Evaluation of Heat Transfer Technologies as a Method to Remediate Firing Positions

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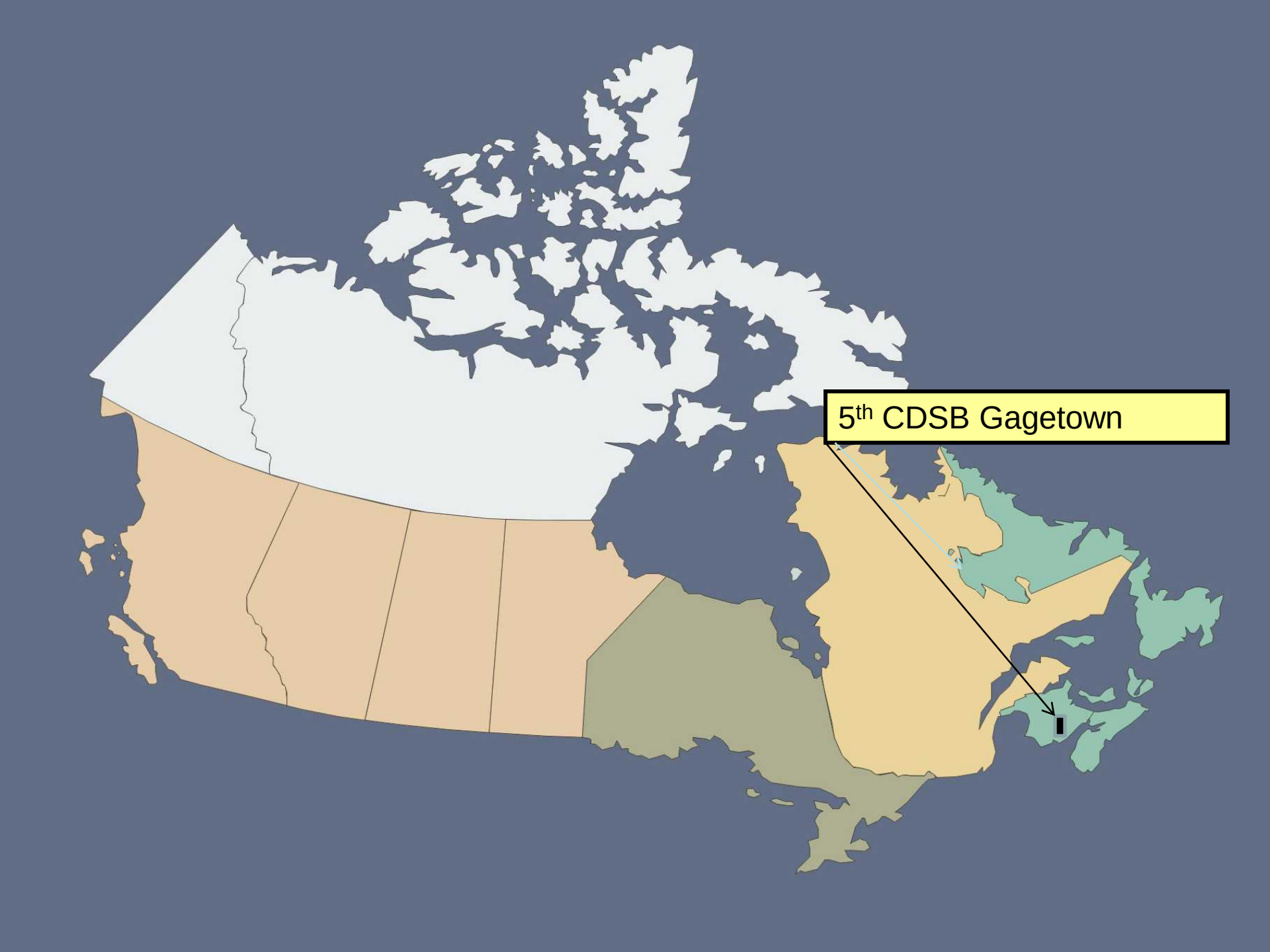
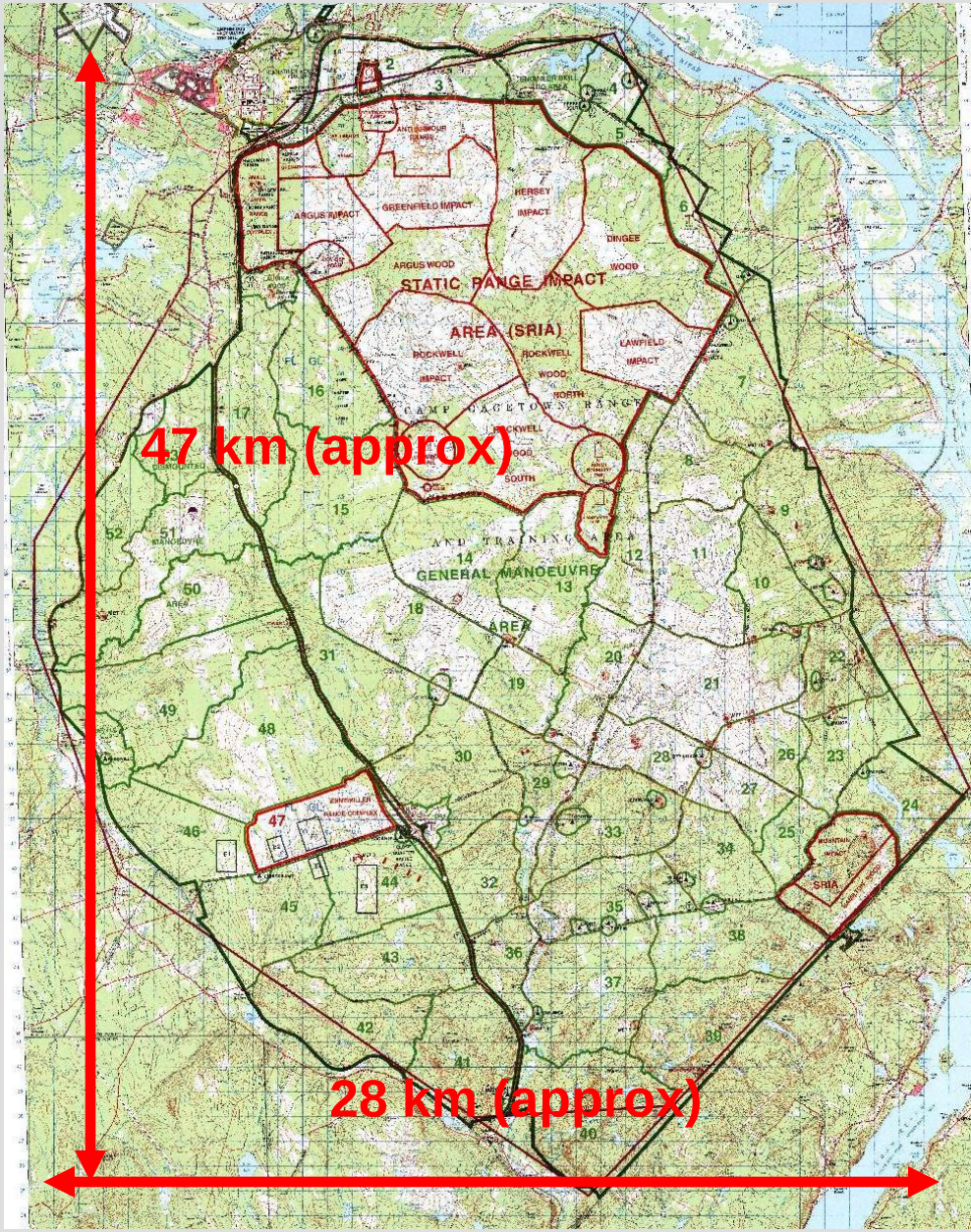

5th CDSB Gagetown

5th CDSB Gagetown RTA

- ✓ Training Area:
  - ➢ 1,100 Sq Km^2
  - ➢ 20,000 hectares of impact area
- ✓ Canada's second largest military training area
- ✓ Centre of Excellence for Army Training



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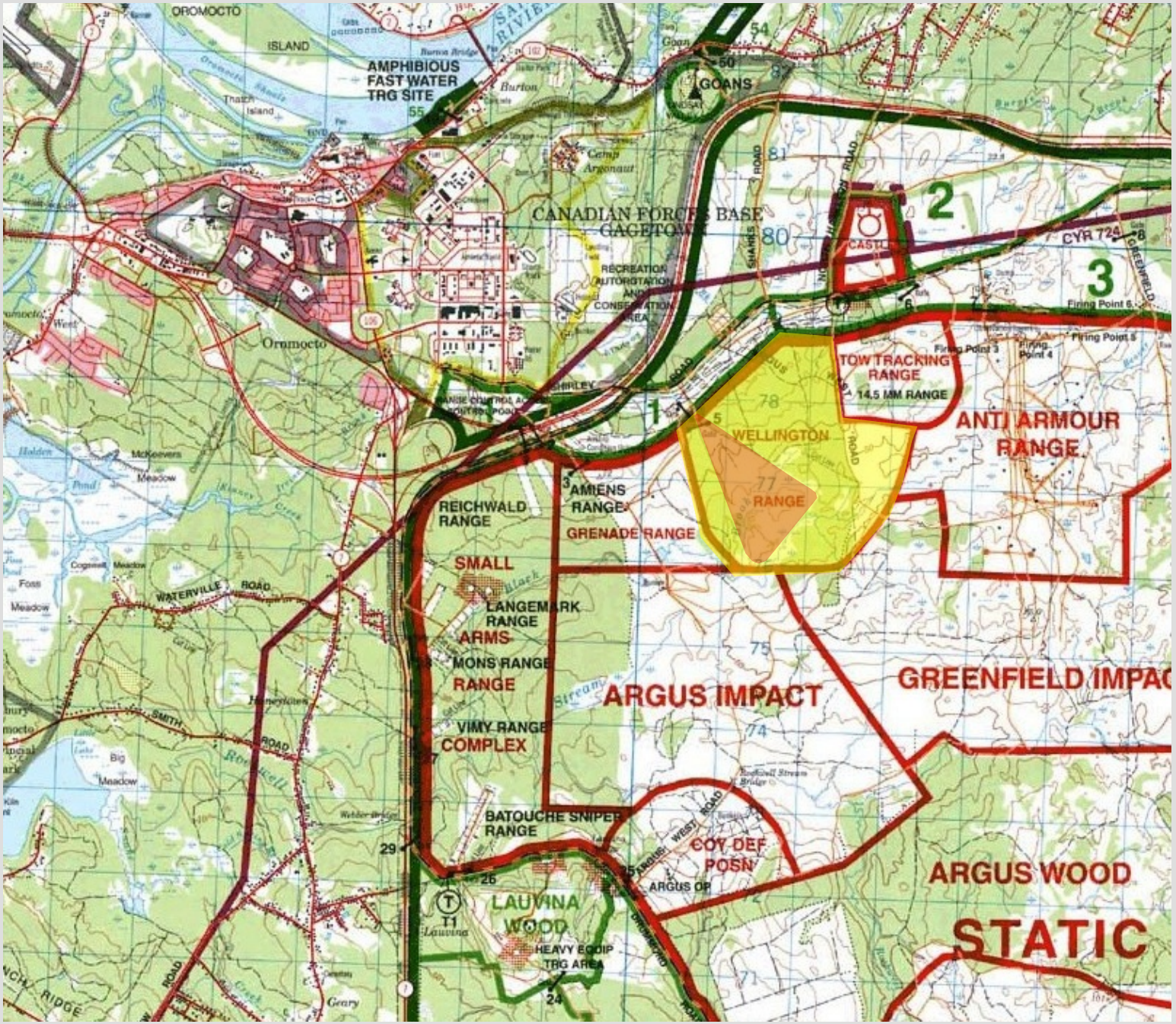

FIRING POSITIONS WELLINGTON RANGE

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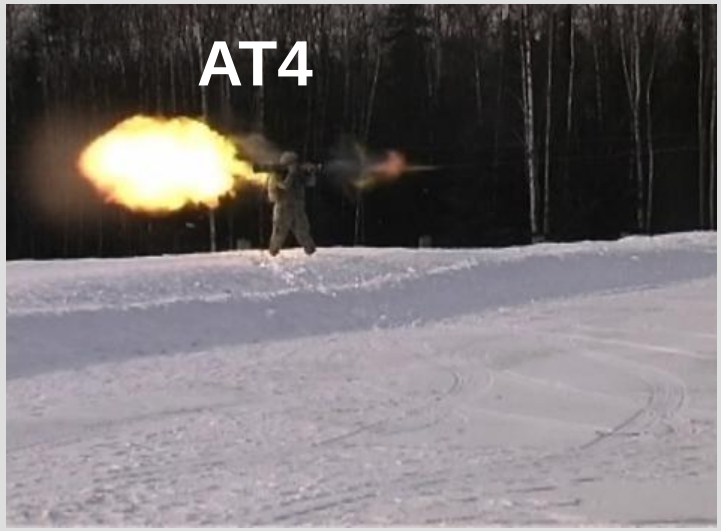
Anti-Tank Firing Background



- High deposition rate of Nitrocellulose fibers (NC) containing Nitroglycerin(NG) based propellant (3% of soil matrix)
- High NG concentrations behind firing positions (10 to 20,000 mg/kg)
- NC is highly insoluble and resilient to biotic and abiotic biodegradation processes
- After 25 years of inactivity, still over 4000 ppm in surface soils

Background Cont.

- NC/NG is not an Env Contaminant of Concern
- Surface ignition could result and munitions are stockpiled on site
- NG is volatile and could represent an health and safety issue to users

Objective

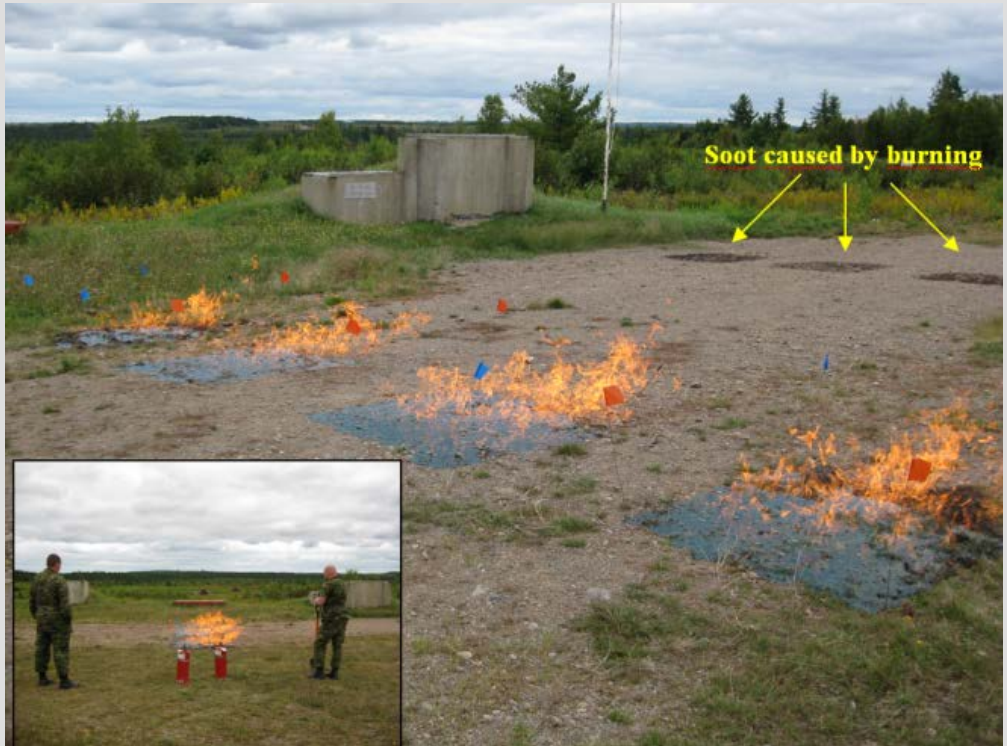
- The objective of this trial was to establish if NG concentrations in soil at firing points could be reduced using this technology

Remedial Option Analyses DRDC

- NC matrix highly water insoluble, prevents the use of bioremediation
- NC resistance prevents the use of chemical reduction, hydrolysis or oxydation
- Ex-situ treatment using soil stabilization (STABLEX) limited by the high concentrations of energetic materials (limit of 5000 mg/kg)
- Contamination concentrated at surface
- Incineration was selected as the preferred option as NG destruction temperature is low at 200^{o}C and according DRDC can combust as low as 60^{o}C

Burning Technologies

- In-situ technology using gelled solvent
- Trials ran from 2009-2011 by Isabelle Poulin from DRDC
- Two drawbacks
  - Too expensive for large scale deployment
  - Temperature not high enough to burn NG in subsurface



Direct Flame Burning

- Hand-held propane burner delivering heat as a direct flame
- Trial conducted at Carpiquet, Quebec the summer of 2013
- Drawbacks
  - Time consuming, not user friendly
  - Difficult to manage for large scale deployment
  - Temperatures not sufficient to burn NG completely at the surface
  - Insufficient heat penetration did now allow burning of NG in sub-surface

Asphalt Heating Technology

- Proposed by 5CDSG Gagetown Environmental Branch, based on radiant blue flame
- Tested in two trials conducted in 2013 and 2014
- First trial performed with a IR-Proheater single unit for durations of 15 and 30 minutes heating at two locations at Wellington firing positions

2013 Trial : IR-Proheater Single Unit

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2013 Trial Results

- After 15 minutes exposure: NG surface soil concentrations decreased from 1960 to 1650 mg/kg for 17% reduction
- After 30 minutes exposure: NG surface soil concentrations decreased from 310 to 260 mg/kg for 14% reduction
- Average of 15% reduction was achieved for both trials
- Technology was cheap ($1000/day), easy to deploy and destroyed 15% of NG after 30 minutes of heating
- We did not sample at depth
- Visual observations of the NG ignition were noted
- Results showed promise but require longer duration of heat exposure and intensity

2014 Trial

- Performed in September 2014 using a larger heater (Asphalt Reheat System – Manta Ray EXT)
- Probes were used to measure the temperature at different depths down to 25 cms
- Location A:
  - Sampled prior to heating
  - Heating period of 30 minutes – resampled
  - Re-heating for another 30 minutes and re-sampled
- Location B:
  - Sampled prior to heating
  - Heating period of 60 minutes – resampled
  - Re-heating for 60 minutes and re-sampled
- Location C: (highest NG concentration)
  - Sampled prior to heating
  - Heating period of 240 minutes
  - Resampled the surface and the sub-surface

Manta Ray EXT Trailer by ARS

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Temperature Probe

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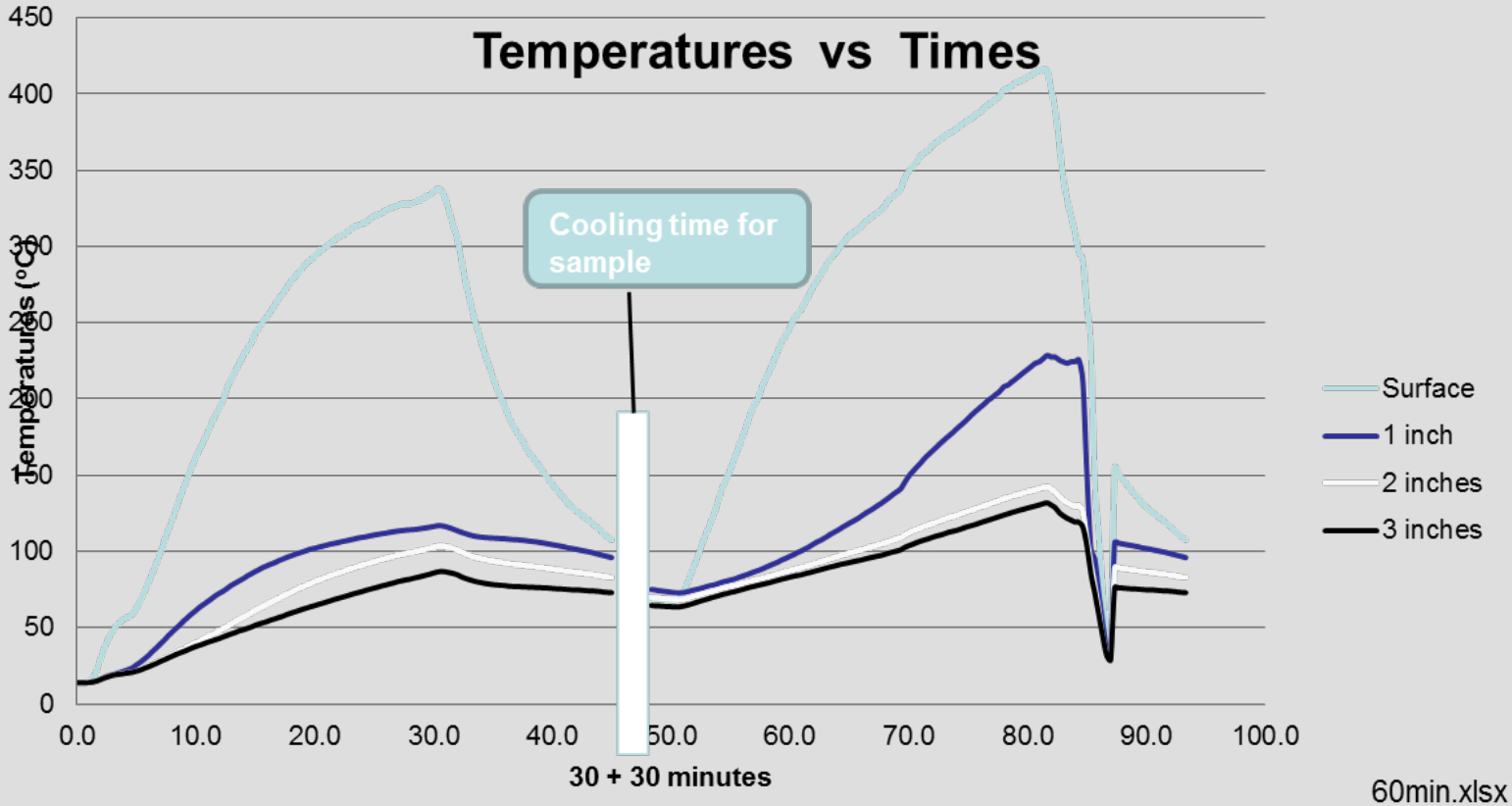
Results – 30+30 Minutes

- After heating 30 minutes, temperature reaches 340ºC, then it goes up to 425ºC. It is suspected that H_2O is boiled off allowing temps to increase



60min.xlsx

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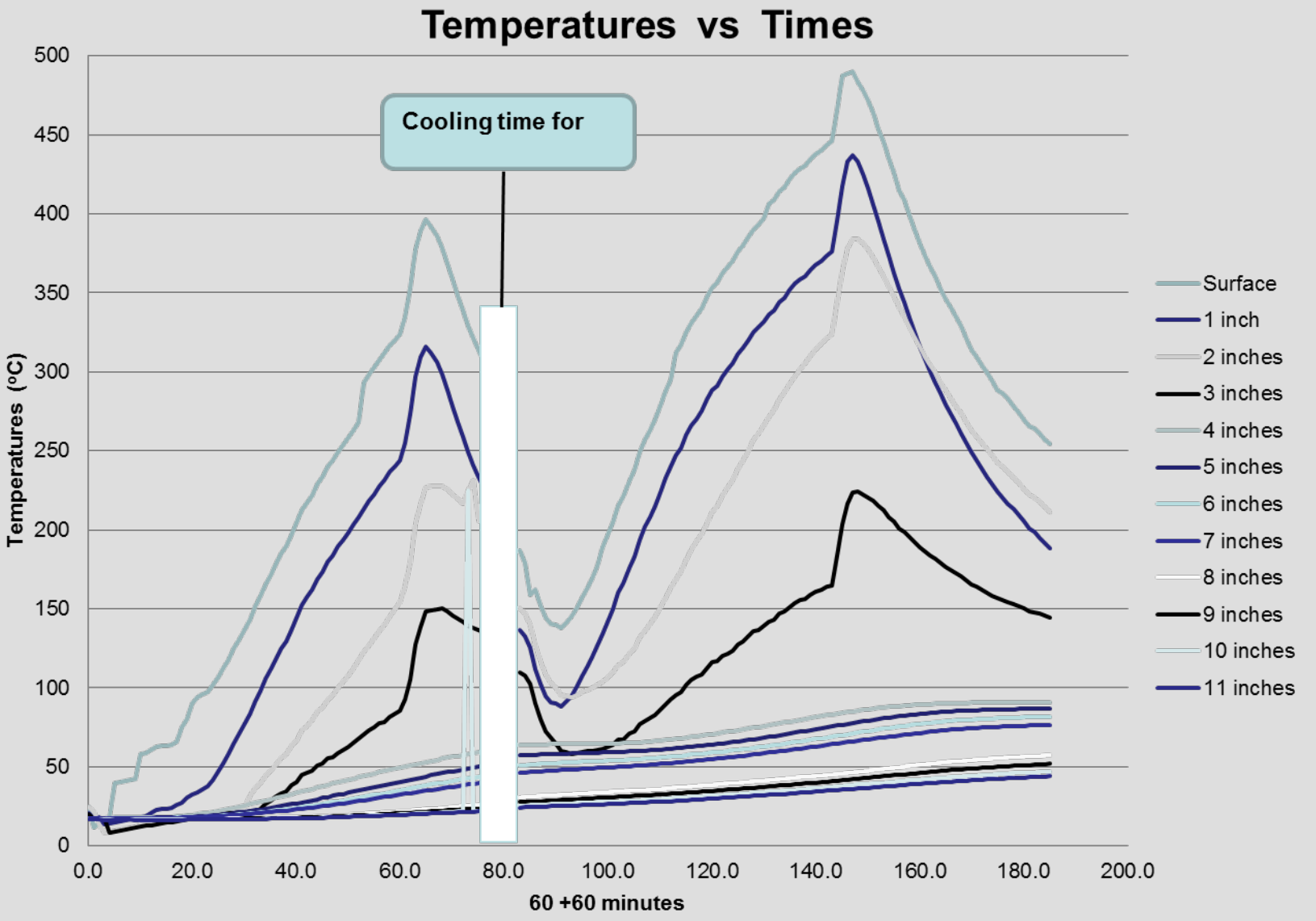
Results 60+60 Minutes Heating



After Heating

Following 4 hours of Heating

- Visual observation of soil drying down to a depth of 15 cm

2014 Results

	NG Concentration (mg/kg) Heating for 30 Minutes (Location A)	NG Concentration (mg/kg) Heating for 30 + 30 Minutes (Location A)	NG Concentration (mg/kg) Heating for 60 Minutes (Location B)	NG Concentration (mg/kg) Heating for 60 + 60 Minutes (Location B)	NG Concentration (mg/kg) Heating for 240 Minutes (Location C)
Before	9300	9300	2500	2500	13000
After	1000	ND	ND	ND	ND
After sub-surface 0-15 cm	___	___	___	___	ND
After sub-surface 15-30 cm	___	___	___	___	75

ND=Non Detect

Conclusions

- Technology easy to deploy, very efficient at heating soils down to 15 cm (no need to go further)
- Adjustments would have to made to the equipment for long duration heating
- Maximum surface soil temperatures achieved: 470 C˚ (900F^{o})
- Temperatures reached were highest following H^2O boil off
- Complete destruction of NG in surface soils after one hour
- Completed destruction of NG after 4 hours down to 5 cm. However we suspect destruction of NG to 15cm
- This technology has high potential to be used as a remedial tool for anti-tank range firing points, but also at sites containing single, double or triple base propellants (Demo Sites)
- Not appropriated for gun propellants (2,4-DNT based)

Way Ahead

- Additional trials will be conducted to establish specific heating times, including subsurface sampling for each trial (before and after)
- Trials will be conducted in other soil types
- Further investigation into this technology will be undertaken this coming summer for RDX
- Small scale remediation and maintenance of firing points are to commenced in 2016
- This technology could be used for certifying that munitions debris are free of explosives residue

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Questions?