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Managing Leakage to Ground from an Aging Nuclear Waste Storage Facility

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Overview

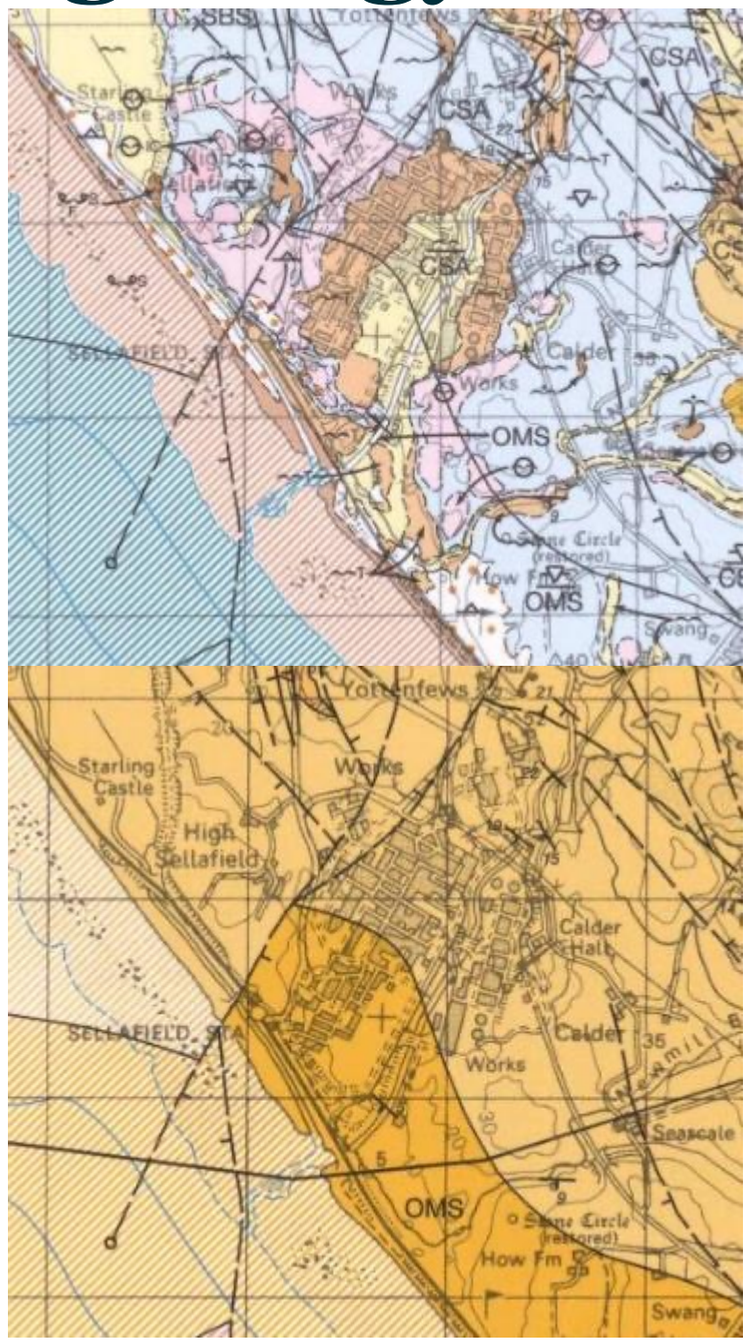
- Facility overview
  - Build and operations
  - Leakage – historical and current
  - Current status
- Leak management
  - Monitoring and characterisation
  - Monitoring enhancements
  - Mitigation options development

Site setting

- Coastal plain setting
- Cumbrian mountains rise from approx. 5km inland
- 80 years of development have significantly modified the site topography and ground cover

Sellafield geology & hydrogeology

- The site is underlain by a complex sequence of glacio-fluvial deposits, overlying Permo-Triassic age sandstone
- Depth to bedrock across site ranges between approx. -60m to 35m AOD
  - Approx. -20m AOD in the area of MSSS
- A number of faults are projected across the site footprint
- Multiple discrete groundwater units
  - Multiple flow directions
  - Complex contamination distribution



Geological Survey of England and Wales 1:50,000 geological map series, New Series. Sheet 37, Gosforth, Solid & Drift. 1999.
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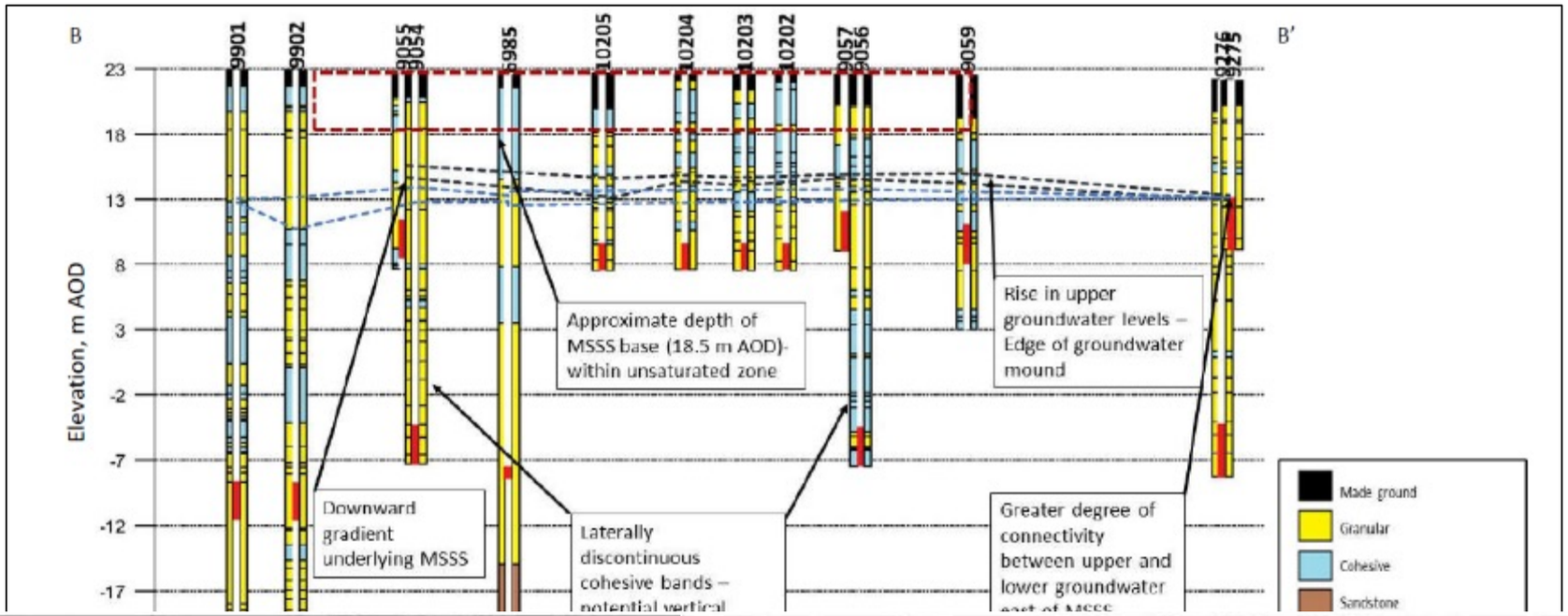
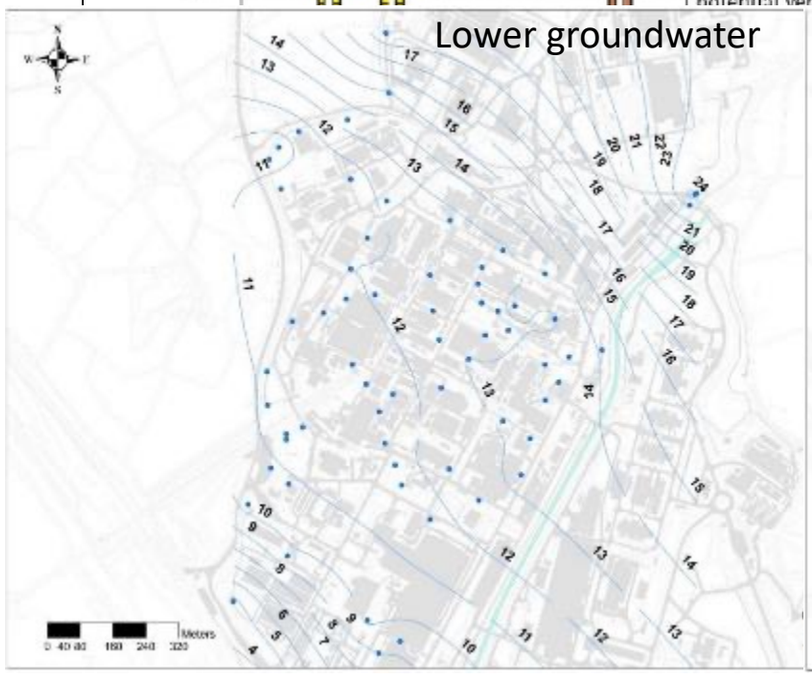
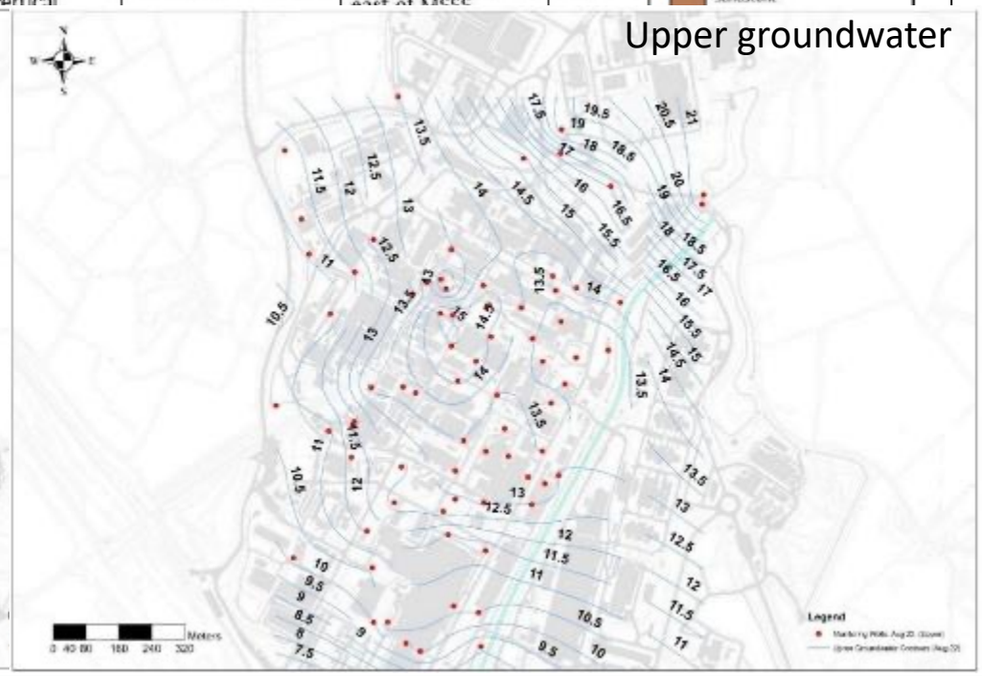
MSSS Geology

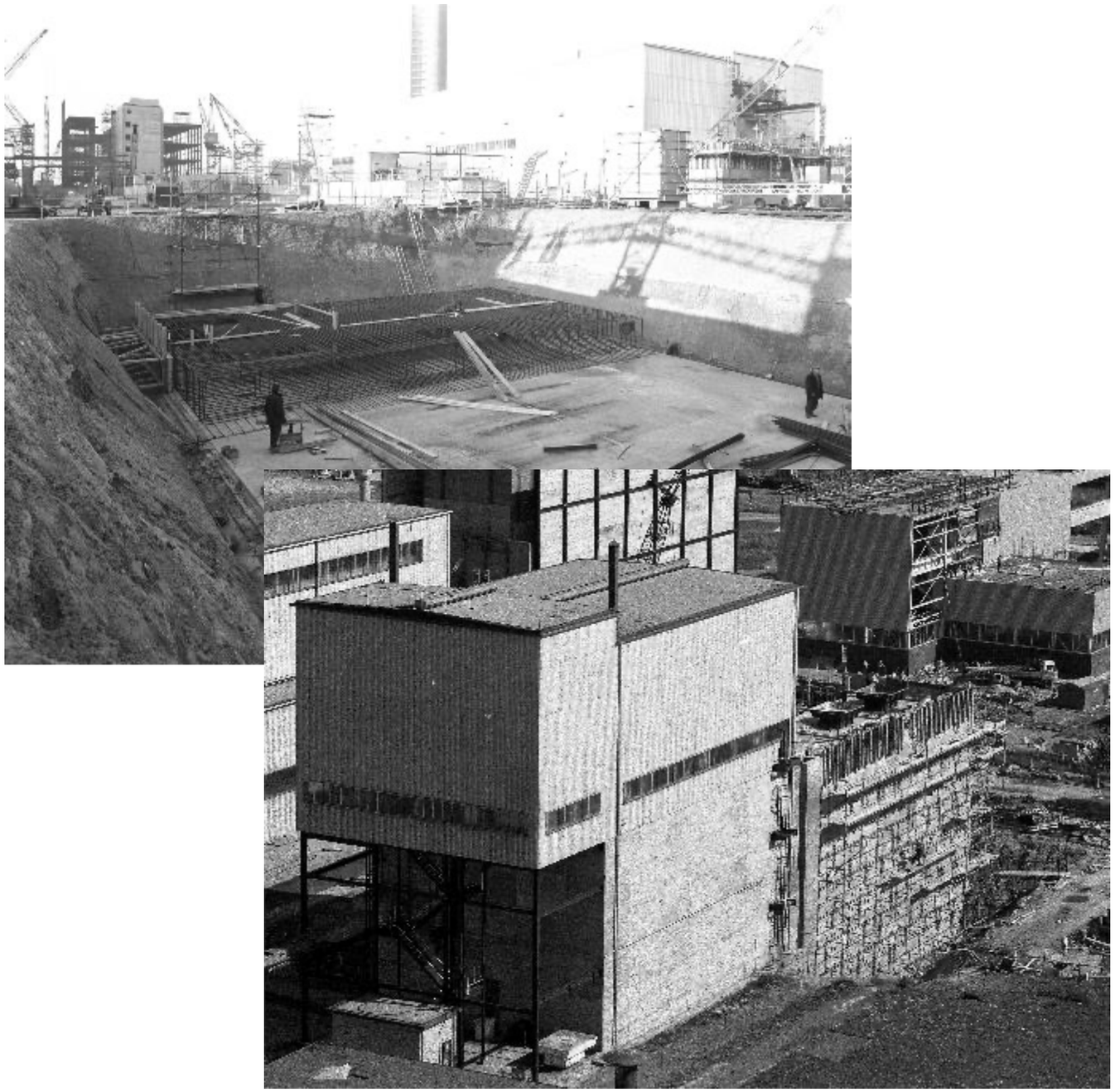
- Complex geology in the MSSS area
- Variable depth to bedrock
- Heterogenous superficial deposits
- Multiple groundwater bodies and flow directions





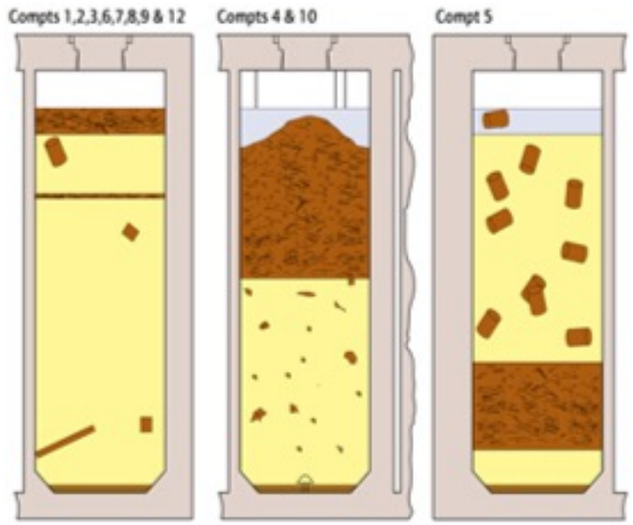


MSSS history



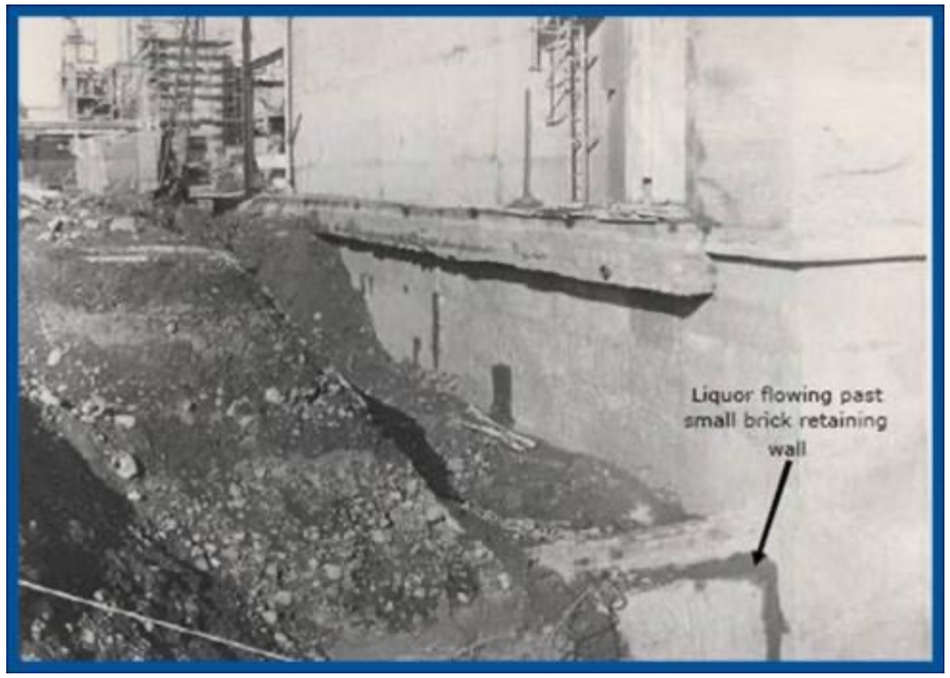
Construction started in the early 1960's:

- Original building – six compartments – primary containment only
- Three extensions, with progressive improvements in containment
- Wet storage of Magnox fuel swarf
- Some miscellaneous β/γ wastes also stored



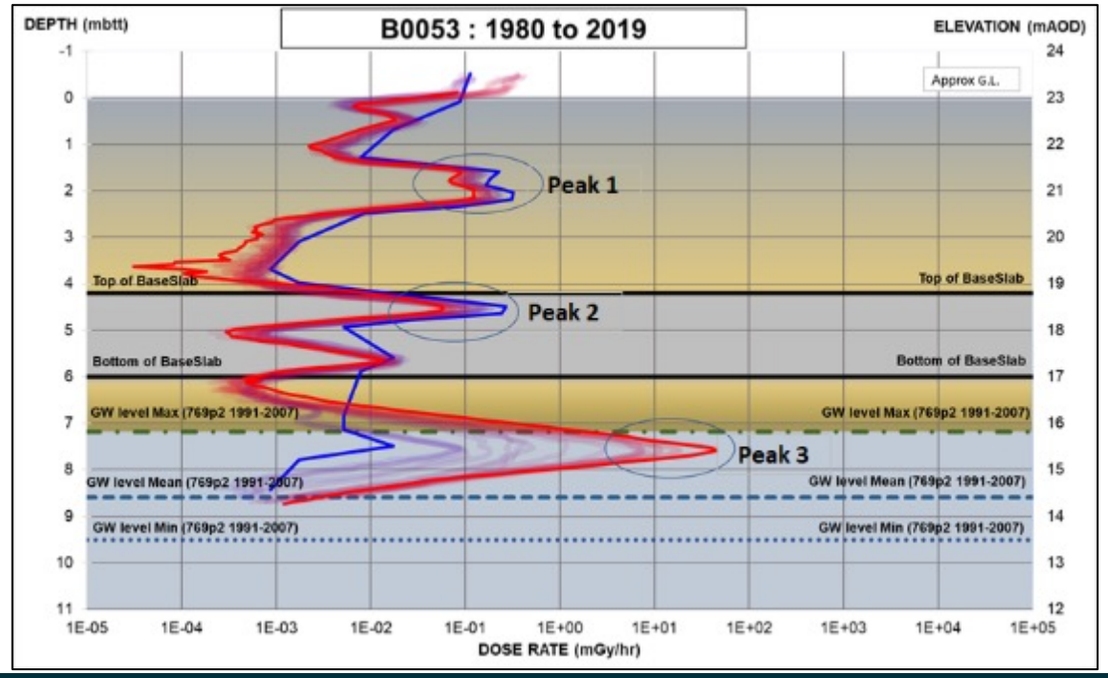
Historical leakage

- Exothermic reactions of swarf with water occurred in silo and damaged the original building
- Below ground leakage discovered during construction of the first extension
- Largest loss of radiological contam. to ground in UK
- Alkaline chemistry (pH ~10.2)
- Leakage dropped below detectable rate, without intervention, around 1980



Leak monitoring and assessment

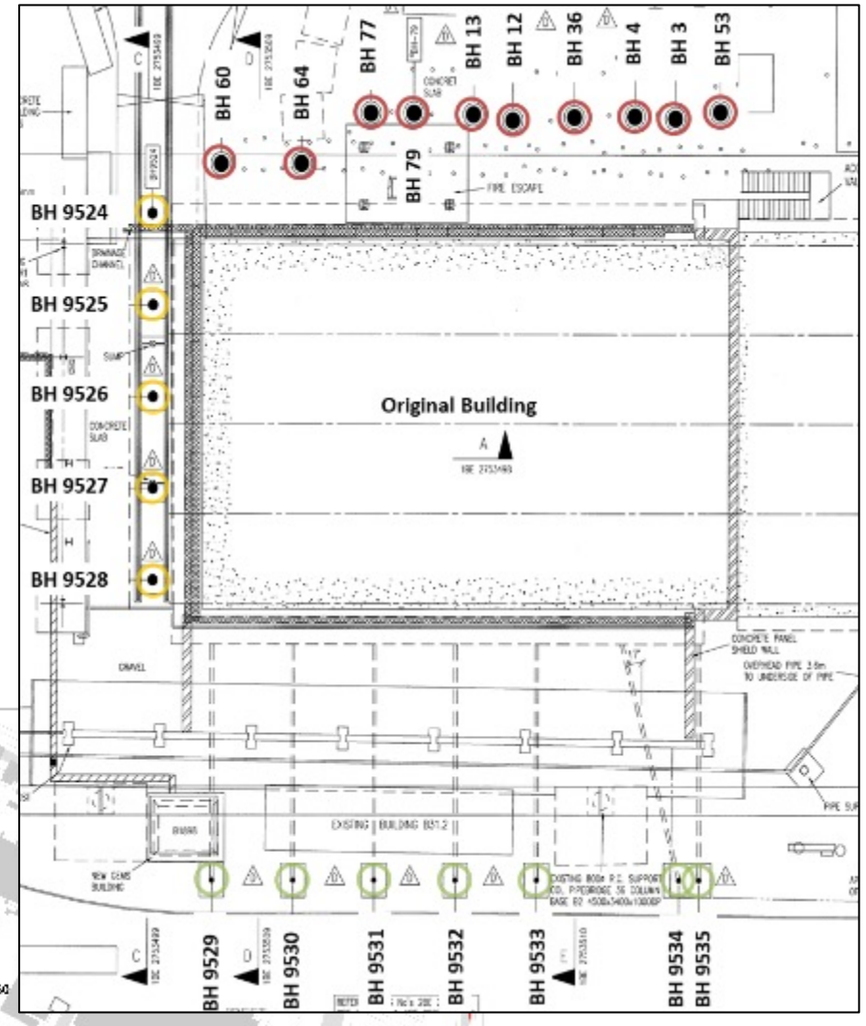
- Limited contemporaneous monitoring
- Lots of assessment undertaken post-leak
  - Estimated 3 m^3/day leak rate
  - Inventory dominated (95%) by Cs-137
  - Significant Sr-90 component
- Progressive improvements to ground monitoring up to 2010's
- Numerous assessments of environmental impact suggest limited off-site risk

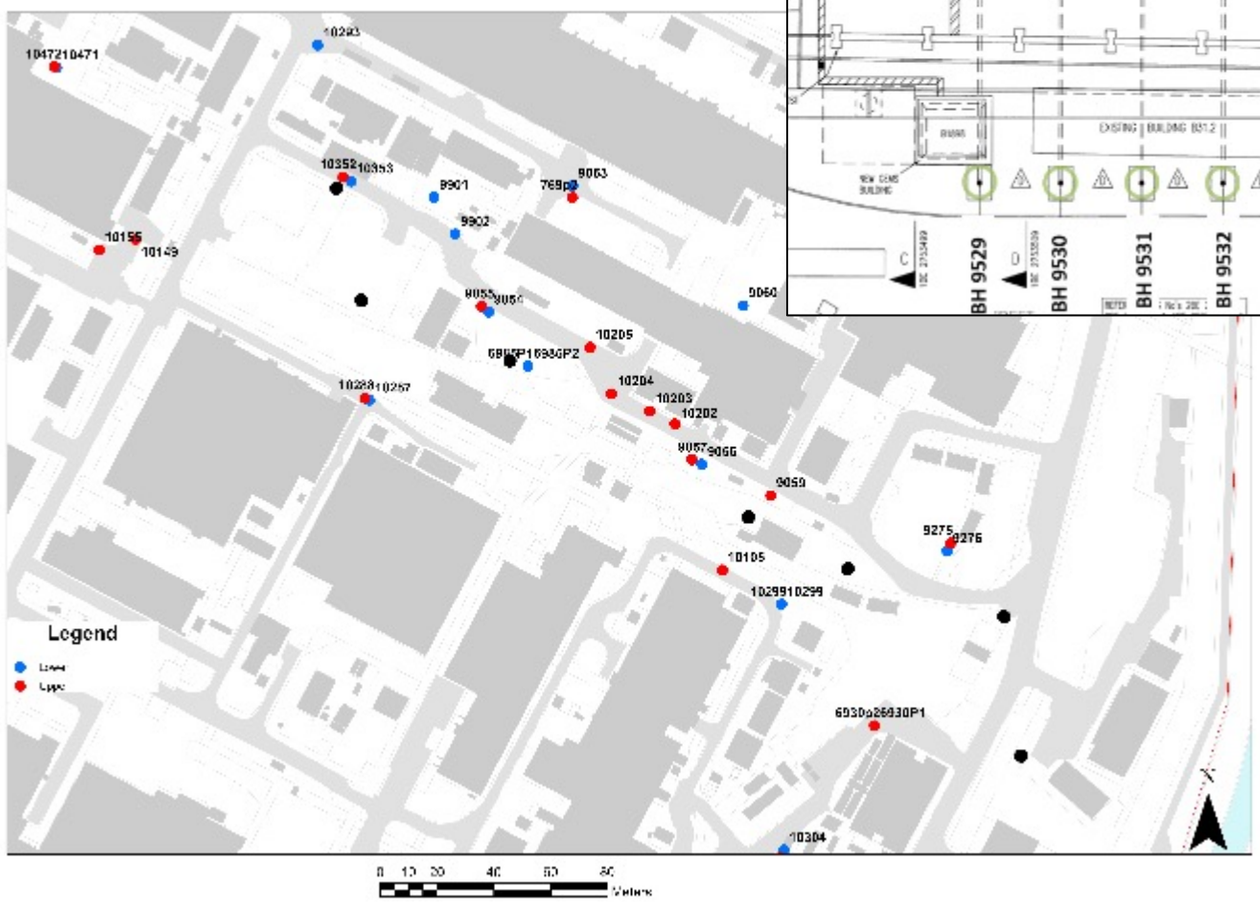


Current Leakage

- Leak declared in November 2019
- Leak rate progressively increased to approx. 2.5 m^3/day – broadly stable at this rate for around three years
- Enhanced monitoring commenced upon declaration of leakage, in line with agreed plans

Post-leak blind tube monitoring



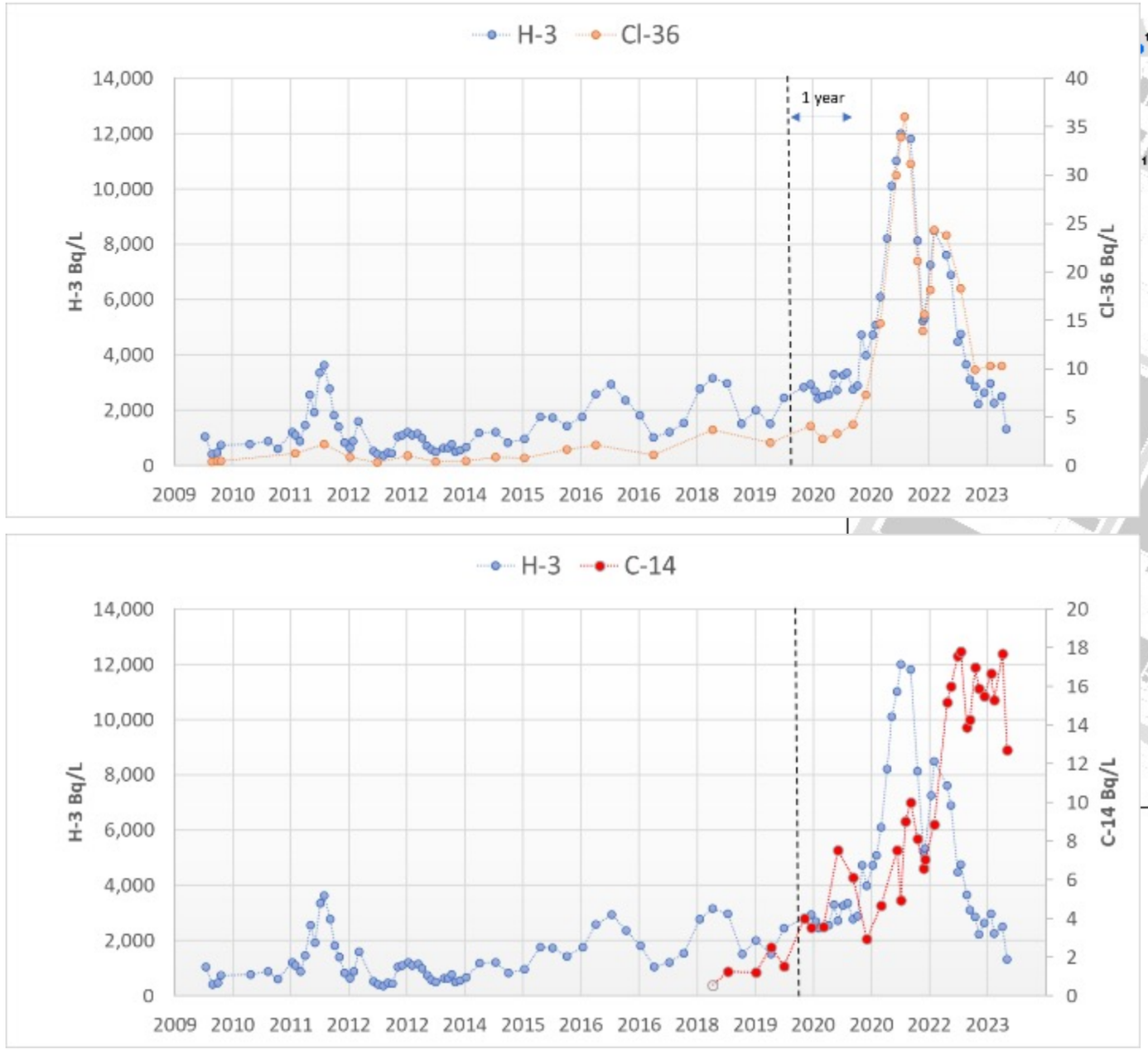


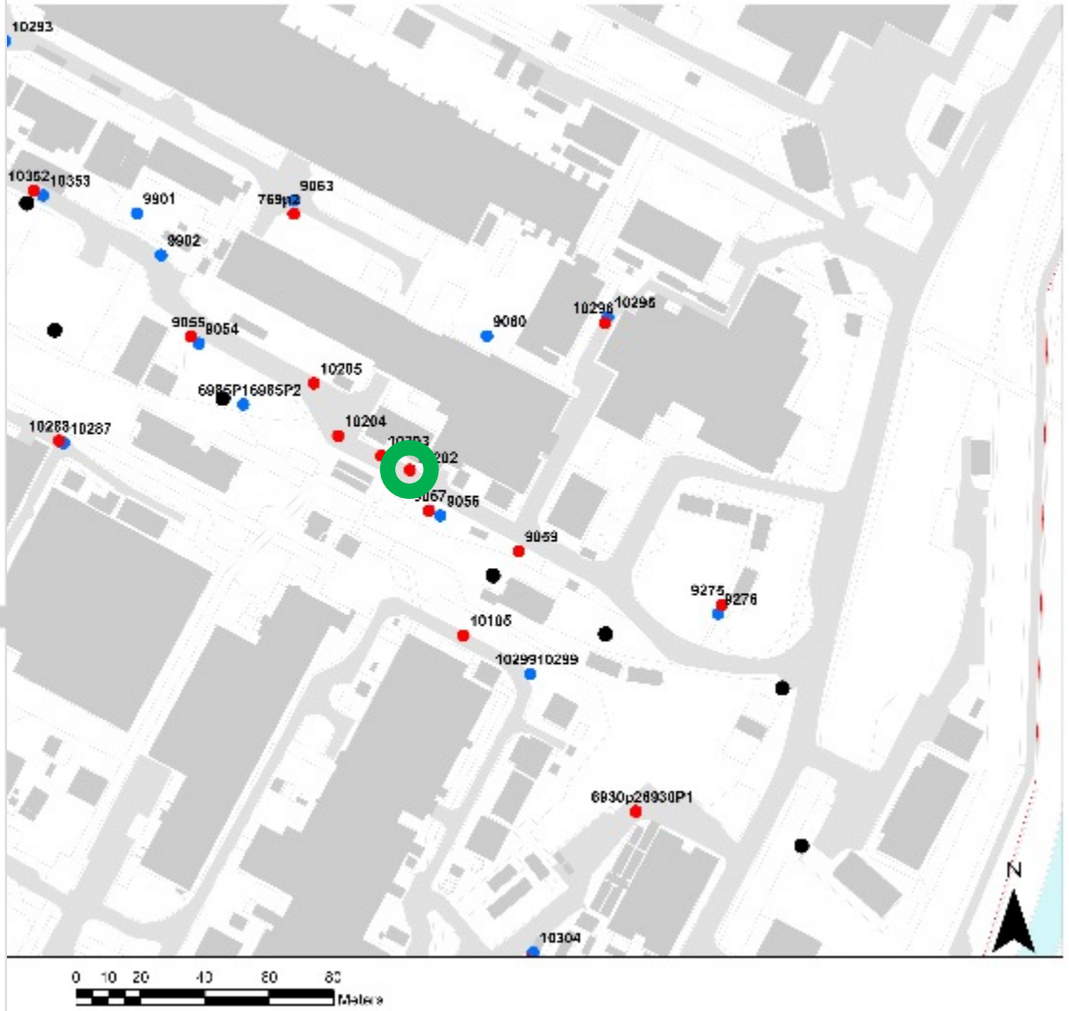
Post-leak groundwater monitoring

Current leakage

- Limited information on leak location, but some clues
  - Evidence from blind tube monitoring
  - ERT trial works (imaging and Mise-a-la-Masse)
- Migration may be influenced by in-ground features

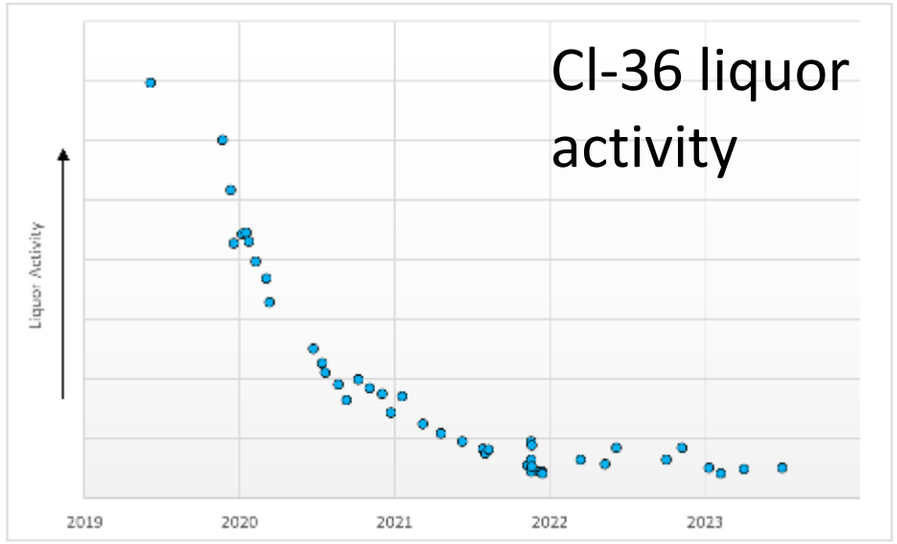
Groundwater monitoring





Groundwater monitoring

- ‘Slug’ of initial activity followed by decline – top-up = leak rate
- Gross Beta (Sr-90) trends show a relationship to ionic strength
- Plume ‘slug’ corresponds with increase in ionic strength
    - Ion-exchange perturbations during migration of plume

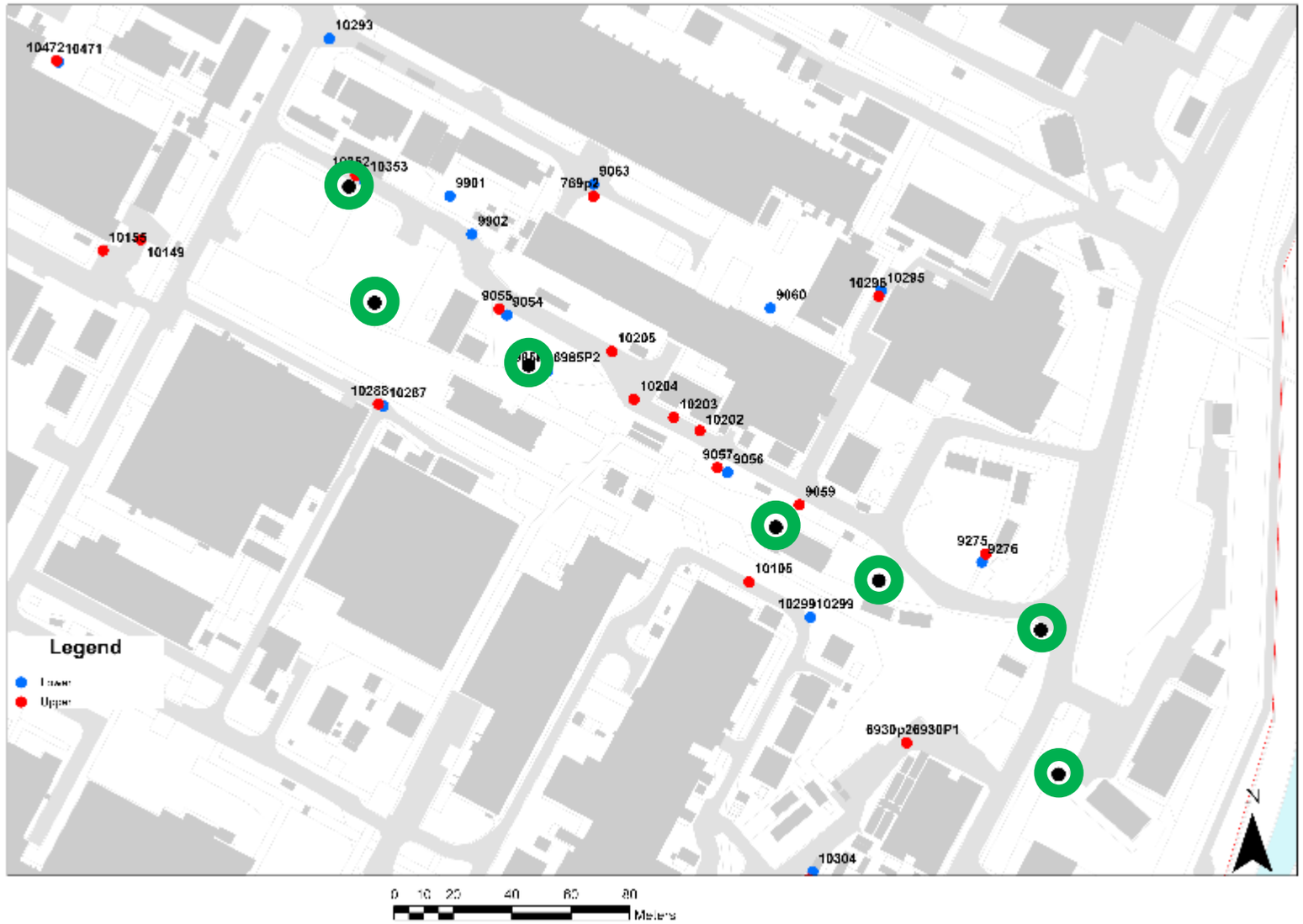


Regulatory action

- Regulation by the Office of Nuclear Regulation (ONR) and Environment Agency (EA)
  - Leakage was recognised as a possibility – work over the last 10+ years in anticipation of this event
  - Agreed action plans (Leak to Ground Risk Management Plan) implemented
- Formal actions placed on Sellafield Ltd by both ONR and EA, covering:
  - On-plant and in-ground monitoring
  - On-plant and in-ground leak mitigation
- Work underway to deliver against commitments made

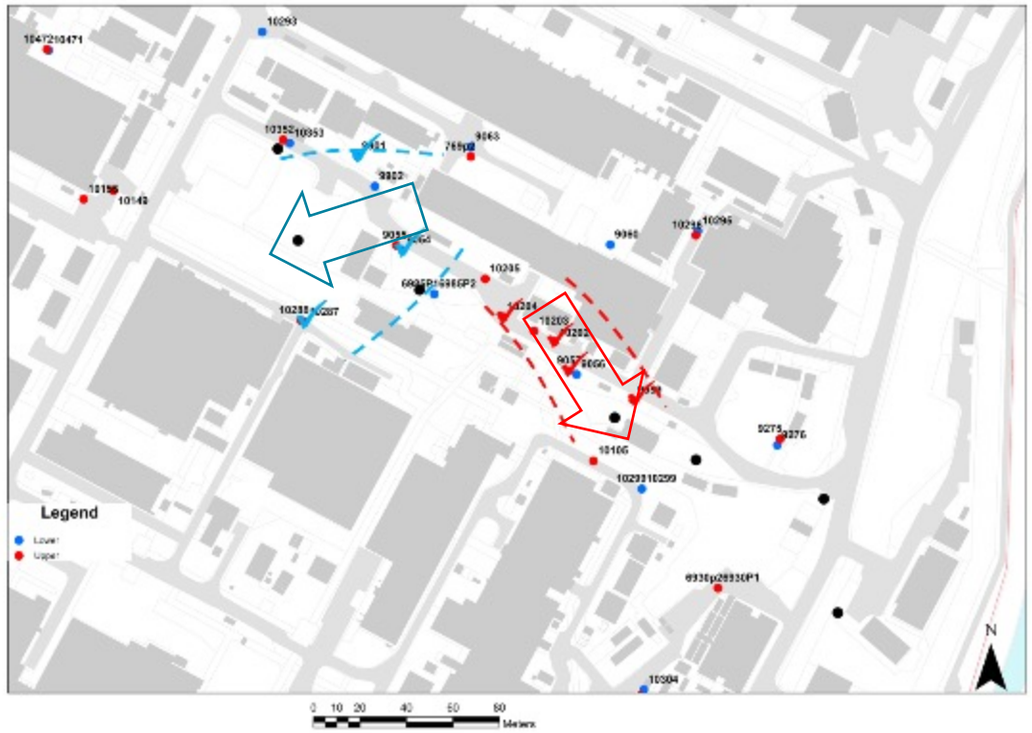
In-ground monitoring

- DQO assessment of current groundwater monitoring arrangements
- Generally good coverage but gaps identified
- Seven new groundwater monitoring wells to be installed south of the building



Multi-level wells

- Complex hydrogeology and distinct groundwater plumes (upper and lower groundwater)
- Improved vertical resolution considered important
- Better head data is likely to provide important insights on mechanisms driving migration to depth
- Technology selection process undertaken
  - Considered Solinst CMT
  - Decided on Solinst G360



Solinst®

CMT Multilevel
Continuous Multichannel Tubing

CMT

Solinst®
G360MPS
(NEW)

Images courtesy of Solinst Inc.

G360 System

- Advantages over Solinst CMT system
  - More configuration options, including larger standpipe diameters – important for large sample volumes (i.e. C-14, Cl-36 etc.)
  - Port failures considered less likely
- However, new system to the UK – no prior experience
  - Trial works undertaken

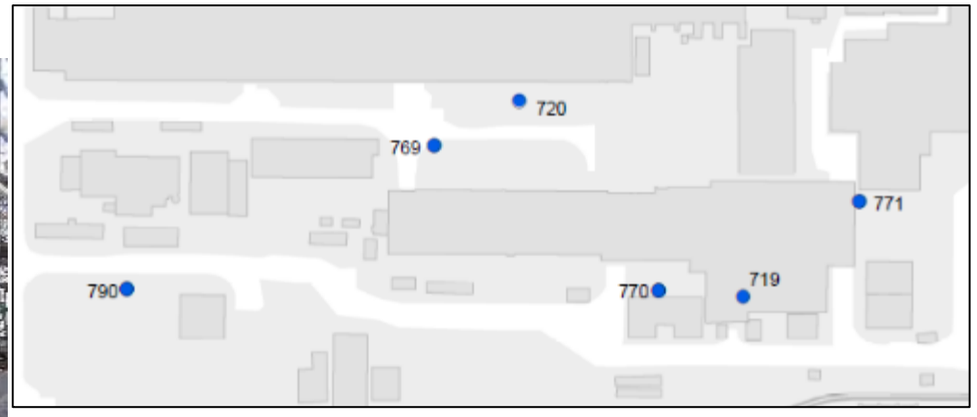



Well installation

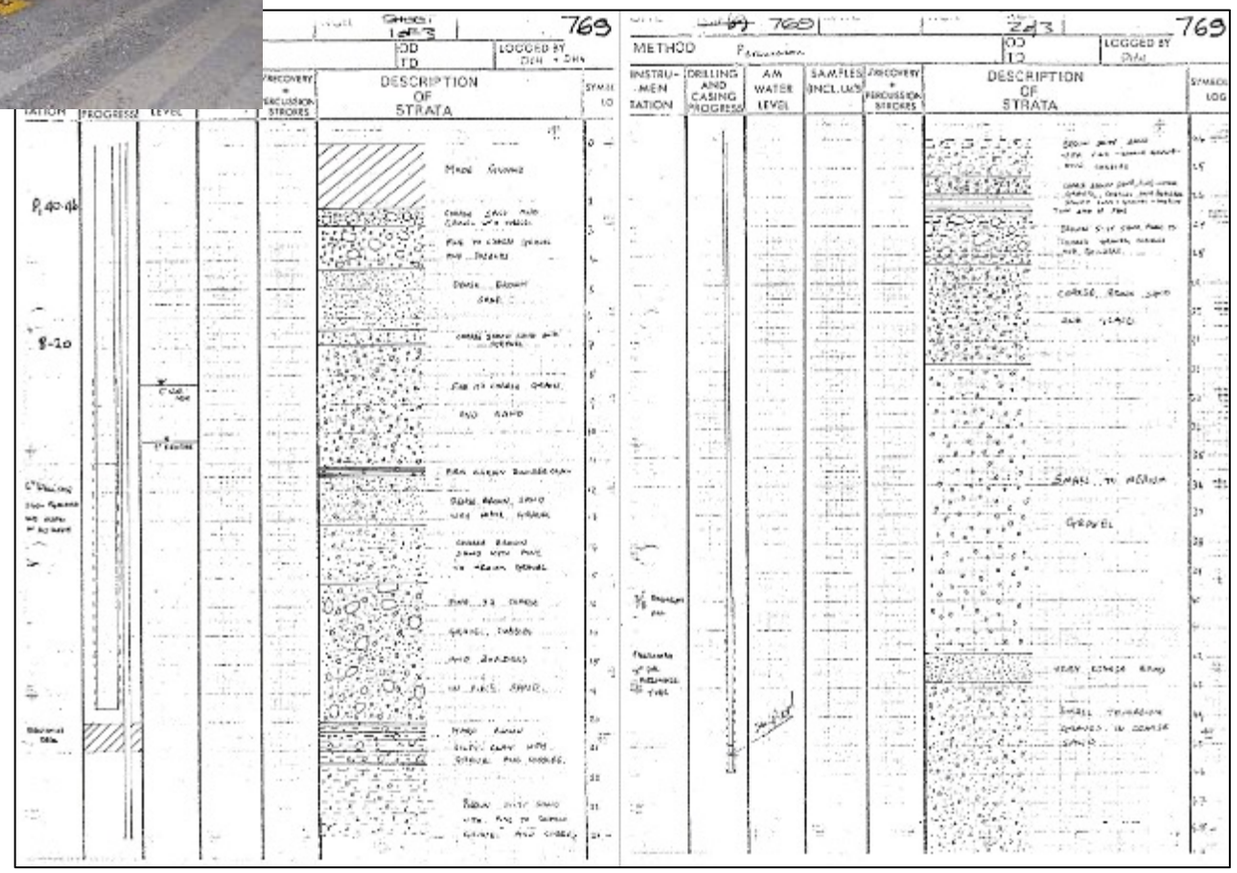
- Drilling underway, but lots of challenges

Well decommissioning

- Numerous old wells that need to be decommissioned
  - Problematic construction
  - Problematic locations – difficult access
- Trial works planned
  - Casing perforation and grouting



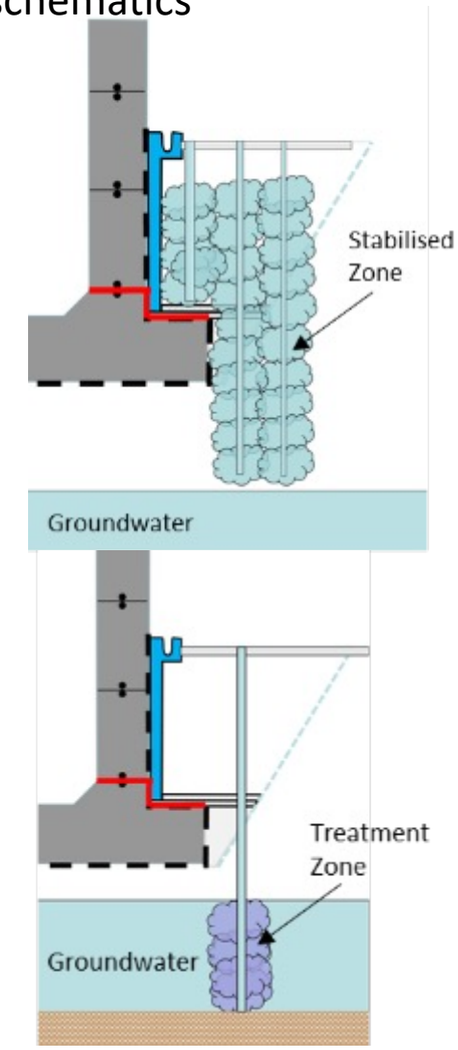
Mills Knife Perforator - Mills Machine Company Inc.



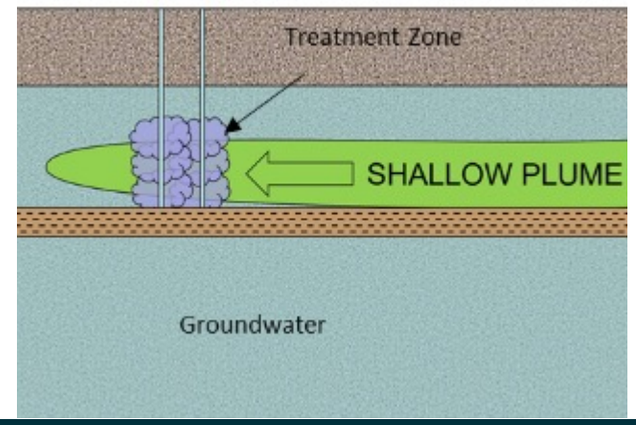
In-ground mitigation

- Work done over last 15 years looked at developing credible mitigation options.
- Post-leak studies revisited much of this work
  - Some change in options considered credible (P&T removed)
  - Sellafield Ltd decision making process (“can we”, “should we”) followed
- Main options to take forward
  - in-ground chemical barriers
    - Near silo
    - In plume
- Deep plume intervention under review – not considered likely to be credible

In-ground, near silo scheme schematics



In-ground, in-plume scheme schematics



In-ground mitigation

- Lots of constraints
  - Near silo
    - High dose
    - Limited space
    - Plant operations
  - In-plume
    - Heterogenous geology / hydrogeology
    - Buried infrastructure
    - Rail lines
- Further characterisation and trials proposed – on and off site
- Trial work commencing next month

Summary

- MSSS is located in an area of complex geology and hydrogeology
- Leak history and migration is complex – current leak offering valuable insights
- Much work undertaken in anticipation of leakage
- Understandable regulatory concern and scrutiny
    - Improvements to in-ground monitoring underway
    - On-going development of credible in-ground mitigation options
- Highly complex local built environment
    - Constrains what work can be done
    - Adds time and cost

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