, uranium, and zinc, and has stabilized between 5% and 50% of its weight in metals depending upon the metal and the environmental conditions. Specific metals can enter the apatite mineral structure during precipitation of new solids or by exchanging with calcium in an existing calcium-apatite. Nucleation on existing apatite and non-specific adsorption can also be important. Metals sequestered in apatite minerals have been shown in previous studies to have great durability and leach resistance because the apatite mineral structure is very stable over a wide range of environmental conditions for geologically long time periods.

Treatment is possible using existing emplacement technologies, such as auguring into contaminated soils, slurry injection, excavation and backfill, a permeable reactive barrier, or above-ground treatment of contaminated groundwater.

### **3.6 CASE STUDIES**

Five case study summaries are provided in Table 2 below. While it is expected that the chemicals to be included in these bench tests will provide sufficient available sulfur to react with copper (to create copper sulfide), this is not certain without conducting the tests. The case studies demonstrate that the conditions required to initiate reactions that reduce metals in situ have been created using these chemicals and that the levels of sulfur available have been sufficient to immobilize chromium, lead, and arsenic, as well as copper at various sites.

Although these case studies do not all focus on reducing copper, the likelihood that copper was also reduced at these sites (even though it might not have been a contaminant of concern) is very high because similar conditions are required for the immobilizing and precipitating reactions to occur.

**TABLE 2: CASE STUDIES**

**Case Study 1: Former Copper Smelter, Southeastern Australia (Miller, 2006).** This site has acidic groundwater (pH 3 – 4) and high concentrations of copper (up to 3,000 milligrams per liter [mg/L]), with lower concentrations of cadmium, lead, manganese, nickel, sulfate, and zinc. To date, only bench-scale batch and leaching tests have been conducted using site materials. Due to the extreme acidity of the groundwater, sodium hydroxide has been added first, to reduce acidity and immobilize some metals. This has been followed by use of **calcium polysulfide**, which has effected sulfide precipitation of metals, provided further acid neutralization, and helped create reducing conditions. Leaching tests indicate low rebound of copper and other metals when treated material is exposed to background groundwater. Pilot testing is planned.

**Case Study 2: Queen Street Metals Site, Vertex Environmental Solutions, Southern Ontario, Canada.** In-situ remediation of a metals plume in groundwater was conducted to treat copper, cobalt, and nickel contamination. **EHC-M™** and a reactive gas were injected as a slurry into the subsurface under moderate pressure using three iterations. Sulfate reducing conditions were observed during post-treatment monitoring. Remediation objectives (the Ontario Ministry of the Environment groundwater criteria) were met for copper within 10 days of the final injection. Cobalt and nickel objectives were met within 55 and 139 days, respectively.

**Case Study 3: Former Wood Treating Plant, Windsor, California.** In-situ treatment of this area was conducted with **calcium polysulfide** (CaS<sub>2</sub>) using Geoprobe injections. Prior to injection, groundwater concentrations of Cr<sup>+6</sup> were between 8 mg/L and 16 mg/L. Two years following the injection of calcium polysulfide, the Cr<sup>+6</sup> was reduced to less than the detection level. Copper was present at this site and was likely reduced as well.

**Case Study 4: Valley Wood Preserving Plant, Turlock, California.** Both calcium polysulfide and sodium metabisulfite were considered at this site during bench tests performed prior to the in-situ application. **Sodium metabisulfite** was selected and injected during the remedial action. The plume size and mass of the dissolved Cr<sup>+6</sup> was reduced by 98% in less than two years of in-situ injection.

**Case Study 5: Eller-Whitlock Landfill Site, Brunswick, Georgia (Willett, 2005).** This active disposal facility had cadmium in groundwater at concentrations above the maximum contaminant level [MCL] of 5 µg/L; corrective measures were required in order to attain compliance with the operating permit. The site is underlain by clayey silt to sand, and treatment of a 15-foot interval was accomplished using **MRC™**, which was injected at nine direct-push points. Cadmium was reduced to below the detection limit (and well below the MCL) within 96 days. Treatment was accompanied by strong reductions in ORP (from +200 to -300 mV) and increases in total organic acids (from 0 to 275 mg/L), both of which are believed to be conducive to metals immobilization.

**Case Study 6: Bunker Hill and Success Mines, Idaho.** Lead, cadmium, zinc, and copper were present in soil and groundwater from these mine sites, with copper present in groundwater at approximately 20 parts per million. The metal-stabilization potential of reactive phosphates from different sources was investigated along with other materials for remediation of contaminated soil and groundwater. **Apatite II** outperformed the other additive materials tested such as zeolites (clinoptilolite and chabazite), compost, various polymers, iron filings, and other apatites. The bioavailability of the metals from the contaminated soil was greatly reduced during the test even when the metal was not in an apatite phase. Leachates from untreated soils prior to testing were in the hundreds to thousands of ppm range for many metals, well in excess of MCLs for drinking water. After the test, results showed that the leachates from treated soils were below the detection limits for lead, zinc, and cadmium (copper results were not available).

#### 4.0 FIELD AND LABORATORY ANALYSES

Representative soil and groundwater samples will be collected for sampling and bench testing as described in Section 2.0 and in Attachment 1. Metals stabilization and/or mobilization in the environment are largely controlled by Eh and pH conditions in the aquifer (as demonstrated by

**Figure 1).** Eh and pH can vary significantly across relatively short distances in the subsurface, and thus measurement of these parameters in the field can be useful in characterizing the subsurface environment with respect to metals mobility. Eh can be assessed by measuring the closely related parameter ORP, which is measured in millivolts. ORP values for groundwater, along with pH, dissolved oxygen (DO), and other parameters, will be measured in the field using portable meters at the time of groundwater sample collection.

Soil and groundwater samples will be analyzed at an off-site analytical laboratory for metals including copper, arsenic, lead, cadmium, chromium, iron, and mercury. Groundwater samples will also be analyzed at the analytical laboratory for general minerals, nitrates, sulfates, and sulfide, as well as biological oxygen demand (BOD) and chemical oxygen demand (COD). Additional soil analysis needed to supplement the RD will include total organic carbon (TOC) and particle size (sieve) analysis.

Additional groundwater analysis of ORP, pH, iron (II), and sulfate will be conducted in the bench-testing laboratory using portable meters (for ORP and pH) and a Hach field analytical kit (for iron and sulfate). The leachability of copper for the untreated (pre-test) and treated (post-test) soil will be estimated by conducting a California Waste Extraction Test (WET).

The analyses to be conducted for the bench-scale test are summarized in Table 3.

<b>TABLE 3 – SUMMARY OF FIELD AND LABORATORY ANALYSES</b>				
<b>PARAMETER</b>	<b>FIELD/LAB ANALYSIS</b>	<b>STAGE</b>	<b>METHOD</b>	<b>COMMENTS</b>
Temperature/ Conductivity/ DO	Field Measurement	Before (GW only)	YSI Field Meter	
pH/ORP	Field Measurement and Bench Testing Laboratory Measurement	Before, During, and After (GW only)	YSI Field Meter/ Portable Probe	
Iron(II) (soluble), and sulfate	Bench Testing Laboratory Measurement	Before, During, and After (GW only)	Hach Kit	
General Minerals	Laboratory Analysis	Before (GW only)	Various Standard Methods	
Nitrate, Sulfate, and Sulfide	Laboratory Analysis	Before (GW only)	EPA 300.0/376.2	
BOD	Laboratory	Before (GW only)	SM5210B or	Unpreserved

	Analysis		EPA 405.1	
COD	Laboratory Analysis	Before (GW only)	SM5220D	Sulfuric Acid
Copper	Laboratory Analysis	Before (Soil and GW), During (GW only), and After (GW only)	EPA 6010/6020	Filtered water samples for dissolved copper
Arsenic, Lead, Cadmium, Chromium, Iron and Mercury	Laboratory Analysis	Before (Soil and GW), During (GW only), and After (GW only)	Metals, dissolved; EPA 6010/6020/7470	Nitric acid preservative; filtered water sample for dissolved metals
Copper Leachability	Bench Testing Laboratory Measurement	Before, During, and After (Soil only)	WET	
TOC	Laboratory Analysis	Before (Soil only)	EPA 415.2	
Particle Size	Laboratory Analysis	Before (Soil only)	ASTM D422-63 (2002)	

ASTM = American Society for Testing and Materials (2002)  
SM = Standard Method

## 5.0 PROCESS DESCRIPTION FOR BENCH TESTS

The bench testing to be conducted should satisfy the following specific study objectives:

- evaluating the removal of copper from groundwater by MRC™, ECH-M™, calcium polysulfide, sodium metabisulfite, Apatite II, sodium lactate (to decrease Eh), and sodium hydroxide (to increase pH);
- assessing the effects of each chemical reagent on secondary water quality;
- determining how much copper in untreated soil can be easily leached;
- determining whether treatment reduces the leachability of copper from soil;
- measuring the buffering capacity of site soil.

An important result of the bench testing will be determining whether the copper in solution prior to treatment precipitates out of solution as a result of the treatment, or whether solid-phase copper is put into solution.

### 5.1 PREPARATION AND CHARACTERIZATION OF SOIL AND GROUNDWATER

In preparation for the bench testing, soil will be removed from the 6-inch tubes and composited under a nitrogen blanket to minimize the intrusion of oxygen. Large particles (> 4 mesh) will be removed. A soil slurry will be mixed in a bucket with a glass or stainless steel stirrer using representative soil mixed with site groundwater as the wetting agent. The minimum amount of water required to saturate the soil is typically several milliliters (mL) for each 10 grams (g) of

soil or a few hundred mL of groundwater for each kg of soil (approximately 200 mL/kg). The slurry will be prepared in a manner that does not significantly alter the geochemistry of the mixture by oxygenating the sample, yet provides a well-mixed sample. A representative sample of the initial (pre-test) soil slurry, along with a sample of representative groundwater, will be submitted to a laboratory and analyzed for the metals listed in **Table 3**. Additional measurements will be conducted in the bench test laboratory, as shown on **Table 3** and described in Section 6.0.

## **5.2 EVALUATION OF STABILIZATION CHEMICALS**

The bench testing laboratory will prepare 37 reactors containing soil and groundwater in a 1:2 soil to liquid ratio. Headspace in reactor vessels will be minimized. Tests will be set up under nitrogen in order to minimize intrusion of oxygen. A high dose and a low dose of each chemical will be tested. MRC™, calcium polysulfide, sodium metabisulfite, EHC-M™, Apatite II, sodium lactate (to decrease Eh), and sodium hydroxide (to increase pH) will be added to the reactor vessels as needed to achieve the initial conditions listed in **Table 4**. Each reagent chemical will be tested for two or three different reaction times, as listed in **Table 4**. Appropriate dosing will be determined based on the results of the pre-treatment laboratory analysis for copper in the soil and groundwater; MRC™ and EHC-M™ will be mixed according to the manufacturer's recommendations.

During the planned field remediation at IR28, the injection of immobilizing chemicals is expected to occur at pressures of approximately 200 pounds per square inch (psi). In addition, groundwater moves in response to hydraulic (pressure) gradients. To roughly simulate groundwater movement, the reactor vessels will be agitated slightly at atmospheric pressure just enough to move the immobilizing chemical into the soil slurry (approximately one minute). After about 30 minutes, one reactor will be destructively sampled and the aqueous phase analyzed for copper. In an attempt to enhance the efficiency of the reactions, the remaining reactors will be shaken by hand approximately twice per day and the reactions will be allowed to proceed for up to 4 weeks, as shown in **Table 4**. Because some of the test chemicals may react slowly in groundwater, requiring several days or weeks to affect changes in ORP or pH, reactors will be sampled over time and the aqueous phase analyzed for copper, ORP, and pH (as shown in **Table 4**). Groundwater samples for post-treatment analysis will be collected from the test

chambers after each appropriate time frame and submitted to an off-site, state-certified analytical laboratory using a standard 10-day turn-around time. Groundwater samples will be filtered by the analytical laboratory.

**TABLE 4: INITIAL CONDITIONS AND LENGTH OF REACTION FOR STABILIZATION TESTS**

TEST	# REPLICATES	STABILIZING AGENT	REACTION TIME
Time 0	1	None	0
Control	4	None	48 hrs, 1 wk, 2 wks, 4 wks
MRC™ - LD	3	MRC™ low dose	1 wk, 2 wks, 4 wks
MRC™ - HD	3	MRC™ high dose	1 wk, 2 wks, 4 wks
CaS <sub>5</sub> - LD	2	CaS <sub>5</sub> low dose	48 hrs, 1 wk
CaS <sub>5</sub> - HD	2	CaS <sub>5</sub> high dose	48 hrs, 1 wk
Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub> - LD	2	Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub> low dose	48 hrs, 1 wk
Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub> - HD	2	Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub> high dose	48 hrs, 1 wk
EHC-M™ - LD	3	EHC-M low dose	1 wk, 2 wks, 4 wks
EHC-M™ - HD	3	EHC-M high dose	1 wk, 2 wks, 4 wks
Apatite II - LD	—	Apatite II low dose	_ wk, _ wks, _ wks
Apatite II - HD	—	Apatite II high dose	_ wk, _ wks, _ wks
Lactate - LD	3	Lactate low dose	1 wk, 2 wks, 4 wks
Lactate - HD	3	Lactate high dose	1 wk, 2 wks, 4 wks
Alkaline pH			
pH ~ 9	3	NaOH, pH ~ 9	1 wk, 2 wks, 4 wks
pH ~ 11	3	NaOH, pH ~ 11	1 wk, 2 wks, 4 wks

The MRC™ and lactate reactors will be connected to Tedlar® polyvinyl fluoride (PVF) vapor bags, sealed with a rubber stopper, with tubing leading from the inside of the stopper through the stopper and into the external Tedlar® bag. The remaining reactors will be capped, but off-gases will not be collected since it is unlikely that any will be generated. In the event that gases are generated within the test vessels attached to Tedlar® bags, the vapor bags will be used to collect and characterize the gas generated. A photoionization detector will be used to measure organic vapors, if present. A hand-held gas analyzer or gas grab-sample detection tubes will also be used in the bench testing laboratory for rough measurements of CO<sub>2</sub>, CH<sub>4</sub> and H<sub>2</sub>S concentrations. The volume of gas in the Tedlar® bags will be estimated using a water displacement method. If more than one liter of gas is collected, the Tedlar® bag will be submitted to a State-certified laboratory for analysis of volatile organic compounds (VOCs) by EPA Method TO-15.

### **5.3 EFFECT OF TREATMENT ON SECONDARY WATER QUALITY**

To assess the effect of treatment on selected secondary water quality parameters, the aqueous phase samples from the tests described in Section 5.2 will be submitted to an analytical laboratory for metals analysis, and measurements will be conducted on-site at the bench testing laboratory for ferrous iron, sulfate, ORP, and pH, as indicated in **Table 3**.

### **5.4 LEACHABILITY OF COPPER—UNTREATED SOIL**

The amount of copper that can easily be leached from untreated site soil will be estimated by repeatedly extracting untreated soil with water. Soil and water will be combined in a 1:10 soil to liquid ratio, then placed on a shaker table. After 48 hours, the aqueous phase will be decanted and analyzed for total copper. Water will be added to the soil and the soil and water again mixed for 48 hours, after which copper in the aqueous phase will be analyzed again. The process will be repeated until the soil has been extracted and analyzed a total of four times.

### **5.5 LEACHABILITY OF COPPER—TREATED SOIL**

Treated soil from the final post-treatment sample for each set of constraints will be subjected to the California WET test for copper. The final post-treatment soil samples in the reactor vessels will also be extracted using upgradient site groundwater (which has low to nondetect concentrations of dissolved copper) and the extract analyzed for copper.

### **5.6 ADDITIONAL TESTING**

As a second phase of the bench testing process, the two chemicals with the most promising results in the initial testing will be selected for further study. Using sequential batch testing and soil from the selected reactor vessels, additional upgradient site groundwater will be added to the saturated soil that was previously treated in the first phase of bench testing. An amount of groundwater equivalent to approximately three pore volumes will be mixed with and removed from the system. After an appropriate reaction time (based on the first phase of testing), soil and groundwater samples will be collected and re-tested for metals; groundwater measurements for other pertinent parameters (such as ORP and pH) will also be performed. These results will be evaluated to understand the possible effects that might occur over time after the actual field implementation of the immobilization remedy, as groundwater continues to move through the treated area.

At the end of each phase of the bench testing, observations will be made and documented as to the physical characteristics and volumes of the precipitates remaining in the test chambers.

## **6.0 DATA ANALYSIS AND REPORTING**

After the conclusion of the experiments, groundwater and soil sample results for copper and the other metals listed in Table 3 will be evaluated for each of the four first-phase bench tests and for the two second-phase tests. The final copper results will be compared to the pretreatment copper concentrations to evaluate the effectiveness of each of the treatment chemicals. Pre- and post-treatment concentrations of arsenic, cadmium, chromium, lead, iron, and mercury will also be evaluated to assess whether or not the concentrations of these metals changed as a result of the addition of the four immobilizing chemicals to the system. The kinetics for each of the reactions will also be evaluated and these results documented in the final report.

The results of the laboratory bench testing will be documented in a written report, which will include:

- a description of the bench-scale testing activities;
- a summary of the analytical results in tabular and in diagrammatic form;
- an evaluation of the results, which will compare pre- and post-test copper concentrations as well as the concentrations of other metals; and
- a recommendation as to the most effective chemical for use in full-scale remediation.

## **7.0 WASTE DISPOSAL**

Any unused IR28 waste soil or groundwater material will be returned to the site by the bench-scale testing subcontractor for proper disposal by ITSI.

## **8.0 SAFETY ISSUES**

Personal protective equipment will include chemical-resistant gloves and safety glasses. Adequate ventilation will be provided by performing the bench tests within a properly vented chemical fume hood in the laboratory. An applicable Chemical Hygiene Plan and/or Worker

Health and Safety Plan will be requested from the bench-testing laboratory and reviewed for adequacy.

## 9.0 REFERENCES

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[www.adventusgroup.com](http://www.adventusgroup.com): Manufacturer of EHC-M™ product

[www.basf.com/businesses/chemicals/pdfs/sodmeta.pdf](http://www.basf.com/businesses/chemicals/pdfs/sodmeta.pdf): BASF, chemical supplier of sodium metabisulfite

[www.regenesis.com](http://www.regenesis.com): Manufacturer of MRC™ product

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## FIGURES

FINAL  
BENCH-SCALE TEST WORKPLAN  
DATA GAP SAMPLING INVESTIGATION  
INSTALLATION RESTORATION SITE 28

DATED 26 SEPTEMBER 2007

FIGURE 1

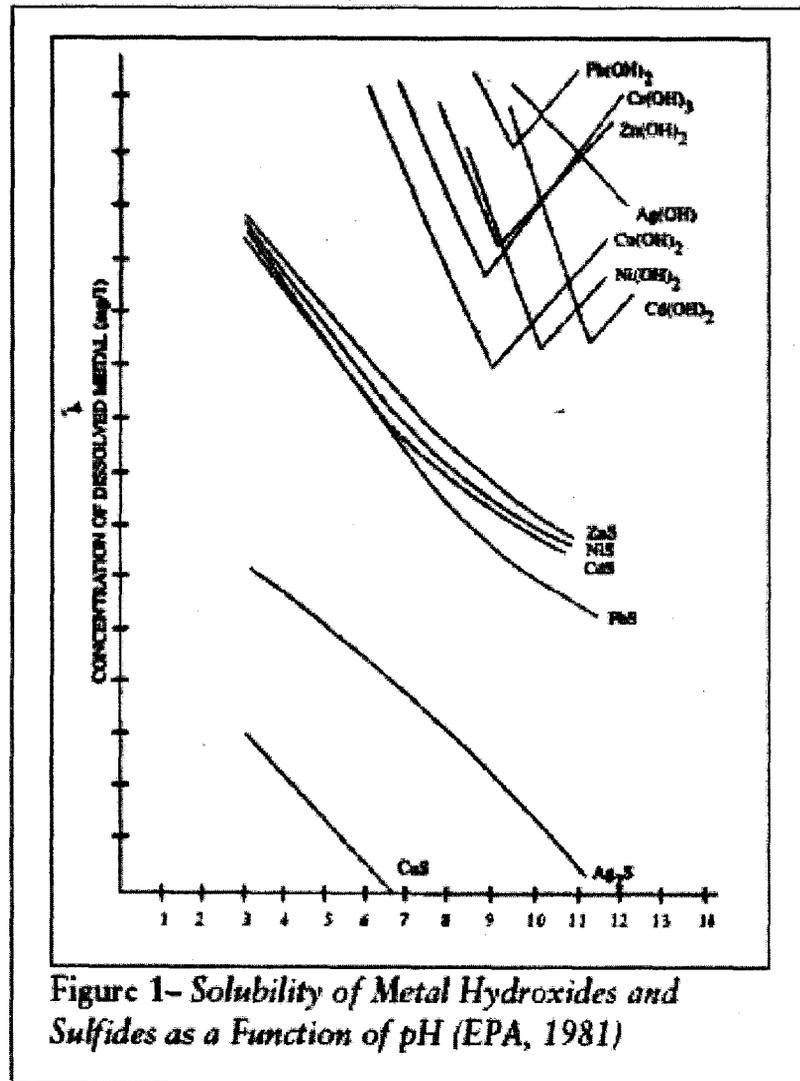


Figure 1- Solubility of Metal Hydroxides and Sulfides as a Function of pH (EPA, 1981)

**ATTACHMENT 1**

**ADDENDUM 1 TO THE SAMPLING AND ANALYSIS PLAN  
(Field Sampling Plan and Quality Assurance Project Plan)**

N00236.002889  
ALAMEDA POINT  
SSIC NO. 5090.3

SAMPLING AND ANALYSIS PLAN  
(FIELD SAMPLING PLAN AND  
QUALITY ASSURANCE PROJECT PLAN)  
DATED 01 JUNE 2007

IS APPENDIX A OF THE FINAL WORKPLAN FOR  
DATA GAP SAMPLING INVESTIGATION  
INSTALLATION RESTORATION SITE 28

DATED 14 JUNE 2007

AND FILED AS ADMINISTRATIVE RECORD NO.  
**N00236.002807**

# **ADDENDUM 1 TO THE SAMPLING AND ANALYSIS PLAN**

**(FIELD SAMPLING PLAN/QUALITY ASSURANCE PROJECT PLAN)**

**DATA GAP SAMPLING  
INSTALLATION RESTORATION SITE 28  
ALAMEDA POINT, ALAMEDA, CALIFORNIA**

**FINAL**

Prepared For:

**Department of the Navy  
Naval Facilities Engineering Command, Southwest Division  
BRAC Operations  
1455 Frazee Road, Suite 900  
San Diego, California 92108-4310**

Prepared Under:

**Naval Facilities Engineering Command, Southwest Division  
Contract Number N68711-02-D-8213  
Contract Task Order 0024**

Prepared By:

**Innovative Technical Solutions, Inc.  
2730 Shadelands Drive, Suite 100  
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Document Control Number: ITSI.02125.2500.006.A1**

**October 2007**

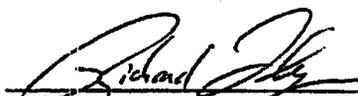
# REVIEW AND APPROVAL

## ADDENDUM 1 TO SAMPLING AND ANALYSIS PLAN (FIELD SAMPLING PLAN/QUALITY ASSURANCE PROJECT PLAN)

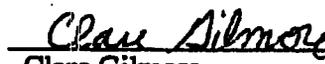
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INSTALLATION RESTORATION SITE 28  
ALAMEDA POINT, ALAMEDA, CALIFORNIA  
CONTRACT NUMBER N68711-02-D-8213, CONTRACT TASK ORDER 0024**

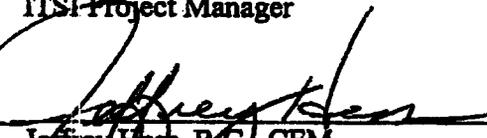
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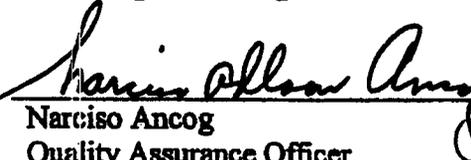
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ITSI Program Manager

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**SAP Worksheet #4 (UFP-QAPP Manual Section 2.3.2) -- Project Personnel Sign-Off Sheet**

Copies of this form must be signed by key project personnel from each organization to indicate that they have read the applicable SAP sections and will perform the tasks as described. Ask each organization to forward signed sheets to the central project file.

**Organization:** Innovative Technical Solutions Inc.

Project Personnel	Organization	Title	Signature	Date QAPP Read
Richard Flynn	ITSI	Chemist		
Clare Gilmore	ITSI	Project Manager		
Jim Schollard	ITSI	Program Quality Control (QC) Manager		
Robert Weidenfeld	Test America, Inc. Analytical Laboratory	Project Manager		
Pam Schemmer	Test America, Inc. Analytical Laboratory	QA Manager		
Cindy Schreier	Prima Environmental, Inc.	Principal		
Brian Dee	ITSI	Field Technician/ QC Manager		
Mark Blaisdell	ITSI	Field Geologist		
Kimberly Tom	ITSI	Field Technician/ Alternate QC Manager		

### SAP Worksheet #3 - (UFP-QAPP Manual Section 2.3.1)

#### Distribution List – Contact Information

Entities to whom copies of the approved SAP, subsequent SAP revisions, addenda, and amendments will be circulated.

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**Elements of the UFP-QAPP and EPA QA/R-5 in Relation to this SAP Addendum**  
**(Elements not included below are unchanged from the Original SAP)**

<b>UFP-QAPP Worksheet</b>	<b>EPA QA/R-5</b>	<b>This SAP Addendum</b>	<b>Variance from UFP-QAPP</b>
#1 Title and Approval Page	A1 Title and Approval Sheet	Review and Approval, Page A-i	
#2 QAPP Identifying Information	A2 Table of Contents	TOC, Page A-vi, (Also see Worksheet #2 in the original SAP)	
#3 Distribution List	A3 Distribution List	Distribution List, Page A-iii, Also see Worksheet #3, Page A-iv	
#4 Project Personnel Sign-Off Sheet	A4 Project Task Organization	Worksheet #4, Page A-ii	
#10 Problem Definition	A5 Problem Definition/Background	Section 1.3: Problem to be Solved (Also see Section 1.3.1 of the original SAP)	
#11 Project Quality Objectives/Systematic Planning Process Statements	A7 Quality Objectives and Criteria	Worksheet #11, Attachment 1 Section 1.6: Data Quality Objectives	
#14 Summary of Project Tasks	A6 Projects/Task Description	Worksheet #14, Attachment 1	
#16 Project Schedule/Timeline Table	A6 Projects/Task Description	Table A-1: Implementation Schedule for Field Activities	
#17 Sampling Design and Rationale	B1 Sampling Process Design (Experimental Design)	Section 1.6, DQO Step 7	
#18 Sampling Locations and Methods/SOP Requirements Table	B2 Sampling Methods	Worksheet #18, Page A-9	
#19 Analytical SOP Requirements Table	B4 Analytical Methods	Worksheet #19, Page A-10	
#30 Analytical Services Table	Not applicable	Worksheet #30, Attachment 1	

I certify that this SAP is in compliance with the latest version of the UFP-QAPP and the EPA QA/R-5

RICHARD FLYNN  
 PRINT NAME (Contractor QA Representative)

  
 SIGNATURE

9/25/2007  
 DATE

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## LIST OF TABLES

<u>Table No.</u>	<u>Title</u>
A-1	Implementation Schedule for Field Activities
A-6	Sample Preservation and Storage Requirements

## LIST OF ATTACHMENTS

Attachment A-1 UFP-QAPP Worksheets

## ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
BEI	Bechtel Environmental, Inc.
BOD	biochemical oxygen demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COD	chemical oxygen demand
CTO	Contract Task Order
DQO	Data Quality Objectives
EPA	U.S. Environmental Protection Agency
ID	identification
IR28	Installation Restoration Site 28
ITSI	Innovative Technical Solutions, Inc.
mL	milliliter
NAVFAC	Naval Facilities Engineering Command
ORP	oxidation reduction potential
PE	polyethylene
Prima	Prima Environmental, Inc.
RD	Remedial Design
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SOW	Scope of Work
TBD	to be determined
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total dissolved solids
TOC	Total organic carbon

## 1.0 INTRODUCTION

Innovative Technical Solutions, Inc. (ITSI) has prepared this document as an addendum to the Final Sampling and Analysis Plan (SAP) (ITSI, 2007b) for the data gap sampling project at Installation Restoration Site 28 (IR28) at Alameda Point, Alameda, California.

The purpose of this SAP Addendum is to describe the sampling and analysis protocol for additional work to be performed in support of this project. The additional work involves conducting a bench-scale test to evaluate the effectiveness of various remediation chemicals in removing copper from groundwater in the contaminant source area to support development of the Remedial Design (RD). These activities will be conducted as described in the Bench-Scale Test Workplan (ITSI, 2007c).

This document contains only changes to the original SAP. All original procedures and specifications not referenced in this document remain applicable.

The following sections from the original SAP are modified as indicated below:

The following text is added to Section 1.0 in the original SAP, after: “The technical approach presented in this SAP has been designed to:”

- Compare the effectiveness of different remediation chemicals for the precipitation and stabilization of copper in order to select the optimal injection chemical(s) for site-specific conditions.

The following text is added to Section 1.0 in the original SAP, after: “The primary project tasks covered by this Plan and the purpose for each task are:”

- Additional soil and groundwater will be collected for laboratory bench-scale testing to evaluate the ability of five different immobilizing chemicals to reduce copper concentrations at IR28.
- In addition to metals, the laboratory analysis to be performed on the soil collected specifically for the bench-scale tests will include: total organic carbon (TOC), Metals Leachability by Toxicity Characteristic Leaching Procedure (TCLP), and particle size analysis. These analyses will support the bench-scale testing and the RD.

- In addition to metals, the laboratory analysis to be performed for groundwater samples will include: nitrate/sulfate/sulfide, hardness, alkalinity, chloride, total dissolved solids (TDS), biological oxygen demand (BOD), and chemical oxygen demand (COD). These groundwater analyses will support the bench-scale testing and the RD.

Table A-1, has been revised with an implementation schedule for the bench-scale testing activities and is included with this addendum.

### **1.2.8: ANALYTICAL LABORATORY**

The following text is added to the end of the section:

Bench-scale testing activities will be conducted by remediation testing laboratory Prima Environmental, Inc. (Prima). Analytical tests associated with the bench-scale testing will be subcontracted by Prima to Alpha Analytical of Sparks, Nevada.

### **1.2.9: DATA VALIDATION SUBCONTRACTOR**

The following text is added to the end of the section:

Analyses conducted in support of the bench-scale testing will be used as screening level data for comparison purposes in interpreting the results of the bench-scale testing. Therefore, these data will not be validated.

### **1.3.1: PROBLEM TO BE SOLVED**

The following text is added to the end of the section:

Bench-scale testing will be conducted because selected remediation and waste treatment technologies and products need to be evaluated for their ability to stimulate the chemical precipitation processes identified in the Proposed Plan as the groundwater remedy for IR28.

### **1.3.2: PURPOSE OF THE ACTIVITIES**

The following text is added to the end of the section:

The results of the bench-scale testing and the associated analyses will provide data to support the development of an effective site remediation strategy and assist in the selection of the most appropriate of the tested chemicals for use at IR28.

## **1.4: PROJECT DESCRIPTION**

The following text is added to the end of the section:

Bench-scale testing activities and associated analytical tests are being proposed to collect data to support the selection of an effective chemical for use in groundwater remediation to immobilize copper at the site.

## **1.5: DATA QUALITY OBJECTIVES**

The following Data Quality Objectives (DQOs) apply to the bench-scale testing and are incorporated in addition to the existing DQOs included in the original SAP. This text is added to the end of the section:

### **Step 1: State the Problem**

#### *Describe the Problem:*

As part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process, a remedial design will be developed for IR28 to describe in detail how to implement the selected remedy. Bench-scale testing is needed to ensure the selection of an effective copper immobilization compound for addressing groundwater contamination. As detailed in Section 5.0 of the Bench-scale Test Workplan (ITSI, 2007c), testing will include the addition of five copper-immobilizing compounds to separate reactor vessels containing site soil and groundwater, performed at a treatability laboratory. The purpose of this testing is to select the most effective compound for future use in site remediation.

#### *Establish the Planning Team:*

DQO Planning Team Members include the Navy Remedial Project Manager (RPM), Navy technical staff, contractors, and other stakeholders including Regulatory Agencies. The Navy is the lead agency at the site; the primary decision-maker is the Navy in consultation with the regulatory agencies.

#### *Describe the Conceptual Model of the potential hazard:*

Based on data from previous investigations (Bechtel Environmental, Inc. [BEI], 2004), elevated copper in IR28 soil occurs in a localized band along the historical shoreline that was present while the former Todd Shipyard was operating. Shipyard activities that left behind paint chips in the soil are the presumed source of copper contamination at the site. (Copper and other metals are frequently used as anti-fouling agents in bottom paints for marine vessels.) The process of dissolution and mobilization of copper during precipitation events has resulted in contamination from the paint chips impacting groundwater. The migration of copper-contaminated groundwater to San Francisco Bay represents an unacceptable risk to aquatic life.

#### *Identify Critical Resources, Constraints, and Deadlines:*

The Navy has provided funds and assigned Contract Task Order (CTO) 0024 to conduct data gap sampling and to generate an RD for the selected remedy at IR28. In accordance with the Scope of Work (SOW), the bench-scale test will be conducted prior to and in support of the RD. The tasks associated with this CTO are projected to be completed by mid-March 2008.

## **Step 2: Identify the Goals of the Study**

### Specify the Principal Study Questions:

1. Will one or more of the metal immobilization compounds effectively reduce copper concentrations in site groundwater in the laboratory?
2. If one or more of the tested chemicals is effective in precipitating and stabilizing copper, which reagent is optimal for site conditions?
3. How will the treated soil be affected by the influx of additional upgradient groundwater over time?

### Specify the Alternative Outcomes or Actions that Can Occur upon Answering the Principal Questions:

1. Copper concentrations from post-treatment groundwater are not significantly reduced as a result of laboratory bench-scale testing, suggesting that the treatment chemicals tested are not capable of immobilizing copper in site groundwater.

**OR**

Copper concentrations from post-treatment groundwater are significantly reduced as a result of laboratory bench-scale testing, suggesting that the treatment chemicals tested are capable of immobilizing copper in site groundwater.

2. A comparison of the percent reduction in copper concentrations supports the conclusion that one of the tested chemicals is the most effective choice for immobilizing copper in site groundwater.

**OR**

A comparison of the percent reduction in copper concentrations is not conclusive, suggesting that none of the tested chemicals is more effective than the others for immobilizing copper in site groundwater.

3. The addition of upgradient groundwater to the treated soil in the laboratory causes re-mobilization of copper from the soil into the groundwater.

**OR**

The addition of upgradient groundwater to the treated soil in the laboratory causes no change in copper concentrations in the groundwater.

### Develop Decision Statements:

1. The change in copper concentrations that result from the addition of various treatment chemicals to site groundwater needs to be evaluated in the bench test laboratory.
2. The percent reductions for each of the tested treatment chemicals need to be compared to evaluate their relative effectiveness.
3. After completion of the treatment tests and analyses, upgradient groundwater (with a known copper concentration) should be added to the soil in the system, and the water re-analyzed for copper after an appropriate amount of elapsed time to understand the likelihood of post-treatment rebound.

### **Step 3: Identify Information Inputs**

#### Identify the *Types* of Information that are Needed to Resolve Decisions

The analytical results of pre- and post-treatment copper sampling are needed to evaluate the effectiveness of the treatment.

#### Identify the *Sources* of Information that are Needed to Resolve Decisions

Analytical data from the testing conducted for this investigation, along with data from the previous site-specific plans and reports listed below, will be used to resolve decisions.

- Final Remedial Investigation Report for IR Site 28 (BEI, 2004)
- Final Feasibility Study, IR Site 28 (BEI, 2005)
- Scope of Work, Remedial Design and Data Gap Sampling, IR Site 28 (Naval Facilities Engineering Command [NAVFAC], 2006)
- Proposed Plan, Site 28 (Navy, 2006).
- Alameda Basewide Annual Groundwater Monitoring Report for Spring 2006 (ITSI, 2006)

#### Identify *Appropriate Sampling and Analysis Methods* for Generating the Information

Representative soil and groundwater samples will be collected from the portions of the site where copper contamination has been highest. Groundwater samples will be collected from the IR28 monitoring well where previous sampling events consistently detected the maximum concentrations of copper at the site (28SW03). Soil samples will be collected from nearby locations, where maximum soil contamination has been detected. The sampling locations were selected based on information from previous soil and groundwater sampling efforts and information on the groundwater flow direction in the area from the documents in the above bullet list.

Soil and groundwater samples will be analyzed for copper and other metals that might be affected by the treatment using Environmental Protection Agency (EPA) Method 6010/6020. The detection limits associated with the method are expected to be sufficiently sensitive to evaluate changes in concentrations that occur as a result of the treatment.

### **Step 4: Define the Boundaries of the Study**

#### Specify the *Target Population of Interest*:

The target population of interest consists of representative soil and groundwater samples from the portion of IR28 that characterizes the area of maximum copper contamination.

#### Specify the *Spatial and Temporal Boundaries and Other Practical Constraints*:

The geographic extent of this study is limited to the area in the immediate vicinity of the sample collection locations, as shown on scaled figures in the Data Gap Investigation Workplan (ITSI, 2007a). The vertical extent is the bottom of the shallow water-bearing zone.

Temporally, the bench-scale testing portion of this study may be conducted over several weeks in August 2007. The entire effort, including development of the RD document, is expected to last through March, 2008, in accordance with the contract task order, unless extended by the Navy.

Specify the Scale of Inference for Decision Making:

Any expected analytical error associated with the laboratory precision and accuracy is expected to be far less than the accuracy required to estimate a 20-percent reduction in copper concentrations.

**Step 5: Develop the analytic approach**

Specify Appropriate Population Parameters for Making Decisions

Individual results from specific batch tests, rather than the population, will be evaluated to determine percent reduction and will be compared to results from other batch tests to decide the relative effectiveness of each chemical.

Specify the Action Level

A 20 percent reduction in copper concentrations will be used to define a significant reduction. This action level represents a change that is of sufficient magnitude that it would not be attributable to random variability in analysis or variations in sample collection techniques, but would represent a true change in contaminant concentration.

Specify the Decision Rule

1. **If** the addition of a treatment chemical results in a significant percent reduction in copper concentrations (greater than a 20 percent reduction), **then** conclude that the treatment chemical is capable of immobilizing the copper in that sample, **else** conclude that the attempt at copper immobilization has not been successful.
2. **If** the percent reduction for one of the tested treatment chemicals is greater than for the others, **then** conclude that the chemical with the greatest percent reduction is the most promising for site remediation, **else** conclude that the none of the treatment chemicals is more promising than the others.
3. **If** the copper concentration in the groundwater added to the treated soil increases more than 20 percent, **then** conclude that copper is being remobilized from the soil, **else** conclude that the immobilized copper is stable.

**Step 6: Specify Performance or Acceptance Criteria**

Specify the Decision Rule as a Statistical Hypothesis Test

A judgmental sampling scheme has been performed for selection of the sample locations in this bench-scale test investigation. The locations were selected based on previous sampling results. Because inputs are subjective, decision errors cannot be rigorously quantified in a statistical hypothesis test.

The decision criterion of a 20 percent reduction in the copper concentration was selected based on the fact that 20 percent is a statistically significant enough change in concentration to be reasonably certain that the difference is not due to sample variability or analytical error.

**Step 7: Develop the Plan for Obtaining Data**

Specify the Sampling Design:

Representative soil samples will be collected in a judgmental sampling scheme from one location in the area where previous sample data suggest that the soil copper concentrations are the highest found at site IR28. Groundwater samples will be collected from existing monitoring well

28SW03, where previous copper concentrations have been consistently the highest and from upgradient monitoring well 28SW04, where much lower copper concentrations have been detected.

### **1.7.5: REPORTS GENERATED**

The following text is added to the second paragraph of this section:

A stand-alone report will be generated to describe the bench-scale testing activities, present the results of the testing, and recommend the optimal injection chemical(s) for site-specific conditions. This report (in its entirety or portions thereof) may later be incorporated into the remedial design document.

## **2.0 DATA GENERATION AND ACQUISITION**

The generation and acquisition of data for the bench-scale testing will be conducted in accordance with the original SAP, with the following changes and additions.

### **2.1.1: SOIL AND GRAB GROUNDWATER SAMPLING**

The following text is added to the end of this section:

For the bench-scale test, soil samples will be collected in accordance with the original SAP using direct-push methodology from a co-located boring adjacent to 28HP002 (refer to Worksheet 18 on Page A-9 of this SAP Addendum and Figure 3 from the original SAP). The samples will be shipped to Prima and put on hold pending finalization of this SAP Addendum and collection of the groundwater samples. Every attempt will be made to conduct the analysis within the six-month holding time; if the holding time is exceeded, the soil will be discarded and additional soil collected. The soil analyses listed in Section 1.0 will be conducted by Alpha Analytical, a subcontractor to Prima, with the exception of TCLP and particle size analysis, which will be conducted by TestAmerica (formerly known as STL Sacramento) and STL Burlington, respectively.

### **2.1.2: MONITORING WELL GROUNDWATER SAMPLING**

The following text is added to the end of this section:

For the bench-scale test, groundwater samples will be collected from two existing wells (28SW03 and 28SW04); the locations are shown on Figure 3 of the original SAP. The samples will be shipped to both TestAmerica and to Prima. Prior to the beginning of the bench-scale testing, the groundwater from well 28SW03 will be analyzed by TestAmerica for the following analyses: nitrate/sulfate/sulfide, hardness, alkalinity, chloride, TDS, BOD, and COD. Metals analyses will be conducted for the samples from both wells before and after the bench-scale testing by Alpha Analytical, a subcontractor to Prima.

Samples and associated analyses are specified on Worksheet 18 on Page A-9 of this SAP Addendum. Additional manual measurements, such as pH and oxidation reduction potential (ORP), will be performed iteratively by the bench-scale test laboratory to monitor the testing process.

#### **2.1.4: BENCH-SCALE TESTING ACTIVITIES**

The following text replaces this section:

As part of the information needed to develop the RD, bench-scale testing will be conducted by Prima, a subcontracted treatability testing laboratory. Tests will be conducted after the completion of the data gap sampling. The objective of the testing is to evaluate the effectiveness of several proposed chemical reagents for immobilizing copper as a site remedy. As described in greater detail in the Bench-scale Test Workplan (ITSI, 2007c), the testing to be conducted by Prima will evaluate five copper-immobilizing compounds, by adding each compound to a reactor vessel containing IR28 soil and groundwater. The vessels will be agitated and, after the reaction times specified in the Workplan, samples will be removed for analysis. Based on the results of the metals analysis to be conducted by Alpha Analytical before and after the bench-scale testing, the calculated percent reduction in copper concentrations will be used to select the most effective of the five compounds. Representative site soil and groundwater for use in the reactor vessels will be collected as follows: approximately 12 kilograms of soil from within the impacted area, 20 liters of groundwater from within the impacted area, and 6 liters of groundwater from an upgradient well. Soil samples will be collected by direct-push at boring location 28HP002 during the data gap investigation sampling. Groundwater samples will be collected during a separate sampling event a few weeks after the completion of the data gap sampling activities just before the start of the bench-scale tests. Soil sampling will be conducted in accordance with Section 2.2.2 of the original SAP, and groundwater sampling will be conducted in accordance with Section 2.2.5 of the original SAP, except that existing wells 28SW03 (within the impacted area) and 28SW04 (upgradient) will also be sampled.

#### **2.2.10: SAMPLE CONTAINERS, COLLECTION SEQUENCE, AND HOLDING TIMES**

The following text is added to the end of this section:

In addition to the containers used for metals analysis described in the original SAP, refer to the revised Table A-6 and Worksheet 19 of this SAP Addendum for sample containers specific to the bench-scale testing. Note that soil sample sleeves cut into approximately 1-foot sections with the ends capped will be utilized in addition to amber glass jars for soil samples destined for bench-scale testing.

### SAP Worksheet #18 (UFP-QAPP Manual Section 3.1.1) -- Sampling Locations and Methods/SOP Requirements Table

List all site locations that will be sampled and include sample/ID number, if available. (Provide a range of sampling locations or ID numbers if a site has a large number.) Specify matrix and, if applicable, depth at which samples will be taken. Only a short reference for the sampling location rationale is necessary for the table. The text of the QAPP should clearly identify the detailed rationale associated with each reference. Complete all required information, using additional worksheets if necessary

**Sampling Locations/IDs, Sample Depths, Sample Analyses and Sampling Procedures Table**

Sampling Location/ ID Number	Matrix	Depth (feet)	Analytical Group	Sampling Reference <sup>1</sup>
28SW03	Groundwater		Dissolved Metals <sup>2</sup> (EPA 6010B/6020/7470A), nitrate/sulfate/sulfide (EPA 300.0/376.0), hardness, alkalinity, chloride, TDS, pH, conductivity, BOD (SM5210B or EPA 401.1), and COD (SM5220D)	Section 2.2
28SW04	Groundwater		Dissolved Metals <sup>2</sup> (EPA 6010B/6020/7470A),	Section 2.2
28HP002	Soil	TBD	Metals <sup>2</sup> (EPA 6010B/6020/7470A), Metals Leachability by TCLP, TOC (EPA 415.2), and particle size (ASTM D422-63)	Section 2.2

Notes:

<sup>1</sup> SAP Section that describes the sample collection procedures (original SAP).

<sup>2</sup> Copper is the primary metal of concern. Other metals are analyzed to provide baseline data to support the RD; metals data will be used to monitor possible changes in geochemical conditions that could occur as a result of the implementation of the remedy in the future.

ASTM = American Society for Testing and Materials

BOD = biochemical oxygen demand

COD = chemical oxygen demand

EPA = U.S. Environmental Protection Agency

ID = identification

TBD = to be determined

TCLP = Toxicity Characteristic Leaching Procedure

TDS = total dissolved solids

TOC = total organic carbon

**SAP Worksheet #19 (UFP-QAPP Manual Section 3.1.1) -- Analytical SOP Requirements Table**  
**Analytical Methods, Containers, Preservatives, and Holding Times Table**

Matrix	Analytical Group	Analytical and Preparation Method	Containers (number, size, type)	Preservation Requirements (chemical, temperature, etc.)	Maximum Holding Time (preparation/analysis)
Groundwater	Dissolved Metals <sup>1</sup>	EPA 6010B/6020/7470A	500-mL PE	HNO <sub>3</sub> to pH < 2, Cool at 4±2 °C	180 days
Groundwater	Nitrate	EPA 300.0	250 mL PE	Cool at 4±2 °C	48 hours
Groundwater	Sulfate	EPA 300.0	250 mL PE	Cool at 4±2 °C	28 days
Groundwater	Sulfide	EPA 376.2	500 mL PE	NaOH + ZnAc Cool at 4±2 °C	7 days
Groundwater	BOD	SM 5210B or EPA 401.1	500 ml PE	Cool at 4±2 °C	48 hours
Groundwater	COD	SM 5220D	250 ml PE	H <sub>2</sub> SO <sub>4</sub> Cool at 4±2 °C	28 days
Groundwater	Hardness	Various	250 mL PE	HNO <sub>3</sub> Cool at 4±2 °C	180 days
Groundwater	Alkalinity	Various	250 mL PE	Cool at 4±2 °C	14 days
Groundwater	Chloride	Various	250 mL PE	Cool at 4±2 °C	28 days
Groundwater	TDS	Various	250 mL PE	Cool at 4±2 °C	7 days
Soil	Metals <sup>1</sup>	EPA 6010B/6020/7470A prep 1311 (TCLP)	500 mL amber Glass and/or acetate sleeves	Cool at 4±2 °C	180 days
Soil	TOC	EPA 415.2	500 mL amber Glass and/or acetate sleeves	H <sub>2</sub> SO <sub>4</sub> Cool at 4±2 °C	28 days
Soil	Particle Size	ASTM D422-63 (200)	500 mL amber Glass and/or acetate sleeves	Cool at 4±2 °C	180 days

Notes:

<sup>1</sup> Copper is the primary metal of concern. Other metals monitored for informational purposes only.

ASTM = American Society for Testing Materials  
 BOD = biochemical oxygen demand  
 COD = chemical oxygen demand  
 EPA = U.S. Environmental Protection Agency  
 ID = identification

mL = milliliter  
 PE = polyethylene  
 TCLP = Toxicity Characteristic Leaching Procedure  
 TDS = total dissolved solids  
 TOC = total organic carbon

## 2.4: ANALYTICAL METHODS AND REQUIREMENTS

The following text is added to the end of this section:

Alpha Analytical, the analytical laboratory subcontracted by Prima to perform some of the chemical analyses of environmental samples in support of this sampling effort, is certified by the State of California and has been approved by the Navy.

### 2.4.2: LABORATORY ANALYTICAL METHODS

The following text is added before the last paragraph of this section:

In addition to metals listed in the original SAP, the laboratory analysis to be performed in support of the bench-scale tests and the RD will include the following tests for soil samples:

- TOC by EPA Method 415.2
- TCLP for metals by EPA Method 1311
- Particle size analysis according to American Society for Testing Materials (ASTM) procedure D422-63.

The laboratory analyses to be performed for groundwater in support of the bench-scale testing and the RD will include:

- Nitrate/sulfate/sulfide
- hardness, alkalinity, chloride, and TDS
- BOD
- COD.

Target analyte lists and reporting limits for metals are presented in Table A-2 of the original SAP, while precision and accuracy criteria for metals are included in Tables A-4 and A-5 of the original SAP. The remaining analytes will be used for screening-level purposes to monitor the bench-scale testing and in support of the RD. The analytes listed in the preceding bullets, therefore, will not require validation or be subject to Quality Control performance criteria.

## 4.0: DATA VALIDATION AND USABILITY

The following text is added to the end of this section:

Metals results will be the only definitive data collected for the bench-scale test. These data will be validated as outlined in Section 4.0 of the original SAP. Since the use of the metals data may include the evaluation of the success of the remedial action to be conducted in the future, validation of the data is considered prudent, although not mandatory. As noted in Section 2.6, above, the results of the remaining analyses will be used to monitor the bench-scale testing and to support the RD, and will not be validated.

## 5.0: REFERENCES

The following additional references are added to this section:

Innovative Technical Solutions, Inc. (ITSI), 2005, *Basewide Monitoring Program Evaluation and Recommendations, Alameda Point, Alameda, California.*

ITSI, 2007a. *Final Workplan Data Gap Sampling Investigation, Installation Restoration Site 28, Alameda Point, Alameda, California, June.*

ITSI, 2007b. *Final Sampling and Analysis Plan, Data Gap Sampling, Installation Restoration Site 28, Alameda Point, Alameda, California, June. (Appendix A to the Final Workplan)*

ITSI, 2007c. *Final Bench-Scale Test Workplan, Data Gap Sampling Investigation, Installation Restoration Site 28, Alameda Point, Alameda, California, July.*

Shaw, 2004. *Work Plan for Basewide Groundwater Monitoring Program, Alameda Point, Alameda, California.*

## **TABLES**

**The following tables supersede and replace the corresponding tables in the original SAP**

**TABLE A-1**

**Implementation Schedule for Field Activities Associated with Bench-scale Testing  
IR28 Data Gap Sampling, Alameda Point**

<b>Task</b>	<b>Start Date</b>	<b>End Date</b>	<b>Duration<sup>1</sup></b>
Direct Push Drilling, Soil Sampling of Borings (COMPLETED)	June 25, 2007	June 26, 2007	2
Groundwater Sample collection for Bench Testing	September 26, 2007	September 26, 2007	1

Notes:

<sup>1</sup> Duration in working days, unless otherwise noted

**TABLE A-6**

**Sample Preservation and Storage Requirements  
 IR28 Data Gap Sampling, Alameda Point**

(Note: This Table contains information similar to that found on UFP Worksheet 19)

Method Number	Parameters	Matrix	Holding Time (from sample date)	Containers	Preservative	Minimum Sample Size
EPA 6010B/6020/7470A	Metals	water	analysis - 180 days	500 mL plastic	HNO <sub>3</sub> to pH < 2, Store at 4±2 °C	500 mL
EPA 300.0	Nitrate	water	analysis - 48 hours	250 mL plastic	Store at 4±2 °C	250 mL
EPA 300.0	Sulfate	water	analysis - 28 days	250 mL plastic	Store at 4±2 °C	250 mL
EPA 376.2	Sulfide	water	analysis - 7 days	500 mL plastic	NaOH + ZnAc Store at 4±2 °C	500 mL
SM 5210B or EPA 401.1	BOD	water	analysis - 48 hours	500 mL plastic	Store at 4±2 °C	500 mL
SM 5220D	COD	water	analysis - 28 days	250 mL plastic	H <sub>2</sub> SO <sub>4</sub> Store at 4±2 °C	250 mL
Various	Hardness	water	analysis - 180 days	250 mL plastic	H <sub>2</sub> SO <sub>4</sub> Store at 4±2 °C	250 mL
Various	Alkalinity	water	analysis - 14 days	250 mL plastic	Store at 4±2 °C	250 mL
Various	Chloride	water	analysis - 28 days	250 mL plastic	Store at 4±2 °C	250 mL
Various	TDS	water	analysis - 7 days	250 mL plastic	Store at 4±2 °C	250 mL
EPA 6010B/6020/7470A prep 1311 (TCLP)	Metals	soil	analysis - 180 days	500 mL amber Glass	Store at 4±2 °C	2 grams
EPA 415.2	TOC	soil	analysis - 28 days	500 mL amber Glass	H <sub>2</sub> SO <sub>4</sub> Store at 4±2 °C	25 grams
ASTM D422-63 (2002)	Particle size	soil	analysis - 180 days	500 mL amber Glass	Store at 4±2 °C	500 grams

ASTM = American Society for Testing and Materials (2002)  
 BOD = biochemical oxygen demand  
 COD = chemical oxygen demand  
 C = Celsius  
 EPA = US Environmental Protection Agency  
 g = gram  
 ICP-MS = Inductively coupled plasma - mass spectroscopy

mL = Milliliter  
 TCLP = Toxicity characteristic Leaching Procedure  
 TDS = total dissolved solids  
 TOC = total organic carbon

**ATTACHMENT 1**

**UFP-QAPP WORKSHEETS**

**Each of the following UFP QAPP Worksheets supersedes and replaces the corresponding UFP QAPP Worksheet in the original SAP**

## SAP Worksheet #11 (UFP-QAPP Manual Section 2.6.1) -- Project Quality Objectives/Systematic Planning Process Statements

### **Who will use the data?**

The data will be used primarily by the Navy and its subcontractors (including ITSI), and also by regulatory stakeholders including USEPA, California Regional Water Quality Control Board–San Francisco, and California Department of Toxic Substances Control.

### **What will the data be used for?**

The data will be used to help acquire operational and effectiveness data to feed into the Remedial Design at IR Site 28. See the text of the project-specific SAP Addendum for the full discussion of Data Quality Objectives.

### **What types of data are needed (matrix, target analytes, analytical groups, field screening, on-site analytical or off-site laboratory techniques, sampling techniques)?**

Collection of representative groundwater and soil samples for inorganic analysis. The target analytes for water are: filtered metals by EPA 6010/6020/7470A, nitrate.sulfate/sulfide by EPA 300.0/376.0, hardness, alkalinity, chloride, TDS, ph, conductivity, BOD by SM5210B or EPA 401.1, and COD by SM 5220D. The target analytes for soil are: metals by EPA 6010B/6020/7470A, metals leachability by TCLP, TOC by EPA 415.2, and particle size by ASTM Method D422-63. Groundwater sampling will be conducted using low-flow sampling protocol.

### **Matrix: Soil and Groundwater**

### **How “good” do the data need to be in order to support the environmental decision?**

Data must be scientifically and legally defensible. Sample collection and analysis methods have been selected to provide data of sufficient quality for the project objectives.

### **How much data are needed (number of samples for each analytical group, matrix, and concentration)?**

Soil samples will be collected from a boring to approximately 25 feet bgs; definitive groundwater data will be collected from 2 existing wells screened in the shallow saturated zone.

**SAP Worksheet #11 (UFP-QAPP Manual Section 2.6.1) -- Project Quality Objectives/Systematic Planning Process  
Statements (continued)**

**Where, when, and how should the data be collected/generated?**

The samples and visual observations will be collected at the site within two months of approval of this plan. The sample and data analysis will be performed according to approved SOPs and final data from the project will be presented in the remedial design.

**Who will collect and generate the data?**

Innovative Technological Solutions, Inc. (ITSI), on behalf of Naval Facilities Engineering Command, Southwest Division (NAVFAC SW), will collect and report the data.

**How will the data be reported?**

Data will be reported in electronic format as specified by ITSI and the Quality Assurance Project Plan (QAPP), and reports will be retained in "pdf" format for archiving. The project team will have access to the data and reports at their convenience. Data for review and final reports will be clearly identified and will be reported in a Remedial Design Document to be distributed to the Navy and other stakeholders.

**How will the data be archived?**

Data will be archived electronically using CD-ROM. Computer readable electronic data files and reports are assured for at least 5 years from project initiation. Hardcopies of all final reports from the site are retained by the NAVFAC technical representative to ensure long-term access to the information.

## SAP Worksheet #14 (UFP-QAPP Manual Section 2.8.1) -- Summary of Project Tasks

Provide a brief overview of the listed project activities. The following table must be completed for each project area.

**Sampling Tasks:** Collect soil samples for metals analysis and bench-scale testing at one boring. Collect groundwater samples for dissolved metals analysis and bench-scale testing at two existing monitoring wells.

**Analysis Tasks:** Groundwater samples will be analyzed for metals by EPA method 6010B/6020/7470A; for nitrate/sulfate/sulfide by EPA method 300.0/376.0; for hardness, alkalinity, chloride, TDS, pH, and conductivity by various methods; for BOD by SM5210B or EPA 401.1; and for COD by SM 5220D. Soil samples will be analyzed for metals by EPA method 6010B/6020/7470A.

**Quality Control Tasks:** Laboratories will perform the applicable QC described in the analytical methods they employ, including initial calibrations, continuing calibrations, tuning, reagent blanks, surrogates, replicates, control spikes, and others as necessary. Media-specific field quality control samples, including source water blanks, equipment rinse samples, trip blanks, and field duplicates, will be used to measure total process performance, as described in Section 2.6.2 of the SAP.

**Secondary Data:** Previously obtained data from wells historically present within the IR 28 area; data presented in the *Work Plan for Basewide Groundwater Monitoring Program, Alameda Point, Alameda, California* (Shaw, 2004a); the *Technical Memorandum, Basewide Monitoring Program Evaluation and Recommendations, Alameda Point, Alameda, California* (ITSI, 2005); and preliminary data from the data gap sampling investigation conducted by ITSI in July 2007.

**Other Data:** Frequent manual measurements of standard field parameters will be performed to monitor the bench-scale testing process.

**Data Management Tasks:** Analytical data generated by the fixed laboratories will be reviewed by the laboratories using three levels of document review and reporting. Review processes will be documented using appropriate checklists, forms, or logbooks that will be signed and dated by the reviewer. Analytical and field data will be uploaded to the Navy's NIRIS database via NEDD. Analytical data validation will be performed for metals analysis only by an independent data validation firm.

## SAP Worksheet #14 (UFP-QAPP Manual Section 2.8.1) -- Summary of Project Tasks (continued)

**Documentation and Records:** All relevant raw data and documentation, including (but not limited to) logbooks, data sheets, electronic files, and final reports, will be maintained by the fixed laboratory for at least five years. ITSI will maintain electronic copies of all purge forms, chain-of-custody forms, and all Navy Electronic Data Deliverables (NEDDs). All data, field notes, raw analytical information, etc. will be stored in hardcopy and electronic format by ITSI in a central project file for the period specified in the contract. A hardcopy of the analytical data will be forwarded to the Navy's Administrative Records Division.

**Assessment/Audit Tasks:** During project activities, ongoing assessments will include peer review, quality control reviews, audits of field operations, checks to see that project personnel have read appropriate planning documents and are following documented procedures, and reviews to ensure that clearance activities and preliminary work have been satisfactorily completed. Laboratory audits are not scheduled to occur in conjunction with this project.

**Data Review Tasks:** All analytical data generated by subcontract laboratories in support of this project will be reviewed internally by the laboratory prior to reporting, to assure the validity of reported data. This internal laboratory process will consist of data reduction and three levels of document review. As the analytical data are received by ITSI, the project chemist will compare the generated data with project goals and objectives to ensure that project DQO's can be met by the data.

**SAP Worksheet #30 (UFP-QAPP Manual Section 3.5.2.3) -- Analytical Services Table**

<b>Matrix</b>	<b>Analytical Group</b>	<b>Concentration Level</b>	<b>Sample Locations/ ID Number</b>	<b>Analytical SOP</b>	<b>Data Package Turnaround Time</b>	<b>Laboratory / Organization</b> (name and address, contact person and telephone number)	<b>Backup Laboratory / Organization</b> (name and address, contact person and telephone number)
Water	Dissolved metals	Low	Wells 28SW03 and 28SW04	EPA 6010B/6020/7470A	21 Days	Prima Environmental, Inc. 10265 Old Placerville Road, Suite 15, Sacramento, CA 95827 Ph: (916) 363-8798 Contact: Dr. Cindy Schreier	Curtis & Tompkins, Ltd. 2323 Fifth St. Berkeley, CA 94710 Ph: 1-800-522-1878 Contact: John Goyette
Water	Nitrate	Low	Well 28SW03	EPA 300.0	21 Days	Test America, Inc. 880 Riverside Parkway West Sacramento, CA 95605 Ph: 916-374-4443 Contact: Robert Weidenfeld	Curtis & Tompkins, Ltd.
Water	Sulfate	Low	Well 28SW03	EPA 300.0	21 Days	Test America, Inc.	Curtis & Tompkins, Ltd.
Water	Sulfide	Low	Well 28SW03	EPA 376.2	21 Days	Test America, Inc.	Curtis & Tompkins, Ltd.
Water	BOD	Low	Well 28SW03	SM 5210B or EPA 401.1	21 Days	Test America, Inc.	Curtis & Tompkins, Ltd.
Water	COD	Low	Well 28SW03	SM 5210B or EPA 401.1	21 Days	Test America, Inc.	Curtis & Tompkins, Ltd.
Water	Hardness	Low	Well 28SW03	Various	21 Days	Test America, Inc.	Curtis & Tompkins, Ltd.
Water	Alkalinity	Low	Well 28SW03	Various	21 Days	Test America, Inc.	Curtis & Tompkins, Ltd.
Water	Chloride	Low	Well 28SW03	Various	21 Days	Test America, Inc.	Curtis & Tompkins, Ltd.
Water	TDS	Low	Well 28SW03	Various	21 Days	Test America, Inc.	Curtis & Tompkins, Ltd.
Soil	Metals	Low	28HP002	EPA 6010B/6020/7470A	21 Days	Prima (Subcontracted to Alpha Analytical)	Curtis & Tompkins, Ltd.
Soil	TOC, TCLP, particle size	Low	28HP002	EPA 6010B/6020/7470A	21 Days	Test America, Inc.	Curtis & Tompkins, Ltd.

## SAP Worksheet #30 (UFP-QAPP Manual Section 3.5.2.3) -- Analytical Services Table (Continued)

Notes:

BOD = biochemical oxygen demand

CA = California

COD = chemical oxygen demand

EPA = U.S. Environmental Protection Agency

ID = identification

NA = not available

Ph = phone number

SM = Standard Method

SOP = standard operating procedures

TDS = total dissolved solids

**ATTACHMENT 2**

**POTENTIAL FOR MOBILIZATION OF ARSENIC DUE TO REMEDIAL  
TREATMENT**

## POTENTIAL FOR MOBILIZATION OF ARSENIC DUE TO REMEDIAL TREATMENT

IR28 is an area of Alameda Point where arsenic is a potential concern, based on the fact that the highest arsenic concentrations at Alameda Point are from one well at IR28 (well 28SW04). This attachment evaluates the possibility that arsenic could be mobilized during performance of the selected remedy.

The mobility of arsenic in the subsurface depends on a variety of geochemical factors, particularly pH, redox conditions (assessed by Eh, or its proxy, oxidation-reduction potential [ORP]), the presence of metal hydroxide particles (especially iron hydroxide particles) to which arsenic can sorb, and the presence of sulfide. Arsenic can exist in four different oxidation states, but in soil and groundwater arsenic generally exists in the +3 or +5 valence state. In both of these states, arsenic exists in ionic complexes bound with oxygen as either arsenite ( $\text{As[III]O}_3^{3-}$ , particularly its protonated form  $\text{H}_3\text{As[III]O}_3$ ) or arsenate ( $\text{As[V]O}_4^{3-}$ , particularly its protonated forms  $\text{H}_2\text{As[V]O}_4^-$  or  $\text{HAs[V]O}_4^{2-}$ ). These complexes all have a tendency to adsorb to iron and aluminum hydroxide particles, with the extent of sorption strongest at low to moderate pH. The charged complexes of the As[V] anions tend to bind most strongly, which accounts for their lower mobility in water compared to As[III].

In reduced waters, dissolved iron can attain high concentrations due to its presence predominantly in its reduced (+2 or ferrous) valence state, which is significantly more soluble than the +3 (ferric) state. The iron in iron oxide particles exists primarily in the +3 ferric state. These iron oxides are not stable in chemically reducing waters, and tend to dissolve and form ferrous iron. The lack of iron oxide particles in reducing waters implies that arsenic does not sorb as extensively as in oxidizing waters; thus, arsenic is present at higher concentrations in reduced waters. Finally, a major caveat to the mobility of arsenic in reduced waters is that sulfide, where present in sufficient quantity in settings such as reduced bottom muds, can form a stable precipitate with arsenic.

As reported from many other groundwater contamination sites, arsenic in groundwater at Alameda Point is most abundant in chemically reduced waters in which dissolved iron is present

at high concentrations in the ferrous (+2) state. These waters are low in dissolved oxygen and ORP, measures of which are available from the basewide sampling program. In nearly every case, wells containing arsenic at concentrations above the MCL (10 µg/L) are marked by high iron (generally 1,000 to 10,000 µg/L) and manganese (greater than 500 µg/L), along with low dissolved oxygen (less than 1 mg/L) and oxidation-reduction potential (ORP) (less than 0 mV). IR28 well 28SW04 is consistent with this pattern.

The use of a chemically reducing reagent such as those under consideration for bench testing would likely alter local geochemical conditions in several ways. One effect would be creation of more reducing chemical conditions, which would tend to increase the mobility of arsenic (absent other effects). However, the treatment chemicals contain reduced sulfur; for example, MRC contains an organosulfur compound that forms metal-organosulfur complexes with arsenic and other metals. With time, the organic portion of this complex is biodegraded, leaving the metal sulfide compound behind in the soil. Based on limited data available from Regensis, the experimental use of MRC has shown significant reduction (98%) of dissolved arsenic to a precipitated form. Based on experimental flushing of the MRC-treated soil by oxidized solutions, Regensis postulated that the precipitated arsenic sulfide was stable enough to not yield leachable arsenic over extended time periods (Regensis website).

Thus the reagent chemicals are expected to exert two contrasting effects on the mobility of arsenic in groundwater at IR28: (1) increased arsenic mobility due to more-reduced conditions, and (2) decreased arsenic mobility due to addition of excess sulfide. However, it is likely that the addition of sulfur (or sulfide) would be the dominant influence, possibly resulting in precipitation of much of the dissolved arsenic within the radius of influence of the treatment chemical. The United States Geological Survey (USGS) (2000) and others (O'Day et al., 2004) report that arsenic sulfide often precipitates in soils and acts as a sink for dissolved arsenic, effectively removing it from groundwater. Further evidence on arsenic mobility is available from the Alameda basewide groundwater sampling program. For all wells where sulfide is present at concentrations of 1.0 mg/L or greater, arsenic concentrations are relatively low (below the MCL of 10 µg/L); conversely, where arsenic concentrations are high (greater than about 10 µg/L), sulfide concentrations are low (much less than 1 mg/L). Thus at Alameda Point there is an inverse relationship between arsenic and sulfide, as there is with iron and sulfide,

presumably due to the fact that arsenic and sulfide (similar to iron and sulfide) have high affinity for each other and tend to form stable precipitates.

Taken together, the above-noted published evidence and the analytical observations from the Alameda Point basewide monitoring program support the idea that addition of any of the sulfide-containing reagent chemicals under consideration would tend to immobilize groundwater-borne arsenic as well as the target metal, copper. As for long-term stability, in an area such as Alameda Point where groundwater flow-through is not substantial, arsenic sulfide will likely be very stable, such that arsenic will remain in the solid state, maintaining sufficiently low concentrations of dissolved arsenic in groundwater.