

# Chemical Neutralization and Destruction of Bulk and Residual Energetics in Different Materials

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USA

COUNTER UXO – ADDRESSING ENVIRONMENTAL  
IMPACTS

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## Presentation Outline

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- Introduction to MuniRem™ technology
- Full scale chemical neutralization of bulk explosives
- Chemical neutralization of bulk explosives abandoned on demilitarization equipment
- On-site demilitarization of recovered underwater munitions
- In-Situ remediation of explosives contaminated soils
- Summary and Conclusions



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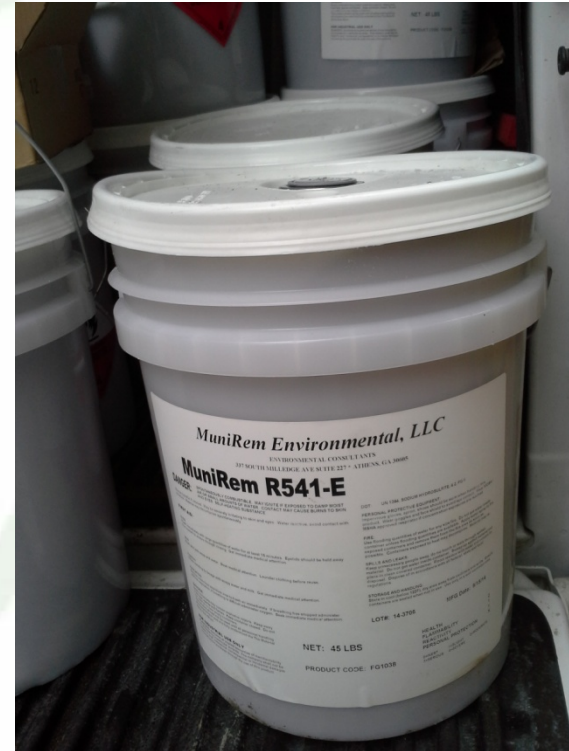
## **INTRODUCTION TO MUNIREM TECHNOLOGY**

# Options for Chemical Neutralization of Energetics

- Chemical Oxidation
  - Alkaline Hydrolysis
  - Activated Persulfate
  - High Temperature Oxidation
- Chemical Reduction
  - MuniRem
  - Nano Zero Valent Iron (nZVI)

# What is MuniRem?

- MuniRem is the commercial name for a University of Georgia Research Foundation patented technology that employs reduction chemistry to rapidly neutralize and destroy explosives and energetics in different media.
- MuniRem also degrades chemical warfare materiel (CWM) and stabilizes metals.
- The end product is non-hazardous.
- MuniRem is licensed exclusively to MuniRem Environmental, LLC

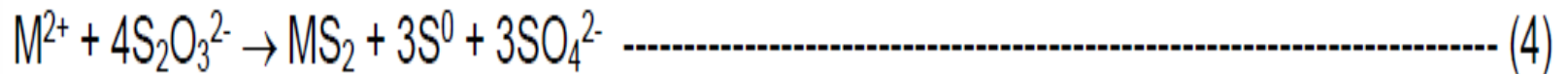
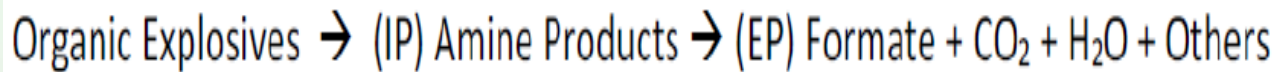
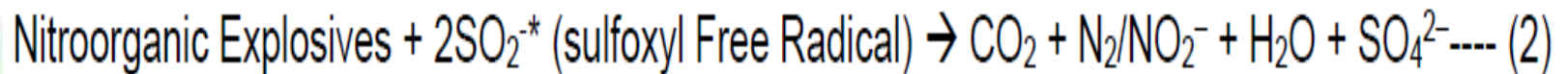
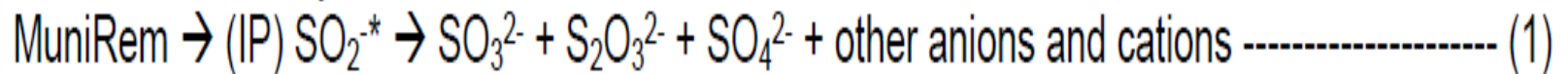


# Multiple Evaluations at Bench & Pilot Scale

- University of Georgia
- Orbital ATK Laboratory, LCAAP
- Army Laboratory, Vicksburg, MS
- NDCEE/AEC Independent Evaluation, Pennsylvania
- Non-Stockpile, Edgewood, MD
- Indian Head (NAVFAC)
- SMS, Inc
- Israel



# Reactions of MuniRem with Oxidized Organic Compounds and some Metals





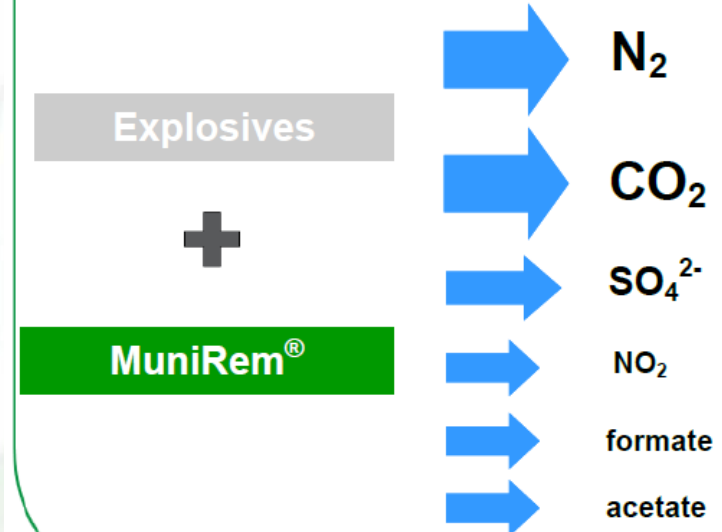
# Types of Explosives Neutralized and End Products

## Effective in Neutralization and Remediation of



- Mustard (CWA)
- HMX / RDX / TNT
- DNTs / ADNTs
- NBs / NDMA
- Nitrocellulose Propellant
- PBX / PETN
- PCBs
- Lead Styphnate
- Lead Azide
- Picric Acid
- AN/TATP
- Reactive Aluminum
- As, Ba, Cd, Cr, Pb, Hg, etc.

## Reliable Green Technology for Remediation of Explosives



The MuniRem reagent is versatile in its ability to neutralize a variety of energetics



# Effect of MuniRem Reagent on Heavy Metals

## Reliable Green Technology for Remediation of Heavy Metals

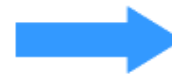
Heavy metals



MuniRem<sup>®</sup>



**Metal  
Sulfide**



$\text{SO}_4^{2-}$

# Evaluation of MuniRem Reagent at US Army Laboratory

- Phase 1 – Lead Styphnate (LS) and Trinitroresorcinol (TNR) Neutralization Efficacy Test
- Phase 2 – Determination of Chemical Reagent Penetration into Wall Sections



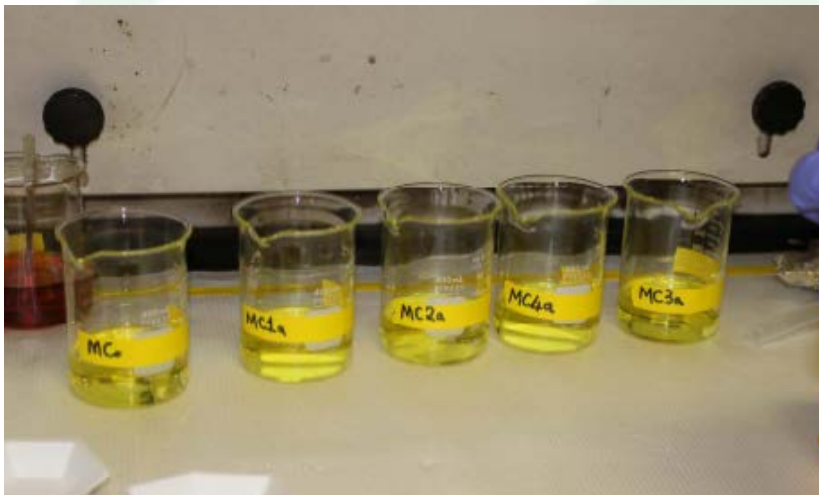
Phase 1: Bench scale evaluation

Phase 2: Simulated wall sections treatment



# Bench Scale Feasibility Tests

## US Army Laboratory



Initial 4,300 ppm TNR solution



Instant color change on contact with MuniRem reagent



Color change as a function of reagent dose

# Results: TNR Concentration, Color, pH and Nitrite Formation (one of multiple test replicates)

Reaction variable: Dose of chemical reagent (neutralent)

Sample ID	Initial Conc'n (ppm)	Initial TNR Color	Initial Color (with Reagent)	Final Color	pH	Nitrite (ppm)	TNR Result
MCO	4,300	Yellow	NA			NA	ND
MC0.01b	4,300	yellow	crimson-purple	dark red	5.76	13.77	ND
MC01b	4,300	yellow	crimson-purple	dark red	7.76	NA	ND
MC1b	4,300	yellow	crimson-purple	dark red	8.69	0.29	ND
MC2b	4,300	yellow	crimson-purple	dark red	8.8	0.81	ND
MC3b	4,300	yellow	crimson-purple	orange	8.9	"-	ND
MC4b	4,300	yellow	crimson-purple	yellow-orange	8.85	26.67	ND

ND = No Detectable TNR; NA = Not Applicable

A large, semi-transparent green globe graphic with white curved lines, centered on the page.

## **CHEMICAL NEUTRALIZATION OF BULK EXPLOSIVES ABANDONED ON DEMILITARIZATION EQUIPMENT**

Camp Minden, Louisiana

# Abandoned Bulk Explosive (H-6) Neutralization

- Melter/Flaker machine contained bulk H-6 (TNT, RDX, AL, Binder) explosives
- Large crystallized chunks of H-6 on equipment
- Wall surfaces and miscellaneous materials contaminated with explosives
- Lead paint chips mixed in with explosives





# Small Footprint of MuniRem Solution Application



Explosives Neutralization Station  
Behind Building





# MuniRem Solution Provided Safe Recovery of Crystallized Explosives

- Large H-6 chunks safely removed while spraying MuniRem solution
- Large explosive pieces transferred to neutralization reactor
- Neutralization of recovered explosives achieved rapidly in reaction tanks



## Neutralization of Recovered Explosives



- 2,000 Lbs of H-6 explosives estimated as present on and in equipment
- >1,000 lbs destroyed in place by spraying concentrated MuniRem solution
- >900 lbs recovered and neutralized on-site in reactor with MuniRem solution
- Sludge and wastewater characterized as non-hazardous waste



## **ON-SITE DEMILITARIZATION OF UNDERWATER MUNITIONS**

MuniRem supports Savannah Harbor Expansion Project (SHEP)



# Neutralization of Civil War Munitions Recovered during Savannah River Harbor Expansion Program



## Breaching of Recovered Projectiles

Total projectiles breached and neutralized = 170

Breaching throughput = 12 projectiles per hour





# Neutralization of the Breached Munitions

- After 150 years explosives still well preserved
- Explosives washout using MuniRem solution
- 170 Munitions neutralized on site
- Fuzes safely removed and inerted
- Munitions certified by SUXOS as safe and handed to US Army Corps for preservation
- Characterization and disposal of non-hazardous waste





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## **Field Scale In-situ Soil Remediation**

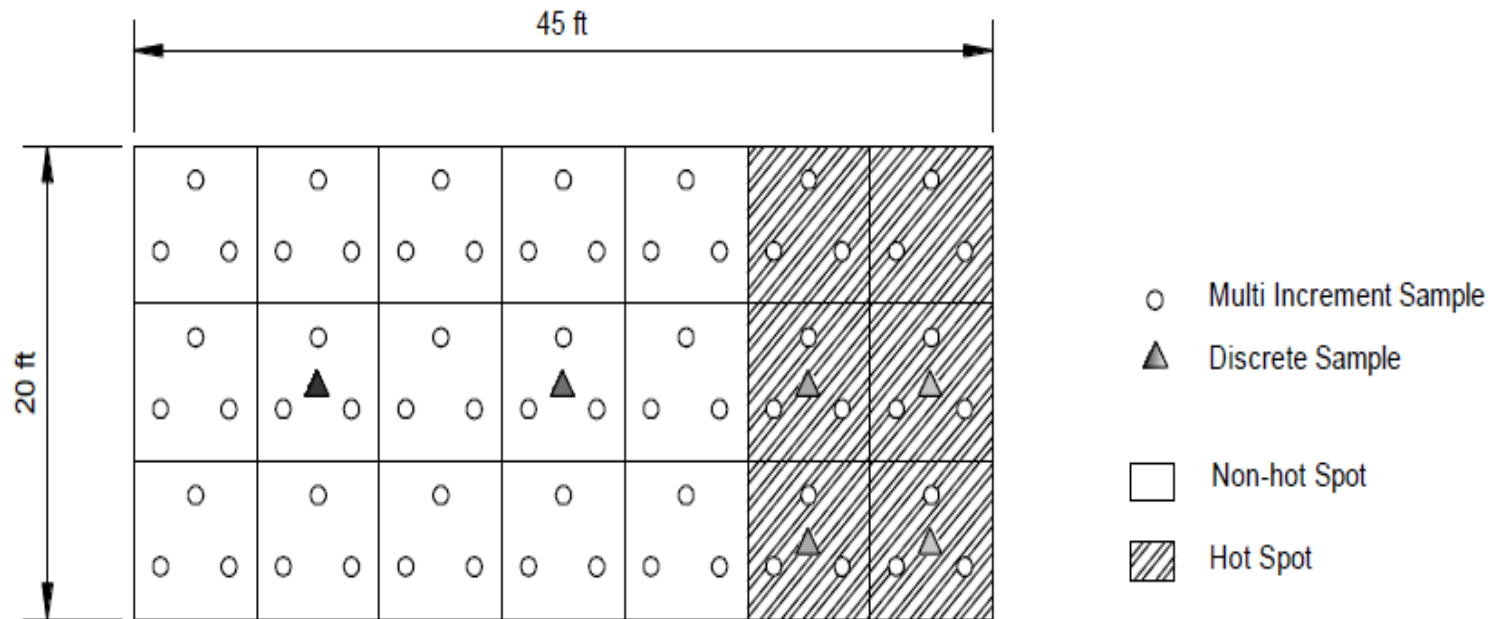


## Site Characteristics of Explosives in Soil

- Dimensions: **19 ft by 45 ft**
- Soil Type: **Silty-Clay with rocks**
- Targeted Treatment Depth: **Top 2 feet**
- **TNT and other explosive compounds were released into the soils at Loading Pad**
- Primary Explosive Compounds of Concern
  - **TNT**
  - **RDX**
  - **HMX**
- Secondary Explosive Compounds of Concern
  - **1,3,5-Trinitrobenzene**
  - **2-Amino-4,6-dinitrotoluene**
  - **4-Amino-2,6-dinitrotoluene**



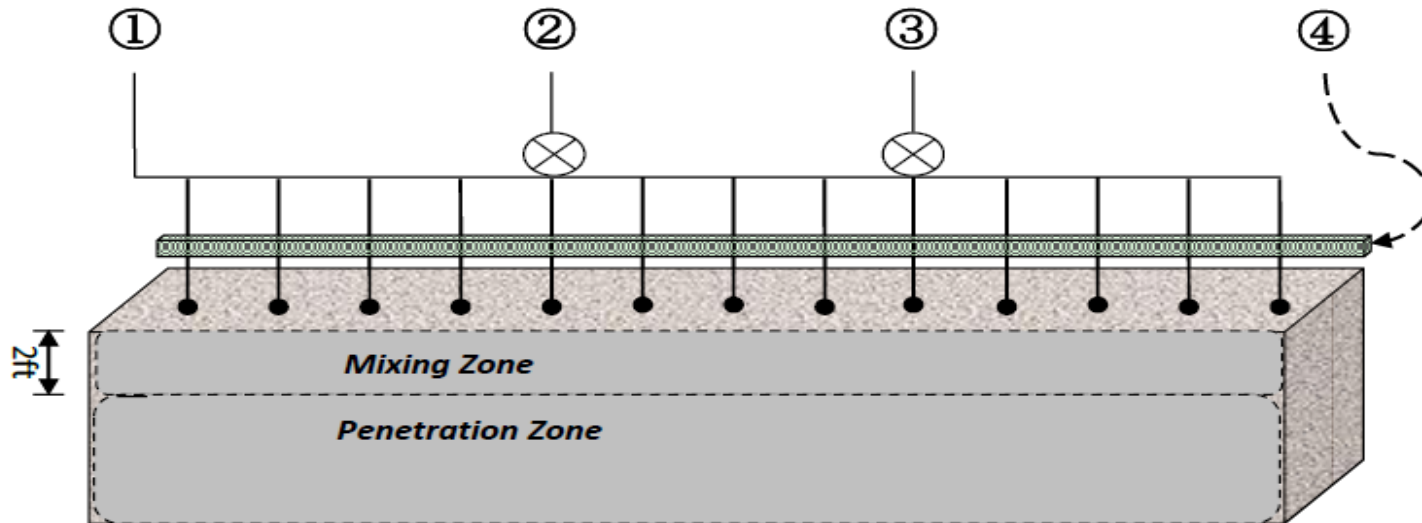
# Schematic diagram of decision unit and sampling locations



## Incremental Sampling (ISM) for Baseline (Initial) Concentrations and Performance Monitoring



# Schematic of MuniRem application in shallow soils



Step ①: Application of MuniRem on surface soil;

Step ②: Soil tilling equipment used to homogenize the surface soils and the mixture of MuniRem chemicals (mixing zone);

Step ③: Application of water until soil becomes saturated in penetration zone;



# Surface Broadcasting and Tilling-in MuniRem into the Soil



# Soil After Treatment with MuniRem Reagent



Left: MuniRem Mixed in with Soil but No Water Added Yet.



Right: MuniRem Mixed in with Soil, Water Added and Covered.

## Sample Analysis

- **Multi-Increment Samples – EPA Method 8330B**
- **Discrete Samples (Hot Spots) – EPA Method 8330A**
- **Transformation Products – Bioremediation Consulting Inc. (Watertown, MA)**
- **pH and TAL Metals**
- **Sampling Events: Baseline (Initial Concentrations), 24 hours after treatment and two weeks after treatment.**
- **Cleanup Goal Adopted: Residential Farmer (Unrestricted use) CUGs TNT: 211 mg/kg RDX: 115 mg/kg**

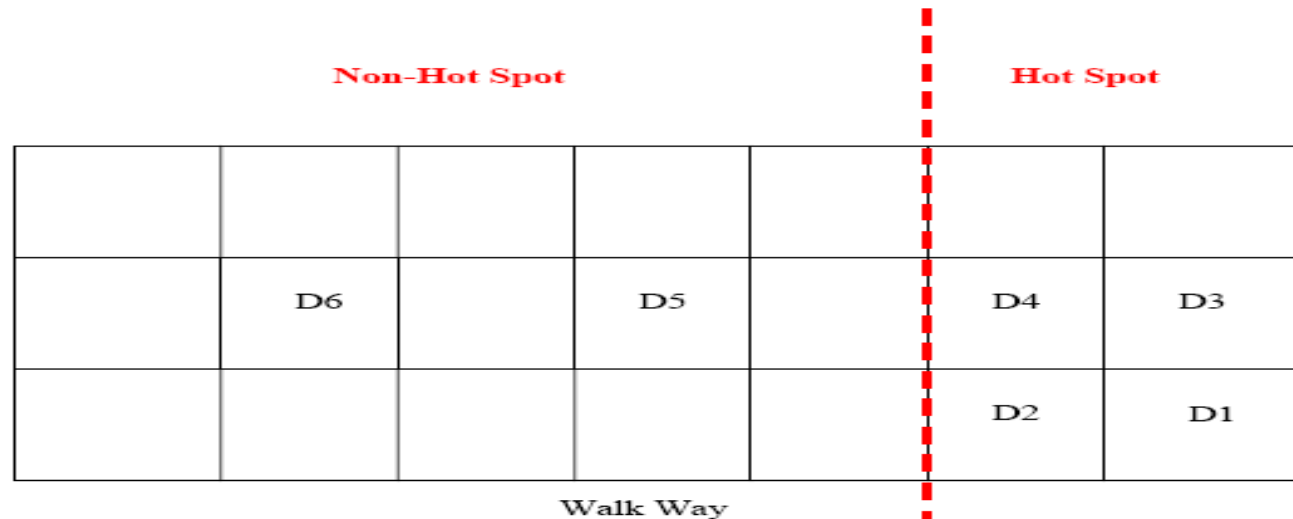


# Heterogeneous Distribution of Explosives

Dimensions of Area Treated with MuniRem® = 19 ft X 45 ft

Multi Increment Samples = 3 from 21 Cells (i.e., 62 individual samples)

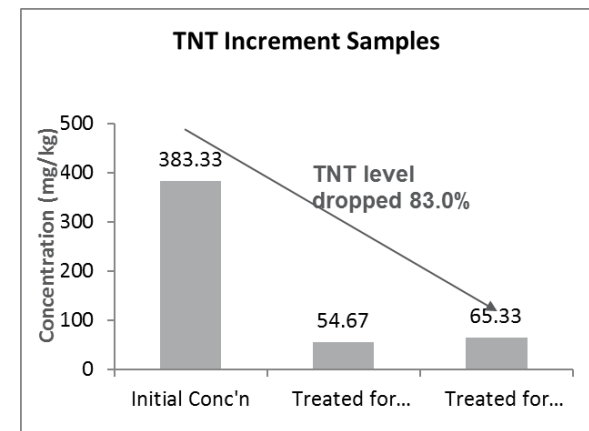
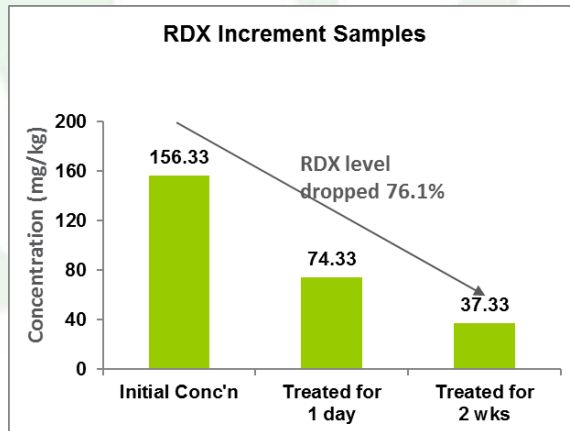
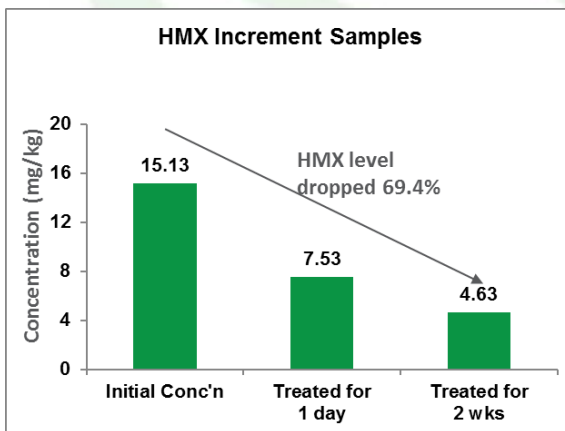
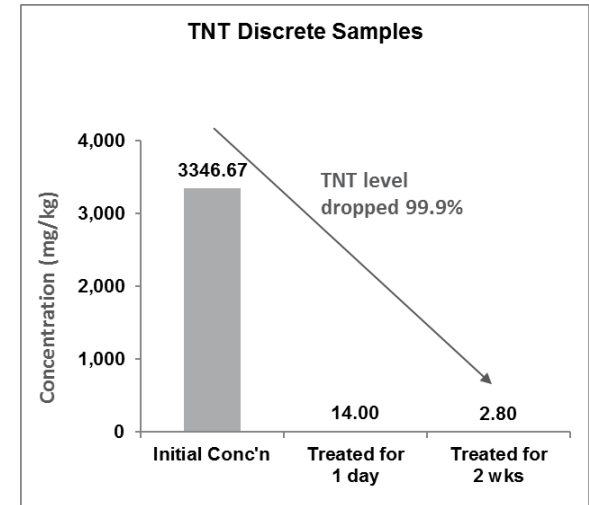
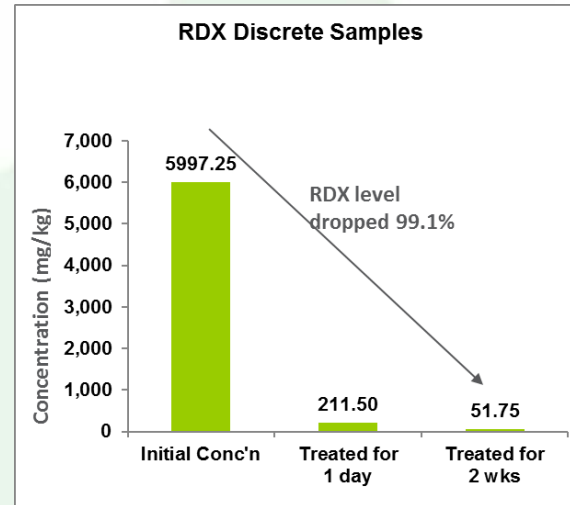
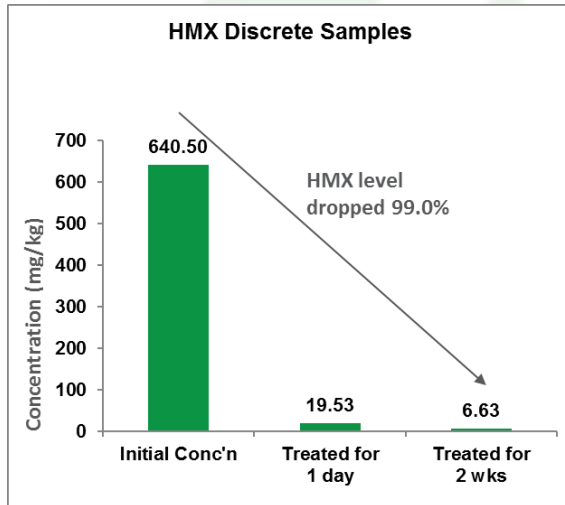
Discrete Samples = 6



**Sample ID Note:**

- D1 (Treated 0-6inch: T1; 0-1ft: TA);
- D2 (Baseline 0-6inch: T3; Treated 0-1ft: TD);
- D3 (Treated 0-1ft: TC);
- D4 (Baseline 0-6inch: T2; 0-1ft: TB);
- D5 (Treated 0-1ft: TE);
- D6 (Treated 0-1ft: TF)

# Results: 0, 24 h and 2 Weeks



## Summary and Conclusion

- MuniRem solution is versatile in its ability to neutralize a variety of energetics, heavy metals and chlorinated compounds (e.g., TCE, Mustard, etc).
- MuniRem solution is easily coupled with munitions breaching methods: waterjet cutting, milling, water saw cutting, steaming, shaped charge & cryogenic fracturing.
- MuniRem solution has supported the following types of projects:
  - ✓ Demilitarization
  - ✓ Recovery and neutralization of bulk explosives
  - ✓ Decontamination of buildings and equipment
  - ✓ Remediation of explosives contaminated soil and wastewater
- ✓ The end-product is a non-hazardous waste