

# Migration of Explosives at the Massachusetts Military Reservation, Cape Cod, MA

Presented by

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**OGDEN**



*ENVIRONMENTAL AND ENERGY SERVICES*

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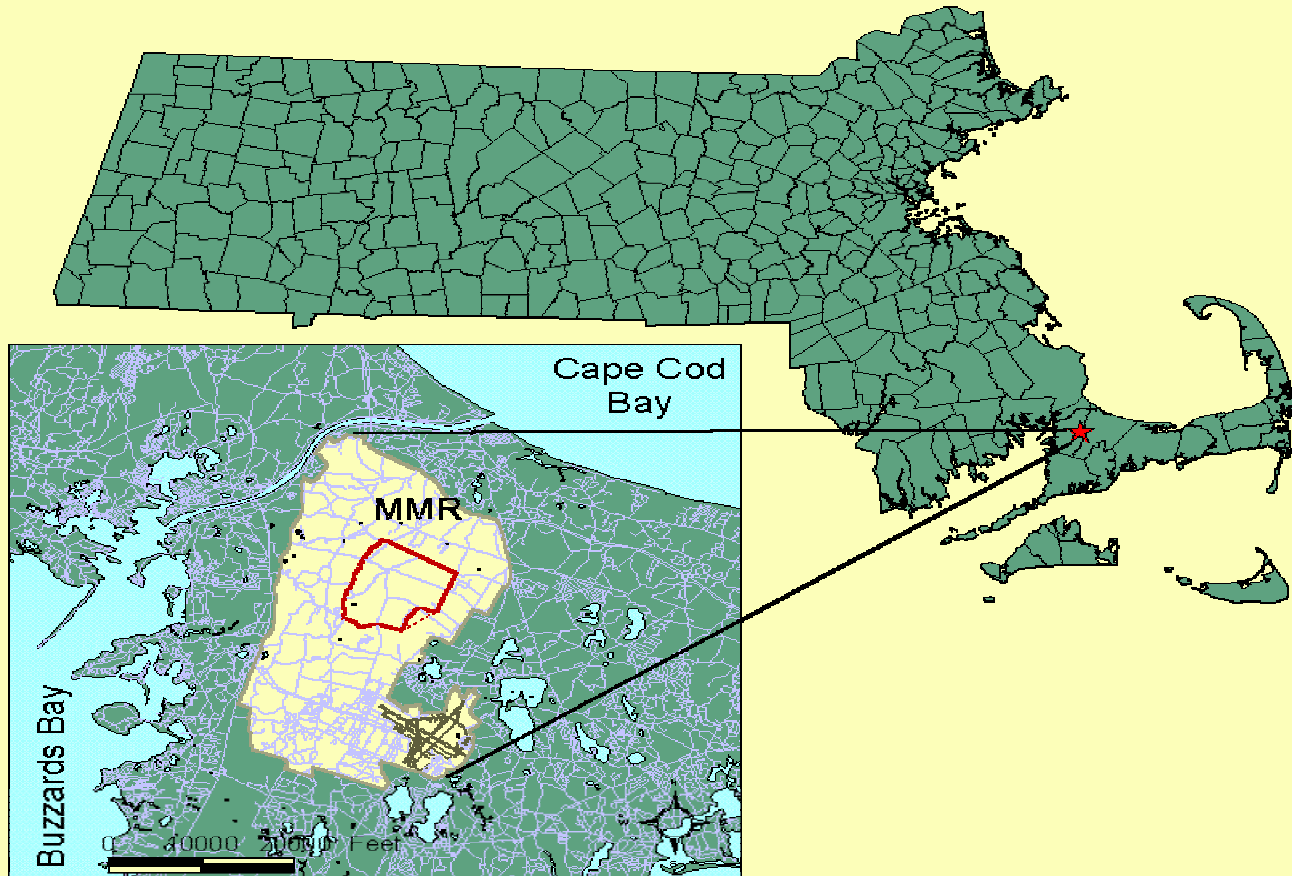
# Acknowledgments

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- LTC Murphy (NGB)
- John Rice (OEES)
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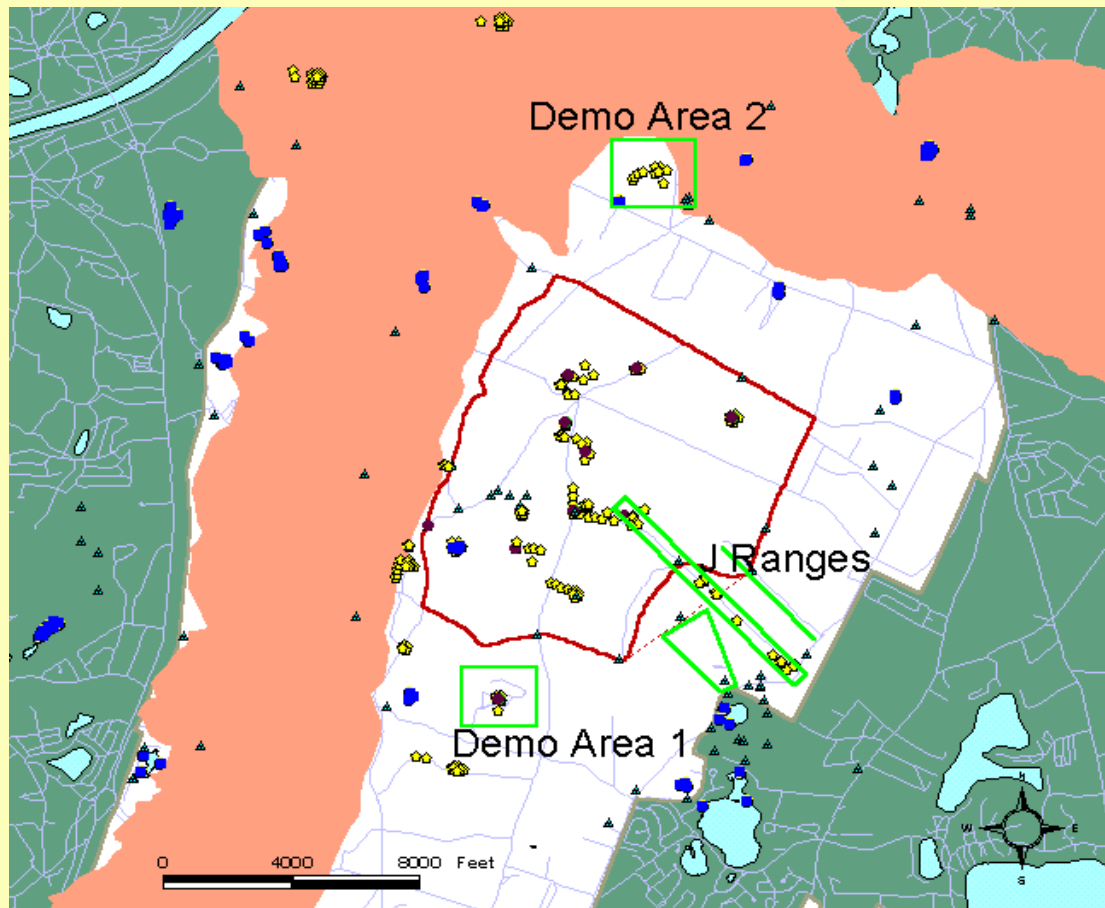
# Introduction

Training and Impact areas have received ordnance discharge from small arms, guns, hand grenades, artillery, mortar, and ordnance demolition for the last 50 years. Environmental concerns related to Impact Area activities led to an Administrative Order under the SDWA between the U.S. EPA and NGB to investigate the effects of training operations on groundwater quality.

# Location Map



# Site Location Map



LEGEND	
★	Soil Grid Samples
■	Sediment Samples
●	Groundwater Grab Samples
■	Surface Water Samples
●	Soil Boring Samples
▲	Groundwater Samples
■	Cape Moraine

# History of Site Use

- Nature of Usage
- Frequency of Usage
- Potential Contaminants of Concern

# Nature of Usage

- Impact Area
  - Artillery Rounds
  - Mortars
  - Rockets
- Small Arms Ranges (42)
  - Rifles, Shotgun, Pistol, and Machine Guns
  - Grenades
- Demolition Areas (2)

# Frequency of Usage

- Training and Impact Areas used since 1911
- Designed to house 30,000 troops
- Records from 1989 indicate 6456 mortars and 1799 artillery rounds fired into the Impact Area
  - munitions usage could exceed 200 x during wartime
  - an artillery round contains ~ 2.5 lbs of explosives



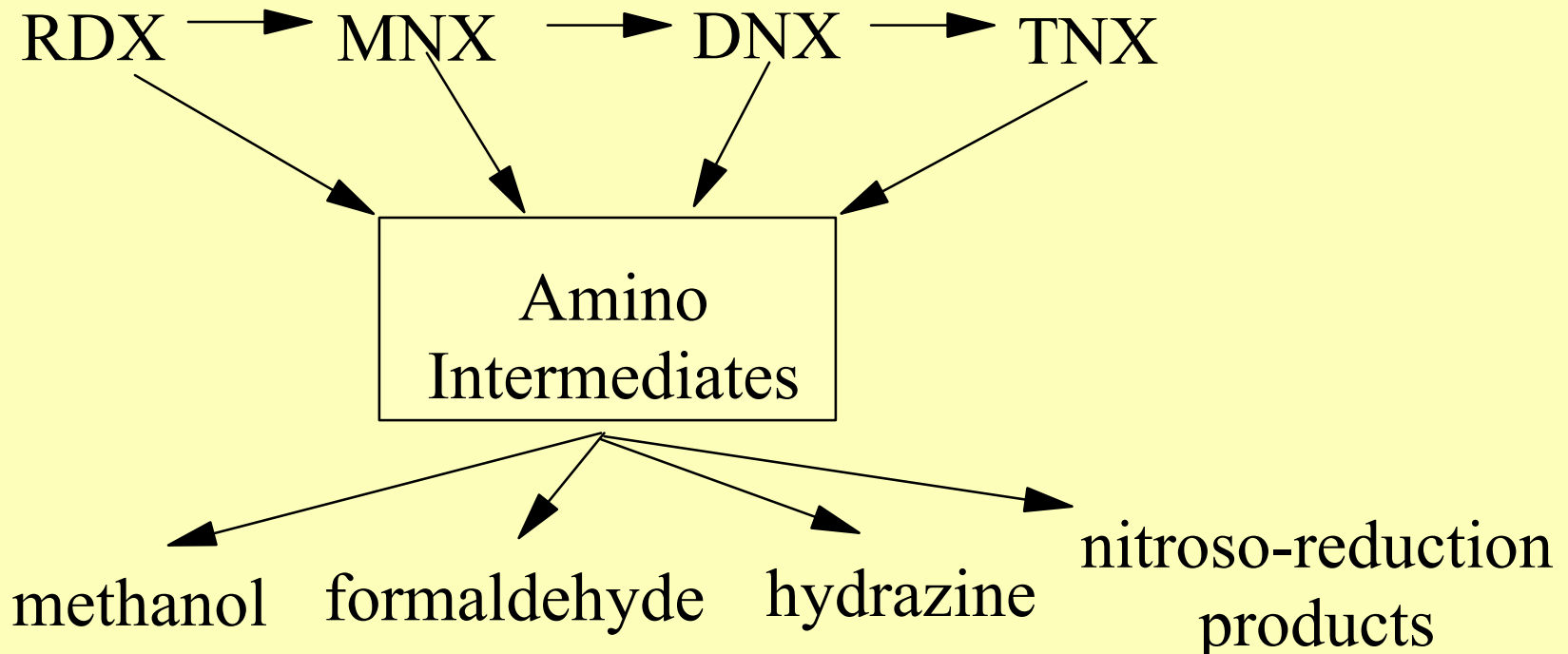
# Potential Contaminants of Concern

- hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
- octahydro-1,3,5,7-tetranitro-1,3,5,7-tetraocine (HMX)
- 2,4,6-trinitrotoluene (TNT)
- TNT Degradation Products
- pentaerythritol tetranitrate (PETN)
- picric acid

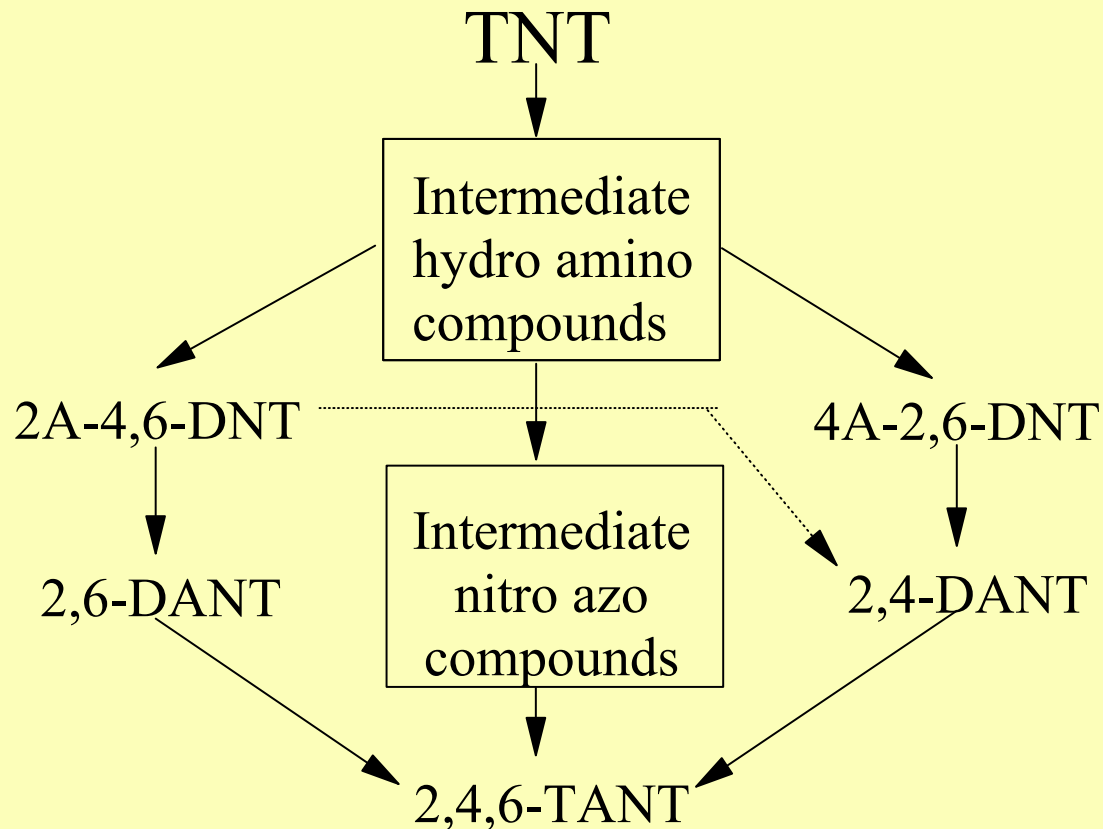
# Explosive Properties

- Crystalline solid at room temperature
- Low water solubility
- Low vapor pressure
- Susceptibility to photolysis and biological degradation

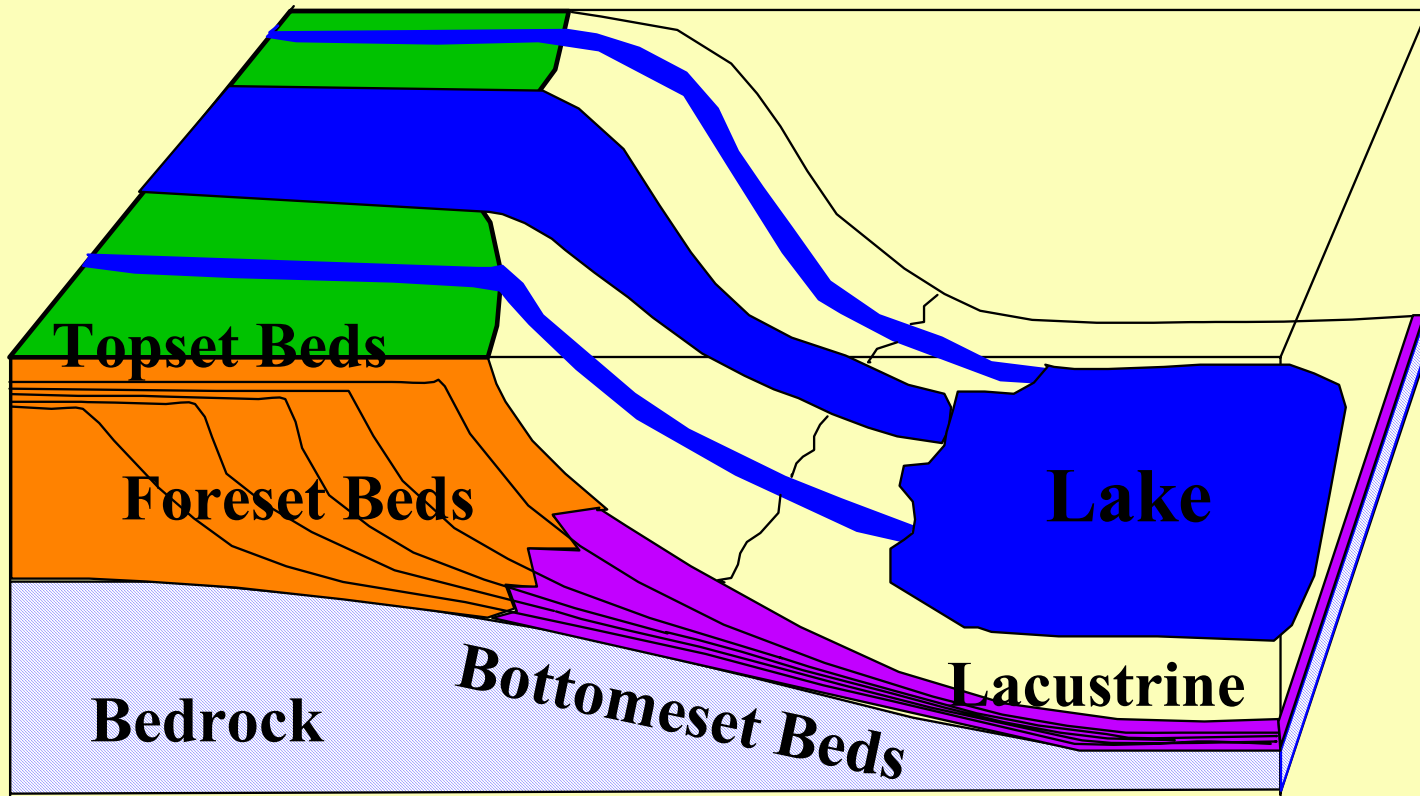
# RDX Transformation Pathways



# TNT Transformation Pathways

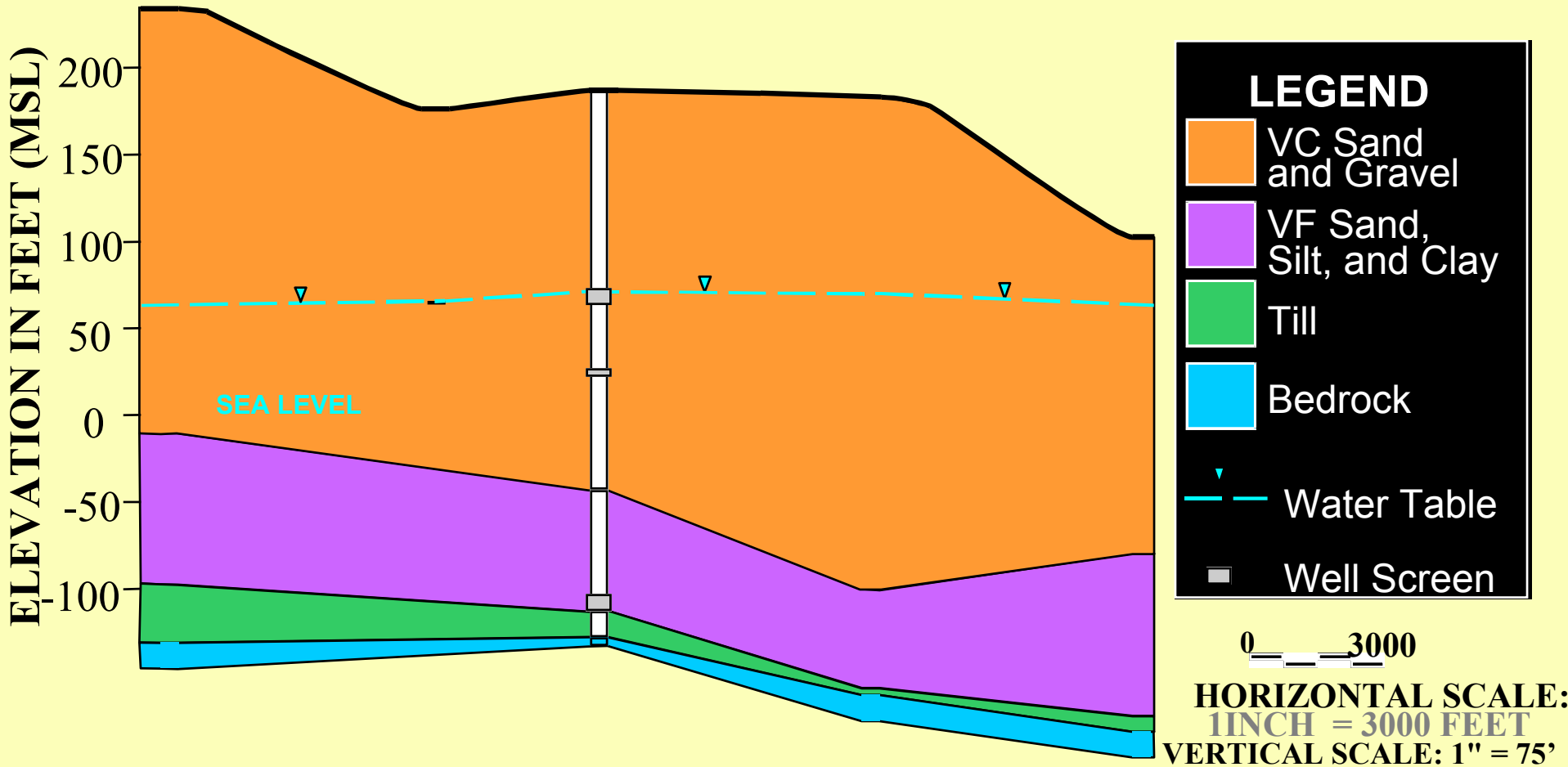


# Sedimentary Sequence at MMR

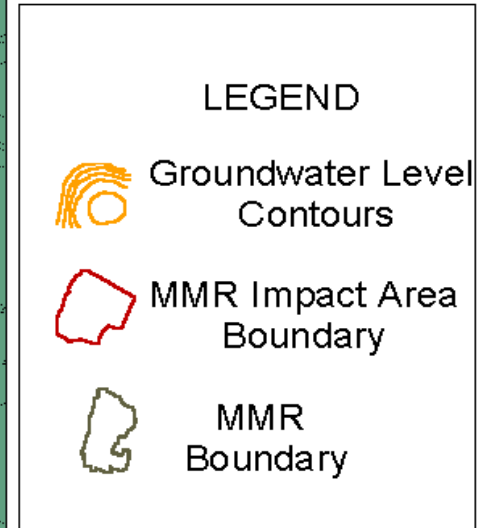
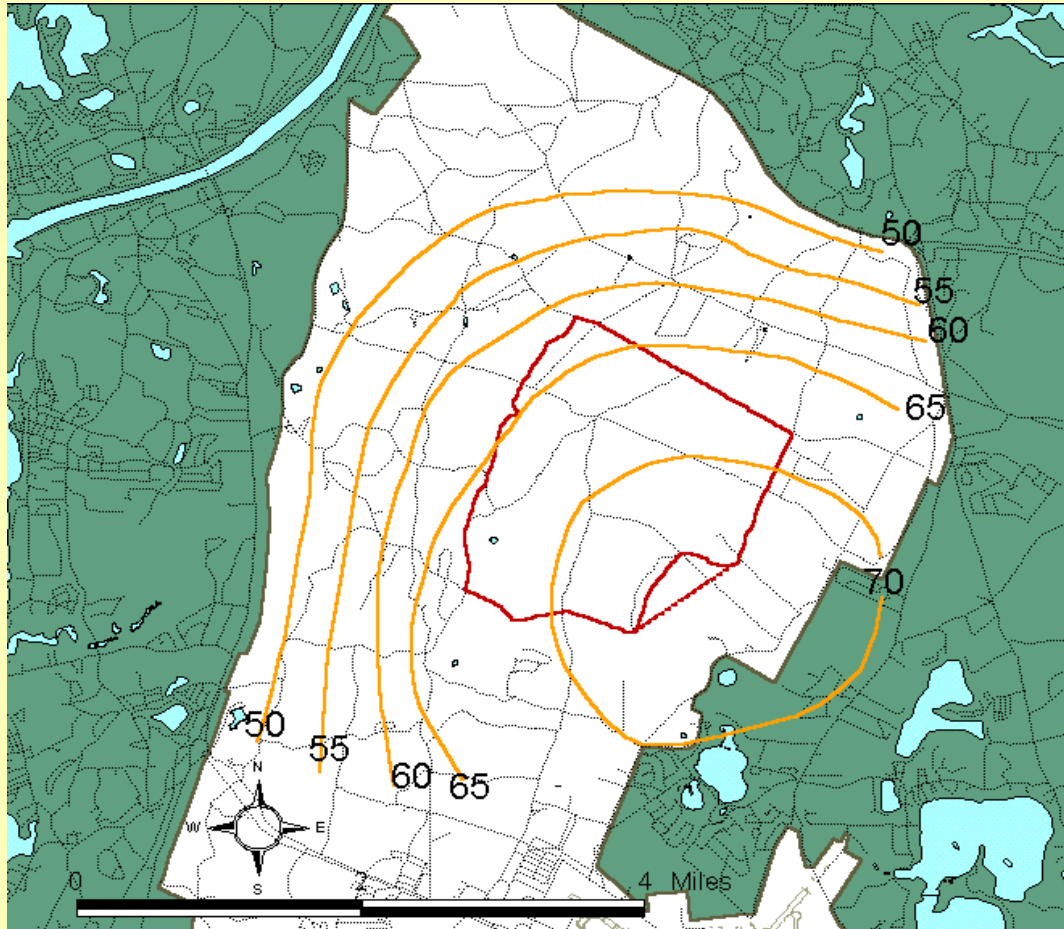


Modified from Smith and Ashley, 1985

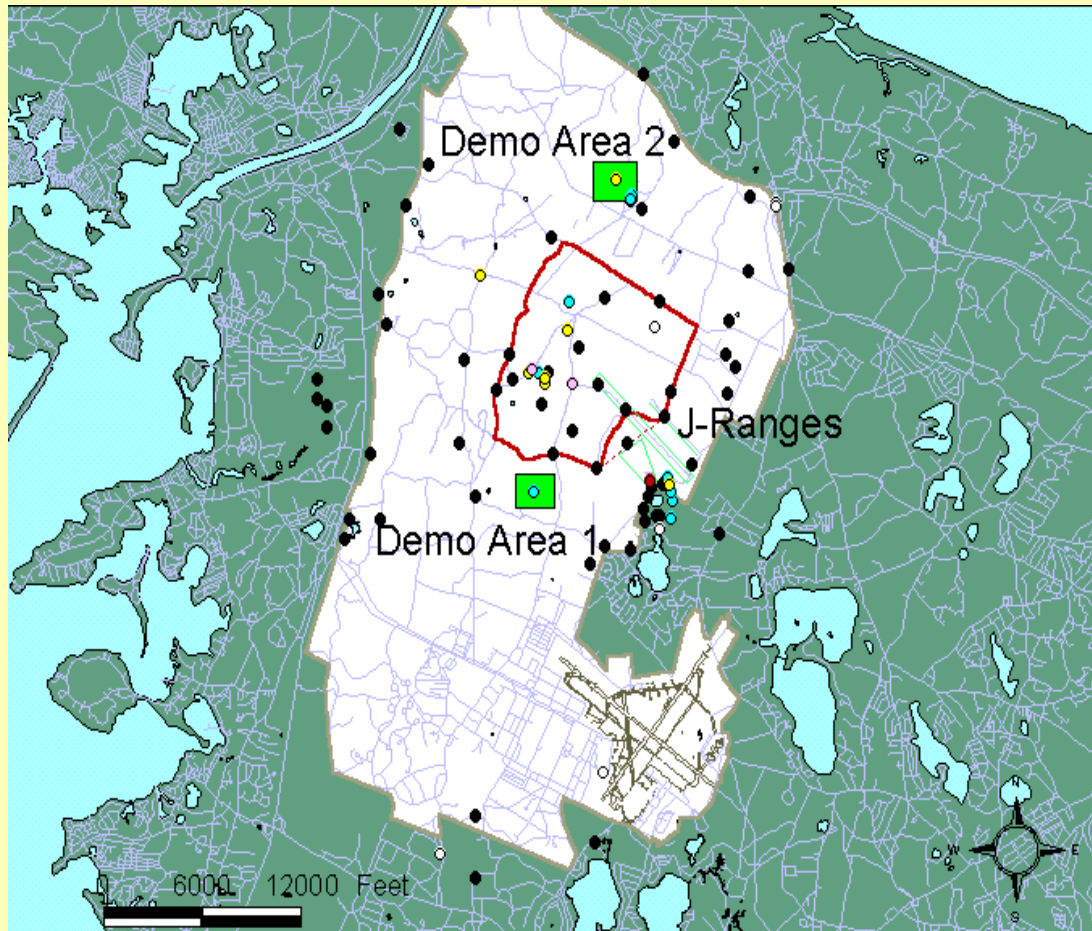
# Conceptual Cross-Section



# MMR Water Table



# Groundwater Explosive Detects

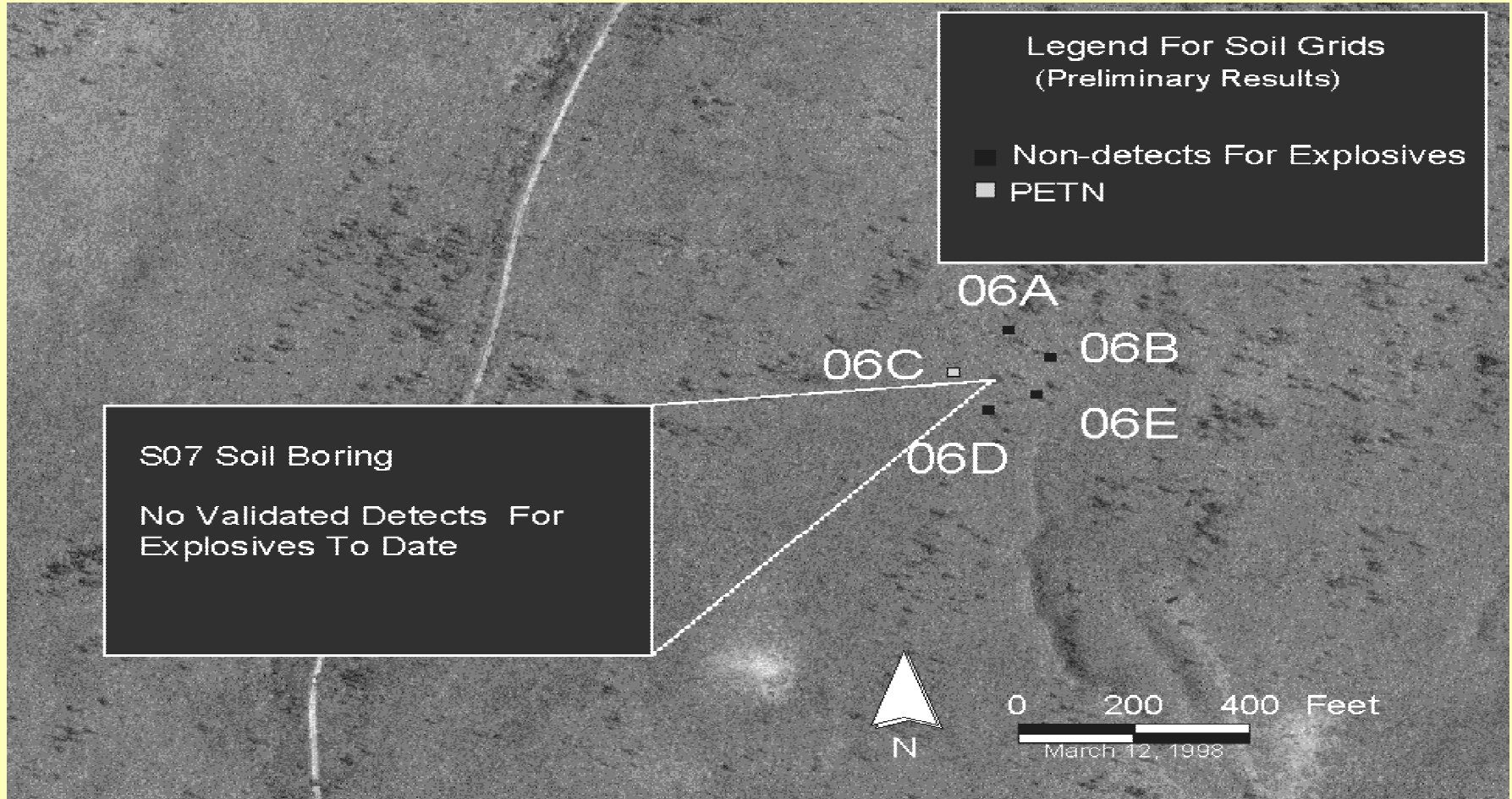


## LEGEND

- Not Sampled To Date
- Detects for RDX
- Detects For HMX
- Detects For RDX & HMX
- Non-detects for RDX/HMX
- Awaiting Lab Results



# Soil Explosive Detects Area 6



# Soil Explosive Detects Area 7

Legend For Soil Grids  
(Preliminary Results)

■ Non-detects For Explosives

S08 (0-6") Soil Boring

2-Nitrotoluene 0.160 ppm J  
Picric Acid 0.180 ppm

S08 (0-6" Duplicate) Soil Boring

2-Nitrotoluene 0.160 ppm J  
Picric Acid 0.200 ppm

07A 07B 07C  
07D  
07E



0 300 600 Feet  
March 12, 1998

# Soil Explosive Detects Area 11

Legend For Soil Grids  
(Preliminary Results)

■ Non-detects For Explosives

S25 (0-6") Soil Boring

PETN 110 ppm NJ

S25 (0-6" Duplicate) Soil Boring

PETN 580 ppm NJ

11A  
11E  
11B 11D  
11C



0 200 400 Feet  
March 12, 1998

# Soil Explosive Detects Area 12

## Explosives Results For Soils In Area 12

### S19 (0-6") Soil Boring

2-Amino-4,6-Dinitrotoluene	0.350 ppm	
4-Amino-2,6-Dinitrotoluene	0.280 ppm	J
RDX	0.610 ppm	
HMX	0.600 ppm	NJ

### S19 (0-6" Duplicate) Soil Boring

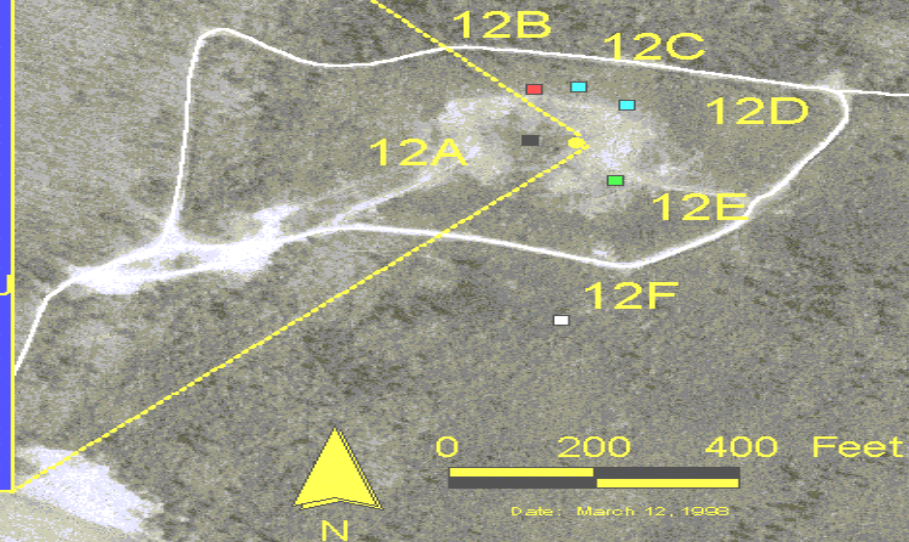
2,4-Dinitrotoluene	1.800 ppm	J
2,6-Dinitrotoluene	0.040 ppm	J
2-Amino-4,6-Dinitrotoluene	0.220 ppm	
4-Amino-2,6-Dinitrotoluene	0.200 ppm	J
RDX	0.520 ppm	
HMX	0.690 ppm	NJ

### S19 (10-12') Soil Boring

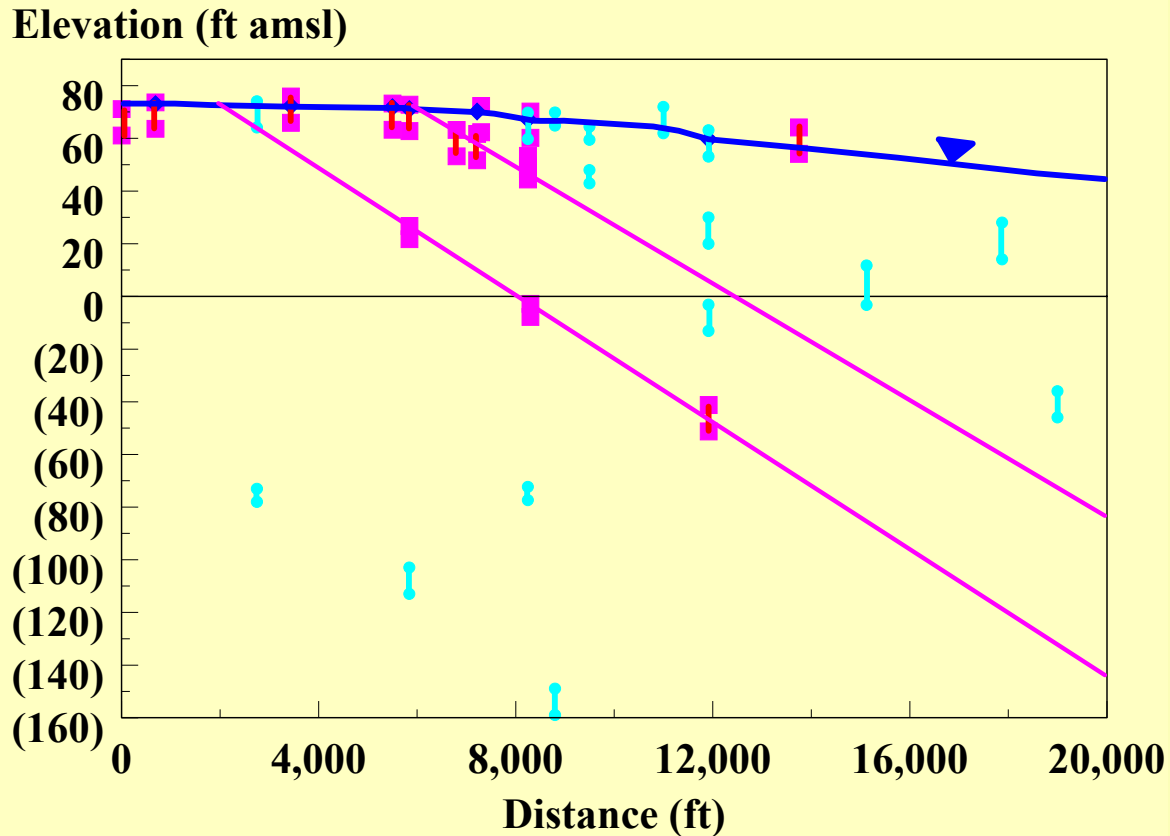
RDX	0.120 ppm	J
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### Legend For Soil Grids (Preliminary Results)

- Non-detects For Explosives
- HMX, RDX
- HMX, RDX, 2-A-4,6-DNT
- HMX
- Awaiting Lab Results

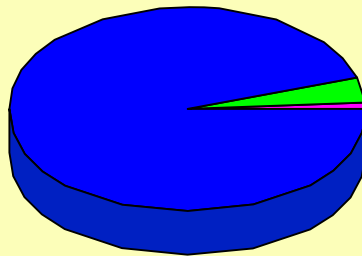


# Explosive Depth Relationship

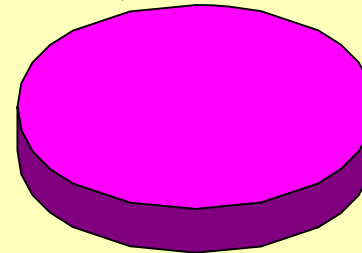


# Explosive Distribution

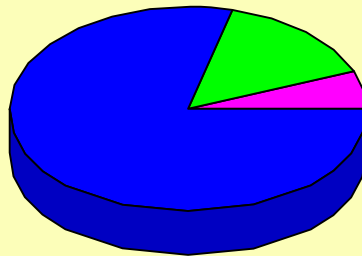
Well 1S




Well 1M, 2M, 23M1, 25S  
CS19-6, CS19-5



CS19-9

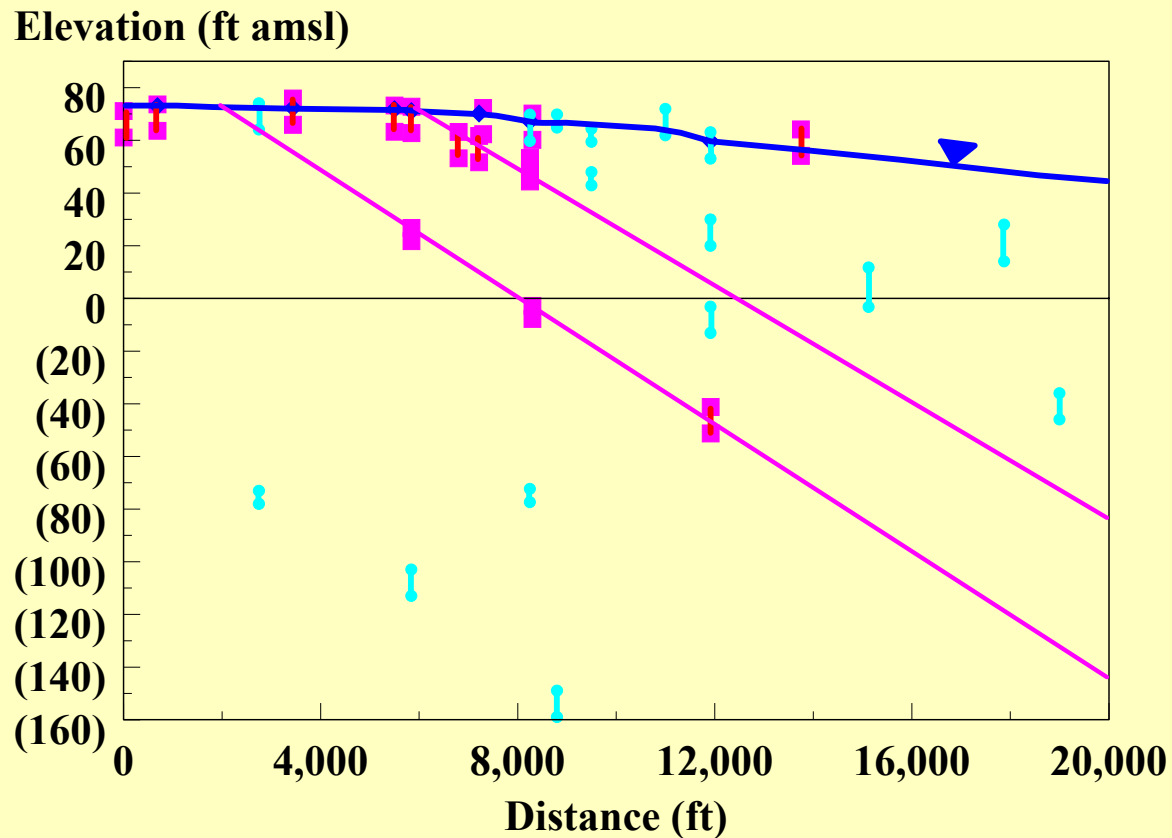


 RDX

 HMX

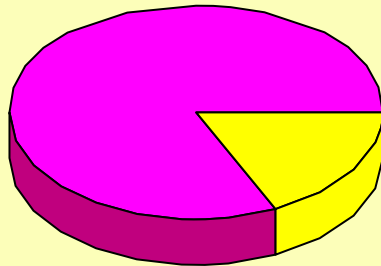
 PETN

# Explosive Depth Relationship

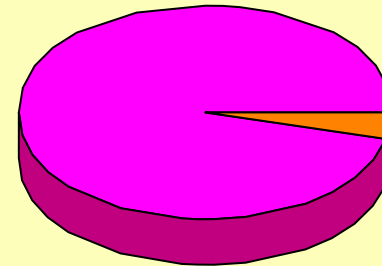


# Explosive Distribution

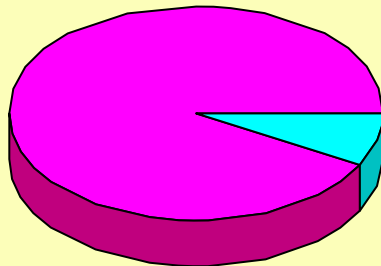
Well 16S




Well 30S





FS19-WT13



 RDX

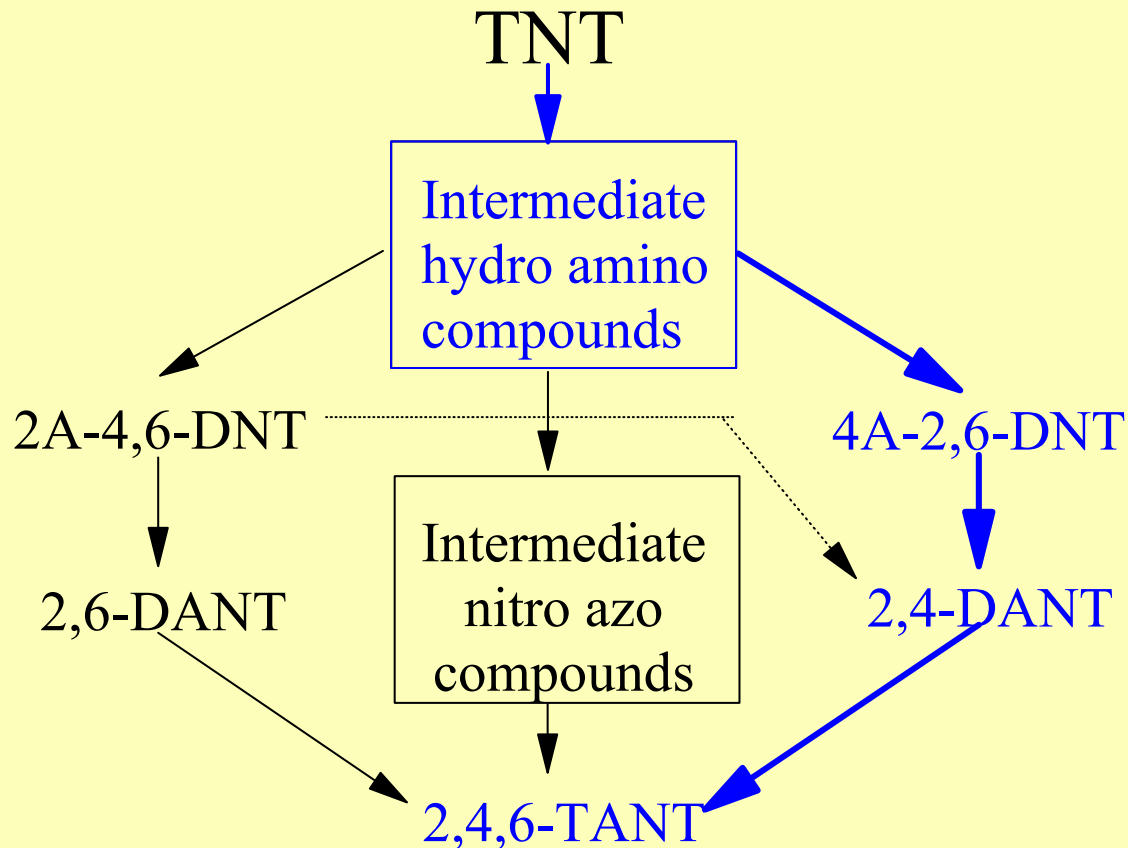
 Picric Acid

 4A-2,6-DNT

 2,4-DANT



# TNT Transformation Pathways



# Conclusions

- Explosives present in surface soils
- Limited explosive subsurface soil contamination
- Absence of TNT suggests active biodegradation
- Groundwater contamination of RDX and HMX
- Groundwater explosive distribution may suggest multiple sources