Coastal evolution processes as a driver for contaminated land stewardship

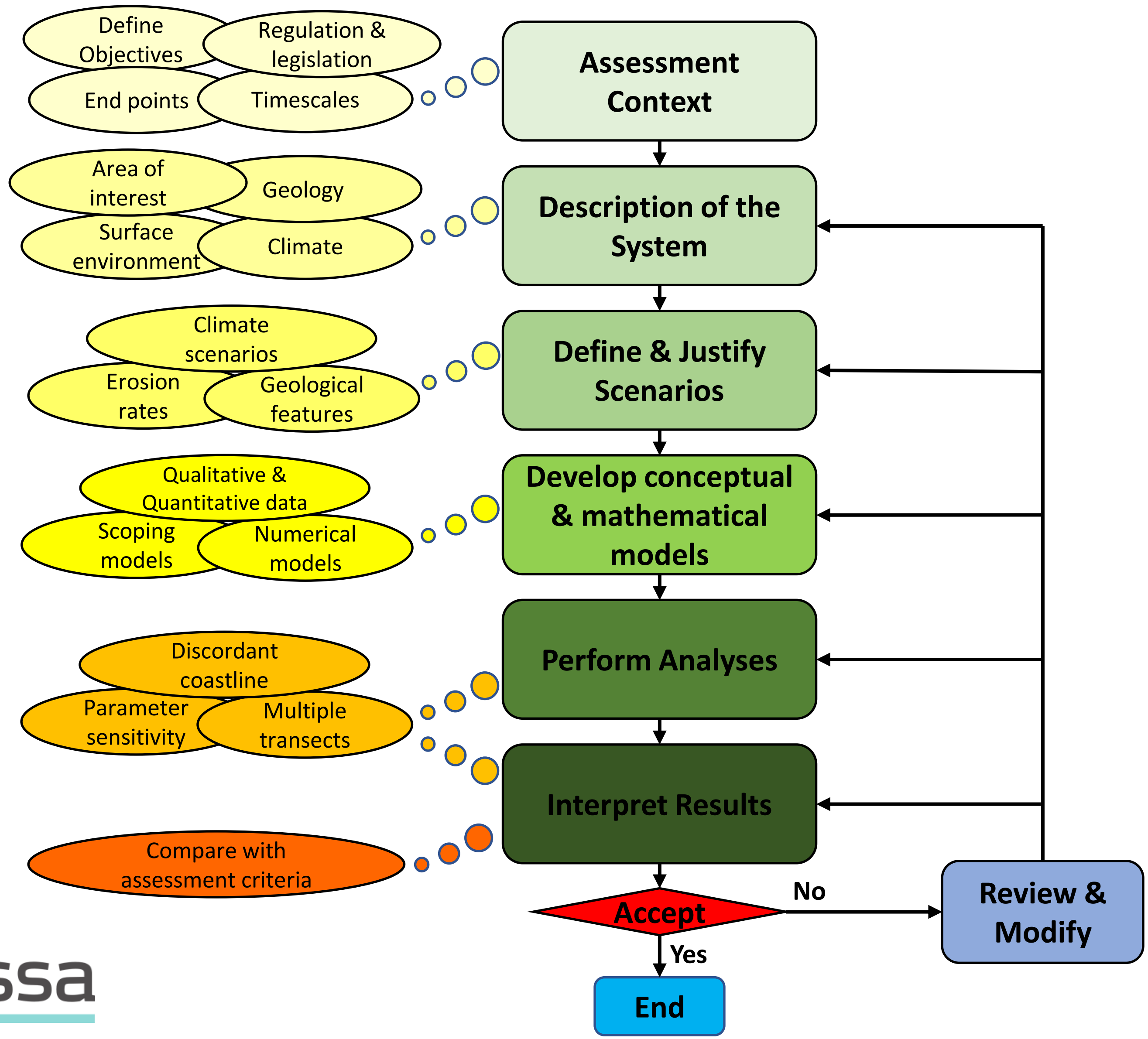
Laura Limer, Renato Zagorscak, Mike Thorne, Vicky Gaskin

20 October 2022

Quintessa

www.quintessa.org

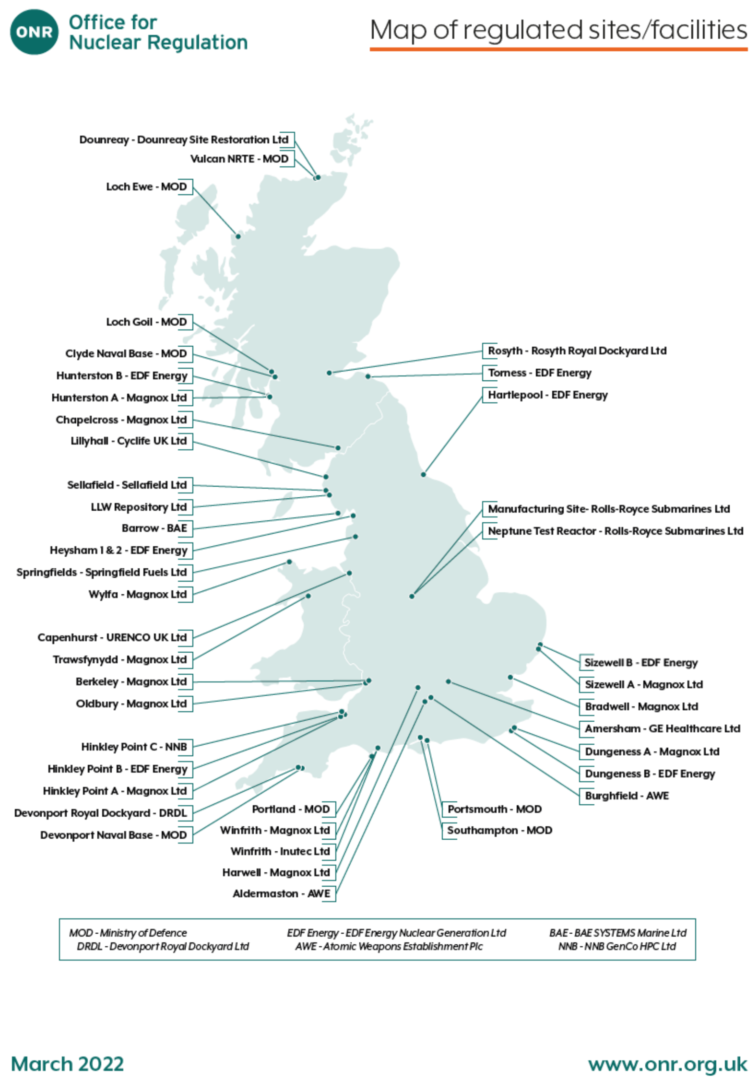
Coastal Evolution Methodology Overview



Quintessa

Assessment Context

- Majority of Nuclear Licensed Sites within the UK have a coastal setting
- Long decommissioning and remediation timescales
- Stewardship of such contaminated land may require consideration of
  - climate change,
  - sea level change,
  - coastal recession and
  - landscape evolution.



Quintessa

Assessment Context

- What is the greater risk to a coastal site?
  - Erosion and exposure of contamination on foreshore
  - Inundation
- How do these risks influence the stewardship plan?
- Which factors affect coastal processes?

Eroding coast in East Anglia over 20 years. ©Mike Page/SWNS

Quintessa

System Description

- Contaminated land site in a coastal location
- Geology and geological formations in that location
- Assumptions for current/future state of land management
  - Presence (or not) of engineered barriers or structures
  - Usage of the land
- Climate

Quintessa

Scenario Definition

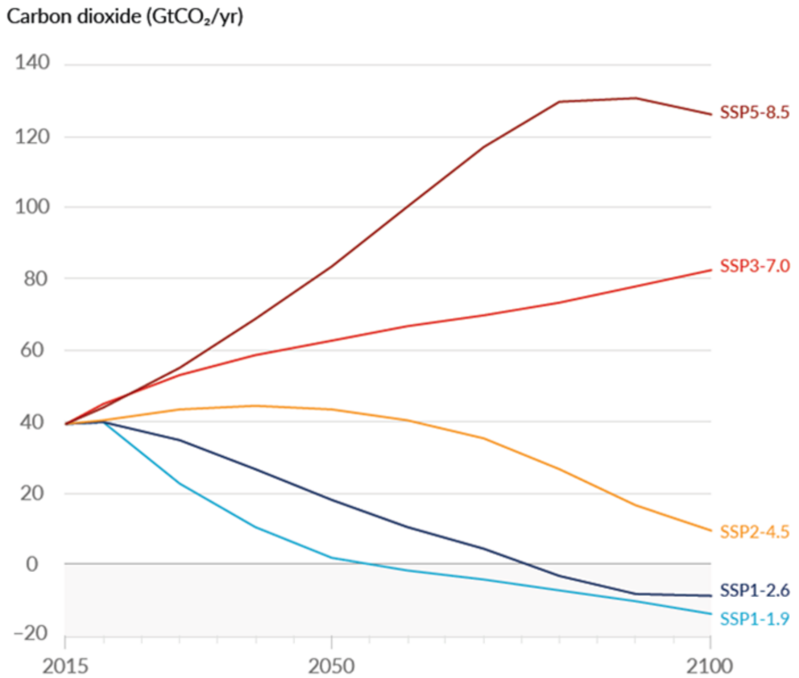
- Climate change projections
  - Typically go out to a few 100 years
- Sea-level change
  - Changes in volume of sea
  - Glaciation and isostatic rebound
- Coastal recession
  - Geological formations
  - Erosion rates of stratigraphy

Need to go from global to local projections

Quintessa

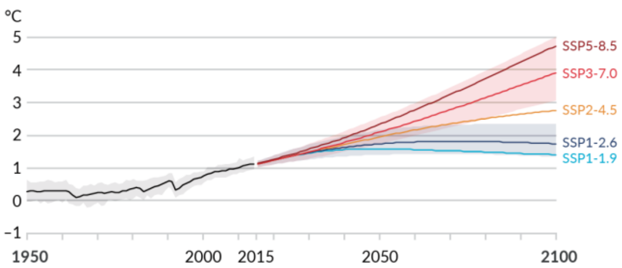
Scenario Definition: Global Climate Change Scenarios

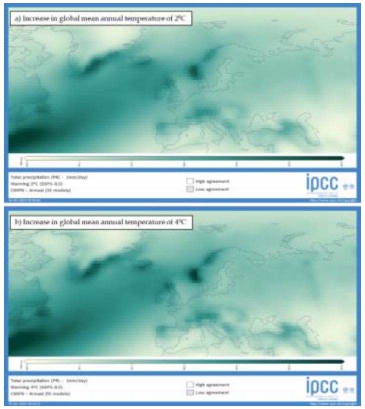
- **SSP1-2.6 (RCP2.6):** Low greenhouse-gas emissions in which CO_2 emissions decline to net zero around 2050, followed by net negative CO_2 emissions;
- **SSP2-4.5 (RCP4.5):** Intermediate greenhouse-gas emissions, in which CO_2 emissions remain around current levels until the middle of the century before declining, though remain positive;
- **SSP5-8.5 (RCP8.5):** Very high greenhouse gas emissions, in which CO_2 emission levels have roughly doubled from current levels by 2050, and peak, at approximately 130 $GtCO_2$ per year, around 1000 years from now.

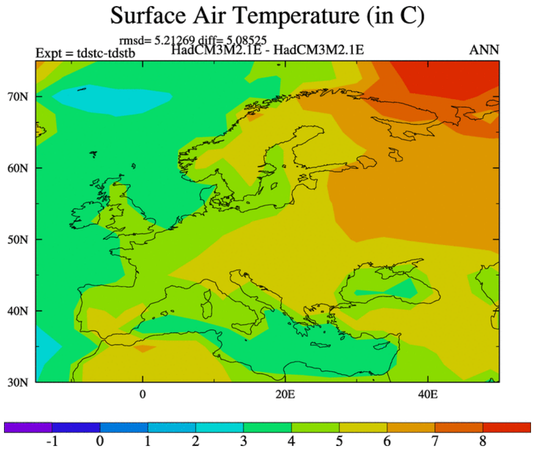


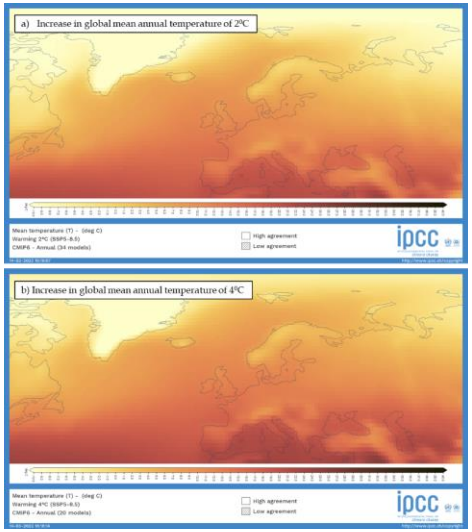
Quintessa

Scenario Definition: Global to Local Climate Change

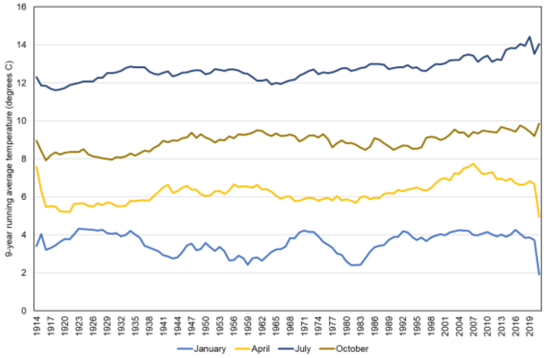


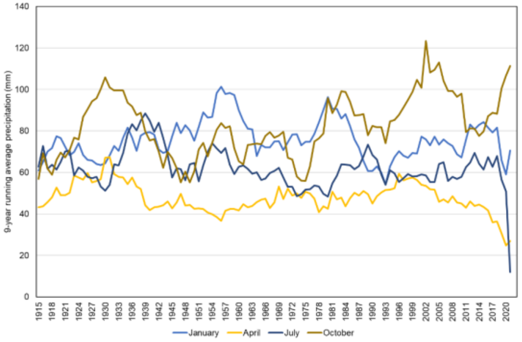






- How do local records compare with global and regional scale climate data and projections?
  - Temperature
  - Precipitation

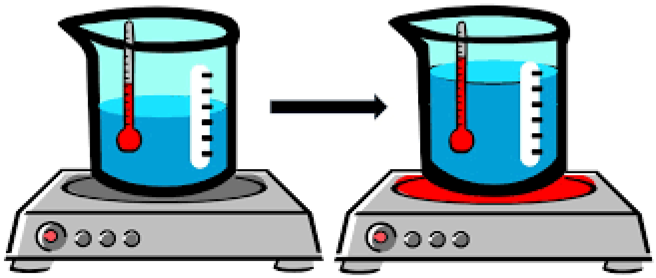




Quintessa

Scenario Definition: Sea-level change

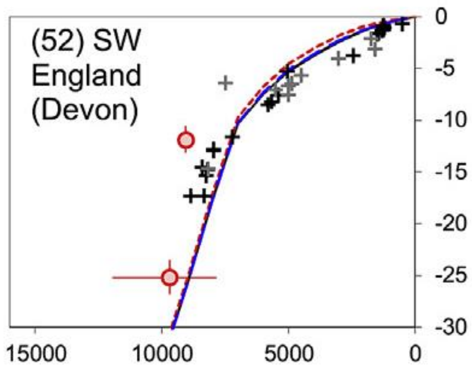
Melting ice caps and valley glaciers



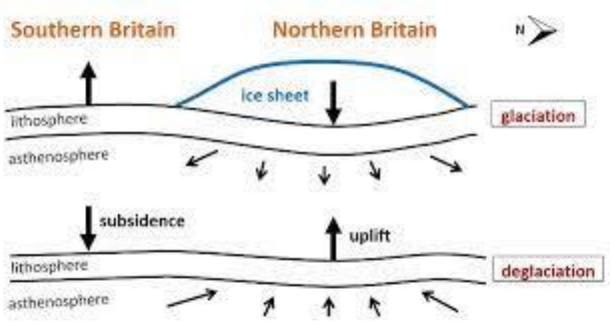
Thermal expansion of seawater

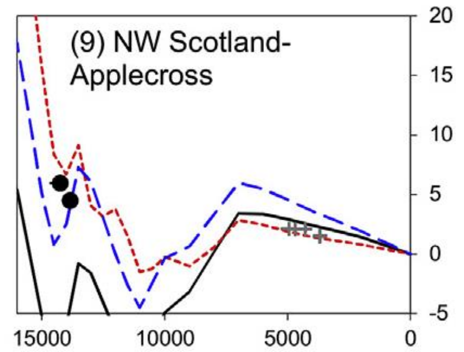
Melting/collapse of ice sheets

Isostatic change – depends on location



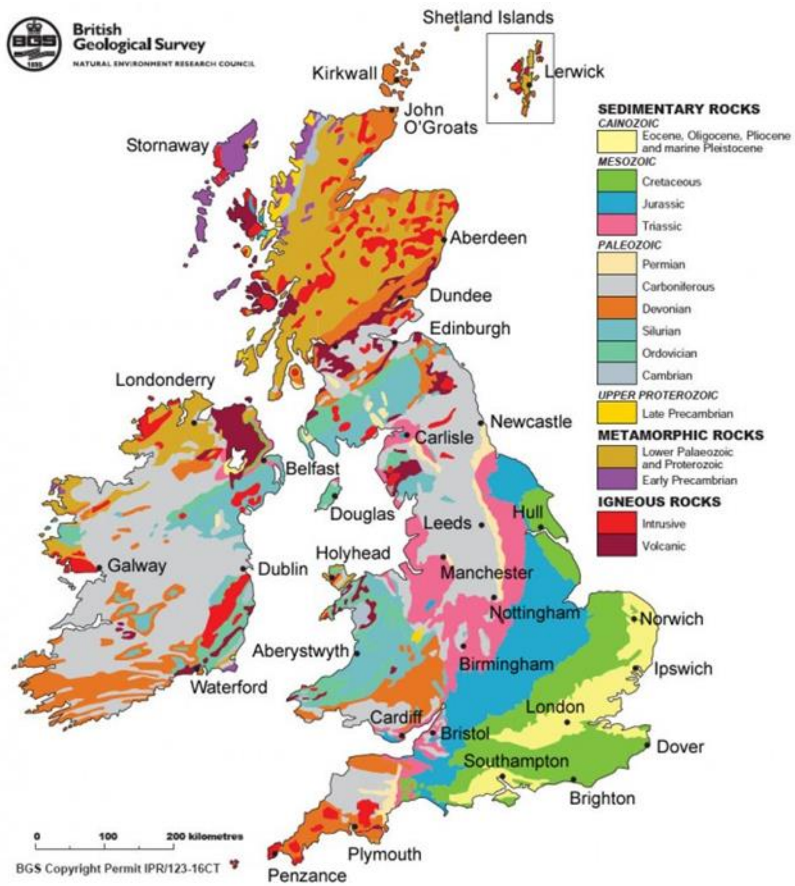
Relative sea-level not affected by glaciation





Relative sea-level affected by glaciation

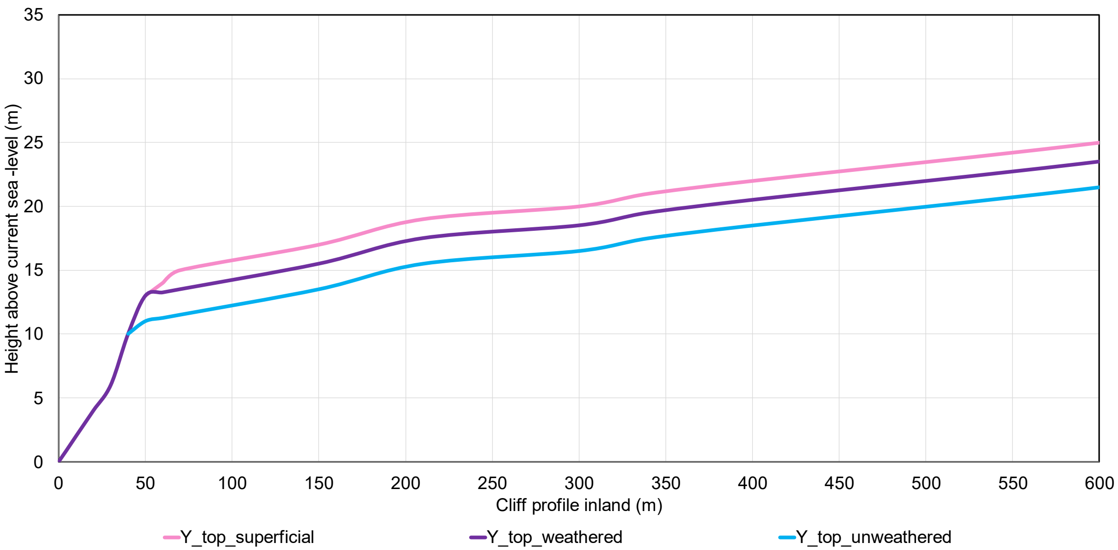
Scenario Definition: UK Geology and Erosion

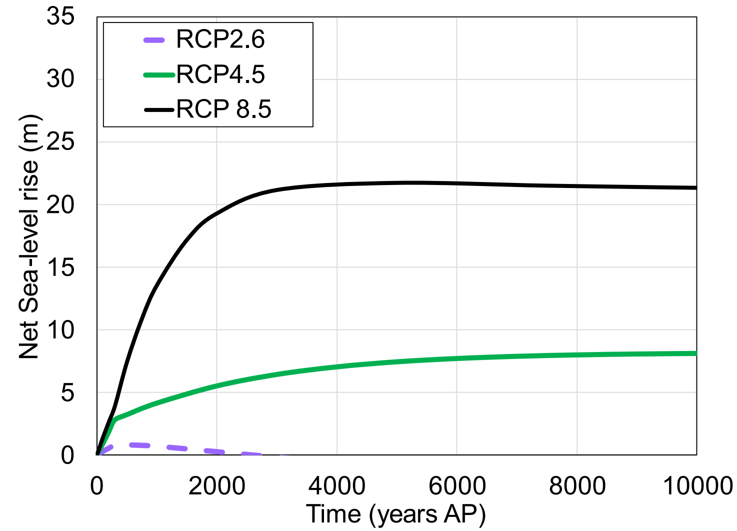


- UK has a varied geological landscape
- Differing resistance to erosion
  - Igneous/Metamorphic
    - ~ 0.001 m y-1
  - Sedimentary
    - ~ 0.01 to 0.1 m y-1
  - Unconsolidated sediments
    - ~ 1 to 10 m y-1

Quintessa

Conceptual Model

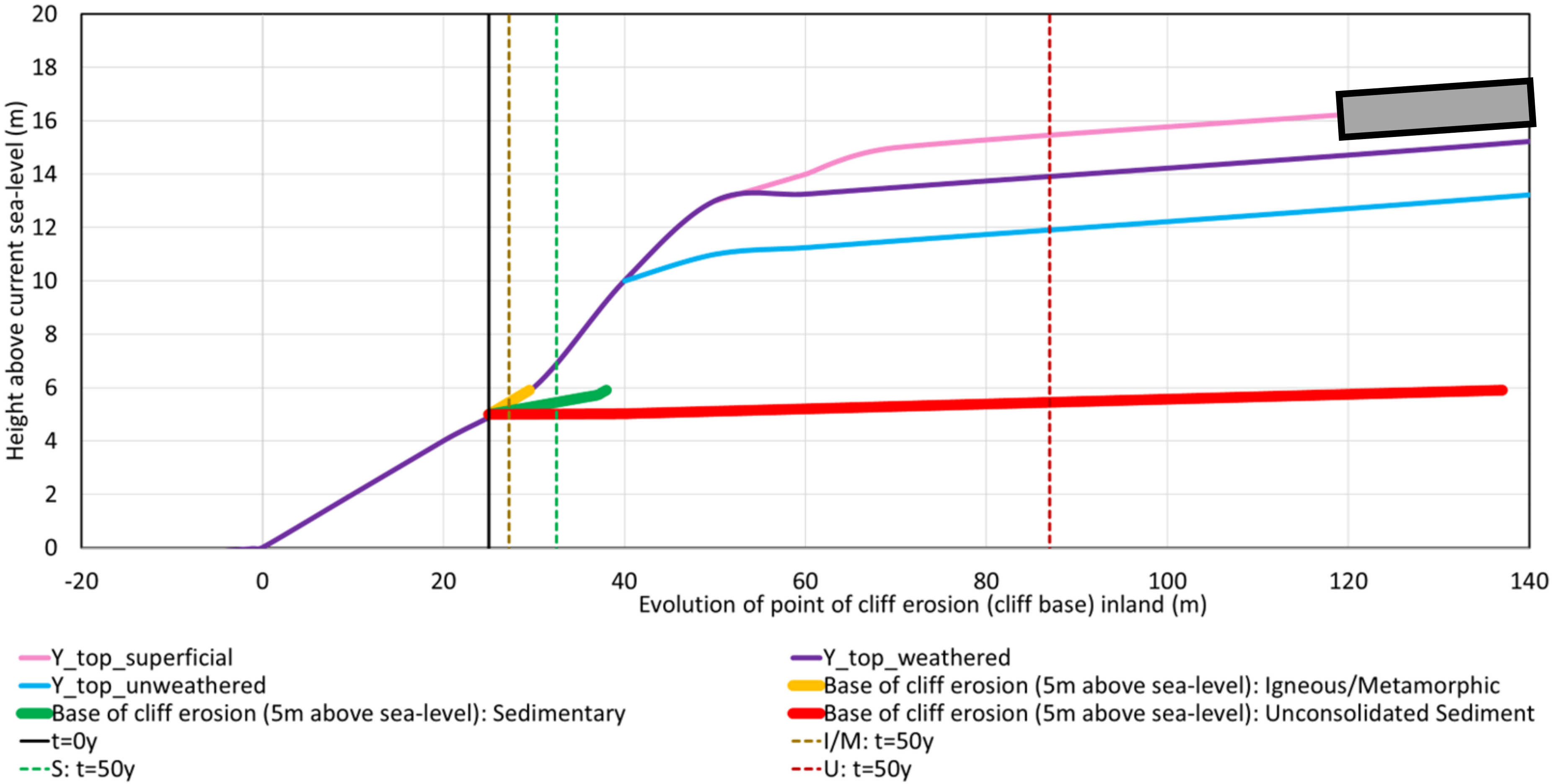




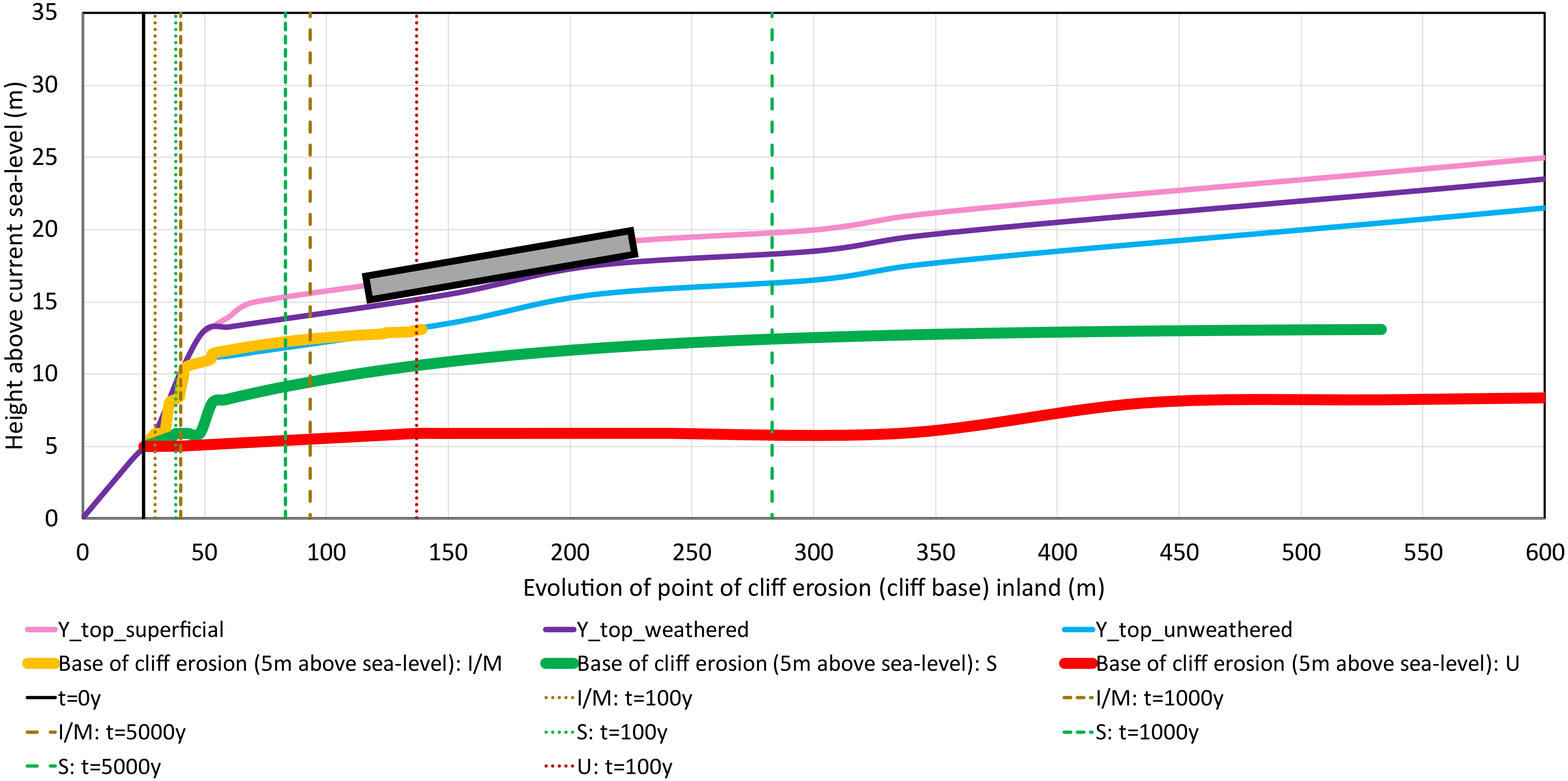
- Definition of transect(s) stratigraphy
  - Superficial deposits, weather rock, unweathered rock
- Consideration of sea-level height over time
  - Assume primary erosion point is at high-level water mark/storm height, approximately 5 m above the sea-level
- Erosion of cliff inland dependent on rock encountered at a given time

Quintessa

Analysis: RCP4.5 (100 years)



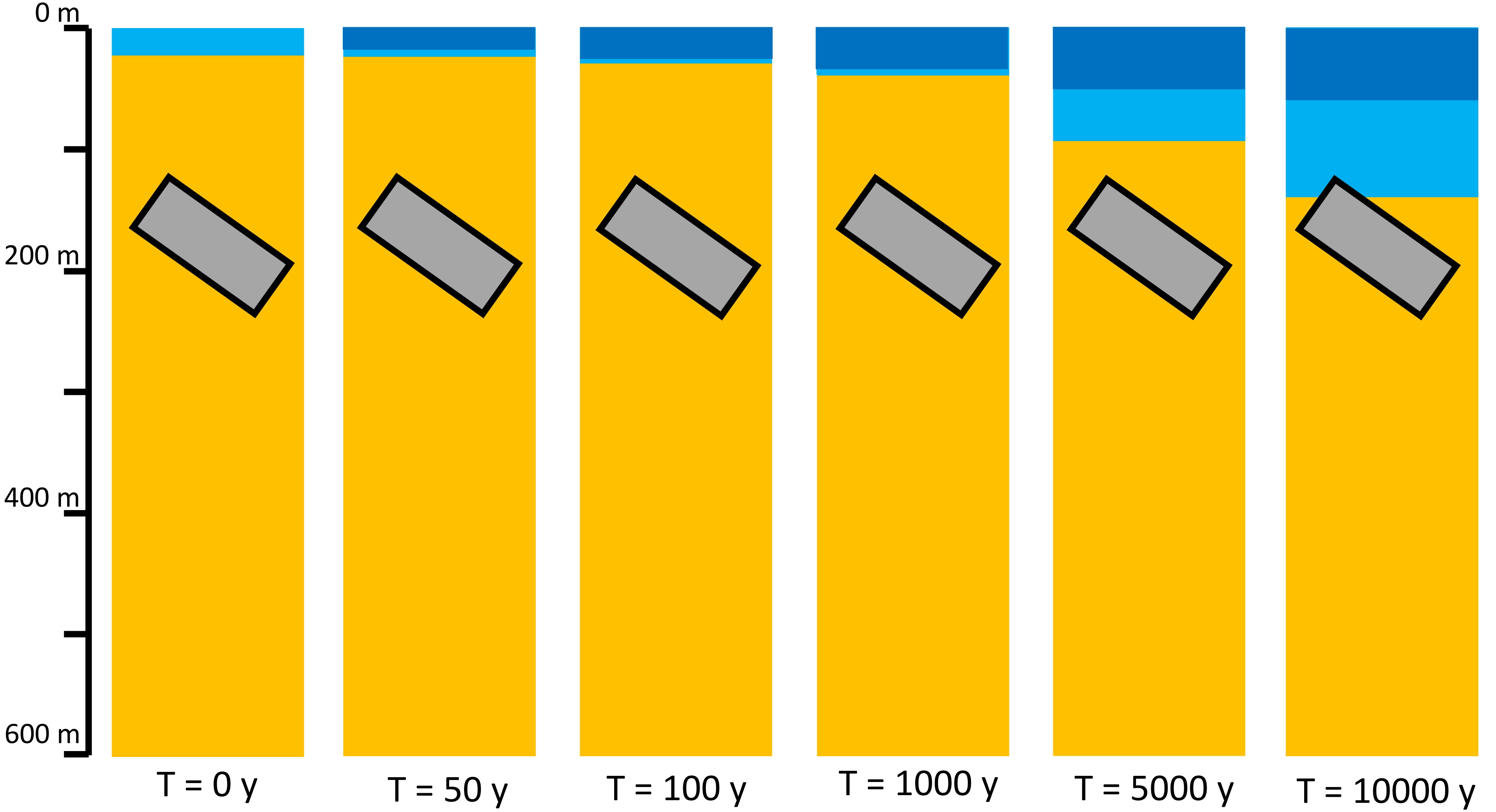
Analysis: RCP4.5 (10 000 years)



NOTE: Within 1000 years, the Unconsolidated Sediments have eroded back over a kilometre from the original cliff base

Quintessa

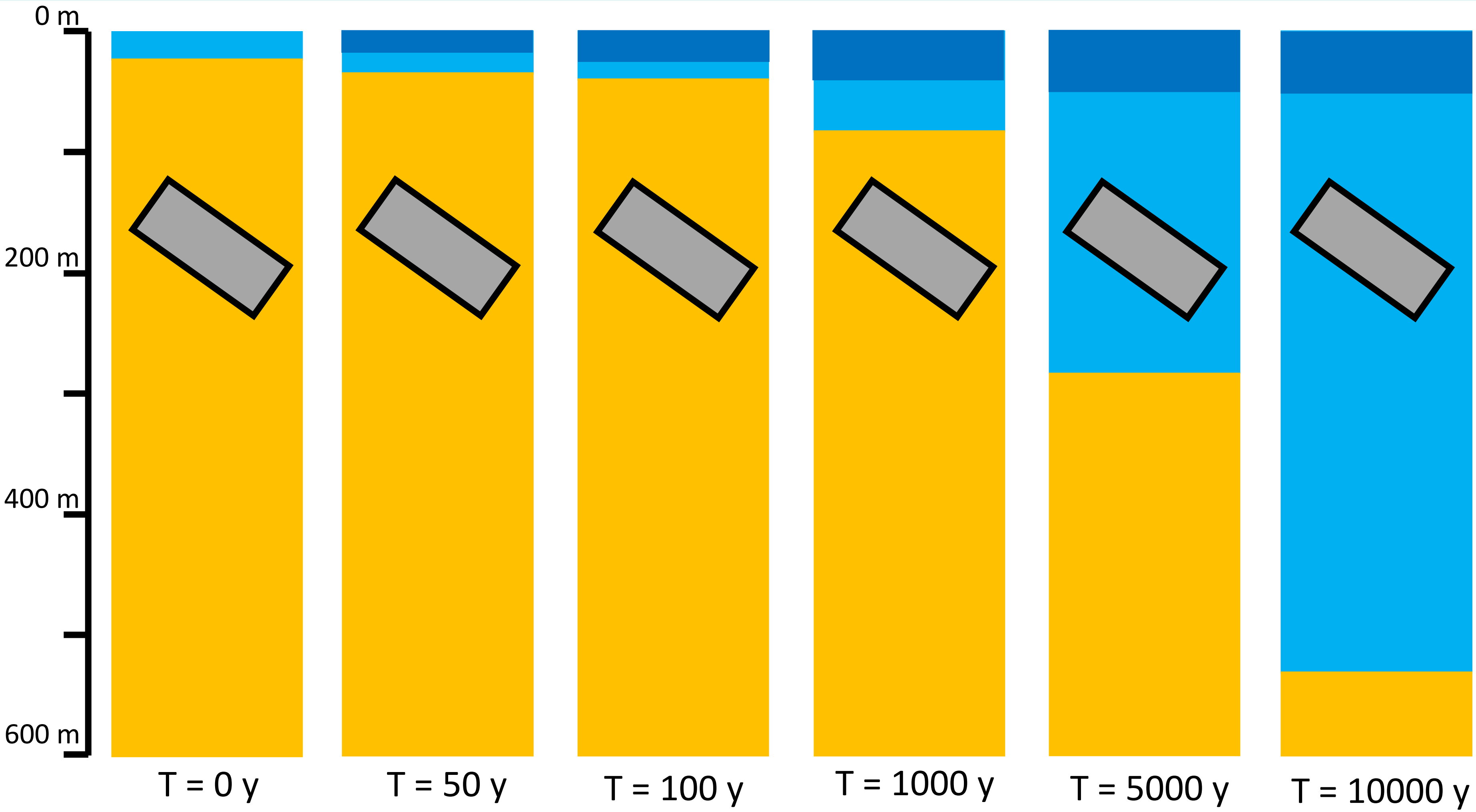
Analysis: RCP4.5 (Igneous/metamorphic rock)



Exposure unlikely until long time in future

Quintessa

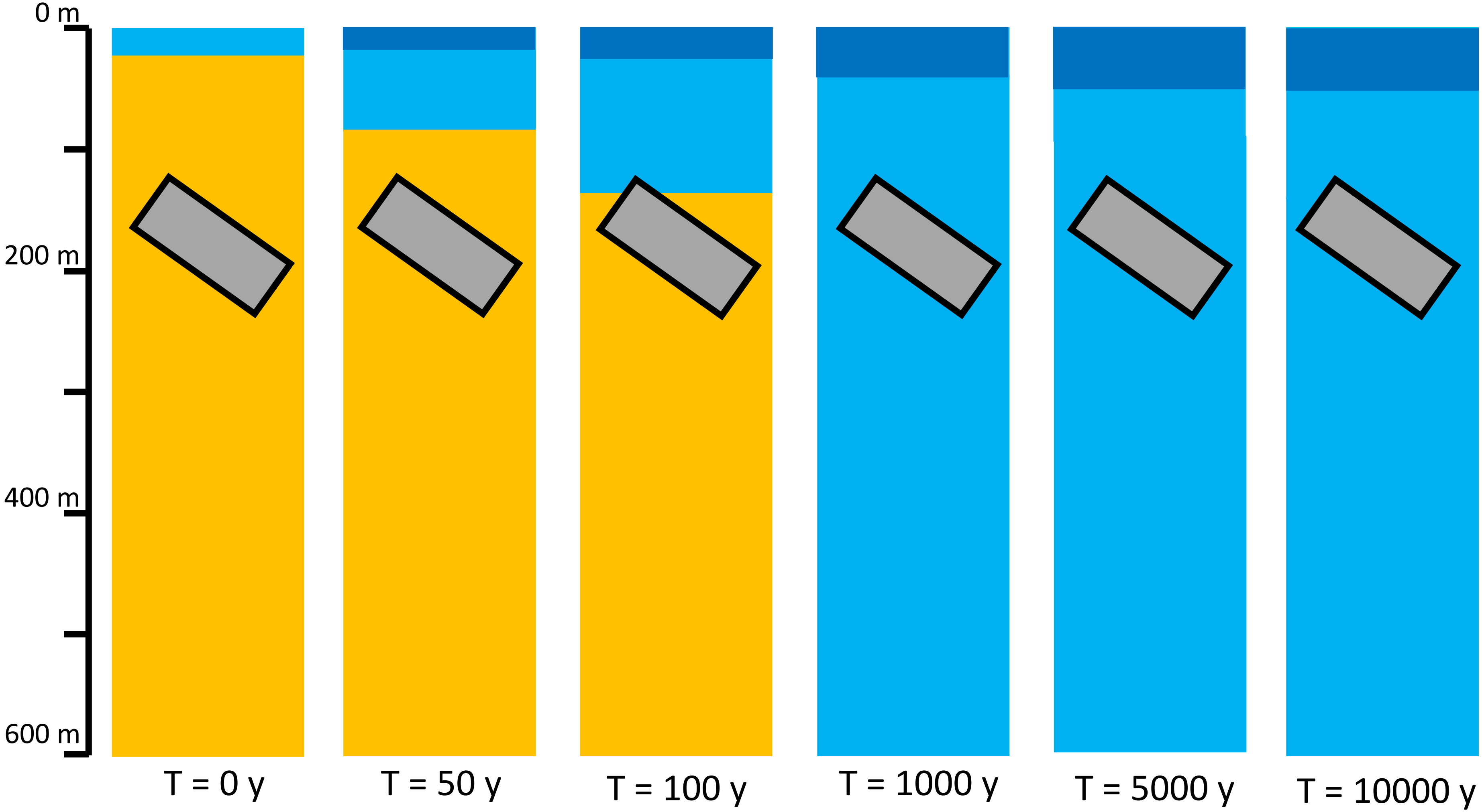
Analysis: RCP4.5 (Sedimentary rock)



Complete exposure on foreshore likely in the longer term

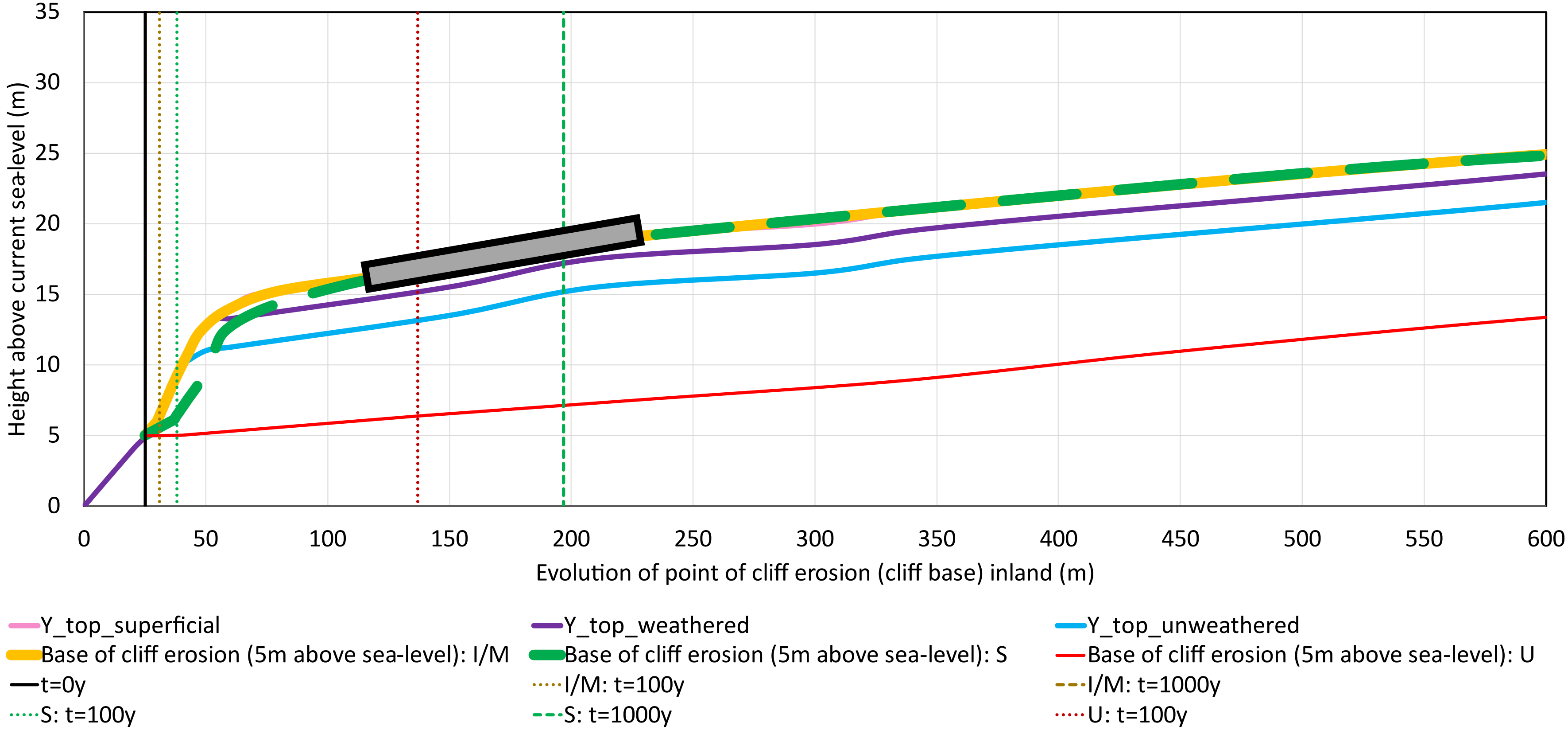
Quintessa

Analysis: RCP4.5 (Unconsolidated sediments)



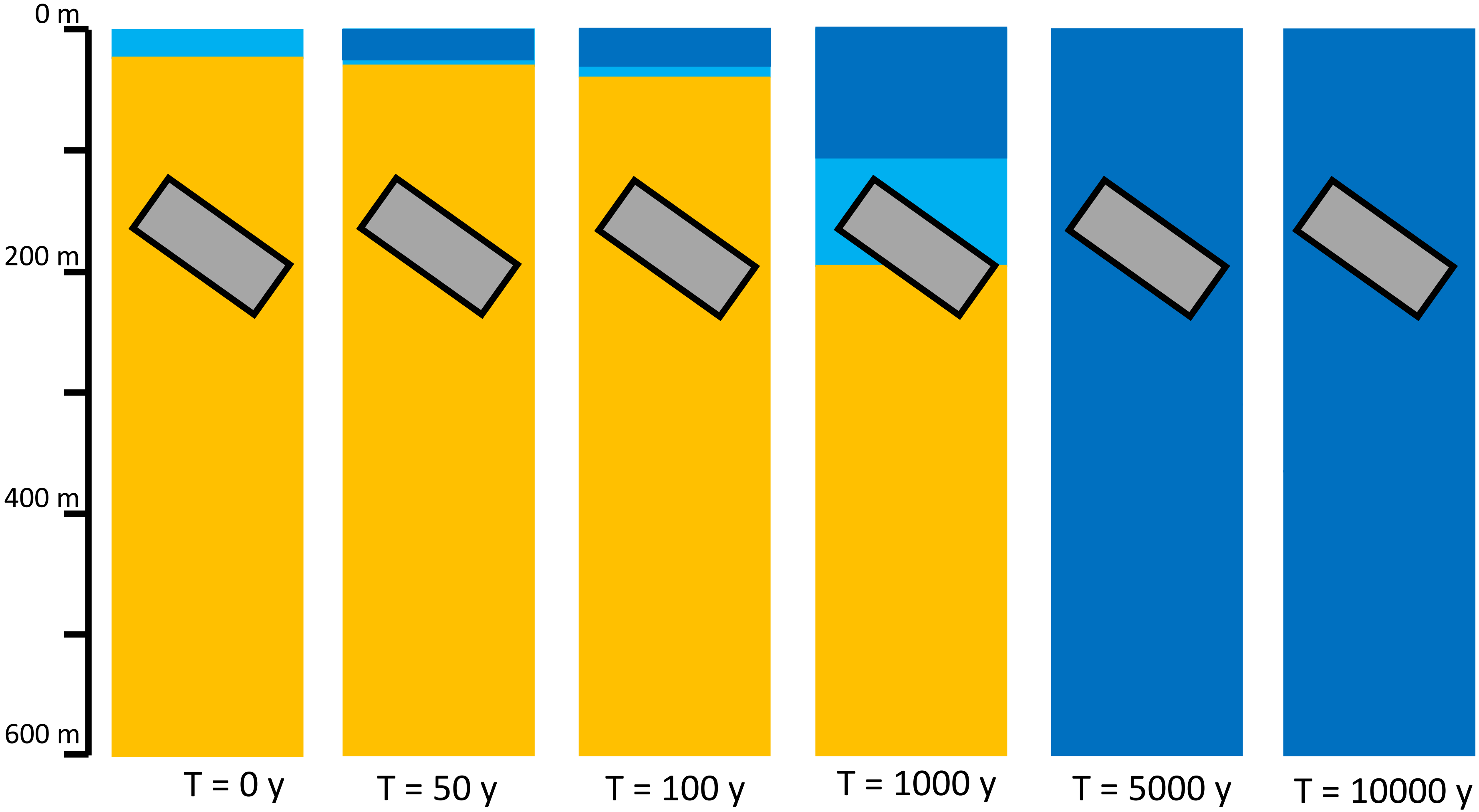
Exposure of some contaminated land on foreshore likely within 100 years, followed by complete exposure on foreshore in the longer term

Analysis: RCP8.5 (10 000 years)

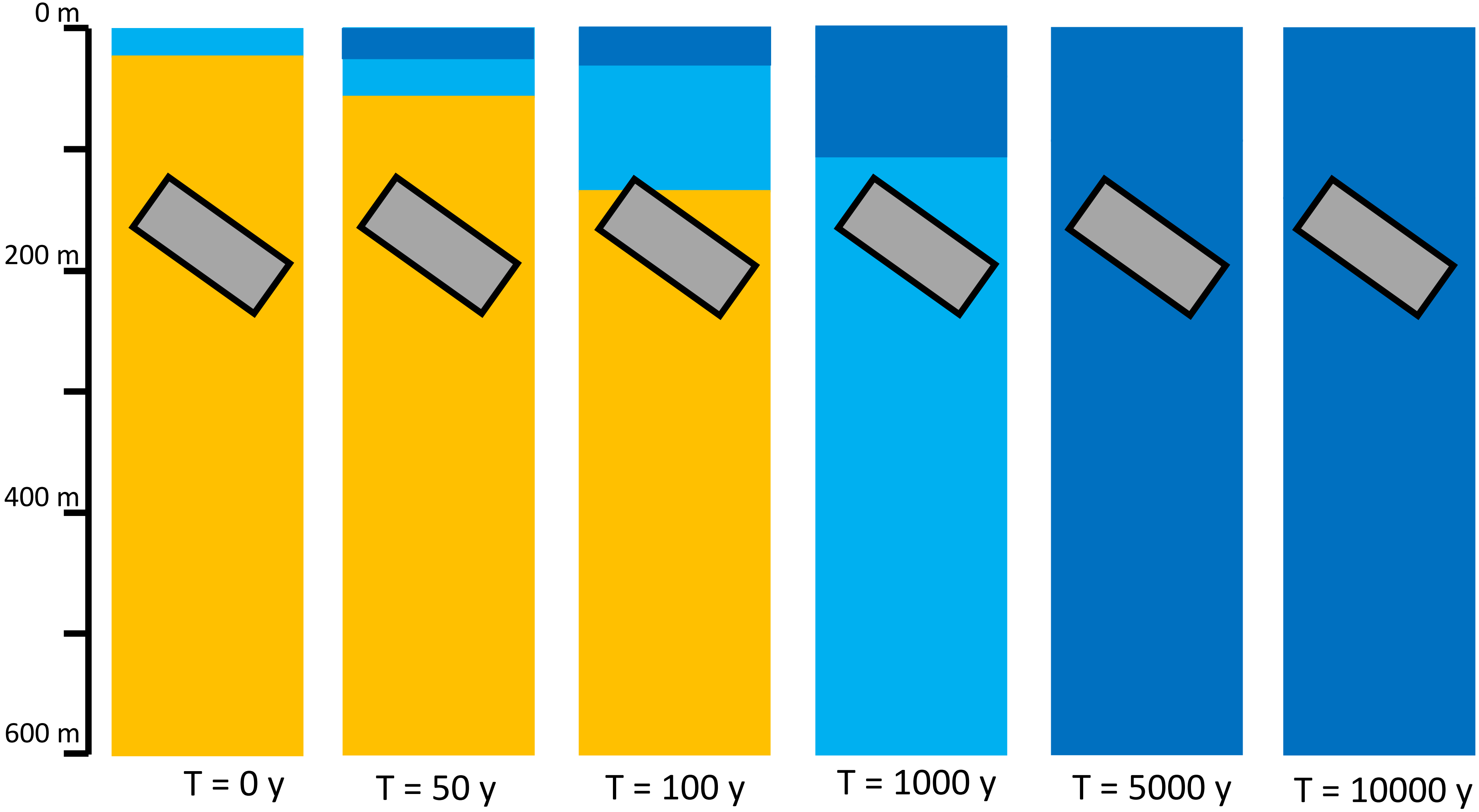


Igneous/metamorphic and sedimentary rocks: partial exposure on foreshore within 1000 years, followed by complete inundation within 5000 years
Unconsolidated sediments: site exposed on foreshore prior to inundation

RCP8.5: Sedimentary rock



RCP8.5: Unconsolidated sediments



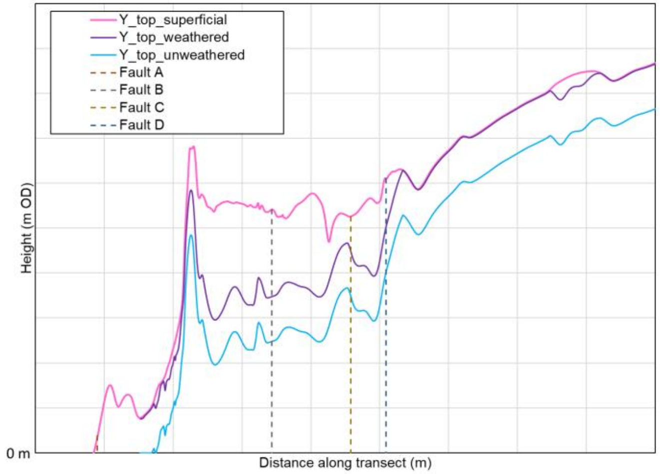
Quintessa

Interpretation: Implications for land stewardship

- Methodology developed for long-term contamination issues
- Supports understanding of timescales for erosion or inundation of contaminated land
- Can be used to inform potential foreshore exposure scenarios for humans and wildlife
  - Pathways affected by erosion, and thus timescales for transport (decay)
- Form arguments for optimised stewardship of the site.

Methodology Extensions and Further Application

- Demonstration has assumed discordant coastline
- Extensions
  - More complex topography and stratigraphy along the transects
  - Consideration of natural complexities:
    - Faults
    - Geological features
    - Concordant coastline
  - Consideration of man-made complexities
    - Engineered structures and barriers



Quintessa

References

- IAEA (2004). Safety Assessment Methodologies for Near Surface Disposal Facilities. Results of a co-ordinated research project. Volume 1: Review and enhancement of safety assessment approaches and tools. https://www-pub.iaea.org/MTCD/Publications/PDF/ISAM/IAEA-ISAM-Vol1_web.pdf
- IAEA (2004). Safety Assessment Methodologies for Near Surface Disposal Facilities. Results of a co-ordinated research project. Volume 2: Test cases. https://www-pub.iaea.org/MTCD/Publications/PDF/ISAM/IAEA-ISAM-Vol2_web.pdf
- IPCC, 2021. Climate change 2021: the physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press. In Press.
- Limer, L, Zagorscak, R, Thorne, M and Auton, C, 2022, Assessment of Climate Change and Coastal Erosion at the Dounreay Site: Final Report, QRS-10080A-1, Version 2.0, 31 March 2022.
- Lord NS, Lunt D and Thorne MC, 2019, Modelling changes in climate over the next 1 million years, SKB Technical Report TR-19-09.
- ONR (2022). Map of regulated sites/facilities, March 2022. https://www.onr.org.uk/documents/map-of-regulated-sites.pdf
- Shennan I, Bradley SL and Edwards R, 2018, Relative sea-level changes and crustal movements in Britain and Ireland since the Last Glacial Maximum, Quaternary Science Reviews, 188, 143-159.