

SCLF Annual Conference 2024

Challenges of complex NAPL characterisation and developing a remediation strategy within condensed development timescales

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Overview

- Site details, proposed development and key dates
- Hydrogeological CSM and data gaps
- Additional investigations to resolve key uncertainties
- NAPL lines of evidence
- Remediation strategy
- Key learning points
- Questions





Proposed development

- Majority of structures in 'undeveloped' area of site
- Piled building foundations
- Concrete apron
- Attenuation pond (impermeable)
- Cut and fill majority of made ground removed
- Planning condition relating to contaminated land investigation, assessment, remediation and verification



RSK Commissioning & Key Dates

- Pre-September 2023: third party SI's commissioned which indicated presence of hydrocarbon contaminants that could present controlled waters risk but unable to satisfactorily address EA concerns
- September 2023: RSK commissioned to assist with resolution of planning conditions. Principal contractor on site completing enabling works (cut/fill and piling mat installation).
- September November 2023: RSK developed controlled waters CSM, designed and supervised supplementary SI, groundwater sampling rounds and interpreted data. LNAPL detected.
- December 2023: Issue of Phase 2 Geo-environmental Interpretive Report, Stage 2 Options Appraisal and Remediation Strategy and Piling Work Risk Assessment. Data gaps identified and piling within northern most boiler house (Zone 3) sterilsed
- 14 December 2023: EA approved pre-commencement planning conditions funding released
- 19 December 2023 22 January 2024: piling completed in all areas except Zone 3
- December 2023 January 2024: design and supervision of additional SI
- February 2024: Issue of supplementary SI interpretive report and updated Stage 2 Options Appraisal and Remediation Strategy and PWRA for Zone 3.
- 28 February 2024: EA approved reports piling in Zone 3 commenced
- March onwards: Design of remediation system, long term groundwater monitoring

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Hydrogeological Conceptual Site Model

Potential contaminant sources

On-Site Sources

Hydrocarbons observed and concentrations detected in unsaturared and saturated zone soils

- Light non aqueous phase product (LNAPL)
- (3) Hydrocarbon concentrations detected in shallow groundwater



- RCL1: dissolution of **NAPL** to shallow groundwater within the granular Till at TP205s and potentially extending to BH7 and BH9
- RCL2: migration of dissolved phase contaminants (hydrocarbons) within shallow groundwater at TP205s (associated with NAPL source) to depth to the principal bedrock aquifer and associated possible abstractions
- RCL3: inhalation exposure of future on and off-site users to vapour from groundwater at TP205s associated with NAPL source

Made ground

Granular Till

- 2 - Geology inferred

Fell Sandstone Group

_____ Groundwater elevation in Till

Driven steel pile

- T- Groundwater elevation in bedrock (inferred)

Hvdrocarbon contamination observation in soils

Light non aqueous phase liquid (LNAPL)



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Key risk areas and uncertainties



Uncertainties:

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- Extent, mobility and chemistry of NAPL source
- Presence of unsaturated soil source
 - Thickness/effectiveness of intermediary cohesive clay layer in providing a barrier to vertical migration
- Limited SI coverage in area of boilers
- Limited groundwater sampling



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Additional site investigations completed







Ground conditions (north – south)











Ground conditions (west – east)





Ground conditions – granular till distribution



Intermediary granular Till layer present >1 m thickness

Intermediary granular Till layer absent or <1 m thickness





Observations of contamination during investigation and monitoring





Observations of contamination typically restricted to the shallow granular till horizon and correlate with presence of groundwater

Correlates with soil testing results indicating hydrocarbon impacts are limited to saturated zone



Direct and indirect evidence for LNAPL

Groundwater monitoring - 5 rounds (Dec-Feb), measured LNAPL thickness

- BH301: 0.3-13.1 cm, mean 3.0 cm
- TP205s: 0.2-0.3 cm

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BH302: 0.1-0.3 cm, <0.01 since 15/01

PID > 500 ppm during GWM:

BH301, TP205s only; area reducing over GWM1-3



[Source: Lahvis et al, 2013: Direct and Indirect Indicators of Residual-Phase LNAPL]





PID spatial plots

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Groundwater lab data >10% pure phase solubility & NAPL based effective solubility (BH301 sample):

BH302, BH305 (R1 only), BH306, BH307

Groundwater lab data benzene >3 mg/l, BTEX >20 mg/l:

BH302, BH305 (R1 and R3)

[Source: Lahvis et al, 2013: Direct and Indirect Indicators of Residual-Phase LNAPL]





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TPH Concentration Profiles in Groundwater Samples



- BH301 LNAPL sample range of aliphatic and aromatic dominated by >C5-C10
- Groundwater samples poorly correlated with LNAPL sample dominated by the most mobile and soluble light aliphatic and aromatic fractions
- Evidence of a moving front of dissolved phase impact
- NAPL does not extend beneath boiler house 1



TPH Ali and Aro >C5-C10 groundwater concentration spatial plots











- RCL1: Dissolution of NAPL to shallow groundwater within the shallow granular Till at BH301 and TP205s (direct evidence).
 Potentially extending to BH302, BH306 and BH307 (indirect evidence).
- RCL2: Migration of dissolved phase contaminants associated with NAPL source across wider area
- RCL3: Inhalation exposure of future on and off-site users to vapour from groundwater at BH301/TP205s and BH302 associated with **NAPL** source



Remediation strategy

- Objective: NAPL source removal which will have corresponding improvement on groundwater quality (betterment)
- Remediation criteria: no measurable thickness (<1 mm) and/or contaminant mass removal from all phases reaches asymptotic condition
- Selected remediation option: multiphase vacuum extraction (MPVE) will remove source and consider both NAPL, dissolved and vapour phases given predominance of petrol range hydrocarbons
- Other considerations: borehole decommissioning; piling work risk assessment and long term monitoring; materials management; watching brief during deep drainage excavations; validation of gas membrane in buildings; validation of attenuation pond membrane, etc.



Key learning points

- Assumptions are just that!
- Good site characterisation and conceptualisation is key to success
- Power of the line of evidence approach
- Regulator engagement







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