



Distribution and Fate of Energetics on DoD Test and Training Ranges: Characterization of Explosives Contamination SERDP Project CP1155

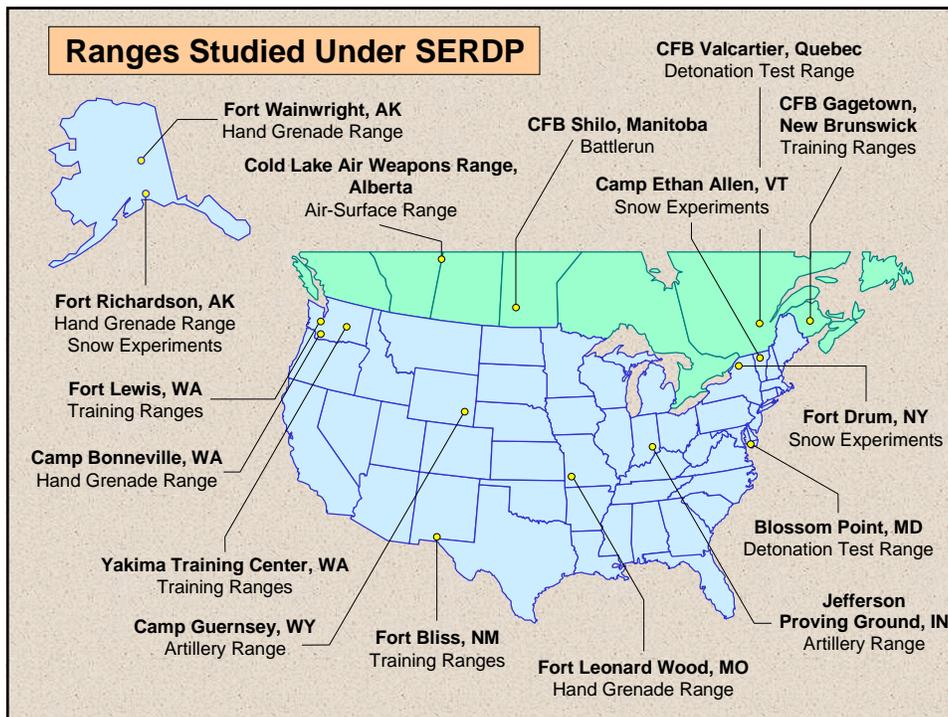


Alan D. Hewitt

**USA Engineer Research and Development Center
Cold Region Research and Engineering Laboratory
Hanover NH 03755**

Co-Authors

- **Dr. Judith C. Pennington**
USA Engineer Research and Development Center
Environmental Laboratory
Vicksburg, Mississippi
- **Thomas Jenkins and Marianne E. Walsh**
USA Engineer Research and Development Center
Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire
- **Dr. Sonia Thiboutot and Dr. Guy Ampleman**
DRD Valcartier
Val-Belair, Quebec, Canada
- **Jay L. Clausen**
AMEC
Westford, Massachusetts
- **Thomas A. Ranney**
Science and Technology Corp.
Hanover, New Hampshire



Sources of Residues of Explosives and Propellants on Training Ranges

- Incomplete propellant combustion during firing activities
- Ordnance blast residues from high-order detonations
- Low-order detonations of various ordnance items
- Incomplete consumption of energetic compounds during UXO blow-in-place operations (BIPs)
- Open burning of excess propellant
- Corrosion of surface and subsurface UXO
- Rupture of UXO items from nearby detonations

TYPES OF RANGES SAMPLED

- **Hand grenade ranges**
- **Antitank rocket range impact areas**
- **Artillery and mortar range impact areas**
- **Air/ground impact range**
- **Firing points**
 - 105-mm and 155-mm artillery
 - LAW rocket
 - Mortars

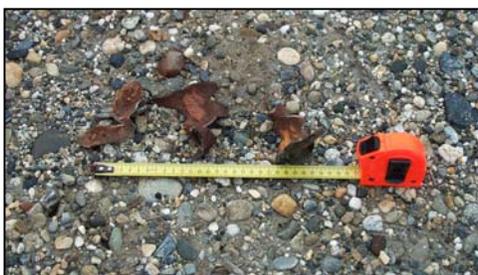
Hand Grenade Ranges Sampled

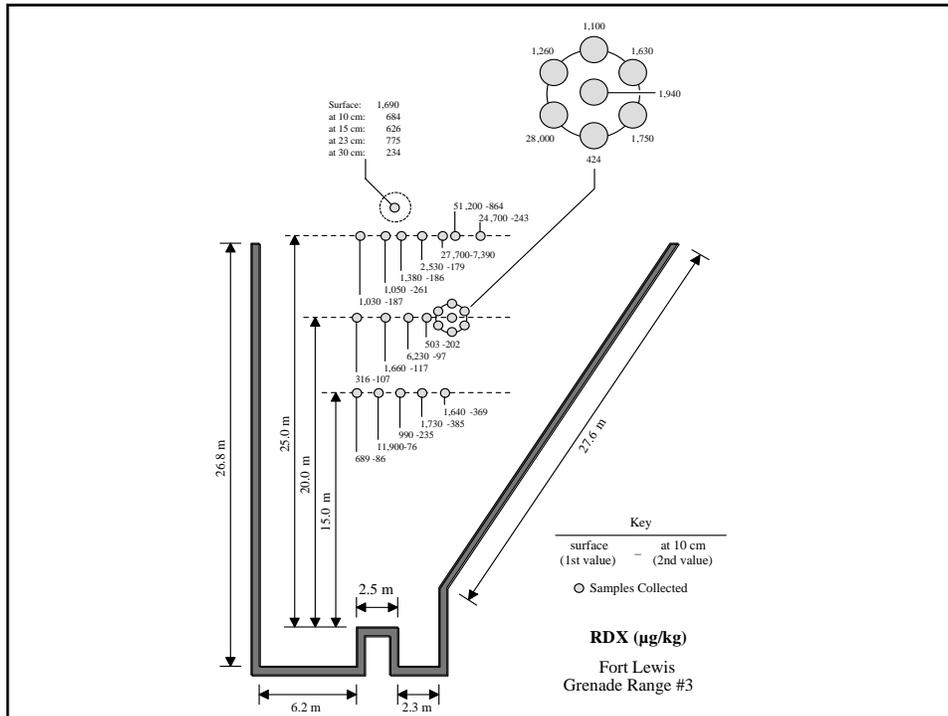
- **Ft. Lewis, Washington**
- **Ft. Richardson, Alaska**
- **Ft. Leonard Wood, Missouri**
- **Ft. Wainwright, Alaska**
- **Camp Bonneville, Washington**
- **CFB Gagetown, New Brunswick**
- **Scholfield Barracks, Hawaii**
- **Pohakuloa Training Range, Hawaii**

Characterization of Explosives Residues at Ft. Lewis Hand Grenade Range



Hand Grenade Low-Order Detonations





Characteristics of Hand Grenade Ranges

- A few acres in size
- Sparsely vegetated or non-vegetated
- Heavily cratered unless the craters are filled
- Metallic fragments heavily distributed
- Undetonated grenades can be present in craters (very dangerous)
- Concentrations of RDX and TNT in high µg/kg (ppb) to low mg/kg (ppm) range

Antitank Rocket Range Impact Areas Sampled

- **Yakima Training Center,
Washington**
- **CFB Gagetown, New Brunswick**
- **Scholfield Barracks, Hawaii**

Sampling at Antitank Range Yakima Training Center



Antitank Range CFB Gagetown



Characteristics of Antitank Rocket Ranges

- **Hundreds of acres in size**
- **Vegetated except around targets, generally grasslands (need line of sight)**
- **Detonations can result in periodic localized fires**
- **Surface UXO present and dangerous**
- **Target debris present**

Conclusions for Antitank Ranges

- HMX is the major contaminant at anti-tank firing ranges because of training with M-72 LAW rockets containing Octol
- Residues reside largely in the top 6 inches of soil
- Concentrations decline with distance from target
- Total characterization error is largely sampling error
- Chunks of propellant present
- Residues largely from ruptured rockets

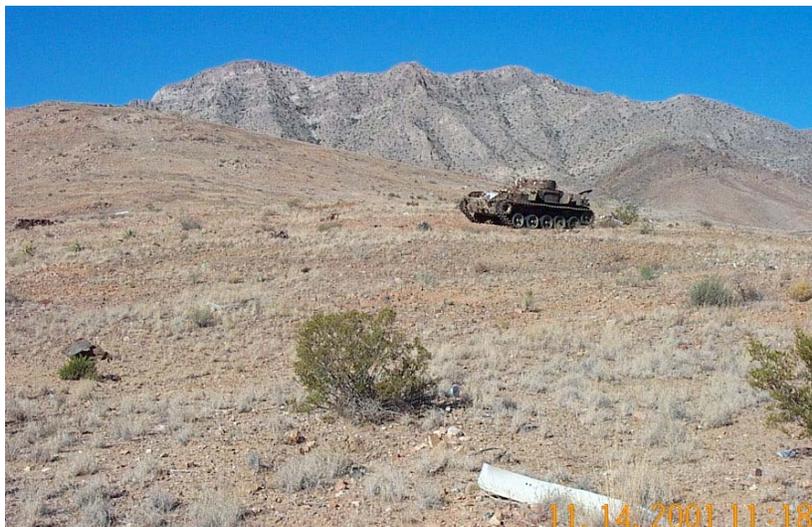
Artillery/Mortar Range Impact Areas Sampled

- **Ft. Lewis, Washington**
- **Yakima Training Center, Washington**
- **Camp Guernsey, Wyoming**
- **CFB Shilo, Manitoba**
- **Ft. Bliss, New Mexico**
- **Jefferson Proving Ground, Indiana**
- **CFB Gagetown, New Brunswick**
- **Scholfield Barracks, Hawaii**

Artillery Range - Ft. Lewis, WA



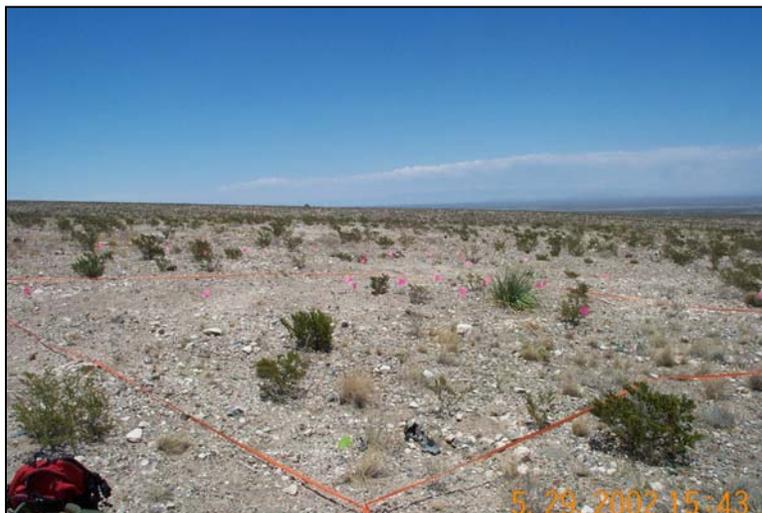
Artillery Range - Ft. Bliss, NM



Fort Bliss Stratified Random Sampling Results

Impact Area Grids sampled-12	Concentration (µg/kg)			
	TNT	RDX	NG	HMX
N	4	3	4	2
Max	49	9	634	66
Min	<1	<3	<2	<26
Median	<1	<3	<1	<26
Firing Points Grids sampled-7	Concentration (µg/kg)			
	TNT	RDX	NG	HMX
N	0	1	1	0
Max	0	9	968	<26
Min	0	<3	<2	<26
Median	0	<3	<2	<26

Judgmental Sampling Ft. Bliss 10-m x 10-m Grid



**Chunks of TNT Collected
from 10-m x 10-m Grid**



**Low Order 155-mm Howitzer Round
Ft. Bliss**



Characteristics of Artillery/Mortar Ranges

- **Square miles in size**
- **Vegetated (grassland, forests, wetlands), ranges in arid regions often sparsely vegetated**
- **Subject to periodic fires (often intentionally burned)**
- **Surface and subsurface UXO present**
- **Targets and debris present, some areas heavily cratered**
- **Wide variety of ordnance used**
- **Firing points subject to heavy equipment traffic**
- **Impact areas have low ppb concentrations of TNT/RDX/HMX/NG or below**
- **Very high localized concentrations near low-order detonations (sometimes % levels)**

Air/Ground Impact Range

- **Cold Lake Air Weapons Range, Alberta**
- **HE impact range hundreds of acres in size**
- **Soil routinely tilled to reduce vegetation and minimize chances of range fire**
- **Regular maintenance reduces presence of UXO items**
- **TNT concentrations in surface soil were up to 400 mg/kg (ppm)**

Bomb crater at CFB Gagetown



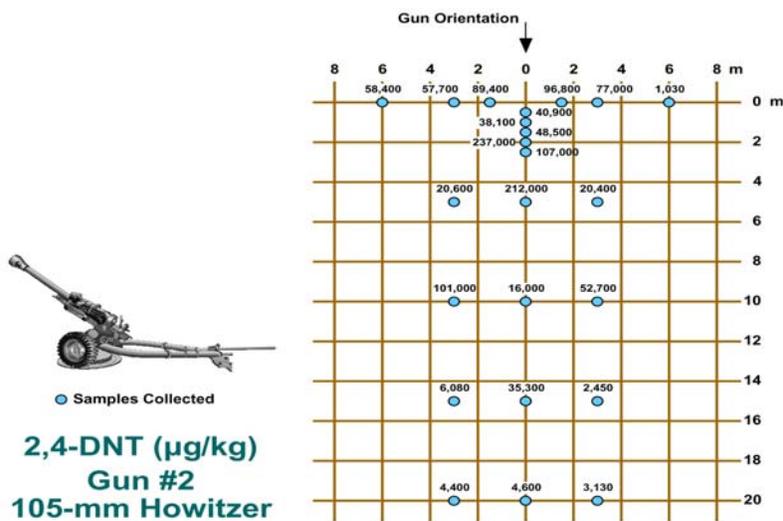
Ruptured 500-lb Bomb Camp Guernsey



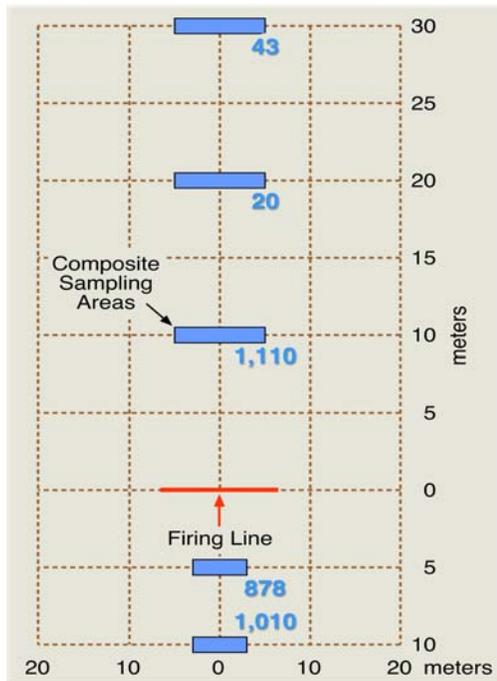
Firing Points Sampled

- **105-mm howitzers** (Ft. Lewis, Ft. Greely, Scholfield, Pohakuloa)
- **155-mm howitzers** (Yakima TC, Camp Guernsey, Jefferson Proving Ground, Pohakuloa)
- **120-mm tank gun** (Yakima TC)
- **LAW rockets** (Ft. Bliss, Yakima TC, CFB Gagetown, Scholfield)
- **Mortars** (Yakima TC, Ft. Greely, Camp Ethan Allen, Ft. Drum, Pohakuloa)

Ft. Lewis - Firing Point



**NG
Concentrations
($\mu\text{g}/\text{kg}$)
LAW Rocket
Range
Ft. Bliss**



**SOIL SAMPLING AND
SUBSAMPLING PROBLEMS
FOR RANGES**

- **Collection of representative samples** in areas of extreme spatial heterogeneity
- **Sample splitting** in the field for QA/QC
- **Laboratory subsampling** to preserve representativeness

Conclusions from Site Characterization Studies

- **Artillery and mortar ranges** – RDX and TNT in surface soils in low $\mu\text{g}/\text{kg}$ (ppb) or lower, distribution spatially heterogeneous
- **Ruptured UXO items and low-order detonations** – Localized residues of main charge explosives in % range in near surface soils
- **Antitank rocket ranges** – Major residue HMX, concentrations in the tens to hundreds of mg/kg (ppm), TNT only about 1/100 as high, HMX concentration a function of distance from target
- **Hand grenade ranges** – Major residues RDX and TNT, concentrations in low ppm range, distribution more homogeneous than found for other impact ranges
- **Firing points** – Major residues NG and 2,4-DNT, concentrations in low ppm range, distribution less heterogeneous than impact areas, deposition at least as far as 100 m from muzzle

Acknowledgements

- **SERDP - Bradley Smith, Dr. Jeff Marqusee and Robert Holst**
- **AEC - John Buck and Martin Stutz**
- **CHPPM - Barrett Borrey, Ken Mioduski, and Mike Brown**
- **EOD support teams**
- **Range control and base environmental personnel**
- **Sampling teams from ERDC, DRDC (Canada), USACHPPM, and Sacramento District Corps of Engineers**