Application of optimisation to define the decommissioning end state for a UK nuclear power station site

IGD-TP Symposium
"The role of optimisation in radioactive waste geological disposal programmes"

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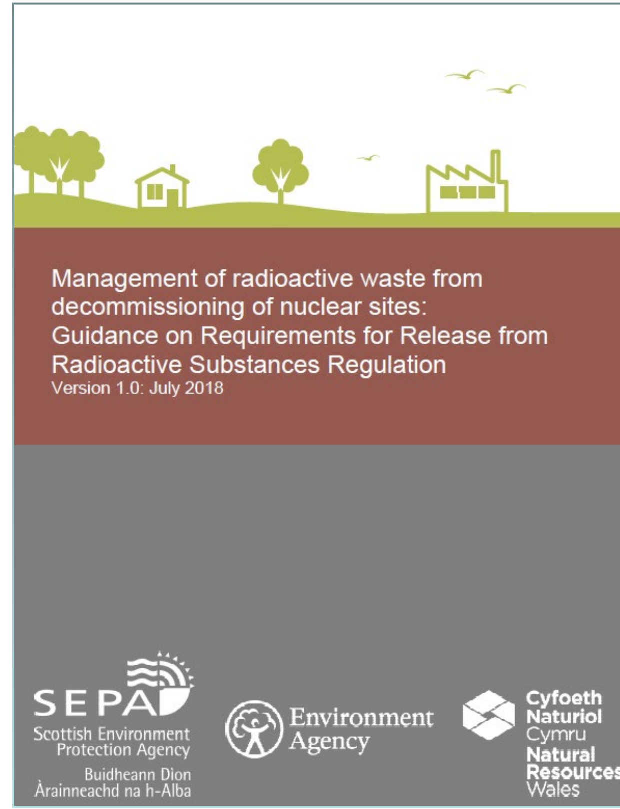
Context

- The UK **Nuclear Decommissioning Authority** (NDA) owns 17 nuclear sites including their assets and liabilities
- Includes 11 **Magnox** reactor sites
- **Trawsfynydd site** in North Wales - example site for this presentation
- **Galson Sciences Ltd** supporting Magnox Ltd in addressing new regulatory requirements relevant to End States of decommissioning & release from regulatory control

The 'GRR'



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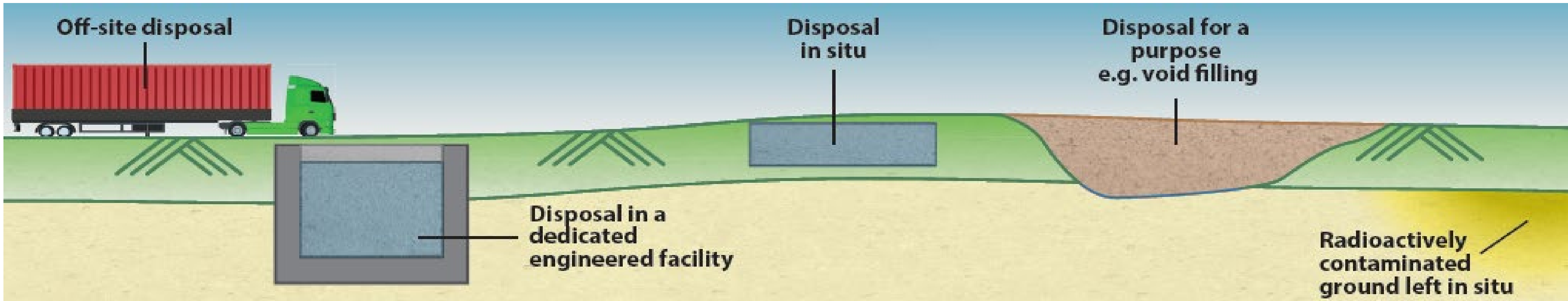
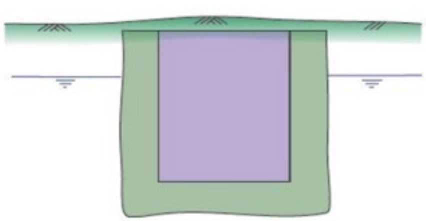
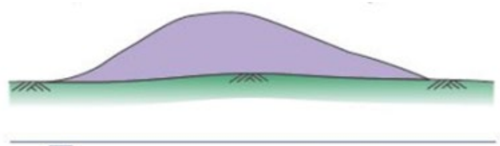
Options for disposal of high-volume low-activity decommissioning waste



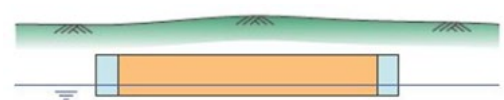
(Not waste unless dug up)

Radioactive waste disposal for filling an existing structure





Radioactive waste disposal for screening bund



Radioactive waste disposed of *in situ* with engineered closure

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Central propositions

- If large volumes of low-activity radioactive structures and/or contaminated ground are present on a site, the optimised End State of decommissioning may include some radioactivity remaining on-site
  - Unless overriding considerations require a ‘clean’ End State
- A ‘**Starting Case End State**’ can serve two main purposes:
  - As a basis for comparison with delivering a ‘clean’ End State
  - As a starting point for **optimisation**, if the envisaged End State is to include some radioactivity remaining on-site
- Using a Starting Case End State makes the process of optimisation **systematic**, **transparent**, **comprehensive** and as **simple** as possible

What is a Starting Case End State?

- Magnox Ltd definition: "*A starting point for optimisation of the End State of a site or zone, defining a conceptual End State configuration that includes radioactive features considered to be* ***credible candidates*** *for remaining after release from regulation*."
- The concept only applies if the envisaged End State could potentially include some radioactivity remaining on-site
- It is not a preferred End State
- "Credible candidate" radioactive features included in the Starting Case End State will typically be large in volume and low in levels (Bq/g) and amounts (Bq) of radioactivity

Methodology: Starting Case End State (SCES) used in ‘GRR’ two-stage optimisation process

- To address GRR Requirement R1: “Optimisation of [radioactive] waste management options” *(including whether on-site disposal is optimal)*
  - Define SCES
  - Assess impacts of SCES (without mitigations)
  - Assessment results inform strategic options assessment (which compares implementing SCES with ‘clean’ End State)
- To address GRR Requirement R13: “Optimisation of on-site disposals” *(if such disposals are the outcome of R1)*
  - Explore effectiveness of potential mitigations of impacts

Methodology was subject to regulatory and peer review

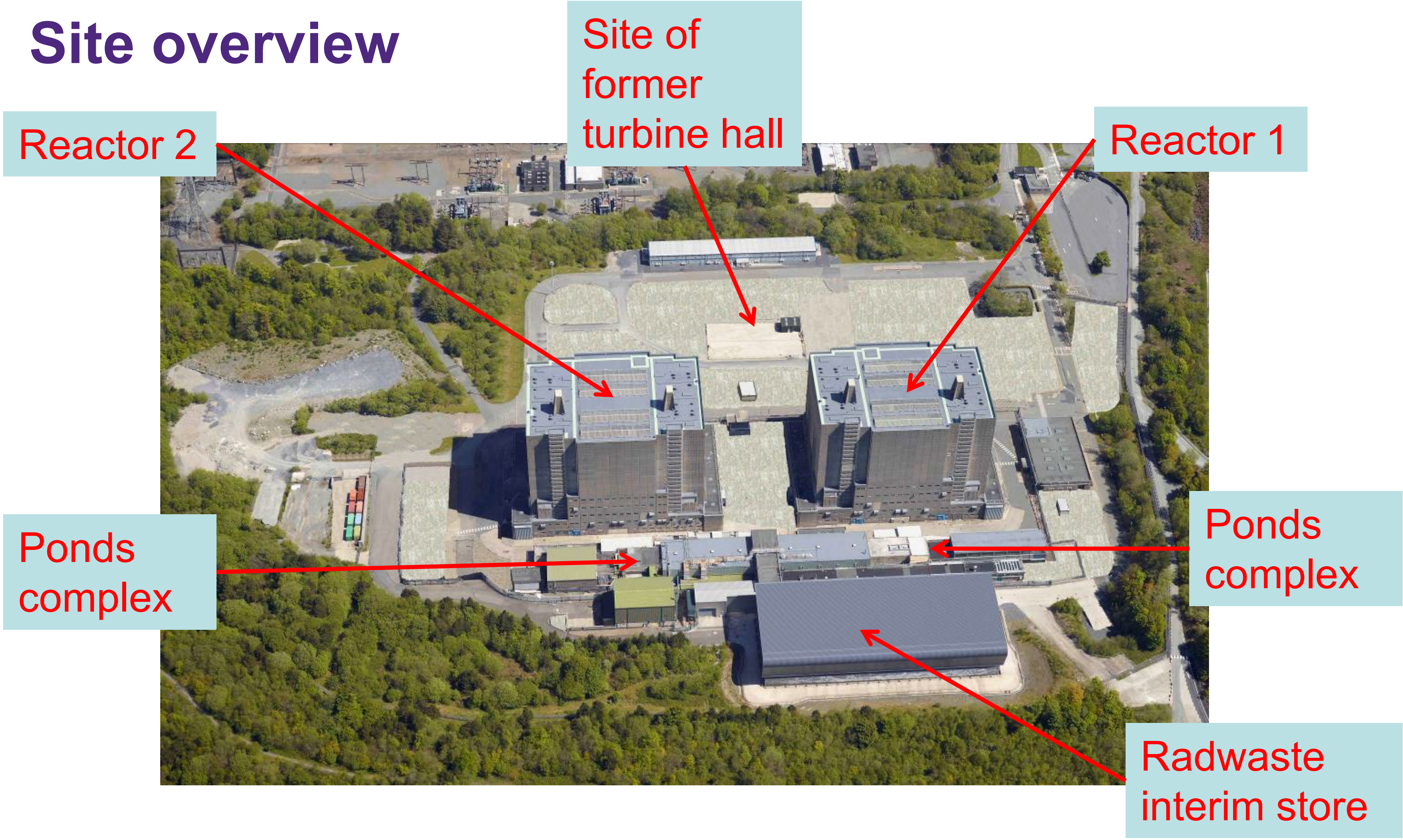
Worked example: Trawsfynydd Site, Wales
[NB – focus of example is on radiological aspects of optimisation]

- Two gas-cooled reactors with separate fuel cooling ponds/waste vaults complex
- Operated 1965 to 1991
- Inland location, in National Park
  - Cooling water from hydro-electric reservoir
- Plan until recently was for End State around 2083, with no remaining radioactivity (i.e. ‘clean’ site)

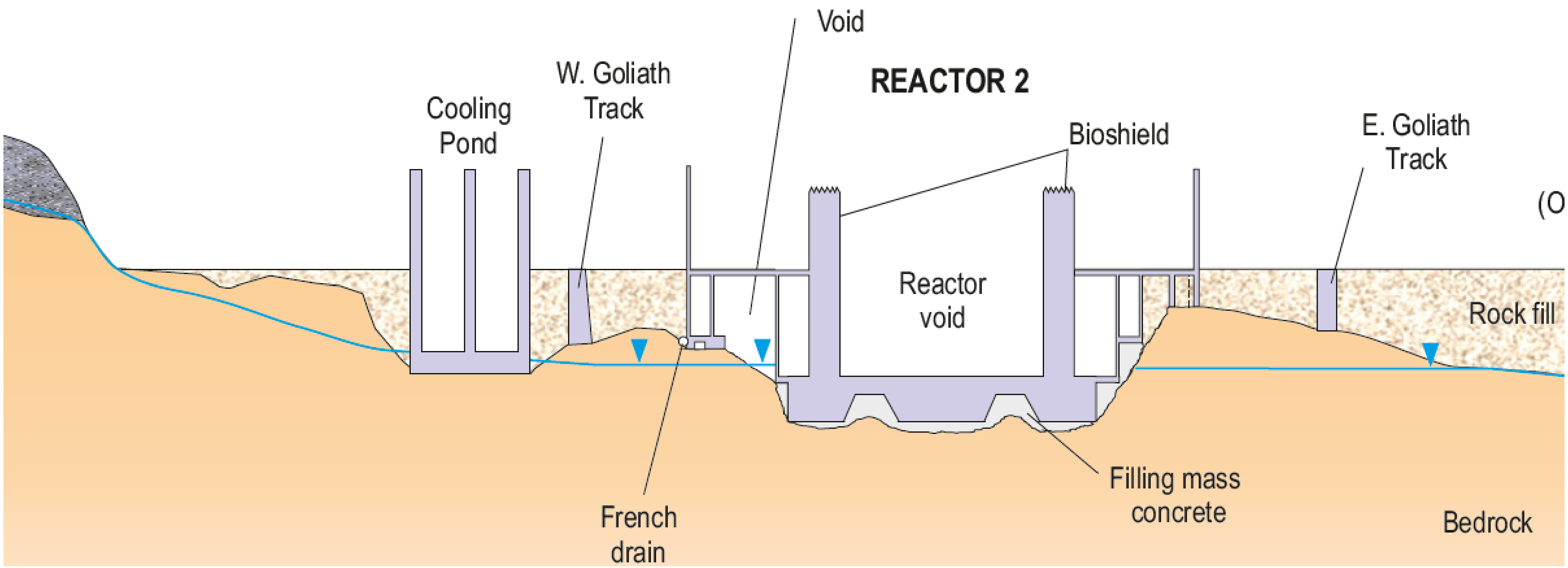
Large-volume radioactive concrete structures with substantial below-ground extent

- Reactor bioshields
- Cooling ponds complex structures

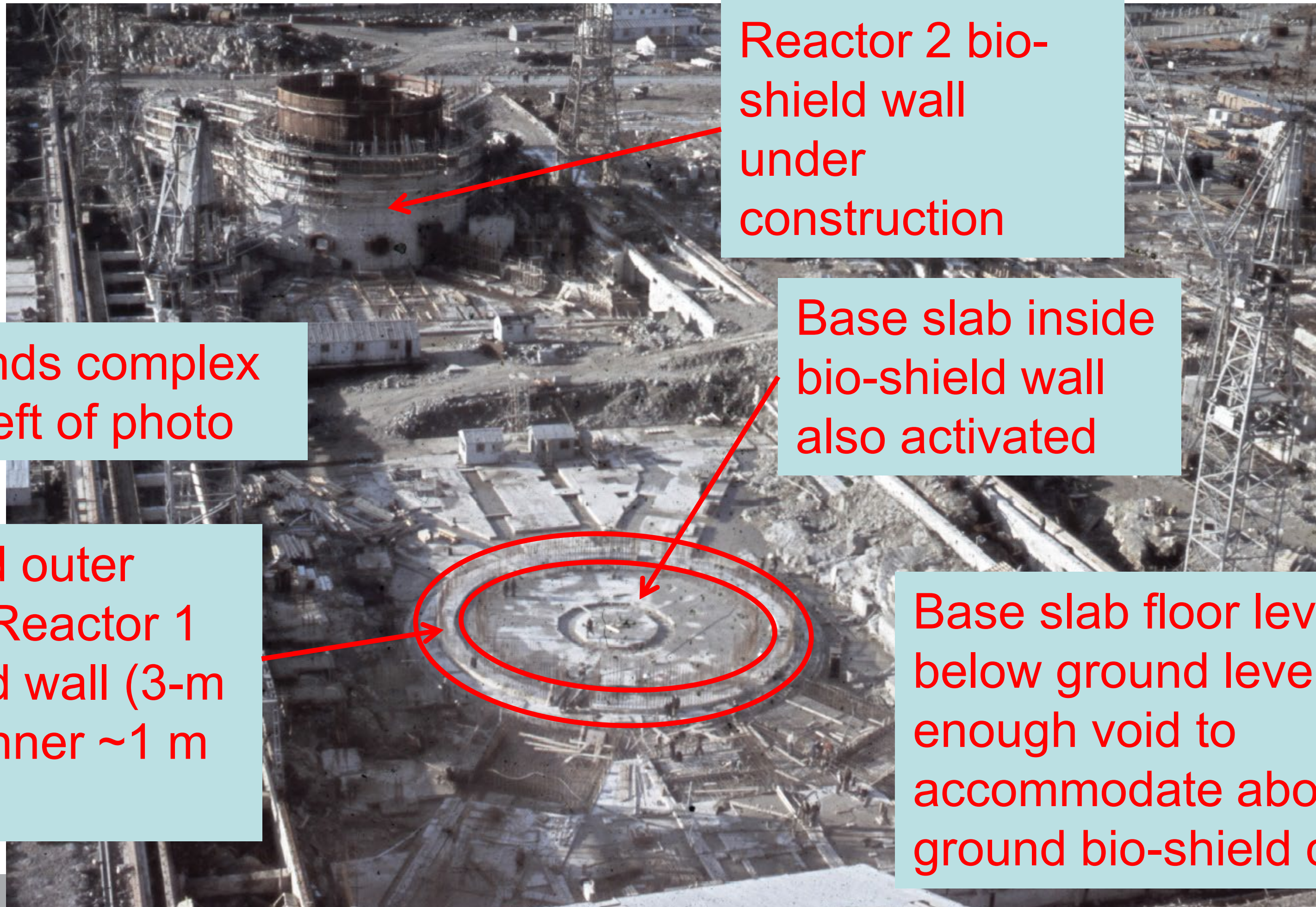
Site overview



Sub-surface structures
(2x vertical exaggeration on section)



Concrete reactor biological shields under construction, 1960



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Define Starting Case End State at Trawsfynydd

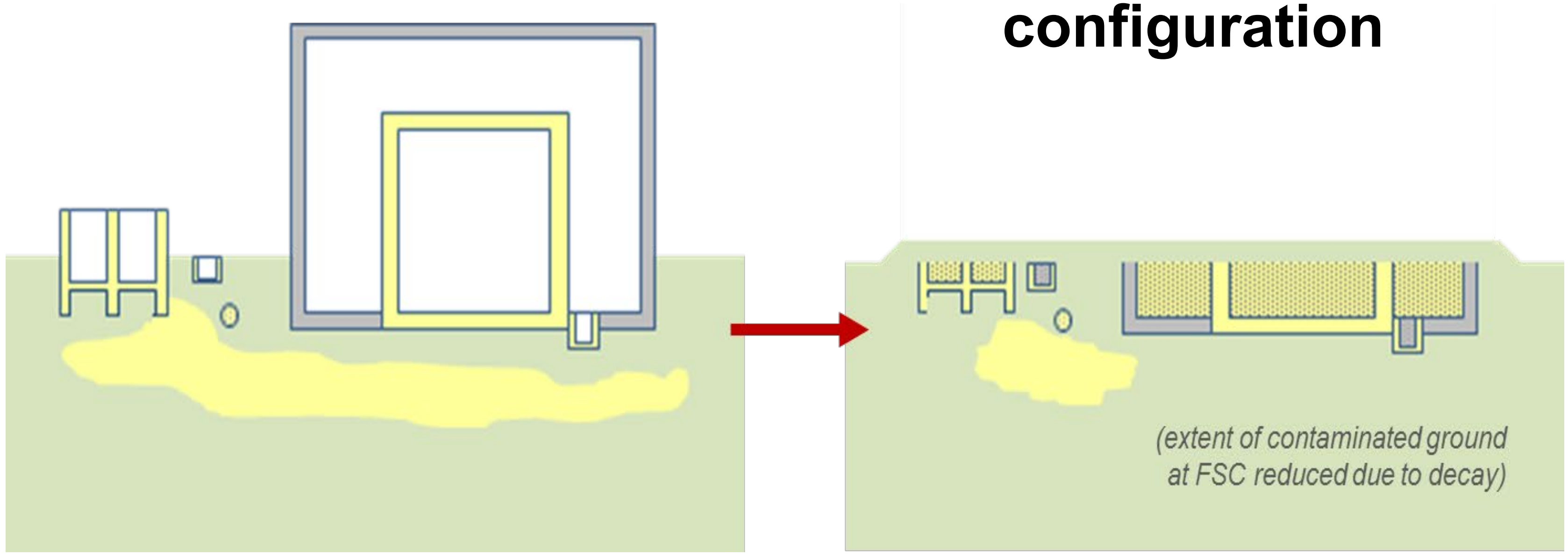
- Exclude features for which on-site disposal is not credible:
  - Higher-activity wastes, including reactor core graphite
  - Hazardous components (e.g. asbestos)
  - Readily removable metallic components
- **Include radioactive features with large volume and low radioactivity levels**:
  - Bio-shield concrete (approx. 22,000 m^3)
  - Cooling ponds complex structures (approx. 7,000 m^3)
  - Contaminated sub-surface infrastructure
  - Sub-surface radioactively contaminated ground
- Also define a **configuration** of the included features

Schematic configurations

Current configuration

Ponds Reactor

Starting Case End State configuration



Non-radioactive structure or infill

Radioactive structure

Radioactive contaminated ground

Radioactive infill

Using the Starting Case End State for initial radiological assessments

- No substantial mitigations in initial assessments
  - just 1 m of non-engineered clean cover
- Two-fold purpose of initial radiological assessments:
  - To inform strategic decision in 2019 that the End State should include radioactivity (as on-site disposals and/or residual contaminated ground)
  - To provide a base case for comparison with variant End States incorporating feasible mitigation measures
- Assessments must be realistic to inform optimisation
  - Over-cautious assessments unlikely to help identify appropriate physical mitigations

Radiological assessments for variant End States incorporating potential mitigations

- Targeted reduction/removal of radioactivity of features causing assessed doses above or approaching regulators’ guidance levels
  - e.g. enhanced decontamination of particular features
- ‘Conditioning’ of wastes for emplacement as void infill
  - e.g. demolition as large concrete blocks, not crushed
- Sub-surface engineering measures
  - e.g. blocking fast pathways such as redundant drains
- Increasing the period of control before release of site from regulation
  - e.g. benefit of decay of Eu-152 in bio-shields (half-life 13.5 y)

Deriving an envisaged optimised End State

[Illustrative – somewhat 'fictionalised']

Feature group	Pathway	Potential mitigation	Radiological impact		Magnitude of net cost of mitigation	Include mitigation?
			Starting case	With mitigation		
Bio-Shields	Groundwater	Cut into blocks, not crushed			High	Yes
Bio-Shields	Human intrusion	Blocks face down			Very low	Yes
Ponds complex	Groundwater	Enhanced decontamination			Medium	Yes
Ponds complex	Human intrusion	Enhanced decontamination			Medium	Yes
Contaminated ground	Groundwater	Grout in situ			High	No
Whole site	Groundwater	Block fast pathways			Low	Yes
Whole site	Human intrusion	Extend period of control			Uncertain	?

Key

	Assessed impact greater than regulatory guidance level
	Assessed impact consistent with regulatory guidance level
	Assessed impact well below regulatory guidance level

- Some mitigations would be essential
- Others contribute to optimisation (ALARA)

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Conclusion: Reasons to use a Starting Case for optimisation of a site's End State

- **Systematic**: The Starting Case End State is a key concept within Magnox Ltd's site-wide process to address UK regulators' guidance (GRR)
- **Transparent**: Clear criteria on what features to include
- **Comprehensive**: Provides framework for assessing a wide range of potential mitigations
- **Simple**: Avoids use of complex options for site-wide assessment
  - …recognising that numerous alternative options and sub-options may still be needed for sub-system optimisation

Lessons for optimisation of geological disposal

- Clearly defined starting point / **base case**
- Early stakeholder and **regulatory engagement**
  - Methodology; details of assessments
- **Staged** – identify and solve high-level question(s) first
- Make sure that all options have the **same endpoint**
- **Balancing** of decision attributes can be challenging
  - May need to illustrate how the range of options compares against all attributes to demonstrate which are key
  - Clear documentation focused on attributes with greatest impact
- Allow for **iteration**
- Base on **realistic assessments**

Acknowledgements

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