FINAL REPORT

In Place Soil Treatments for Prevention of Explosives Contamination

ESTCP Project ER-0434
Grenade Range

JANUARY 2010

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14. ABSTRACT

A combination of *Sphagnum* peat moss and crude soybean oil (PMSO) was examined as an in place treatment option for reducing the transport of dissolved explosives from munition residues on active training ranges. An evaluation was performed using outdoor ex situ soil plots at the Massachusetts Military Reservation (MMR) in MA. The study was directed at measuring the reduction in the flux of explosive compounds (i.e., RDX, HMX, TNT) from freshly deposited Composition B detonation residues into the underlying soil. Over a 1 year period, the PMSO treatment layer reduced the average flux of RDX at approximately 30 centimeters below the soil surface by between 5- and 500-fold compared to control plots. Treatment effectiveness was dependent on the specific proportions of peat moss and crude soybean oil in the PMSO. Detections of TNT, HMX, and the RDX degradation products MNX, DNX, and TNX in pore water were minimal and sporadic at all sample depths.

A parallel demonstration examining the compatibility of the PMSO technology with range activities was performed at a hand grenade training range at Fort Jackson, SC. The PMSO material was not adversely affected by the hand grenades, which redistributed the material horizontally and vertically. However, large detonations of C4 explosives, and hot, dry, and windy conditions resulted in some smoldering and generation of nuisance dust from the PMSO.

These results indicate the potential for this inexpensive and readily available PMSO material to significantly reduce the migration of explosives residues into groundwater. This technology would be expected to be as effective as reducing explosive compound fluxes if it was emplaced as a barrier below a layer of soil to prevent generation of nuisance dust, and it would be most applicable at grenade ranges, mortar firing points, OB/OD areas, and EOD training facilities that are under active management.

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List of Acronyms

2,4-DNT / 2,6-DNT	2,4- and 2,6-dinitrotoluene
DoD	Department of Defense
EPA	Environmental Protection Agency
EOD	explosive ordnance disposal
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
OB/OD	open burn/open detonation
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
TNT	2,4,6-trinitrotoluene
UXO	unexploded ordnance
MNX	hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine
DNX	hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine
TNX	hexahydro-1,3,5-trinitroso-1,3,5-triazine
2ADNT	2-amino-4,6-dinitrotoluene
4ADNT	4-amino-2,6-dinitrotoluene

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Executive Summary

NOTE: This project was conducted as two parallel and different types of demonstrations. These two types of demonstrations were meant to address and evaluate very different aspects of the technology, and as such, they were very different in terms of scope.

The first demonstration, described in Part I of this report, was the Aboveground Soil Plot (SP1) Demonstration. The key focus of the SP1 demonstration was to evaluate the effectiveness of immobilization of explosives by the treatment layer under real (outdoor) environmental conditions. The SP1 demonstration was performed at the Massachusetts Military Reservation (MMR).

The second demonstration, described in Part II of this report, was the Grenade Range (GR) Demonstration. The key focus of the GR demonstration was to assess the compatibility and robustness of the technology with actual range activities (i.e., how is the treatment material redistributed and/or otherwise affected by detonations). The GR demonstration was performed at Fort Jackson, SC. <u>The GR demonstration was terminated early due to range management activities which were not compatible with meeting some of the demonstration goals, therefore some performance objectives were not able to be met.</u>

Background. Ranges and other areas used by the Department of Defense (DoD) for testing new ordnance and for training personnel are common sites for environmental contamination with explosives. The munitions used by DoD contain a number of different explosive compounds including 2,4,6-trinitrotoluene (TNT), hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) in the fuse (6). Residues from munitions are dispersed over the soil surface and then serve as point source for explosive compounds, which can migrate into the soil and eventually contaminate the underlying groundwater. Technologies are needed to reduce the impact of range activities involving munitions on environmental resources.

Objectives. The overall objective of this project (as detailed in PART I and PART II of this Final Report) was to evaluate a surface-applied material composed of peat moss plus crude soybean oil (PMSO) as a technology to prevent and mitigate near-surface soil contamination

with explosive compounds, thereby protecting the subsurface and groundwater at active DoD ranges.

PART I of this report details the evaluation of the effectiveness of the PMSO technology with respect to reducing the flux of dissolved explosive compounds in soil emanating from surface deposited munition residues. This work was done using simulated soil mesocosms and was designated the SP1 Demonstration. ***Please see PART I of this report for more specific details.***

PART II of this report details the evaluation of the compatibility of the PMSO technology with DoD training activities at ranges, with a focus on hand grenade training activities, and was designated the GR Demonstration. The specific objectives of the GR Demonstration were to:

1) Determine to what extent the PMSO material is redistributed by grenade detonations after being emplaced;
2) Determine any incompatibilities between hand grenade training activities and the PMSO technology, and;
3) Perform an initial assessment of the effectiveness of the PMSO technology for preventing new soil contamination.

Methods. Soil core samples were collected from two bays at the Remagen hand grenade training range at Fort Jackson, SC to establish background levels of explosive residues in soil. A 10 cm layer of PMSO (1:1 peat moss:crude soybean oil, w:w) was then applied across the surface of a 10 m x 10 m area in a single bay. After the PMSO was applied, hand grenade training continued. The redistribution of the PMSO was monitored and recorded using digital photography and image analysis.

Performance Objectives and Performance Evaluation. The results obtained during the GR Demonstration compared to the performance objectives yielded the following:

Performance Objective 1: The PMSO be maintained as a continuous layer after multiple grenade detonations.

Results:

1) The PMSO material was redistributed horizontally and mixed vertically into the soil by grenade detonations. After three days of training and 128 grenade detonations in or near the PMSO layer, 88% of the original 1000 m^2 area remained covered with some amount of PMSO.

Performance Evaluation: Objective was met.

Performance Objective 2: The PMSO will be incorporated into soil profile.

Performance Objective 3: The PMSO will remain in the treated area with no significant losses due to wind or rainfall.

Performance Objective 4: The PMSO-treated area will have a 50% reduction in total new explosives residues compared to the control area (composite 0-30 cm depth).

Performance Objective 5: The PMSO-treated area will have 50% lower explosive residue concentrations at discrete depths compared to the control area.

Results:

1) The grenade detonations themselves did not result in any dramatic destruction of the PMSO. However, EOD activities which employed a large amount of C4 explosives to detonate dud grenades did ignite smoldering areas in the PMSO layer. Water application was required to quench the slow burn of the PMSO.
2) The ash from the smoldering PMSO, as well as the finer portions of the peat moss were stirred up by wind in the hot and dry summer conditions at Fort Jackson, creating nuisance dust. In light of this, and in an effort to not adversely affect training activities, the bay containing the PMSO underwent major re-grading activities. The GR

Demonstration was therefore terminated without being able to make an initial assessment of the effectiveness of the PMSO for reducing new soil contamination with explosive residues.

Performance Evaluation: Objectives were not able to be accurately evaluated due to the early termination of the GR Demonstration.

Overall Project Conclusions and Recommendations. Even with the early termination of the GR Demonstration, the results from both the SP1 Demonstration (PART I) and the GR Demonstration (PART II) allow for some important conclusions and recommendations:

- The PMSO material was very effective at reducing the migration of RDX into and through the soil when it was dissolving from surface applied Composition B residues. The RDX flux reduction was ~500-fold in PMSO (10 cm depth of 1:2 peat moss:soybean oil) vs. control (no PMSO) treatments. Dissolved TNT and HMX were not detected with enough frequency to allow calculation of fluxes of these compounds, but based on the previously developed model, the effectiveness for these compounds would be expected to be very high as well.
- It is expected that the PMSO would be effective at reducing the transport (flux) of other munition and propellant compounds including 2,4- and 2,6-DNT, nitroglycerin, and nitroguanidine (based on the physico-chemical properties of these compounds, as wells as some preliminary laboratory results).
- Surface applied PMSO would not likely be drastically affected by grenade (or other munition) detonations themselves, but it would be redistributed horizontally and mixed vertically into the soil in the treated area.
- EOD activities which employ large quantities of C4 could result in smoldering of a surface-applied layer of PMSO.
- Dry conditions and strong winds would likely result in the production of nuisance dust at a grenade range, especially in low precipitation climates.

- Based on current results and model predictions, the PMSO material would be effective as a barrier to reduced explosive compound transport (flux) if it were either i) applied and buried under a layer of soil 30 to 60 cm (1 to 2 ft) depth of soil, or; ii) mixed into the top 15 to 30 cm (0.5 to 1 ft) of soil. This would avoid most of the issues involving smoldering and generation of excessive fugitive dust. The exact depth of burial or mixing would be dependent on the type of training area at which the PMSO was being applied. For a hand grenade range, cratering is usually less than 45 cm (1.5 ft) deep, so PMSO burial at 60 cm should be sufficient. At a mortar target area, deeper burial may be needed due to deeper cratering, while treatment at a mortar firing point to capture and treat propellant residues might require burial at only 15 cm (1 ft), depending on the amount of heavy equipment or track vehicles that would be expected to be moving across the treated zone (eg., the PMSO would need to be buried deep enough to prevent the vehicle traffic from digging up and removing the PMSO layer).
- The PMSO technology would be most applicable for portions of the range where UXO is not of concern, such as OB/OD areas and EOD training areas, as well as grenade training areas and mortar firing points. PMSO would also be applicable for inclusion as a sustainable range management technology for use in areas that have been cleared of all past UXO.

1. INTRODUCTION

1.1 Background

Impact ranges, which are used by the Department of Defense (DoD) for testing new ordnance and for training personnel to use mortars, rockets, and other munitions, are common sites for environmental contamination with explosives. The munitions that are tested at DoD impact ranges contain a number of different explosive compounds. For example, a 60-mm mortar round contains 2,4,6-trinitrotoluene (TNT) in the primer, 2,4- and 2,6-dinitrotoluene (2,4-DNT and 2,6-DNT, respectively) in the propellant charge, TNT and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) in the filler, and RDX and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) in the fuse (6).

After full- or partial- detonation of a high explosive, residues of these materials can remain in the impact area. In addition, munitions that fail to detonate during training (i.e., unexploded ordnance (UXO)) are also a potential long-term source for the release of explosive compounds into soils. In sandy soils with little organic matter or clay content, such as those present at the Massachusetts Military Reservation (MMR; Cape Cod, MA), transport of TNT, RDX, and HMX to the vadose zone and ultimately to groundwater is possible. Recent reports of groundwater contamination at MMR with RDX confirm this assumption (8). The contamination of groundwater underlying these facilities is particularly problematic because the explosive residues have the potential to adversely impact local drinking water supplies.

Explosive-related compounds have been observed to be recalcitrant in many environments, leading to the potential for long-term contamination at sites where they are released (11). However, under the proper conditions (i.e., low oxygen concentrations, presence of labile carbon sources), the ability of microorganisms to biotransform and biodegrade these compounds has been shown to be very widespread (3, 5).

The challenges to effectively addressing the pollution issues associated with live fire range activities which stem from several factors that are summarized in the Table 1-1 below. The proposed technology was develop to address and overcome all of the listed challenges.

The proposed technology is a soil amendment process designed to enhance the immobilization and biodegradation of explosives residues generated during live fire training, explosive ordnance disposal (EOD) and training activities, and open burn/open detonation (OB/OD) procedures. The basic components of the amendment are a long-lived, high-capacity sorbent (i.e., peat moss and/or sawdust) and a slow-release microbial stimulant (i.e., soybean oil and/or molasses). These are natural materials that are nontoxic and environmentally benign. The materials can be obtained inexpensively in most areas in large quantities, mixed, and applied to large areas using readily available landscaping/agricultural equipment (i.e., mulch/bark blowers), or from the air, if required.

Table 1.1-1. Key factors and associated challenges that need consideration when addressing prevention of live fire range contamination with energetic compounds.

FACTOR	RESULTING CHALLENGE/DIFFICULTY
Large Size of Impact Areas	• Additives must be low cost • Additives must be effective in reasonable amounts • Additives should be available locally
Existence of Unexploded Ordnance (UXO)	• Surface application required (no tilling) • May require aerial application
Existing Vegetation	• Additives must be compatible with vegetation • May require aerial application
Permeable Soils (i.e., MMR)	• Rapid migration of contaminants and additives • Additives must be non-toxic
Low Organic Content Soils (i.e., MMR)	• Rapid migration of contaminants • Aerobic conditions limit biodegradation • Low microbial populations
Recalcitrant Contaminants	• Low rates of biodegradation • Limited populations of natural degraders
Slow Release of Contaminants from UXO	• Requires long term treatment/protection • Additives must be long-lived • May require repeated applications
Ongoing Activities	• Application and additive must not impact operations • May require repeated applications

1.2 Objectives of the Grenade Range (GR) Field Demonstration

The objective of this field demonstration was to:

1) Determine to what extent the treatment materials are redistributed by grenade detonations after being emplaced?
2) Perform an initial assessment of the effectiveness of the treatment layer material for preventing new soil contamination.

The overall objective of this project was to address the three questions listed below by performing <u>two different types of field demonstrations</u>. These were important issues to be resolved, and would assist the potential end-users in deciding whether this technology would be appropriate to meet the challenges and need of their particular site. Specifically:

1) Will this technology act to *prevent* further contamination of soil and groundwater with explosives residues AND *reduce* the current contaminant levels in already contaminated soils?

2) Is this technology useful over a sufficiently long period after deployment so as to be cost effective?

3) Is the technology compatible with live fire range activities (i.e., how will detonations affect the distribution and reactivity of the treatment layer).

1.3 Regulatory Drivers

The explosive compounds being examined during this project are currently or expected to be regulated. 2,4- and 2,6-DNT and RDX are currently on the U.S. EPA's Unregulated Drinking Water Contaminants list (http://www.epa.gov/safewater/dw_unregcontaminants.html). Health advisory limits in the low part-per-billion range for the above three compounds, as well as RDX, HMX, TNT, nitroguanidine, and nitrocellulose have also been issued by the EPA (http://www.epa.gov/waterscience/drinking/standards/dwstandards.pdf).

Several DoD sites, most notably MMR, have already come under regulatory pressure to stop activities that may result in contamination of groundwater with these compounds, as well as to begin remediating contaminated groundwater and overlying soil. This technology has been designed to help the DoD meet these challenges.

2. TECHNOLOGY

2.1 Technology Description

The technology that was tested is a soil amendment process designed to enhance the immobilization and biodegradation of explosives residues generated during live fire training, explosive ordnance disposal (EOD) and training activities, and open burn/open detonation (OB/OD) procedures. The basic components of the amendment are a long-lived, high-capacity sorbent (i.e., peat moss) and a slow-release microbial stimulant (i.e., soybean oil), combined to yield PMSO. These are natural materials that are nontoxic and environmentally benign. The materials are generally available and inexpensive, can be easily mixed, and are easily applied to large areas using readily available landscaping/agricultural equipment (i.e., mulch/bark blowers), or tilled into or buried under a layer of soil, as required.

2.2 Technology Development and Application

The development of this technology was initiated under the Strategic Environmental Research and Development Program (CU-1229) and has continued for one year of laboratory studies under the Environmental Security Technology Certification Program (CU-200434). All the initial screening and assessment work has been completed, with relevant details described below.

Over three years of research developing and evaluating the proposed technology under laboratory conditions has resulted in very promising results (1, 2, 4, 10). TNT, RDX, and HMX all demonstrated strong sorption onto peat moss and several other materials compared to sorption onto native soil from MMR (Figure 2.2-1). The desorption of these compounds from peat moss demonstrated hysteresis, indicating that the explosives desorb more slowly than they adsorb. This contributes to the effectiveness of the proposed technology because it allows explosives residues generated during detonation to be quickly immobilized at the soil surface, then slowly released from the sorbent to be biotransformed and biodegraded by microorganisms.

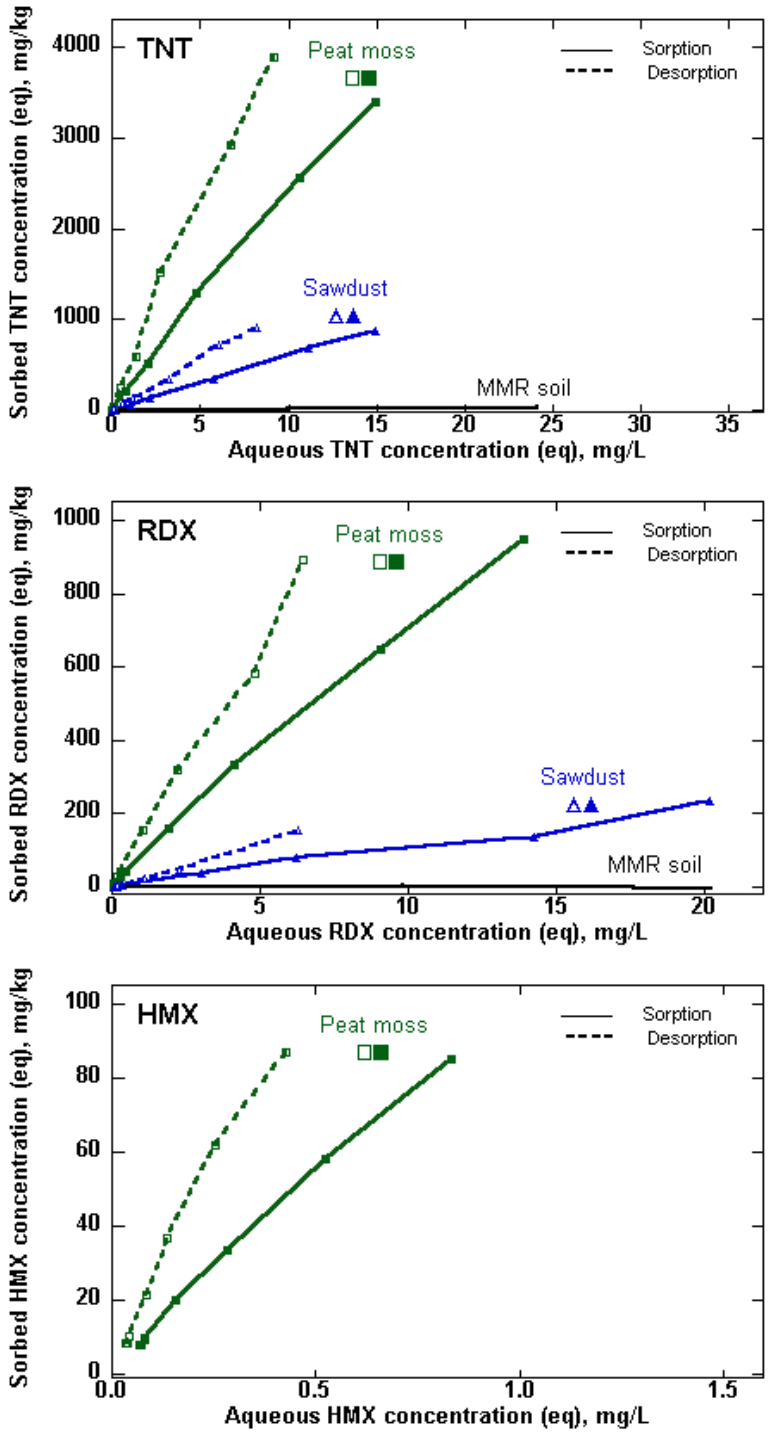


Figure 2.2-1. Sorption-desorption isotherms of TNT, RDX, and HMX.

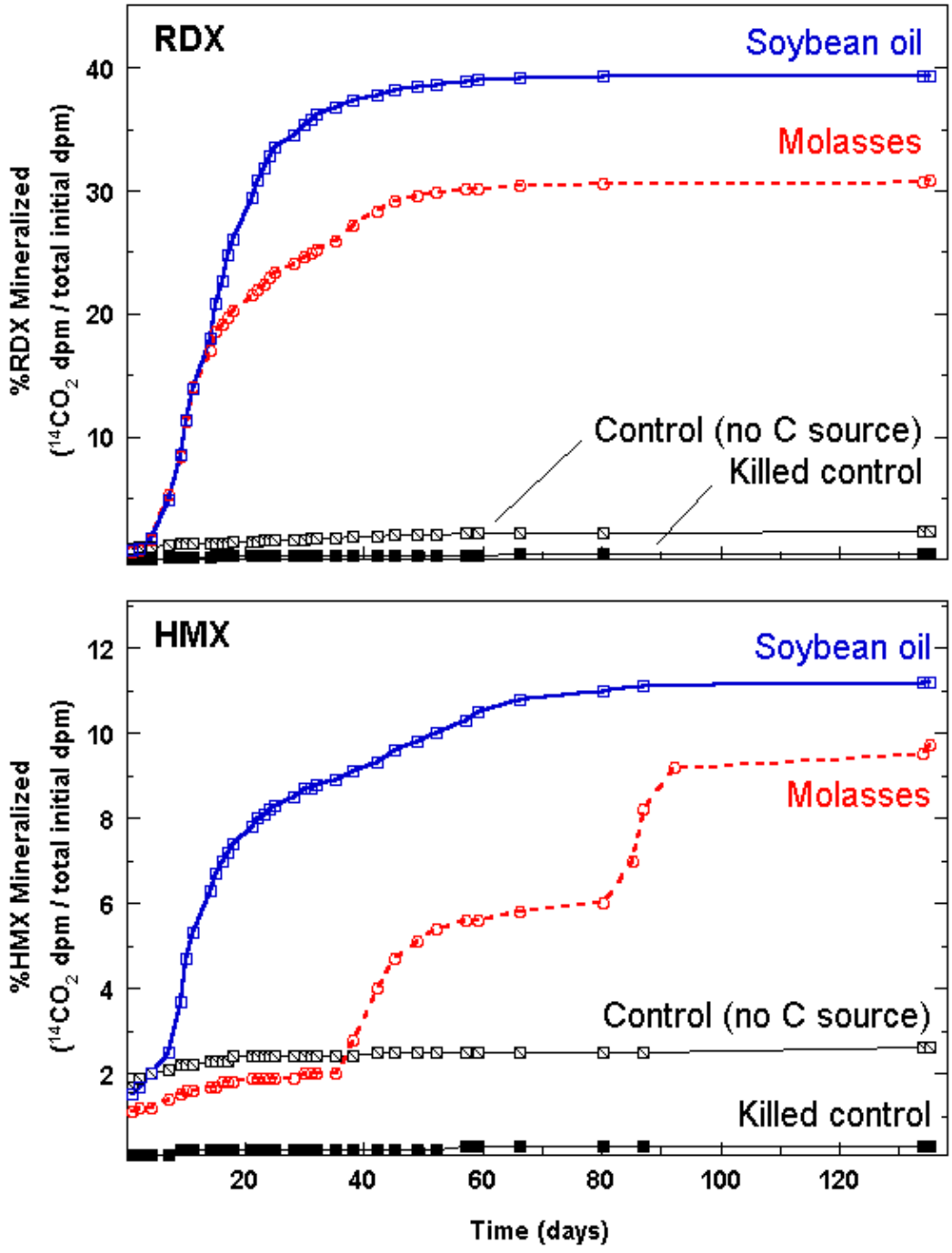


Figure 2.2-2. Mineralization of RDX and HMX in with different cosubstrates.

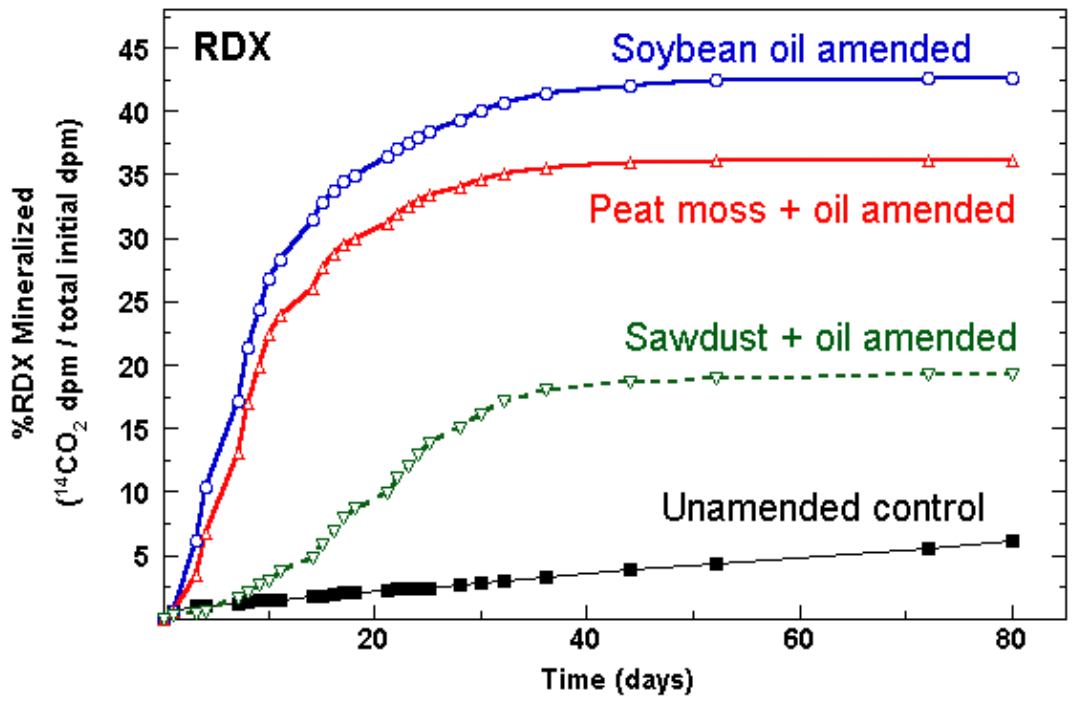


Figure 2.2-3. Mineralization of RDX in unsaturated soil microcosms amended with various combinations of sorbents and cosubstrates.

Our research has also examined how to stimulate native soil microorganisms to biodegrade TNT, RDX, and HMX. Experiments using soil slurry microcosms amended with microbial stimulants (cosubstrates) indicated that explosives were transformed and/or mineralized (converted to H_2O, CO_2 and other innocuous products) to a much greater extent in amended soil than in unamended soil. An example of these results for RDX and HMX is presented in Figure 2.2-2, which indicated that crude soybean oil was the cosubstrate that stimulated the greatest mineralization. Mineralization of TNT was minimal under all conditions tested, as observed by other researchers. However, TNT was degraded without significant accumulation of the amino-containing breakdown products in the presence of soybean oil. These amino compounds are also considered to be toxic/hazardous. Therefore, these results indicate that soybean oil promotes the biotransformation of TNT to compounds that are less of a concern in regards to human health and environmental safety than the breakdown products that occur when other cosubstrates are

employed. The cosubstrates soybean oil and molasses also stimulated explosive biodegradation in unsaturated soil microcosms amended with peat moss and sawdust sorbents as well (Figure 2.2-3).

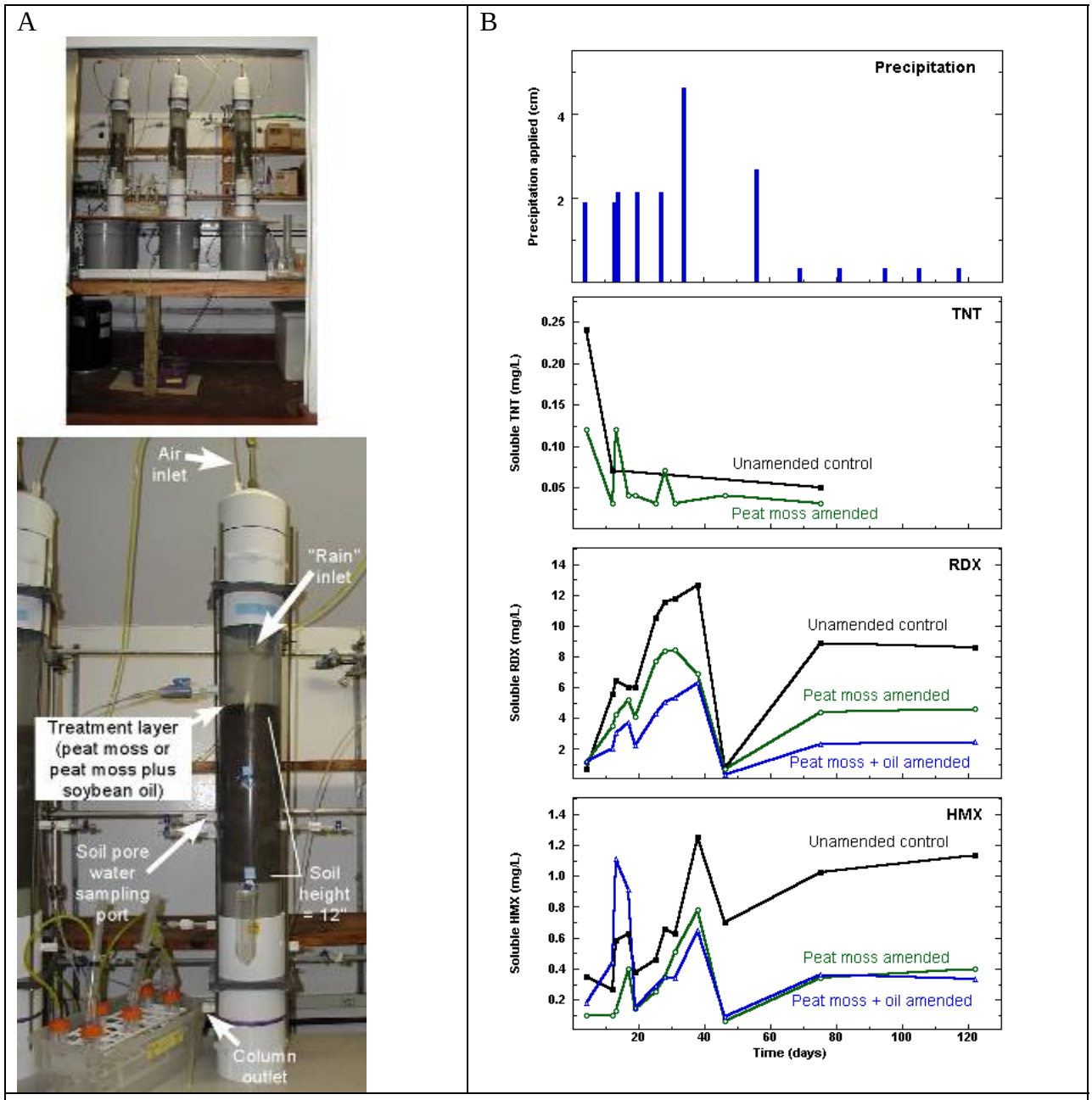


Figure 2.2-4. Results of unsaturated soil column experiments. (A) Unsaturated soil column apparatus for evaluating the in place soil treatments for immobilizing range contaminants. (B) Precipitation events and aqueous concentrations of TNT, RDX, and HMX measured at a depth of 4 inches below the soil surface in columns with no treatment, 0.5 inches of peat moss, or 0.5 inches of peat moss plus soybean oil.

Based on these results, peat moss and a combination of peat moss and soybean oil were tested in unsaturated soil core experiments (illustrated in Figure 2.2-4A). A control column without either amendment was also included in these experiments. Explosives-spiked soil was dispersed at the top of the columns, and artificial precipitation was applied to initiate dissolution and migration of explosives into the columns. Samples of soil pore water wee collected at several depths over the course of four months and analyzed for TNT, RDX, and HMX, and their breakdown products. The results indicated that a 0.5 inch layer of peat moss reduced the concentration of TNT, RDX, and HMX migrating four inches into the soil by about 50% compared to the unamended control core (Figure 2.2-4B). When crude soybean oil was added along with peat moss, no TNT was detected at a depth of 4 inches, and RDX concentrations were reduced to 25% of those observed in the control core (Figure 2.2-4B). At a depth of 8 inches, no TNT was detected in either of the amended treatments and RDX and HMX concentrations declined further. Additionally, the concentration of nitroso-containing breakdown products of RDX and the amino-containing breakdown products of TNT were reduced by the peat moss and the peat moss plus soybean oil in comparison to the control (data not shown).

Additional research was performed focusing on peat moss as the sorbent and crude soybean oil as the cosubstrate/sorbent, examining the transport of explosives through a one inch layer of the proposed soil treatment in small, well-controlled laboratory columns. These experiments were performed at explosives residue loading rates higher than expected under actual field deployment in order to speed up the collection of data needed to model the fate and transport processes (actual “rainfall” rates ranged from about 1 inch per hour, which is comparable to a thunderstorm rain event, to less than ¼-inch per hour, which is comparable to a light to moderate rainfall event). The relatively short residence time of the columns (<12 hours) limited the ability to evaluate biodegradation processes. However, insight was attained regarding physical (i.e., mass transfer) and chemical (i.e., pore water pH) processes. In all cases, column experiments showed that the peat moss and peat moss plus soybean oil treatments significantly reduced contaminant effluent concentrations. Very low concentrations of the breakdown products of TNT and RDX were only observed sporadically in the column effluent, due to either high adsorption of these

compounds by the peat moss and soybean oil, or limited biotransformation of TNT and RDX. These experiments also allowed desorption of sorbed explosives from the treatments to be examined (the influent concentration reduced to zero to allow for desorption). Final analysis of the contents of each of the columns allowed for an estimate of the contaminant mass balance and the reversibility of contaminant sorption in the peat moss and soybean oil matrix.

Simulation results are shown in Figure 2.2-5. These results compared the effectiveness of various treatments in reducing the vadose zone pore water concentrations of TNT and RDX at a depth of 10 feet below ground surface. These simulations were performed using a combination of data obtained during the batch microcosm studies (to determine contaminant mineralization rates) and column studies (to determine mass transfer rates of contaminants in to the various sorbents). Since mineralization rates were used, these simulations likely underestimate the biological component of explosive residue attenuation because significant biotransformation can occur without mineralization. Aqueous concentrations of TNT and RDX entering the treatment layer were assigned values of 54 and 1.5 mg/L, respectively, which are quite reasonable based on published dissolution rates and our empirical data from our laboratory experiments. A rainfall rate of 120 cm/year was used in the simulation (corresponding to the annual rainfall total at MMR).

These simulation results indicated that TNT transport through the subsurface was significantly reduced by addition of peat and soybean oil. This reduction was due primarily to TNT uptake into both the peat moss and soybean oil phases (i.e., short residence time and minimal mineralization of TNT was observed in the batch studies). Simulated RDX transport was also significantly reduced in the presence of the peat moss plus soybean oil mixture, but was only marginally reduced in the presence of peat moss alone. This observation reflected the relatively low partitioning of RDX into peat or soybean oil, coupled with the relatively large biodegradation rate when soybean oil was added to the treatment. Transport of HMX was similar to, but less than, RDX.

Additional studies have evaluated mass transfer and biological processes as a function of rainfall rate, including the effects of intermittent rainfall on overall contaminant transport. Immobile pore water in the peat moss plus soybean oil layer between intermittent rain events tended to increase the residence time of the contaminants, allowing time for biological processes to further reduce dissolved concentrations.

These previous results laid the foundation for the field demonstrations presented in Parts I and II of this Final Report.

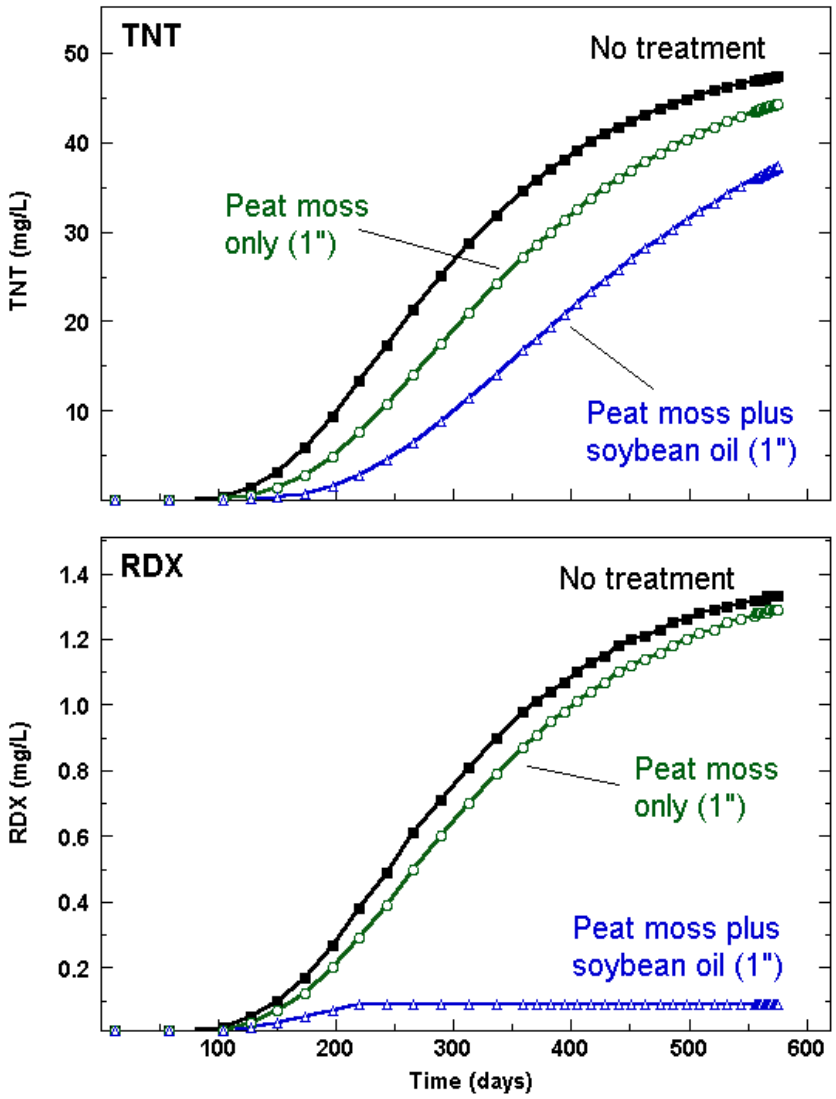


Figure 2.2-5. Modeling of treatment material effectiveness. The results illustrate the predicted reduction in vadose zone pore water concentrations of TNT and RDX at a depth of 10 feet below ground surface with no in place treatment, a one inch layer of peat moss, or a one inch layer of peat moss plus soybean oil. Simulations were performed using a combination of data obtained during the batch microcosm studies (to determine contaminant biodegradation rates) and column studies (to determine mass transfer rates of contaminants in to the various sorbents). A rainfall rate of 120 cm/year, and aqueous concentrations of 54 mg TNT/L and 1.5 mg RDX/L, were used in the simulation (corresponding to the annual rainfall total at MMR).

2.3 Advantages and Limitations of the Technology

The major advantages of this technology are that the components are relatively inexpensive, available in most areas, and environmentally benign. This technology would have the same potential limitations as any of the other technologies being developed for surface application at live fire ranges. The largest currently unknown parameter is how well the technology will perform once it is dispersed, redistributed, and mixed into the soil by detonations. This was one of the main parameters to be assessed during the field demonstrations.

The main factors affecting the cost of the technology are the size of the area to be treated, the availability and cost of bulk quantities of the treatment components (peat moss, soybean oil), and the need for multiple treatment applications over a given period of time. Additionally, the environmental variables at a given site (rainfall, temperature) may also affect the cost and performance by increasing or decreasing both the dissolution and transport of the explosives and the biodegradation rates. Some of these factor began to be assessed during this project in terms of the PMSO effectiveness over periods longer than have been possible to study in the laboratory.

3. PERFORMANCE OBJECTIVES

The GR Demonstration was focused on the evaluation of the compatibility of the PMSO technology with DoD training activities at ranges, with a focus on hand grenade training activities (designated the GR Demonstration). The specific objectives of the GR Demonstration were to:

1) Determine to what extent the PMSO material is redistributed by grenade detonations after being emplaced;
2) Determine any incompatibilities between hand grenade training activities and the PMSO technology, and;
3) Perform an initial assessment of the effectiveness of the PMSO technology for preventing new soil contamination.

In light of the overall demonstration objectives outlined above, the Performance Objectives listed in Table 3-1 were established for this part of the project.

Table 3-1. Performance objectives for this project.				
	Type of Performance Objective	**Primary Performance Criteria**	**Expected Performance (Metric)**	**Actual Performance Objective Met?**
1	Qualitative / Semi-Quantitative	Redistribution of treatment layer	Range maintains a continuous layer of the treatment material after multiple grenade detonations	Yes
2	Qualitative / Semi-Quantitative	Redistribution of treatment layer	Treatment material incorporated into soil profile	Yes
3	Qualitative / Semi-Quantitative	Long term fate of treatment material	Treatment material remains in the treated area with no significant losses due to wind or rainfall	Demonstration terminated early; unable to accurately assess
4	Semi-Quantitative	Effectiveness of treatment layer	50% reduction in new explosives residues in soil with treatment compared to control (composite 0-30 cm depth)	Demonstration terminated early; unable to accurately assess
5	Semi-Quantitative	Effectiveness of treatment layer	50% lower explosive residues at discrete depths with treatment compared to the control	Demonstration terminated early; unable to accurately assess

6	Quantitative	Effectiveness of treatment layer	Sorption capacity of treatment material varies less than 20% over 1 year time frame	Demonstration terminated early; unable to accurately assess

Detailed descriptions of each performance objective are presented in Table 3-2.

NOTE: The demonstration was terminated early, so the samples required to assess performance objectives 3, 4, 5, and 6 were not able to be collected and analyzed. Additionally, the assessment of performance objectives 1 and 2 were limited to the initial days after the PMSO was applied.

However, for completeness of this report, the explanation of each objective, the sample data that would have been required to assess each objective, and the way in which the data would have been interpreted have been included.

Table 3-2. Detailed performance objectives for this project.		
1	**Redistribution of treatment layer** Range maintains a continuous layer of the treatment material after multiple grenade detonations.	
	Explanation	This qualitative / semi-quantitative performance objective was the main focus of this GR demonstration. In order for this technology to be effective at a given site, it needs to remain in place, either as a relatively even intact layer, or mixed into the soil profile within the treated area. The question this performance objective was attempting to answer was, "Will grenade detonations disrupt the PMSO layer to a large extent?"
	Data Collected	The primary data used to assess this performance objective were digital photographs. Photodocumentation was performed immediately after the 10 cm PMSO layer was emplaced in the 10 m x 10 m treated area, and after each of three successive hand grenade training sessions. Photographs were taken from the same vantage points at each timepoint. Markers were included in the photographs to allow exact scales to be determined. Selected areas of the treated area were also photograph from other angles and with different levels of magnification (wide angle vs. telephoto). After the initial three days of photodocumentation, visual reporting from site personnel were used to qualitatively assess the extent of the PMSO treatment layer coverage, accompanied by quarterly photodocumentation of the test area.
	Data Interpretation	Photographs were analyzed qualitatively by eye to assess PMSO coverage extents. The PMSO coverage in selected photographic series was measured by using image analysis software.
	Success Criteria Met?	Yes. After three training sessions and 128 grenade detonations within or near the test area, approximately 88% coverage of the area by the PMSO remained. Although detonations were moving the PMSO around, it appeared that the PMSO was maintained close to the boundaries of the initial treated area.

2	**Redistribution of treatment layer** Treatment material incorporated into soil profile.	
	Explanation	This qualitative / semi-quantitative performance objective was included to answer the question, "Will the PMSO be mixed into the soil due through grenade detonations creation of craters and other mixing effects?" This is important to determine as mixing of the PMSO into the soil profile would help to maintain the treatment materials in the designated area. Based on modeling efforts, it was assumed that the PMSO would be as effective at adsorbing and promoting the degradation of explosive residues if it was present as a single layer or if it was mixed into the soil matrix.
	Data Collected	Part of the data needed to assess this Performance Objective (digital photodocumentation) were the same as for Performance Objective #1. Additionally, 25 randomly placed soil cores were collected over an interval of 0 to 60 cm at the start of the demonstration. Had the demonstration not been terminated, additional cores would have been collected quarterly until the end of the demonstration. Cores were subsampled and analyzed for total organic carbon concentrations (TOC) (as a proxy for PMSO) as a function of depth. Soil cores were also collected from the bay which did not receive PMSO (the control area) and analyzed for TOC.
	Data Interpretation	Photographs were analyzed qualitatively as described for Performance Objective #1. The soil core data would have been analyzed in terms of differences in TOC versus depth over time in the treatment area, as wells as differences in TOC versus depth at a given timepoint in the treated compared to the control area. Higher levels of TOC in the treated soil at various depths would be interpreted as evidence of incorporation of PMSO into the soil profile.
	Success Criteria Met?	Yes/Partial. This criteria was met in terms of the <u>qualitative</u> assessment of the photographs, which clearly documented that the PMSO was being mixed into the soil profile by grenade detonations. Craters formed by one detonation would then have PMSO from the surrounding area fall into it when another grenade

		detonated nearby. However, a semi-quantitative assessment of this Performance Objective based on the TOC profiles in soil cores over time, and in the treated versus the control areas was not possible due the early termination of the demonstration.

3	**Long term fate of treatment material** Treatment material remains in the treated area with no significant losses due to wind or rainfall.	
	Explanation	This qualitative / semi-quantitative performance objective was directed at providing an answer to the question, "Will weather conditions prohibit the PMSO material from staying where it was placed?" This is an important question to answer both in terms of knowing how frequently the PMSO may need to be rejuvenated or replaced, as well as to assess if there is the potential for off-site migration of explosive residues on the PMSO if it is transported buy runoff or wind.
	Data Collected	25 point bulk soil composite samples (collected from 0 to 15 cm) were collected at the start of the demonstration. Had the demonstration not been terminated, additional cores would have been collected quarterly until the end of the demonstration. Cores were subsampled and analyzed for total organic carbon concentrations (TOC) (as a proxy for PMSO) as a function of depth. Soil was also collected from the bay which did not receive PMSO (the control area) and analyzed for TOC.
	Data Interpretation	The soil data would have been analyzed in terms of differences in TOC over time in the treatment area, as wells as differences in TOC at a given timepoint in the treated compared to the control area. Higher levels of TOC in the treated soil would be interpreted as evidence of the continuing presence of PMSO in the soil.
	Success Criteria Met?	The assessment of this Performance Objective based on the TOC in the soil over time, and in the treated versus the control areas, was not possible due the early termination of the demonstration.

4	**Effectiveness of treatment layer** 50% reduction in new explosives residues in soil with treatment compared to control (composite 0-30 cm depth).	
	Explanation	This semi-quantitative Performance Objective was included to provide data for an initial assessment of the overall effectiveness of the PMSO technology with respect to maintaining lower explosive compound concentrations than untreated soils when it was deployed at an actual active training range under real-world conditions.
	Data Collected	25 point bulk soil composite samples (collected from 0 to 15 cm) were collected at the start of the demonstration Had the demonstration not been terminated, additional cores would have been collected quarterly until the end of the demonstration. Samples were analyzed for total explosive compound concentrations. Soil was also collected from the bay which did not receive PMSO (the control area) and analyzed for total explosives.
	Data Interpretation	The soil data would have been analyzed in terms of differences in total explosives over time in the treatment area, as well as differences in explosive compound concentration at a given timepoint in the treated compared to the control area. Lower average levels of explosive compounds in the treated area soil compared to the control area soil would be interpreted as evidence of the continued effectiveness of the PMSO.
	Success Criteria Met?	The assessment of this Performance Objective based on the explosive compound concentrations in the soil over time, and in the treated versus the control areas, was not possible due the early termination of the demonstration.

5	**Effectiveness of treatment layer** 50% lower explosive residues at discrete depths with treatment compared to the control.	
	Explanation	This semi-quantitative Performance Objective was included to provide data for an initial assessment of the how effective the PMSO technology would be in keeping the concentrations of explosive compounds at different depths lower than observed in untreated areas when it was deployed at an actual active training range under real-world conditions.
	Data Collected	25 soil core samples (collected from 0 to 60 cm) were collected at the start of the demonstration. Had the demonstration not been terminated, additional cores would have been collected quarterly until the end of the demonstration. Samples were analyzed for total explosive compound concentrations. Soil was also collected from the bay which did not receive PMSO (the control area) and analyzed for total explosives.
	Data Interpretation	The soil core would have been analyzed in terms of differences in total explosives versus depth over time in the treatment area, as wells as differences in explosive compound concentration versus depth at a given timepoint in the treated compared to the control area. Lower average levels of explosive compounds at each depth in the treated soil would be interpreted as evidence of the continued effectiveness of the PMSO.
	Success Criteria Met?	The assessment of this Performance Objective based on the explosive compound concentrations versus depth in the soil profile over time, and in the treated versus the control areas, was not possible due the early termination of the demonstration.

6	**Effectiveness of treatment layer** Sorption capacity of treatment material varies less than 20% over 1 year time frame.	
	Explanation	This quantitative Performance Objective was designed to determine how the effectiveness of the actual PMSO material might change as it is exposed to the elements (heat, precipitation), grenade detonations, and deterioration (biological, UV). The data collected was meant to answer the question, "For how long will PMSO maintain its ability to immobilize and promote the degradation of explosive residues when it is deployed at an active range under real-world conditions?"
	Data Collected	Bulk soil samples (25 composites) from the treated areas were collected initially. Had the demonstration not been terminated, additional cores would have been collected quarterly until the end of the demonstration. Subsamples of the soil were to be extracted and analyzed for total explosive concentrations. Subsamples would also be homogenized and placed into small columns. The explosives in the soil would be leached out using artificial rainwater, and the leachate would be analyzed for explosives using HPLC.
	Data Interpretation	The amount of leachable explosives in the PMSO-treated soil, as a function of the total explosives present, would have been calculated for each sampling timepoint. Differences in the ratio of leachable to total explosives in the soil of less than 20% over one year would be interpreted as evidence of the continued effectiveness of the PMSO for adsorbing the explosives.
	Success Criteria Met?	The assessment of this Performance Objective based on the sorption capacity of the PMSO-amended soil for TNT and RDX was not possible due the early termination of the demonstration.

4. SITE DESCRIPTION

4.1 Selecting Test Site

The criteria developed during the site selection process are presented in Table 4.1-1.

Table 4.1-1. Site Selection Criteria.

Parameter	Preferred Value(s)	Relative Importance (1, high - 5, low)	Site 1	Site 2
Frequency of training activities	Regular/frequent	1	Frequent	Infrequent
Training schedule	Breaks to allow site access for sampling	1	Yes	Yes
Site access	Accessible for bark blower / mulch spreader	2	Yes	Yes
UXO	None	2	None	(None)
Multiple grenade range areas or “bays”	At least 2	2	Yes	Yes
Existing explosive residues	None or low	3	Low	(Low)

Site 1: Fort Jackson, SC
Site 2: Fort McCoy, WI

Based on these criteria, Fort Jackson was chosen as the preferred site for the GR field demonstration. Fort Jackson was willing to provide the needed support and site access to achieve the project objectives, as well as being a site which was hosting at least one other innovative technology evaluation.

4.2 Site Location and History

Fort Jackson is a 21,000 hectare (52,000 acre) installation located in central South Carolina, situated northeast of the state capital Columbia (see maps Figure 3.3-1). Fort Jackson was established in 1917 as an infantry training center, originally built on 485 hectares (1,200 acres) donated by the City of Columbia. After World War I, Fort Jackson was demobilized as a full-time training site, and the post was state-controlled as a training area for troops of the South Carolina National Guard. The installation was returned to Federal control in 1940 for U.S. Army infantry training for World War II (WWII). During WWII, the fort was expanded to approximately its present size. Following WWII, the Fort was used to station various U.S. Army Divisions. The Fort has been an active U.S. Army Basic Training Center since 1973 (9).

Fort Jackson is the U.S. Army's premier basic training facility where 35,000 to 40,000 soldiers complete basic training annually. Several thousand buildings are present at Fort Jackson, the majority of which occupy a 5 square km (3 square mile) region in the southeastern quadrant of the Fort (the cantonment area). The remaining areas of the site are mainly training areas and ranges (9).

The GR technology demonstration was conducted at Remagen Range at Fort Jackson (see map Figure 3.3-1). Remagen Range is a Grenade Familiarization Range – Live (FCC 17883). The primary munitions used are live fragmentation hand grenades. Remagen range receives heavy annual use, with approximately 33,000 live hand grenades thrown each year.

The range consists of four open bays consisting of a throwing pit and a group of approximately five upright targets placed 30 meters (~100 ft) from the pit. Grenades impacts are concentrated in a 10-meter (~30 ft) diameter area in front of the targets. This area was characterized by impact craters as deep as 60 cm (2 ft) of generally uncompacted soil. The soil was a clay sand mix with low to moderate soil permeability. The area was nonvegetated. A photograph of one of the bays is presented in Figure 4.2-2.

Figures 4.2-1. Maps of Fort Jackson, S.C. and the surrounding area.

Adpated from Public Domain map source and http://yellowpages.superpages.com/supermaps/geoinit.jsp?STYPE=S&map.x=212&map.y=125&GV=0&streetaddress=4394+Strom+Thurmond+Blvd&city=Columbia&state=SC&POI1name=Fort+Jackson

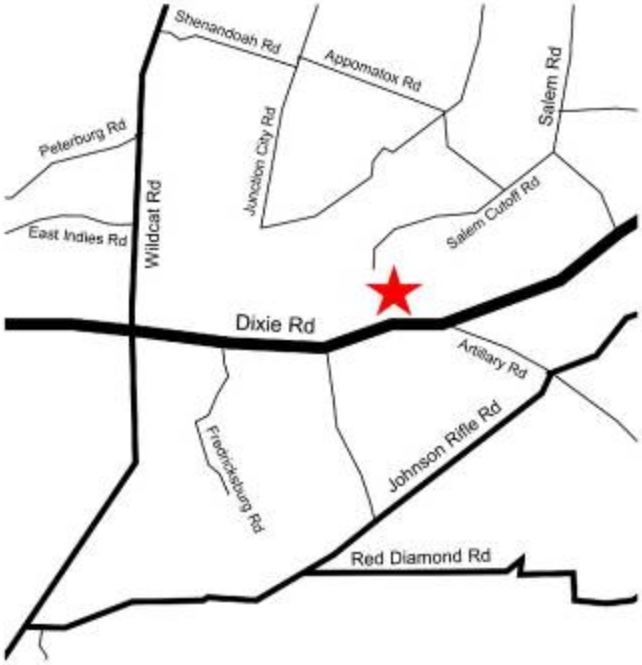


Figure 4.2-2. Photograph of one of the bays at the Fort Jackson hand grenade training range.

The Remagen Hand Grenade Range at Fort Jackson was currently under no regulatory drivers regarding explosive compound residues, and therefore there were no existing full-scale remedial operations in progress.

The Remagen Range is actively used for hand grenade training, so access was mainly limited to weekends from April through October. Additionally, an ESTCP field demonstration (ER-0216, "Grenade Range Management Using Lime for Dual Role of Metals Immobilization and Explosives Transformation") being directed by Dr. Steve Larson was underway in two of the four bays at the Remagen Range. Consultation, and potential collaboration, with project ER-

0216 was undertaken to minimize any cross-project interferences, as well as to maximize any benefits that could be gained from sharing data and coordinating sampling of the control (no treatment) areas.

4.3 Site Geology/Hydrogeology

Due to the limited extent of the project, no extensive investigation was performed regarding the site geology and/or hydrogeology of the Remagen range. A more complete description of Fort Jackson's hydrogeologic setting was presented in the Field Demonstration Plan for ESTCP Project ER-0216, "Grenade Range Management Using Lime for Dual Role of Metals Immobilization and Explosives Transformation", compiled by Dr. Steve Larson.

4.4 Contaminant Distribution

The contamination at the Remagen range was limited to the grenade training bays. A preliminary assessment was performed and presented by Dr. Steve Larson during ESTCP Project ER-0216, "Grenade Range Management Using Lime for Dual Role of Metals Immobilization and Explosives Transformation". Contamination consisted mainly of explosive residues (RDX) and some metals (Fe, Zn). Based on other work characterizing contaminants hand grenade training ranges (7), it was expected that the concentrations were highest in the middle of each training bay were the majority of the grenades detonate, and likely extended to depths of up to 60 cm. However, the hard clay soils at Fort Jackson probably limited the movement of particulate residues into depths greater than 15-30 cm.

5. TEST DESIGN

5.1 Conceptual Experimental Design

Demonstration Design for GR Demonstration

The GR demonstration was performed under field conditions, and the basic demonstration design was as follows:

1) The demonstration was performed at the Remagen Grenade Training Range at Fort Jackson, SC
2) An area in one of the training bays that corresponded to the location where the majority of grenade detonations occur received a layer of peat moss/soybean oil (PMSO). The corresponding area in another training bay did not receive any treatment materials and served as a control.
3) Grenade training activities resumed.
4) Digital photographs of the treated area were collected. The photos underwent image analysis to determine the percent area coverage and horizontal movement of the PMSO in response to grenade detonations.
5) The results were analyzed, specifically looking at how well the integrity of the treatment layer was maintained during training activities.

NOTE: The following aspects were part of the original demonstration design, but were not able to be implemented due to early termination of the GR Demonstration.

6) Soil core samples were collected to determine the extent of vertical mixing of the PMSO into the soil.
7) Samples of the treatment material were collected to determine the leachability of any immobilized explosive residues that have accumulated.

8) Soil samples from the treated and untreated areas were collected and analyzed for explosives concentrations to assess to what degree the treatment material has reduced the loading of explosive residues to soil.
9) The results were analyzed, specifically looking at how effective the treatment material was for reducing new soil contamination with explosive residues.

5.2 Baseline Characterization

Some baseline data already collected during project ER-0216 indicated that the concentrations of explosives in the grenade range soils were quite low and very heterogeneous. For instance, the overall RDX concentration across all the bays was 2.8 ± 1.9 mg/kg, and the soil RDX concentrations in the two bays that were available for this demonstration (Bays 1 and 3) were 3.5 ± 2.1 and 3.0 ± 1.2 mg/kg, respectively (ER-0216, Field Demonstration Plan, Table 2). These data also suggested that care needed to be taken to collect enough samples during the demonstration to allow significant differences in concentrations between the control and treatment bays to be detected even with the high degree of explosive residue heterogeneity.

Additional soil samples from the two training bays to be used in this demonstration were obtained prior to the application of the treatment materials. Both composite and soil core samples were collected and analyzed for explosive concentrations and total organic carbon to establish a baseline for qualitative/semi-quantitative comparison with samples collected over the duration of the demonstration.

5.3 Treatability or Laboratory Study Results

The main laboratory treatability results were presented in a previous reports submitted to ESTCP:

- "Treatment of Explosives Residues from Range Activities (ER-0434) - Treatability Study Report", December 2006

A question regarding the potential for the PMSO igniting and burning due to grenade detonations was raised during the preparation of the Field Demonstration Plan. To address this concern, additional laboratory testing was performed.

Briefly, the ignitibility of peat moss, peat moss plus soybean oil, and soybean oil was tested under laboratory conditions. Testing was done with the peat moss or peat moss plus soybean oil in a very dry and a moderately wet state. Both an open flame (butane-type lighter used for lighting candles, barbecues, etc.) and a hot metal wire (steel wire heated till it was glowing orange in a bunsen burner) were used as sources of ignition. These sources were meant to represent the fireball during grenade detonations, and the hot metal grenade fragments. The ignition sources were held near or directly touch to the test materials and the results were filmed.

Although there was some smoldering observed, it was markedly less with the combined peat moss plus soybean oil than with the peat moss, it quickly self-extinguished. No open flames were ever observed. Based on this information, it was deemed that under normal grenade training activities that the PMSO material would not burn.

5.4 Design Layout of Technology Components

There was no specially designed instrumentation required for this demonstration. Wells were not emplaced, nor was any site engineering required. All operational details are provided in Section 5.5 below.

5.5 Field Testing

Detailed descriptions of each phase of mobilization are described below. The general mobilization activities were as follows:

- All site-specific reviews and clearances were obtained. The site was also be checked for UXO and cleared as required.

- The peat moss and soybean oil were delivered directly to Fort Jackson prior to the project.
- Equipment for applying the treatment materials was rented locally.

Site Preparation

Site activities were coordinated with Fort Jackson hand grenade management personnel. The grenade range undergoes periodic maintenance to re-grade the surface, fill in craters, etc. Every effort was be made to coordinate the collection of pre-demonstration soil samples and the application of the treatment material with the range maintenance activities.

PMSO Materials Acquisition

Horticulture grade, *Sphagnum* peat moss was obtained from a local home and garden center. The best means of purchasing and delivering the peat moss to Fort Jackson was determined to be buying the material in 2.2 cu ft. bags. Since a total of about 10 cubic meters (350 cubic feet) was required, a total of 85 bags were purchased. The peat moss was used bag "wet", but all calculations were performed using the peat dry weight basis. Peat moss water content was determined on a subsample prior to mixing and applying the PMSO. A total of 1200 lbs of crude soybean oil was purchased from Grain States Soya, Inc. (West Point, NE, USA) and shipped to the site in three 55 gallon plastic drums.

Treatment Layer Preparation

The PMSO mixture was prepared in a ratio of peat moss and crude soybean oil of 1:1 (w:w). The PMSO was prepared in batches using a small tow-behind plastic drum gas cement mixer (9 cu. ft capacity). Peat moss bags were weighed, and then emptied into the drum. The amount of oil required was then weighed out into a bucket and dumped into the drum. An average "recipe" consisted of two bags of peat moss plus one 5 gallon bucket of soybean oil, although each batch was mixed specifically to achieve the 1:1 (w:w) ratio based on the weights of each bag of peat moss added to the mixer. The peat and oil was then mixed until it was judged that the oil had thoroughly combined with the peat moss. Photographs of the PMSO preparation are presented in Figure 5.5-1.

Treatment Layer Application

The bays at Remagen that were used for the demonstration were: Bay 1, Treatment applied; Bay 3, Control. According to the Cadre, these two bays are used to a comparable degree by "short" throwers, and hence experience a similar number of grenade detonations over a given period of time.

The treatment material were applied to achieve a uniform 10 cm (4") thick layer across a 10 x 10 m (~33 x 33 ft) area centered in the area of Bay 1 where most of the detonations occur (based on the distribution of cratering). PMSO was applied by dumping the contents of the cement mixer, moving the mixer forward/backward/sideways, and repeating the process until the entire area was covered. A plumb line and grid system on the outside of the area allowed the PMSO to be roughly applied at the appropriate depth and location. Areas of excess or deficit in the layer were later manually redistributed using a rake. The area covered with the treatment material was approximately 100 square meters (~1000 square feet). Photographs of the PMSO application process are presented in Figure 5.5-2. PMSO was applied on 22 May 2007.

Post-Application Activities

Hand grenade training activities began again on 23 May 2007. Photographs of the PMSO interactions with some of the grenades is presented in Figure 5.5-3.

During an EOD effort on 24 May 2007 to detonate a dud grenade, a large amount of C4 was used. The flaming fragments from this larger detonation initiated some smoldering of the PMSO layer (Figure 5.5-4) that required the application of water to completely extinguish. To avoid and/or minimize the potential for subsequent ignition issues, a decision was made to till the PMSO into the top layer of soil (Figure 5.5-5)

The only potential residue from this demonstration was the peat moss material remaining on and in the range surface at the conclusion of the demonstration. Given that this material was a

natural soil amendment, and that it would slowly breakdown over time, it was not expected that this material would be needed to be removed and/or disposed after the demonstration. Once the initial mobilization and set-up was complete, the only labor requirements were be for sample collection and analysis (quarterly).

Figure 5.5-1. Photographs depicting the preparation of the PMSO material.

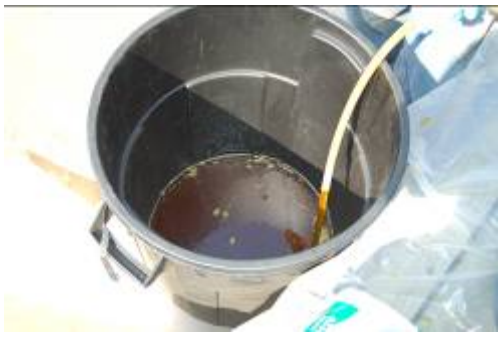
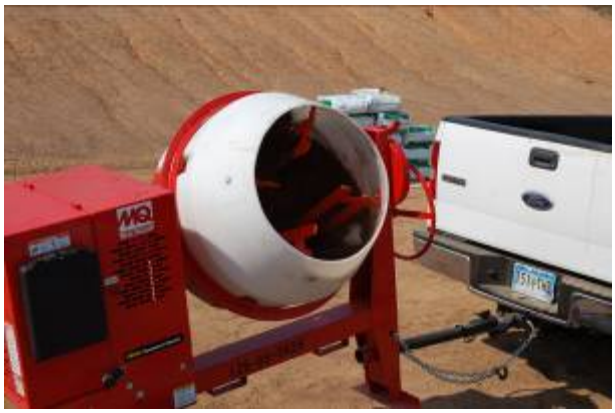
Peat staged around test area 	
Transfer of oil from drum to small vessel 	
Adding peat to cement mixer 	**Batch of PMSO mixing** 

Figure 5.5-2. Photographs showing the application of the PMSO material to Bay 1.

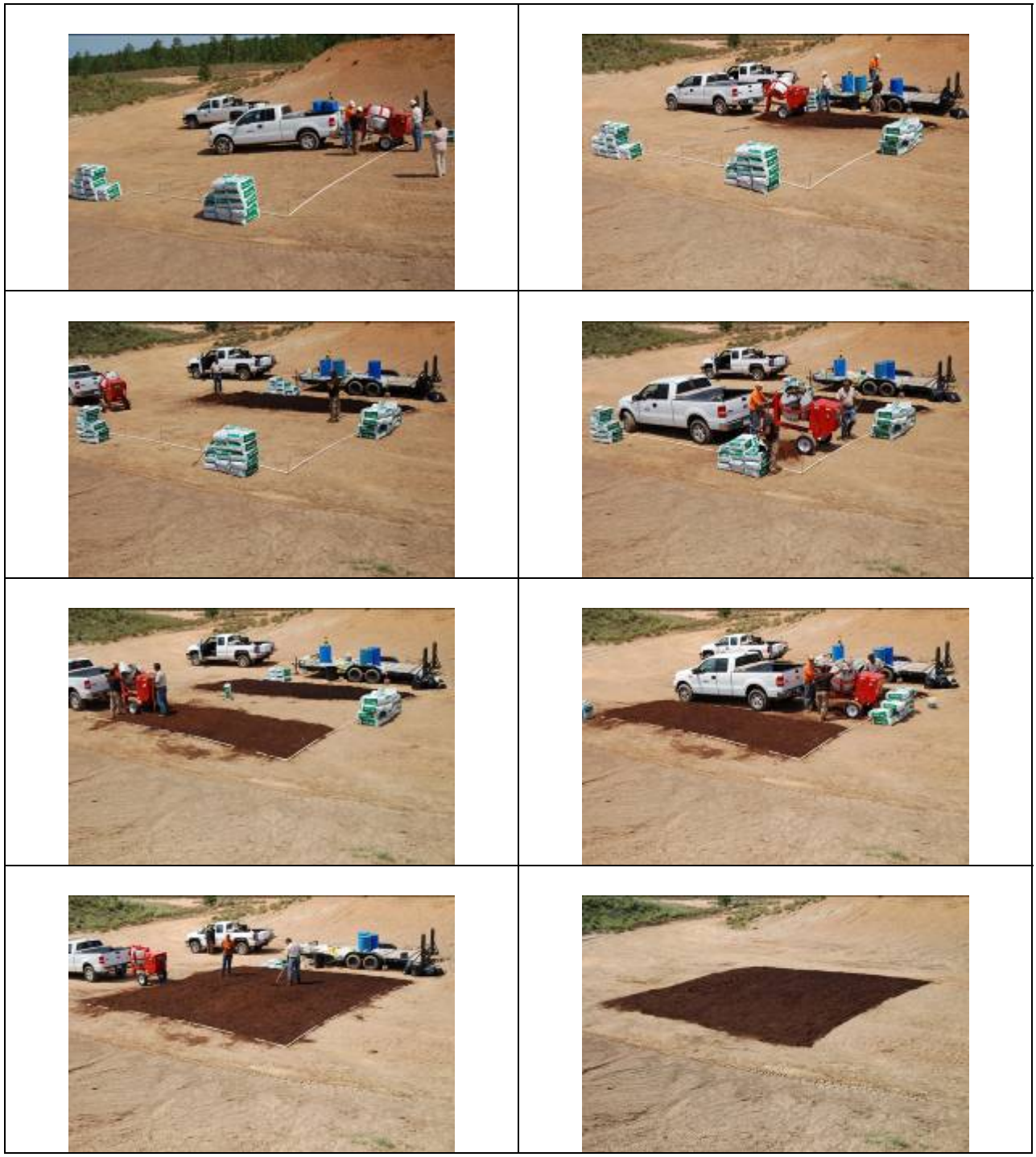


Figure 5.5-3. Photographs showing a grenade detonations on the PMSO layer in Bay 1.

Figure 5.5-4. Photographs showing smoldering and extinguishing of the PMSO layer in Bay 1 after EOD activities.

Figure 5.5-5. Photographs showing the PMSO layer being tilled into the soil in Bay 1.

(pre-till)

5.6 Sampling Methods

The sampling plan developed for this field demonstration was designed to meet the data needs required for 1) evaluating the technology performance with respect to the performance objectives listed in Table 3-1, and 2) comparing the actual field data to the predicted explosive residue fate and transport based on modeling. Additionally, given the variable nature of field demonstrations with respect to weather conditions, the sampling plan was designed to be flexible while still delivering high quality, accurate data. The data collected are relevant only to the actual field demonstration being conducted, but did provide supporting data for future decisions by range management personnel who may be considering deploying this technology, and should provide a basis for regulatory agency acceptance of the technology.

5.6.1 Personnel

All samples collected during this demonstration were collected by Shaw Environmental, Inc. The personnel performing the sampling followed established sampling protocols and given additional training as needed.

5.6.2 Sample Types & Methodology

The samples and data that were collected during the demonstration are presented in Table 5.6.2-1. Due to the early termination of the GR Demonstration, quarterly sampling events did not occur (shaded areas of Table 5.6.2-1) and only in initial samples before the PMSO was applied were collected.

Table 5.6.2-1. Treatability test matrix for the GR demonstration. The following sample types were collected at the designated sampling frequencies. ***SHADED items indicates sampling and/or analyses were planned but not performed due to early termination of the demonstration. Sampling occurred only during mobilization (pre-PMSO application).***

Sample type	Samples per area	Areas sampled	Analytes	Frequency	Rationale
Digital images	multiple	-Control -Treatment	-area coverage	Pre- and post-training, TBD	-Assess horizontal redistribution of treatment materials by grenade detonations
Soil samples (25 point composite)	5	-Control -Treatment	-explosives -TOC -explosives leachability	Quarterly	-Monitor loading of new residues from grenade detonations to soil (semi-quantitative secondary criteria) -Assess effectiveness of entrained treatment materials
Soil corings (shallow, 0 to 15 cm)	25	-Control -Treatment	-TOC -explosives	Quarterly	-Assess vertical mixing of treatment material with soil by grenade detonations -Monitor loading of new residues from grenade detonations to soil (semi-quantitative secondary criteria)
Soil corings (deep, 0 to 60 cm)	25	-Control -Treatment	-TOC -explosives	Pre- and post-demonstration	-Assess vertical mixing of treatment material with soil by grenade detonations -Monitor loading of new residues from grenade detonations to soil (semi-quantitative secondary criteria)

5.6.3 Sampling Rationale

The rationale for the sample parameters listed in Table 5.6.2-1 was as follows:

Digital photographs for image analysis

Digital images of the training bay that received the treatment material were collected from different vantage points (differing in elevation and/or location) to be determined based on discussions with Fort Jackson range management. Some vantage points were the same between tests to allow assessment of the layer over the duration of the demonstration, while some vantage points varied between tests based on the initial image analysis results. A visual assessment by the personnel performing the sampling was performed to allow corroboration with the results of the image analysis (i.e., ground truth the image analysis results).

Photographs were taken that included objects of known size (cardboard boxes painted bright orange) to allow determination of scale during later processing. White paper sheets were also included so that white balance differences due to changes in solar illumination (cloudy vs. direct sun) could be corrected for later on.

Images were collected pre- and post-training within a timeframe that minimized the potential of non-training impacts on the movement and transport of the treatment material (i.e., wind, precipitation).

Bulk soil

Grab samples of the soil were collected from the control and treatment training bay before the PMSO was applied and analyzed for explosive concentrations. A total of five grab samples were collected, and each consisted of point samples from 25 random locations throughout the bay, according to the sampling protocols included in Appendix B of this part of the report. Soil was collected from the top 30 cm (12”) of the soil at each location.

Soil cores.

Approximately twice per month the soil in the bays is graded with a backhoe scoop to backfill craters and level the target area. The soil is a very dense red clay. It is compacted by the backhoe use, and is only easily sampled by hand tools below about 15 to 17 cm (6”-8”) in areas disrupted by the grenades and backfilled by the grading. Therefore, soil core samples were obtained by use of a truck-mounted geoprobe rig. Cores were collected prior to application of the treatment materials, and analyzed for total organic carbon and explosive concentrations.

5.6.4 Sample Identification and Handling

Each sample collected was given a unique identifier. At a minimum, the sample was labeled with the project name, the location from which the sample was taken, and the date or sample timepoint.

The following designations/abbreviations were used throughout the project for samples from the:

Project Identifier	GR
Bay Identifier	C, control; T, treatment
Date Format	mmddyy
Time Format (digital images)	hhmm (24 h)
Location (digital images)	1, 2, 3, 4 (TBD)
Depth (core samples)	1 thru 6

The composite soil samples and soil core samples were identified as “Area Identifier-#” where the number represented the replicate. Digital images files were named using the following format: “GR-T-Location-Date-Time”. Subsamples from within the soil cores were collected in 5 cm (2”) intervals and were further identified with the depth identifier

Chain-of-Custody (CoC), Recordkeeping, and Shipping

Samples collected for delivery to Shaw Environmental laboratories were shipped and logged using standard Shaw procedures and forms. A sample of the standard Shaw CoC is included in Appendix B. Samples were logged into a field logbook during/after collection. Samples

received by Shaw laboratories were logged into a designated project sample logbook. Samples collected for delivery to an outside analytical laboratory were logged into the field logbook and shipped and logged using the forms required by the laboratory.

Samples were carefully wrapped with bubble wrap (or other applicable shipping materials) and shipped in plastic coolers by a commercial carrier priority overnight in ice.

Holding Times

Field samples from this ESTCP project were given priority for processing and analysis. The time between receipt of samples from the field and sample processing (sample drying and extraction) was as short as possible. The samples were air dried to minimize any biological activity during storage prior to extraction and analysis. If instrument problems or other issues preclude immediate analysis of the extracts, the samples were stored at 4°C in the dark until the analysis can be performed.

Sampling Schedule

The sampling schedule was designed to provide high sampling density with respect to determining how the treatment layer material was redistributed by training activities. The basic sampling interval for other parameters was quarterly, but due to the early termination of the demonstration, only the initial samples were collected.

5.6.5 Sample Analysis.

The main focus of this field demonstration was determination of the redistribution and weathering of the treatment material under live hand grenade training conditions. The key analyses was processing the digital images documenting the treatment movement. Due to the early termination of the demonstration, only the first three training sessions after the PMSO was applied was fully photodocumented. Additionally, the analysis of soil core samples to assess the vertical mixing of the treatment into the soil profile was not possible, nor was an assessment of the sorption and/or biodegradation capacity of the PMSO over time.

The analyses and analytical methods that were employed during this demonstration are summarized in Table 5.6.5-1 below.

Table 5.6.5-1. Analytical methods employed during this project. SHADED items indicates sampling and/or analyses were planned but not performed due to early termination of the demonstration. Sampling occurred only during mobilization (pre-PMSO application).

Analyte	**Method**	**Instrumentation**	**Detection limit (or accuracy)**	**Units**
Field				
Digital imaging - test area	-	digital camera	-	%coverage
Digital imaging - soil cores	-	digital camera or scanner	-	-
Laboratory				
Explosives	SHAW ORG-006A[a]	HPLC	0.025	mg/L or mg/kg
Total organic carbon (TOC)	EPA Method 415.1	thermal combustion	0.1	mg/kg
	Loss On Ignition (LOI)[b]	combustion	0.5	%

[a]Shaw Environmental, Inc. performs a modified EPA Method 8330 for in-house explosive compound analysis. The method includes the standard EPA Method 8330 analytes, as well as the primary RDX breakdown products MNX, DNX, TNX, for which semi-quantitative standards are used.
[b]An alternative "loss on ignition" method for determination of peat moss in bulk soil may be substituted for EPA Method 415.1. This method allows larger samples to be analyzed, thereby reducing the bias introduced by small sample sizes.

Image analysis

An example of the type of image analysis that was performed is presented in Figure 5.6.5-1. Images from the same vantage point, taken under similar lighting conditions (i.e., at the same time of day pre- and post-training) was processed using the program ImageJ (v1.35p, National Institutes of Health; public domain) or equivalent software. Given the light color of the soil at the Fort Jackson grenade range and the relatively dark color of the peat moss plus soybean oil treatment materials, the contrast between covered and uncovered areas should be robust.

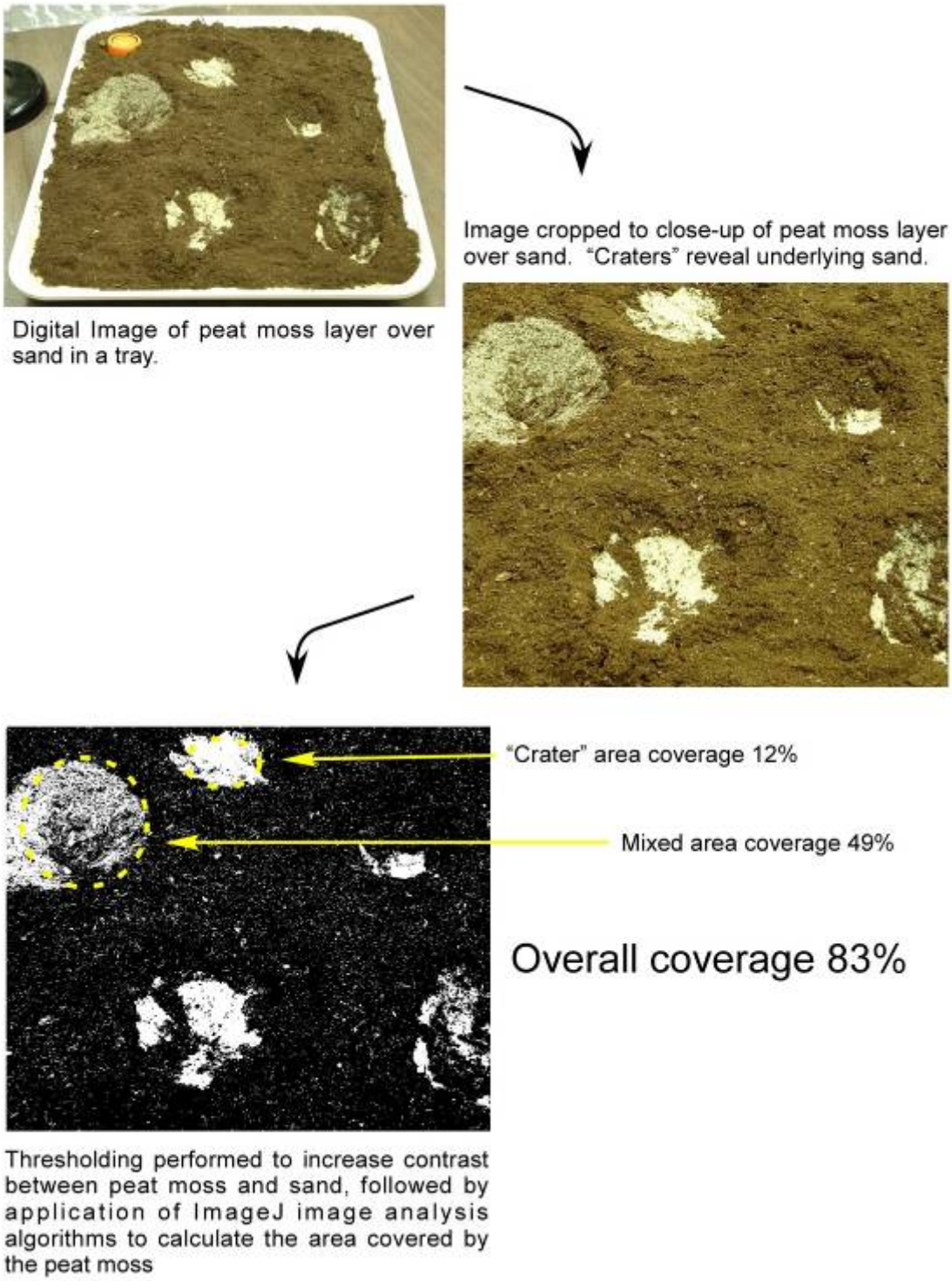
Bulk soil analysis

The 25-point composite soil samples were analyzed for total organic carbon and explosives concentrations. Soil was air dried and metallic metal shards were removed with a magnet. The entire sample was pulverized for in a liquid-nitrogen chilled A-11 analytical mill (IKA Works, Inc., Wilmington, NC, USA), with each soil portion (~25 g) being ground for 2 bursts of 30 s each using a A11.1 basic cutting blade. The total organic carbon analysis was performed according to EPA Method 415.1 and explosive compound extraction and analysis were performed in-house according to a modified EPA Method 8330 (see Appendix D, Part II of this report).

Soil core analyses

The soil cores were analyzed for the vertical distribution of total organic carbon and explosives concentrations. Cores were gently extruded in 2.5 to 5 cm intervals (1” to 2”) into pre-labeled sample jars. Soil in each core segment was dried, ground and analyzed for total organic carbon and explosive compound concentrations as described above for bulk soil.

Figure 5.6.5-1. Example of digital image analysis process using ImageJ software.



5.6.6 Experimental Controls.

The experimental controls for this field demonstration was an area of the hand grenade range that was designated as a control and did not receive any of the peat moss/soybean oil treatment material. Communication with Fort Jackson personnel highlight the importance of having equivalent training activities occur (i.e., the same number of grenades detonated) in both the control and treatment bays.

5.6.7 Data Quality Parameters.

Data quality parameters to ensure the representativeness, completeness, comparability, accuracy, and precision of the data were described in the QAPP, Appendix D of the Part II of this report.

5.6.8 Calibration Procedures, Quality Control Checks, and Corrective Action.

All reasonable and necessary calibration procedures, duplicate and control testing, and data reduction and reporting were performed as described in the QAPP, Appendix D of the Part II of this report.

The most important data from this demonstration are those related to the redistribution of the treatment layer during training activities. Multiple digital photos were collected during each sampling event to allow selection of the best images for further analysis.

For explosive concentrations in soil samples via HPLC a standard curve was generated every three months using known concentrations of the EPA Method 8330 explosive standards. Qualitative retention time standards were included with every batch of samples analyzed. A new standard curve was generated in the event of an HPLC column replacement, detector replacement or repair, or in the event of other major repairs. Routine maintenance of the HPLC was performed as recommended by the HPLC manufacturer.

HPLC data (chromatograms) from each sample was examined visually, and the sample was re-analyzed if deemed necessary. Peaks that were clearly visible but which were not automatically

integrated were manually integrated using the HPLC software. Hardcopies of HPLC data were retained for the duration of the project, and digital HPLC data files were backed-up to CD/DVD.

HPLC data (concentration, µg/kg) were entered into Microsoft Excel for analysis and compilation. Concentrations falling below the detection limit were reported as either "0" or "BD", depending on the use to which the data were used (i.e., for some data presentations like graphing, a value of "BD" is not included in the graph and a zero is required).

Based on previous experience, the most common data entry errors are placing retention time and area count data in the wrong column of the spreadsheet, and errors in which the decimal point is mistyped. These type of errors readily become evident when data is compiled and examined across treatments or over time. Errors during data entry were corrected by referring to the original datafiles/printouts.

5.6.9 Data Quality Indicators.

Data quality indicators were described in the QAPP, Appendix D of Part II of this report.

5.7 Selection of Analytical/Testing Methods and Analytical Laboratory

The key focus of this GR field demonstration was the redistribution of the treatment layer material in response to the detonation of grenades. This assessment was performed by image analysis of digital images (horizontal movement of treatment material). There were no "standard" methods applicable for this type of image analysis, but sufficient controls (scale standards, white balance sheets) were included to assure the data collected would be accurate.

All other analytical procedures were performed according to established Standard Operating Procedures and EPA Methods (where applicable).

The primary analyses for this demonstration was performed in-house by Shaw. Shaw laboratory personnel have the required expertise, experience, and analytical instrumentation to analyze the samples for explosive concentrations. Samples submitted for TOC were handled by Shaw's Analytical Testing Laboratory, 17 Princess Road, Lawrenceville, NJ 08648.

5.8 Sampling Results

Due to the early termination of this demonstration, the bulk of the data collected consisted of the pre- and post-training digital images that were collected during the first three days after the PMSO was applied at the Remagen range.

We also were able to collect the pre-application bulk soil and soil core samples from the treatment area (Bay 1) and the control area (Bay 2). The data is only briefly summarized in this report because the lack of post-application quarterly samples severely limited the ability to assess the PMSO redistribution via TOC or the PMSO effectiveness.

5.8.1 Image analysis

A series of images of the PMSO layer in Bay 1 taken pre- and post hand grenade training sessions are presented in Figure 5.8.1-1. These photographs were taken from The number of grenades detonated in Bay 1 and the percent coverage, based on image analysis, is also given. Figure 5.8.1-2 presents the four images of the PMSO (pre, post 1, post 2, post 3) after they had been processed (white-balance correction, decolorized, integration area specified, etc.) for image analysis.

The image analysis indicated that the PMSO layer coverage was not immediately and drastically reduced by the grenade detonations. While PMSO material was removed from some areas, it was redistributed to others. This is the likely reason why the areal coverage slightly increased between the second and third training sessions, as PMSO that had been removed and/or piled up in some areas during training event 2 was moved back during the latter grenade training event 3. Figure 5.8.1-3 presents some additional images of areas of the PMSO layer that were impacted

by the grenade detonations in Bay 1. It was apparent from these images that the PMSO layer's coverage was not significantly decreased by the detonations, as the treatment materials were observed to fall back and fill in the craters during subsequent detonations. Also, the total area covered actually increased as the PMSO was moved beyond it original boundaries. (NOTE: This spreading was not included in the image analysis; only the initial 10 m x 10 m area was analyzed.)

Figure 5.8.1-4 shows an additional photograph of Bay 1 after four months of grenade training. A total of 2500 grenades had been detonated, as well as 8 grading events. This images was not able to be used for image analysis due to the different vantage point. However, it was quite obvious that the grenade detonations and grading activities had basically buried the PMSO under the soil in the Bay.

Figure 5.8.1-1. Photographs of the PMSO treatment layer in Bay 1.	
	Time: Pre-Training 1 Date: 23 May Grenades: 0 Coverage: 100%
	Time: Post-Training 1 Date: 23 May Grenades: 32 Coverage: 95%

	Time: Pre-Training 2 (same as Post-Training 1) Date: 23 May Grenades: 32 Coverage: 95%
	Time: Post-Training 2 Date: 24 May Grenades: 70 Coverage: 83%

	Time: Pre-Training 3 (same as Post-Training 2) Date: 25 May Grenades: 70 Coverage: 83%
	Time: Post-Training 3 Date: 25 May Grenades: 128 Coverage: 88%

Figure 5.8.1-2. Processed photographs of the PMSO treatment layer in Bay 1 used for image analysis.

Pre-Training 1

Post-Training 1

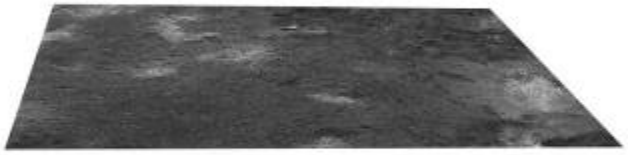
Post-Training 2 
Post-Training 3

Figure 5.8.1-3. Photographs of specific areas of the PMSO treatment layer in Bay 1.

Crater showing PMSO redistribution and backfilling.

White marker is approximately 21 cm x 36 cm

Movement of PMSO material from the treated area outward to non-treated areas.

Dashed line represents the original boundary of the PMSO treated area.

Detonation crater just outside the area covered by the PMSO.

Orange marker is approximately

Figure 5.8.1-4. Photographs of Bay 1 before and after four months of training and grading activities.

Pre-training

Dashed line represents approximate area where PMSO had been applied.

5.8.2 Bulk soil analysis

Bulk soil samples collected prior to PMSO application from Bay 1 and Bay 2 were analyzed for water content, total organic carbon, and explosive compound concentrations. Five bulk samples comprised of 25-point composites were collected. The 25-point locations for each of the five bulk samples from Bay 1 and Bay 3 are presented in Figure 5.8.1-1 and Figure 5.8.1-2. The results of these analyses are presented in Table 5.8.3-1. The organic carbon contents of the two bays was similar. Only HMX and RDX were detected in the soils above the detection limit, and the levels in the soil from both bays was also similar.

5.8.3 Soil core analysis

The complete set of soil core data is presented in Table E-5.8.3 of Appendix E of Part II of this Report. The explosives that were detected and their maximum concentrations at each depth are listed in Table 5.8.3-2 and Table 5.8.3-3 for Bay 1 and Bay 2, respectively. Average concentrations for both bays are presented in Table 5.8.3-4 and Table 5.8.3-5.

Figure 5.8.2-1. Location of 25-point samples that contributed to the five bulk composite samples in Bay 1. Grids were orientated such that the grenade throwing box was centered and parallel to the lower boundary.

1

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

2

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

3

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

4

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

5

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Figure 5.8.2-2. Location of 25-point samples that contributed to the five bulk composite samples in Bay 3. Grids were orientated such that the grenade throwing box was centered and parallel to the lower boundary.

1

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

2

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

3

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

4

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

5

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Table 5.8.2-1. Characteristics of the Remagen range soil in Bay 1 and Bay 3 based on bulk composite samples.

	Bulk	Water	C*	Total extractable explosive compounds (ug/kg)																
Location	Sample	%	%	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
Bay 1	1	3.60	0.83	<125	<125	<125	35	155	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	2	3.35	0.85	<125	<125	<125	27	224	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	3	6.50	0.82	<125	<125	<125	41	662	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	4	6.80	0.92	<125	<125	<125	48	374	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	5	3.65	0.85	<125	<125	<125	69	371	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	Average	4.78	0.85	<125	<125	<125	44	357	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Standard Deviation		1.71	0.04	<125	<125	<125	16	195	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Bay 3	1	5.50	1.23	<125	<125	<125	57	429	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	2	5.20	1.26	<125	<125	<125	82	848	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	3	4.20	1.37	<125	<125	<125	129	509	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	4	9.65	1.28	<125	<125	<125	59	309	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	5	3.85	1.70	<125	<125	<125	81	263	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
	Average	5.68	1.36	<125	<125	<125	82	471	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Standard Deviation		2.32	0.19	<125	<125	<125	29	232	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50

*Percent carbon based on loss on ignition analysis

Figure 5.8.2-3. Locations in Bay 1 and Bay 3 where geoprobe cores were collected. Grids were orientated such that the grenade throwing box was centered and parallel to the lower boundary.

Bay 1

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Bay 3

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Table 5.8.2-2. Explosives detected and maximum concentration versus depth in soil of Bay 1 based on 25 core samples. A "0" or "-" indicates no detections of a given compound.

Depth	Explosive Detections																
(cm)	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	5	6	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	8	10	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	6	8	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Maximum Concentration																
Depth	ug/kg																
(cm)	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	-	-	-	-	163	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	600	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	981	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	87	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	92	298	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	179	645	-	-	-	-	-	-	-	-	-	-	-	-
35	-	-	-	3080	15800	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	1840	5270	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	3370	4160	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	16	274	-	-	-	-	-	-	-	-	-	-	-	-
55	-	-	-	39	321	-	-	-	-	-	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8.2-3. Explosives detected and maximum concentration versus depth in soil of Bay 3 based on 25 core samples. A "0" or "-" indicates no detections of a given compound.

Depth	Explosive Detections																
(cm)	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	0	0	0	6	7	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	5	7	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	4	6	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	2	3	1	0	0	1	0	0	0	0	0	0	0	0
25	0	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Maximum Concentration																
Depth	ug/kg																
(cm)	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	-	-	-	612	4260	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	573	865	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	203	1426	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	1640	10500	19	-	-	161	-	-	-	-	-	-	-	-
25	-	-	-	2280	5740	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	770	5120	-	-	-	-	-	-	-	-	-	-	-	-
35	-	-	-	11800	74000	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	790	4710	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8.2-4. Average and standard deviation of explosive concentration versus depth in soil of Bay 1 based on 25 core samples. A "-" indicates the compound was not detected. "NA" indicates that the calculation was not applicable.

	Average Concentration																
Depth	ug/kg																
(cm)	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	-	-	-	-	163	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	298	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	549	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	69	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	92	266	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	110	370	-	-	-	-	-	-	-	-	-	-	-	-
35	-	-	-	883	3904	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	483	1207	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	610	834	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	16	204	-	-	-	-	-	-	-	-	-	-	-	-
55	-	-	-	39	220	-	-	-	-	-	-	-	-	-	-	-	-
	Standard Deviation																
Depth	ug/kg																
(cm)	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	-	-	-	-	NA	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	262	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	NA	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	16	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	NA	52	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	70	222	-	-	-	-	-	-	-	-	-	-	-	-
35	-	-	-	1279	6227	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	742	1901	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	1353	1356	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	NA	55	-	-	-	-	-	-	-	-	-	-	-	-
55	-	-	-	NA	NA	-	-	-	-	-	-	-	-	-	-	-	-

Table 5.8.2-5. Average and standard deviation of explosive concentration versus depth in soil of Bay 3 based on 25 core samples. A "-" indicates the compound was not detected. "NA" indicates that the calculation was not applicable.

	Average Concentration																
Depth	ug/kg																
(cm)	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	-	-	-	237	997	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	188	312	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	105	487	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	977	3658	19	-	-	161	-	-	-	-	-	-	-	-
25	-	-	-	1154	1609	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	551	2005	-	-	-	-	-	-	-	-	-	-	-	-
35	-	-	-	11800	74000	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	790	4710	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Standard Deviation																
Depth	ug/kg																
(cm)	TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	-	-	-	189	1498	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	222	256	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	76	506	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	NA	5926	NA	-	-	NA	-	-	-	-	-	-	-	-
25	-	-	-	NA	2754	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	NA	2698	-	-	-	-	-	-	-	-	-	-	-	-
35	-	-	-	NA	NA	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	NA	NA	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

6. PERFORMANCE ASSESSMENT

6.1 Performance Criteria

Table 6.1-1 lists the performance criteria by which the demonstration was assessed. Performance criteria were selected based on factors that would likely be considered when bringing the proposed technology to full-scale application. Primary criteria are linked directly to the project performance objectives, while secondary criteria include additional factors that can be used to assess overall project performance.

Table 6.1-1. Performance criteria for this project.

Performance Criteria	Description	Primary or Secondary
Redistribution Of Treatment Layer	Continuous layer of the treatment material remains after multiple grenade detonations.	*Primary*
Redistribution Of Treatment Layer	Treatment material are mixed into the soil profile.	*Primary*
Reduced New Contamination	TNT, RDX, HMX (and other explosive compounds).	*Secondary*
Hazardous Materials	No hazardous materials would be produced or remain.	*Secondary*
Process Waste	During this phase of the project, only small quantities of potentially explosive-contaminated treatment material would be generated.	*Secondary*
Factors Affecting Technology Performance	The performance of the technology would be affected by prevailing climatic conditions. Excessive rainfall or strong winds may lead to movement of the treatment materials.	*Secondary*
Reliability	Same as previous.	*Secondary*
Ease of Use	This technology was designed to be very easy to deploy, and requires minimal maintenance.	*Secondary*

Versatility	The technology as designed is a pollution prevention measure. However, initial results indicate it may also be effective for enhancing remediation of low concentrations of existing explosive residues as a cleanup option, used as either a surface-applied or tilled-in soil additive.	*Secondary*
Maintenance	Once deployed and applied, this technology requires very little maintenance. Additional applications may be periodically required.	*Secondary*
Scale-Up Constraints	There are no readily identifiable issues regarding the scale-up of this technology except how it would be redistributed by detonations.	*Secondary*

6.2 Performance Confirmation Methods

Performance confirmation methods are provided in Table 6.2-1. The key outcome expected from the GR demonstration was a better understanding of how the treatment layer was redistributed by grenade detonations. The primary method for determining this was image analysis of the digital photographs taken before and after grenade training activities. Additionally, redistribution of the treatment layer material was expected to be determined as function of depth in soil cores by measurement of soil total organic carbon using EPA Method 415.1 (as a surrogate for the peat moss plus soybean oil mixture). However, these TOC measurements were not possible due to early termination of the demonstration.

The other outcome of the this demonstration was supposed to be a determination of the effectiveness of the treatment layer for reducing the loading of grenade residues to soil. EPA Method 8330 was chosen as the primary quantitative method for measuring explosive residues based on its successful application during several years of SERDP/ESTCP research and development at Shaw Environmental, Inc., as well as its broad acceptance and use as a standard method during site characterization and site remediation efforts at explosives-contaminated sites. However, early termination of the demonstration precluded this assessment.

Other factors that were evaluated included the ease of use, maintenance, and scale-up assessment (Table 6.2-1). These were assessed qualitatively based on observation and experience gained during the demonstration. Early termination of the demonstration precluded evaluation of the semi-quantitative secondary criteria. Reference to the relevant sections of the report are given, as appropriate, for more details.

Table 6.2-1. Expected Performance and Performance Confirmation Methods.

Performance Criteria	**Expected Performance Metric (pre demo)**	**Performance Confirmation Method***	**Actual (post demo)**
PRIMARY CRITERIA - Semi-Quantitative/Qualitative			
Redistribution Of Treatment Layer	Treatment material remains as an integral layer within the designated area.	Image Analysis	Yes Section 5.8.1
Redistribution Of Treatment Layer	Treatment material mixes into the underlying soil within the designated area.	EPA Method 415.1	(Yes/partial and <u>only qualitatively</u> based on photodocumentation of initial days post-application) Section 5.8.1
SECONDARY CRITERIA - Semi-Quantitative/Qualitative			
Parent Compound and Daughter Product Contaminant Mobility	>50% lower <u>total explosives concentrations</u> in soil underlying the treatment material than in soil in the control area (assessed by bulk soil samples).	Modified EPA Method 8330*	Unable to evaluate due to early termination of demonstration

Parent Compound and Daughter Product Contaminant Mobility	>50% lower explosive concentrations at discrete depths in soil underlying the treatment material than in soil in the control area with treatment compared to the control (assessed using soil sore samples)	Modified EPA Method 8330*	Unable to evaluate due to early termination of demonstration
SECONDARY PERFORMANCE CRITERIA - Qualitative			
Ease of Use	Peat moss and soybean oil are easy to handle, mix, and apply.	Experience from demonstration operation	Yes Section 5.5
Maintenance	Treatment layer remains in place and is not adversely affected by precipitation, drying/wetting, etc.	Observation	Yes, but dry and windy conditions generated nuisance dust Section 5.8.1
Scale-Up	Peat moss and soybean oil are easy to handle, mix, and apply.	Experience from demonstration operation	Scale would be quite manageable Section 5.5

*Refer to Appendix A or Appendix B for further details.

6.3 Data Analysis, Interpretation and Evaluation

The primary goal of this demonstration was to assess the redistribution of the treatment layer in response to grenade training activities. Data analysis for the horizontal redistribution focused on the image analysis of the digital photos of the treatment material before and after training activities. Image analysis yielded simple percent area coverage values. The baseline for coverage was the photos taken after the treatment layer was emplaced but before grenade training activities resumed.

Total organic carbon measurements were to be used as a surrogate for the treatment material to determine vertical redistribution of the materials into the soil profile. TOC values in the control were to serve as the “baseline”, so that the amount of incorporation of the treatment material

versus depth in the treatment training bay can be determined. As a secondary performance criteria, soil concentrations (bulk and at discrete depths) of explosive residues from the grenade range training bay that received the surface applied treatment were to be compared to the untreated control bay. ***However, early termination of the demonstration precluded the assessment of either of these performance objectives.***

7. COST ASSESSMENT

7.1 Cost Model

This section describes the cost performance criteria that were evaluated in completing the economic analysis of the PMSO technology for *in situ* remediation of explosives. The actual costs for performance of the SP1 and GR demonstrations are presented in Table 7.1-1.

PLEASE NOTE: Due to the goals and approach of this project, most of the costs presented in Table 7.1-1 are specific to the demonstrations that were performed and are not reflective of the costs that would be incurred during an actual field implementation of the technology. The cost categories and costs associated with employing the PMSO technology at a "typical" site are presented in Tables 7.3-1 and 7.3-2.

7.2 Cost Drivers

The main cost drivers for use of this technology would be the cost of the materials (peat moss, crude soybean oil), and the labor required to perform the application. These costs, in turn are dependent on the ratio of peat moss to oil being used, the size of the area to be treated, the depth of material to be applied, and the period between required reapplications. The results of the SP1 and GR Demonstrations supplied data to provide general guidelines to allow determination of the depth of material to apply to achieve a given level of explosive residue immobilization (given estimates of residue loading, precipitation, etc.). Knowing this value, calculation of the amount of materials needed and the labor required to apply it would be easily calculated. It was also possible to estimate of the longevity of the treatment materials.

7.3 Cost Analysis

The cost analysis is based primarily on the GR demonstration due to its larger, more full-scale-relevant scope, but the majority of the quantitative performance data were derived from the SP1 demonstration to allow a more detailed and relevant cost estimate to be calculated.

The cost analysis was developed in conjunction with the technical protocol for implementing the technology, which was based on the use of the predictive model of treatment performance and the technical requirements for full-scale implementation. The cost analysis is presented for a typical site, assuming full-scale application. The cost analysis includes provisions and contingencies related to application of the technology to different sized areas as well as different methods of application (surface vs. buried PMSO layer) in light of the lessons learned.

Table 7.1-1. Actual SP1 and GR Demonstration Costs.

Note 1: Data analysis, reporting, and non-field work travel costs are not included.

Note 2: The only costs in this table that would be partially applicable to an actual field implementation of the PMSO technology are the treatment materials (peat moss, crude soybean oil). Please see Tables 7.3-1 and 7.3-2 for a more realistic cost model.

	Cost Category *SP1 Demonstration*	**Subcategory**	**Details**	**Cost ($)**
1	Start-Up	Engineering and design	Labor	106,938
		Site characterization	Analytical and labor	2,284
		Treatment materials	Peat moss (0.1 m^3, 3.5 ft^3)	11
			Crude soybean oil (16.5 lb, 7.5 kg)	8
		Structures, components, and equipment	Berm liner, pallet racks, concrete barriers, fencing, tanks, fittings, sensors, dataloggers, forklift (+ operator), etc.	30,098
		Deployment	Labor	33,803
2	Operations & Maintenance	Sampling	Labor and shipping	83,172
		Analytical	Dissolved explosives, total organic carbon, etc.	90,082
3	Demobilization		Labor, analytical, waste disposal	18,752
			TOTAL	**365,147**
		Media treated (6 soil plots)	m^2	0.99
			yd^2	1.18
		Cost/area treated for PMSO materials	m^2	19
			yd^2	16
		Cost/area treated for total demonstration	m^2	370,708
			yd^2	309,972

Table 7.1-1. Actual SP1 and GR Demonstration Costs (cont.)

Note 1: Data analysis, reporting, and non-field work travel costs are not included.

Note 2: The only costs in this table that would be partially applicable to an actual field implementation of the PMSO technology are the treatment materials (peat moss, crude soybean oil). Please see Tables 7.3-1 and 7.3-2 for a more realistic cost model.

	Cost Category *GR Demonstration*	**Subcategory**	**Details**	**Cost ($)**
1	Start-Up	Engineering and design	Labor	34,012
		Baseline site work	Labor	12,655
			Analytical	18,617
		Treatment materials	Peat moss (10.6 m^3, 373 ft^3)	572
			Crude soybean oil (1200 lb, 544 kg)	598
			Soybean oil transport	1,583
		Equipment	Cement mixer	200
		Deployment	Labor	2,044
2	Operations & Maintenance			0
3	Demobilization			0
			TOTAL COST	**70,281**
		Media treated (Bay 1)	m^2	100
			yd^2	120
		Cost/area treated for PMSO materials plus application	m^2	50
			yd^2	42
		Cost/area treated for PMSO materials plus application (excluding transport)	m^2	34
			yd^2	28
		Cost/area treated for total demonstration	m^2	703
			yd^2	586

Basic site description

The PMSO technology would be most effective at areas ranging from a few hundred to a few thousand square meters. Sites that would be most likely to benefit from deployment of the PMSO technology include:

- hand grenade training area
- open burn/open detonation facilities
- mortar and rocket firing points
- EOD training areas
- small arms firing points (where there is a concern about NC/NG/DNT residues)

The data obtained during the GR demonstration (Part II of this report) clearly indicated that the PMSO technology would be better either tilled into to emplaced beneath a layer of soil. The costs for tilled deployment is the baseline, but an option for burial is included.

Treatment timeframe

The PMSO technology is designed to prevent contamination of subsurface and groundwater resources. As such, the treatment timeframe is defined here as the length of time before the PMSO's ability to sorb and enhance the degradation of dissolved explosive compounds is decreased, requiring that the material needs to be rejuvenated and/or replaced.

Based on the previous research, and the data obtained during this project, the previously developed model of Schaefer et al (10) was used to estimate the effective reduction in the fluxes of TNT, RDX, and HMX over time. A 10 cm layer of PMSO having a composition of 1:2 peat moss:crude soybean oil (w:w), and a annual rainfall of 70 cm was assumed. Retardation factors for HMX, RDX, and TNT were based on a 1:2 PMSO material, but biodegradation rate constants were based on a 1:1 PMSO material as this was the only dataset available. Biodegradation rates would likely be higher in the 1:2 PMSO material.

The model estimate is presented in Figure 7.3-1. The flux of TNT and RDX are reduced by >50% for more than 48 months, while that of HMX starts to increase above the 50% mark around 48 months. Therefore, for the cost analysis a baseline re-application rate of 48 months was selected (i.e., it would be advised that the PMSO be rejuvenated or replaced every 48 months).

Life-cycle assessment

The following items were considered in the life-cycle cost estimate:

1) **Facility capital costs (deployment and reapplication).** The facility capital costs are expected to be minimal and may include the purchase of some commercially available equipment for mixing and application of the peat moss plus soybean oil treatment materials and basic soil manipulation. It is just as likely that this equipment would be rented or bought, or that this activity would be subcontracted to a private vendor, so these options are included in the cost analysis.

2) **Maintenance costs.** As stated above, the results of previous model development and the SP1 and GR demonstrations indicated that the duration of PMSO effectiveness (>50% reduction in contaminant flux to the subsurface) was approximately 48 months. The costs for activities to rejuvenate the treatment layer by adding more treatment materials, or to replace the PMSO entirely, were estimated.

Cost comparison

The results were compared to the only other competing technology, topically-applied lime. ESTCP funded research on a topical applied lime technology that has a similar goal of reducing explosive residue leaching to groundwater (project ER-0216). Efforts were made to make a parameter-relevant comparison between the peat moss plus soybean oil-based technology and the lime-based technology. The Cost and Performance Report for ER-0216 was used as the source of the costs for the lime technology (specifically, Table 10, p. 29). The costs assume that soil is "treated" to an effective depth of 1 m (or 1 yard) under the area covered, so application of either lime or PMSO to 600 m^2 effectively treats 600 m^2. A cost comparison for a 4 year reapplication

rate to achieve a >50% reduction in HMX, and >99% reductions in RDX and TNT loadings is presented in Table 7.3-1. A cost comparison for a 2.5 year reapplication rate to achieve a >90% reduction in HMX, and >99% reductions in RDX and TNT loadings is presented in Table 7.3-2.

Because the baseline re-application rate was assumed to be 48 months as opposed to every quarter for the lime technology, the costs comparison is only presented based on rental of the needed equipment. Rental periods of 1 week were assumed.

Costs for materials were based on:

Crude soybean oil:

Amount: 14,400 lbs to cover 600 m^2 of 1:2 peat:oil PMSO, based on 1200 lbs for 100 m^2 at 1:1 peat:oil ratio.

Cost: Average $/lb of oil of $0.3476 based on April/May 2009 commodity data from Iowa, Illinois, Indiana-Ohio, and Minnesota, plus $0.0125/lb for the distributor's charge (what was charged when the oil for the GR demonstration was purchased). Shipping of oil was based on freight transport of 7200 lbs of oil from Iowa City, IA to Columbia, SC, using a National Motor Freight Classification NMFC# 65, which is the classification for biodiesel.

Peat moss:

Amount: 2250 cu. ft. to cover 600 m^2, based on 373 cu. ft. for 100 m^2 at 1:1 peat:oil ratio.

Cost: Average $/cu. ft of peat moss of $3.06 based on the actual purchase made for the GR demonstration. It is likely that with large bulk purchases of peat moss, the costs would decrease by around $3.00 to 5.00 dollars per unit treated. Costs of around $1.50/cu. ft. of peat moss were obtained for large "super bales" from one supplier.

Cost comparison summary

On a 4 year life-cycle, the PMSO would be cheaper per unit soil than the lime by about a factor of 2. On a 2.5 year life-cycle, using the PMSO realizes a ~25% cost savings compared to the lime. There is not a great difference between the tilled and the buried application methods. These results indicate that the PMSO would be competitive with surface applied lime.

Figure 7.3-1. Model predictions of PMSO performance over time in terms of mass flux of TNT, RDX, and HMX relative to no PMSO application.

Assumptions: 10 cm of PMSO having a composition of 1:2 peat moss:crude soybean oil (w:w); annual rainfall of 70 cm. Mass flux measured at the bottom of the PMSO/top of the underlying soil boundary.

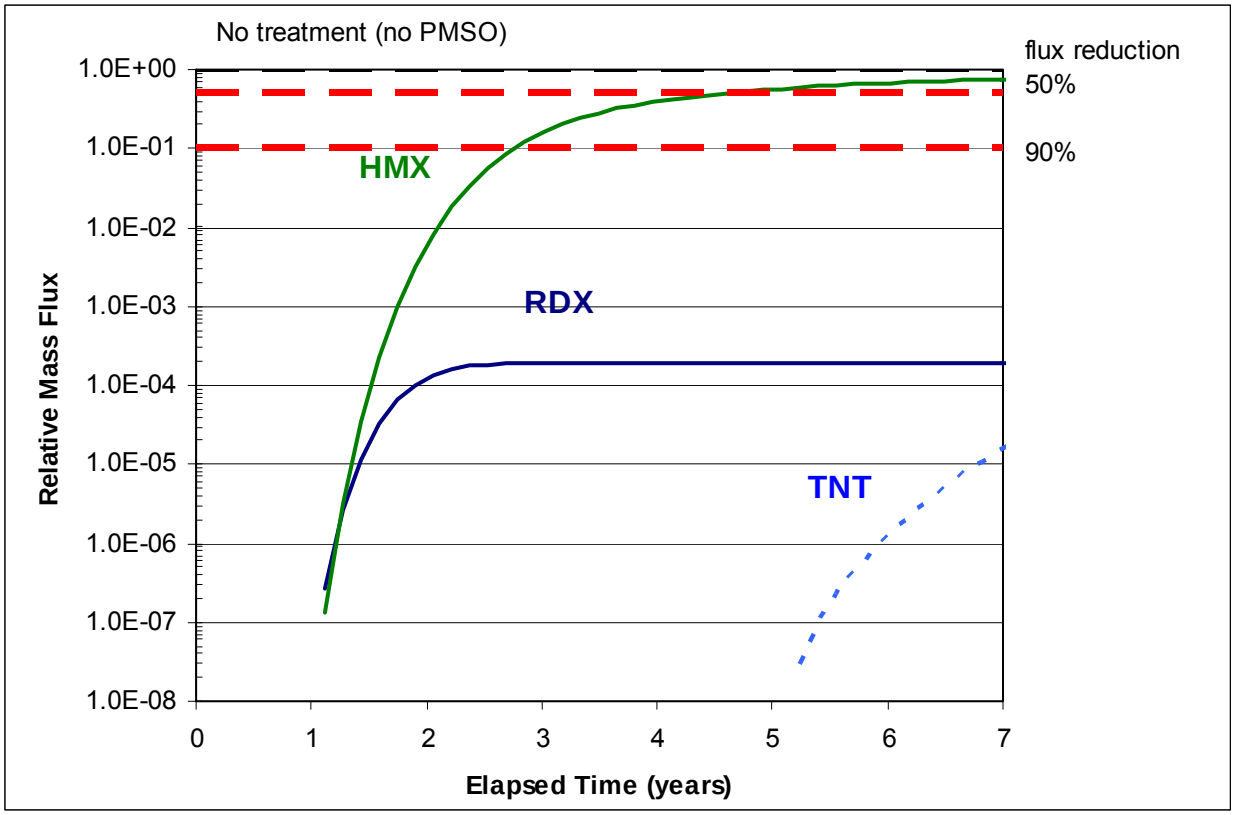


Table 7.3-1. Cost analysis for PMSO technology compared to topical lime (4 year life-cycle).

4 year reapplication rate to achieve >50% reduction in flux of HMX and >99% reduction in the flux of RDX, and TNT.

LIFE CYCLE	4 Years	4 Years	4 Years
APPLICATION METHOD	Tilled	Tilled	Buried
EQUIPMENT	Rented	Rented	Rented
	Lime	PMSO	PMSO
1. Capital Cost			
Application Equipment			
-ATV (5% interest, 5 years)	4,000	1,000	0
-Disc plow	500	125	0
-Dropseed spreader	600	0	0
-Hydroseeder	8,000	0	0
-Drum Mixer (cement mixer)	0	200	200
-Road grader (140 HP)	0	0	1,720
-Vibratory roller (5 ton)	0	0	620
-Frontend loader (2.5 cu. yd.)	0	1,070	1,070
Other			
-Treatability testing for lime requirement	8,000	0	0
Total Capital Cost	**21,100**	**2,395**	**3,610**
2. O&M			
Labor (UXO clearance by base)[a]	32,000	12,264	12,264
Materials[b]	6,400	13,343	13,343
Fuel[c]	800	200	400
Soil testing	300	0	0
Other[d]	800	200	200
Total O&M Cost	**40,300**	**26,007**	**26,207**
Total Technology Cost	**61,400**	**28,402**	**29,817**
Quantity treated (m^3 / yd^3)	600 / 785	600 / 785	600 / 785
Unit cost (per m^3 / per yd^3)	**102.33 / 78.22**	**47.34 / 36.18**	**49.70 / 37.98**

Assumptions:

[a] Labor for lime technology estimated at $8000/yr for quarterly lime application. Labor for PMSO technology is based on the labor required at Fort Jackson grenade range demonstration to apply 100 m^2 PMSO ($2044, 4 field laborers x 8 hr x ~$64/hr burdened labor rate) then multiplying by six (6) for application of 600 m^2.

[b] Materials for lime technology included lime at $1600/year for quarterly lime application. Materials for PMSO technology included peat moss ($6885) and crude soybean oil (5005), including shipping of oil as described in Cost Comparison section above.

[c] Fuel for equipment listed in section 1 for each scenario. For lime technology, estimated as $200/year. For PMSO technology, estimated as $200 for tilling in PMSO once every 4 years, and $400 for burial of PMSO once every 4 years.

[d] Lime technology assume costs of $200/yr for protective equipment for quarterly lime application. PMSO technology assumes a total of $200 for PMSO application once every four (4) years for protective clothing and miscellaneous garden tools (shovels, rakes, etc.).

Table 7.3-2. Cost analysis for PMSO technology compared to topical lime (2.5 year life-cycle).

2.5 year reapplication rate to achieve >90% reduction in flux of HMX and >99% reduction in the flux of RDX, and TNT.

LIFE CYCLE	2.5 Years	2.5 Years	2.5 Years
APPLICATION METHOD	Tilled	Tilled	Buried
EQUIPMENT	Rented	Rented	Rented
	Lime	PMSO	PMSO
1. Capital Cost			
Application Equipment			
-ATV (5% interest, 5 years)	2,500	1,000	0
-Disc plow	313	125	0
-Dropseed spreader	375	0	0
-Hydroseeder	5,000	0	0
-Drum Mixer (cement mixer)	0	200	200
-Road grader (140 HP)	0	0	1,720
-Vibratory roller (5 ton)	0	0	620
-Frontend loader (2.5 cu. yd.)	0	1,070	1,070
Other			
-Treatability testing for lime requirement	5,000	0	0
Total Capital Cost	**13,188**	**2,395**	**3,610**
2. O&M			
Labor (UXO clearance by base)[a]	20,000	12,264	12,264
Materials[b]	4,000	13,343	13,343
Fuel[c]	500	500	500
Soil testing	188	0	0
Other[d]	500	200	200
Total O&M Cost	**25,188**	**26,307**	**26,307**
Total Technology Cost	**38,375**	**28,702**	**29,917**
Quantity treated (m^3 / yd^3)	600 / 785	600 / 785	600 / 785
Unit cost (per m^3 / per yd^3)	**63.96 / 48.89**	**47.84 / 36.56**	**49.86 / 38.11**

Assumptions:

[a] Labor for lime technology estimated at $8000/yr for quarterly lime application. Labor for PMSO technology is based on the labor required at Fort Jackson grenade range demonstration to apply 100 m^2 PMSO ($2044, 4 field laborers x 8 hr x ~$64/hr burdened labor rate) then multiplying by six (6) for application of 600 m^2.

[b] Materials for lime technology included lime at $1600/year for quarterly lime application. Materials for PMSO technology included peat moss ($6885) and crude soybean oil (5005), including shipping of oil as described in Cost Comparison section above.

[c] Fuel for equipment listed in section 1 for each scenario. For lime technology, estimated as $200/year. For PMSO technology, estimated as $200 for tilling in PMSO once every 4 years, and $400 for burial of PMSO once every 2.5 years.

[d] Lime technology assume costs of $200/yr for protective equipment for quarterly lime application. PMSO technology assumes a total of $200 for PMSO application once every 2.5 years for protective clothing and miscellaneous garden tools (shovels, rakes, etc.).

8. IMPLEMENTATION ISSUES

8.1 Regulatory Issues

The soybean oil (CAS# 8001-22-7) used in the PMSO is classified as Generally Recognized as Safe (GRAS) according to the following Environmental Protection Agency document.

- Registration Eligibility Decision (RED), Flower and Vegetable Oils. December 1993. EPA# 738-R-93-031. http://www.ntis.gov/search/product.aspx?ABBR=PB94152048

The peat moss (no CAS number) used in PMSO is categorized as "4A - Minimal Risk Inert Ingredients" on the Environmental Protection Agency's "List of Inert Pesticide Ingredients", which was updated in August 2004 (http://www.epa.gov/opprd001/inerts/inerts_list4Acas.pdf).

Based on this information, no permits would expected to be required for implementation of this technology at any site. The material is meant to be left in place once it is deployed, although additional peat moss or soybean oil might be added to rejuvenate the treatment. If the PMSO was to be permanently removed, some analyses for easily desorbed or leachable explosive residues should be performed prior to disposal.

8.2 End-User Issues

The primary end-users of this technology would likely be DoD site managers and DoD contractors responsible for protecting groundwater resources at military installations. The general concerns of these end users include the following: (1) technology applicability under local site conditions; (2) technology performance; (3) technology scale-up; and (4) technology cost.

This project, performed as two separate yet complimentary demonstrations, have provided information that can be used to address these concerns. General findings are presented below, with reference to the relevant sections of the report where details can be found.

1) technology applicability under local site conditions

- The use of PMSO would be .

2) technology performance

- The PMSO material reduced the flux of RDX through the soil by approximately 500-fold compared to flux of RDX in the untreated control. See PART I, Sections 5.8.2 and 6.3.
- The PMSO material reduced the residual concentrations of explosive compounds as a function of depth compared to the explosive compound concentration profile observed in the untreated control. See PART I, Sections 5.8.3 and 6.4.

3) technology scale-up

- The PMSO materials were relatively easy to handle and apply using readily available equipment. Scale-up of mixing and spreading the PMSO would likely actually be easier than the demonstration performed during this project. As the peat moss part of the PMSO is routinely used for horticultural and landscaping purposes, handling at these larger scales would be readily feasible. See Section 5.5.

4) technology cost

- A cost estimate of $40-50 per 600 m^3 of soil treated per 48 months (including material, labor, and equipment rental costs) was calculated based on data from both the SP1 and GR demonstrations. See Section 7.

8.3 Procurement Issues

The materials used in the PMSO are readily available in most areas. Peat moss and crude soybean oil can be obtained in bulk (or large unit sizes) from a number of suppliers. Contacts for some of the suppliers are presented in Table 8.3-1 below.

Table 8.2-1. Supplier Contact Information

Company	Address	Phone/Fax
Peat moss suppliers		
Sun Gro Horticulture Distribution, Inc.	15831 N.E. 8th Street Suite 100 Bellevue, WA 98008	P: 801-244-0245 F: 801-406-0272 www.sungro.com
Waupaca Northwoods	P.O. Box 569 801 W. Fulton St. Waupaca, WI 54981	P: 715-256-4020 F: 715-256-4030 www.waupacasoilblenders.com
Crude soybean oil suppliers		

Grain States Soya Inc.	400 Johnson Road West Point, NE 68788	P: 402-372-2429 F: 402-372-3305 www.soybest.com
Cargill Industrial Oils & Lubricants	P.O. Box 5700, MS 66 Minneapolis, MN 55440	P: 800-842-3631 F: 952-742-6722 www.techoils.cargill.com
Zeeland Farm Services, Inc.	P.O. Box 290 • 2525 - 84th Avenue Zeeland, MI 49464	P: 800-748-0595 F: 616-772-7075 www.zfsinc.com

No claims regarding material quality or availability are made regarding these suppliers. They simply represent the suppliers which provided information about their product availability.

The equipment needed for applying the PMSO material would be dependent on the size of the area to be treated and the mode of emplacement. At a minimum, and as per the recommendations presented elsewhere in this report, it is expected that the following equipment would be required:

- grader for soil removal and replacement
- rotary type mixer for preparing the PMSO material (eg. cement mixer)
- forklift for moving drums of oil or bulk peat moss
- bucket loader for moving loose peat moss and/or prepared PMSO

Larger or smaller versions of this equipment would be needed depending on the scale of the planned application. Additionally, the following types of equipment may be needed under some circumstances:

- bark/straw blower for dispersing the PMSO across broad areas
- tractor and tiller attachment for incorporation of the PMSO into the soil

8.4 Lessons Learned

Based on this entire project, including both the SP1 and GR Demonstrations, the recommendation for application of PMSO would be as follows.

-Plan to use PMSO with a ratio of 1:2 (peat moss:oil)

-After UXO/range clearance, remove the top layer of soil using a bulldozer or grader. The depth of soil to remove will vary depending on the type of training area being treated. Remove more soil in areas where deeper cratering is expected, or where vehicle traffic might dig into the soil. For a hand grenade range, a depth of 60 cm (2 ft) would be recommended.

-Apply the PMSO as a continuous layer of between 10 and 15 cm (4 to 6 inches) within the excavated area.

-Re-apply the soil over the PMSO layer. Compact the soil if vehicle traffic is expected.

-As an ongoing preventative range management measure, apply a 10 cm (4 inch) layer of PMSO every 4 to 6 years and till (or otherwise mix) the material into the top 30 cm (1 ft) of the soil.

9. REFERENCES

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2. Fuller, M. E., J. M. Lowey, C. E. Schaefer, and R. J. Steffan. 2005. *A peat moss-based technology for mitigating residues of the explosives TNT, RDX, and HMX in soil.* Soil Sediment Contam 14:373-385.

3. Fuller, M. E., and J. F. Manning, Jr. 1997. *Aerobic gram-positive and gram-negative bacteria exhibit differential sensitivity to and transformation of 2,4,6-trinitrotoluene (TNT).* Curr Microbiol 35:77-83.

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amended with soybean oil for mitigation of dissolved explosive compounds leaching into the subsurface: Insight into mass transfer mechanisms. Environ Eng Sci 22:337-349.

11. Spain, J. 1995. *Biodegradation of nitroaromatic compounds.* Annu Rev Microbiol 49:523-555.

Appendix A

Points of Contact

POINT OF CONTACT Name	ORGANIZATION Name Address	Phone/Fax/email	Role in Project
Mark E. Fuller	Shaw Environmental, Inc. 17 Princess Road Lawrenceville, NJ 08648	P: 609-895-5348 F: 609-895-1858 mark.fuller@shawgrp.com	Lead Investigator
Charles E. Schaefer	Shaw Environmental, Inc. 17 Princess Road Lawrenceville, NJ 08648	P: 609-895-5372 F: 609-895-1858 charles.schaefer@shawgrp.com	Modeler
Robert J. Steffan	Shaw Environmental, Inc. 17 Princess Road Lawrenceville, NJ 08648	P: 609-895-5350 F: 609-895-1858 rob.steffan@shawgrp.com	Scientific & Fiscal Manager
Michael A. Rose*	Shaw Environmental & Infrastructure 318 Avocet Street Shaw AFB, SC 29152	P: 803-666-4626 F: 803-666-4830 mike.rose@shawgrp.com	Field Manager
Beth-Anee Johnson	DPTM/ITAM 2179 Sumter St. Fort Jackson, SC 29207	P: 803-751-6427 beth-anee.johnson@jackson.army.mil	Fort Jackson Liason
William A. (Andy) Martin	US Army ERDC Environmental Laboratory Chief Environmental Engineering Branch CEERD-EP-E 3909 Halls Ferry Rd. Vickburg, MS 39180	P: 601-634-3710 F: 601-634-3518 andy.martin@erdc.usace.army.mil	DoD Liason/COR

*No longer with Shaw

Appendix B

Sampling Methods Supporting the Experimental Design

Procedure No. SOP T-FS-101 Revision No. Date of Revision 08/28/03 Last Review Date
STANDARD OPERATING PROCEDURE

Subject: Trowel/Spoon Surface Soil Sampling

1. PURPOSE

The purpose of this document is to provide the methods and procedure for sampling of surface soils using trowels or spoons. Trowels or spoons can be used when matrices are composed of relatively soft and non-cemented formations and to depths of up to 12 inches into the ground surface, dependent on site conditions. Samples for VOC analysis should not be collected via trowel or spoon method. However, a trowel or spoon may be utilized to penetrate to and expose the undisturbed material at the desired depth for sampling by more applicable methods.

2. SCOPE

This procedure is applicable to all Shaw E & I projects where surface soil samples will be collected via trowel or spoon methods.

3. REFERENCES

U.S. Army Corps of Engineers, 2001, *Requirements for the Preparation of Sampling and Analysis Plans*, Appendix C, Section C.6, EM200-1-3, Washington, D.C.

4. DEFINITIONS

Trowel - A sample collection device with a curved and pointed metal blade attached to a handle. All trace environmental samples should be collected using stainless steel blades.

Spoon - A sample collection device with a round metal blade attached to a handle.

Surface Soil - Soil that is removed from the surface no greater than 6 inches below grade after removing vegetation, rocks, twigs, etc.

Weathered Soil - The top 1/2 to 1/4 inch of soil impacted by heat from sun, rain or foot traffic that could evaporate, dilute, or otherwise deposit contaminants from an adjacent location, thereby misrepresenting the actual soil characteristic.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations,

reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

6.1 Equipment

Decontaminated trowel or spoon, stainless construction for trace environmental sampling. If samples will be collected at depth (0-6 inches) the trowel or spoon will require decontamination prior to collection of the targeted-depth sample. Alternatively, a different trowel or spoon can be used to remove the material to the targeted depth and the sample collected using a clean dedicated trowel or spoon.

Engineers rule or stiff measuring tape

Decontaminated stainless steel mixing bowl

6.2 Sampling

1. Don a pair of clean gloves.

2. If desired, place plastic sheeting around the targeted location to keep sampled material in place. Use a knife to cut an access hole for the sample location.

3. Remove any surficial debris (e.g. vegetation, rocks, twigs) from the sample location and surrounding area until the soil is exposed. Once exposed the soil surface is designated as —at grade“, or 0 inches.

4. Use a trowel to scrape and remove the top 1/8 to 1/4 inch of weathered soil. (A spoon can be interchanged with trowel).

5. If collecting a sample for VOC analysis, collect the sample first following more applicable methods.

6. With a new trowel, place the point of the blade on the ground. While holding the handle of the trowel partially rotate the blade in a clockwise/counter-clockwise motion while pushing at a downward angle until the blade is inserted to the required depth or the blade is nearly covered. Be certain that the trowel is not inserted to a depth where the soil will touch the handle or other non-stainless steel portion of the trowel or the sampler‘s hand.

7. With a prying motion lift up the trowel with soil on the blade and place soil into the stainless steel mixing bowl.

8. Repeat 6 and 7 until the required depth of soil is placed into the mixing bowl.

9. Measure the depth of the sample location with a rule or tape to verify the sampling depth and record in the field logbook.

10. Homogenize the non-VOC sample and transfer the sample directly into the sample container(s). Cap the sample container(s), label, complete documentation, and place into the sample cooler.

Procedure No. SOP T-FS-011 Revision No. Date of Revision 08/14/03 Last Review Date
STANDARD OPERATING PROCEDURE

Subject: Compositing

1. PURPOSE

This procedure establishes the method for compositing samples collected in the course of environmental program activities. The objective of this procedure is to provide a standard method for creating composite samples of environmental media. Composites are used to represent the average distribution of properties and can be used to reduce analytical costs or represent well-defined decision boundaries.

2. SCOPE

This procedure applies to solid and liquid samples whenever there is a need or desire to perform analysis on a sample representative of a defined boundary (time, area, etc.). Field composite methods are not appropriate for VOC analysis of solids. Composites for these methods must be laboratory derived using either individual grab extracts or other laboratory methods.

3. REFERENCES

U.S. Environmental Protection Agency, 1987, *Compendium of Superfund Field Operations Methods*, EPA 540/P-87/001a, OSWER 9355.0-14, Washington, DC.

Shaw E & I Standard Operating Procedure T-FS-010, *Sample Mixing/Homogenization*.

4. DEFINITIONS

Composite Sample - A sample that is comprised of roughly equal amounts of discrete grabs from a set of sample locations or time/flow increments known as a sample group.

Sample Group - A predetermined number or time/area span of discrete samples, which is composited into one sample for analytical purposes.

5. RESPONSIBILITIES

5.1. Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

5.2. Project Responsibility

Shaw E & I employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw E & I employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager or designee is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

The discrete samples that are used to prepare a composite sample must be of equal volume and must each be collected in an identical manner. Field documentation must clearly indicate the composite elements on either a map or composite logsheet. There are several types of

composite samples.

Flow-proportioned composite - Flow-proportioned composite samples are collected proportional to the flow rate during the sampling period by either a time-varying/constant-volume or time-constant/varying-volume method. Flow-proportioned composite samples are typically collected using automatic samplers paced by a flow meter. This sampling method is commonly used for wastewaters.

Time composite - A time composite sample is composed of a discrete number of grab samples collected at equal time intervals during the compositing period. Time composite sampling is often used to sample wastewater or streams.

Volume/mass composite - A volume/mass composite is composed of a discrete number of grab samples collected at defined volume or mass intervals. Volume/mass composite sampling is often used to sample the output of a process system such as a Thermal Destruction Unit or pug mill.

Areal composite - Areal composite samples are samples collected from individual grab samples located on a regularly spaced grid or along a pile at defined locations and depths. Each of the grab samples must be collected in an identical fashion and must be of equal volume.

Vertical composite - Vertical composites are composed of individual grab samples collected across a vertical cross section. Like areal composites, the grab samples must be collected in an identical fashion and must be of equal volume. Soils and sediments can be used to create vertical composites.

6.1. Solid Composites

To ensure the integrity of the composite, all discrete grab samples must be collected in an identical manner.

Composite samples can be created by combining discrete grab samples into the same mixing/holding container as they are collected or by combining and mixing equal aliquots of containerized and homogenized discrete grab samples.

Remove coarse fragments and organic material from the mixing bowl. Homogenize the sample as per SOP T-FS-010, Sample Mixing/Homogenization.

Remove sample aliquots and place into the appropriate sample containers for shipment to the laboratory.

Label the sample and document the sampling event according to the project procedures

Procedure No. SOP T-FS-010 Revision No. Date of Revision 06/05/2003 Last Review Date
STANDARD OPERATING PROCEDURE

Subject: Sample Homogenization

1. PURPOSE

The purpose of this procedure is to establish the method for homogenizing soil, sediment, and other solid or semi-solid matrices so that a uniform matrix is available for sampling. Proper homogenization is very important because it helps ensure that sample aliquots are representative of the whole collected sample and helps minimize sampling error so that other errors included in the measurement process, such as laboratory sample preparation and test measurement, can be better assessed.

2. SCOPE

This procedure applies to Shaw Environmental & Infrastructure (Shaw E & I) personnel responsible for the collection of solid matrix samples. The solid matrix must be amenable to mixing. This SOP applies to the collection of solid samples that are to be tested for all analytes except volatile analytes.

3. REFERENCES

3.1 The following are Shaw E & I soil sampling and miscellaneous matrix sampling SOPs to which sample mixing/homogenization may apply:

T-FS-100 Hand Auger
T-FS-101 Trowel/Spoon
T-FS-102 Bulb Planter
T-FS-103 Soil probe/corer
T-FS-106 Pile
T-FS-107 Roll-off
T-FS-116 Drum
T-FS-119 Sludge judge
T-FS-123 Sediment corer

3.2 The following are examples of approved techniques or methods for performing sample homogenization.

4. DEFINITIONS

Homogenize - The use of physical mixing motions to make a uniform sample matrix.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting

information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

Sampling equipment materials shall be selected so as to minimize contamination of samples. Sampling equipment shall be either new (never used previously), documented to have been decontaminated, or dedicated to each specific sampling point. Samples for organics analysis should be collected and mixed using glass or stainless steel bowls, trowels, and/or spoons. Samples for metals analysis should be collected and mixed using equipment made of glass or Teflon.

Certain types of solid matrices may not be amenable to mixing using conventional techniques. For example, certain solids may require grinding and thorough mixing to ensure that the analytes of interest within the sample are homogeneously distributed. It is extremely important that soil and sediment samples be homogenized to ensure that the entire sample is as representative as possible of the media being sampled.

6.1 Solid Samples

The following two methods are examples for homogenizing solid samples. Other homogenization techniques may be employed using approved standard methods such as ASTM C702, Reducing Samples of Aggregate to Testing Size.

Quartering

Place the sample on a hard, clean, level surface such as a pan. If such surface is too small for the desired quantity, a clean sheet of plastic may be used.

Mix the solid material by turning the entire quantity over three times with a trowel or shovel. For the third time, shovel the material into a cone-shaped pile.

Carefully press down on the apex of the pile to create a soil layer of uniform thickness and diameter, so that the diameter is approximately 4 to 8 times the thickness and the material in each quarter of the resulting layer is approximately the same as what was in the corresponding quarter from the cone-shape pile.

Divide the material in the sample pan or the plastic into quarters using shovel or trowel.

Option 1- Mix each quarter individually; Two quarters should then be mixed to form halves; the two halves should be mixed to form a homogenous matrix. Option 1 should be repeated if necessary to produce a homogeneous sample.

Option 2- Remove two diagonally opposite quarters including any fine material and brush the surface clean; mix and quarter (as per Option 1) the remaining material until the sample media has taken on a uniform appearance.

Mixing in a Bowl

Place the sample in a bowl. Samples for organic analysis should be mixed using bowls and stirrers made of glass or stainless steel, while samples for metals analysis should be mixed using equipment made of glass, stainless steel, or hard plastic. Make sure the bowl is large enough to accommodate the sample, with extra volume to allow for mixing the sample.

Mix the sample with the stirrer. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction, and occasionally turning

the material over. High moisture samples are more difficult to homogenize. Use an adequate mixing motion for as long as needed to determine by visual observation that the sample media has taken on a uniform appearance.

6.2 Aqueous Samples

Aqueous samples do not require homogenization since water is well mixed due to diffusion and bulk convection. If the sample matrix is a viscous liquid, semi-solid, or an aqueous one with suspended solids, the sample shall be thoroughly mixed with a tool of compatible composition for all analyses fractions except volatile analytes. After mixing, immediately transfer the material into the appropriate containers. The sample should be mixed frequently during the container-filling step, in particular if there are a large number of containers, so that the condition of the bulk sampled fluid will be approximately the same when each parameter-specific sample container is filled.

Once a sample has been mixed, it will typically have to be transferred into separate containers for different analyses. However, samples collected for volatile organic compounds, oil and grease, and short-chain organic sulfides analyses may not be homogenized. For these parameters, dedicated samples must be collected without mixing.

Procedure No. SOP T-FS-014 Revision No. Date of Revision 06/05/2003 Last Review Date
STANDARD OPERATING PROCEDURE

Subject: Decontamination of Contact Sampling Equipment

1. PURPOSE

This procedure defines the Shaw E & I standard that must be implemented for decontamination of contact sampling equipment. Contact sampling equipment is equipment that comes in direct contact with the sample or portion of sample that will undergo chemical analyses or physical testing. This SOP is intended to provide minimum guidelines and general procedures for decontaminating contact sampling equipment used during field sampling activities. The benefits of its use include the following:

Minimizing the spread of contaminants within a study area and from site to site

Reducing the potential for worker exposure by means of contact with contaminated sampling equipment

Improved data quality and reliability

2. SCOPE

This procedure applies to all instances where non-disposable direct contact sampling equipment is utilized for sample collection. This procedure is not intended to address decontamination of peristaltic or other sampling pumps and tubing. The steps outlined in this procedure must be executed between each distinct sample data point.

3. REFERENCES

U.S. Environmental Protection Agency, Region 4, 2001, *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, 980 College Station Road, Athens, Georgia. November.

US Army Corp of Engineers, Washington, D.C., 2001, Requirements for the Preparation of Sampling and Analysis Plans (EM-200-1-3), February.

4. DEFINITIONS

Soap - A standard brand of phosphate-free laboratory detergent, such as Liquinox®.

Organic Desorbing Agent - A solvent used for removing organic compounds. The specific solvent would depend upon the type of organic compound to be removed. See Attachment 1 for recommendations.

Inorganic Desorbing Agent - An acid solution for use in removing trace metal compounds. The specific acid solution would depend upon the type of inorganic compound to be removed. See Attachment 1 for recommendations.

Tap water - ater obtained from any municipal water treatment system. An untreated potable water supply can be used as a substitute for tap water if the water does not contain the constituents of concern.

Analyte-free water (deionized water) - Water that has been treated by passing through a standard deionizing resin column, and for organics either distillation or activated carbon units. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds, and/or no detectable organic compounds (i.e., at or above analytical

detection limits). Analyte-free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.

Other solvents may be substituted for a particular purpose if required. For example, removal of concentrated waste materials may require the use of either pesticide-grade hexane or petroleum ether. After the waste material is removed, the equipment must be subjected to the standard cleaning procedure. Because these solvents are not miscible with water, the equipment must be completely dry prior to use.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

6.1 Health and Safety

Minimum Health and Safety Procedures should be implemented based on the site-specific decontamination protocol that is designed. Health and Safety procedures should take into consideration the potential use of either dangerous solvents or corrosive liquids.

6.2 Implementation

A decontamination area should be established. A separate tub needs to be available for each of the first four steps. Each type of water and soap solution can be placed in hand-held sprayers made of an inert material. The analyte-free water needs to be placed in a container that will be free of any compounds of concern. Special containers will be needed if solvents or acid solutions are used. For example, an acid solution cannot be placed in a sprayer that has any metal parts that will come in contact with the acid solution.

The minimum steps for decontamination are as follows:

-Remove particulate matter and other surface debris using appropriate tools such as a brush or hand-held sprayer filled with tap water.

-Scrub the surfaces of the contact sampling equipment using tap water and soap solution and a second brush made of inert material.

-Rinse contact sampling equipment thoroughly with tap water.

-Rinse contact sampling equipment thoroughly with analyte-free water (not necessary if sampling for disposal profiling purposes).

-Place contact sampling equipment on a clean surface appropriate for the compounds of concern and allow to air dry.

It is Shaw E & I policy to containerize all decontamination fluids. This policy will be followed unless an the client specifically directs an alternate procedure in writing.

The use of solvents and/or acid solutions will be dependent on the site-specific conditions. A site with a high probability of high concentrations of compounds or with waste material present will require additional decontamination procedures. The following table provides some guidance for additional decontamination procedures.

Recommended Decontamination Procedures.

Compound	Detergent Wash	Tap Water	Inorganic Desorbing Agent	Tap Water	Organic Desorbing Agent[1]	Deionized Water	Air Dry
ORGANICS							
Volatile Organic Compounds	X	X			Methanol Purge & Trap grade	X	X
Base Neutrals Acid Extractables PCBs Pesticides	X	X			Hexane	X	X
Organic Bases[2]	X	X	1% nitric acid	X	Isopropyl Alcohol	X	X
Organic Acids[3]	X	X	1% nitric acid		Isopropyl Alcohol	X	X
INORGANICS							
Trace Metals Radio Isotopes	X	X	10% Nitric acid - Trace metals grade	X		X	X
Cations/Anions	X	X				X	X
Acidic Compounds	X	X				X	X
Basic Compounds (caustic)	X	X	1% nitric acid	X		X	X

1 – All organic solvents must be Pesticide Grade or better. The selection of appropriate solvent rinses should first consider if a known or suspected contaminant requires removal from sampling equipment. Secondly, identify whether the subsequent analytical protocol would be impacted by the proposed solvent or an impurity thereof (e.g., residual acetone present in isopropyl alcohol would be measured with certain volatile organics analysis).

2 -Organic bases include amines, hydrazines.

3 –Organic acids include phenols, thiols, nitro and sulfonic compounds.

Adapted from: Appendix E, Requirements for the Preparation of Sampling and Analysis Plans (EM-200-1-3), February 2001. US Army Corp of Engineers, Washington, D.C.

Procedure No. SHAW-MMR-GRID-1 Revision No. Date of Revision 03/21/06
STANDARD OPERATING PROCEDURE

Subject: Soil Grid Sampling Procedure for Munition-Related Compounds

1. PURPOSE

The purpose of this procedure is to provide a sound method for sampling of impact and training range soils in a manner that accounts for and attempts to address the observed contaminant heterogeniety in these soils.

2. SCOPE

This procedure applies to the sampling of range soils where the intent is to determine a gross average for a specific property or parameter set for comparison to decision levels. Examples include determining disposal issues, reuse determination, treatment confirmation, and backfill usability.

3. REFERENCES

This procedure is based on the findings of several U.S. Army Corps reports:

Jenkins, T.F., T.A. Ranney, A.D. Hewitt, M.E. Walsh and K.L. Bjella (2004) Representative sampling for energetic compounds at an antitank firing range. Cold Regions Research and Engineering Laboratory. ERDC/CRREL TR-04-7.

Jenkins, T.F., A.D. Hewitt, T.A. Ranney, C.A. Ramsey, D.J. Lambert, K.L. Bjella and N.M. Perron (2004) Sampling strategies near a low-order detonation and a target at an artillery impact area. Cold Regions Research and Engineering Laboratory. ERDC/CRREL TR-04-7.

4. DEFINITIONS

Composite Sample - A sample created by the mixing of several discrete samples into one sample representative of the average characteristics of the entity sampled.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Project Manager and Field Manager are responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be directed to both persons.

5.2 Project Responsibility

Shaw employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Field Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (i.e. checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

6.1 Determine Sample Locations

All sampling ocations shall be screened and cleared of UXO. The area shall be selected based on either 1) previously determined areas of interest or 2) areas deemed to be generally representative of the site.

6.2 Establish Grid

Once the area is selected, a sampling grid will be established. The grid will be a total of 10' x 10' in size, and will be composed of 25 2' x 2' subgrids. A larger grid area with a similar node breakdown should be used for larger area (i.e., 100 x 100 m grid, with 100 1 x 1 m nodes). Where contaminants are expected along a transect, or in a radial pattern, other grid shapes are permitted.

For a low to moderate amount of smapling, the physical grid will be prepared using either jute twine rope or nylon string. If a large amount of sampling is expected, the grid can be constructed from small diameter PVC tubing to provide durability.

The grid will be placed on the soil surface of the sample location and secured using stakes or other devices to keep it in place.

6.3 Collect and Composite Subsamples

Ten (10) of the squares within the grip will be designated as sample "nodes", while the remaineder of the nodes will not be sampled. The designated sample nodes will be selected randomly from the 25 available nodes using Microsoft Excel's random number generator (=RANDBETWEEN(1,25)) or free randomizer program (such as that at http://www.randomizer.org/form.htm, which will generate several sets of random numbers at once for sampling multiple locations). An example of selected nodes is presented below:

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

Sampled node

Unsampled node

The entire top 1 to 3 inches of soil from within each sampled node shall be collected and placed on a tarp. Once all the nodes are sampled, the soil will be thoroughly homogenized as described in Shaw SOP T-FS-011 to produce the composite.

Samples (number determined based on the specific project), duplicates and MS/MSDs shall be taken from the homogenized soil.

Soil samples will be uniquely identified with a sample ID that contains a reference to the sample location.

6.4 Equipment Decon

All equipment will be decontaminated as described in Shaw SOP T-FS-014, Revised 06/05/2003

Shaw
17 Princess Rd
Lawrenceville, NJ 08648
609-895-5340 // 609-895-1858
Shaw Environmental and Infrastructure Inc.

CHAIN OF CUSTODY

Ref. Document # _____

Page 1 of 2

Project Contact: _____ (name & phone #)

Send Report To: *Mark Fuller*
Phone/Fax Number: *609-895-5348*
Address: *17 Princess Road*
City/State: *Lawrenceville, NJ 08648*

Sampler's Name(s): _____

Project Number/Cost code: *109163-01010000*
Project Name / Location: *SERDP/Microbiology*
Purchase Order #: _____

Shipment Date: _____
Waybill/Airbill Number: _____
Lab Destination: *Lawrenceville, NJ*
Lab Contact Name / ph. #: *Mark Fuller / 609-895-5348*

Lab No.	Sample ID Number	Sample Description	Collection Information: Date	Time	G/C	Matrix	# of containers	Container type	Preservative: HCL	NaOH	HNO_3	H_2SO_4	Ice		Analyses Requested									Turn Around Time Requested

Special Instructions:

Known Waste Stream Circle:
RCRA PCB/dioxin PAH/oil NAD Corrosive Flammable Reactive

QC/Data Package Level Required:
I II III IV NJ EDD GIS EDD Preliminary data

Relinquished By: Date: Time:
Received By: Date: Time:

Relinquished By: Date: Time:
Received By: Date: Time:

Relinquished By: Date: Time:
Received By: Date: Time:

G/C Codes
C = Composite G = Grab

QC Package Codes
Level I = data summary
Level II = data summary + basic QC
Level III = New Jersey QC reduced deliverable
Level IV = Full deliverable CLP package

Cooler temperature upon arrival at Lab:

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Shaw Environmental and Infrastructure Inc.

COC Ref. Document # _____ Page ____ of ____

Project Number/ cost code: 109163-01010000 Shipment Date: _____

Project Name / Location: SERDP/Microbiology

Lab No.	Sample ID Number	Sample Description	Collection Information			Matrix	# of containers	Container type	Preservative						Analyses Requested										Turn Around Time Requested
			Date	Time	G/C				HCL	NaOH	HNO_3	H_2SO_4	Ice												

Appendix C

Analytical Methods Supporting the Sampling Plan

Analyte	**EPA or Shaw Method**	**Included in Appendix B**
Explosives	SHAW ORG-006A	Yes
Total organic carbon (TOC)	EPA Method 415.1	Yes
	Loss on Ignition (LOI, alternative method)	Yes

SHAW METHOD:	**SHAW ORG-006A**
EPA METHOD:	**8330modified**
TITLE:	**Analysis of Explosives**
ANALYTE:	**Nitroaromatics and nitramines**
INSTRUMENTATION:	**Chromatograpy (HPLC)**
VERSION:	**2005-1**

NITROAROMATIC AND NITRAMINES (SHAW ORG-006; EPA METHOD 8330)

1.0 SCOPE AND APPLICATION

1.1 Method 8330 is intended for the trace analysis of explosives residues by high performance liquid chromatography using a UV detector with or without combination of a diode array detector (DAD). This method is used to determine the concentration of various nitroaromatic compounds (see table below) in a water, soil or sediment matrix.

1.2 Method 8330 provides low level extraction procedures for low concentration (parts per trillion, or nanograms per liter) of explosives residues in surface or ground water. Direct injection of diluted and filtered water samples can be used for water samples of higher concentration

1.3 All of the compounds listed in the table below are either used in the manufacture of explosives or are the degradation products of compounds used for that purpose. When making stock solutions for calibration, treat each explosive compound with caution. See NOTE in Sec. 5.4, 7.2 and Sec. 12 on Safety.

1.4 The estimated quantitation limits (EQLs) of target analytes determined by modified Method 8330 in water and soil are presented in Shaw's QAPP.

1.5 This method is restricted to use by or under the supervision of analysts experienced in the use of HPLC, skilled in the interpretation of chromatograms, and experienced in handling explosive materials. (See Sec. 121.0 on SAFETY.) Each analyst must demonstrate the ability to generate acceptable results with this method.

COMPOUND	ABBREVIATION	CAS #
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	HMX	2691-41-0
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-Trinitrobenzene	1,3,5-TNB	99-35-0
1,3-Dinitrobenzene	1,3-DNB	99-65-0
2,4,6-Trinitrophenylmethylnitramine	Tetryl	479-45-8
Nitrobenzene	NB	98-95-3
2,4,6-Trinitrotoluene	2,4,6-TNT	118-96-7
4-Amino-2,6-dinitrotoluene	4Am-DNT	1946-51-0
2-Amino-4,6-dinitrotoluene	2Am-DNT	355-72-78-2
2,4-Dinitrotoluene	2,4-DNT	121-14-2
2,6-Dinitrotoluene	2,6-DNT	606-20-2
2-Nitrotoluene	2-NT	88-72-2
4-Nitrotoluene	3-NT	99-08-1
3-nitrotoluene	4-NT	99-99-0

Additionally, the primary RDX breakdown products below are included in this analysis and quantified using semi-quantitative standards:

COMPOUND	ABBREVIATION	CAS #
Hexahydro-1,3,5-trinitroso-1,3,5-triazine	TNX	NA[a]
Hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine	DNX	NA
Hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine	MNX	NA

[a]NA, not available.

2.0 SUMMARY OF METHOD

2.1 Method 8330 provides high performance liquid chromatographic (HPLC) conditions for the detection of ppb levels of certain explosives residues in water, soil and sediment matrix. Prior to use of this method, appropriate sample preparation techniques must be used.

2.2 Low-Level (Method 1) Salting-out Method With No Evaporation: Aqueous samples of low concentration are extracted by a salting-out extraction procedure with acetonitrile and sodium chloride. The small volume of acetonitrile that remains undissolved above the salt water is drawn off and transferred to a smaller volumetric flask. It is back-extracted by vigorous stirring with a specific volume of salt water. After equilibration, the phases are allowed to separate and the small volume of acetonitrile residing in the narrow neck of the volumetric flask is removed using a Pasteur pipet. The concentrated extract may be diluted 1:1 with reagent grade water if necessary to improve chromatography. An aliquot is separated on a C-18 reverse phase column, determined at 254 nm, and confirmed on a CN reverse phase column if necessary due to any coelution of compounds.

2.3 Low-Level (Method 2): Cartridge solid-phase extraction Extraction cartridges are fitted with frits at one end, then packed tightly with Porapak RDX. A second frit is placed over the open ends of the cartridges to retain the material inside. Using a

Visiprep Solid-Phase Extraction Manifold (Supelco), the aqueous samples are extracted through the cartridges; the cartridges are then eluted using acetonitrile. The resulting eluate may be diluted 1/1 with reagent-grade water prior to analysis if necessary.

2.4 Low-Level (Method 3) Membrane solid-phase extraction Empore styrene-divinyl benzene (SDB) RPS disks are placed in a vacuum filter apparatus and soaked with acetonitrile. The acetonitrile is pulled through the disk, followed by reagent-grade water. Just before all the water has been pulled through, the vacuum is turned off and an aqueous water sample aliquot is placed in the reservoir. Turning the vacuum back on, the aliquot and any remaining water is pulled through the membrane. Air is then pulled through the disks for a short time to remove any excess water. Once they are dry, acetonitrile is added to the reservoir and allowed to soak into the membrane. Next, the acetonitrile is pulled through the disks into a test tube that has been fitted into the vacuum flask. The resulting extract is removed using a Pasteur pipette and placed into a graduated cylinder where it is diluted 1/1 with reagent-grade water prior to analysis.

2.5 High-level Direct Injection Method: Aqueous samples of higher concentration can be diluted 1/1 (v/v) with methanol or acetonitrile, filtered, separated on a C-18 reverse phase column, determine at 254 nm, and confirmed on a CN reverse phase column if necessary. If HMX is an important target analyte, methanol is preferred.

2.6 Soil and sediment samples are extracted using acetonitrile in an ultrasonic bath, filtered and chromatographed as in Sec. 2.2.

3.0 INTERFERENCES

3.1 Solvents, reagents, glassware and other sample processing hardware may yield discrete artifacts and/or elevated baselines, causing misinterpretation of the chromatograms. All of these materials must be demonstrated to be free from interferences.

3.2 2,4-DNT and 2,6-DNT may elute at similar retention times (retention time difference of 0.2 minutes). A large concentration of one isomer may mask the response of the other isomer. If it is not apparent that both isomers are present (or are not detected), an isomeric mixture should be reported.

3.3 Tetryl decomposes rapidly in methanol/water solutions, as well as with heat. All aqueous samples expected to contain tetryl should be diluted with acetonitrile prior to filtration and acidified to pH <3. All samples expected to contain tetryl should not be exposed to temperatures above room temperature.

3.4 Degradation products of tetryl appear as a shoulder on the 2,4,6-TNT peak. Peak heights rather than peak areas should be used when tetryl is present in concentrations that are significant relative to the concentration of 2,4,6-TNT.

4.0 APPARATUS AND MATERIALS

4.1 HPLC system

4.1.1 HPLC - equipped with a pump capable of achieving 4000 psi, a 100 µl loop

injector, a variable wavelength UV detector, and a diode array detector (optional). For the low concentration option, the detector must be capable of a stable baseline at 0.001 absorbance units full scale.

4.1.2 Recommended Columns:

4.1.2.1 Primary column: C-18 Reverse phase HPLC column, 25 cm x 4.6 mm (5 µm), (Supelco LC-18, or equivalent).

4.1.2.2 Secondary column: CN Reverse phase HPLC column, 25 cm x 4.6 mm (5 µm), (Supelco LC-CN, or equivalent). This is required only if there is a questionable identification of one or more compounds

4.1.3 Strip chart recorder or printer.

4.1.4 Digital integrator (optional).

4.1.5 Autosampler (optional).

4.2 Other Equipment

4.2.1 Temperature controlled ultrasonic bath.

4.2.2 Vortex mixer.

4.2.3 Balance, ± 0.0001 g.

4.2.4 Magnetic stirrer with stirring pellets.

4.2.5 Water bath - Heated, with concentric ring cover, capable of temperature control (± 5°C). The bath should be used in a hood.

4.2.6 Oven - Forced air, without heating.

4.3 Materials

4.3.1 High pressure injection syringe - 500 µL, (Hamilton liquid syringe or equivalent).

4.3.2 Disposable cartridge filters - 0.45 µm Teflon filter.

4.3.3 Pipets - Class A, glass, Appropriate sizes.

4.3.4 Pasteur pipets.

4.3.5 Scintillation Vials - 20 mL, glass.

4.3.6 Vials - 15 mL, glass, Teflon-lined cap.

4.3.7 Vials- 40 mL, glass, Teflon-lined cap.

4.3.8 Disposable syringes - Plastipak, 3 mL and 10 mL or equivalent.

4.3.9 Volumetric flasks - Appropriate sizes with ground glass stoppers, Class A.

NOTE: The 100 mL and 1 L volumetric flasks used for magnetic stirrer extraction must be round.

4.3.10 Vacuum desiccator - Glass.

4.3.11 Mortar and pestle - Steel.

4.3.12 Sieve - 30 mesh.

4.3.13 Graduated cylinders - Appropriate sizes.

4.3.14 Disposable 0.45-micron Teflon syringe filters (25 mm).

4.3.15 Disposable 0.45 -micronglass microfiber syringe filters (Whatman 13 mm GD/X or equivalent).

4.3.16 Disposable 0.45-micron nylon syringe filters (25 mm).

4.4 Equipment specific to cartridge solid-phase extraction

4.4.1 Visiprep Solid-Phase Extraction Manifold: from Supelco.

4.4.2 Porapak RDX (80/100) mesh: from Supelco. Or prepacked SPE columns

4.4.3 Extraction cartridges (one per sample).

4.5 Equipment specific to membrane solid-phase extraction

4.5.1 Vacuum filter apparatus: 47 mm, with 25 x 200 mm or 25 x 250 mm vacuum flask.

4.5.2 Empore styrene-divinyl benzene (SDB) RPS disks: 47 mm (one per sample).

4.6 Preparation of Materials

4.6.1 Prepare all materials to be used as described in Chapter 4 for semivolatile organics.

5.0 REAGENTS

5.1 Reagent grade inorganic chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lowering the accuracy of the determination.

5.1.1 Acetonitrile, CH_3CN - HPLC grade.

5.1.2 Methanol, CH_3OH - HPLC grade.

5.1.3 Calcium chloride, $CaCl_2$ - Reagent grade. Prepare an aqueous solution of 5 g/L.

5.1.4 Sodium chloride, NaCl, shipped in glass bottles - reagent grade.

5.2 Organic-free reagent water - All references to water in this method refer to organic-free reagent water, as defined in Chapter One of Method 8000.

5.3 Mobile-phase reagent (500 mL methanol to 500 mL of organic-free reagent water).

5.4 Stock Standard Solutions

5.4.1 Dry each solid analyte standard to constant weight in a vacuum desiccator in the dark. Place about 0.100 g (weighed to 0.0001 g) of a single analyte into a 100 mL volumetric flask and dilute to volume with acetonitrile. Invert flask several times until dissolved. Store in refrigerator at 4°C in the dark. Calculate the concentration of the stock solution from the actual weight used (nominal concentration = 1,000 mg/L). Stock solutions may be used for up to one year. Alternatively premixed stock solutions can be purchased from a certified source.

> NOTE: The HMX, RDX, Tetryl, and 2,4,6-TNT are explosives and the neat material should be handled carefully. See SAFETY in Sec. 11 for guidance. HMX, RDX, and Tetryl reference materials are shipped under water. Drying at ambient temperature requires several days. DO NOT DRY AT HEATED TEMPERATURES!

5.5 Intermediate Standards Solutions

5.5.1 If both 2,4-DNT and 2,6-DNT are to be determined, prepare two separate intermediate stock solutions containing (1) HMX, RDX, 1,3,5-TNB, 1,3-DNB, NB, 2,4,6-TNT, and 2,4-DNT and (2) Tetryl, 2,6-DNT, 2-NT, 3-NT, and 4-NT. Intermediate stock standard solutions should be prepared at 1,000 µg/L, in acetonitrile when analyzing soil samples, and in methanol when analyzing aqueous samples. These solutions are also available commercially.

5.5.2 Dilute the two concentrated intermediate stock solutions, with the appropriate solvent, to prepare intermediate standard solutions that cover the range of 2.5 - 1,000 µg/L. These solutions should be refrigerated on preparation, and may be used for 30 days.

5.5.3 For the low-level method, the analyst must conduct a detection limit study and devise dilution series appropriate to the desired range. Standards for the low level method must be prepared immediately prior to use.

5.6 Working standards

5.6.1 Calibration standards at a minimum of five concentration levels should be prepared through dilution of the intermediate standards solutions in acetonitrile or methanol. These solutions must be refrigerated and stored in the dark, and prepared fresh on the day of calibration.

5.7 Surrogate Spiking Solution

5.7.1 The analyst should monitor the performance of the extraction and analytical system as well as the effectiveness of the method in dealing with each sample matrix by spiking each sample, standard and reagent water blank with one or two surrogates (e.g., analytes

not expected to be present in the sample and do not coelute with target compounds).

5.8 Matrix Spiking Solutions

5.8.1 Prepare matrix spiking solutions in methanol such that the concentration in the sample is at least five times the Estimated Quantitation Limit. All target analytes should be included.

5.9 HPLC Mobile Phase

5.9.1 To prepare 1 liter of mobile phase, add 500 mL of methanol to 500 mL of organic-free reagent water.

5.9.2 The mobile phase may also be mixed "in-line" by the HPLC system drawing from bottles of 100% methanol and 100% organic-free reagent water.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 Follow conventional sampling and sample handling procedures as specified for semivolatile organics in Chapter Four. Dry all soil samples in air at room temperature or colder to a constant weight (less than 10% moisture), being careful not to expose the samples to direct sunlight.

6.2 Samples and sample extracts must be stored in the dark at 4°C. Holding times are the same as for semivolatile organics.

7.0 SAMPLE PREPARATION

7.1 Aqueous Samples: It is highly recommended that process waste samples be screened with the high-level method to determine if the low level method (1-50 µg/L) is required. Most groundwater samples will fall into the low level method.

7.1.1 Low-Level Method 1 (salting-out extraction)

7.1.1.1 Add 251.3 g of sodium chloride to a 1 L volumetric flask (round). Measure out 770 mL of a water sample (using a 1 L graduated cylinder) and transfer it to the volumetric flask containing the salt. Add a stir bar and mix the contents at maximum speed on a magnetic stirrer until the salt is completely dissolved.

7.1.1.2 Add 164 mL of acetonitrile (measured with a 250 mL graduated cylinder) while the solution is being stirred and stir for an additional 15 minutes. Turn off the stirrer and allow the phases to separate for 10 minutes.

7.1.1.3 Remove the acetonitrile (upper) layer (about 8 mL) with a Pasteur pipet and transfer it to a 100 mL volumetric flask (round). Add 10 mL of fresh acetonitrile to the water sample in the 1 L flask. Again stir the contents of the flask for 15 minutes followed by 10 minutes for phase separation. Combine the second acetonitrile portion with the initial extract. The inclusion of a few drops of salt water at this point is unimportant.

7.1.1.4 Add 84 mL of salt water (325 g NaCl per 1000 mL of reagent water) to the

acetonitrile extract in the 100mL volumetric flask. Add a stir bar and stir the contents on a magnetic stirrer for 15 minutes, followed by 10 minutes for phase separation. Carefully transfer the acetonitrile phase to a 10 mL graduated cylinder using a Pasteur pipet. At this stage, the amount of water transferred with the acetonitrile must be minimized. The water contains a high concentration of NaCl that produces a large peak at the beginning of the chromatogram, where it could interfere with the HMX determination.

7.1.1.5 Add an additional 1.0 mL of acetonitrile to the 100 mL volumetric flask. Again stir the contents of the flask for 15 minutes, followed by 10 minutes for phase separation. Combine the second acetonitrile portion with the initial extract in the 10 mL graduated cylinder (transfer to a 25 mL graduated cylinder if the volume exceeds 5 mL).Record the total volume of acetonitrile extract to the nearest 0.1 mL. (Use this as the volume of total extract [V_t] in the calculation of concentration after converting to µL). The resulting extract, about 5 - 6 mL, may be diluted 1:1 with organic-free reagent water (with pH <3 if tetryl is a suspected analyte) prior to analysis if necessary or can be run without dilution.

7.1.1.6 If the diluted extract is turbid, filter it through a 0.45 -µm Teflon filter using a disposable syringe. Discard the first 0.5 mL of filtrate, and retain the remainder in a Teflon-capped vial for RP-HPLC analysis as in Sec. 7.4. NOTE: turbididty my be the result of a compound coming out of solution and thus SHOULD NOT be diluted with water prior to analysis.

7.1.2.7 Samples should be stored at 4°C in the dark until analysis. Samples must be warmed to room temperature before RP-HPLC analysis is performed.

7.1.2 Low-Level Method 2: Cartridge solid-phase extraction

7.1.2.1 Fit 20-microm frits at the bottom of the empty extraction cartridges, then pack each cartridge with 0.5 g of the Porapak RDX. Place another frit on top of each cartridge to retain the material and help minimize channeling. Prepacked SPE cartridges are also available commercially for nitroaromatic extraction. In this case follow manufacturers procedure for usage.

7.1.2.2 Place the cartridges on the Visiprep Solid-Phase Extraction Manifold and clean and condition them by eluting with 30 mL of acetonitrile by gravity flow, followed by 50 mL of reagent-grade water at 10 mL per minute.

7.1.2.3 Measure a 500-mL aliquot of each water sample using a 1-L graduated cylinder. Pull the sample through a cartridge at about 10 mL per minute. Use a new cartridge for each sample.

7.1.2.4 Elute the samples by passing a 5-mL aliquot of acetonitrile through each cartridge at about 2 mL per minute and collect the eluate in a 10-mL graduated cylinder.

7.1.2.5 The resulting extract (about 5 mL) may be diluted with 1:1 with reagent-grade water prior to analysis but is not necessary.

7.1.2.6 Samples should be stored at 4°C in the dark until analysis. Samples must be warmed to room temperature before RP-HPLC analysis is performed.

7.1.3 Low-Level Method 3: Membrane solid-phase extraction

7.1.3.1 Rinse the Empore SDB-RPS disks with acetonitrile and center on the 47-mm vacuum filter apparatus.

7.1.3.2 To clean and condition the disks, add a 20-mL portion of acetonitrile and allow to this to soak into the disk for 3 minutes. Turn the vacuum on and allow most (but not all) of the solvent to be pulled through the disk.

7.1.3.3 Add a 50-mL aliquot of reagent-grade water to the disk and turn the vacuum on once again, pulling the water through the membrane. Just before the last of the water is pulled through, turn the vacuum off.

7.1.3.4 Fill the reservoir with a 500-mL aliquot of water sample, turn the vacuum on, and pull the sample through the membrane. This will take 5 to 7 minutes, with resulting flow rates ranging from 70 to 100 mL per minute.

7.1.3.5 Once the water is exhausted, draw air through the membrane for 1 minute to remove any excess water. Turn the vacuum off and remove the flask.

7.1.3.6 Remove the water and place a test tube in the flask so that it fits over the funnel exit when the flask is reattached to the fritted base. The actual size of the test tube depends upon the brand of vacuum flask.

7.1.3.7 Add a 5-mL aliquot of acetonitrile to the reservoir, and allow this to soak into the membrane for 3 minutes. Apply the vacuum, drawing the acetonitrile through the membrane into the test tube. Remove the resulting extract with a Pasteur pipette and store it for analysis.

7.1.3.8 If needed add an appropriate portion of reagent-grade water (< 5.0 mL) to dilute the acetonitrile extract 1:1 prior to analysis.

7.1.3.9 Samples should be stored at 4°C in the dark until analysis. Samples must be warmed to room temperature before RP-HPLC analysis is performed.

7.1.4 High-level method

7.1.4.1 Samples are prepared by directly filtering approximately 1.5 mL of the aqueous sample through a 0.45-micron glass microfiber syringe filter (Whatmaninto an HPLC autosampler vial. No dilution with solvent is required.

7.1.4.2 Samples may also be prepared as follows: Place a 5-mL aliquot of each water sample in a scintillation vial. Add 5 mL of acetonitrile, shake thoroughly, and filter through a 0.45-microm Teflon filter using a disposable syringe. NOTE: HMX quantitation can be improved by using methanol (instead of acetonitrile) for dilution

before filtration. Discard the first 3 mL of filtrate and retain the remainder in a Teflon-capped vial for RP-HPLC analysis.

7.1.4.3 Regardless of method chosen, samples should be stored at 4°C in the dark until analysis. Samples must be warmed to room temperature before RP-HPLC analysis is performed.

7.2 Soil and sediment samples

7.2.1 Dry the soil samples in air at room temperature (or colder) to a constant weight, being careful not to expose the samples to direct sunlight. Grind and homogenize the dried sample thoroughly in an acetonitrile-rinsed mortar to pass a 30-mesh sieve.

NOTE: Soil samples should be screened by Method 8515 prior to grinding with the mortar and pestle. Soil samples as high as 2% 2,4,6-TNT have been safely ground, but take care: samples containing higher concentrations should not be ground with the mortar and pestle. Method 8515 is for 2,4,6-TNT, the analyte most often detected in high concentrations in soil samples; however, the other nitroaromatics will also cause a color change that would provide a rough estimate of their concentrations. Visual observation of a soil sample is also important when the sample is taken from a site expected to contain explosives. Lumps of material that have a chemical appearance should be suspect and not ground. Explosives are generally a very finely ground grayish-white material.

7.2.2 Place a 2.0-g subsample of each soil sample in a 15-mL glass vial. Add 10.0 mL of acetonitrile, cap with a Teflon-lined cap, vortex swirl for 1 minute, and place in a cooled ultrasonic bath for 18 hours.

7.2.3 Subsamples of the ground and sieved soil must also be taken for determination of absolute water content so dry-weight-basis (105°C oven dry) explosive concentrations can be calculated.

7.2.4 After sonication, shake the samples vigorously to suspend the settled material, then allow the sample to settle for 30 minutes.

7.2.5 THIS IS AN OPTIONAL STEP. Remove 5.0 mL of supernatant and combine it with 5.0 mL of calcium chloride solution (see Section 7) in a 20-mL vial. Shake and let stand for 15 minutes.

7.2.6 Filter the supernatant (or diluted sample from 7.2.4) through a 0.45-micron Teflon filter. Discard the first 3 mL and retain the remainder in a Teflon-capped vial for RP-HPLC analysis. NOTE: For undiluted acetonitrile supernatants, a 0.45-micron nylon filter can be used.

7.2.7 Samples should be stored at 4°C in the dark until analysis. Samples must be warmed to room temperature before RP-HPLC analysis is performed.

8.0 ANALYTICAL PROCEDURE

8.1 Chromatographic Conditions (Recommended)

8.1.1 Primary Column: C-18 reverse phase HPLC column, 25-cm x 4.6-mm, 5 µm, (Supelco LC-18 or equivalent).

8.1.2 Secondary Column: CN reverse phase HPLC column, 25-cm x 4.6-mm, 5 µm, (Supelco LC-CN or equivalent). This is required only for confirmation of analyte identification.

8.1 3 Mobile Phase: 50/50 (v/v) methanol/organic-free reagent water.

8.1 4 Flow Rate: 1.5 mL/min

8.1 5 Injection volume: 100-µL

8.1 6 UV Detector: 254 nm

8.2 Currently Used Chromatographic Conditions

8.2.1 Column: C-18 reverse phase HPLC column, 25-cm x 4.6-mm, 5 µm, (Restek Allure C18)

8.2 3 Mobile Phase: 50/50 (v/v) methanol/organic-free reagent water.

8.2 4 Flow Rate: 0.9 mL/min

8.2 5 Injection volume: 10-µL (increased to 100-µL for repeat analysis of “non-detect” samples)

8.2 6 UV Detector: 230 nm

8.2.7 Column temperature: 25°C

8.3 Calibration of HPLC

8.3.1 All electronic equipment is allowed to warm up for 30 minutes. During this period, at least 15 void volumes of mobile phase are passed through the column (approximately 20 min at 1.5 mL/min) and continued until the baseline is level at the UV detector's greatest sensitivity.

8.3.2 Initial Calibration. External calibration technique is used for calibration where the response factor for each target compound is determined. Injections of each calibration standard and surrogate over the concentration range of interest are made sequentially into the HPLC in random order. Peak heights or peak areas are obtained for each analyte or surrogate. Experience indicates that a linear calibration curve with zero intercept is appropriate for each analyte. Therefore, a response factor for each analyte can be taken as the slope of the best-fit regression line.

8.3.3 Daily Calibration. Analyze midpoint calibration standards, at a minimum, at the beginning of the day, singly at the midpoint of the run, and singly after the last sample of the day (assuming a sample group of 10 samples or less). Obtain the response factor for each analyte from the mean peak heights or peak areas and compare it with the response factor obtained for the initial calibration. The mean response factor for the daily calibration must agree within ±15% of the response factor of the initial calibration. The

same criteria is required for subsequent standard responses compared to the mean response of the triplicate standards beginning the day. If this criterion is not met, a new initial calibration must be obtained.

8.4 HPLC Analysis

8.4.1 Analyze the samples using the chromatographic conditions given in Sec. 8.2. If column temperature control is not employed, special care must be taken to ensure that temperature shifts do not cause peak misidentification Only if required by specific project QA are positive measurements confirmed by injection onto a CN column.

8.4.2 Follow Sec. 7.0 in Method 8000 for instructions on the analysis sequence, appropriate dilutions, establishing daily retention time windows, and identification criteria. Include a mid-level standard after each group of 10 samples in the analysis sequence. If column temperature control is not employed, special care must be taken to ensure that temperature shifts do not cause peak misidentification.

8.4.3 Record the resulting peak sizes in peak heights or area units. The use of peak heights is recommended to improve reproducibility of low level samples. Printed Chromatograms of each sample run should include all needed information (peak area, height, retention time etc) to calculate concentration based on calibration factor if being tabulated using a separate spreadsheet.

8.4.4 Calculation of concentration is covered in Sec. 7.0 of Method 8000. Chromatography software using the calibration curve for the target compounds can also be used to determine concentration of target analytes.

9.0 QUALITY CONTROL

9.1 Refer to Chapter One for specific quality control procedures. Quality control to validate sample extraction is covered in Method 3500.

9.2 At a minimum a standard check and blank sample must be run with every 10 samples. An MS/MSD sample is run with every batch of 20 samples and each sample, blank, standard or QC sample will be spiked with a surrogate. Samples will be spiked with a surrogate prior to any sample preparation in order to determine extraction efficiency of the procedure. Surrogates will be added to a sample to give a concentration in the final extract that is in the linear range of the surrogate response curve.

9.3 Quality control required to validate the HPLC system operation is found in Method 8000, Sec. 8.0.

9.4 Prior to preparation of stock solutions, acetonitrile, methanol, and water blanks should be run to determine possible interferences with analyte peaks. If the acetonitrile, methanol, or water blanks show contamination, a different batch should be used.

10.0 METHOD PERFORMANCE

10.1 Accuracy and Precision is determined for each analyte being measured according to Shaw's Quality Assurance Program.

11.0 REFERENCES

Bauer, C.F., T.F. Jenkins, S.M. Koza, P.W. Schumacher, P.H. Miyares and M.E. Walsh (1989). Development of an analytical method for the determination of explosive residues in soil. Part 3. Collaborative test results and final performance evaluation. USA Cold Regions Research and Engineering Laboratory, CRREL Report 89-9.

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Leggett, D.C., T.F. Jenkins and P.H. Miyares (1990) Salting-out solvent extraction for preconcentration of neutral polar organic solutes from water. Analytical Chemistry, 62: 1355-1356.

Miyares, P.H. and T.F. Jenkins (1990) Salting-out solvent extraction for determining low levels of nitroaromatics and nitramines in water. USA Cold Regions Research and Engineering Laboratory, Special Report 90-30.

12.0 SAFETY

12.1 Standard precautionary measures used for handling other organic compounds should be sufficient for the safe handling of the analytes targeted by Method 8330. The only extra caution that should be taken is when handling the analytical standard neat material for the explosives themselves and in rare cases where soil or waste samples are highly contaminated with the explosives. Follow the note for drying the neat materials at ambient temperatures.

SHAW METHOD	**SHAW CON-014**
METHOD #: 415.1	**Approved for NPDES (Editorial Revision 1974)**
TITLE:	**Organic Carbon, Total (Combustion or Oxidation)**
ANALYTE:	**CAS # Total Organic Carbon (TOC) C 7440-44-0**
INSTRUMENTATION:	**Appollo 9000**
STORET No.	**2005-1**

TOTAL ORGANIC CARBON (SHAW CON-14; EPA 415.1)

1.0 Scope and Application

1.1 This method includes the measurement of organic carbon in drinking, surface and saline waters, domestic and industrial wastes. Exclusions are noted under Definitions and Interferences.

1.2 The method is most applicable to measurement of organic carbon above 1 mg/L.

2.0 Summary of Method

2.1 Organic carbon in a sample is converted to carbon dioxide (CO_2) by catalytic combustion or wet chemical oxidation. The CO_2 formed can be measured directly by an infrared detector The amount of CO_2 is directly proportional to the concentration of carbonaceous material in the sample.

3.0 Definitions

3.1 The carbonaceous analyzer measures all of the carbon in a sample. Because of various properties of carbon-containing compounds in liquid samples, preliminary treatment of the sample prior to analysis dictates the definition of the carbon as it is measured. Forms of carbon that are measured by the method are:

A) soluble, nonvolatile organic carbon; for instance, natural sugars.
B) soluble, volatile organic carbon; for instance, mercaptans.
C) insoluble, partially volatile carbon; for instance, oils.
D) insoluble, particulate carbonaceous materials, for instance; cellulose fibers.
E) soluble or insoluble carbonaceous materials adsorbed or entrapped on insoluble inorganic suspended matter; for instance, oily matter adsorbed on silt particles.

3.2 The final usefulness of the carbon measurement is in assessing the potential oxygen demanding load of organic material on a receiving stream. This statement applies whether the carbon measurement is made on a sewage plant effluent, industrial waste, or on water taken directly from the stream. In this light, carbonate and bicarbonate carbon are not a part of the oxygen demand in

the stream and therefore should be discounted in the final calculation or removed prior to analysis. The manner of preliminary treatment of the sample and instrument settings defines the types of carbon which are measured. Instrument manufacturer's instructions should be followed.

4.0 Sample Handling and Preservation

4.1 Sampling and storage of samples in glass bottles is preferable. Sampling and storage in plastic bottles such as conventional polyethylene and cubitainers is permissible if it is established that the containers do not contribute contaminating organics to the samples. NOTE: A brief study performed in the EPA Laboratory indicated that distilled water stored in new, one quart cubitainers did not show any increase in organic carbon after two weeks exposure.

4.2 Because of the possibility of oxidation or bacterial decomposition of some components of aqueous samples, the lapse of time between collection of samples and start of analysis should be kept to a minimum. Also, samples should be kept cool (4°C) and protected from sunlight and atmospheric oxygen.

4.3 In instances where analysis cannot be performed within two hours (2 hours) from time of sampling, the sample is acidified (pH <2) with or H_2SO_4 or H_2PO_3

5.0 Interferences

5.1 Carbonate and bicarbonate carbon represent an interference under the terms of this test and must be removed or accounted for in the final calculation.

5.2 This procedure is applicable only to homogeneous samples which can be injected into the apparatus reproducibly by means of a microliter type syringe or pipette. The openings of the syringe or pipette limit the maximum size of particles which may be included in the sample.

6.0 Apparatus

6.1 Apparatus for blending or homogenizing samples:

6.2 Apparatus for total and dissolved organic carbon: currently in use an Appollo 9000 without an autosampler

7.0 Reagents

7.1 Distilled water used in preparation of standards and for dilution of samples should be ultra pure to reduce the carbon concentration of the blank. Carbon dioxide-free, double distilled water is recommended. Ion exchanged waters are not recommended because of the possibilities of contamination with organic materials from the resins.

7.2 Potassium hydrogen phthalate, stock solution, 1000 mg carbon/liter: Dissolve 0.2128 g of potassium hydrogen phthalate (Primary Standard Grade) in

distilled water and dilute to 100.0 mL. KHP crystals must be dry and stored in a dessicator. Other-wise, dry by placing in the oven at 105°C for 2 hours prior to preparation of the stock solution. Potassium Hydrogen Phthalate, KHPACS Acidimetric Standard, 99.95%-100.05%1,000 ppm C and 2,000 ppm C KHP certified standards are available from Teledyne Tekmar

7.3 Sodium Bicarbonate (ACS Reagent Grade)

7.4 Potassium hydrogen phthalate, standard solutions: Prepare standard solutions from the stock solution by dilution with distilled water.

7.5 Blank solution: Use the same distilled water (or similar quality water) used for the preparation of the standard solutions.

7.6 Sodium Bicarbonate (ACS Reagent Grade)

8.0 Procedure

8.1 Follow instrument manufacturer's instructions for calibration, procedure, and calculations (summary below).

8.2 Instrument set up

8.2.1 Select Instrument from the Setup menu of the TOC Talk Control screen to open the Instrument Setup/Status dialog.

8.2.2 Select Ready to wake up the instrument

8.2.3 The gas flow will turn on and the detector signal will begin to stabilize. Look for the flow rate display in the To Furnace field.

8.2.4 Select the following parameters:

a) Select Without Autosampler from the Sample Introduction list
b) Check Print Data Report after Each Sample Set (optional).
c) If you wish, you may type in your name and give your instrument a name. All other choices should remain un-checked.

8.3 Sample Set up

8.3.1 From the menu bar of the Control screen, click Run.

8.3.2 The Run screens are actually three separate screens that display real-time data

a) Sample Analysis displays the last Sample ID, Mode, etc. if not running or the current Sample ID, etc. while running. The Sample Setup button accesses the Sample Setup table.
b) Strip Chart shows the detector signal and can be changed to magnify small peaks or accommodate larger peaks .
c) Analysis Results updates analysis data at the end of each sample analysis rep.

8.3.3 Click the Sample Setup button in the Sample Analysis screen

8.3.4 In the Without Autosample Analysis Setup screen, enter a name for the sample run in the Sample ID field

8.3.5 Select Sample from the Sample Type list

8.3.6 Select TOC 0-20 ppm C from the Method ID list. The analysis Mode displayed should match the Method and the Calibration

Curve should display the default unless another curve is set as active and in memory.

8.3.7 Select TOC 0-20 ppm C from the Method ID list. The analysis Mode displayed should match the Method and the Calibration Curve should display the default unless another curve is set as active and in memory.

8.3.8 Select appropriate number of analyses in Repeats field.

8.3.9 Click Save/Use.

8.3.10 Before you begin the analysis run, verify that the:

a) sample line runs from Port D of the 8-port valve into the correct sample vessel
b) acid supply line runs from Port A of the 8-port valve into the acid reagent container
c) DI Water line runs from Port G of the 8-port valve to a fresh DI Water supply

8.3.11 Start analysis Click Start

8.4 For calibration of the instrument, it is recommended that a series of standards encompassing the expected concentration range of the samples be used.

9.0 Precision and Accuracy

9.1 See Current QAPP for summary of Precission and Accuracy measurements

Bibliography

Annual Book of ASTM Standards, Part 31, "Water", Standard D 2574-79, p 469 (1976).

Standard Methods for the Examination of Water and Wastewater, 14th Edition, p 532, Method 505, (1975).

ALTERNATE PROCEDURE
PEAT MOSS CONTENT (TOC) BY LOSS OF WEIGHT ON IGNITION
(Adapted from Storer, 1984)

Equipment:

1. Oven capable of being heated to approximately 650°C.
2. Crucibles - 20 mL.
3. Crucible racks and dessicator for cooling.
4. Balance sensitive to ±1 mg in draft-free environment.

Procedure:

1. Scoop 5 to 10 g of dried soil into tared crucibles.
2. Dry to a constant weight at 105°C. Cool in dessicator before weighing.
3. Record weight to ±1 mg.
4. Heat at 550°C for two hours (after temperature reaches 550°C). NOTE: Temperature should be reduced to between 350 and 440°C for high carbonate soils to avoid loss of inorganic carbon.
5. Cool in dessicator.
6. Weigh in a draft-free environment to ±1 mg.

Calculation:
Loss of weight on ignition (LOI) is calculated by the following equation:

$$\text{LOI (\%)} = \frac{\text{Weight at 105°C - Weight at 550°C}}{\text{Weight at 105°C}} \times 100$$

Calculation of peat moss by LOI is done by regression analysis. Soils covering the range in peat content expected in the samples are analyzed by LOI. Regress peat content of known samples vs. LOI. Use the resulting equation to convert LOI to peat moss content.

References

Storer, D. A. 1984. A simple high sample volume ashing procedure for determining soil organic matter. Commun. Soil Sci. Plant Anal. 15:759-772.

Appendix D

Quality Assurance Project Plan (QAPP)

ACRONYMS AND ABBREVIATIONS

ATL	Shaw's Analytical and Treatability Laboratory
CA	Corrective Action
COC	Chain of Custody
EPA	Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
HPLC	High Performance Liquid Chromatography
LCS/LCSD	Laboratory Control Sample/ Laboratory Control Sample Duplicate
MDL	Method Detection Limit
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NIST	National Institute of Standards and Technology
PQL	Practical Quantitation Limit
QAO	Quality Assurance Officer
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
Shaw	Shaw Environmental, Inc.
SOP	Standard Operating Procedures
STL	Severn Trent Laboratories

Purpose and Scope of the Plan

Shaw Environmental, Inc. (Shaw) will conduct a grenade range demonstration to obtain the data and information necessary to evaluate the effectiveness of a soil amendment process designed to enhance the immobilization and biodegradation of explosive residues. To obtain the necessary data, Shaw will conduct a sampling program to collect and analyze samples from various environmental media. The GR Field Demonstration Plan describes the tasks to be completed, including the proposed sampling and analytical methods.

This Quality Assurance Project Plan (QAPP) has been developed for use on this project. This document is designed to complement the GR Field Demonstration Plan by providing the data quality requirements that will be applied to data generated as part of the field investigations. The Sampling Methods included in Appendix A of the GR Field Demonstration Plan, which will guide all field data collection activities, also support the quality goals of this effort.

Tables and figures accompanying this document are located within the text or immediately after the document text.

Quality Assurance Responsibilities

The grenade range demonstration program is being performed by Shaw under the Environmental Security Technology Certification Program (ESTCP). An organization chart showing the relationship between ESTCP, Shaw, and other entities is provided in Figure 1.

Primary project personnel and responsibilities are listed in Table 1. Personnel who conduct work activities will have the necessary experience and training to satisfactorily complete the assigned tasks.

Figure 1. Project Organizational Chart

Figure 1

Project Organizational Chart

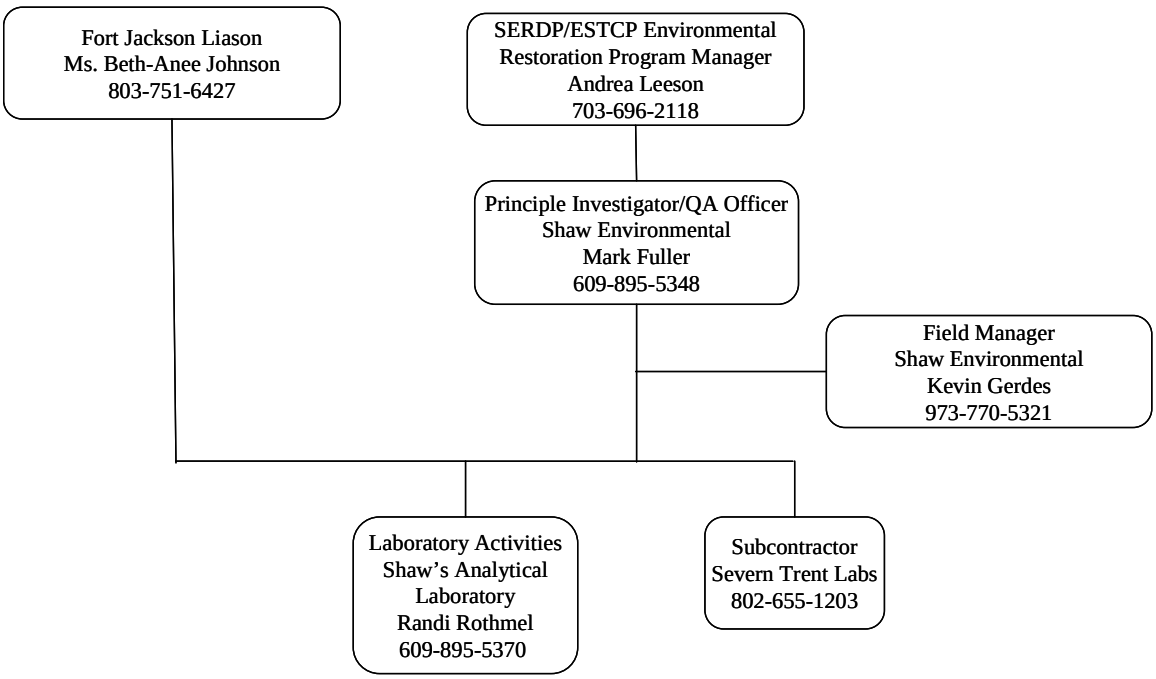

Table 1
Personnel Responsibilities

Name	Organizational Affiliation	Responsibilities	Contact Information
Mark Fuller, Ph.D.	Shaw, Lawrenceville, NJ	Principle Investigator/QA Officer – coordinates and oversees project management.	609-895-5348 (phone) 609-895-5340 (fax) mark.fuller@shawgrp.com
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Field Demonstration Inspection

Shaw will inspect the demonstration area at the same time that samples are collected. As part of this demonstration includes assessment of how the treatment material is redistributed by natural factors (wind, rain), notes and photos relevant to the current state of the demonstration will be taken. Depending on the degree of redistribution, a decision to re-apply and/or perform maintenance to the treatment material will be made after consultation between the Principal Investigator and the Field Manager.

Data Quality Parameters

Data will be evaluated based on adherence to acceptance criteria for precision, accuracy, representativeness, comparability, and completeness. These data quality indicators and the methods to be used to determine them are discussed below. Equations used to calculate data quality indicators are included in Section C.6.

Precision. Precision is defined as the agreement among individual measurements of the same chemical constituent in a sample, obtained under similar conditions. Precision will be expressed as relative percent difference (RPD) and percent relative standard deviation (%RSD).

Precision objectives apply to both field and laboratory duplicates. However, field duplicates based on the analytical results take into account the level of error introduced by field sampling techniques, field conditions, and analytical variability. The laboratory duplicate results are used to measure analytical variability. The RPD of all laboratory duplicates will be reported by the

laboratory, and the RPD of field duplicates and matrix spikes/matrix spike duplicates will be calculated by Shaw to evaluate the sample precision.

When three or more results are available, the %RSD will be calculated as a measure of precision. The %RSD provides a measure of precision relative to the magnitude of the measurement. The lower the %RSD, the more precise the measurement.

If poor overall precision of data is observed, it may be an indication of poor sampling technique, field sample nonhomogeneity, sample transport problems, or analytical methodology variations. Poor field sampling precision is commonly experienced with explosives sampling due to sample nonhomogeneity and sample compositing limitations. For sample nonhomogeneity issues, data must be interpreted accordingly (i.e., more representative concentrations may be obtained from averaging sample concentrations over an appropriately sized area of concern). If poor precision is related to sampling techniques, transport, or methodology phenomena (such as poor sample extraction efficiencies) causes and corrective actions will be taken.

Accuracy. Accuracy is defined as the degree to which the analytical measurement reflects the true concentration level present. Accuracy will be measured by percent recovery for matrix spikes as the primary criterion and percent recovery of the surrogate spikes as a secondary QC criterion. Percent recoveries of the surrogate, blank spike (synonymous with laboratory control sample), and matrix spikes will be reported by the laboratory.

If poor overall accuracy of data is observed, the cause may be related to sampling techniques, sample transport problems, sample matrix, or analytical methodology limitations. Positive or negative biases can be caused by poor sampling techniques such as ineffective decontamination procedures or use of inappropriate sample containers or preservation procedures. Improvements in sampling techniques must be taken to correct these deficiencies. Poor accuracy can also be attributed to matrix effects (evidenced by poor recovery of spiked analytes) or by methodology limitations (e.g., poor extraction efficiency). If this phenomenon is observed, investigations into modifications to improve the accuracy of analytical Standard Operating Procedures (SOPs) will be made.

Representativeness. Representativeness is a qualitative term that expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness of samples will be achieved to the greatest degree possible by adhering to the sampling design and collection methods described in the Demonstration Plan. Representativeness is also evaluated through collection and analysis of field duplicate samples.

Lack of representativeness among samples is observed by poor precision of sample duplicates or from samples collected at various time intervals. If field duplicate precision indicates that spatial variability is an issue, subsequent resampling may be warranted. Representativeness is expected to be good, since the majority of the samples collected will be aqueous, and these will be well mixed.

Comparability. Comparability is term that expresses the measure of confidence that one data set can be compared to another. To evaluate comparability, split samples will be analyzed at two separate laboratories. Shaw's Analytical and Treatability Laboratory (ATL) will be the primary analytical laboratory for the project. Ten percent of samples (as splits/duplicates) will be sent to Severn Trent Laboratories (STL) in Burlington, Vermont for confirmatory analysis.

Lack of comparability among samples may be attributed to differences in analytical protocols or reporting procedures. If split samples are collected and analyzed at independent laboratories, an investigation into possible inconsistencies between procedures will be investigated. Reporting procedures will be reviewed to verify that results are reported on the same unit basis (e.g., dry weight basis for soil).

Completeness. Completeness is a measure of all information necessary for a valid study. Data completeness is determined based on the number of usable data points compared to the number of samples collected for a specific matrix and method. Lack of completeness for samples may be attributed to sample transport issues (i.e., breakage of samples) or laboratory issues (i.e., poor quality control resulting in rejection of data). If data completeness goals (90%; 100% for critical data points) are not met, causes of failure will be determined and corrective action measures will be taken.

Calibration Procedures, Quality Control Checks, and Corrective Action

Field Analytical Method Requirements

There are no field analytical methods being performed during this demonstration.

Fixed Laboratory Analytical Method Requirements

Fixed Laboratory Analytical Methods and SOPs

Fixed laboratory methods are described in Section 3.6.7.2 of the Demonstration Plan. Shaw's ATL will be the primary analytical laboratory on the project. ATL's method applicable to this project (8330 modified) is included in Appendix B of the Demonstration Plan.

Ten percent of samples (as splits/duplicates) will be sent to STL in Burlington, Vermont for confirmatory analysis of explosive concentrations by modified Method 8330. SOPs and method modifications are summarized in Table 3. Analytical laboratory SOPs and laboratory QA or Management Plans are kept on file at the lab.

Table 3
STL Laboratories Analytical Method/SOP Reference Table

Title, Revision Date and/or Number	Definitive or Screening Data	Region I NESTS Method Code	Analytical Parameter	Instrument	Modified for Project Work Y or N
SOP for Extraction of Explosives in Water and Soils, 12/18/03; SOP for the Determination of Nitroaromatics and Nitramines by HPLC, 10/17/02	Definitive	8330	Explosives	HPLC	Y [1]

HPLC = High Performance Liquid Chromatography
[1] Method modification for explosives (based on method 8330) includes five additional target analytes (nitroglycerin, PETN, picric acid, 2,4-diamino-6-nitrotoluene, and 2,6-diamino-4-nitrotoluene). Secondary column confirmation is performed for analytes identified as positive hits on the primary column. For analytes confirmed by secondary column, photodiode array (PDA) spectral confirmation is performed (for primary column data). The sample PDA is compared to the analytical standard closest in concentration to the sample concentration. The laboratory is not required to interpret PDA spectra, but is required to include the information in data packages. PDA spectra review is included as an element of the data validation effort. Also, 2,6-dinitrotoluene detects in water samples are confirmed by GC/MS. A supplemental method modification (used at selective locations only) expands the target reporting list to include the RDX degradates MNX, DNX, and TNX.

It is not expected that modifications to these SOPs will be required. However, if modifications become necessary during the course of the demonstration to meet project quality objectives, the laboratory will consult with Shaw prior to implementing the modification. The laboratory also will summarize changes to SOPs in the data report narrative. When appropriate, modifications to fixed laboratory analytical SOPs will be made, and revised SOPs will be filed with the QAPP in the project's permanent files.

Fixed Laboratory Instrument Calibration

Fixed laboratory instruments and equipment used to collect, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's and method specifications.

Calibration of laboratory equipment will be accomplished according to the applicable EPA method requirements or in accordance with good laboratory practices. Records of calibration, repairs, or replacement will be filed and maintained by the designated laboratory personnel performing quality control activities. These records will be filed at the location where the work is performed and may be subject to QA audit. For all instruments, the laboratory will assure technicians are trained in normal instrument maintenance and repair, and/or maintain service

contracts with vendors or certified repair companies. A summary of instrument maintenance and calibration is provided in Table 4.

Table 4
Fixed Laboratory Instrument Maintenance and Calibration

Instrument	Activity	Maintenance, Testing and Inspection Activities	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA
HPLC- STL	Explosives Analysis	Check for leaks	Quantitative: As deemed necessary by Analyst Qualitative: Retention time standards analyzed once per 10 samples analyzed	Calibration curve: r ≥0.995 per analyte (minimum) Retention time standards: ±0.1 min per analyte	Perform maintenance, Recalibrate, Prepare new standards; Reanalyze impacted samples	Analyst
HPLC-Shaw	Explosives Analysis	Check for leaks	Quantitative: Once per month (minimum) and as deemed necessary due to maintenance and/or repairs. Qualitative: Retention time standards analyzed once per 20 samples analyzed	Calibration curve: r ≥0.995 per analyte Retention time standards: ±0.5 min per analyte	Perform maintenance, Recalibrate, Prepare new standards; Reanalyze impacted samples	Analyst

Fixed Laboratory Instrument/Equipment Maintenance, Testing, and Inspection Requirements

Equipment, instruments, tools, gauges, and other items requiring preventative maintenance will be serviced in accordance with the manufacturer's specified recommendation. Typical maintenance for major instrumentation is provided in Table 4. In the absence of any manufacturer's recommended maintenance criteria, a maintenance procedure will be developed by the operator based upon experience and previous use of the equipment.

Manufacturer's procedures identify the schedule for servicing critical items in order to minimize the downtime of the measurement system. It will be the responsibility of the operator to adhere to this maintenance schedule, and to arrange necessary and prompt service as required. Service to the equipment, instruments, tools, gauges, etc. will be performed by qualified personnel.

In the event that a method mandates specific preventive maintenance procedures, which are more frequent than that recommended by the manufacturer, the frequency required in the method will be followed. Logs will be established to record maintenance and service procedures and schedules. All maintenance records will be documented and traceable to the specific equipment, instruments, tools, and gauges. Records produced for laboratory instruments will be reviewed, maintained, and filed by the operators at the laboratories. A list of critical spare parts will be requested from the manufacturer and/or identified by the operator. These spare parts will be acquired and maintained in order to reduce downtime. In some cases, commercial vendor service contracts are used to maintain and service instrumentation.

Fixed Laboratory Inspection and Acceptance Requirements for Supplies

The laboratory manager or designee is responsible for tracking laboratory supplies to ensure that a sufficient quantity is available to meet the project/laboratory needs. Supplies that may contribute to common laboratory contamination are checked prior to use at the laboratory. Records are maintained which document inspection and acceptance of laboratory supplies.

Each laboratory SOP contains a list of the supplies and reagents that are required for the method. The majority of supplies come from laboratory supply companies, such as Fisher Scientific. Chemical reagents, solvents, gases, glassware, and general supplies are ordered as needed to maintain sufficient quantities on hand. Traceability of measurements is assured through a system of documentation, calibration, and analysis of reference standards. Reagent cleanliness is assured by purchasing certified high purity materials and monitored through use of the preparation/method blanks with each sample batch.

Quality Control Requirements

Sampling Quality Control

As a quality assurance and quality control check on field sampling, equipment rinsate samples and field duplicates will be sent to the laboratory with specified frequencies. Acceptance limits for results and corrective action measures for field QC samples are summarized in Table 5.

Table 5
Field Sampling Quality Control

Field QC Sample	Frequency/ Number	Acceptance Limits	Corrective Action (CA)	Person Responsible for CA	Data Quality Indicator
Equipment Blanks/ Rinsate Blanks	Each day that decontamination is performed per equipment type	No target compounds ≥ Quantitation Limit	Qualify data	Laboratory Manager/ Analyst	Accuracy/bias-Contamination
Field Duplicate Pairs (Duplicate Subsamples)	10%	RPD ≤ 50% for soil; RPD ≤ 30% for water	Qualify data	Laboratory Manager/ Analyst	Precision
Split Samples	10%	< Factor of 2 difference	Qualify data	Laboratory Manager/ Analyst	Comparability
Cooler Temperature Blanks	Cooler temperature blanks are not used. However, cooler temperatures are measured using an infrared temperature gun, or equivalent.	4°C, ± 2°C	Qualify data	Laboratory Manager/ Analyst	Accuracy/bias-Preservation

NOTE: Blanks and duplicates apply primarily to pre- and post-demonstration soil samples taken from the field site. The splits and field duplicates of aqueous samples from the Soil Plots will be from the drainage water samples, for which more volume is expected.

Equipment Rinsate Blanks - Equipment rinsate blanks are used to determine the effectiveness of the field decontamination process. Equipment rinsate blanks are defined as deionized water used for decontamination; e.g., poured over field equipment that has been decontaminated. This rinsate water is then transferred to a sample bottle. Equipment rinsate samples will be taken every day that decontamination occurs for each type of sampling equipment that is decontaminated. The equipment rinsate samples will be analyzed for the same analytes as the samples that are collected that day.

Field Duplicates - Field duplicates are used to measure field sample homogeneity and measure precision of the field sampling techniques and laboratory analyses. A field duplicate is defined as two or more samples collected independently at a sampling location during a single act of sampling. The total number of field duplicates for each analysis is equal to 10 percent of the samples collected. Field duplicates will be indistinguishable by the laboratory from other samples.

Split Samples - Split samples are analyzed at independent laboratories to evaluate the comparability of results between laboratories and/or methods.

Sample Documentation

The on-site Field Manager will coordinate with the off-site laboratories for shipment and receipt of sample bottles, coolers, icepacks, chain-of-custody (COC) forms, and Custody Seals. Upon completion of sampling, the COC will be filled out and shipped with the samples to the laboratory. An important consideration for the collection of environmental data is the ability to demonstrate that the analytical samples have been obtained from predetermined locations and that they have reached the laboratory without alteration. Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal must be documented to accomplish this. Documentation will be accomplished through a COC Record that records each sample and the names of the individuals responsible for sample collection, transport, and receipt. A sample is considered in custody if it is:

- in a person's actual possession;
- in view after being in physical possession;
- sealed so that no one can tamper with it after having been in physical custody; or
- in a secured area, restricted to authorized personnel.

Sample custody will be initiated by field personnel upon collection of samples. Samples will be packaged to prevent breakage or leakage during transport, and will be shipped to the laboratory via commercial carrier, or transported via car or truck.

Sample Identification. A discrete sample identification number will be assigned to each sample. These discrete sample numbers will be placed on each bottle and will be recorded, along with other pertinent data in a field notebook dedicated to the project. Specifics of sample designations are given in section 3.6.7.1, Sample Collection of the main text of the Field Demonstration Plan.

Chain-of-Custody Forms. The COC Record used by Shaw's laboratory is shown in Figure 2. This COC form will be supplied with sample bottles that are shipped to the site. All samples collected for off-site analysis will be physically inspected by the Field Manager (or designee) prior to shipment.

Each individual who has the sample in their possession will sign the COC Record. Preparation of the COC Record will be as follows:

- The COC Record will be initiated in the field by the person collecting the sample, for every sample. Every sample shall be assigned a unique identification number that is entered on the COC Record.
- The record will be completed in the field to indicate project, sampling person, etc.
- If the person collecting the samples does not transport the samples to the laboratory or ship the samples directly, the first block for "Relinquished By _____, Received By _____" will be completed in the field.
- The person transporting the samples to the laboratory or delivering them for shipment will sign the record for as "Relinquished By _____".
- The original COC Record will be sealed in a watertight container, taped to the top (inside) of the shipping container, and the shipping container sealed prior to being given to the commercial carrier. A copy of the COC Record will be kept on-site.
- If shipping by commercial carrier, the waybill will serve as an extension of the COC Record between the final field custodian and receipt by the off-site laboratory.
- Upon receipt by the off-site laboratory, the laboratory QC Coordinator, or designated representative, shall open the shipping container(s), compare the contents with the COC Record, and sign and date the record. Any discrepancies shall be noted on the COC Record.
- The COC Record is completed after sample disposal.
- COC Records will be maintained with the records for the project, and become part of the data package.

Laboratory Sample Receipt. Following sample receipt, the Laboratory Manager will:

- Examine all samples and determine if proper temperature has been maintained during transport. If samples have been damaged during transport, the remaining samples will be carefully examined to determine whether they were affected. Any samples affected shall be considered damaged. It will be noted on the COC Record that specific samples were damaged and that the samples were removed from the sampling program. Field personnel will be instructed to re-sample, if appropriate.
- Compare samples received against those listed on the COC Record.
- Verify that sample holding times have not been exceeded.
- Sign and date the COC Record, attaching the waybill if samples were shipped for off-site analysis.
- Denote the samples in the laboratory sample log-in book which will contain, at a minimum, the following information:

    - Project Identification Number
    - Sample numbers
    - Type of samples

- Date and time received

♦ Place the completed COC Record in the project file.

The date and time the samples are logged in by the Sample Custodian or designee should agree with the date and time recorded by the person relinquishing the samples. Any nonconformance to the stated procedures that may affect the cost or data quality should be reported to the Principle Investigator.

Other Documentation. Following sample receipt at the laboratory, the Laboratory Manager or sample custodian will clearly document the processing steps that are applied to the sample. The analytical data from laboratory QC samples will be identified with each batch of related samples. The laboratory log book will include the time, date, and name of the person who logged each sample into the laboratory system. This documentation will be thorough enough to allow tracking of the sample analytical history without aid from the analyst. At a minimum, laboratory documentation procedures will provide the following:

♦ Recording in a clear, comprehensive manner using indelible ink;
♦ Corrections to data and logbooks made by drawing a single line through the error and initialing and dating the correction;
♦ Consistency before release of analytical results by assembling and cross-checking the information on the sample tags, custody records, bench sheets, personal and instrument logs, and other relevant data to verify that data pertaining to each sample are consistent throughout the record;
♦ Observations and results identified with the project number, date, and analyst and reviewer signatures on each line, page, or book as appropriate;
♦ Data recorded in bound books or sheaf of numbered pages, instrument tracings or hard copy, or computer hard copy; and,
♦ Data tracking through document consolidation and project inventory of accountable documents: sample logbook, analysis data book, daily journal, instrument logbook, narrative and numerical final reports, etc.

Analytical Quality Control

Quality control data are necessary to determine precision and accuracy of the analyses, and to demonstrate the absence of interferences and contamination of glassware and reagents. Laboratory generated QC will consist of method blanks, laboratory control samples (LCSs), matrix spikes, and surrogate spikes.

Quality control results will be calculated by the analyst and reviewed by the laboratory supervisor to determine the accuracy and precision of the analytical results. The Laboratory Supervisor or the Laboratory Manager will review all final reports and associated quality control

data. Approval will be indicated by signature. Results will be recorded on the QC report. The QC results will also be used to prepare control charts for each test and type of matrix. Deviations from the established QC criteria will be noted and reanalysis or other corrective action will be instituted as appropriate for the situation.

Method Blanks

Method blanks will be run for all appropriate analyses to verify that the procedures used do not introduce contaminants that affect the analytical results. At a minimum, one method blank will be processed for every batch (up to 20) of samples analyzed. Method blanks are prepared for water samples using reagent or deionized water and for soil samples using Ottawa Sand or anhydrous sodium sulfate. The method blank undergoes all of the procedures required for sample preparation. The resultant extract is analyzed with the field samples prepared under identical conditions.

Laboratory Control Sample

Laboratory control samples (LCS) are used to determine the effectiveness of the extraction and analysis on a clean matrix (laboratory grade water or soil). A known quantity of target analytes is spiked into the sample, which is prepared and analyzed at the laboratory. The recovery of the spiked analytes is calculated as a measure of the accuracy of the laboratory method. An LCS is typically analyzed with each sample batch (up to 20 samples). Laboratory control sample duplicates (LCSD) may also be analyzed to assess analytical precision and accuracy.

Matrix Spike/Matrix Spike Duplicate

Matrix spike/matrix spike duplicate (MS/MSD) samples are used to determine the effect of matrix interference on analytical results. MS/MSD samples are spiked with known concentrations of target analytes. The samples are prepared in the laboratory and receive consistent treatment as field samples throughout the analytical method. Method recommended matrix spiking solutions may be used to determine if matrix affects extraction or analysis efficiency. The percent difference between the percent recovery values of the spike duplicates is taken as a measure of the precision of the analytical method. A matrix spike duplicate sample is prepared in the same manner as the matrix spike sample. Matrix spike and matrix spike duplicate analyses are used for organic analyses. MS/MSDs are analyzed with each sample batch (up to 20 samples).

Surrogate Analysis

Surrogate spike analysis is used to determine the efficiency of recovery of analytes in the sample preparation and analysis. Surrogates are not target analytes or contaminants typically found in environmental matrices. Calculated percentage recovery of the spike is used as a measure of the accuracy of the total analytical method. A surrogate spike is prepared by adding to a sample (before extraction) a known amount of pure compound similar to that for which the sample is

being analyzed. Surrogate compounds are added to all samples that are to be analyzed by HPLC, including QC samples, such as method blanks, LCS/LCSDs, and MS/MSDs , using the compounds recommended in the respective methods. If the recovery does not fall within established limits, the corrective actions described in the method will be implemented.

Data Reduction, Validation, Reporting

This section describes procedures for reducing, validating, and reporting data. All validated analytical data generated within the off-site laboratories will be checked for accuracy and completeness by laboratory and project personnel. Records will be kept throughout the analytical process, during data generation, and during reporting so that adequate documentation to support all measurements is available. Recordkeeping, data reduction, validation, and reporting procedures are discussed in this section.

Data Reduction

Data reduction will follow the requirements contained in the analytical methods cited previously. Reduction involves the reformatting of data to present the desired end-product, *i.e.*, the concentrations of the contaminants. Reformatting will involve the process of performing calculations on the raw data and presenting all values in appropriate units. The information generated by the data reduction step will be used in the interpretation of the data qualifiers.

The responsibility for data acquisition and reduction of raw data resides with the analysts who perform the analysis. Raw data for the quantitative 8330 analysis (explosives) procedure used during this project will consist of peak areas for surrogates, standards, and target compounds by HPLC. Analytical results will be reduced to concentration units appropriate for the medium being analyzed, i.e. milligrams per kilogram (mg/kg) for soil samples.

Data Validation

Data validation involves a review of the QC data and the raw data in order to identify any qualitative, unreliable, or invalid measurements. As a result, it will be possible to determine which samples, if any, are related to out-of-control QC samples. Laboratory data will be screened for inclusion of and frequency of the necessary QC supporting information, such as detection limit verification, initial calibration, continuing calibration, duplicates, matrix spikes, surrogate spikes, and the method and preparation blanks. QC supporting information will be screened to determine whether any datum is outside established control limits. If out-of-control data are discovered, appropriate corrective action will be determined based upon QC criteria for precision, accuracy, and completeness. Any out-of-control data without appropriate corrective action will be cause to qualify the affected measurement data.

Levels of data validation for the demonstration are defined below:

Level I. For Level I field data quality control, a data "package", including which samples were taken will be recorded in the field logbook and/or on log sheets maintained in an on-site binder. The sample results and QC parameters will be routinely evaluated by site personnel to verify sample identity, sample location, etc.

Level III. For Level III validated data quality, a CLP-like data package will be provided. For the EPA Method 8330 explosives analyses, this includes CLP-like summary forms 1 through 10 and all raw data associated with the samples, without the chromatograms of calibration standards, matrix spikes, or matrix spike duplicates. The laboratory deliverable format for each of the analytical labs will conform to their respective guidelines, and as requested upon entering into a contract for analysis of samples from this demonstration. All off-site Level III analyses will be accompanied by data packages as described in the previous section. The data package will include a case narrative generated by laboratory personnel as a product of validation procedures described above. The data packages will not be included in the Technology Application Analysis Report. Sample results will be evaluated according to the current version of the U.S. EPA functional guidelines for organic and inorganic analyses for selected QA/QC parameters, and 10% of the analytical raw data results will be reviewed to verify sample identity, instrument calibration, detection limits, numerical computation, accuracy of transcriptions, and calculations.

At a minimum, the following data validation procedures will be followed.

Each data package will be reviewed and the data validated prior to submission. Checklists will be used to demonstrate that the data review was accomplished. The Laboratory Manager or designee will perform the data review and validation.

The data review will include, but not be limited to, the following subjects:

- Completeness of laboratory data;
- Evaluation of data with respect to reporting limits;
- Evaluation of data with respect to control limits;
- Review of holding time data;
- Review of sample handling;
- Correlation of laboratory data from related laboratory tests;
- Comparison of the quality of the data generated with data quality indicators outlined above (on a daily basis, during routine analyses, and during internal laboratory audits); and
- QC chart review, performed yearly. Review shall consist of assessing trends, cycles, patterns, etc. This review shall also assess whether control corrective actions have been implemented.

The elements of data validation shall include, but not be limited to, the following items:

- Examination of COC records to assess whether custody was properly maintained;
- Comparison of data on instrument printouts with data recorded on worksheets or in notebooks;
- Comparison of calibration and analysis dates and assessment of whether the same calibration was used for all samples within a lot;
- Comparison of standard, sample preparation, and injection records with instrument output to assess whether each output is associated with the correct sample;
- Examination of calibration requirements, as specified in the methods;
- Use of a handheld calculator to perform all calculations on selected samples to assess the correctness of results; and
- Examination of all papers and notebooks to ensure that all pages are signed and dated, that all changes are initialed, dated, have sufficient explanation for the change, and that all items are legible.

Reporting

Data and information generated during the demonstration will be summarized in a Technology Application Analysis Report, to be submitted at the completion of the project. The report will be reviewed to ensure that it accurately describes the methods and standard operating procedures, and that the reported results accurately reflect the raw data of the demonstration.

QA/QC analysis will be performed by laboratory personnel as a product of validation procedures described above, and nonconforming data will be brought to the attention of the Laboratory Manager and/or the Project Manager. All off-site Level III analyses will be accompanied by data packages as described in the previous section. The data packages will not be included in the Technology Application Analysis Report, but will be made available upon request. The ultimate data set produced for project use will consist of all values reported in appropriate units flagged with respective data qualifiers for entry into the project database as described below. Analytical results will be reduced to concentration units appropriate for the medium being analyzed:

"µg/kg" or "mg/kg", depending on analyte and method, for soil/solid samples.

The laboratory will retain all samples and sample extracts for 6 weeks following data package submittal.

The results for each analyte in spiked QC samples will be determined using the same acceptable calibration curve that is used for environmental samples in the lot. Values above the practical quantitation limit (PQL) shall be reported as the found value. Raw values that fall below the method detection limit (MDL) will be reported as "less than" the PQL. Values above the MDL

and less than the PQL will be reported and flagged with a ”J”. Results for QC samples will not be corrected, except as described below. Because all spike levels must be within the calibrated range, no dilutions should be required. Data will be reported using the correct number of significant figures.

Each day of analysis, the analyst will quantify each analyte in the method blank and spiked QC samples. Data from the method blank will be reported, usually as less than the PQL for each analyte. Any values above the PQL shall be reported as the found value. Corrections to the QC samples, necessitated by background levels in the method blank, will be performed using instrument response values and not the found values calculated from the linear calibration curve. Reported entries will be in terms of concentration. The importance attached to finding measurable concentrations in the method blank is dependent on analyte and method. Identification of measurable concentrations in the method blanks will be reported in writing to the Principal Investigator for possible corrective actions.

The following additional data reporting procedures will be followed.

All data will be reported, and numerical results will be reported in terms of concentration in the environmental sample. Resultant found concentrations will be adjusted for dilution, etc. before being reported, and both the raw data and correction factors (e.g., percent moisture, and dilution factor) will be recorded in the data package submitted. Laboratory comments on the usability of the data will also be included.

In reporting results, rounding to the correct number of significant figures will occur only after all calculations and manipulations have been completed. As many figures as are warranted by each analytical technique will be used in pre-reporting calculations. Rounding will be accomplished using the following rules:

Rule 1 - In expressing an experimental quantity, retain no digits beyond the second uncertain one.

Rule 2 - In rounding numbers (i.e., in dropping superfluous digits):

- Increase the last retained digit by one if the first uncertain digit is larger than 5;
- Retain the last digit unchanged if the first uncertain digit is less than 5;
- Retain the last digit unchanged if even, or increase it by one if odd, if the first uncertain digit is 5 and the second uncertain digit is 0;
- Increase the last retained digit by one if the first uncertain digit is 5 and the second uncertain digit is greater than 0.

The correct number of reported significant figures, by validation type, is 3 significant figures. The number of allowable significant figures is reduced when added uncertainties are included in

the analysis, i.e., the results for samples diluted into the validated range allow one less significant figure due to the uncertainty added by the dilution process.

Corrective Action Plan

If routine procedures (e.g., equipment calibration), QC sample analysis, or performance and system audits indicate that sampling or analysis systems are unsatisfactory, a corrective action shall be implemented. If previously reported data are affected by the situation requiring correction or if the corrective action will impact the project budget or schedule, the action will directly involve the Principal Investigator. ESTCP will be informed of all major performance problems, and will be included in corrective action planning.

Corrective actions are of two kinds:

1. Immediate, to correct or repair nonconforming equipment and systems. The need for such an action will most frequently be identified by the analyst or technician as a result of calibration checks and QC sample analyses. Immediate corrective actions address problems peculiar to a single measurement or lot of samples. Immediate corrective action may include:

- Re-run of analyses if sample holding times have not been exceeded;
- Instrument recalibration using freshly prepared standards;
- Replacement of reagents or solvents that give unacceptable blank values;
- Examination of data calculation errors; and
- Replacement of reference standards that have been degraded.

If corrective action indicates that nonconformance is due to problems with laboratory equipment, procedures, and/or calibration, once the problem is resolved, the nonconforming samples will be re-analyzed if holding times have not been exceeded. If holding times have been exceeded, new samples will be collected if the completeness criteria require that these samples be collected. If corrective action indicates that nonconformance of duplicate samples is due to sampling technique, once the problem is corrected, new samples will be collected if the completeness criteria requires that these samples be collected.

2. Long-term, to eliminate causes of nonconformance. The need for such actions will probably be identified by audits. Long-term corrective actions may address procedural deficiencies or unsatisfactory trends or cycles in data that affect multiple lots of samples. Examples of long-term corrective action may include:

- Staff training in technical skills or in implementing the QAPP;
- Rescheduling of laboratory routine to ensure analysis within allowed holding times;
- Identifying alternate vendors to supply reagents of sufficient purity; and

- Revision of the QAPP.

For either immediate or long-term corrective action, steps comprising a closed-loop corrective action system will be implemented as follows:

- Define the problem;
- Assign responsibility for investigating the problem;
- Investigate and determine the cause of the problem;
- Determine a corrective action to eliminate the problem;
- Assign responsibility for implementing the corrective action; and
- Verify that the corrective action has eliminated the problem.

Unsatisfactory items or situations may be identified by anyone involved with the project, particularly the analysts, field engineers, technicians, or QA personnel. Depending on the nature of the problem, the corrective action employed may be formal or informal.

To enhance the timeliness of corrective action and thereby reduce the generation of unacceptable data, problems identified by assessment procedures will be resolved at the lowest possible management level. Problems that cannot be resolved at this level will be reported to the Principle Investigator. The Principle Investigator will determine the management level at which the problem can best be resolved, and will notify the appropriate manager. Progress reports from the on-site Field Manager will be submitted if problems arise, and will detail all problems and subsequent resolutions.

In all cases, the occurrence of the problem, the corrective action(s) employed, and verification that the problem has been eliminated will be documented. In addition, if the corrective action results in the preparation of a new standard or calibration solution(s), then a comparison of the new versus the old standard or solution will be performed, and the results supplied with a full QC report as verification that the problem has been eliminated. Corrective action reports that relate to a particular lot analysis will be included in the data package for that lot.

Calculation of Data Quality Indicators

The quality assurance objective for all measurement data includes considerations for precision, accuracy, completeness, representativeness, and comparability. For organic parameters, the protocols are found in the Contract Laboratory Program Statement of Work OLM03.2 and OLC02.1 and EPA *SW846 Test Methods for the Evaluating Solid Waste, Physical and Chemical Methods, Update III*.

Precision

Precision is a quantitative measure of the variability between two duplicate samples. One measure of precision is expressed as the relative percent difference (RPD) in concentration between duplicate and original sample analyses, as calculated from the following formula:

$$RPD = \frac{|S - D|}{\frac{1}{2}(S + D)} \times 100$$

Where:

RPD = Relative percent difference (percent);
S = Concentration of analyte in first (original) sample (mg/kg or µg/L); and
D = Concentration of analyte in second (duplicate) sample (mg/kg or µg/L).

The precision of the analytical data is evaluated by calculating RPD values for the following types of duplicate samples: field duplicates, MSDs, and LCSDs. The QC criterion is method or laboratory specific QC criterion. Data qualifiers may be applied in the data validation process to certain analytical results where RPD values do not meet the established QC criteria (RPD ≤ 50% for soil; RPD ≤ 30% for water).

When three or more results are available, the percent relative standard deviation (%RSD) also will be calculated as a measure of precision. The %RSD is defined as:

%RSD = (Standard Deviation / Mean) x 100

The %RSD provides a measure of precision relative to the magnitude of the measurement. For example, if the mean and standard deviation of four results are 4 and 2, the %RSD will be 50%; whereas, if the mean and standard deviation are 10 and 2, the %RSD will be 20%. The lower the %RSD, the more precise the measurement.

Accuracy

Spike sample analyses are conducted by the laboratory to assess the accuracy of specific analytical methods and to provide information on the effect of the sample matrix on the analytical methodology. Spike sample analyses are performed by adding known amounts ("spikes") of representative target compounds to a sample aliquot that is subjected to the entire analytical procedure. The original sample (non-fortified) and the spike sample results are compared. Accuracy is reported as percent recovery (%R) of the spike, as calculated from the following equation:

$$\%R = \frac{SSR - SR}{SA} \times 100$$

Where:

%R = Percent recovery (percent);
SSR = Spike sample result (concentration units);
SR = Original sample result (concentration units); and
SA = Spike added (concentration units).

The accuracy of the analytical data is evaluated by calculating %R values for matrix spike (MS) and laboratory control samples (LCS). MS samples are prepared by spiking actual field samples. LCS samples are prepared by spiking laboratory grade clean water or analyte-free soil samples. QC acceptance criteria for %R may be method or laboratory specific QC criteria. Data qualifiers may be applied in the data validation process to certain analytical results where the %R values do not meet the established laboratory QC criteria.

Representativeness

Representativeness expresses the extent to which the analytical data reflect the actual media at the site. In general, the data should be representative of the site conditions and characteristics. Proper sampling and sample management procedures achieve acceptable representativeness. Representativeness will be evaluated with respect to general sample management issues including sample documentation, preservation, handling, and transport as well as a discussion of representativeness with respect to analytical-method specific issues including method deviations, presence of potential laboratory or field artifacts, indications of sample nonhomogeneity, internal standard recovery deficiencies, and surrogate recovery deficiencies.

Comparability

Comparability is a parameter that expresses the confidence with which one data set can be compared to another. Split samples will be analyzed at independent laboratories to evaluate the comparability of results between laboratories and/or methods. Anything less than a factor of 2 difference will be considered acceptable. Differences with a factor between 2 and 3 will be considered minor discrepancies. Anything greater than a factor of 3 difference will be considered a major discrepancy.

Completeness

Completeness is a measure of the amount of usable data resulting from the sampling and analysis program. Completeness of the sampling and analytical programs is evaluated separately. Sampling completeness is generally defined as the number of samples collected divided by the number of samples required to adequately assess site conditions. Analytical completeness is

defined as the percentage of acceptable (i.e., not rejected) data points for individual methods and analytes. The overall completeness objective for the sampling and analytical program is 90 percent. The completeness objective for critical samples is 100 percent.

The percent complete (PC) is calculated as follows:

$$PC = \frac{N_A}{N_1} \times 100$$

N_A = actual number of valid analytical results obtained.
N_1 = theoretical number of results obtainable under ideal conditions.

Quality Assurance Audits

Systems Audits

Shaw will audit field procedures to ensure that the facilities, equipment, personnel, methods, practices, records, and controls are in conformance with the data quality objectives. Quality assurance audits will be performed by the project Quality Assurance Officer (QAO) or designee. To the extent practical, personnel conducting audits will be separate from and independent of the personnel engaged in the execution of the demonstration.

The mobilization stage will be audited before work begins to assure that all procedures, training, and materials are ready to support the QAAP. Field activities will be audited during operation in order to assure compliance with the QAAP. Field technical systems audits include review of sampling procedures, sample custody, sample storage and preservation, equipment decontamination, field forms and logbook entries, and field measurement equipment calibration and use.

Shaw has its own laboratory QA program. Audits may be performed to check and document that QC measures are being utilized to provide data of acceptable quality, and that subsequent calculations, interpretations, and other project outputs are checked and validated. Just recently (February 8 & 9, 2006), Shaw completed an audit at STL's Vermont laboratory as part of its involvement with the Massachusetts Military Reservation Impact Area Groundwater Study Program.

Performance Audits

Split samples will be used for performance audit purposes. Split samples are analyzed at independent laboratories to evaluate the comparability of results between laboratories and/or methods. This may bolster the credibility and usability of the data generated by the primary laboratory.

Quality Assurance Reports

Field QA audits will be conducted at least once during the one year duration of the demonstration. A written report of a QA audit will be submitted to the Principle Investigator, and will include the following:

- Description of what was audited,
- Clear statements of areas requiring improvements or problems to be corrected,
- Recommendations and assistance regarding proposed corrective actions or system improvements (if no action is required, the report will state that the QA audit was satisfactorily completed), and
- Timetable for any corrective action required.

Conditions when corrective actions may be initiated include:

- When predetermined acceptance standards are not attained (objectives for precision, accuracy, completeness, sensitivity),
- When procedures or data compiled are determined to be incorrect or incomplete,
- When equipment or instrumentation is found to be malfunctioning,
- When samples and test results cannot be traced with certainty,
- When quality assurance requirements have been violated,
- When designated approvals have been circumvented,
- As a result of system and performance audits, or
- As a result of laboratory/inter-laboratory comparison studies.

Following identification of an adverse condition or quality assurance problem, notification of the deficiency will be made to the Principle Investigator and the individual in charge of the activity found to be deficient, along with recommendations for correction. A record of this notification will be attached to the audit report. Following implementation of corrective action, the individual in charge will report actions taken and results to the Principle Investigator and the QAO. A record of action taken and results will also be attached to the audit report.

Data Storage and Archiving Procedures

All raw data, documentation, records, test plans, analyses, reports and correspondence generated as a result of this demonstration will be properly stored and archived in paper and electronic file formats as appropriate. Project data and analyses will be stored in an organized fashion to facilitate retrieval in an expedient fashion. Paper files will be maintained and stored so as to minimize deterioration during and after the project is complete. Electronic files associated with the project will be automatically backed-up on a monthly basis during the active phase of the

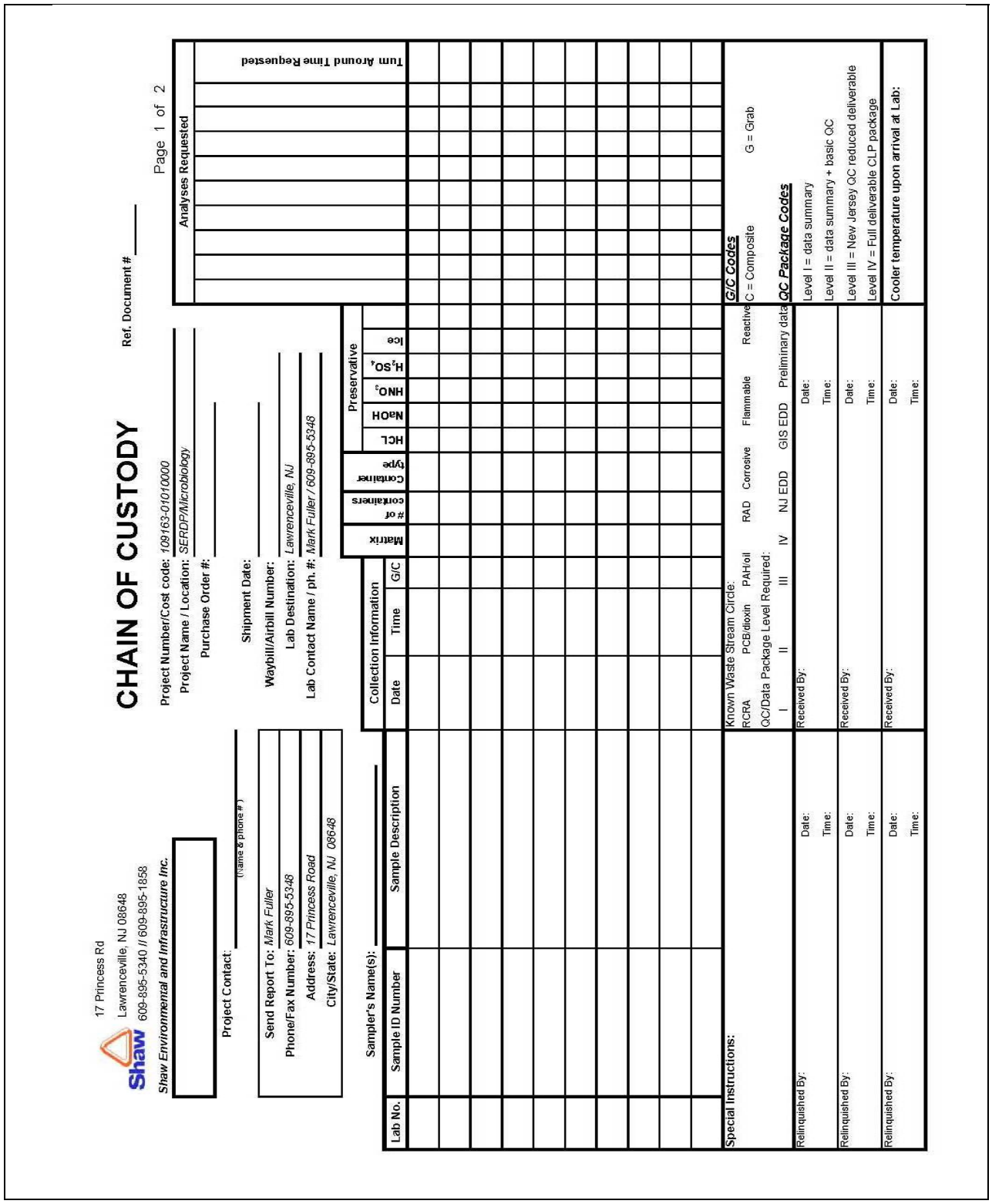
project. Electronic files will be archived on CD-ROM or tape backup upon completion of the project to ensure data integrity.

References

United States Environmental Protection Agency (USEPA) Region I. 1996. *New England Data Validation Functional Guidelines for Evaluating Environmental Analyses, Part II*. July 1996. Revised December 1996.

United States Environmental Protection Agency (USEPA). 2000. USEPA Test Methods for Evaluating Solid Waste Physical/Chemical Methods, Office of Solid Waste SW846. Third edition, Update III. December.

Figure 2 - Chain of Custody Forms



Shaw
17 Princess Rd
Lawrenceville, NJ 08648
609-895-5340 // 609-895-1858
Shaw Environmental and Infrastructure Inc.

CHAIN OF CUSTODY

Ref. Document # _____

Page 1 of 2

Project Contact: _____ (name & phone #)

Send Report To: *Mark Fuller*
Phone/Fax Number: *609-895-5348*
Address: *17 Princess Road*
City/State: *Lawrenceville, NJ 08648*

Project Number/Cost code: *109163-01010000*
Project Name / Location: *SERDP/Microbiology*
Purchase Order #: _____

Shipment Date: _____
Waybill/Airbill Number: _____
Lab Destination: *Lawrenceville, NJ*
Lab Contact Name / ph. #: *Mark Fuller / 609-895-5348*

Sampler's Name(s): _____

Lab No.	Sample ID Number	Sample Description	Collection Information: Date	Time	G/C	Matrix	# of containers	Container type	Preservative: HCL	NaOH	HNO_3	H_2SO_4	Ice	Analyses Requested	Turn Around Time Requested

Special Instructions:

Known Waste Stream Circle:
RCRA PCB/dioxin PAH/oil RAD Corrosive Flammable Reactive
QC/Data Package Level Required:
I II III IV NJ EDD GIS EDD Preliminary data

G/C Codes
C = Composite G = Grab

QC Package Codes
Level I = data summary
Level II = data summary + basic QC
Level III = New Jersey QC reduced deliverable
Level IV = Full deliverable CLP package

Relinquished By:	Date:	Received By:	Date:
	Time:		Time:
Relinquished By:	Date:	Received By:	Date:
	Time:		Time:
Relinquished By:	Date:	Received By:	Date:
	Time:		Time:

Cooler temperature upon arrival at Lab:

Shaw Environmental and Infrastructure Inc.

Project Number / cost code: 106163-010000

Project Name / Location: SERDP/Microbiology

Shipment Date:

COC Ref. Document #

Page ____ of ____

| Sample Description | Sample ID Number | Lab No. | Collection Information | | | Matrix | # of containers | Container Type | Preservative | | | | | | Analyses Requested | | | | | |

Appendix E

Compiled Demonstation Data

Table E-5.8.3. (Following pages) Explosives detected in soil core samples. A "-" indicates that no sample was available for analysis. Values listed that are below the detection limits are "J", estimated (<125 µg/kg for MNX/DNX/TNX; <50 µg/kg for all other compounds). Cores designated "GR-T" were collected from Bay 1 and cores designated "GR-C" were collected from Bay 3.

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-2 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/10/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	111	437	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	937	5870	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	39	169	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	96	439	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	16	182	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		<125	<125	<125	<50	120	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-4 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/17/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-10 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	09/20/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	147	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	56	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	298	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	264	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	79	595	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	50	455	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	37	291	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	229	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		<125	<125	<125	39	321	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-11 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/04/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	92	294	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	179	645	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	243	918	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	173	721	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-13 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	09/21/07	<125	<125	<125	<50	163	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	146	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	116	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	65	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	206	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	134	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	65	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	48	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	51	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	274	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-15 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/03/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	39	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-21 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/04/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	74	177	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	58	205	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	41	455	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	207	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-23 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/04/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	3080	15800	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	298	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-26 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	11/28/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	600	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	981	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	87	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-27 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/11/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	1510	4270	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-40 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/05/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	354	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	648	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-41 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/18/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	82	279	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	81	403	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-44 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/03/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-46 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	11/29/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-48 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/04/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-54 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/10/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-60 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/18/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-66 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/11/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-72 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/03/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	108	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	3370	4160	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-73 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/05/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	32	224	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-82 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/17/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	1840	5270	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	126	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-84 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/11/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-86 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/03/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-87 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/18/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-T-92 from Bay 1

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	12/03/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-7 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/18/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-9 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/28/08	<125	<125	<125	211	1307	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	146	213	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-13 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/06/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	573	865	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	128	719	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	275	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-18 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/17/08	<125	<125	<125	104	85	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-20 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	10/10/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-24 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/16/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-27 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/18/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-40 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/17/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	2280	5740	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	770	5120	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-48 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/07/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-51 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/06/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-53 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/28/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-54 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/29/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-55 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/29/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-56 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/06/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	332	420	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	11800	74000	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	790	4710	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-60 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/16/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	74	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	153	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	1640	10500	19	<50	<50	161	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-61 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/05/08	<125	<125	<125	<50	633	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-62 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/15/08	<125	<125	<125	612	4260	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	32	284	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	162	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-65 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/29/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	155	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-68 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/30/08	<125	<125	<125	127	243	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	45	170	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	49	236	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-73 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	10/10/07	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	203	1426	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-77 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/17/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-79 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/30/08	<125	<125	<125	148	205	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	144	275	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-84 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/15/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	314	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	284	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
55		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-88 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/30/08	<125	<125	<125	219	246	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	302	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	40	228	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	198	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	27	258	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	474	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table E-5.8.3. Total extractable explosive concentrations in core GR-C-94 from Bay 3

Depth (cm)	Analyzed	Explosive Concentration ug/kg TNX	DNX	MNX	HMX	RDX	TNB	DNB	NB	TNT	2,4 DNT	Tetryl	4ADNT	2ADNT	2,6 DNT	2-NT	4-NT	3-NT
5	01/16/08	<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
10		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
15		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
20		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
25		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
30		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
35		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
40		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
45		<125	<125	<125	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
50		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-