Comprehensive List of Chemicals Likely to be Found at Military Ranges - A Case Study of Camp Edwards, Massachusetts

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Site History

- Training and Impact Areas used since 1911
- Activities included small arms, machine gun, artillery, mortar, ground to ground rocket, air to ground rocket, open burning/open (OB/OD), detonation of explosive ordinance, and pyrotechnics training
- Designed to house 30,000 troops during WWII
- USEPA banned artillery and mortar training in 1997 through an Administrative Order
- Camp Edwards exhaustively studied
Introduction

• Over 200 compounds analyzed
  – Explosives
  – Volatile organic compounds (VOCs)
  – Semi-volatile organic compounds (SVOCs)
  – Pesticides/Herbicides
  – Polychlorinated biphenyls (PCBs)
  – Polychlorinated napthalenes (PCNs)
  – Dioxins/Furans
  – Metals
  – Other (White Phosphorous, Cyanide, Dyes, Anions)
• Tentatively identified compounds (TICs) exhaustively evaluated
Training Areas at Camp Edwards
Samples Collected by Media

- 7,800 surface soil samples (0 to 2 ft)
  - 1,989 individual locations
  - 182 areas of investigation;
- 1,533 soil boring profile samples (10 to 300 ft) from 146 borings
- 69 sediment samples from 19 water bodies
- 64 surface water samples from 19 water bodies
- 5 storm water samples from the perimeter of the Impact Area
- 3,959 groundwater profiling samples from 256 borings
- 1,467 groundwater samples
  - 651 monitoring wells at 256 locations
Sample Locations at Camp Edwards

Legend
- Green triangle: Groundwater Sample
- Blue circle: Surface Water/Sediment
- Yellow circle: Soil Sample
Lithology at Camp Edwards

Legend

- VC Sand & Gravel
- F Sand & Silt
- Till
- Bedrock
- Water Table
- Well Screen

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ELEVATION IN FEET (MSL)

-200
-150
-100
-50
0
50
100
150
200

Sea Level
Unsaturated Zone
Aquifer
**Soil Analytical Methods**

<table>
<thead>
<tr>
<th>Analytes</th>
<th>Methods</th>
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<tbody>
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## Groundwater Analytical Methods

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Explosive Analyte List for Camp Edwards

1,3-dinitrobenzene
1,3,5-trinitrobenzene (TNB)
2-amino-4,6-dinitrotoluene (2A-DNT)
4-amino-2,6-dinitrotoluene (4A-DNT)
2,4-diamino-6-nitrotoluene (2,4-DANT)
2,6-diamino-4-nitrotoluene (2,6-DANT)
2,4-dinitrotoluene (2,4-DNT)
2,6-dinitrotoluene (2,6-DNT)
2-nitrotoluene (2-NT)
3-nitrotoluene (3-NT)
4-nitrotoluene (4-NT)
dinitroso-hexahydro-1,3,5-triazine (DNX)
nitroso-dinitro-hexahydro-1,3,5-triazine (MNX)
tri-nitroso-hexahydro-1,3,5-triazine (TNX)
octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
nitrobenzene
Nitroglycerine (NG)
pentaerythritol tetryl nitrate (PETN)
Picric acid (PA)
hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
2,4,6-trinitrotoluene (TNT)
tetryl
Contaminant Transport Conceptual Model
Impact Area Explosive Distribution

Soil
- aDNTs: 32.3%
- 2,4-DNT: 1.3%
- HMX: 20.3%
- Other: 2.7%
- TNT: 6.3%
- RDX: 37.0%

Groundwater
- aDNTs: 12.4%
- RDX: 65.7%
- HMX: 21.9%
Explosive Soil Detections in the Impact Area
RDX and Perchlorate Groundwater Distribution in the Impact Area
Gun and Mortar Firing Position Findings

- 37 positions evaluated
- 1,200 soil samples collected
- M1, M2, & M3 propellant used
- 39 soil COPCs identified
  - 2,4-DNT (4%)
  - 2,6-DNT
  - Diethyl phthalate
  - N-nitrosodiphenylamine
  - Lead
- Soil contamination limited to 2 ft
- No groundwater impacts observed
KD Rocket Range

- Secondary Target Area
- Primary Target Area
- Former TOW Firing Point
- Former Dragon Firing Point
- Former 90mm Firing Point
- Former Rocket Firing Point
KD Rocket Range Findings

- 300 soil samples collected
- Soil contamination limited to 2 ft
- No groundwater impacts observed
- Nitroglycerin found only at firing points
Demolition Area 1

- Site used for OB/OD activities and Engineer and EOD training
- Over 500 soil samples have been collected
- Perchlorate, dyes, and dioxin/furans added to standard analyte list
Demolition Area 1 Findings

- Perchlorate, RDX, HMX, 2A-DNT, 4A-DNT, and TNT routinely detected in soil
- Di-n-butyl phthalate, N-nitrosodiphenylamine antimony, barium, calcium, copper, lead, manganese, silver and zinc exceeds background.
- A dye, perchlorate, and dioxin were detected in soil at low-levels
- Explosives and perchlorate detected in groundwater forming a plume
Groundwater Contaminants at Demo 1
J Ranges Findings

- Consists of 4 ranges used by defense contractors for munitions testing
- 800 surface soil samples collected
- Explosives and polychlorinated naphthalenes detected in soil
- 61 monitoring wells have been installed with over 800 groundwater samples collected
- RDX, HMX, and perchlorate present in groundwater forming several plumes
J Ranges Groundwater Plumes

Snake Pond
Conclusions

• Camp Edwards represents an extreme environment in regards to contaminant mobility

• PEP compounds are present in soil from a variety of activities; firing positions, firing ranges, OB/OD, EOD, weapons testing, and rocket ranges

• Method 8330 may not be sensitive enough for range investigations unless method modifications are considered

• Explosives and perchlorate should be the only analytes of interest for range soils

• Perchlorate, metals, and PCNs may be appropriate if a surface risk pathway exists on ranges

• At gun and mortar firing positions SVOCs should be considered if a surface risk pathway exists on ranges
Conclusions (continued)

• If rocket firing positions are investigated Method 8330 should be modified to improve the sensitivity to NG
• Methods used for ranges would be appropriate at OB/OD sites with possible addition of SVOCs and dioxins
• No evidence warranting the collection of VOCs, SVOCs, herbicides/pesticides, PCBs, dioxins, or evaluating TICs for range soils
• NG and 2,4-DNT not mobile
• Explosives and perchlorate are the only warranted analytes for groundwater
• No other analyte suites (VOCs, SVOCs, pesticides, herbicides, PCBs, metals, PCNs, dioxins, dyes, or TICs) should be evaluated in groundwater