TechData Sheet

Naval Facilities Engineering Command
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Contaminated Sediments at Navy Facilities: Policy, Guidance, and Characterization

Addressing contaminated sediments at Naval facilities presents technical and managerial challenges. The state of the science is still evolving, as are the environmental regulations that apply to contaminated sediments. The Chief of Naval Operations (CNO) promulgated the "*Policy on Sediment Site Investigation and Response Action"* (CNO, 2002) to address ongoing sediment policy issues relative to the Navy's cleanup program. Likewise, Naval Facilities Engineering Command (NAVFAC) developed the "*Implementation Guide for Assessing and Managing Contaminated Sediments at Navy Facilities"* (NAVFAC, 2002) to provide sediment-specific technical information for Remedial Project Managers (RPMs) and their technical support responsible for contaminated sediment sites, and to assist in streamlining the decision-making process. The implementation guide encourages a consistent and effective approach to site characterization, risk assessment, remedial option evaluation, long-term monitoring, and site closeout. The implementation guide is consistent with various Navy policies related to the Installation Restoration (IR) and Base Realignment and Closure (BRAC) programs and with the substantive requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and existing United States Environmental Protection Agency (U.S. EPA) guidance.

This TechData Sheet describes current Navy policy toward sediment cleanup efforts, and focuses on the technical considerations and decision-making framework contained in the NAVFAC implementation guide.

NAVY POLICY AND GUIDANCE DEVELOPMENT

Contaminants enter sediments from a variety of point sources such as spills, industrial or municipal discharges, and outfalls, as well as nonpoint sources such as runoff; atmospheric fallout; and ship waste or bilge waste. This is depicted in Figure 1. Major sediment contaminants are nonvolatile and insoluble compounds that persist in the environment. The U.S. EPA (1997) estimates that 6 to 12% of U.S. sediment is contaminated. Approximately 2,800 fish advisories are currently in force nationwide (U.S. EPA, 2001).

In a 1993 survey of Navy facilities, 94% of the respondents reported the presence of at least one contaminant of potential concern in sediments. The most common contaminants reported were metals (76%), PCBs (72%), other hydrocarbons (72%), pesticides (55%), and fuels (45%). Based on the 1993 survey, it was estimated that the cost-to-complete would exceed $500 million for contaminated sediment at IR and BRAC sites. More recent information indicates that costs-to-complete could be more than twice that figure.

The regulatory and policy framework surrounding sediment site investigation and cleanup can be challenging. Sediment investigations are often more complex than terrestrial investigations for a variety of reasons, including the inherently dynamic sediment ecosystem, contaminant mobility, and the variety of potential exposure pathways. There is also a lack of promulgated sediment quality criteria, incomplete knowledge and understanding of aquatic food webs, and lack of published risk-based threshold data (e.g., toxicity reference values) for many chemicals of potential concern. Additionally, sediments commonly require specialized methods for sampling, analysis, and remediation. RPMs responsible for sediment sites must make informed, site-specific decisions that reflect an understanding of the Federal, State, and local regulations and requirements, and that balance risk reduction, public benefit, and costs.

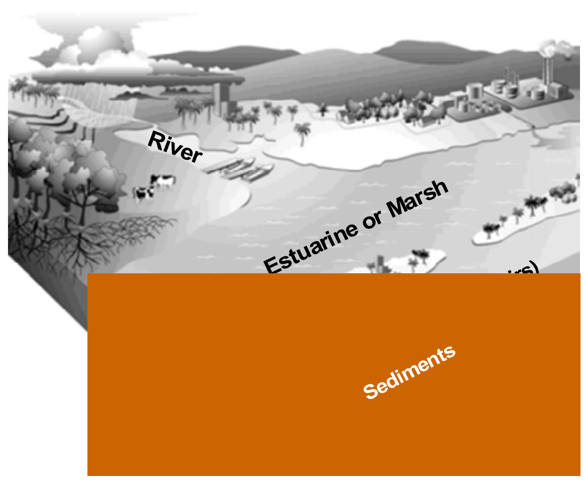

Figure 1. Plan view of aquatic setting.
Modified from http://www.epa.gov/owow/oceans/factsheets/fact5.html

One important Navy document is CNO's "*Policy on Sediment Site Investigation and Response Action"* (CNO, 2002), which outlines guiding principles to be followed for all sediment investigations. The CNO policy statements are:

1. All sources shall be identified to determine if the Navy is solely responsible for the contamination.
2. All investigations shall primarily be linked to a specific Navy CERCLA/RCRA site.
3. All sediment investigations and response actions shall be consistent with Navy policies on risk assessment and background chemical levels.
4. Sediment cleanup goals shall be developed based on site-specific information and shall be risk-based.
5. The Navy shall not clean up contamination from a non-Navy source where the Navy has not contributed to the risk in sediments. The Navy will not clean up a site before the source is contained. Any potential re-contamination by non-Navy sources shall be documented.
6. A monitoring plan with exit strategies shall be developed before collecting the first monitoring sample.

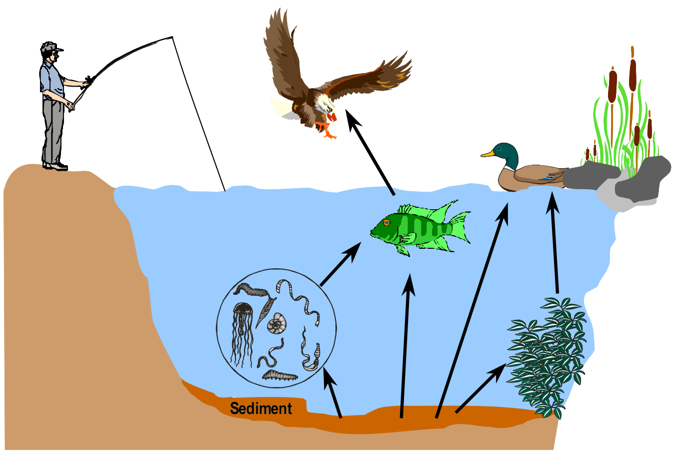

Figure 2. Biological food web.

IMPLEMENTATION GUIDE

Another key Navy document is the NAVFAC's "*Implementation Guide for Assessing and Managing Contaminated Sediments at Navy Facilities*" (NAVFAC, 2002), which contains practical, focused guidelines for conducting sediment site assessments, and remedial alternative evaluations within the Navy's Environmental Restoration Program at IR and BRAC sites. It provides RPMs and their technical support staff with stepwise guidance applicable to most Navy sediment investigations under CERCLA. The NAVFAC implementation guide complements the CNO sediment policy, as well as other applicable policies and guidance on risk assessment and the use of background chemical levels.

Specifically, the guide identifies and discusses sediment-specific issues related to site characterization, risk assessment, and remedial alternative evaluation, and links the reader to related Web sites and resources for more detailed technical information. This document is intended to help RPMs avoid unfocused or unnecessary studies and to coordinate and integrate data collection activities across all aspects of the sediment investigation. Critical issues discussed in the NAVFAC implementation guide include:

- Addressing multiple contaminant sources (Navy and non-Navy).
- Conducting sediment vs. terrestrial site investigations.
- Developing a detailed and accurate conceptual site model (CSM) that is refined throughout the process.
- Collecting important geochemical and physical information for characterizing the source, fate and transport of chemicals in sediment and supporting the evaluation of remedial alternatives.
- Selecting and using appropriate tests for ecological risk assessments.
- Using background and reference site data in risk assessments.
- Using a weight-of-evidence approach and other decision-making tools.
- Developing site-specific risk-based cleanup goals.
- Evaluating remedial options for sediment and the risk and liabilities associated with each option.

The NAVFAC implementation guide is organized into four principal sections: Introduction, Site Characterization, Risk Assessment, and Remediation; followed by a glossary and references. Hyperlinks throughout the document connect the reader to related Web sites and documents. A summary of the Site Characterization, Risk Assessment, and Sediment Remedial Alternative Evaluation sections follows.

Sediment Site Characterization

This section of the NAVFAC implementation guide presents an overview of the site characterization process relative to sediment investigations, including planning considerations, developing a CSM, identifying sources, defining the nature and extent of contamination, and characterizing contaminant fate and transport. Figure 2 shows a typical food web model with the ecological processes evaluated during the sediment site characterization. This section also identifies important physical and chemical data that should be collected as part of a sediment investigation, with an emphasis on coordinating data collection for all aspects of the investigation (site characterization, risk assessment, and evaluation of remedial alternatives). An overview of sample design and sample collection methods and equipment is also presented.

Contaminant Fate and Transport

Fate and transport refers to the processes responsible for the movement, partitioning, transformation, or degradation of contaminants in the environment. The main processes controlling the transfer of contaminants in the aquatic environment include: (1) hydrodynamic transport, (2) sediment deposition and resuspension, (3) sediment burial, and (4) chemical and biological transformation processes. Contaminants enter the aquatic environment primarily sorbed to particles; therefore, particle size and settling velocity impact the fate of sorbed contaminants in the aquatic environment. Most organic contaminants found in sediments are insoluble or only sparingly soluble. Soluble contaminants and volatile contaminants are easily diluted in the water column and do not concentrate in sediments.

In contrast to terrestrial sites, aquatic (sediment) sites almost always have a complex mixture of contaminants from multiple point and nonpoint sources that have been integrated by the above processes, transported, and deposited away from their origins. Because of the dynamic nature of the aquatic environment, contaminants can potentially migrate both on and off Navy property. Compiling existing regional data can help distinguish between Navy-related contamination and contaminant loading from background and non-Navy sources. Fate and transport studies can range in complexity from cursory to involved, and should be designed appropriately for the scale of the site.

Sediment Sampling Methods

The implementation guide provides an overview of advanced sediment sample collection methods including the applicability of different sediment sampling methods. Figure 3 shows a benthic flux sampling device, which measures diffusional fluxes of contaminants between sediment and overlying water. Surface sediment samples are usually collected with a grab sampler such as a box corer, an Eckman grab, a Ponar grab, or a Van Veen grab. Sediment cores can be collecting using gravity corers or Vibracore. Rapid sediment characterization (RSC) tools are field transportable tools that provide rapid measurements of chemical, biological, and physical characterization parameters. Examples of RSC tools include x-ray fluorescence for metals; immunoassay for PAHs, PCBs, and pesticides; and the QwikSed bioassay for biological effects. RSC tools are encouraged in Navy policy and guidance to:

- Optimize field sampling design.
- Increase the probability of successful, high impact sampling.
- Cost-effectively use high-quality laboratory analytics in combination with RSC tools.
- Provide the ability to fill gaps and reduce uncertainty at several steps in the Remedial Investigation/Feasibility Study (RI/FS) process without the high cost of traditional sampling methods.
- Map contaminated sediment volumes more efficiently to reduce remediation cost.

Site Characterization Parameters

The implementation guide provides a concise summary of the key physical, chemical, and biological parameters pertinent to sediment studies, describes the importance and relevance of each item, and suggests appropriate analytical and test methods.

Physical: Physical characteristics must be considered in sediment site investigations because they can influence contaminant loading, affect bioavailability, and introduce factors that confound test results. Additionally, geotechnical data are needed to evaluate sediment-engineering properties for remedial design. Once measured in sediments, physical characteristics can be used to better understand contaminant distributions and sources, toxicity results, and local hydrodynamics. Primary physical parameters include total organic carbon, sediment grain size, ammonia, sulfide, acid volatile sulfide, salinity, and geotechnical data. The recommended analytical and test methods for these physical parameters are summarized in the implementation guide.

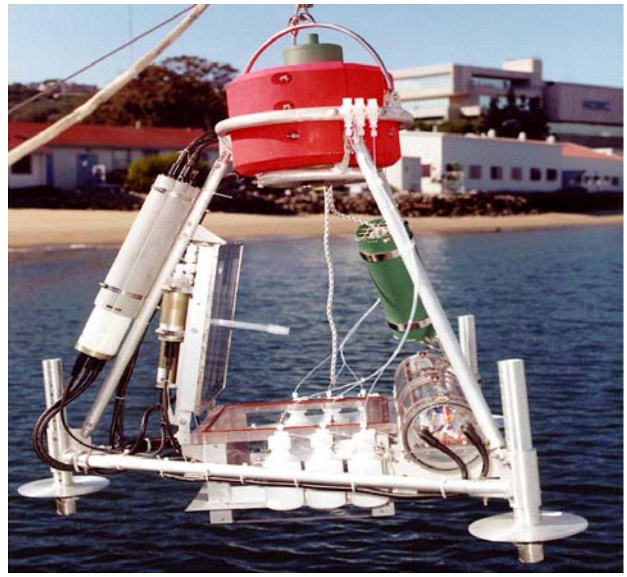

Figure 3. Benthic flux sampling device.

Chemical: Chemical parameters include metals, chlorinated pesticides, PAHs, PCBs, and organotins. Appropriate analytical methods recommended by the Navy are summarized in the guide. Chemical parameters are used to assess site risk, but also can be useful in source identification (e.g., distinguishing between Navy and non-Navy causes of contamination).

Forensic chemistry can be used to evaluate contaminant loading or identify a potential contaminant source. For example, anthropogenic metal contamination can be distinguished from naturally occurring background levels based on the ratio of trace metals to either aluminum or iron in a given sample. Other methods in chemical fingerprinting can be used to identify sources of petroleum and chlorinated hydrocarbon contaminants (e.g., PAHs, PCBs). The ability to "fingerprint" a sample depends on several conditions including: (1) the ability to resolve chemicals from different geological sources, (2) relative state of weathering (or aging) of organic contaminants, (3) presence of specific product additives and refinery process signatures (for petroleum-related contamination), and (4) availability of reference source materials.

Biological: Biological data are not appropriate in initial characterization efforts at Navy sediment sites. However, for the baseline risk assessment, biological test samples should be collected with the relevant chemical and physical samples. The implementation guide discusses the most common types of biological data collected in support of sediment site investigations including benthic bioassays, bioaccumulation studies, and benthic community characterization.

Risk Assessment

This section of the NAVFAC implementation guide presents step-by-step procedures for conducting ecological and human health risk assessments at sediment sites within the Navy's tiered framework. Elements within the ecological and human health risk assessment framework that are unique to sediment investigations are identified. For ecological assessments, the key differences for sediment sites stem primarily from the use of aquatic assessment and measurement endpoints, the data collection and analytical methods used for aquatic media, and issues concerning contaminant exposure and fate and transport in water bodies. For human health assessments, additional exposure routes must be considered such as potential exposures via surface water or sediment contact and ingestion of fish or shellfish. The guide also outlines effective approaches to complete fish tissue and fish consumption studies as part of the risk assessment process. Figure 4 provides an example of the aquatic environment being studied for these assessments.

Figure 4. Aquatic environment.

Sediment Remedial Alternative Evaluation

This section of the NAVFAC implementation guide addresses remedial planning considerations and determination of site-specific risk-based cleanup levels. Remedial options, including monitored natural recovery, in situ capping, and removal, are described along with monitoring considerations and sediment management issues.

CONCLUSION

Contaminated sediment remediation is a relatively new and rapidly evolving field, and comparatively few cleanup technologies have been applied at sediment sites to date. Challenges to the successful selection and implementation of remedies at sediment sites include the following: (1) presumptive remedies for contaminated sediments have not been identified; (2) development and verification of cleanup goals is difficult; (3) logistical challenges can include lack of visibility, interference by currents and waves, contaminant release during cleanup, or accessibility issues; and (4) limited data is available on long-term effectiveness of remedies. The CNO's *Policy on Sediment Site Investigation and Response Action* addresses ongoing sediment policy issues, and the NAVFAC *Implementation Guide* addresses planning considerations, determination of site-specific cleanup levels, and determination of sediment remediation boundaries and volume. Remedial options, including natural recovery, in situ capping, and dredging are covered, along with monitoring considerations and sediment management issues. The short and long-term risks and liabilities associated with each type of remedial action are discussed.

REFERENCES

United States Environmental Protection Agency (U.S. EPA). 1997. *"The Incidence and Severity of Sediment Contamination in Surface Waters of the United States, Vol. 1: National Sediment Quality Survey."*

United States Environmental Protection Agency (U.S. EPA). 2001. *"National Listing of Fish and Wildlife Advisories."*

U.S. Navy Chief of Naval Operations (CNO). 2002. *"Policy on Sediment Site Investigation and Response Action."*

Naval Facilities Engineering Command (NAVFAC). 2002. *"Draft Final Implementation Guide for Assessing and Managing Contaminated Sediment at Navy Facilities."*

FOR FURTHER INFORMATION

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