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IMEMTS
ROME★2015
INSENSITIVE MUNITIONS & ENERGETIC MATERIALS TECHNOLOGY SYMPOSIUM

New Stabilizers for NC-propellants Evaluated In Rockets Propellants

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Accelerated Degradation Tests of IM-Compliant Polymer Bonded Explosives

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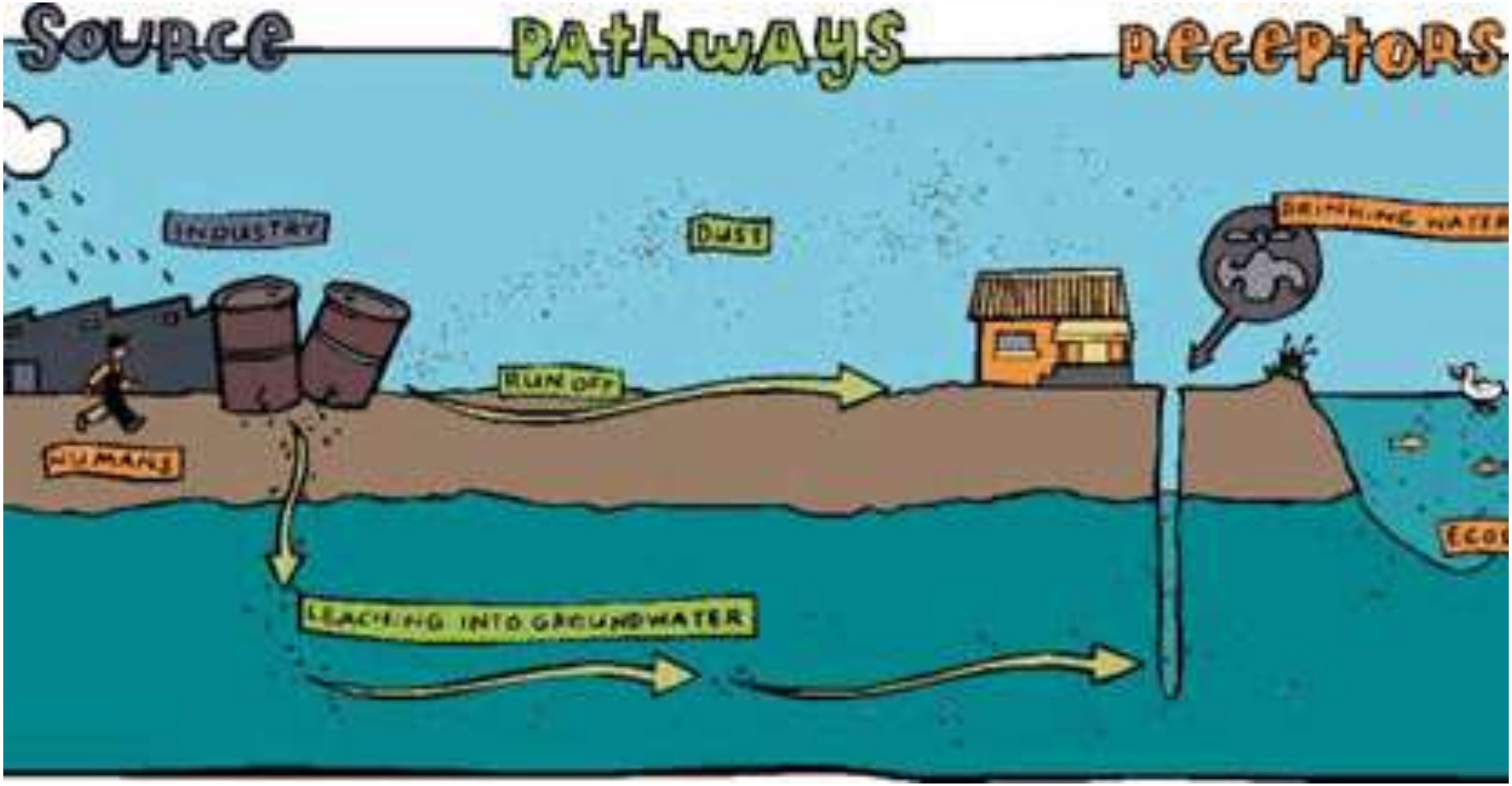
Source-Pathway-Receptor



Source- pathway-receptor-model

Source:www.marlborough.govt.nz/Environment/Land/

Fate and Transport of Explosive Compositions

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Degraded munitions in a military training area

Degraded munitions washed up from the sea

Previous Studies

- Environmental fate of conventional RDX/TNT (Comp B) explosives fillings studied
  - Susan Taylor's work (Dartmouth College NH), Walsh et al….
- Trend in defence is towards IM-compliant fillings, research to date:
  - USA: Melt-cast DNAN-based formulations (Taylor et al,)
- **RDX based PBXs utilising a rubbery polyurethane binder (HTPB…)**

Future Environmental Management of PBX in the UK

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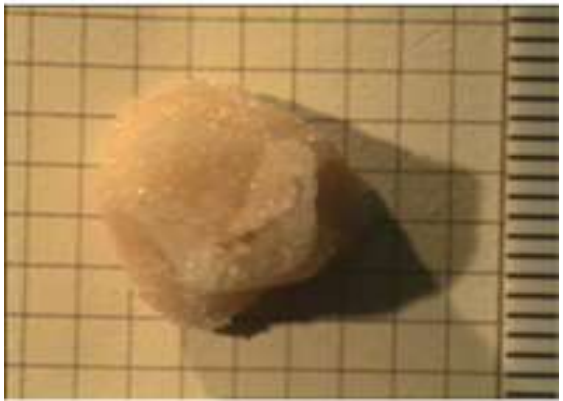
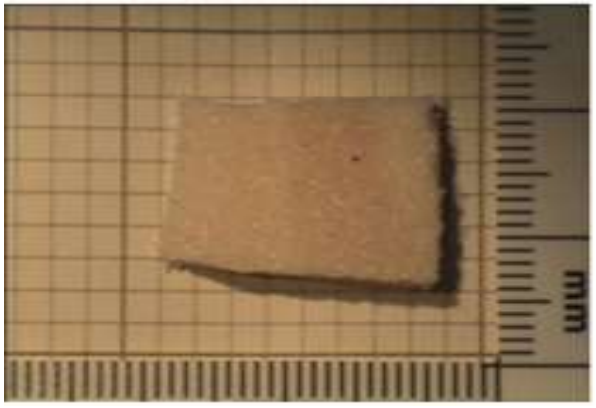
Questions to be answered:

1. Rate of RDX transport into groundwater from PBX?
2. Fate of RDX in soil and groundwater?
3. Impact to receptors, e.g. toxicology?

PBX Samples

- Generic RDX-based PBX composition used:
  - 88% RDX, 5% HTPB binder cured with IPDI, 7% DOA plasticiser
- Lab hand-mixed «pristine» samples and industrially-made «cut» samples
  - Supplied by BAE Systems at Glascoed UK
- Sample masses 1.0 – 1.5 g





Drip Test Experiments
Simulated Rainfall

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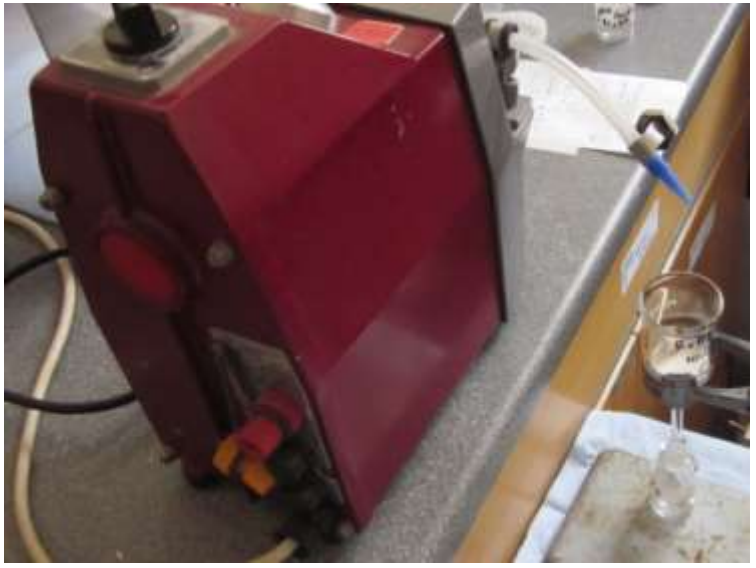
Low Flow Rate

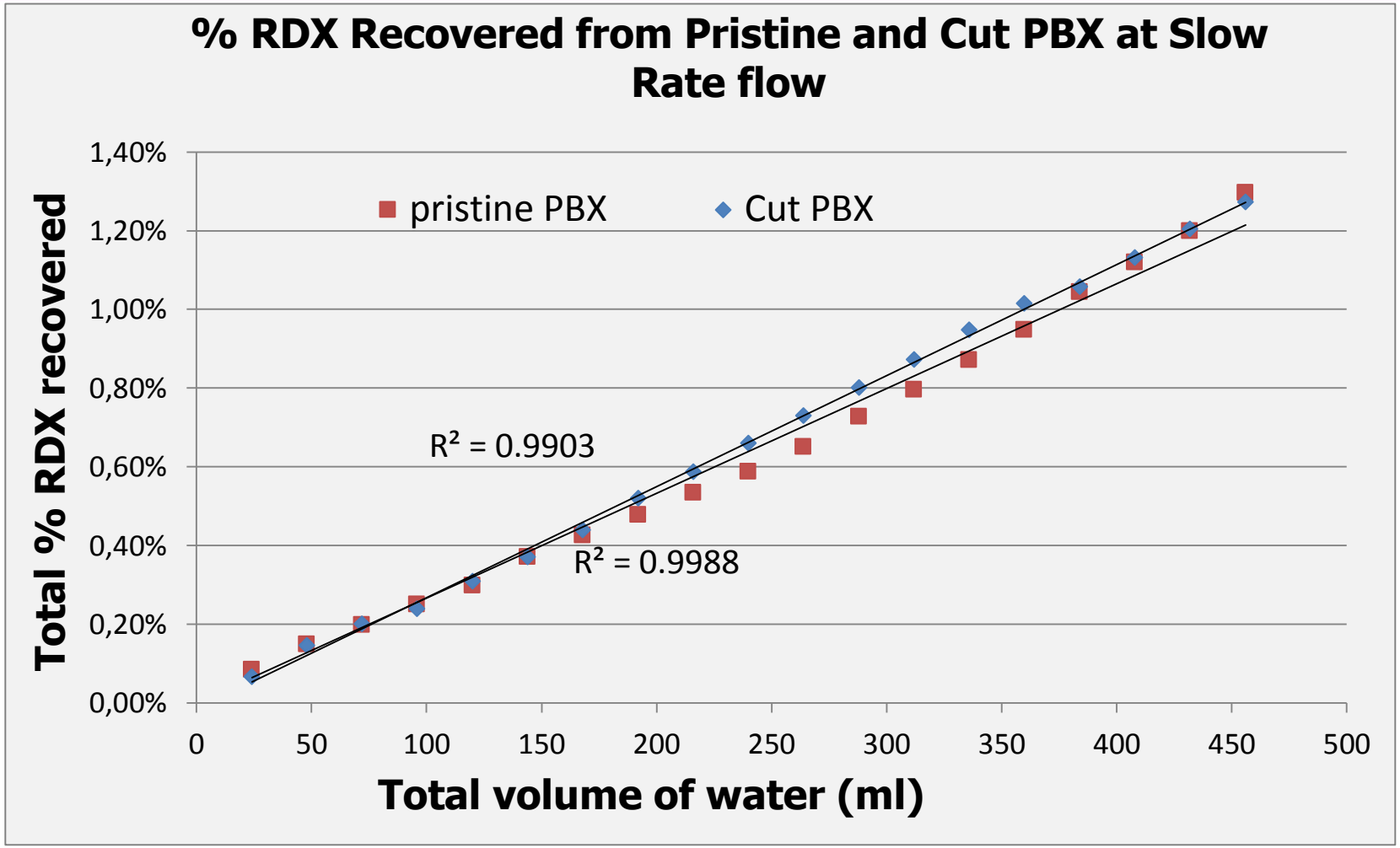
- Syringe pumps (25 ml syringe)
- Programmed flow rate 1 ml/h
- Approx 26 ± 2 drops/h
- 24 ml per day of distilled water
- Run 24 hrs a day Monday-Friday

High Flow Rate

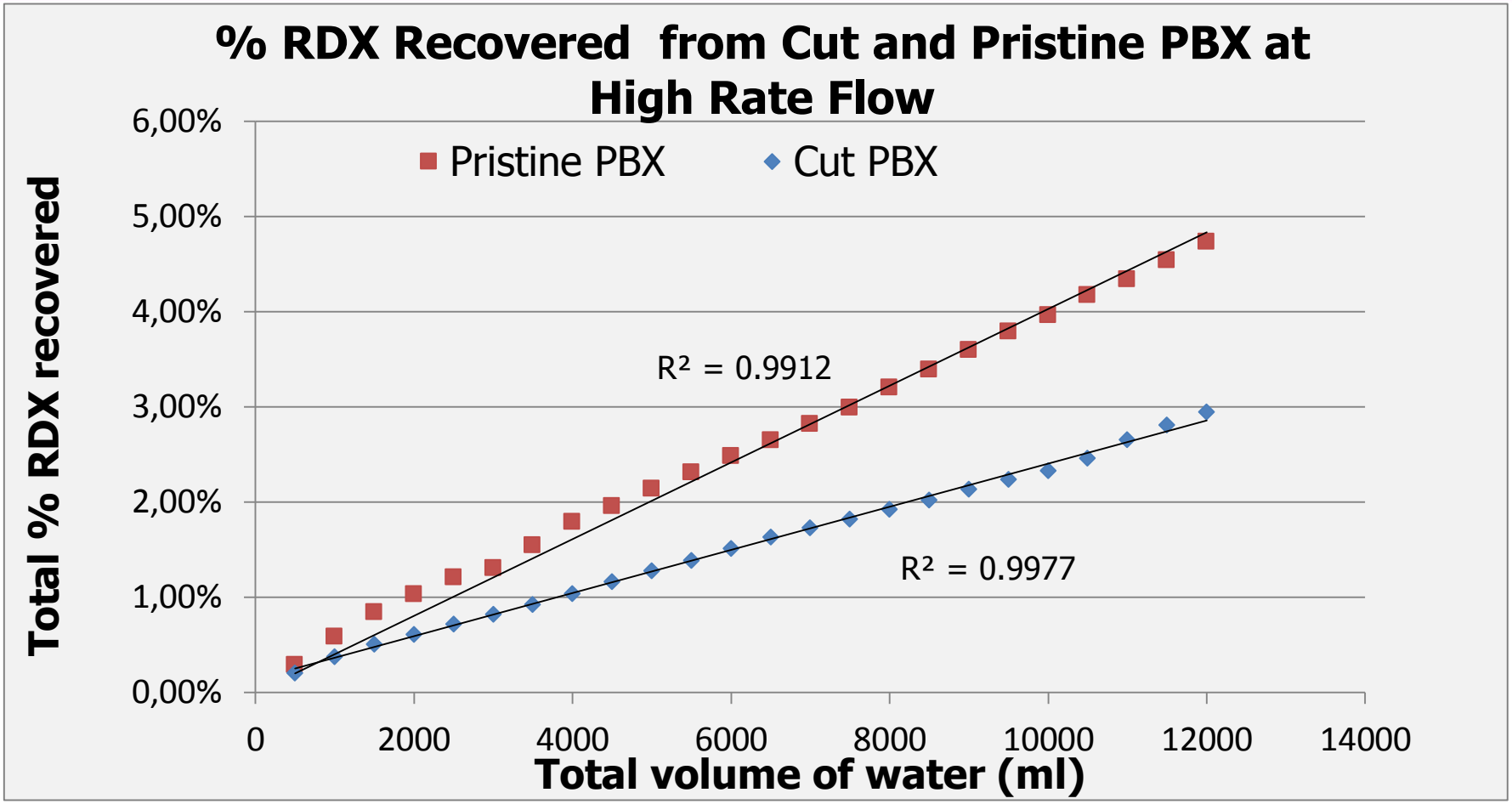
- Peristaltic pump
- Programmed flow rate 10 ml/min
- Approx 125 ± 2 drops/min
- 500 ml collected in 50 min



Laboratory Results – Slow Flow Rate

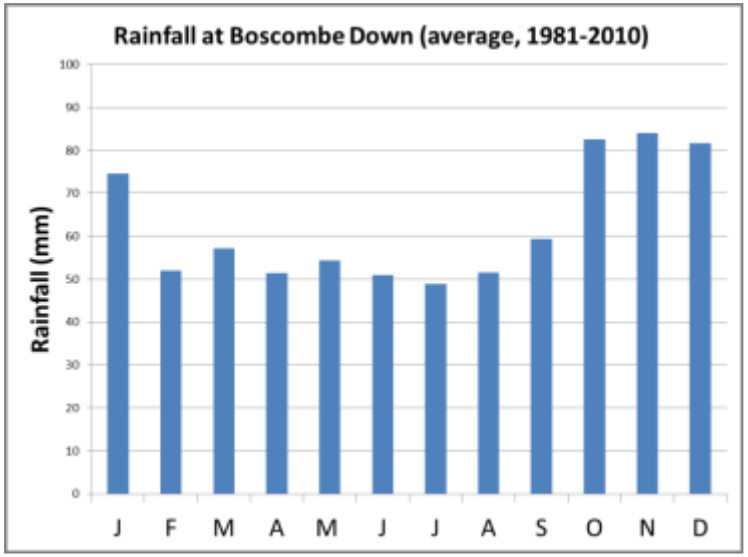


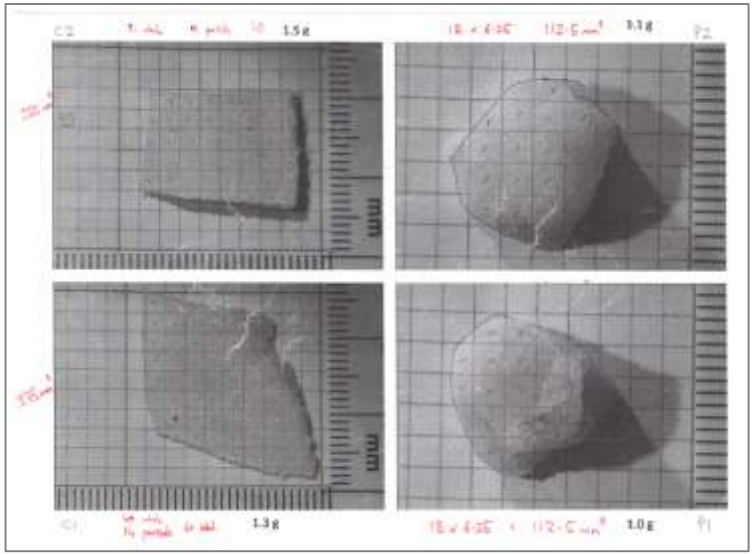
Laboratory Results – High Flow Rate



How does this equate to the real world?

- Met Office data from Boscombe Down on Salisbury Plain Training Area (SPTA) (average data 1981-2010)
  - Annual average 750 mm/year
- Normalised for size of sample
  - Area estimated from photos
- Volume dripped on to sample converted to rainfall depth





Data «normalised» to sample size

		Sample area (mm^2)	Rainfall (mm)	Years of rain	Extraction rate (%RDX/year)
Slow (1 ml/h)	C1	375.0	1216	1.62	0.783
	P1	112.5	4053	5.40	0.241
Fast (10 ml/min)	C2	250.0	48000	64	0.046
	P2	112.5	106667	142	0.033

- Observations:
  1. Extraction rate of «cut» samples faster than «pristine»
     - Exposed RDX crystals
  2. Extraction rate of the slow tests is an order of magnitude greater than in the fast tests
     - In the fast test, the droplets of water are not given chance to dissolve the RDX before being washed away

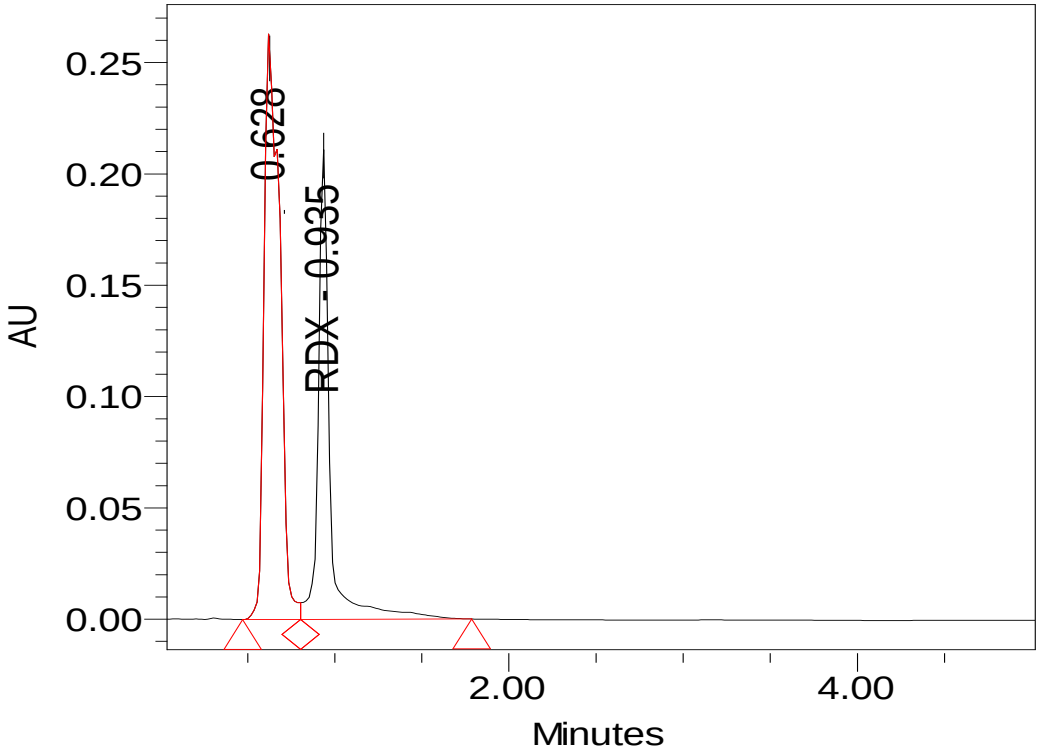
Analysis of Dissolution Test

- Binder did not completely prevent the RDX from leaching out of the PBX sample.
- Neglecting other factors such as acid rain, temperature, bacterial activities, we can predict the rate at which RDX will leached from a sample of PBX in a training range.

RDX Degradation in Aqueous Solution

- Geology of SPTA predominantly chalky soil
  - i.e. calcium carbonate – basic (soil pH ≈ 7.1 – 8.0)
- What effect does soil pH and UV light have on RDX degradation?
  - RDX degraded in saturated $CaCO_3$ solution (pH ≈ 8.3)
  - And under UV light
  - Control experiments conducted in pure water and in darkness

RDX Degradation in Aqueous Solution



- HPLC shows a new peak appearing at 0.63 minutes
  - We do not know what it is!

RDX Degradation in Aqueous Solution

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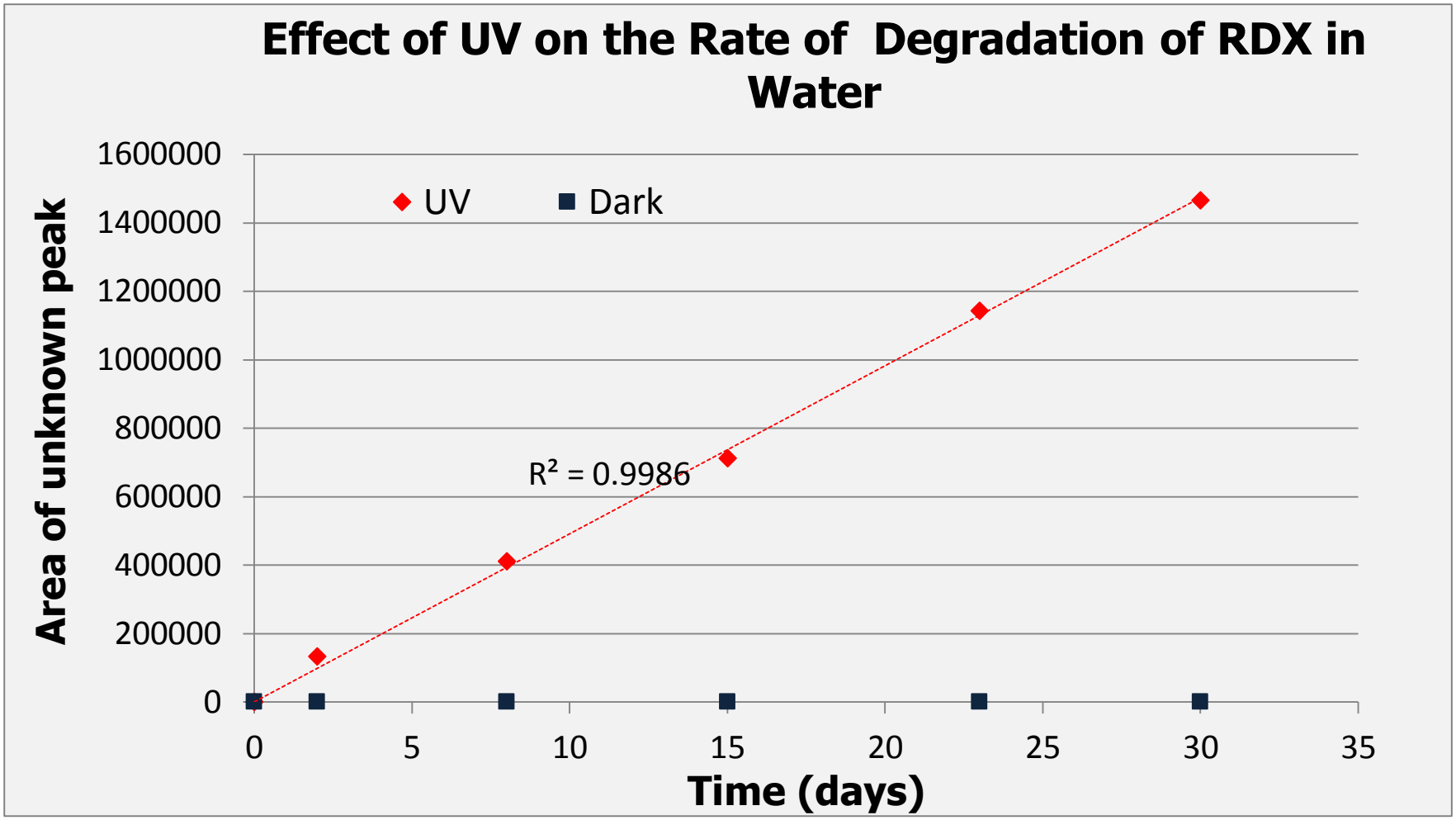

RDX Degradation in Aqueous Solution

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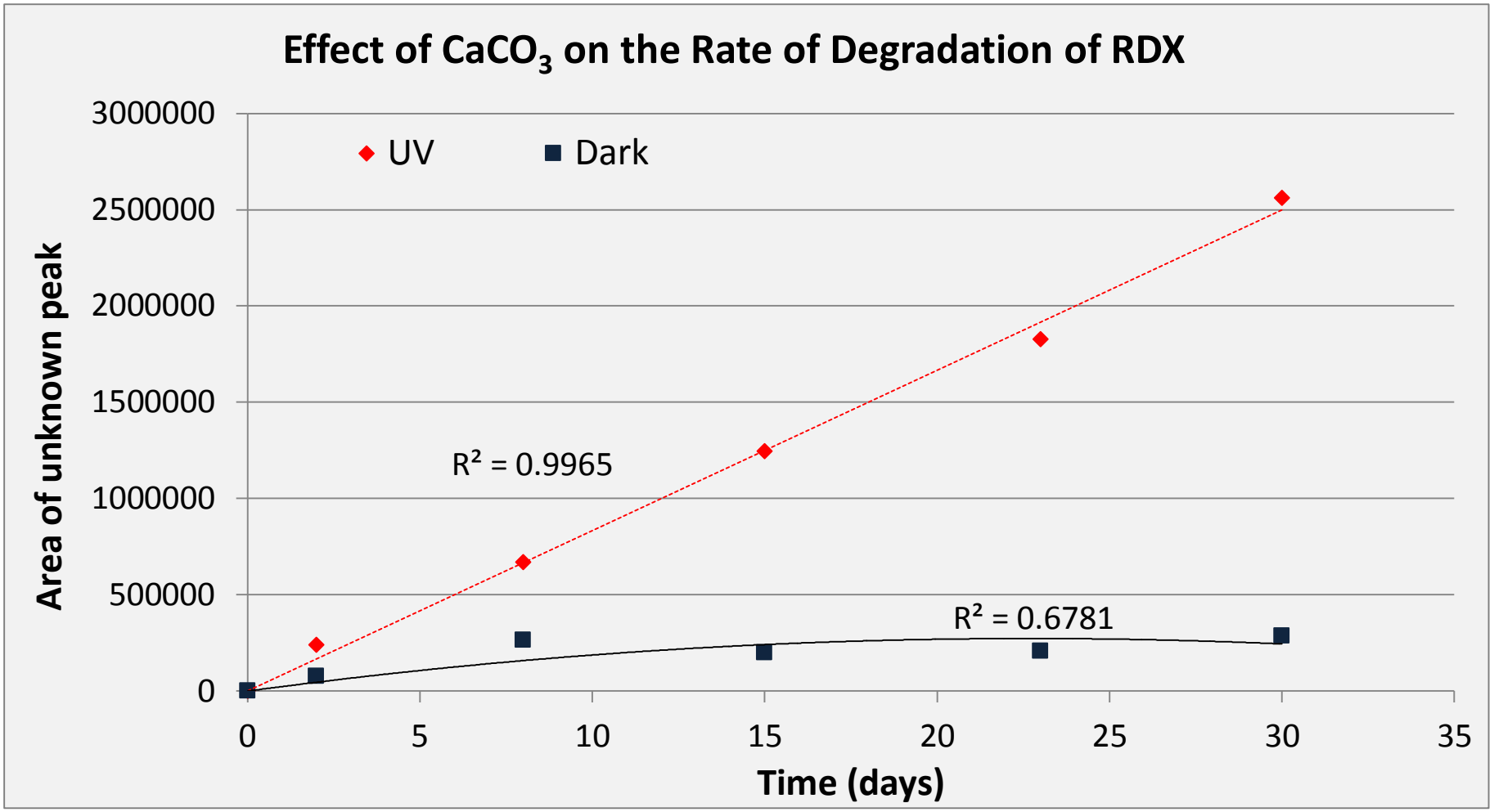

Overall Conclusion

	Pure water	Sat. aq. $CaCo_3$
Dark	No degradation	Some degradation, but very small effect
UV light	Degradation observed	Degradation rate 70% faster than UV alone

Overall Conclusions

- RDX will leach out of PBX particles deposited on military ranges
  - Extraction rates by rainfall into soil very low (< 1% per year)
- Neglecting other factors such as acid rain, temperature, bacterial activities, we can predict the rate at which RDX will be leached from PBX in a training range.

- UV photolytically degrades RDX
- Basic conditions accelerate this, by around 70%
- Once RDX leaches below surface level, we speculate *chemical* degradation very slight
- However, we do not know what the product of chemical degradation is
  - Is it harmful?
  - Does it biodegrade?

Current / future work

- Current MSc projects at Cranfield University are looking at:
  - Seasonal variations in degradation
  - Transportation rates of individual components of PBX through soil (soil columns)
  - Samples supplied by RWM Italia

- Correlation of lab experiment to «real world» results
- Experiments conducted on a rooftop at Cranfield over a period of 24 months
  - Awaiting results…
- Further lab tests are required – more replicates!
  - This study only used 1 each of cut and pristine at each flow rate
  - Concentrate on slow flow rates