TECHNOLOGY TRANSFER

Supporting the Navy's Efforts *To Promote* Innovative Solutions *To Meet* Environmental Challenges and *To Reduce* Cleanup Costs

Five Year Program Plan for Environmental Restoration 2010-2014

Foreword

The challenges faced by the Navy and Marine Corps continue to evolve as we work toward restoring and maintaining a clean environment in which to support military operations. The Naval Facilities Engineering Command (NAVFAC) continuously works towards keeping ahead of these challenges and raising awareness among its staff of cutting edge technology developments. The NAVFAC Technology Transfer (T2) Program for Environmental Restoration (ER) supports these efforts to share information on innovative technologies and lessons learned from field applications at Navy, Marine Corps, and Base Realignment and Closure (BRAC) sites.

This T2 Five Year Program Plan was prepared in order to identify remaining technical challenges in the ER Program. Over the next five years, the T2 Program will seek to help NAVFAC Remedial Project Managers (RPMs) in meeting the 2014 Remedy-in-Place (RIP) and Response Complete (RC) goals for the Installation Restoration Program (IRP). The T2 Program will also adapt its focus as the Munitions Response Program (MRP) grows in size and scope to further encompass the challenges faced under this evolving program. Several cross-cutting challenges have been identified including evaluating impacts of evolving regulations, identifying appropriate cleanup goals and exit strategies, and understanding site conditions and stakeholder concerns. The technical challenges discussed in this T2 Five Year Program Plan include the following:

Installation Restoration Program Challenges

- Contaminated Sediment Sites
- Increasing Significance of Vapor Intrusion Pathway
- Groundwater Plume Management
- Source Zone Strategies for LNAPL and DNAPL
- Innovation Needs For In Situ and Passive Remediation Technologies
- Long-Term Management
- Incorporating Optimization and Sustainable Environmental Remediation Practices

Munitions Response Program Challenges

This T2 Five Year Program Plan is meant to guide the focus of the T2 Program in order to maintain awareness of RPMs challenges. This will be supplemented by annual feedback from the NAVFAC ER community over the next five years to continually adjust and adapt to RPM needs. This T2 Five Year Program Plan describes the remaining environmental challenges that are faced before the 2014 RIP/RC goal is met for the IRP and for the ongoing MRP. It reviews the T2 process, mechanisms, and products that are planned for the future and provides overall conclusions on future directions.

We encourage your interest and participation in T2 efforts.

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INTRODUCTION

"This [Environmental Restoration] program is committed to providing state-of-the-art training to its Remedial Project Managers (RPMs), finding innovative solutions to difficult environmental problems, and optimizing the efficiency of cleanup to reduce time and avoid costs while achieving environmental standards."

Department of the Navy
Environmental Restoration Program
Progress Report, 2008

The Department of the Navy (DON) continues to make progress toward achieving its goals for completion of the Environmental Restoration (ER) Program. The ER Program is made up of two components, the Installation Restoration Program (IRP), which addresses primarily chemical contamination, and the Munitions Response Program (MRP), which addresses munitions and explosives of concern (MEC) and munitions constituents (MC) present at closed ranges and munitions disposal sites. The Naval Facilities Engineering Command (NAVFAC) Technology Transfer (T2) Program supports information sharing for both the IRP and MRP in order to identify the Navy's environmental restoration challenges and to promote the use of innovative and cost-effective solutions. The environmental restoration needs of the Base Realignment and Closure (BRAC) Program are also tracked and assistance is provided through the T2 Program. This Five-Year Program Plan was prepared in order to identify remaining technical challenges in the ER and BRAC Programs and to guide the focus of the T2 Program in order to maintain awareness of RPM challenges.

DON's goal for the IRP is to have all sites with Remedy-in-Place (RIP) or Response Complete (RC) by the year 2014. As of 2008, the IRP was well on its way to meeting this goal with only 611 of the 3,723 sites still pending the RIP/RC milestone (Figure 1). While the Navy is steadily progressing toward the RIP/RC goal, T2 activities supporting the ER Program continue to add value because many of the remaining IRP sites are those with the most complex conditions and/or contaminants that are difficult to remediate. In addition, at many sites where RIP has been achieved, the remedy will continue to operate for a number of years before

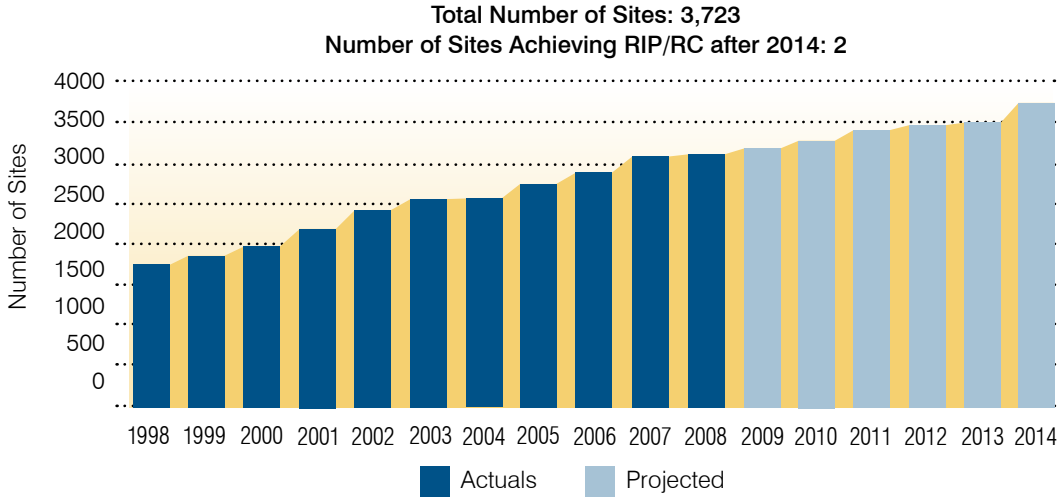


Figure 1. Number of Sites Projected to Reach RIP/RC Status Through 2014

the site can be closed and long-term monitoring may be required. It is important that innovative methods are developed to address these challenging sites and that operating remedial systems are continuously optimized for cost-effective cleanup. Although, the primary goal is to meet the RIP/RC dates for the original IRP sites, it is also acknowledged that potential changes in the eligibility for the ER Program may bring more sites into the program over time.

The MRP is a relatively new program initiated in 2001. At the end of 2008, the MRP had identified 257 sites and 191 of these had been prioritized using the Munitions Response Site Prioritization Protocol (MRSPP). The DON's goal for this program is to have all MRP sites achieving RIP/RC status by 2020.

Over the next five years, the T2 Program will communicate information about ongoing innovations to the NAVFAC ER community for both the IRP and MRP. It will also facilitate the sharing of lessons learned regarding optimized remedies at RIP sites including successful transitions to more passive and sustainable remediation approaches over time. This Five-Year Program Plan describes the remaining environmental challenges that are faced before the 2014 RIP/RC goal is met for the IRP and for the ongoing MRP (Section 2), reviews the T2 process, mechanisms, and products that are planned for the future (Section 3), and provides overall conclusions (Section 4).

T2 PROGRAM OBJECTIVES FOR 2010 TO 2014

Identify and help address challenges faced by Navy RPMs in achieving the 2014 RIP/RC Goal for the IRP

- Assist in information sharing efforts for munitions-related topics as the needs and challenges continue to expand for the MRP
- Facilitate the transfer of lessons learned by one Navy RPM and/or Field Engineering Command (FEC) for the benefit of the entire NAVFAC ER community
- Communicate information about recent advances and new innovations to leverage ongoing Department of Defense (DoD) research and development (R&D) investments
- Continue to innovate in order to enhance and improve methods of information exchange
- Use feedback mechanisms to measure customer satisfaction and to circulate knowledge and ideas

MEETING ENVIRONMENTAL RESTORATION CHALLENGES

As the ER Program moves forward, the DON continues to be a leader among military components in fostering the development and use of faster, more cost-effective, and more efficient environmental remediation technologies. T2 efforts will support this continued leadership through raising awareness of new technological innovations and offering reliable third-party information resources to improve understanding of the advantages and limitations of various remedial approaches. The various challenges faced by the ER Program need to be fully understood in order to further focus and enhance the value of the T2 program for Navy RPMs and others in the NAVFAC ER Community.

Navy RPMs who manage the cleanup efforts at IRP sites continue to face major technical, economic, and regulatory challenges to achieving successful remediation and site closeout. As of 2008, only 611 of the 3,723 sites in the IRP were still pending the RIP/RC milestone. The focus of this plan will be on tackling the challenges specific to these 611 remaining sites with a focus on high cost-to-complete projects, challenging contaminants, media-specific issues, and technology-specific issues. In addition to current challenges at sites in the IRP, the Navy faces the added requirement of responding to evolving environmental regulations and emerging contaminants when new toxicity information or exposure pathways are defined that impact cleanup goals and risk assessment. Regulatory changes may also include newly issued state regulations and guidance such as those in development for vapor intrusion. Another growing area of interest is a new approach towards more sustainable remediation practices (e.g., energy efficient, low-impact remediation methods). The T2 Program will continue to assist in raising awareness of evolving regulatory provisions and new guidance, protocols, and best practices for IRP sites.

At the end of 2008, the MRP had identified 257 sites and the DON's goal for this program is to have all MRP sites achieving RIP/RC status by 2020. Although there are fewer sites, the MRP has the added challenge of addressing potential explosive hazards in addition to risks from chemical contaminants. There are several administrative challenges faced in developing standardized processes for uniform

and safe execution of the program. There are technical challenges faced in detection, discrimination, and removal of MEC, in situ treatment of MCs, and underwater MEC issues. Because the MRP is a relatively new program, the T2 needs can be expected to expand over the next five years as the MRP progresses and new challenges arise.

The sections below summarize the technical areas representing known major challenges that Navy RPMs will face in the next five years as they move toward completing the IRP and the MRP to meet the Navy's goals for environmental cleanup.

Installation Restoration Program Challenges

Although the IRP has made continuous and substantial progress toward its goals, the Navy still faces several major technical challenges to achieving RIP/RC at all sites by 2014. A review was undertaken to identify key challenges and was conducted through discussions with subject matter experts from NAVFAC workgroups and through analysis of data for those sites pending RIP/RC in the Navy's NORM/ Cost-to-Complete (CTC) database. This section describes the major challenges that were identified and how the NAVFAC T2 Program will assist in meeting those challenges. The text box shown on the next page summarizes key features of the IRP sites pending the RIP/RC milestone through 2014.

Major challenges faced by the IRP include the following topic areas, each of which is discussed below:

- Contaminated Sediments Sites
- Increasing Significance of Vapor Intrusion Pathway
- Groundwater Plume Management
- LNAPL and DNAPL Source Zone Strategies
- Innovation Needs for In Situ and Passive Remediation Technologies
- Long-Term Management Challenges
- Incorporating Optimization and Sustainable Environmental Remediation Practices.

REVIEW OF KEY FEATURES FOR RIP/RC PENDING SITES IN THE IRP

The NORM/CTC database was reviewed to analyze the following data for IRP sites pending RIP/RC. BRAC and MRP site data was not included in this analysis, but can be analyzed in the future.

Geographic Distribution. The remaining sites are distributed across 22 states plus the District of Columbia and Puerto Rico. Over 41% (254) of the sites are in the NAVFAC Southwest footprint and 24% (154) of the sites are in the NAVFAC Atlantic footprint. This is followed by 14% (84) in the NAVFAC South footprint, 14% (83) in the NAVFAC Pacific Division footprint, and 7% in the footprints of the other FECs. The states with the top three counts of IRP sites are California 250 sites (41%), Hawaii 74 sites (12%), and Florida 38 sites (6%).

Media Distribution. Over 42% of the IR sites report constituents of concern (COCs) detected in groundwater, while 82% have reported COCs detected in soil. There are also impacts to sediments (up to 11% representing a potential human health risk) and surface water (up to 10% representing a potential human health risk). The sediment contamination is primarily located in marine compared to fresh water environments (at a ratio of 2:1). Surface water impacts are evenly distributed between fresh water (5%) and marine (4%).

Inorganic Contaminant Distribution by Media. The types of inorganic COCs detected were evaluated for each media and the top five COCs were identified based upon the number of detections.

- ***Groundwater***: (1) lead, (2) barium, (3) arsenic, (4) chromium, and (5) zinc
- ***Soil***: (1) lead, (2) arsenic, (3) chromium, (4) zinc, and (5) vanadium
- ***Sediment***: (1) lead, 64 hits; (2) copper, 44 hits; (3) zinc, 43 hits; (4) arsenic, 43 hits; and (5) cadmium, 39 hits for both fresh and marine combined. For fresh water sediment, lead (15 hits) and mercury (11 hits) received the highest number of detections. For marine sediments, lead (49 hits) and copper (37 hits) received the highest number of detections.
- ***Surface Water***: (1) lead, (2) copper, (3) zinc, (4) barium, and (6) aluminum.

Organic Contaminant Distribution by Media. The types of organic COCs detected were evaluated for each media and the top five COCs were identified based upon the number of detections.

- ***Groundwater***: (1) trichloroethylene (TCE), (2) benzene, (3) xylene, (4) toluene, and (5) naphthalene. Contamination source is primarily from chlorinated solvents and benzene, toluene, and xylene (BTEX) from petroleum spills.
- ***Soil***: (1) toluene, (2) acetone, (3) chrysene, (4) benzo(a)pyrene, and (5) polychlorinated bipehnlys (PCBs).
- ***Sediment***: (1) benzo(a)pyrene, (2) acetone, (3) chrysene, (4) DDT, and (5) pyrene. Polycyclic aromatic hydrocarbons (PAHs) and pesticides were found primarily in sediments. PCBs were detected most often in fresh water sediment and benzo(a)pyrene was detected mostly in marine sediments.
- ***Surface Water***: (1) TCE, (2) dieldrin, (3) vinyl chloride, (4) acetone, and (5) benzene.

Technology Distribution by Media and Budget. Approximately, $880M has been budgeted for remedial action (Phase 4), interim removal action (Phase 5), and operation and maintenance (Phase 6) for cleanup of the remaining IR sites. Out of this, approximately $223M is listed as User Defined Costs, which could not be evaluated based on media impacted. However, for the remaining portion of the budget, the following were determined to be the top three remediation technologies by media.

- ***Groundwater***: Enhanced bioremediation ($51M), treatment wall ($14M), and pump-and-treat ($9.7M).
- ***Free Product***: Two-phase extraction and bioslurping ($8.8M), six-phase heating ($2.8M), and skimming ($0.5M).
- ***Soil***: Excavation and off-site disposal ($149M), Resource Conservation and Recovery Act C/D Capping ($62M), and soil vapor extraction (SVE) including off-gas treatment ($27M).
- ***Sediment***: Capping ($44M) and dredging ($41M including confined disposal facilities).

Contaminated Sediment Sites

Sediment contamination is known or suspected at 82 sites within the IRP and represents almost 32 percent of the remaining IRP funds to be expended for site investigation and cleanup (Figure 2). The BRAC program also has 42 sites with confirmed sediment impacts. Contaminated sediment sites exhibit a wide range of issues from source identification and general policy issues to the need for innovative remedial technologies and long-term monitoring. Source identification is required by Navy policy and can be difficult to achieve due to the commingling of contaminants from both Navy and non-Navy sources. In addition, innovative investigation and remediation approaches for sediments are in the developmental stages or are yet to proven in the field. The challenges outlined below will benefit from continued T2 efforts to relay information about innovative solutions to those NAVFAC RPMs managing contaminated sediment sites. The type of T2 information to be deployed will be discussed with the NAVFAC Sediment Focus Team and used to update the T2 Contaminated Sediment Web Portal and to identify appropriate topics for upcoming Remediation Innovative Technology Seminars (RITS).

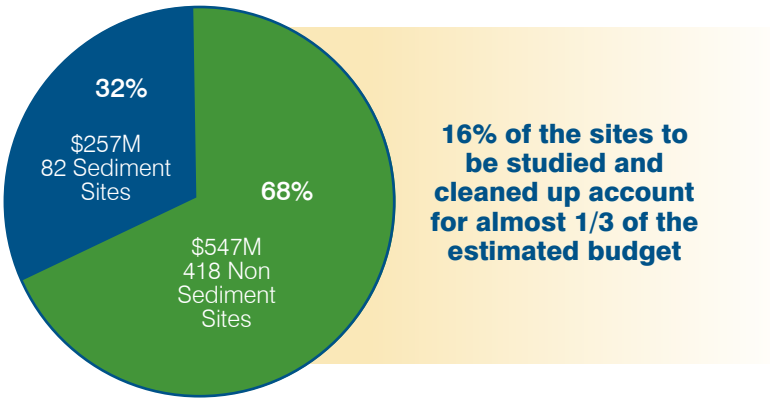


Figure 2. Distribution of $804M Total on 500 Sites

Identification of Sediment Sites and Associated Costs

Despite considerable effort and some investment, NAVFAC is still challenged with the not-so-simple task of identifying and enumerating its sediment sites and then quantifying the associated cost of investigation, cleanup, and restoration. There may be considerable difference of opinion between RPMs over what constitutes a contaminated sediment site. For instance, is it limited to navigable water bodies? Or does it include small creeks, drainage ditches, or small fresh-water bodies (such as ponds) if impacted by contamination? Based on a recent review of IRP sites conducted in 2009 by the NAVFAC Atlantic Division, there are an additional 82 sites that are being tracked as uncertain or potential sediment sites. Fresh water or brackish sediment sites, albeit usually smaller and typically less complicated than most large Navy marine sediment sites, still have similarities about them when it comes to cleanup and restoration. Resolution of this key component will help RPMs better assess the true number of sites and ultimately provide better estimates of the Navy's total cost associated with site cleanup.

General Policy Issues

Navy sediment sites are complex and frequently include active shipyards. These sites often require routine maintenance dredging in order to complete their mission, and ongoing activities may disturb or exacerbate existing contamination. Near-shore activities (such as pier maintenance, shoreline construction, mooring, etc.) could potentially have negative environmental impacts on tidal-zone or deeper sediments depending on the site. Deeper contaminated sediments covered with newer, cleaner sediment or even near-shore, in-place sediment caps have the potential to be impacted by these activities. Therefore, policy and controls need to be put in place to mitigate these environmental impact concerns.

Establishing Background Conditions

The Navy has sufficient policies and guidelines for establishing background conditions at contaminated sediment sites and, when implemented, these policies have been shown to work well. However, many Navy sediment sites pre-date these policies and, as a consequence, Navy RPMs struggle to deal with clean-up goals where background conditions are ill-defined. Sometimes background conditions at these historic sites are based on data sets that would be unacceptable under today's standards or there are no data to establish background conditions at all. Furthermore, the subject of background conditions is typically met with some reservation by the regulatory community.

Increased Use of Innovative Tools

Source identification is required based on Navy policy in order to identify contaminants from Navy and non-Navy sources and to minimize recontamination from upstream sources. Innovative tools such as chemical forensics, principal component analysis (PCA) or polytrophic-vector analysis (PVA) are sometimes not well understood by practitioners. However, these tools can be powerful discriminators of contaminant source(s) and facilitate determination of anthropogenic background conditions. Some RPMs may have to depend on their contractors, whose site characterization experience or understanding of innovative technological tools will vary.

Dynamic Site Conditions

Contaminated sediment sites are dynamic and often sediment transport potentials are not realized or well understood. The transport of contaminant-bound sediment particles should be considered an important part of the conceptual site model (CSM). The understanding of sediment dynamics can have a profound influence on the way that site decisions are or should be made. A misunderstanding of site dynamics can lead to ineffective cleanup actions. In addition, there is a risk of recontamination of sites from ongoing releases such as discharges from National Pollutant Discharge Elimination System (NPDES) permits, which allow ongoing releases of wastewater contaminated at levels higher than screening levels.

Establishing Defensible Cleanup Goals

Cleanup goals, which are derived from the results of site-specific risk assessments, can become a "balancing act" between human health goals, ecological goals, and reference data. At some older sites, cleanup goals could arguably be called background and may not be well defined, as mentioned above. RPMs need tools to facilitate establishing defensible cleanup goals based on site-specific risk assessments for sediment sites.

Bioavailability Concepts/Eco-Risk/Ecotoxicity

The general field sampling approaches and analytical tools for determining bioavailability today are the same that have been used for well over a decade, even while it is understood that these approaches can be problematic in varied environments.

Two primary concerns include sample representativeness and overly conservative estimates of bioavailability or uptake. While there are no specific standard methods that have been developed to overcome these difficulties, today's sediment investigators give more consideration to these issues and work to improve field sampling designs to better estimate these parameters.

As an example, field sampling designs of today give more consideration to overcoming the sample "nugget effect" and the need to improve sample homogeneity. Starting with a more representative sample not only aids in understanding the nature and extent of contamination, but serves as the appropriate baseline for which to develop concepts of bioavailability and risk models. In addition, careful consideration is given to the method of sample extraction, which can often over-predict the fraction of the contaminant that is truly available to biological endpoints. Lastly, field investigations of today often include biological deployments to either provide confirmation of the traditional uptake values derived from tables or to provide better estimates for site-specific conditions. These are just a few examples of approaches that have been taken to better predict ecological risks.

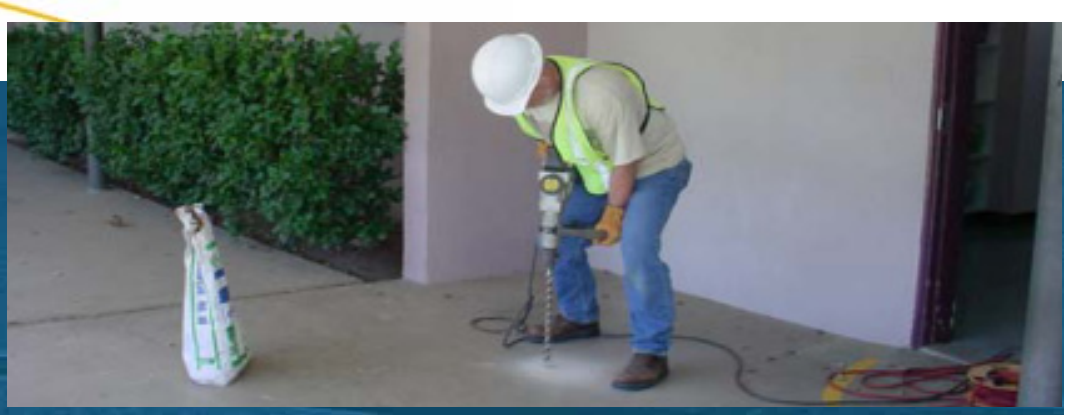
These approaches generally tend to be implemented on a site-specific basis and the Navy RPM is faced with the challenge of incorporating new measures into sediment programs and with the burden of convincing regulators of their integrity, precision, and accuracy.

Innovation in Remedy or Containment Approaches

The NORM/CTC database includes the following cleanup technologies for sediment sites: capping ($44 million) and dredging ($41million including confined disposal facilities). This does not include User Defined Costs, which may involve monitored natural recovery (MNR) or more innovative sediment remediation technologies. There is a general challenge of T2 associated with new or innovative approaches to site characterization and remedial alternatives for contaminated sediment sites. There have been several bench-scale advances and pilot programs that have seen only limited field-scale implementation because the technology was not communicated or known to the end user. An approach that better integrates the end user into technology development/deployment would be beneficial and would help to pave the path forward for potential implementation of new remedial alternatives at sites where these approaches make sense. Navy RPMs will need to coordinate with regulators to bring these approaches into the field, perhaps first at pilot-scale and then, if successfully demonstrated, at full-scale.

Long-Term Monitoring Plans (LTMP)

Developing and implementing well-conceived LTMPs is a considerable challenge on sediment sites. LTMPs must be well-focused and designed with enough flexibility to accommodate decisions to increase or decrease monitoring and sampling or analysis of certain parameters if necessary.



Increasing Significance of Vapor Intrusion Pathway

Vapor intrusion (VI) is increasingly being identified as a pathway of concern at restoration sites. In some cases, previously closed sites have been required to evaluate this pathway during the five-year review process. In addition, this pathway continues to present major technical challenges because both the science needed to assess the VI pathway and the regulatory guidance directing its evaluation and remediation continue to evolve. The Navy issued a policy applicable to VI site investigations and response actions funded under ER,N and BRAC on April 29, 2008. In addition, the Tri-Service Environmental Risk Assessment Work Group released the DoD Vapor Intrusion Handbook in 2009. Together, the policy and guidance provide direction on the approach to be taken at Navy sites; however, technical challenges associated with evaluating this complex pathway continue to exist.

In a recent draft document, "Review of Best Practices for the Navy Vapor Intrusion Focus Areas" (July 2008), the Navy identified several challenges for assessing the VI pathway. As can be seen from the challenges listed below, assessment of the VI pathway is complex and requires extensive knowledge and understanding of site conditions in order to determine whether or not VI is occurring and to calculate the associated risks. T2 efforts will be required in the future to communicate new information on methods to overcome these challenges and more accurately assess risks posed by the VI pathway.

Regulatory Screening Values Are Very Low

Generic indoor air screening concentrations tend to be very low and thus require special care in sample collection and analysis to maintain good quality data. Site-specific modeling, if allowed by regulators, may be used to provide alternative indoor air risk-based concentrations; however, this requires additional characterization data and often does not result in a significant change in the target indoor air concentrations. This may be overcome in the future with improvements to models used to simulate the VI pathway.

Background Concentrations May Confound Results

Typical indoor air background concentrations in residential buildings are similar to 10^{-6} risk-based target concentrations for several common chemicals and it can be very difficult to distinguish the relative contributions from the subsurface versus interior background sources such as consumer products and building materials. Thus, consideration of background contributions is essential when comparing indoor air sampling results to screening levels to determine if a VI risk exists. NAVFAC is currently developing a guidance document on establishing background at VI sites.

Sub-Surface and Sub-Slab Investigations Must Be Customized to Site Conditions

Subsurface sampling (groundwater or soil gas outside the building footprint) generally focuses on the source and/or the pathway and, in some cases, can be used to demonstrate that transport of contaminants does not extend to a building. Subsurface sampling can also be used as a screening tool to focus the interior sampling on buildings that have a reasonable potential for adverse VI impacts. In general, sub-slab sampling inside and directly beneath buildings is intrusive and requires well-planned risk communication with building occupants.

Site-Specific Conditions Can Significantly Affect VI Processes

Factors such as geologic setting, climate, building design and condition, ventilation system design and operation, and building occupancy vary over wide ranges. Therefore, a generic assessment approach that will work for all sites cannot be established. Current VI models address generic conditions, which results in frequent inaccuracies in model predictions. New methods and models are being developed to address this problem, such as a recently suggested taxonomy approach, where certain categories of sites are identified and a focused logic for site assessment is developed for each category.

Temporal and Spatial Variability Introduce Uncertainty

Indoor air quality is subject to temporal variations imposed by weather conditions (e.g., wind, rain, barometric pressure), occupants' living style (e.g., open windows, use of heating/cooling systems, etc.), and site conditions (e.g., varying groundwater table elevations). Risk assessment is typically based on 25- to 30-year exposure scenarios, while most indoor air samples for VI investigations are collected over 24 hours or less with variation of about 1 order of magnitude over this time. With this level of temporal variability inherent in indoor air monitoring, regulators are inclined to ask for multiple rounds of sampling and analysis, which increases costs. Decision makers often have difficulty incorporating spatial and temporal variability in the data into the decision-making and, if they err on the side of caution, the risk management approaches may be overly conservative by a large margin.

VI Compounds of Potential Concern Are Not Fully Understood

Approximately 115 compounds are considered by various regulatory agencies to have the potential to pose a VI risk; however, for more than half these compounds, there is little or no empirical data to demonstrate whether they are sufficiently volatile, mobile, persistent, and toxic to pose a bona fide risk via the VI pathway. Many volatile petroleum hydrocarbons degrade rapidly where oxygen is present, so their behavior will be significantly different than chlorinated solvents and other recalcitrant compounds in well-oxygenated subsurface environments. Thus, VI investigations need to be tailored to ensure that the right data are gathered to accurately assess the fate and transport of COCs for the site.

Variability Exists Between State and Federal Guidance and Regulations

Variability exists across guidance and regulations from the national to state level, from state to state, and even within a state, reflected in differences in inhalation toxicity values, target risk levels, default attenuation factors, ways for dealing with background concentrations, preferred lines of evidence, protocols for data collection, or personal experiences of the regulators. Some states are highly prescriptive, while others allow more flexibility. Familiarity with the technical aspects of VI also varies within agencies and across the consulting profession, so guidance is not always consistently followed. In addition, regulatory approaches including those recommended by EPA continue to evolve.

VI for Occupational Settings Is an Unresolved Issue

For occupational settings, determining when Occupational Health and Safety Administration (OSHA) rules apply and when risk-based VI guidance applies is an important decision point that is not always clearly delineated. It can be especially challenging to assess VI at industrial sites because indoor air concentrations present in industrial settings can be a reasonable margin below OSHA permissible exposure limits (PELs) and yet be several orders of magnitude higher than risk-based target concentrations. The Navy VI policy requires that OSHA standards and workplace

requirements are considered and incorporated into the CSM when evaluating the VI pathway for industrial settings; however, regulatory agencies are inconsistent on how to address this scenario. EPA is developing a policy for addressing non-residential settings, which is currently in the government review process.

Stakeholder Concerns Are Often Greater for VI

It is more common to have significant stakeholder involvement with VI than other pathways because avoidance is difficult and the various challenges often make it difficult to determine whether or to what extent VI may be occurring.

Groundwater Plume Management

Over 42 percent of the IR sites report COCs detected in groundwater including metals, chlorinated solvents (such as TCE), and BTEX compounds. Navy experience has shown that groundwater remediation poses a number of challenges, especially at sites with difficult conditions such as large, low concentration plumes, deep alluvial aquifers, fractured bedrock, and low permeability formations. Even those sites that have achieved the RIP milestone will require continued updating of the CSM and ongoing evaluation of the groundwater remedy effectiveness. It may also be appropriate at some sites to transition to more passive remedial strategies or to long-term monitoring over time. In addition, regulatory challenges can be a significant issue where agencies require stringent cleanup goals such as drinking water maximum contaminant levels (MCLs) to be met throughout the plume. This can result in costly active remediation systems and sustained elevated monitoring costs.

The RPMs' challenge is to consider all of the factors relating to the site, including the CSM, regulatory programs and stakeholder concerns, and to develop an appropriate and cost-effective remedial strategy to manage the risks associated with complex groundwater plumes. Over the next five years, the T2 Program will assist

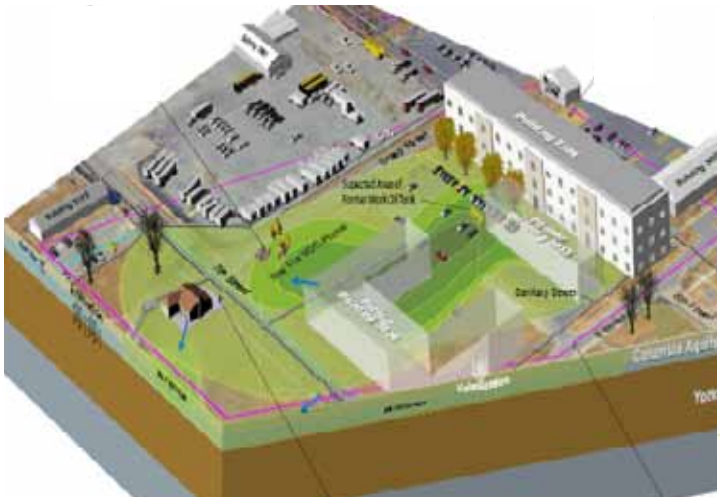
in promoting awareness of effective CSM use and groundwater risk management strategies that are appropriate for sites in various phases of selecting, optimizing, or phasing out groundwater remedies. NAVFAC ER sites that have employed successful approaches for groundwater plume management will also be highlighted. Several challenges faced in the management of groundwater plume cleanup sites are listed below.

Effective Use of Conceptual Site Models

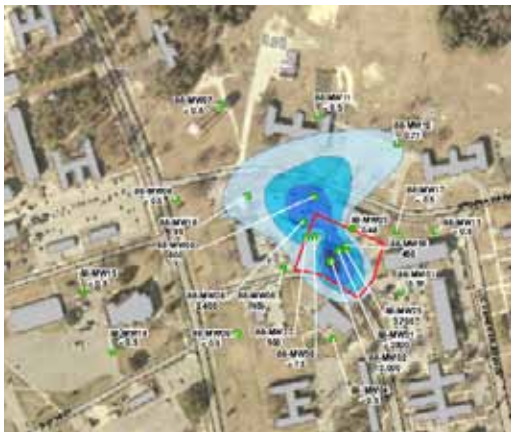
The development of a comprehensive CSM can be challenging and is an important ongoing process in groundwater plume management. The CSM should clearly demonstrate an understanding of groundwater flow, chemical transport conditions, and pathways to receptors. An effective CSM can help a project team to make improved site decisions and to concisely define overall project objectives. This helps to ensure consensus on key issues in order to minimize the need for re-work because stakeholders have different CSMs in mind. A comprehensive and updated CSM can enhance the potential for reduced remediation costs, while still meeting the overall remediation objectives.

Linking Remediation Goals to Current and Future Resource Use Classifications

Remediation goals should ultimately be linked to current and reasonable future resource use. The overall goal is to return usable groundwater to its beneficial use wherever practicable, within a reasonable time frame. Several states have implemented a system that classifies/designates all groundwater-bearing units based on current and potential use, water quality, and/or vulnerability. Groundwater quality standards are then established for each class that commonly indicates whether the groundwater is potable, non-potable without treatment, or non-potable regardless of treatment. Alternatively, some states have an anti-degradation policy, which classifies all groundwater as high priority and/or as a potential drinking water source regardless of actual or likely future use, and provides state-specific numeric and/or narrative groundwater quality criteria. An understanding of the proper groundwater classification is important to effective management of these sites.



State-to-State Variability in Risk Management Provisions



For many groundwater plumes, restoration of contaminated groundwater to drinking water standards currently is not achievable due to technology limitations. For this reason, Navy RPMs should consider the use of risk management strategies to guide the decision-making process at their groundwater sites. Groundwater risk management strategies can include establishing points of compliance (POCs) or alternate concentration limits (ACLs), performing mixing zone analyses, seeking technical impracticability (TI) waivers, using land use controls (LUCs), and implementing other strategies. However, the availability of risk management options will depend on applicable Federal and state regulations for that particular environmental program. Several states have adopted tiered risk-based corrective action options, which recognize the technical difficulty and high cost of continuing remediation of groundwater plumes that may pose minimal risk. For example, some states will allow contamination to remain in place at concentrations exceeding risk-based criteria if groundwater remediation is impractical and then using LUCs to prevent exposure. These approaches can require a significant amount of site characterization and analysis (e.g., groundwater fate and transport modeling, mixing zone analysis) to meet the criteria and to demonstrate no unacceptable risk, but in some cases the remedy can be limited to LUCs with limited long-term monitoring.

Optimized Use of Treatment Trains and Passive Remedies for Groundwater Remediation

Partial source zone treatment combined with passive technologies, such as monitored natural attenuation (MNA) or bioremediation, and institutional controls (ICs) restricting groundwater use may be an appropriate risk management strategy even if this requires a prolonged period of monitoring. If partial source zone treatment is not an option, it may be appropriate to develop a containment remedy that relies on engineering controls (ECs) such as permeable reactive barriers (PRBs), biobarriers, or other technologies to prevent further plume migration from a source area or to prevent a plume from crossing a property or site boundary.

Emerging Contaminants

Regulations may change in the future, which could cause the reopening of sites as part of the five year review process. This might occur due to the identification of new contaminants that haven't previously been tested and/or changes in the risk assessment process such as incorporating measures of cumulative risk. Navy RPMs face the challenge of identifying emerging contaminants as regulations evolve and determining when and how to test for these contaminants in accordance with DON policies.

Source Zone Strategies for LNAPL and DNAPL

The presence of nonaqueous phase liquids (NAPLs) continues to pose challenges for cleanup at many Navy sites. Light NAPLs (LNAPLs) are less dense than water and tend to float in an aquifer. LNAPLs include fuels and petroleum products. Dense NAPLs (DNAPLs) are denser than water and tend to sink in an aquifer. DNAPLs include many chlorinated solvents such as trichloroethylene (TCE). Both LNAPL and DNAPL share several similar challenges in site characterization and remediation. DNAPL sources are often difficult to detect or even infer and obtaining accurate estimates of LNAPL or DNAPL mass continues to be elusive. Absolute cleanup goals (e.g., complete NAPL removal or cleaning up to MCLs) are nearly impossible and very expensive to meet. Although remediation is completed or well underway at many of the "easier" Navy sites, achieving RIP by 2014 continues to be a costly challenge at the more complex remedial sites where NAPLs may be present. Over the next five years, there is a continuing need for T2 in site characterization and remediation where NAPLs are involved. The T2 Program will communicate information on improved metrics and remedial approaches for NAPL site cleanup.

NAPL Site Characterization Challenges

The difficulties in detection and obtaining accurate estimates of NAPL mass creates a need for continued development of more cost-effective detection methods and encouragement for the application of these new methods once developed. Also, practitioners and regulators are beginning to come to a consensus that total mass estimates are inherently inaccurate and that a shift is called for more reliance on mass flux measurements. Mass flux is a calculation of the mass of dissolved contaminants that passes through a cross-sectional area over time. To support the use of this metric, the development of more reliable ways to measure, model, interpret, and apply mass flux concepts is needed. Other site characterization challenges for NAPLs include developing a better understanding of the role of back-diffusion from low permeability source zones and improving comprehension of contaminant transport in fractured bedrock formations.

NAPL Risk Management Concepts

Because absolute cleanup goals for NAPLs are nearly impossible and very expensive to meet, there is a critical need to find ways to reach agreement with stakeholders on reasonable risk-based cleanup objectives. At NAPL sites, the Navy ER Program needs to find ways to establish clear and reasonable exit strategies and fully shift from absolute cleanup goals (e.g., MCLs) to risk-based cleanup goals. Potential benefits should be weighed against the negative impacts of active mass reduction and sustainability concepts need to be brought into this evaluation. For example, active mass removal could result in negative impacts to the environment from energy usage, air emissions, or site worker risk and these should be weighed against the net benefit and risk reduction from cleanup. Partial mass removal should be evaluated to determine if it is a viable option. Mass flux concepts need to be implemented in risk management. Namely, it needs to be determined if remediation will effectively reduce the mass flux emanating from the source area, and substantially reduce the overall risks and time of cleanup. RPMs, particularly new RPMs, will need training and tools to effectively implement the above risk-management concepts and to effectively communicate these concepts to regulators and other stakeholders in order to arrive at reasonable cleanup goals.

NAPL Remediation Challenges

Based on the total budget in NORM/CTC, the most prevalent NAPL remediation technologies are two-phase extraction or bioslurping, six phase heating, and skimming. To attain RIP by 2014 at NAPL sites, achievable remediation goals need to be established. Performance objectives and improved metrics to evaluate performance are needed to demonstrate that these goals are being met. Also, better monitoring tools are needed to predict likely success of various remedial technologies. A better understanding of the likelihood and role of rebound is needed. Clearly understanding the potential role of bioremediation in source zone remediation and applying bioremediation as part of the remedial process will potentially improve remediation success. Another important aspect is acknowledgement and understanding that site characteristics often change during remediation and that the CSM needs continuous updating to incorporate these changes. A clear exit strategy needs to be established in remedial documents and should include a flexible plan in the event that remedial goals for NAPL removal are not met. This would involve integrating the concept of "treatment trains" into the Feasibility Study and improved Record of Decision (ROD) process.

Innovation Needs for In Situ and Passive Remediation Technologies

In situ and passive remediation technologies include technologies that rely on the subsurface placement or injection of chemical and biological amendments to promote the in situ destruction or immobilization of contaminants such as chlorinated solvents, metals, and perchlorate. These technologies include: (1) in situ bioremediation (ISB), which may include the injection of bacteria as well as a wide variety of commercially available electron donors; (2) in situ chemical oxidation (ISCO), which relies on the addition of chemical oxidants; and (3) technologies that rely on abiotic mechanisms to convert or immobilize contaminants, which include the introduction of zero valent iron (ZVI) or other innovative metals into the subsurface. Remedies utilizing these technologies are designed to directly treat the source area or be used as a passive barrier to prevent the migration of the dissolved phase plume located downgradient of the source area. There are several innovation needs for in situ and passive remediation technologies that may be addressed over the next five years through DoD research programs and through ongoing commercial development of technologies. The T2 Program can increase awareness of these innovations as they become available for field-scale application at NAVFAC ER sites.

Development of Improved In Situ Injection Methods

Successful design and application of in situ remediation technologies is often limited by inadequate distribution of the amendments in the subsurface. Improved delivery mechanisms are needed to ensure adequate contact between amendments and COCs. Additional guidance is required to establish the pros and cons of the various commercially available methods, which include hydraulic and pneumatic fracturing, recirculation systems, and a variety of innovative equipment and techniques. Further guidance that defines the selection criteria among these methods is needed to aid the practitioner in choosing the correct combination of injection technique and physical properties of the amendments to be injected in order to ensure adequate distribution within the subsurface. Additional research is needed to further improve injection methods and to investigate other innovative ways to facilitate transfer of materials into the subsurface such as nanoscale materials, sheer-thinning fluids, and polymer formulations.

Development of Improved In Situ Amendments

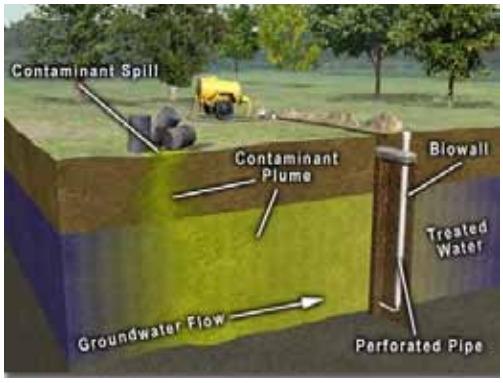
Assuming that amendments can be adequately distributed in the formation, the success of the in situ remedy is dictated by the ability of the amendments to retain their longevity in the subsurface, as well as their ability to support the desired chemical or biological reaction, while minimizing the production of adverse byproducts. Much is known regarding both chemically and biologically mediated reactions of chlorinated alkenes and their resulting byproducts. However, much less is known regarding the reactions of other potential COCs including chlorinated alkanes, polychlorinated biphenyls (PCBs), 1,4-dioxane, and other emerging contaminants.

Better Understanding of the Impact of Geochemistry

A better understanding of the impact of the chemical and biological reactions on groundwater geochemistry, and, conversely, the impact of groundwater chemistry on these reactions, is necessary to ensure the longevity of the remedy. Many reactions produce byproducts which may adversely impact the performance of the remedy. For instance, stimulating ISB by adding an amendment such as lactate can result in a drop in aquifer pH, which can inhibit the complete degradation of TCE to ethane. Sulfide solids may precipitate, which can reduce the hydraulic conductivity of the aquifer, causing groundwater to flow around a passive barrier as opposed to flowing through it and severely limiting its performance. Therefore, it is necessary to streamline the evaluation process to ensure that cost-effective technically practicable technologies are selected based on a detailed understanding of how site-specific characteristics could impact performance of available amendments.

Technology Selection

Additional guidance is needed to provide the RPM with a better understanding of the pros and cons of innovative remedies and the criteria that will impact the cost and performance of the remedy at a given site. Lessons learned and rules of thumb could be developed for the most widely used in situ remedial applications. In addition, guidance is needed to aid the RPM to determine the advantages and disadvantages of applying a low-cost mulch biowall as opposed to applying a remedy such as ZVI or ISCO. The Environmental Security Technology Certification Program (ESTCP) information on the state-of-the-technology for mulch biowalls can be further shared



within the ER community. Additional guidance is also needed to better understand when it is appropriate to optimize a remedy by using a combined sequential approach to "couple" existing technologies to expedite site closure. For instance, ZVI may be combined with emulsified oil and ISCO may be combined with ISB to reduce cleanup time and cost. Therefore, even a site that has achieved RIP may need to consider a treatment train approach with technology transitions over time. As guidance is developed and as new innovative technologies are developed, additional T2 will be needed to communicate this information to RPMs.

Long-Term Management

There are many and varied challenges facing the Navy in long-term management of sites. The primary technical challenges in this area include those associated with implementation of long-term monitoring and LUCs. In addition, the challenge of properly managing and maintaining site data and records over the long term was identified. Landfill sites also present unique technical and administrative challenges in terms of long-term management of sites. Information resources on these topics can be shared through future T2 efforts.

Long-Term Monitoring Challenges

Long term monitoring challenges are focused on ensuring that project data quality objectives (DQOs) are satisfied, while minimizing associated costs of the program. Long term monitoring costs include direct monitoring costs, data management, and reporting. Direct monitoring costs can be reduced by implementing innovative monitoring strategies, such as passive samplers and real-time sensors, into the monitoring program. The decision to implement passive samplers is based on many factors, including applicability and cost. The transition from a conventional sampling method to passive sampling could be advantageous at some sites. This would involve concurrent sampling and development of a flow chart or decision diagram to outline the criteria that will be used to validate the sampling method. The decision to implement and the magnitude of the concurrent sampling effort (i.e.,

number of wells and number of samples per well) is based on the CSM and project DQOs. Real-time sensors also can be considered for monitoring; however, although they provide rapid analysis, they are currently considered primarily as screening tools and the results must be compared to benchmarks or a percentage of confirmatory samples must be submitted for laboratory analysis. It is anticipated that future advancements in the reliability of real-time sensors may increase their usefulness and cost-effectiveness for long-term monitoring.

Accurate in-field collection, submittal, storage, and retrieval of electronic data are crucial in meeting project quality assurance/quality control (QA/QC) goals and assuring timely dissemination of data to stakeholders. The more widespread use of the recently deployed Naval Installation Restoration Solution (NIRIS) will streamline the long-term management process and assist in regulatory data submission requirements (i.e., NIRIS Electronic Data Deliverable). It is important that RPMs know the intended use of their site data before it is gathered and stored in NIRIS to ensure completeness. The use of the geographic information system (GIS) and other user friendly tools in NIRIS will further enhance project management capabilities over time. One further challenge is compiling historical data into NIRIS to facilitate data review and tightening up of the minimum data standards for new data to support CSM development.

Continual optimization of sampling programs is a crucial component of long-term management and reduction of project costs. In optimizing the monitoring program, all data should be collected with an understanding of how the data will be used and how they contribute to a validation of remedy performance and success. Establishing clearly defined monitoring objectives and corresponding exit criteria is central to any well-defined, well-managed, and optimized monitoring program. Exit criteria should be used to help decision-makers determine when they can move on to other steps in the site management process. Techniques for optimizing the long-term monitoring of ER sites include the following:

- Trend analysis or statistics may be used to support a decision to stop monitoring at a well or a site if contaminant concentrations are found to be stable over a long period of time
- As monitoring progresses, the list of analytes can be reduced to only those COCs and other parameters needed to evaluate the performance of the remedy
- With regulatory concurrence, the analyte list may be further reduced by evaluating the detected analytes against regulatory standards
- Monitoring optimization software packages (including MAROS, Summit Monitoring tools, the GTS algorithm, and the NIRIS system) can be applied.

LUC Challenges

LUCs are restrictions used to protect human health and the environment from potential exposure to residual contamination during or after completion of a response action. Challenges facing the LUC component of long-term management include ensuring awareness of the LUC, adequate LUC monitoring, and LUC optimization.

Because the failure of a LUC could lead to exposure and harm to the environment or human health, it is essential to have a well-defined LUC monitoring plan to ensure long-term integrity and implementation of the LUCs. The existence of LUCs at a site must be widely known or easily ascertainable in order for them to be considered as an effective remedial approach; LUCs will be effective only if stakeholders understand and adhere to the LUC. Guidelines for the frequency and duration of LUC monitoring should be linked to the monitoring objectives and milestones set forth for other components of the remedial action, and not necessarily for a specified time period. Optimization of LUCs is an integral component of the long-term monitoring strategy, and long-term monitoring results and goals from other facets of the remedial action should be reviewed in conjunction with the LUCs to see whether the boundary or duration of the LUC can be optimized to include only those areas currently affected by residual contamination at unacceptable levels. NAVFAC has developed LUC management tools such as LUC Tracker to assist with the LUC management process. LUC Tracker provides a Web-based process for actively managing interim LUCs placed on parcels transferred under the early transfer process and also long-term LUCs associated with remedial actions. The LUC Tracker is deployed as part of NIRIS.

Environmental Data Management, Communication, and Documentation

New methods for project management will develop over time and improved approaches to data management, communication, and documentation will be discussed through the T2 Program. Recent advances in this area include using NIRIS, incorporating risk communication strategies, and developing an improved ROD. Advances and case studies in data acquisition strategies such as TRIAD (which includes systematic planning, dynamic work strategies, and real-time measurement systems) can be shared among the ER community. An additional challenge is to ensure full documentation to meet current and future Freedom of Information Act (FOIA) requests and other records requests. The documents produced are typically the primary records of work performed and decision-making rationales. These documents remain long after sites are closed (50 or more years). It has been the experience of those in charge of the Administrative Record that the public wants to know what happened many years after the work is finished. It is critical that documents, defined in the Environmental Restoration Recordkeeping Manual, be submitted in a timely manner to the appropriate Command Records Manager or designated representative in order to ensure that current and future FOIA and other record requests will receive the best possible response. Managing records effectively reduces the risks associated with litigation and potential penalties. Additionally, Commands achieve full compliance with Federal and state laws and regulations. The site data and records document the activities and actions of Commands and serve as part of a Command's history.

Landfill Site Challenges

Landfill sites at NAVFAC installations present a wide array of challenges based on their historical use, physical location, site conditions, and planned future use. At many landfill sites, waste disposal activities spanned many years (e.g., 30 to 50 years), which has led to significant uncertainty about the exact contents and volume of waste present in the landfill. At some sites, regulatory and stakeholder concerns can lead to characterization and assessment activities that are above and beyond those described in the U.S. EPA Directive No. 9355.0-67FS, *Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills* (1996). It is important that characterization activities at landfills be optimized by developing an up-to-date CSM and ensuring that all data collection is guided by the DQO process.

For landfill sites that are located adjacent to marine or fresh surface water bodies, there are concerns related to the discharge of contaminants in groundwater to surface water. The T2 Program could help to share information on standardized approaches for groundwater/surface water modeling, offshore sediment and surface water characterization, and methods for investigating the potential impacts from contaminants in groundwater underlying landfill sites. If the landfill is adjacent to a tidally influenced surface water body, then there are additional concerns about potential future rises in sea level and how such rises will be accounted for in the remedial design and long-term monitoring program. Shoreline erosion and shoreline stabilization near landfills may also be a long-term issue and could arise as part of the five-year review process required by CERCLA.

Additional challenges associated with landfill sites that could be considered by the T2 program include:

- Seismic activity and/or geotechnical instability results in discharge of landfill waste or a compromise to the integrity of the landfill cover
- Burrowing mammals dig through landfill cover and become exposed to landfill waste or bring the waste to the surface for potential exposure to other receptors
- Administrative challenges associated with identifying which Federal and state regulations apply as Applicable or Relevant and Appropriate Requirements (ARARs), and how those ARARs will be effectively monitored and enforced for perpetuity
- All of the challenges identified for the LUC component of long-term monitoring above apply at landfill sites. Typically digging and land use restrictions are a part of the selected remedy at landfill sites, therefore, it is important that LUC awareness, monitoring, and optimization be incorporated throughout the long-term management process or else remedial action objectives may not be achieved.

Incorporating Optimization and Sustainable Environmental Remediation Practices

Optimization is the process of identifying and prioritizing options for addressing the ongoing challenges described above. NAVFAC has conducted successful optimizations studies at over 224 sites. As a result, $82 million in cost avoidance or direct cost savings have been identified with a 7-times return on investment (ROI) compared to the optimization study and implementation costs. The T2 Program can assist with identifying new ways to optimize cleanup projects, identify successful optimization case studies, and communicate this information to Navy RPMs.

In addition to the standard optimization approach described in existing Navy guidance, sustainable environmental remediation (SER) is emerging as a new strategy that takes a more holistic approach in prioritizing remedies and minimizing collateral impacts to the environment and stakeholders. The T2 Program can communicate to RPMs about how to incorporate SER into their remediation projects.

Ongoing Needs for Remedial Optimization

The challenge to all Navy RPMs is to ensure that remedial programs are optimized to achieve protective site closeout in the most efficient and cost-effective manner. To assist the RPMs in meeting this objective, Navy optimization policy and guidance have been established, including:

- DON Policy for Optimizing Remedial and Removal Actions Under the Environmental Restoration Program (April, 2004)
- NAVFAC Guide for Optimizing Remedial Action Operation (April 2001)
- NAVFAC Guidance for Optimizing Remedy Evaluation, Selection, and Design (April 2004)
- NAVFAC Guidance for Planning and Optimizing Monitoring Strategies (August 2008)
- DON Improved ROD Handbook (March 2009).

The concepts discussed in these documents should be incorporated throughout the entire remediation process and optimization reviews should be performed at key points in the process. Emphasis should be placed on considering and

selecting appropriate remedial alternatives in the pre-Feasibility Study stage or earlier if possible. Another key component is to effectively incorporate CSMs into the optimization process. CSMs should evolve and be kept up to date as the site understanding changes and the amount of available data is increased. The CSM is critical in communicating with stakeholders on the progress of activities at a site and changes to the CSM over time can be used document key decision points for exit strategies. Optimization also includes building decision points into the ROD at the remedy selection phase. The increased use of the improved ROD format will result in more flexible remedies and incorporation of remedial exit strategies. Optimization activities must also be conducted periodically during the Remedial Action – Operation (RA-O) and LTM phases. RPMs are faced with the challenge of ensuring that remediation schedules include sufficient time to perform optimization reviews and make modifications to the remedy as a result of the review. Budgets should be allocated to perform optimization reviews and contracts with remediation contractors need to include flexibility to promote optimization efforts. Regulatory agencies should be informed of the optimization process and need to understand that remedy modification may be proposed as a result of optimization reviews. Finally, all agreements made with regulatory agencies and stakeholders, particularly RODs, need to include sufficient flexibility to promote optimization.

Increasing Focus on Sustainable Environmental Remediation Practices

In addition to optimization, requirements are increasing for incorporating SER, sometimes referred to as "green remediation," into project decision-making. Executive Order (EO) 13423, released on January 26, 2007, requires Federal agencies to conduct environmental, transportation, and energy activities in a sustainable manner. In addition, regulatory agencies are beginning to request that sustainability be considered during remedy implementation. This presents a new set of challenges to RPMs, particularly since this is a new area of focus and protocols have not yet been established for inclusion of sustainability practices into the ER Program. The RPM is faced with the challenge of determining the following:

- What sustainability metrics are to be characterized and how are they quantified?
- How are metrics weighted against each other and against traditional criteria (e.g., effectiveness, implementability, and cost) in selecting the remedial approach?
- What efforts should be undertaken to reduce sustainability impacts?
- What decision criteria are used to determine if additional funding should be used to reduce sustainability impacts?

Munitions Response Program Challenges

At the end of 2008, the MRP had identified 257 sites. This includes 61 Navy installations with 171 sites and 9 U.S. Marine Corps installations with 86 sites (Figure 3). Out of these, 191 had been prioritized using the MRSPP. All of the sites have completed the Preliminary Assessment (PA) phase and approximately 39 percent have completed the Site Inspection (SI) phase as of 2008. The DON's goal for this program is to have all MRP SIs completed by 2010 and all MRP sites achieving RIP/RC status by 2020.

Navy RPMs managing the cleanup efforts at sites under the MRP face several challenges to achieving successful site inspection, remediation, and site closeout. These challenges cover a wide spectrum of issues and are related to programs and policy development, site inspection, cleanup technologies, and personnel and training. Because the MRP is a relatively new program, the T2 needs can be expected to expand as the MRP progresses and new technical challenges arise. Over the next five years, new guidance and tools for addressing MRP sites can be expected and the T2 Program can assist in communicating this information to RPMs and the NAVFAC ER community.

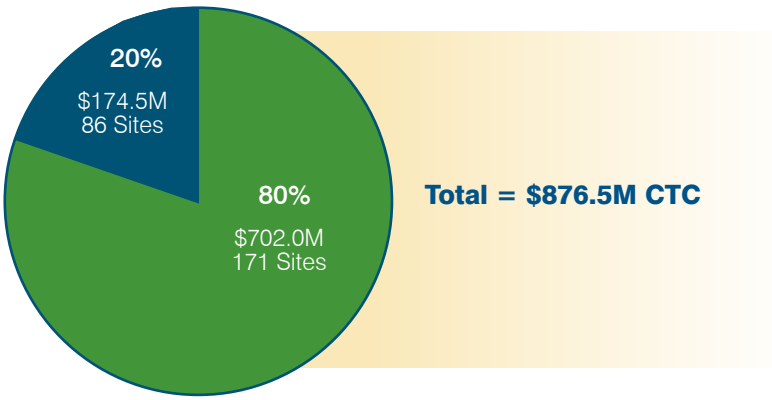


Figure 3. MR Program Cost-to-Complete Distribution

Developing and Implementing Standardized Practices

There are several administrative challenges faced in developing standardized processes for uniform execution of the MRP. These standardized processes will help to ensure safety and proper Quality Assessment throughout the MRP process. The NAVFAC Munitions Response Workgroup has initiated efforts in this area through the preparation of Statement of Work (SOW) templates for the major project phases including Preliminary Assessment (PA), Site Inspection (SI), Remedial Investigation/ Feasibility Study (RI/FS), Quality Assessment, and Removal Action SOWs. In addition, a MEC Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP) template has been prepared which can be shared by all Services. Further guidance on the establishing and maintaining LUCs at MRP sites would also be useful. Several efforts to develop standards, processes, and protocols are underway and expected to yield results that can be communicated to NAVFAC RPMs through T2 efforts.

Understanding the Relationship Between Hazard Reduction and Cleanup Costs

NAVFAC is currently evaluating the Interim MEC Hazard Assessment Methodology developed by EPA and DoD. After a two-year trial period, DON shall determine whether to continue further evaluation of this tool. The Interim MEC Hazard Assessment Methodology does not address underwater MRP sites. An objective hazard assessment model for underwater MRP sites needs to be designed and supporting policy should be developed for arriving at decisions on the degree of hazard associated with an underwater MRP site. Lacking such a model, regulatory agencies are mandating investigation and cleanup of MRP sites to a zero tolerance and zero uncertainty end-points. Consequently, DoD may be at risk of investigating and remediating MRP sites without full consideration of the relationship between cost and the reduction of hazard at the site. In a related issue, guidance for depth of clearance, which is linked to various land uses, should be established.

Deploying Technologies for Detection, Discrimination, and Removal of MEC

There are several technical challenges faced in detection, discrimination, and removal of MEC, and in situ treatment of MCs. Field-scale demonstrations are now ongoing under ESTCP and challenges include sites with mixed MEC (e.g., more than one type) and smaller UXO items. Several of these technologies are emerging and will be ready for deployment at the full-scale over the next five years.

Understanding the Management and Technical Needs for Underwater Sites

There is clearly a definitive need for programmatic support for underwater munitions. Guidelines should be developed for the investigation, mitigation, budgeting, and remediation of underwater MRP sites. An improved understanding is needed of the hazards and response requirements associated with munitions in a marine environment. There is an immediate need for developing a hazard assessment approach that will objectively measure the potential hazards associated with underwater munitions. Further R&D funding is also required to develop methods for the investigation and characterization of underwater sites and for appropriate hazard mitigation for underwater MEC. R&D should develop technologies that support better MEC detection, discrimination, reacquisition, recovery, and treatment in underwater site settings. Cost estimation tools and focused specifications for the types of technologies needed to meet the investigation and cleanup goals could be prepared. An improved understanding of the natural underwater processes is imperative to develop underwater munitions management strategies. These processes include currents, waves, sediment transport, MEC mobility, habitat effects, MC fate and toxicity, temperature, pressure, and more. Furthermore, R&D may be required for mitigation of impacts to marine life. This is crucial to managing underwater munitions sites where regulatory oversight exists. It was suggested by a subject matter expert that a dedicated MRP underwater munitions subcommittee be established under the MR Workgroup in order to develop the appropriate Navy underwater munitions policy, R&D priorities, site management, and response strategies.

Assisting New and Transitioning Staff

Additional T2 efforts will also be useful for new staff or current staff transitioning from the management of IRP to MRP sites. This will help NAVFAC to train and retain qualified staff to meet the growing needs of the MRP.

T2 PROCESS, MECHANISMS, AND PRODUCTS

T2 Process for Environmental Restoration

This Five-Year Program Plan facilitates and promotes T2 efforts by defining the T2 process to be used within the NAVFAC ER community (Figure 4). This process will involve the participation of key players, opinion leaders, and other early technology adopters to enhance T2 efforts within the NAVFAC ER community.

The T2 Program will gather applicable information from personnel within NAVFAC Workgroups and DoD-funded R&D programs. It will also gather information on overall IRP and MRP trends directly from Navy RPMs through their inputs into the NORM/CTC database. The T2 Program will consider input regarding the latest advances being made by industry and academic leaders in the field. A T2 Annual Survey will be used as a feedback mechanism to improve understanding of end user requirements. All of this input will then be synthesized into updates to the Five-Year Program Plan and the next Fiscal Year's Work Plan. These mechanisms for receiving input and feedback for the T2 Program are described below in more detail.

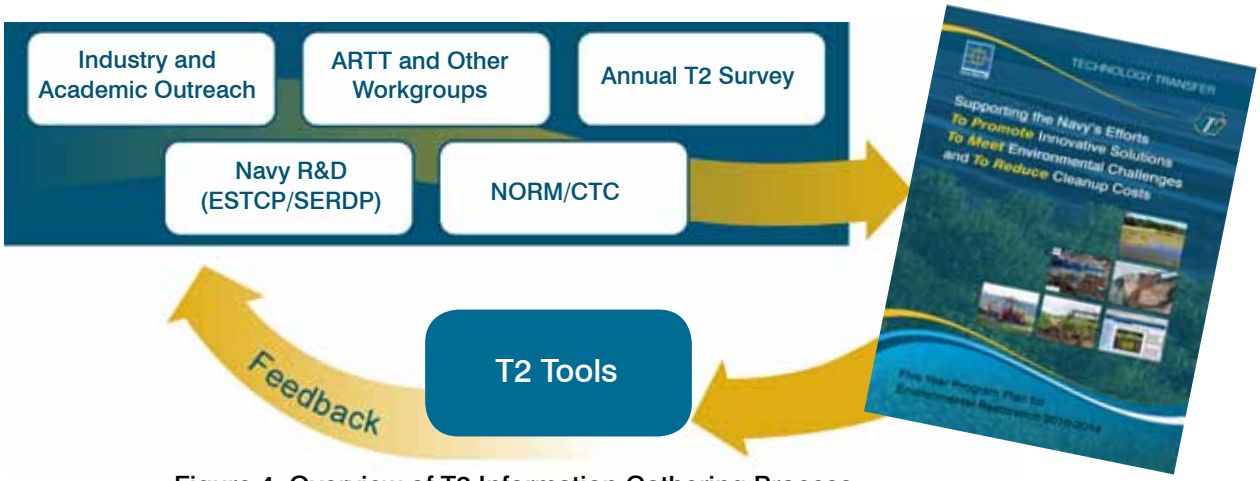


Figure 4. Overview of T2 Information Gathering Process

T2 Mechanisms for Environmental Restoration

The T2 Program relies upon many groups of subject matter experts and other mechanisms to gather and disseminate information. The input and feedback provided through these T2 mechanisms allows us to focus the T2 Program on relevant topics. Below is a summary of the primary T2 mechanisms through which T2 topics are generated and T2 products are reviewed.

NAVFAC Technical Workgroups

The NAVFAC Engineering Service Center focuses the T2 process through engagement of the Alternative Restoration Technology Team (ARTT) and other NAVFAC Workgroups. Table 1 provides a list of NAVFAC Workgroups and their stated mission. Meetings with the ARTT and other NAVFAC Workgroups are very productive for the T2 Program. This source of feedback results in interesting case studies, emerging contaminants, new regulatory challenges, as well as new technical approaches to site remediation, optimization, and closure. The T2 Products are reviewed by the ARTT and other relevant NAVFAC Workgroups and then revised according to their comments.

Table 1. NAVFAC Workgroups

Group Name	Mission
Alternative Restoration Technology Team (ARTT)	Promotes the use of cost-effective, innovative technologies
Cost-to-Complete (CTC) Workgroup	Promotes sound cost-estimating practices
Naval Installation Restoration Information Solution (NIRIS) Workgroup	Develops corporate methodologies for GIS and Web-based data collection, storage, and analysis
Munitions Response (MR) Workgroup	Develops NAVFAC-wide MR guidance and promotes the use of best available technologies for cleanup of MC and MEC
Environmental Restoration Optimization Workgroup	Supports optimization of RA-O/LTM and sustainable environmental remediation activities
Risk Assessment Workgroup (RAW)	Promotes consistency in assessing human health and ecological risks at ER sites
Sediment Focus Team	Provides guidance on sediment site investigations and cleanup.

DoD-Funded R&D Programs

Table 2 lists programs that benefit from DoD R&D funding such as the Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP). In addition, internal R&D efforts at NAVFAC are typically conducted under Broad Agency Announcements (BAA) and the Navy's Environmental Sustainability Development to Integration (NESDI) Program. The Navy has a vested interest in transferring information about the new technologies and methodologies developed under these programs to the entire NAVFAC ER community. These DoD-funded R&D programs typically produce case studies and emerging technologies that either appear to be beneficial or are found to be too immature or impractical for full-scale application. Personal contacts with program managers and principal investigators will be conducted to derive the information that is most suitable for distribution throughout NAVFAC at the time. This feedback will be in the form of project documentation, reports, and presentations for a given demonstration project. The Statements of Need (SONs) developed by SERDP and ESTCP will also be considered in the T2 process. Other branches of the Navy such as the Office of Naval Research (ONR) and Space and Naval Warfare Systems Command (SPAWAR) also conduct research that is relevant to the ER Program and T2 topics may arise out of this research.

Table 2. DoD-Funded R&D Programs with Navy Participation

Program	Mission
SERDP	Improves mission readiness through environmental research to resolve environmental problems
ESTCP	Promotes innovative, cost-effective environmental technologies through demonstration and validation at DoD sites
BAA	Identifying a wide range of innovative environmental technologies and methodologies that are either new, innovative, advance the state-of-the-art, or increase knowledge or understanding of environmental issues
NESDI	Demonstrates and validates environmental shoreside technology to support Fleet readiness by minimizing operational risk, constraints, and costs, while ensuring environmental stewardship and regulatory compliance
ONR	Coordinates, executes, and promotes the science and technology programs of the United States Navy and Marine Corps
SPAWAR	Conducts research, development, test and evaluation activities for command, control, communication systems, and ocean surveillance.

NORM/CTC Database

The NORM/CTC database will be evaluated to track trends in the Navy ER Program and identify typical challenges faced by Navy RPMs at these sites. The NORM/CTC database is a comprehensive compilation of data from all Navy IR, MRP, and BRAC sites. The data is updated on an annual basis by Navy RPMs and others directly involved at each site. This database represents a valuable source of data for analysis and interpretation for focusing T2 efforts. Key observations from this data are discussed in Section 2 of this Five Year Program Plan.

Industry and Academic Outreach

One lesson learned from the RITS was that Navy RPMs request and utilize information from industry leaders who can discuss technology trends that have become evident across the nation or over time. This "big picture" view helps Navy RPMs to prioritize work and to avoid costly fads that get too much attention, but provide little or no net benefit. Awareness will be maintained of important technology trends through both the ARTT Workgroup discussions and through industry and academic outreach from conferences and peer-reviewed journals.

Annual T2 Survey

The T2 survey is used as a feedback mechanisms to measure customer satisfaction and to circulate knowledge and ideas instead of relying on just one-way methods of communication. A T2 survey is released on an annual basis to gather information from RPMs and other stakeholders on T2 topics of interest. The results of this survey are then used to guide the T2 Program and to ensure that it remains focused on useful and applicable environmental restoration topics. The questions for the survey are developed in conjunction with the ARTT Workgroup and the results are reviewed with the ARTT Workgroup in order to plan for future T2 activities and products. The survey is released as both a hard copy version at each Spring RITS and in an online Web-based version.

T2 Products for Environmental Restoration

The transfer of information about a new technology or improved methodology is predominately a process of communication. Communication mechanisms can take many forms including the printed word, formal instruction, personal interaction, conferences, multi-media, social media, and other approaches. This Plan outlines a broad range of T2 products that will promote interaction with end users and encourage information exchange with technology developers.

The type of T2 Product selected to communicate information will be flexible and determined based on the amount and nature of the technical information to be conveyed. Several T2 products are proposed in this Plan to effectively communicate new information to Navy RPMs and others within NAVFAC's ER community. Over the next five years, these types of T2 products will be deployed, while continuing to explore new and improved ways of sharing information through online and interactive formats. As discussed below, these online and interactive approaches enhance, but do not replace traditional media and face-to-face communications among practitioners and key stakeholders.

T2 Email Updates

These monthly email updates are used to alert participants of newly available publications, the latest Navy initiatives and policies, training events, release of T2 products, and more. The T2 email list has grown from 500 or more in 2004 to 1,000 or more in 2009. Over the next few years, the goal is to increase the number of contractor personnel joining the T2 email list. Previously, the list was limited primarily to Navy personnel. In addition, past T2 email editions are archived and made available online.

T2 Events Calendar

A T2 ER Events Calendar is updated on a monthly basis and made available online. It includes links to internet training seminars, conferences, classroom training courses, and more. This includes events conducted by the Navy such as RITS, NAVFAC Workgroup meetings, Civil Engineer Corps Officers School classes, and the NAVFAC ER Cleanup Conference. Other relevant events are included that are sponsored by the Interstate Technology Regulatory Council, U.S. EPA, industry conferences, and more.

NAVFAC Portal and NAVFAC ERB Web Site

The NAVFAC ER and BRAC (ERB) Web site is located on the NAVFAC Portal. This Web site is the primary hub for all information shared within the NAVFAC ER community. It includes the following resources:

- *Guidance, Policy, and Regulations* – Provides a list of the latest NAVFAC Guidance and DON Policies
- *NAVFAC Workgroups* – Provides access to charters, member information, meeting minutes, and handouts for the NAVFAC Workgroups
- *Conferences/Seminars* – Provides access to register and view past presentations
- *Newsletters* – Quarterly updates on remediation project success stories, new document releases, and more
- *Documents* – Provides an alphabetical list of technical documents
- *Technologies* – Provides an alphabetical list of remedial technologies including applicability, advantages, and limitations
- *Navy Environmental Restoration Program (NERP) Manual* – A comprehensive reference on major steps in the ER process
- *Technical Insight & Problem Solving (TIPS) Forum* – Meeting minutes and handouts.

Multimedia Web Tools and Interactive Web-Based Media

Web-based tools are meant to enhance, but do not replace valuable face-to-face interactions and traditional media. Since 2004, more than 55 multimedia T2 Web tools have been deployed on a wide range of topics. These T2 Web tools feature concise text and improve information exchange through animated graphic art, video, audio, tables, and hypertext Web links. Links to useful references for more detailed information are provided. The T2 Web tools contain contaminant-specific, media-specific, and technology-specific information and also illustrate data from real world applications at Navy, Marine Corps, and BRAC sites. The T2 Web tools are accessed through a Web browser by clicking on a link and in a short time period the user can review a consolidated summary of key issues for a given topic of interest. A Web Portal is also used to serve as a hub to convey relevant information and links to policies and guidance. Examples of T2 Web Tools and T2 Web Portals are below.

The state-of-the-art in online multimedia and social media continues to rapidly evolve and the T2 Program will continue to evaluate updated methods and formats for online information sharing. For example, NAVFAC's improved ROD initiative is enhancing traditional RODs through hyperlinks and improved visual graphics similar to the Web-based interactive tools described above. One recent trend is the use of social media, which is made up of user-generated content. Social media can take many different forms, including forums, blogs, podcasts, pictures, and video. DoD has recently instituted a "DoD Chat" with Instant Messaging where regardless of geographic location several users can collaborate in real-time directly from their desktop and will have presence awareness of anyone on their buddy list. The DoD has acknowledged the importance of social media. This is just one example of how communications evolve over time and the T2 Program will continue to investigate ways to implement new communication methods within the Navy's Navy/Marine Corps Internet (NMCI) computer network.

An awesome T2 product!!! The Web Tool provides a very good basic overview for a RPM on sediment issues. What really blew me away was the comprehensive listing (and links) to all the NAVFAC Guidance, T2 Resources, Conferences, and Other Resources… Gathered in one place (and) readily accessible… excellent resources available for the RPM (or anyone else) working sediment issues. WOW!

NAVFAC RPM
June 2009

PLANNING FOR FUTURE T2 PRODUCT UPDATES

Department of Defense Weighs Greater Use of Social Media

"For leaders... it's really important to be connected to [social networking tools] and understand it," said Navy Admiral Mike Mullen, chairman of the Joint Chiefs of Staff, noting that he has his own Facebook page. "I think communicating that way and moving information around that way—whether it's administrative information or information in warfare—is absolutely critical."

Navy Admiral Mike Mullen
Chairman of the Joint Chiefs of Staff
Government Computer News
June 22, 2009

RPM Newsletter

NAVFAC's RPM Newsletter is a quarterly publication dedicated to sharing environmental restoration news and information. Each issue contains a one-page T2 News that announces newly released technical documents, guidance documents, white papers, completed research reports, and more. In addition, full length articles are prepared to describe case studies for innovative investigation and/or remedial technologies.

Technical Documents

Guidance documents and handbooks are prepared on key topics to assist Navy RPMs and contractors in the most challenging aspects of environmental remediation where detailed and in-depth technical information is needed to summarize best practices.

Cost and Performance (C&P) Reports

C&P reports review data from field-scale applications of innovative technologies at Navy, Marine Corps, and BRAC sites in order to assist RPMs in planning and/or using similar technologies at their sites. This information can be used to summarize lessons learned, success stories, and best practices for specific site characterization and remedial technologies.

Brochures, Conference Posters, and Other Printed Media

In addition, print media can include brochures, conference posters, success stories, journal articles, and other documents. Brochures have been useful for conveying information about the goals and activities of the NAVFAC Workgroups, general environmental service offerings, and more. Conference posters are used to raise awareness of the T2 Program and T2 products produced on an annual basis and presented at the NAVFAC ER Cleanup Conference.

Conference, Seminars, and Presentations

Face-to-face communication is still critical for sharing information and obtaining immediate feedback. There are several venues through which face-to-face communications are promoted including Technical Service Representative visits and brown bag presentations, RITS, NAVFAC Environmental Cleanup Conference, and other industry conferences attended by the NAVFAC booth. Although these activities are not formally part of the T2 Program, close communication is maintained to coordinate between these activities and the T2 Program in order to leverage these successful venues for information sharing.

CONCLUSIONS

"There are a growing number of DON sites approaching site closeout and achieving this milestone in an efficient manner is important to the DON."

NAVFAC
Site Closure Document

The DON's environmental restoration mission is supported by NAVFAC's continued T2 efforts to assist Navy RPMs in understanding improved methods for enhanced performance and cost-effectiveness of the ER Program. This Five-Year Program Plan was assembled to identify remaining technical challenges in the ER Program. Several cross-cutting challenges have been identified including evaluating impacts of evolving regulations, identifying appropriate cleanup goals and exit strategies, and understanding site conditions and stakeholder concerns.

While the challenges faced by Navy RPMs will continue to evolve as the IRP reaches the 2014 RIP/RC goal, continued information sharing is needed to support optimized execution of the remaining cleanup activities and sharing of lessons learned. The focus of the T2 Program will also adapt as the MRP grows in size and scope to further encompass the challenges faced under this evolving program.

This Five-Year Program Plan is meant to guide the focus of the T2 Program in order to maintain awareness of RPMs challenges. This will be supplemented by annual feedback from the NAVFAC ER community over the next five years to continually adjust and adapt to RPM needs.