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WORK PLAN FOR CONDUCT OF SEDIMENT TOXICITY IDENTIFICATION EVALUATION
DEMONSTRATION NSWC INDIAN HEAD MD
10/10/2000
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

WORK PLAN FOR:**CONDUCT OF NAVY SEDIMENT TOXICITY IDENTIFICATION
EVALUATION DEMONSTRATION:****INDIAN HEAD
NAVAL SURFACE WARFARE CENTER****SUBMITTED TO:****DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING SERVICE CENTER
NCBC CODE 27162 BUILDING 41
1000 23RD Avenue
Port Hueneme, CA 93043-4410****SUBMITTED BY:****SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
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1.0 INTRODUCTION

The Naval Surface Warfare Center at Indian Head, Maryland, a location with tidal fresh, potentially contaminant-impacted habitats, was chosen as one of two sites that will be evaluated as part of the Sediment Toxicity Identification Evaluation (TIE) Demonstration project for the Naval Facilities Engineering Service Center. The Technical Proposal for the Demonstration Project was submitted and approved in March 2000 (SAIC 2000a). Indian Head was chosen as a Demonstration site because it conforms with the principal site-selection criteria developed for the project designed to resolve ecological risk concerns:

1. An identified need exists for information that may clarify the source of apparent toxicity in creek sediments adjacent to Site 42 (Olson Road Landfill). Thus, results from the TIE should help to resolve regulatory uncertainties and site management decisions.
2. The study site presents a unique case study in relation to environmental and contaminant characteristics relative to the other chosen site. Thus, the TIE program should demonstrate applicability in diverse habitat conditions, and serve to address uncertainties with regard to the principal toxic agents that may be found across a wide variety of navy sites.

The Program Team involved in addressing remediation at the site includes the primary technical team (SAIC), the oversight/liaison team (Navy Northern Division), the Installation Restoration support team (EFACHes IR staff and contractors), the Activity Team (Indian Head NSWC staff) and the Regulatory Team (Region III Biological Technical Assistance Group (BTAG)). The Program Team is committed to a close collaboration with the TIE effort to assure successful and efficient study designs and sampling efforts.

1.1 Background and Objectives

Sufficient data were presented in a Remedial Investigation report (Tetra Tech NUS 1999a) to propose that two locations at Indian Head are appropriate for the TIE Demonstration: Site 42, known as the Olsen Road Landfill and Site 39/41 where an Organics Plant and Scrap Yard are located. The principal identified Contaminant of Concern (COPC) was silver.

A remedial excavation to remove silver-contaminated soils from two swales that drained into Site 42 was completed in 1994, and resulted in reductions to below the 10 mg/kg action level for silver (a value that marks the concentration distribution for 99% of sediments in the National Sediment Inventory; EPA 1997). However, silver was measured at concentrations above the action level in Site 42 sediments, and was identified by the BTAG as the Chemical of Potential Concern (CoPC) for aquatic receptors at this site. Recently, bulk sediment toxicity tests have been conducted with Site 42 samples (Tetra Tech NUS 1999b), and toxicity was demonstrated in each of the thirteen representative sediments. Ammonia has been implicated as a confounding factor contributing to observed toxicity (Tetra Tech NUS 1999b), and other contaminants have not been conclusively excluded as contributors to toxicity (Tetra Tech NUS 1999a). The Indian Head Remedial Investigation also found silver concentrations at Sites 39/41 in the same range or higher than in Site 42, along with some additional COCs that were not identified for Site Area 42

(Tetra Tech NUS 1999a). The Remedial Investigation Report characterizes Sites 39/41 and Site 42 using chemistry and physical data from an historic site inspection (E/A&H 1992; E/A&H 1994) and from a 1997 survey conducted for the Remedial Investigation and indicated mercury, nickel and nitrocellulose were included as CoCs for Site 39/41, in addition to silver.

The objectives of the proposed Phase 1 TIE study are to provide data to identify sources and magnitude of toxicity associated with contaminants at the site as well as to characterize the extent to which confounding factors (e.g., ammonia) are potentially involved in the toxic response. The sampling design derived to meet these objectives is discussed in Section 2; the technical approaches for field and laboratory analysis procedures are discussed in Section 3.

2.0 SAMPLING DESIGN FOR THE INDIAN HEAD SITE

The choice of sampling locations within Site 39/41 and Site 42 is specifically directed at evaluating the potential contribution of silver relative to other sources of toxicity to aquatic receptors at the Indian Head sites. For purposes of the TIE Demonstration, the stations were selected for one or more of the following characteristics:

- Bulk sediment silver concentrations that exceed benchmarks for potential/probable effects;
- Divalent metal concentrations (SEM) that enhance potential for silver toxicity;
- Confounding factors (e.g., TOC, AVS) that may affect chemical bioavailability;
- Confounding factors (e.g., NH_4) that directly contribute to toxicity;
- Contaminants other than metal CoCs (e.g., total petroleum hydrocarbons, nitrocellulose) that exceed benchmarks and hence may contribute to toxicity;
- Spatial variation that might reflect novel environmental conditions or CoC distributions that may represent gradients in chemical availability.

2.1 Strategy for Evaluating Potential Toxicity of Silver-contaminated Sediments

Many variable characteristics of sediments are known to mediate toxicity associated with silver contamination beyond the absolute silver concentration. Acid Volatile Sulfides (AVS), dissolved and particulate organic carbon, chlorides, ammonia, presence of other heavy metals and enzymatic biological processing within organisms are the major factors that have been reviewed in a recent issue of Environmental Toxicology and Chemistry (Volume 18:1 January 1999). Though progress has been made, current understanding of the mechanisms that govern bioavailability and toxicity of silver is still not well resolved.

The following discussion summarizes the state-of-knowledge with regard to silver bioavailability and data evaluation techniques used in selection of locations for TIE evaluation.

Bulk sediment concentrations. The correlative benchmark value representing threshold concentrations for potential effects of silver in bulk sediment (4.5 $\mu\text{g/g}$ dry weight) is based on the Upper Effects Threshold concentration observed for the *Hyallolela azteca* bioassay (NOAA 1998). The benchmark is relevant to the Indian Head site as it is based on a freshwater species

that can be expected to occur in the region. Still, it is the only published benchmark for silver in freshwater sediments, and thus it is difficult to assess the degree of protectiveness that this benchmark affords. It should also be noted that other sediment contaminant benchmarks for silver that are derived from field measurements frequently reflect the co-occurrence of multiple contaminants, and often these co-contaminants are at very elevated levels. The skewing is because more data have been reported for highly contaminated sites than for sites with low contaminant issues. With these uncertainties in mind, the sediment concentrations were compared against the UET value for purposes of selecting stations representing *potential* silver toxicity.

Recent studies have shown that toxicity in laboratory silver-only spiking experiments tends to occur only at concentration much higher than sediment benchmark values (Call et al. 1999; Berry et al. 1999; Rogers et al. 1997). This discrepancy may be in part due to other collocated contaminants or confounding factors in the benchmark samples that contributed to toxicity. The study of Call et al. (1999) was deemed applicable to Indian Head sediments given that it focused on freshwater sediments with AVS and TOC concentrations similar to the candidate TIE demonstration stations with highest silver concentrations. Briefly, the study found reduced growth of the midge, *Chironimus tentans* when sediments were in the 200-500 $\mu\text{g}/\text{kg}$ range (Table 2-1). Hence, sediment concentrations were also compared against the 200 $\mu\text{g}/\text{g}$ value for purposes of selecting stations representing *probable* silver toxicity.

Simultaneously Extracted Metal (SEM) concentration. Research into the bioavailability and toxicity of metals (DiToro et al. 1992) has found that for some metals, sulfides (measured as Acid Volatile Sulfides, AVS) in sediments can act as an important binding compound that can prevent toxicity as long as the quantity of AVS is in excess of the total amount of metals (measured as SEM). Sulfides are a common constituent of organic-rich sediments that do not have prolonged exposure to oxygen in the water column (e.g., hypoxic). As for the bioavailability of silver in particular, Berry et al. (1999) demonstrated that this metal does respond like other SEM metals in binding to AVS, in that, when the metal occurs in excess of the available AVS concentration ($\text{Ag}/2\text{-AVS}$), toxicity appears to be accurately predicted in several cases. Hence, available SEM:AVS data was used to identify locations of potential metal toxicity, including silver.

Until very recently, silver was not typically included in the SEM measurements. However, due to similarity in the chemical extraction methods for SEM and typical bulk sediment metals analysis (both are 10% nitric acid digestion methods), the concentration of SEM can be roughly estimated to be equal to the corresponding bulk sediment concentration. In addition, due to the absence of site-specific information regarding AVS and organic carbon concentrations, it is possible to roughly estimate potential for metal-binding by considering measured concentrations of iron. As the principal form of AVS is iron monosulfide (FeS), iron concentration in bulk sediment may be an indicator of AVS binding capacity. It is acknowledged that the degree to which iron is present as the more stable pyrite form (FeS_2) confounds the direct interpretation of iron as a limiting factor, but for the purposes of station selection for TIE demonstration, this uncertainty was deemed tolerable. Hence, estimated SEM:AVS data was used to identify locations of potential metal toxicity.

Confounding factors affecting bioavailability and toxicity. In the historical and recent surveys conducted at the Indian Head site, sediment constituents were measured to varying degrees, resulting in uncertainty with regard to the potential for toxicity of silver vs. confounding factors. A limited number of samples were analyzed for organic carbon, AVS or ammonia. Still, the available data indicate that locations generally characterized by lower organic carbon and AVS or alternatively, high ammonia, have the greatest potential for toxicity. This supports a hypothesis of low binding potential for the chemical to the sediment matrix and therefore an enhanced potential for toxicity to aquatic organisms at the reported concentrations. Hence locations of varying TOC, AVS and ammonia were evaluated to select stations that address site-specific effects on potential contaminant toxicity.

Published effect concentrations for freshwater amphipods exposed to ammonia are not available. However, for marine amphipods, concentrations where effects were not observed in ammonia-only toxicity tests (i.e., no observable effect concentrations (NOECs)) ranged between 30 and 60 mg/L for total ammonia and between 0.4 and 0.8 mg/L un-ionized ammonia (U.S. EPA 1994). In a TIE evaluation conducted for the Army Corp of Engineers with pore waters from Blackstone River, Massachusetts sediments, *Hyalloella* survival was unaffected by total ammonia concentrations up to 25 mg/L or 0.5 mg/L unionized ammonia (SAIC 2000b). In the same study, SAIC data demonstrated a strong correlation between fathead minnow (*Pimephales promelas*) larval mortality and pore water ammonia concentrations, suggesting that it may be useful to pair this species with *Hyalloella* in the Indian Head TIE demonstration. Available ammonia data corresponding to observed bulk sediment toxicity of Indian Head site sediments is all below 25 mg/L, but uncertainty regarding pH over the course of the test makes calculations of the more toxic un-ionized fraction unreliable.

Contaminants other than metal COCs. A limited number of organic contaminants were identified in Indian Head sediments at concentrations that are above known benchmarks. Potential risks for acute toxicity to aquatic receptors from these compounds should not be dismissed from the TIE study. As with the confounding factors associated with metal toxicity, organic contaminants in sediments at Indian Head were measured to varying degrees, resulting in uncertainty with regard to the potential for toxicity. Measurements reported for Total Petroleum Hydrocarbons (TPH) at two locations (119 and 215 µg/kg) that were included in the 1994 survey for Site 41 warrant consideration. They exceed values that have been used as screening levels applied to evaluate contamination at ecologically protected airport-associated sites, and are also associated with measured Polycyclic Aromatic Hydrocarbon (PAH) measurements that exceed the NOAA ERL values for high molecular weight PAHs. Lacking more complete information regarding the individual constituents of the TPH at the Indian Head sites, it is prudent to include samples that represent this unique type of contamination in the TIE Demonstration. The result will be a better characterization of the constituents of the TPH, along with organic carbon levels that drive bioavailability, and ultimately, their contribution to potential toxicity of the organic contaminant fraction.

Lastly, another potentially important group of contaminants represented in the chemical profiles presented in the Remedial Investigation is explosives. In particular, some unusually high values for nitrocellulose were reported at Site 39, with a maximum of 1,580,000 µg/Kg. While no data

are available regarding the potential acute effects of this compound on aquatic receptors, production of explosives at the site warrants consideration with regard to 'energetic' constituents. The high nitrocellulose value serves as a marker for this group of compounds that represents a highly uncertain risk.

Spatial distributions. Another important consideration in selecting stations for the TIE Demonstration at Indian Head is that characterizations of Sites 39/41 and Site 42 have demonstrated a high degree of spatial variability, reflecting multiple sources of contamination as well as a range of factors that affect bioavailability. Therefore, the distribution of station locations was chosen not only to incorporate the greatest potential sources of toxicity, but also to broadly assess the potential factors governing toxicity.

2.2 Rationale for Selection of Specific Sites

Table 2-2 describes each of 15 proposed locations in terms of the characteristics that led to its selection, with particular emphasis on factors that may influence toxicity associated with elevated silver and other heavy metals. The stations have been chosen not only to maximize opportunities to observe and characterize potential toxicity from silver, other COC and confounding factors, but also to provide a representation of the varying contaminant signatures and sediment characteristics that occur across Site 39/41 and Site 42. The locations of each station, coded to represent the apparent CoCs or confounding factors, are displayed in Figure 2-1. A rationale for the selection of each individual recommended station is presented in Table 2-3.

3.0 TECHNICAL APPROACH

In a TIE investigation, the physical/chemical properties of sediment pore water samples are manipulated in order to alter or render biologically unavailable generic classes of chemicals (U.S. EPA 1991). Because sediments posing potential risks are usually toxic to aquatic organisms, fractions exhibiting toxicity reveal the nature of the toxicant(s). Depending upon the responses, the toxicant(s) can be tentatively categorized as having chemical characteristics of non-polar organics, cationic metals or confounding factors such as ammonia (U.S. EPA 1996).

Procedures for conducting specific TIE steps developed by EPA (1996) describing specific methodologies and QA/QC procedures form the basis for the proposed technical approach. SAIC has improved on the EPA approach by applying sequential testing of fractions and documentation of cumulative removal up to and including the production of a completely non-toxic samples (Figure 3-1). Using the sequential approach, absence of residual toxicity provides a clearer demonstration that all the relevant chemical exposures in a sample can be adequately accounted for. SAIC's approach has been successfully demonstrated at the Naval Submarine Base-New London, CT at an IR site (Goss Cove) for Northern Division (Navy RPM News 1999; SAIC 1999). Prior remedial investigation and risk assessment studies for the site have suggested actionable risk although considerable uncertainty existed as to the contaminants responsible for risk. The application of the improved TIE process revealed that ammonia (a ubiquitous non-CoC

sediment constituent) and not the conventional sediment contaminants (e.g., PAHs, metals) was responsible for the risk.

For the Indian Head site Demonstration, SAIC will conduct sediment sampling, bulk toxicity and pore water TIE testing, and chemical analyses. The following sections describe the design and methodology for sample collection, the rationale and methods for laboratory testing, chemical analysis and data interpretation.

3.1 Field Sampling

Station positioning. To address the TIE data needs, the 15 selected stations will be sampled for chemical and toxicological characterization. Precision navigation for each sampling location will be achieved through the use of differentially corrected Global Positioning System (DGPS) data, where it is deemed reliable. A Garmon GPS receiver will be used to provide survey location positioning data in the horizontal control of North American Datum of 1983 (NAD 83) for all three phases of field operations. At some sampling stations, vegetative cover may preclude use of GPS. At those stations, markers identifying station locations from previous surveys will be used.

Sediment collection and handling. A 0.04 m² Young-modified van Veen and or mini Ponar grab sampler(s) will be used to collect undisturbed surface sediment to a penetration depth comparable to that used in the Remedial Investigation. The stainless steel grab sampler is first cleaned with an Alconox solution, site water rinsed, alcohol rinsed, and acid rinsed, followed by a final site water or distilled water rinse before use at each station. Clean polyethylene scoops may also be used to collect sediment at shallow sites. Photographs will be taken of a representative grab using a flash camera to illustrate lithographic features (e.g., redox depth, recent depositional patterns). Five gallons of sediment will be collected into pre-cleaned polyethylene buckets at each station for transport to a shore-side location. Compositing and sub-sampling into pre-cleaned containers will take place for various measurements at the sub-contractor's site where bulk sediment assays are to be performed. Samples are subsequently packed on blue ice and shipped for overnight delivery to selected chemical analysis laboratories. Full chain of custody procedures will be followed.

3.2 Toxicity Characterizations

Bulk sediment toxicity characterization. Phase I TIE methods are designed for acutely toxic samples and are based on the use of small test organisms. The 10-day *Hyalella azteca* test (Table 3-1; U.S. EPA 1994) will be used. It was previously chosen for bulk sediment tests at Site 42 and toxicity was observed. *Hyalella* also tolerates the full range of grain sizes that might be encountered at the study sites.

The tests will be conducted with eight replicates and will include a performance control sediment from a pristine freshwater site with known sediment characteristics, such as the sediment that is routinely provided by Chesapeake Cultures for *Hyalella* testing.

TIE sample selection/porewater extraction. Upon completion of the 15 bulk sediment toxicity tests, the ten most toxic sediment samples will be selected for pore water extraction using the syringe method (Winger and Lassier 1991) and for subsequent chemical analysis of metals according to National Oceanic and Atmospheric Administration (NOAA) National Status and Trends Program protocols (NOAA 1997). Also, treatments for TIE tests will include pore water extracted from the performance control sediment. Finally, water-only control exposures and dilution water will utilize clean, alkalinity and hardness-adjusted fresh water (filtered to 10 μ) in all TIE tests, unless alternative control water is deemed more suitable by SAIC.

TIE procedures. The proposed Phase I TIE characterization will consist of the following recommended characterization steps or tiers: (1) Baseline Toxicity Test; (2) C₁₈ column extraction; (3) sodium thiosulfate; (4) Ethylenediamine Tetraacetic Acid (EDTA); (5) graduated pH; and (6) zeolite. Guidelines for TIE data interpretation are presented in U.S. EPA (1991) and are summarized below:

1. **Baseline Toxicity Test:** Toxicity in exposures to whole pore water indicates the presence of bioavailable chemicals or other confounding factors (e.g., ammonia). Good survival in these exposures indicates that toxicity observed in the solid phase test is due to a factor(s) that is solely associated with the particle phase of the sediments. Toxicity due to extremes of sediment grain size (e.g., extremely coarse or fine) is an example of this type of effect.
 - 1a. **Filtration.** Prior to C₁₈ extraction, the pore water may be filtered with 0.45 μ m filter paper to remove particulates that would otherwise consume sites on the extraction column. In addition, toxicity tests conducted on the pre- and post-filtered fraction will allow for expression of any potential toxicity associated with large colloids or particulates trapped on the filter.
2. **C₁₈ column extraction:** Pore water samples will be subjected to C₁₈ extraction to remove organic compounds and metals that are relatively non-polar (U.S. EPA 1991). A non-toxic response in these exposures will indicate the potential role of organic compounds as the sole contributor to toxicity of pore waters. A fully toxic response will indicate that organic compounds are not responsible for observed pore water toxicity. A partial reduction in toxicity would define a joint toxic action by organic compounds and other factors.
3. **Sodium thiosulfate:** Sodium thiosulfate (Na₂S₂O₃) will be used to reduce oxidants such as chlorine, ozone, chlorine dioxide, mono and dichloramines, bromine, iodine, manganous ions, and some electrophilic organic chemicals and to remove cationic metals including Cd²⁺, Cu²⁺, Ag¹⁺, and Hg²⁺ in the pore water samples (U.S. EPA 1991). Reduced toxicity or a non-toxic response will indicate oxidants or cationic metals as contributors to toxicity.
4. **EDTA chelation:** Samples will be subjected to EDTA chelation to remove divalent cationic metals (i.e., Al²⁺, Ba²⁺, Fe²⁺, Mn²⁺, Sr²⁺, Cu²⁺, Ni²⁺, Pb²⁺, Cd²⁺, Co²⁺, and Zn²⁺) (Schubauer-Berigan et al. 1993a; U.S. EPA 1991). A non-toxic response or a partial reduction in toxicity indicates metals as a toxic component of the pore water. A fully or partially toxic response

indicates that something other than divalent cationic metallic compounds is a contributor to sediment toxicity.

5. **Graduated pH:** In this procedure, sample pH is manipulated to determine if pH dependent toxicants such as speciated metals, ammonia, hydrogen sulfide, cyanide and some ionizable organic compounds (e.g., pentachlorophenol) are responsible for observed toxicity (Schubauer-Berigan et al. 1993a; Schubauer-Berigan et al. 1993b; U.S. EPA). For instance, if sample toxicity increases with increasing pH, toxicants such as ammonia are suspected. Conversely, if sample toxicity increases with decreasing sample pH, toxicants such as hydrogen sulfide are suspected. Typical pH adjustments include 1.5 pH units above and below ambient pH (e.g., pH 6 and pH 9, for ambient pH = 7.5 ; or pH 6 and pH 7 for ambient pH 8).
6. **Zeolite treatment:** Samples will be manipulated using a zeolite cation exchange resin to remove ammonia (Ankley et al. 1990; Besser et al. 1998; Jop et al. 1991; Van Sprang and Janssen 1997). A non-toxic sample will indicate the presence of ammonia as contributing to pore water toxicity in the precursor sample. A partial toxic response is not expected since organics, metals, oxidants, hydrogen sulfide, pH-dependent toxicants, and ammonia will have been sequentially removed from the samples.

The pore water will be manipulated according to the sequential extraction scheme shown in Figure 3-1. The test species are appropriate for the site and are also amenable to TIE testing protocols. In addition to the ten site sediments, the TIE protocol requires that pore water from a performance control (i.e., clean freshwater) be evaluated. In addition, a clean freshwater sample spiked to produce toxic concentrations of a metal CoC (e.g. silver) and an organic contaminant may be included as a positive control, for a total of 12 treatments. One freshwater control will be run in parallel to each manipulation. Thus, 84 toxicity tests (12 samples x 7 treatments) will be performed for each species 3.2).

Biological Tests. For the purposes of this demonstration, it is assumed that the two species being tested will include an amphipod and a fish and that the seven manipulations as described above (pH = two treatments) will be performed. For riverine sites such as the Indian Head study areas, the freshwater amphipod *Hyallela* and the fathead minnow *Pimephales promelas* are recommended species.

Toxicity tests will generally be performed as described by U.S. EPA (1993) and modified in Ankley et al. (1991), Jop et al. (1991), and U.S. EPA (1991b). The amphipod method described in U.S. EPA (1996) and Ho et al. (1997) and the larval fish method described in U.S. EPA (1996) will be used. Standard toxicity test methods will be adapted for use in TIEs to accommodate reduced exposure volume (EPA/600/R-96-054). For this program, procedures for marine TIEs using the amphipod *Ampelisca abdita* will be adapted for *Hyallela* and the fish test using *Pimephales* will be performed as described US EPA 1991 (Table 3-3). For each method, animals will be obtained from laboratory cultures of commercial vendors. A dilution series of four test concentrations (10%, 25%, 50%, 100% porewater) will be performed.

3.3 Chemical Analyses

Laboratory analysis of metal, AVS and organic contaminants in sediment, and metals in porewater will be conducted according to methods outlined in the NOAA Status and Trends Program (NOAA 1998). Sulfides in pore water will be measured using either the iodometric or electron specific method recommended by the American Public Health Association for analysis of waste waters (American Public Health Association, 1995) Multi-elemental techniques such as these provide sensitive results with a high degree of accuracy and precision (NOAA 1998). Recommended target analytes are listed in Table 3-4.

The percent moisture of sediment samples are determined prior to sample extraction or analysis and sample volumes are adjusted to achieve desired quantitation limits (dry basis) for all sediment samples regardless of the high moisture content of the samples. Samples are to be maintained at 4 ± 2 °C consistent with the Contract Laboratory Program (CLP) instruction procedures for sample storage. All sample results will be reported on a dry weight basis according to the methodology described by Sweet and Wade in the NOAA Status and Trends Report (NOAA 1998).

Quality control samples are processed along with each batch of samples. Adherence to the specified QA/QC procedures is particularly important in that it provides a basis for comparing data among different methods and different laboratories.

Ten surface sediment samples from the fifteen proposed sampling stations will be selected for detailed chemical analysis of pore water metals. Split samples of pore water taken for toxicity analysis will be prepared for chemical analysis.

For QA/QC purposes control water will be spiked with a known concentration(s) of a site-related CoC. For this study, the control water will be spiked with 1000 µg/L silver, and also 200 µg/L fluoranthene. This sample will be subjected to the seven TIE manipulations, and chemical analyses will be performed on pre-and post-manipulation subsamples.

Finally, in order to assess the bioavailability of these contaminants, measurements are needed of the dissolved organic carbon (DOC) in the pore water samples (EPA Method 415.1) and the total organic carbon (TOC) of the sediments (EPA Method 415.1).

3.4 Data Analysis and Reporting

The LC₅₀ values (calculated using ToxCalc [version 4.0.8] from Tide Pool Scientific Software) will be evaluated for conformance within the normal bounds of variance applied for these tests. The supplier of test organisms will also be required to supply results from recent reference toxicity tests. Results from each sediment or pore water exposure will be evaluated using a one-way, unpaired t-test (alpha = 0.05) assuming unequal variance for statistical calculations to determine differences from controls.

A report documenting data results and conclusions produced from the TIE investigation will be produced. From this report, SAIC will be prepared to present the results of the site investigation to the regulators, BTAG, and RAB members.

4.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

SAIC will be responsible for the overall technical and fiscal management of the project including the field collection and laboratory analyses activities described below. NFESC personnel will be responsible for the contract management, supportive technical oversight and coordination among federal and state regulatory agencies, if needed. NORTHDIV personnel will be responsible for additional technical oversight and project management dealing with on-site activities and coordination between SAIC, NFESC, and Navy site representatives.

Key Navy personnel for this project are:

Ruth Owens, NFESC Technical Point of Contact (POC)
Jason Speicher, NORTHDIV Technical Point of Contact (POC)
Dave Barclift, NORTHDIV Technical Point of Contact (POC)
Robert Sadorra, Remedial Project Manager (EFACHES)
Shawn Jorgensen, Indian Head Facility Contact

Key SAIC personnel supporting the project include:

Gregory Tracey, Program Manager
Sherry Poucher, Lead for Toxicological Analyses
Michael Cole, Lead for Field Sample Collection

5.0 DELIVERABLE PRODUCTS AND SCHEDULE

A summary of Deliverable Products (DP) and schedule are summarized below. All deliverable products are considered accepted upon delivery. SAIC will prepare all reports and products in SAIC-specified format.

5.1 Field Sampling/Laboratory Analysis

SAIC will conduct field sampling and laboratory analyses according to this work plan.

- Deliverable Product: Completion of field sampling as documented in monthly progress reports. Due Date: 4 weeks after completion of final work plan (DP 4.1; 17 October 2000).
- Deliverable Product: Completion of laboratory analyses as documented in monthly progress reports. Due Date: 4 weeks after completion of field sampling (DP 4.2; 14 November 2000).

5.2 Site Report Preparation

SAIC will prepare a draft and final TIE site report (50-100 pp text). Electronic copies of the report will be sent to all Navy personnel and Navy Contractors involved with each project, as designated by the NORTHDIV POC. Up to ten copies of the draft and final report, including all appendices, photographs, and graphics will be distributed. One electronic copy of the final report will also be submitted on 3.5" disk PDF format.

- Deliverable Product: Draft Site 1 TIE Report.
Due date: (DP 5.1, 12 December 2000).
- Deliverable Product: Final Site 1 TIE Report, incorporating comments on Draft report.
Due date: 4 weeks after receipt of all comments on Draft Report (DP 5.2; 6 February 2001).

6.0 TECHNICAL ASSUMPTIONS

6.1 Assumptions regarding Field and Laboratory Activities.

- Field operations for the site will be completed during only one mobilization. For each sampling program, SAIC has included an assumption of one stand-by day to allow for inclement weather and/or other unforeseen complications with materials or equipment.
- The Navy will assist in relocation of sampling sites selected for TIE evaluations.
- SAIC will subcontract all necessary chemical and toxicity analyses in accordance with the TIE work plan.
- All laboratory chemical analyses conducted by SAIC will be performed in accordance with NOAA NS&T (1998) protocols. Laboratory data reports will be included in the TIE report and contain detail sufficient for EPA Reduced Level III data validation.

6.2 Assumptions regarding Deliverable Reports.

- The evaluation report will be provided in two iterations: Draft, and Final.
- Draft and Final Reports will be sent to 1) the facility environmental representative, 2) the Navy's IR RPM for the facility, 3) the NFESC POC, 4) the Northern Division POC, and 5) to regulators and trustees as designated by the Northern Division POC. Ten copies of the report are assumed for each deliverable.
- In addition to the hard copy distribution of the final report, a copy of the final report will be provided in PDF format to the Navy IR RPM and NFESC POC.
- The SAIC PM (and supporting personnel as deemed necessary by SAIC) will attend one technical meeting coupled with a Restoration Advisory Board (RAB) meeting to present the results of the investigation and SAIC's recommendations.

7.0 QUALITY ASSURANCE

The letter of transmittal for the report submission will include a certification that the submission has been subjected to SAIC's own review and coordination procedures to insure: (a) completeness for each discipline commensurate with the level of effort required for that submission, (b) elimination of conflicts, errors, and omissions, and (c) the overall professional and technical accuracy of the submission.

8.0 REFERENCES

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Figure 2-1. Recommended Stations for the Indian Head TIE Demonstration.

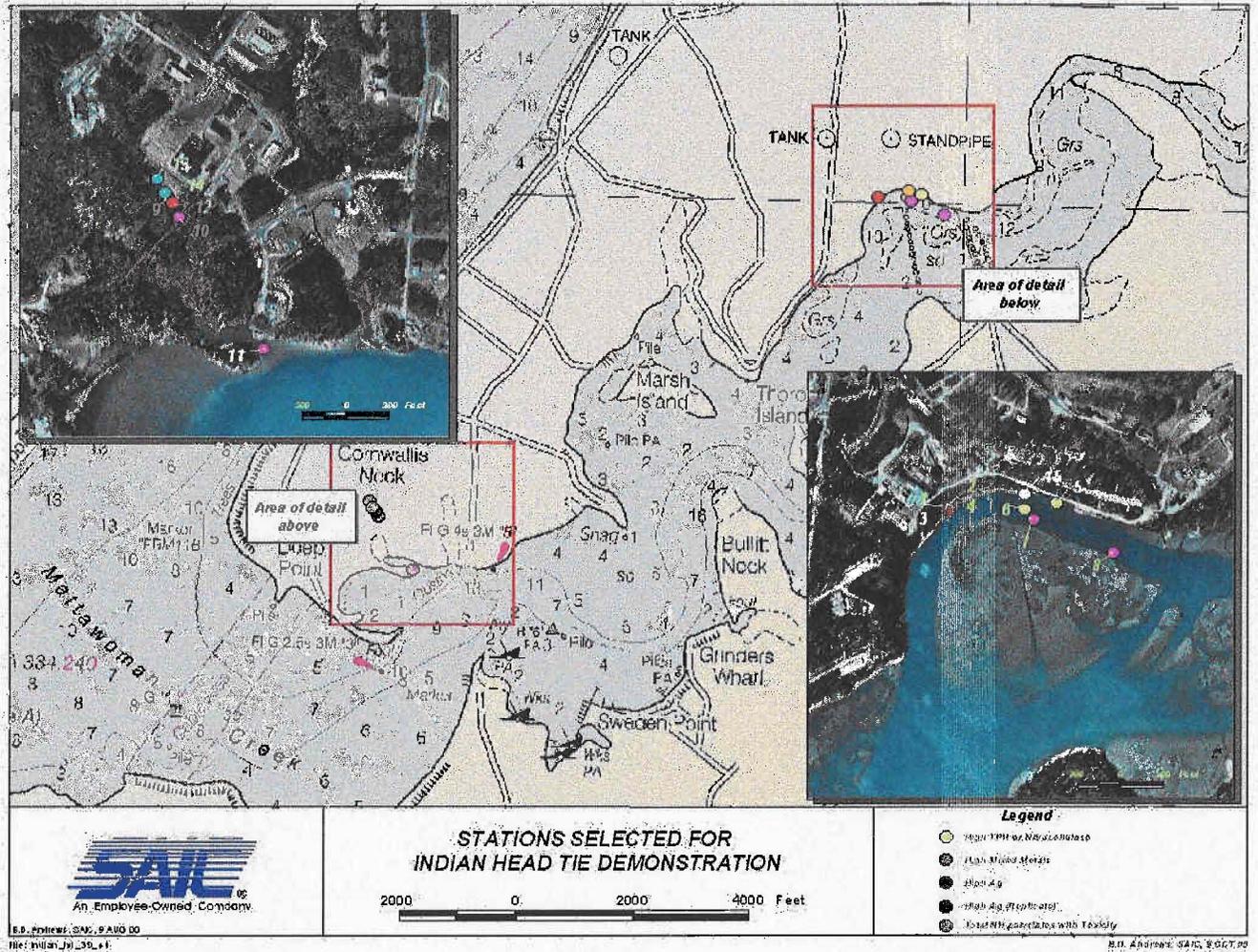


Figure 3-1. Toxicity Identification Evaluation porewater chemical fractionation procedure.

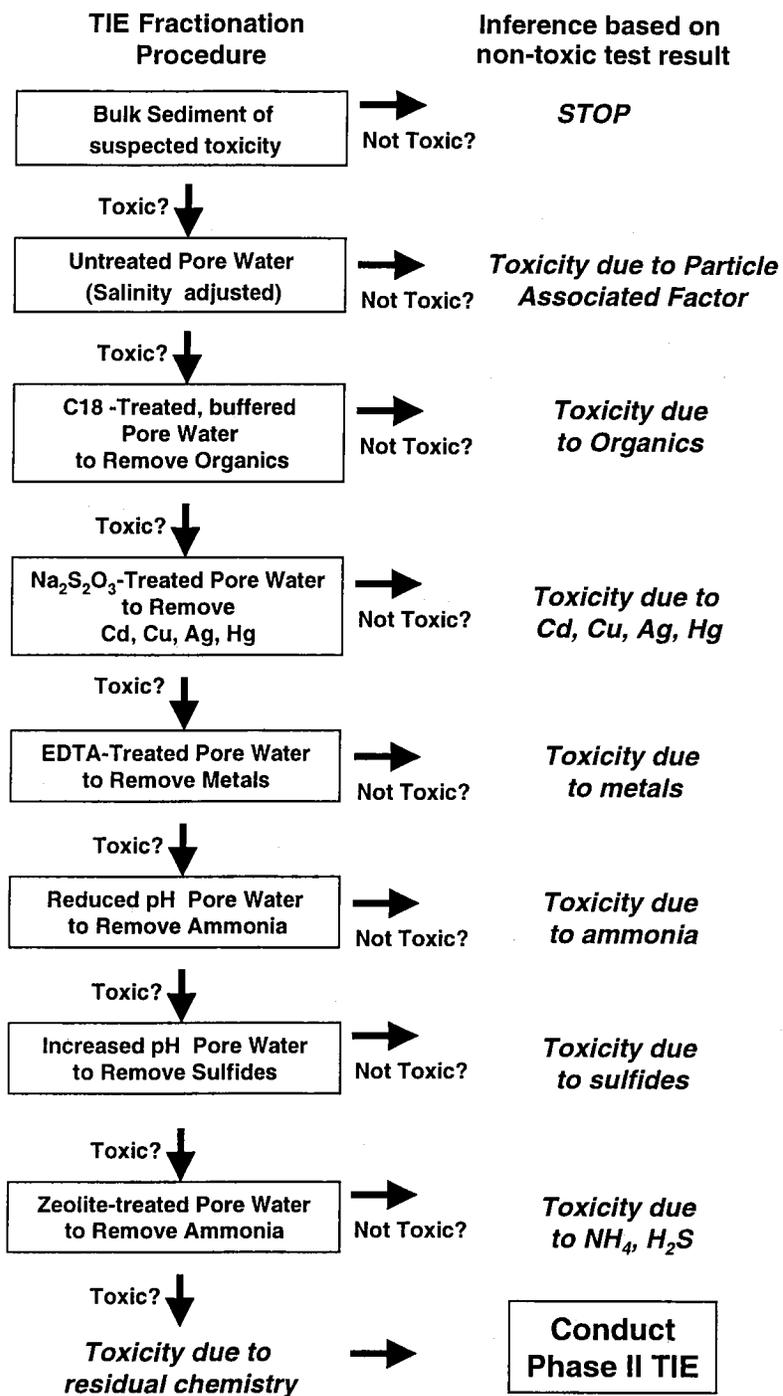


Table 2-1. Results from silver spiking study^a.

Sample	Silver (mg/Kg)	TOC (%)	AVS (μM/g)	Ag HQ SED/PW ²	SEM ³ (μM/g)	NH4 (mg/L)	Toxicity
Bond Lake	200	0.22	<0.1	44.4/11.0	0.071	≤ 100 ¹	-
Bond Lake	500	0.22	<0.1	111/41.0	0.071	≤ 100	* 33% less Growth

^a data from Call et al. 1999

¹ Non-toxic in control sediment

² benchmarks of 4.5 ug/g and 3.1 ug/L used for sediment and porewater, respectively.

³ SEM concentration excludes silver.

Table 2-2. Characteristics of Recommended Sites for the Indian Head TIE Demonstration.

SAIC TIE Sta.	Site Sample ID	Silver (g/Kg)	TOC ¹ (%)	AVS (μM/g)	Ag HQ ² Ag/2 (μM/g) ³	Cationic Metals (μM/g)	NH4 (mg/L)	Bulk Sed. Toxicity	Characteristics
1	S39SD04-a	308	0.14	0.04	68 1.4	1.5 0.5 ^a	NM	NM	High Ag
2	S39SD04-b								Field Rep.
3	S39SD03	66.4	0.14	0.02	15 0.3	3.9 1.9 ^a	NM	NM	High Ag; Mixed metals
4	S39SD03b								Field Rep
5	41DP04	4.5	NM	NM	1.0 0.02	3.8	NM	NM	TPH; Mixed metals; Low Ag
6	41DP05	7.8	NM	NM	1.7 0.04	4.2	NM	NM	TPH; Mixed metals; Low Ag
7	41DP07	6.3	NM	NM	1.4 0.03	4.6	NM	NM	Mixed metals; Low Ag
8	41DP09	8.7	NM	NM	1.9 0.04	5.6	NM	NM	Mixed metals; Low Ag
9	42SS6	99	NM	NM (Low Fe)	22 0.5	3.5	NM	NM	High Ag; Mixed metals
10	S42SD01/	16.9	3.4	0.08	3.8/ 0.08	6.5 4.8 ^a	NM	NM	Mixed metals
11	S42SD026	10.1	0.85	NM	2.2/ 0.04	2.1	3.6	*	Mod. Tox. Mixed metals
12	S42SD014a S42SD014b	75 88.7	1.37 1.3	NM	15.6-18.7/ 0.4		10.5	**	High Ag; High tox. Ammonia

SAIC TIE Sta.	Site Sample ID	Silver (g/Kg)	TOC ¹ (%)	AVS ($\mu\text{M/g}$)	Ag HQ ² Ag/2 ($\mu\text{M/g}$) ³	Cationic Metals ($\mu\text{M/g}$)	NH4 (mg/L)	Bulk Sed. Toxicity	Characteristics
13	S42SD008	3.7 5.5	0.90	NM (Low Fe)	1.2/ 0.02	0.8-1.2	5.9	**	High tox. Ammonia Low metals
14	S42SD0011	4.5	0.82	NM	1.7/ 0.03	1.8	5.3	**	High tox. Low metals
15	39SD08	1.7	3.8	NM	0.37/ 0.07	0.7	NM	NM	Nitro-cellulose Other explosive derivatives

- 1 Toxicity of silver has been demonstrated to be reduced in proportion with dissolved organic carbon (Karen, et al. 1999; Bury et al. 1999). A similar correlation can be expected with TOC.
 - 2 HQ = Hazard Quotient (the quotient of silver in mg/Kg divided by the Upper Effect Threshold reported for "Hyallolela" tested in sediments contaminated with silver; lowest of reported values).
 - 3 Ag/2, expressed in $\mu\text{M/g}$ in order to estimate concentrations in excess of AVS (silver readily binds with sulfides to form insoluble silver sulfide which is not generally a source of toxicity; Berry et al. 1999). Note that molar silver concentrations greatly exceed AVS concentrations in the three samples where AVS was measured, indicating that most of the silver present may be bioavailable.
NM= Not Measured
- * "Hyallolela" Survival < statistically less than control
** "Hyallolela" Survival < statistically less than control and 20% of control
^a Measured Simultaneously Extracted Metals (SEM). Sum of cationic metals (Cu, Cd, Pb, Ni, Zn) reported here (top value) because data were available for most samples. Four measured SEM values ranged from 33-75% of summed cationic metals.

Table 2-3. Recommended sites for the Indian Head TIE Demonstration and rationale for selection.

TIE Station	Rationale for Selection
1	Site with the highest silver concentration (308 mg/Kg) from all of the RI Indian Head data. This value is 63 times the Upper Effect Threshold (UET HQ=63). TOC was very low (0.14%), increasing the potential for toxicity. SEM at this site was low, but positive (1.5 µM/g).
2	Serves as an additional sample for the Station 1 site because of the uncertainty and variability in silver and other metal concentrations surrounding this apparent silver hot spot. It is important to gain a better understanding of the spatial representation of this sample. See also Station 3 below.
3	Silver concentrations were high (15 times PEL), but four times lower than the proximate Station 1 (within a few meters) listed above. TOC was very low and equal to Site 1(0.14%). Similarly, SEM at this site was low, but positive (1.85 µM/g). Ni and Pb measurements exceeded the Probable Effect Level (PEL).
4	Again, an additional sample next to Station 3 is recommended because of the uncertainty and variability in silver and other metal concentrations surrounding this station. It is important to gain a better understanding of the spatial representation of this sample. See also Station 1 above.
5	Represents potentially different contaminant sources with the highest measured values of Total Petroleum Hydrocarbons (TPH = 215 mg/Kg). Location is adjacent to former transformer storage facility. Low silver (HQ=1), occurs at this site which is otherwise characterized with a moderate molar concentration of metals (3.8 µM/g).
6	Characteristics similar to Station 5, above, with TPH = 119 mg/Kg, but with slightly higher silver (HQ=1.7) and cationic metals (4.2 µM/g).
7	Subtidal station in Mattawoman Creek approximately 100 feet from shore locations of Stations 5 and 6 but with 50 mg/Kg TPH. Moderate concentrations of divalent cationic metals (4.6 µM/g). The silver HQ was 1.4. Cadmium was at the PEL level, Zn was measured at 3.2 µM/g (0.6 times PEL).
8	Mattawoman Creek station, approximately 100 feet from the easternmost limits of Site 41 and with chemical characteristics similar to Site 7. Divalent cationic metals were relatively elevated (5.6 µM/g). Silver HQ=1.8. Cadmium was at the PEL level, Zn was measured at 3.9 µM/g (0.8 times PEL).
9	Site with highest measured silver of the Site 42 Landfill stations. Data do not include TOC, but iron values are an order of magnitude lower than other Site 42 samples. Cadmium was at the PEL level, but other metals were lower than at proximate stations.
10	Highest molar concentrations of divalent metals of the Site 42 stations. Silver HQ= 3.8 (0.08 µM/g). Zn was measured at 4.2 µM/g (0.9 times PEL). TOC was higher (3.4%) than other stations at Site 42.
11	Mouth of the stream locations; silver concentration (HQ= 2.1-4.) similar to Station 10, but with lower TOC (1.0%) and low cationic metals (1.5 µM/g).
12	Highly toxic to <i>Hyallela</i> . Total ammonia values were also higher than in any other tested sample (10 mg/L). Silver values were almost as high as in Station 9, but other metals were not measured. TOC was 1.4 %. One of few stations where phenolics were measured, and some were above UET and AET values.
13	Highly toxic to <i>Hyallela</i> , with low silver (HQ = 1.2) and other metal concentrations (0.8-1.2 µM/g). High toxicity to <i>Hyallela</i> correlated with relatively high total ammonia concentrations (5.9 mg/L). Low individual metal concentrations (highest was 0.3 µM/g).
14	Highly toxic to <i>Hyallela</i> , and similar to Station 13, but with slightly higher silver (HQ = 1.7) and other metal concentrations (1.8 µM/g).
15	Site to investigate the potential explosive-related toxicity. The site represents the highest concentration of nitrocellulose (1,580,000 µg/Kg) measured for Site 39/41 and Site 42.

Table 3-1. Summary of the bulk sediment toxicity test procedures with *Hyallolella azteca*^a

Test Duration	10 days
Number of Organisms per Chamber	20
Number of Replicates per Treatment	8
Test Chambers	800 mL glass jars
Test Temperature	23 °C
Salinity	0 ppt
Photoperiod	7-14 days
Volume of Sediment	175 mL
Volume of Overlying Water	625 mL
Type of Water	clean freshwater
Bay Feeding/Chamber	YCT
Endpoint	survival
Acceptance Criteria	85% survival in control

^a EPA, 1998. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates. Second Ed. EPA 600/R-98/XXX. EPA Office of Research and Development, Duluth, MN.

Table 3-2. Summary of TIE Tiers/Characterizations and study treatments.

	Base-line	C ₁₈	EDTA	Na ₂ S ₂ O ₃	PH ~ 6	PH ~ 7	Zeolite
Sediment PW 1	X	X	X	X	X	X	X
Sediment PW 2	X	X	X	X	X	X	X
Sediment PW 3	X	X	X	X	X	X	X
Sediment PW 4	X	X	X	X	X	X	X
Sediment PW 5	X	X	X	X	X	X	X
Sediment PW 6	X	X	X	X	X	X	X
Sediment PW 7	X	X	X	X	X	X	X
Sediment PW 8	X	X	X	X	X	X	X
Sediment PW 9	X	X	X	X	X	X	X
Sediment PW 10	X	X	X	X	X	X	X
Sediment PW Control	X	X	X	X	X	X	X
Spiked FW		A	a	A	a	a	a
Performance Control	X	Xb	Xc	Xd	Xe	Xf	Xg

PW = pore water, Ref. = reference station, SW = seawater, FW = freshwater, performance control = freshwater or seawater.

a = spiked control will be manipulated and analyzed for chemistry only, toxicity tests will not be performed;

b = C₁₈ control

c = EDTA performance control; d = Na₂S₂O₃ performance control; e = low pH performance control; f = high pH performance control; g = zeolite performance control

Table 3-3. Summary of test conditions for acute water-only toxicity tests with the freshwater fish, *Pimephales promelas*^a and the freshwater amphipod, *Hyallela azteca*^b

	<i>P. promelas</i>	<i>H. azteca</i>
Test type	Static non-renewal	Static non-renewal
Test Duration	72 hr	48 hr
Number of Replicates per Treatment	3	3
Number of Organisms per Chamber	5	5
Test Chambers	25 mL vial	25 mL vial
Test Temperature	25°C	23 °C
Test concentrations	4 (10, 25, 50, 100%)	4 (10, 25, 50, 100%)
Salinity	0 ppt	0 ppt
Photoperiod	16:8	16:8
Age/Size of Test Organisms	24 hr. old	7-14 days
Volume of Overlying Water	20 mL	20 mL
Type of Water	clean freshwater	clean freshwater
Bay Feeding/Chamber	none	none
Endpoint	survival	survival
Physical measurements ^l	Dissolved oxygen, pH ammonia, temperature	Dissolved oxygen, pH ammonia, temperature
Acceptance Criteria	80% survival in control	85% survival in control

a. U.S. EPA 1991. Methods for aquatic toxicity identification evaluations: Phase I toxicity characterization procedures. EPA-600/3-88-034. Environmental Research Laboratory, Duluth, MN.

b. U.S. EPA 1998. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates. Second Ed. EPA 600/R-98/XXX. EPA Office of Research and Development, Duluth, MN.

l- measured for each treatment prior to addition of test organisms, and as required to monitor stability

Table 3-4. Contaminants measured in sediments and pore waters for the Indian Head TIE demonstration program.

<i>Analytes for Sediment Analyses</i>	<i>Method</i>	<i>Description</i>	<i>Unit</i>	<i>MDL</i>	<i>Laboratory RL</i>
INORGANICS					
TOC	SW9060	Combustion	mg/kg	547	6000
METALS					
Aluminum	SW3050B/6010B	ICP	mg/kg	3.7	20.0
Antimony	SW3050B/6010B	ICP - Trace	mg/kg	0.22	0.60
Arsenic	SW3050B/6010B	ICP - Trace	mg/kg	0.093	1.0
Cadmium	SW3050B/6010B	ICP - Trace	mg/kg	0.022	0.50
Chromium	SW3050B/6010B	ICP - Trace	mg/kg	0.091	1.0
Copper	SW3050B/6010B	ICP - Trace	mg/kg	0.17	1.0
Lead	SW3050B/6010B	ICP - Trace	mg/kg	0.093	0.30
Iron	SW3050B/6010B	ICP	mg/kg	3.1	10.0
Nickel	SW3050B/6010B	ICP - Trace	mg/kg	0.25	1.0
Silver	SW3050B/6010B	ICP - Trace	mg/kg	0.28	1.0
Zinc	SW3050B/6010B	ICP	mg/kg	0.79	2.0
Mercury	SW7471A	Cold Vapor	mg/kg	0.027	0.10
PESTICIDES					
Aldrin	SW3540C/8081A	GC/ECD	ug/kg	0.52	1.7
a-Chlordane	SW3540C/8081A	GC/ECD	ug/kg	0.70	1.7
g-Chlordane	SW3540C/8081A	GC/ECD	ug/kg	0.35	1.7
4,4'-DDD	SW3540C/8081A	GC/ECD	ug/kg	0.42	3.3
4,4'-DDE	SW3540C/8081A	GC/ECD	ug/kg	0.40	3.3
4,4'-DDT	SW3540C/8081A	GC/ECD	ug/kg	0.66	3.3
Dieldrin	SW3540C/8081A	GC/ECD	ug/kg	0.43	3.3
Endosulfan I	SW3540C/8081A	GC/ECD	ug/kg	0.72	1.7
Endosulfan II	SW3540C/8081A	GC/ECD	ug/kg	0.36	3.3
Endrin aldehyde	SW3540C/8081A	GC/ECD	ug/kg	0.94	3.3
Heptachlor	SW3540C/8081A	GC/ECD	ug/kg	0.60	1.7
Heptachlor epoxide	SW3540C/8081A	GC/ECD	ug/kg	0.81	1.7
Hexachlorobenzene	SW3540C/8081A	GC/ECD	ug/kg	0.84	3.3
Alpha-Hexacyclochlorohexane	SW3540C/8081A	GC/ECD	ug/kg	TBD	1.7
Beta-Hexacyclochlorohexane	SW3540C/8081A	GC/ECD	ug/kg	TBD	1.7
Mirex	SW3540C/8081A	GC/ECD	ug/kg	TBD	3.3
Toxaphene	SW3540C/8081A	GC/ECD	ug/kg	14	170
PCB CONGENERS					
2,4'-dichlorobiphenyl (BZ # 8)	SW3540C/8082	GC/ECD	ug/kg	0.10	1.0
2,2',5-trichlorobiphenyl (BZ # 18)	SW3540C/8082	GC/ECD	ug/kg	0.10	1.0
2,4,4'-trichlorobiphenyl (BZ # 28)	SW3540C/8082	GC/ECD	ug/kg	0.037	1.0
2,2',3,5'-tetrachlorobiphenyl (BZ # 44)	SW3540C/8082	GC/ECD	ug/kg	0.11	1.0
2,2',5,5'-tetrachlorobiphenyl (BZ # 52)	SW3540C/8082	GC/ECD	ug/kg	0.10	1.0
2,3',4,4'-tetrachlorobiphenyl (BZ # 66)	SW3540C/8082	GC/ECD	ug/kg	0.056	1.0
3,3',4,4'-tetrachlorobiphenyl (BZ # 77)	SW3540C/8082	GC/ECD	ug/kg	0.082	1.0
2,2',4,5,5'-pentachlorobiphenyl (BZ # 101)	SW3540C/8082	GC/ECD	ug/kg	0.058	1.0
2,3,3',4,4'-pentachlorobiphenyl (BZ # 105)	SW3540C/8082	GC/ECD	ug/kg	0.18	1.0
2,3',4,4',5-pentachlorobiphenyl (BZ # 118)	SW3540C/8082	GC/ECD	ug/kg	0.069	1.0
3,3',4,4',5-pentachlorobiphenyl (BZ # 126)	SW3540C/8082	GC/ECD	ug/kg	0.049	1.0
2,2',3,3',4,4'-hexachlorobiphenyl (BZ # 128)	SW3540C/8082	GC/ECD	ug/kg	0.048	1.0
2,2',3,4,4',5'-hexachlorobiphenyl (BZ # 138)	SW3540C/8082	GC/ECD	ug/kg	0.043	1.0
2,2',4,4',5,5'-hexachlorobiphenyl (BZ # 153)	SW3540C/8082	GC/ECD	ug/kg	0.037	1.0
2,2',3,3',4,4',5-heptachlorobiphenyl (BZ # 170)	SW3540C/8082	GC/ECD	ug/kg	0.071	1.0
2,2',3,4,4',5,5'-heptachlorobiphenyl (BZ # 180)	SW3540C/8082	GC/ECD	ug/kg	0.087	1.0

2,2',3,4',5,5',6-heptachlorobiphenyl (BZ # 187)	SW3540C/8082	GC/ECD	ug/kg	0.060	1.0
2,2',3,3',4,4',5,6-octachlorobiphenyl (BZ # 195)	SW3540C/8082	GC/ECD	ug/kg	0.087	1.0
2,2',3,3',4,4',5,5',6-nonachlorobiphenyl (BZ # 206)	SW3540C/8082	GC/ECD	ug/kg	0.13	1.0
2,2',3,3',4,4',5,5',6,6'-decachlorobiphenyl (BZ # 209)	SW3540C/8082	GC/ECD	ug/kg	0.16	1.0
SVOCs					
Acenaphthene	SW3540C/8270C -Low	GC/MS	ug/kg	0.6	2
Acenaphthylene	SW3540C/8270C -Low	GC/MS	ug/kg	0.67	2
Anthracene	SW3540C/8270C -Low	GC/MS	ug/kg	0.67	2
Benzo[a]anthracene	SW3540C/8270C -Low	GC/MS	ug/kg	0.76	2
Benzo[b]fluoranthene	SW3540C/8270C -Low	GC/MS	ug/kg	1.5	2
Benzo[k]fluoranthene	SW3540C/8270C -Low	GC/MS	ug/kg	0.85	2
Benzo[a]pyrene	SW3540C/8270C -Low	GC/MS	ug/kg	0.86	2
Benzo(e)pyrene	SW3540C/8270C -Low	GC/MS	ug/kg	1.11	2
Benzo[ghi]perylene	SW3540C/8270C -Low	GC/MS	ug/kg	1.71	2
Biphenyl	SW3540C/8270C -Low	GC/MS	ug/kg	0.9	2
Chrysene	SW3540C/8270C -Low	GC/MS	ug/kg	0.6	2
Dibenzo[a,h]anthracene	SW3540C/8270C -Low	GC/MS	ug/kg	1.86	2
Fluoranthene	SW3540C/8270C -Low	GC/MS	ug/kg	0.46	2
Fluorene	SW3540C/8270C -Low	GC/MS	ug/kg	0.42	2
Indeno[1,2,3-cd]pyrene	SW3540C/8270C -Low	GC/MS	ug/kg	1.78	2
2-Methylnaphthalene	SW3540C/8270C -Low	GC/MS	ug/kg	0.4	2
2,6-Dimethylnaphthalene	SW3540C/8270C -Low	GC/MS	ug/kg	0.99	2
2,3,5-Trimethylnaphthalene	SW3540C/8270C -Low	GC/MS	ug/kg	1.14	2
Naphthalene	SW3540C/8270C -Low	GC/MS	ug/kg	0.22	2
1-Methylphenanthrene	SW3540C/8270C -Low	GC/MS	ug/kg	0.42	2
Phenanthrene	SW3540C/8270C -Low	GC/MS	ug/kg	0.47	2
Perylene	SW3540C/8270C -Low	GC/MS	ug/kg	1.13	2
Pyrene	SW3540C/8270C -Low	GC/MS	ug/kg	0.42	2
1-Methylnaphthalene	SW3540C/8270C -Low	GC/MS	ug/kg	0.61	2
EXPLOSIVES					
HMX	SW8330	HPLC	ug/kg	190	500
RDX	SW8330	HPLC	ug/kg	180	500
135TNB	SW8330	HPLC	ug/kg	83	250
13DNB	SW8330	HPLC	ug/kg	73	250
NB	SW8330	HPLC	ug/kg	110	250
TETRYL	SW8330	HPLC	ug/kg	240	750
246TNT	SW8330	HPLC	ug/kg	180	500
2amDNT	SW8330	HPLC	ug/kg	140	500
4amDNT	SW8330	HPLC	ug/kg	220	500
24DNT	SW8330	HPLC	ug/kg	86	250
26DNT	SW8330	HPLC	ug/kg	200	500
2NT	SW8330	HPLC	ug/kg	150	500
3NT	SW8330	HPLC	ug/kg	230	500
4NT	SW8330	HPLC	ug/kg	120	500
Pentaerythritol tetranitrate (PETN)	SW8330	HPLC	ug/kg	660	2000
Nitroglycerin	SW8330	HPLC	ug/kg	240	1000
SEM					
Cadmium	US EPA 1992/6010B	ICP/AES	umol/g	0.002	0.1
Copper	US EPA 1992/6010B	ICP/AES	umol/g	0.005	0.1
Lead	US EPA 1992/6010B	ICP/AES	umol/g	0.015	0.1
Nickel	US EPA 1992/6010B	ICP/AES	umol/g	0.045	0.1
Silver	US EPA 1992/6010B	ICP/AES	umol/g	TBD	TBD
Zinc	US EPA 1992/6010B	ICP/AES	umol/g	0.030	0.1
Acid Volatile Sulfides	US EPA 1992/6010B	ICP/AES	umol/g	0.075	0.1

Analytes for Pore Water Analyses-Fresh					
Cadmium	6020	ICP/MS	µg/L	0.19	2.0
Copper	6020	ICP/MS	µg/L	1.4	2.0
Lead	6020	ICP/MS	µg/L	0.22	2.0
Nickel	6020	ICP/MS	µg/L	1.1	2.0
Silver	6020	ICP/MS	µg/L	0.15	2.0
Zinc	6020	ICP/MS	µg/L	4.0	10.0
Arsenic	6020	ICP/MS	µg/L	0.24	2.0
Iron	6020	ICP/MS	µg/L	85	200
Aluminum	6020	ICP/MS	µg/L	17	20
TOC	SW9060	Combustion	mg/L	0.19	1.0
Sulfide	SW9034	Titration	mg/L	0.25	1.0