ABSTRACT

The Fate And Transport Of Ordinance-Derived RDX – An Example from Camp Edwards. Jay L. Clausen and Marc Grant, AMEC, Ben Gregson, MAARNG. The National Guard Bureau is conducting an extensive investigation of the Impact Area at Camp Edwards to characterize the nature and extent of possible soil contamination and its potential impact on groundwater. The Impact Area has been used since the early 1900s for artillery and mortar firing. Over 2000 soil samples have been collected along with the installation of over 300 monitoring wells. Several explosive compounds, including RDX, were found in soil and groundwater. The highest soil concentration of RDX was found in shallow samples immediately adjacent to targets. In contrast to manufacturing, loading, and packing facilities, the form of explosive introduced initially into the environment from Range activities is as a particulate. Laboratory studies were conducted to measure the explosive fate-and-transport properties of hexahydro-1,3,5- trinitro-1,3,5-triazine (RDX) along with other explosives. Computer modeling of the unsaturated and saturated zone was conducted to evaluate the flow and transport behavior of explosives. A key mechanism controlling the environmental fate of explosives from Range activities is the dissolution rate of explosive particulates. A conceptual model for the behavior of RDX is presented using lessons learned from the Camp Edwards site.

Author 1: Jay L. Clausen
AMEC Earth and Environmental
239 Littleton, Road, Suite 1B
Westford, MA 01886
Tel: 978-692-9090
Fax: 978-692-6633

Presenting Author: Jay Clausen

Author 2: Marc Grant
AMEC Earth and Environmental
239 Littleton, Road, Suite 1B
Westford, MA 01886
Tel: 978-692-9090
Fax: 978-692-6633

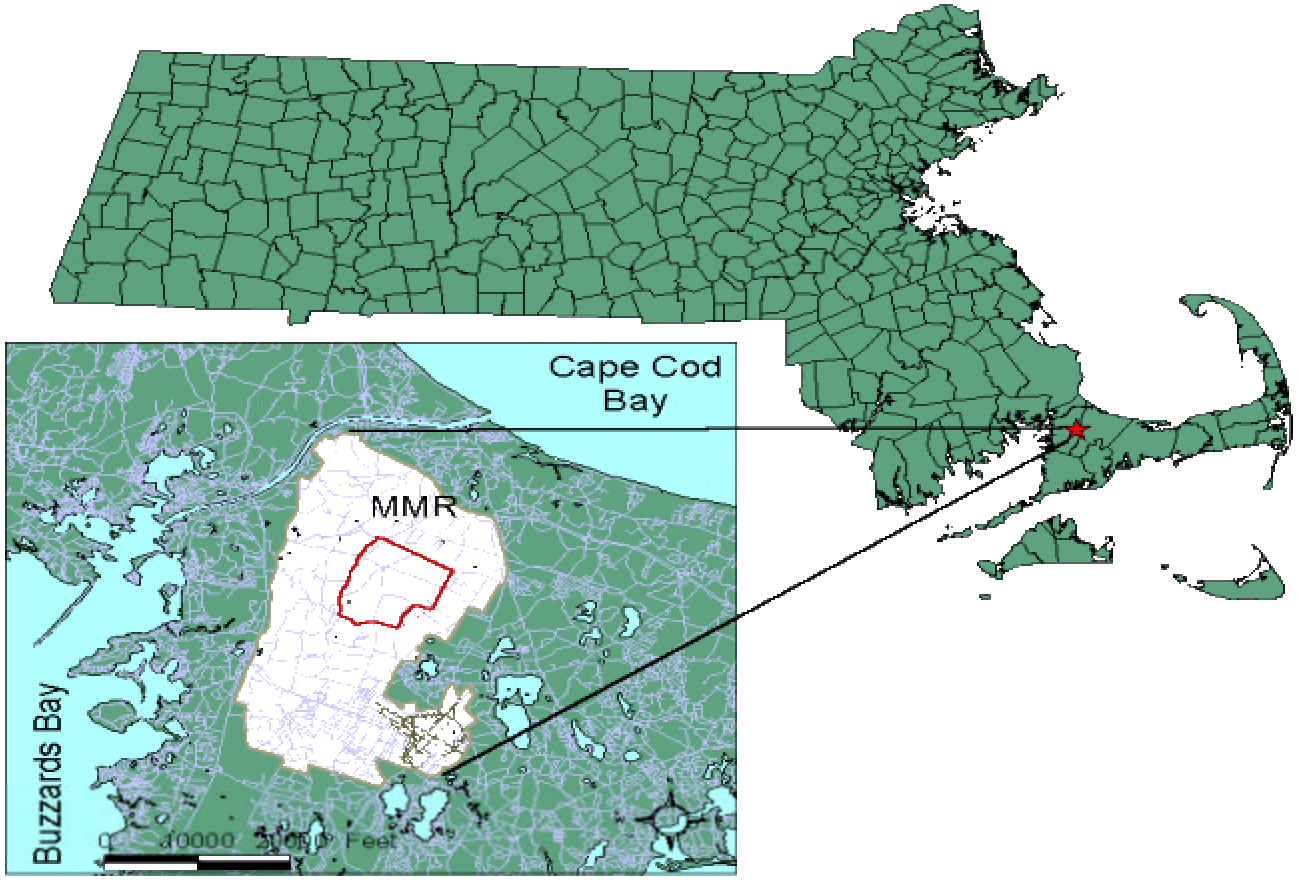
Author 3: Ben Gregson
Impact Area Groundwater Study Program
565/567 West Outer Perimeter Road
Camp Edwards, MA 02542

Presented at the 17th Annual International Conference on Contaminated Soils, Sediments and Water. October 22-25, 2001. Amherst, MA.

BACKGROUND

- Massachusetts Military Reservation (MMR) at Camp Edwards covers approximately 2,000 acres
- Training began in the early 1900s and included the firing of various types of munitions including artillery and mortar rounds.
- The most intensive U.S. Army activity occurred during World War II from 1940-1944 and during demobilization after the war.
- The predominant explosive compound used in artillery and mortar munitions, since WWII is Composition B, which is a mixture of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and 2,4,6-trinitrotoluene (TNT)
- The site overlies the Sagamore Lens, which is a sole source aquifer for the Upper Cape.

LOCATION OF CAMP EDWARDS
MASSACHUSETTS MILITARY RESERVATION (MMR)

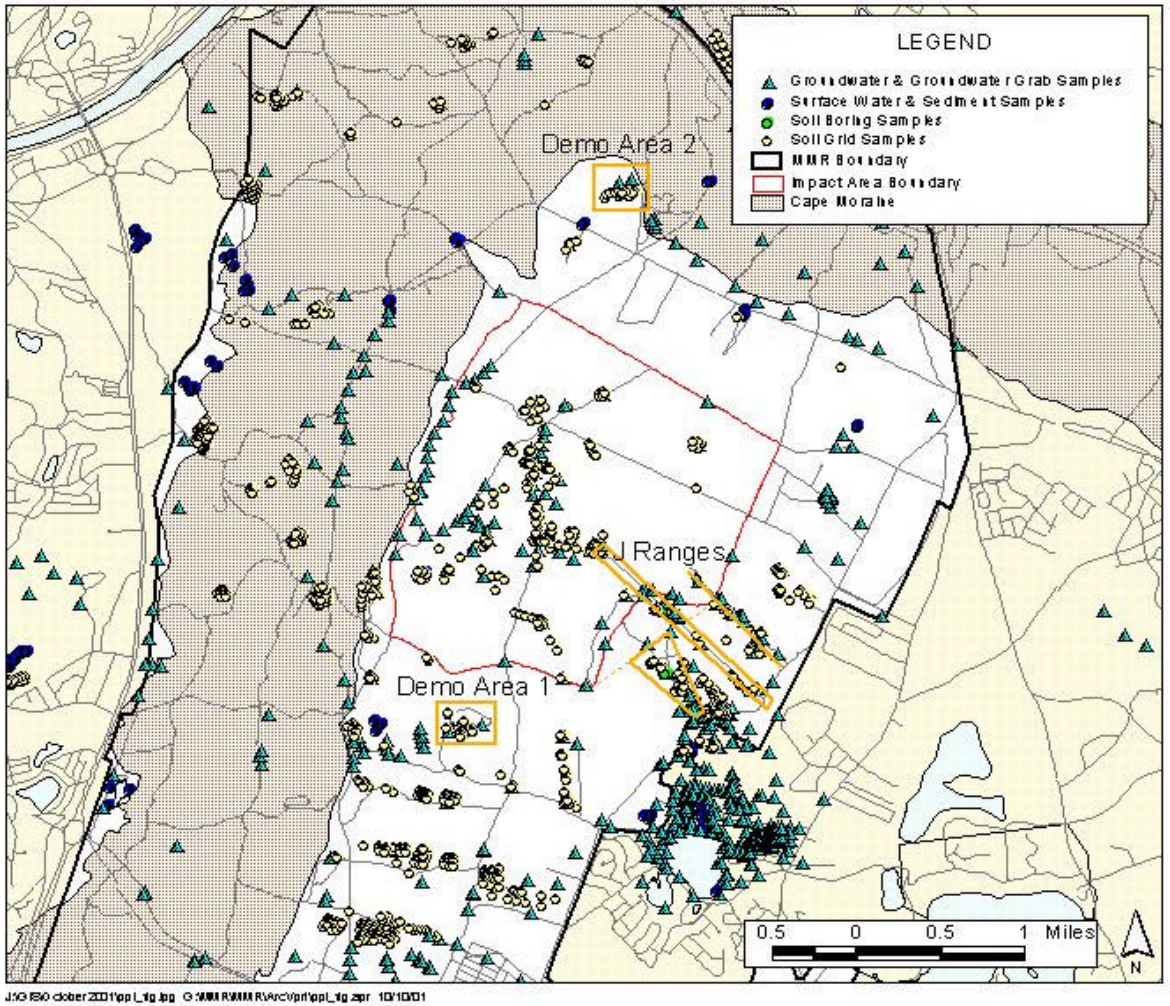


METHODS

The Nature and Extent of Soil Contamination and its Potential Impact on Groundwater were Investigated Through:

- Soil Sampling - Over 2000 Soil Samples Collected
- Groundwater Sampling - Over 300 Wells Installed
- Laboratory Studies - Being conducted for AMEC by University of Texas
- Modeling - Existing Models Refined w/Current Data

SOIL, SEDIMENT & GROUNDWATER COLLECTION SITES



SOIL METHODS

- Samples are collected from
  - 0 - 3 inches bgs
  - 3 - 6 inches bgs
  - 6 - 12 inches bgs
  - 18 - 24 inches bgs
  - 10-foot intervals in borings down to the water table
- Both composite and discreet samples are collected

GROUNDWATER METHODS

- Profile grab samples are collected beginning at the water table and extending downward to bedrock
- Monitoring well location and screened intervals are installed based on profile results and modeling data

LABORATORY Methods

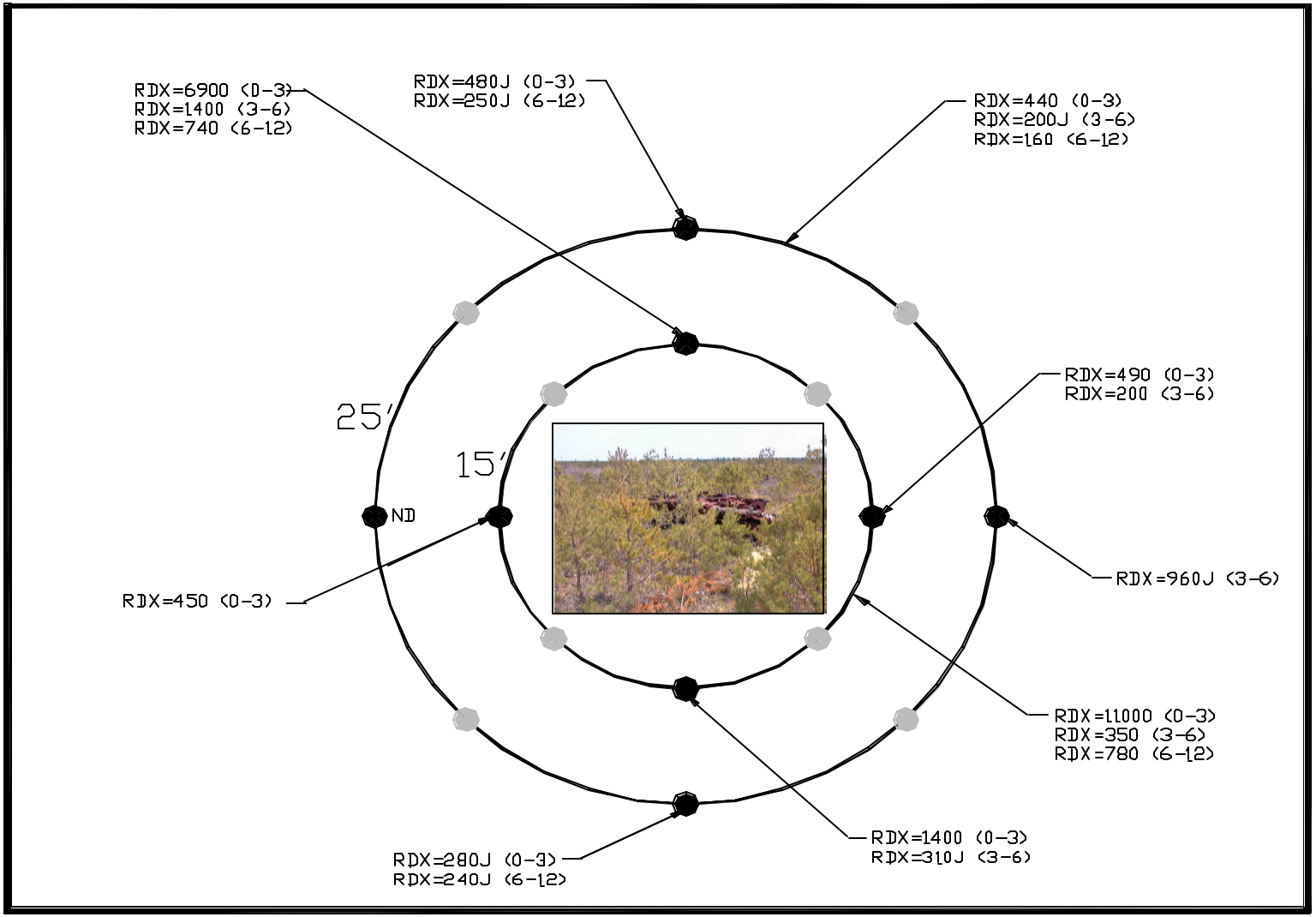
Laboratory tests are being conducted for AMEC by the University of Texas. These tests include:

- Batch Experiments
  - sorption evaluation
  - desorption evaluation
  - biological degradation rates
  - dissolution kinetics
- Column Experiments
- Measurement of Site-Specific Soil Parameters

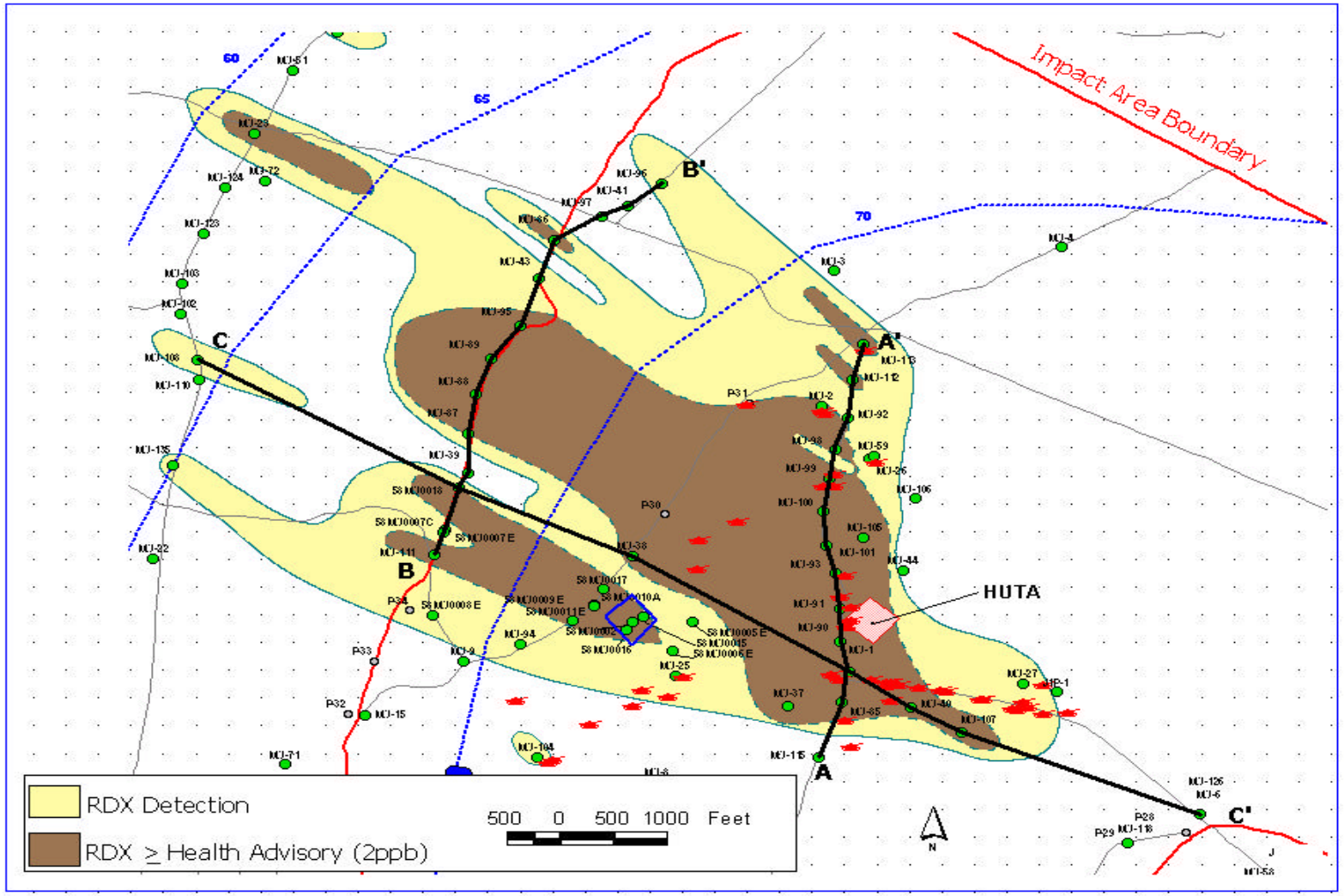
RESULTS

- |RDX present in surface soil samples, ie. less than 2 ft
- RDX absent in deeper soil samples
- RDX present in groundwater at the water table near presumed source
- RDX presence in soil and groundwater is co-located with known high density of UXO and craters and existing targets

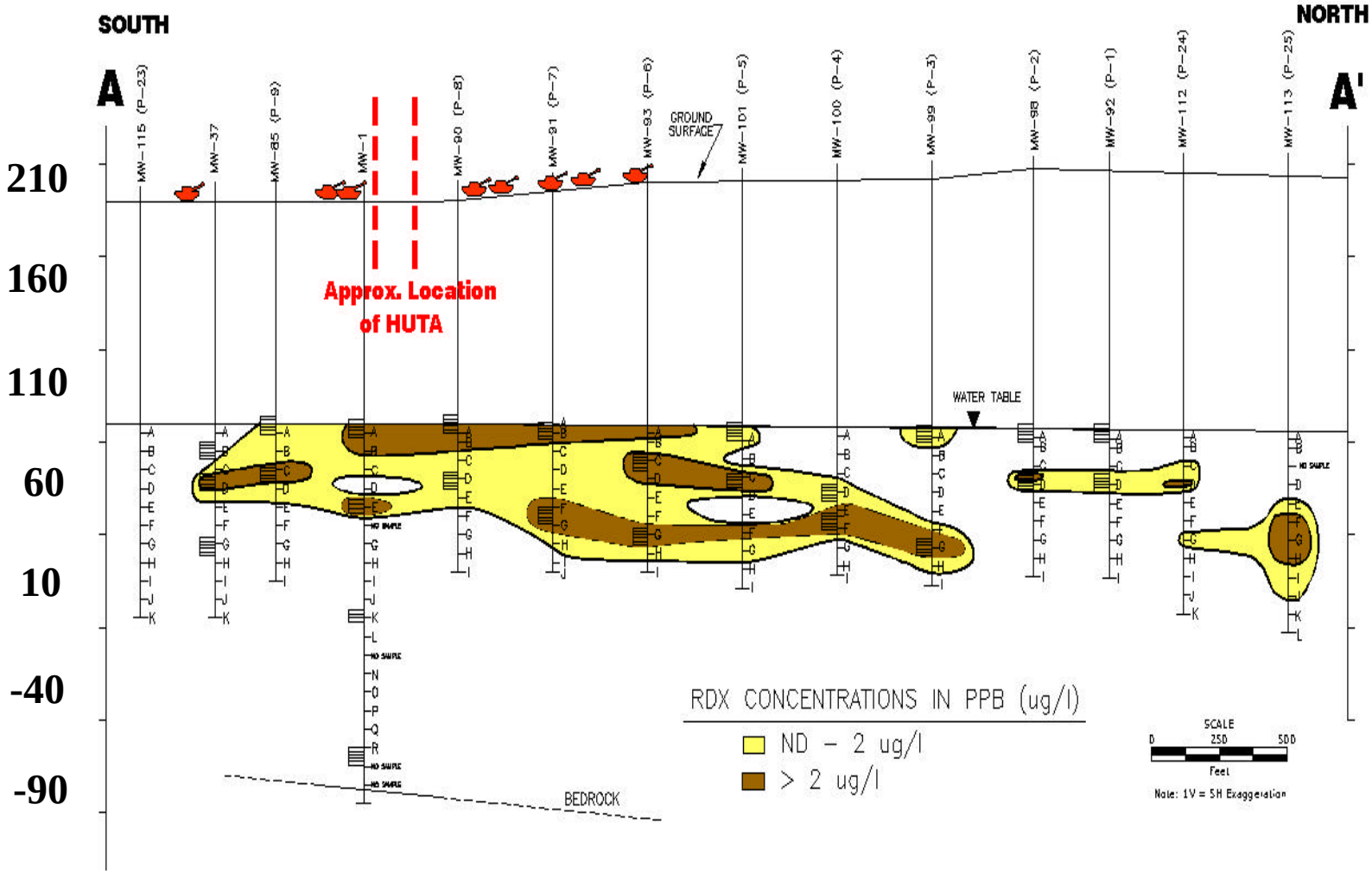
Soil Results at Artillery Target 42



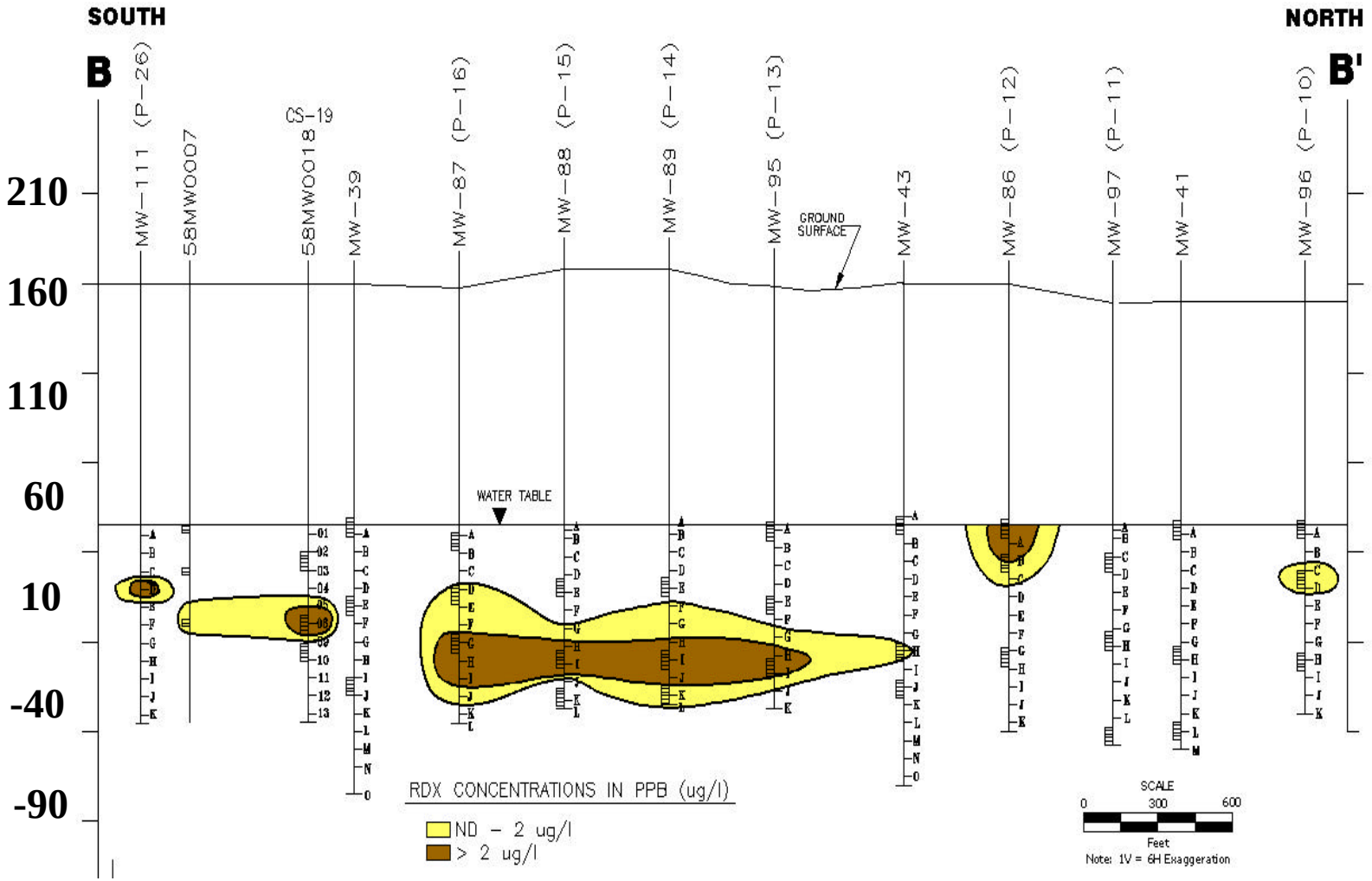
GROUNDWATER SAMPLING - RDX DETECTION



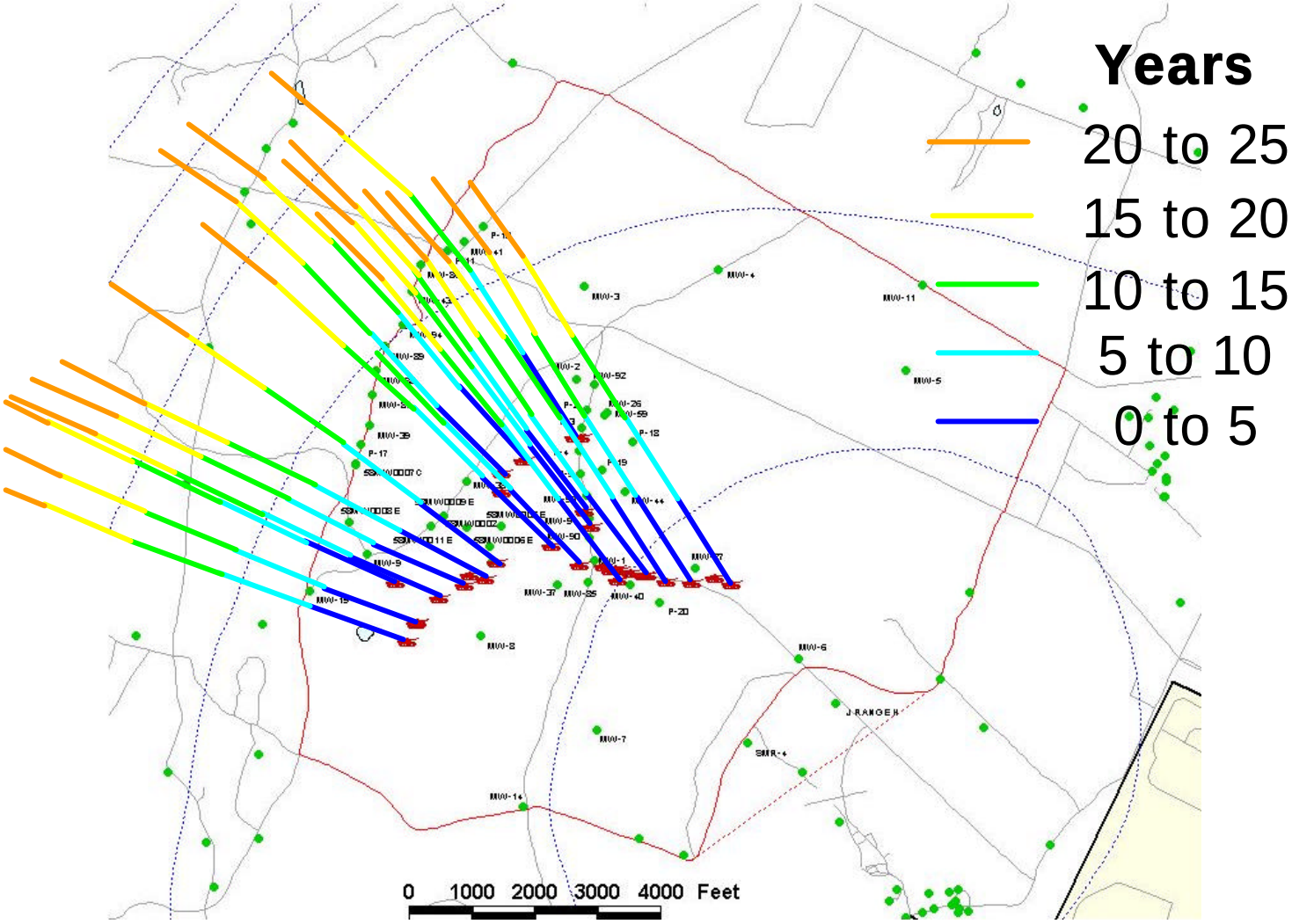
Inner Groundwater Transect within the Impact Area



Outer Groundwater Transect within the Impact Area



MODELING - Potential Contaminant Migration Over Time



Discussion

- Shallow surface soil detections reflect presence of solid particulates
  - evidence of soil concentrations in excess of RDX solubility limit
- Absence of RDX in deeper soil may be the result of:
  - very small spatial footprint
  - dissolved RDX only present in wetting front
  - the amount of RDX residual in solution is inconsequential compared to the total volume of soil

Explosive Fate-and-Transport Conceptual Model

- Deposition of particulates to ground surface
- Slow dissolution of particulates
- Rapid movement of dissolved explosives through unsaturated zone, leaving little residual contamination (RDX and HMX)
- Introduction to groundwater results in rapid transport away from source
- Conceptual model for RDX consistent with peer-reviewed literature

Comparison with Fate & Transport Literature

- Literature indicates degradation of RDX only occurs under anaerobic conditions
- Limited presence of RDX in surface soils indicates attenuation at MMR is occurring through dilution, sorption, and diffusion
- Literature indicates varying K_d values <1 L/kg depending on soil characteristics
- University of Texas provides preliminary value of 0.018 L/kg

CONCLUSIONS

- These studies indicate once RDX is in solution it will be readily transmitted through most aquifer materials and will not adsorb significantly onto the aquifer matrix.
- The key fate-and-transport process is the rate of dissolution of RDX from a solid particulate.
- The principal fate-and-transport processes for RDX once in solution are dispersion, dilution, and diffusion.