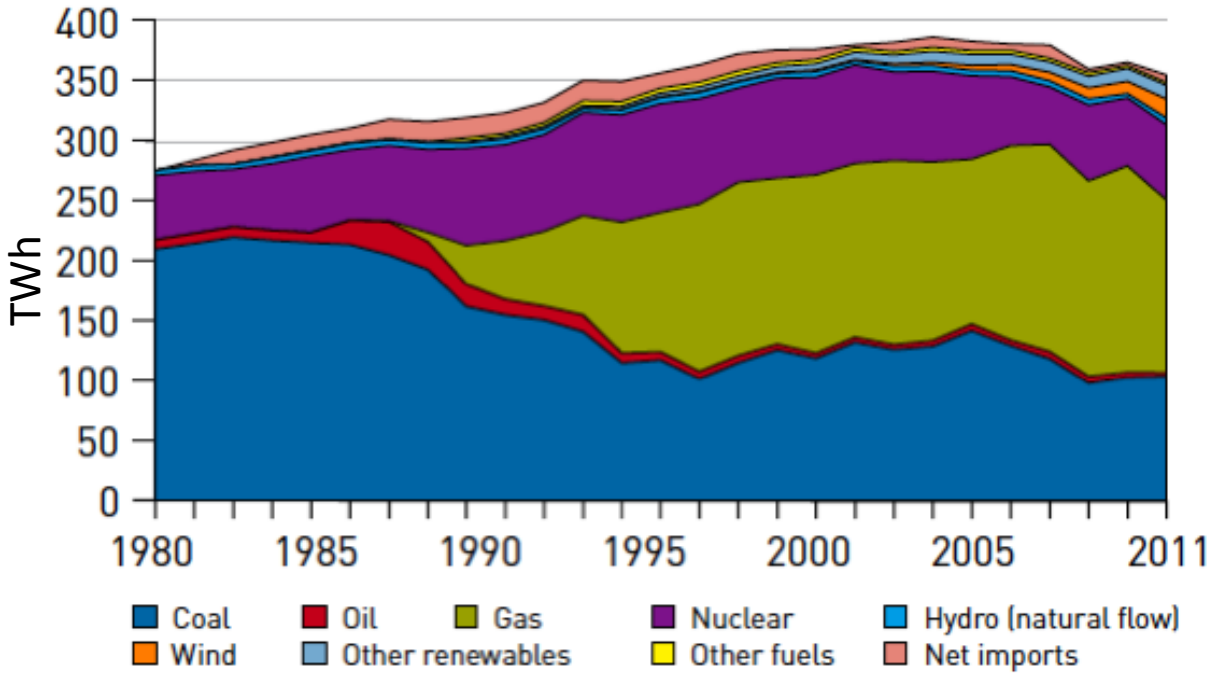
Department of Civil & Environmental Engineering

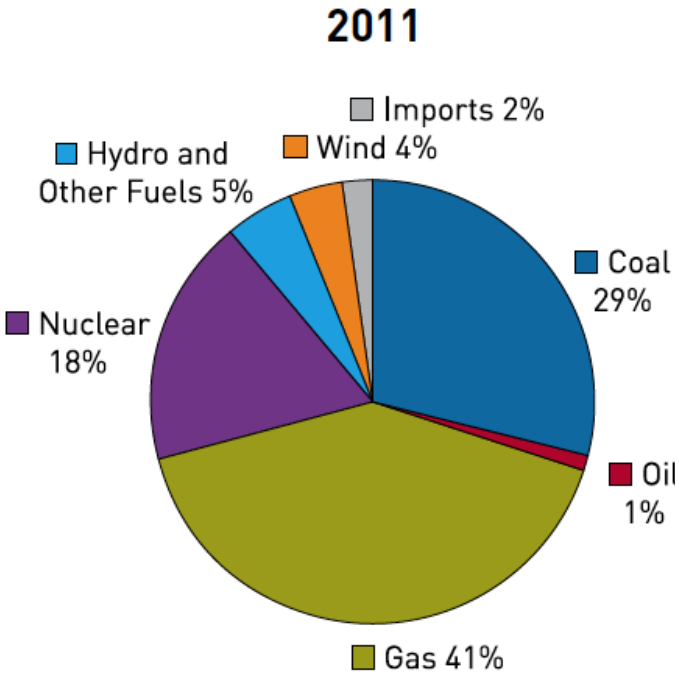
University of Strathclyde Engineering

Meeting the challenge: Geological disposal of UK higher activity radioactive waste

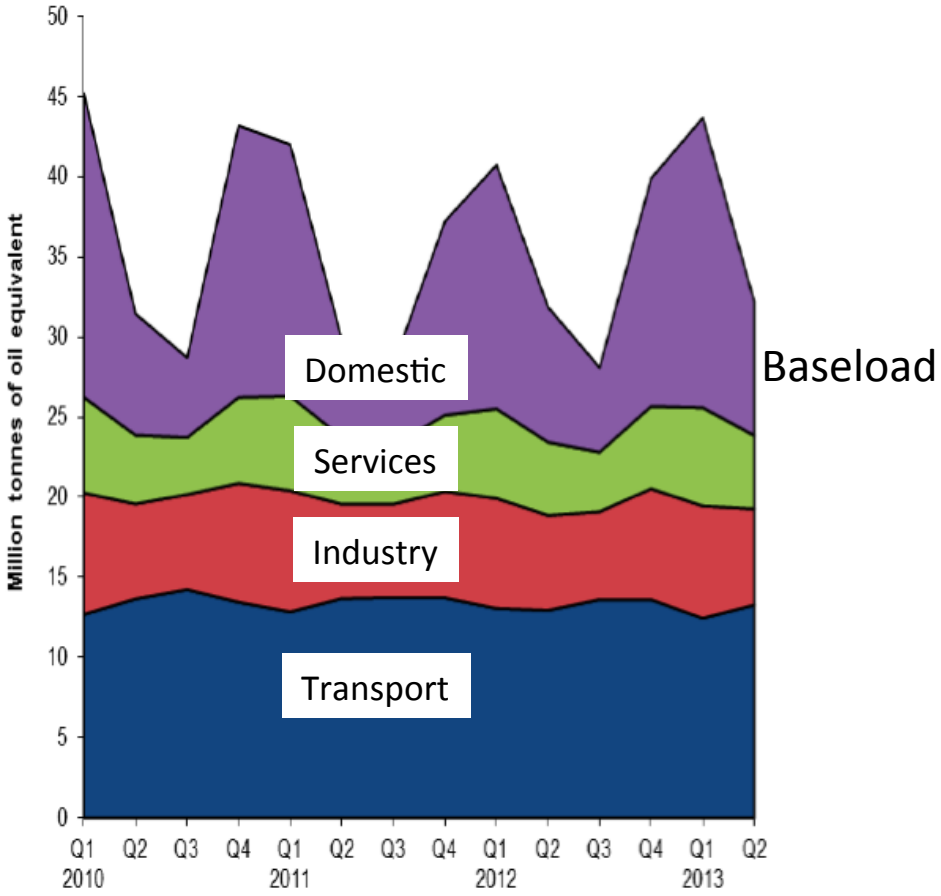
Professor Becky Lunn

Electricity supplied by fuel type, 1980 to 2011





Energy demand, 2010 to-date



Baseload

UK Total Energy Production

Baseload energy

- Oil and gas
- Nuclear
- Biofuel
- Geothermal
- Hydropower
- Tidal

Peak load energy

- Wind
- Solar
- Hydropower

Nuclear Power

Advantages: Doesn't depend on fossil fuels, isn't affected by fluctuating oil and gas prices, not reliant on foreign energy imports.

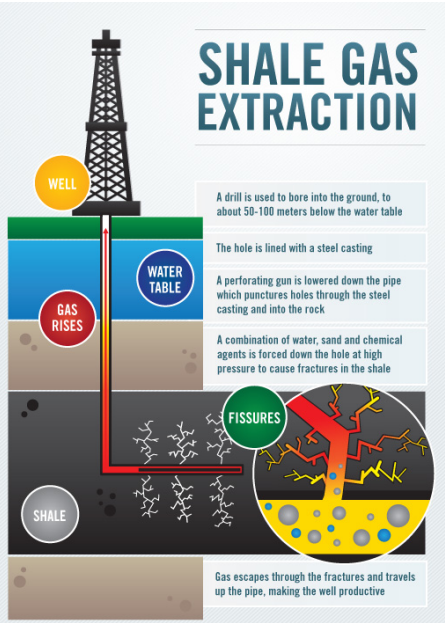
- Nuclear Energy Institute estimate the power produced by the world's nuclear plants would normally produce 2 billion metric tons of CO_2 per year if they depended on fossil fuels

Disadvantages: Current technology produces nuclear wastes that must be managed to 10,000s to 1,000,000s of years

Tough decisions

- Need to meet baseload energy demand
- Need to meet targets for greenhouse gas emissions

- Carbon capture and storage technology immature
- Need energy storage solution for baseload renewables



What is radioactive waste?

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Low Level Waste

- Mostly building rubble, soil and steel

Intermediate Level Waste

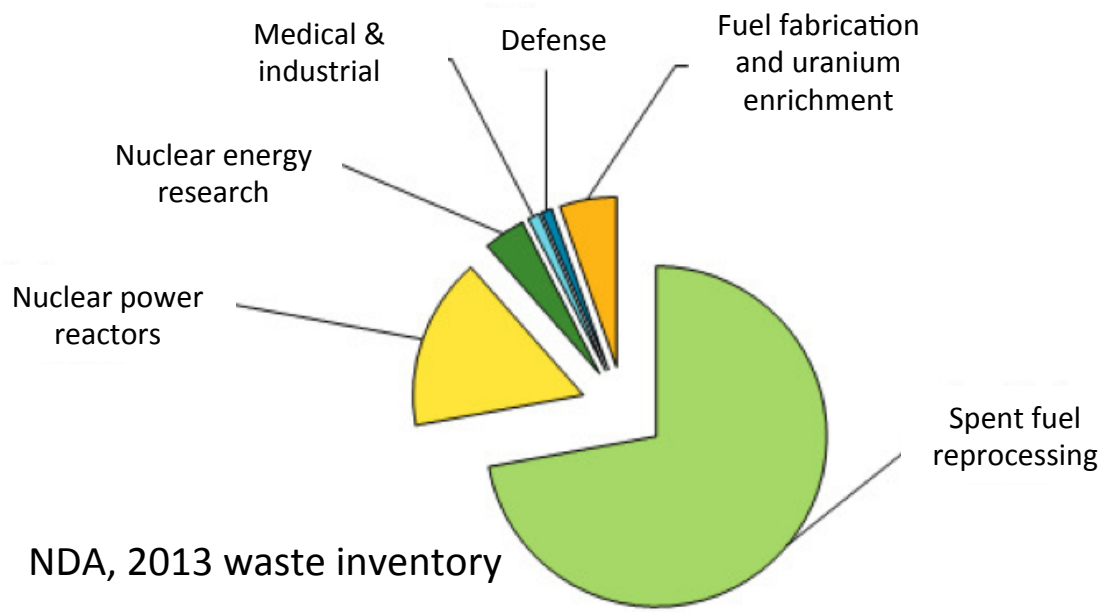
- Nuclear fuel casing, sludges from treatment of radioactive liquids, graphite from reactor cores

High Level Waste

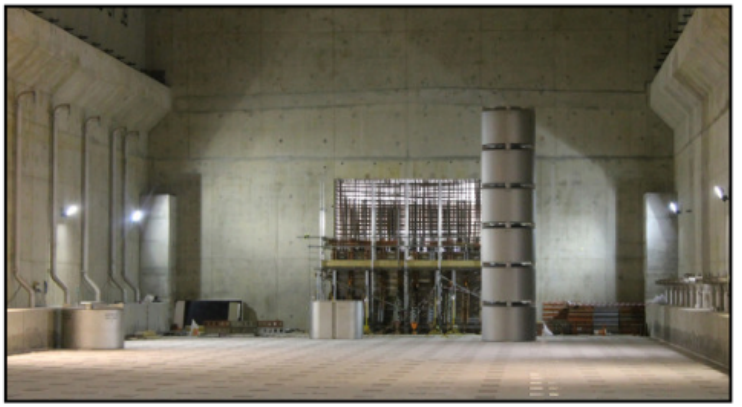
- Heat generating wastes derived from nuclear fuel reprocessing

How waste much do we have and where does it come from?

- 4,500,000 m^3 (4 times the volume of Wembley Stadium)
- Most wastes stored at existing nuclear facilities
- New build nuclear power



NDA, 2013 waste inventory



Inside the ILW Store at Hunterston A

Inside the Vitrified High Level Waste Store

What should we do with the waste?

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- In 2003, UK Government set up an independent Committee for Radioactive Waste Management (CoRWM)
  - Contained non-technical experts
  - Very extensive public consultation including citizens panels
  - **Recommended Geological Disposal (2006)**

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CoRWM reconstituted as expert technical committee

- New membership
- Independent scrutiny and advice to Ministers
- I joined CoRWM in 2009

What is Geological Disposal?

- A nuclear waste repository is an *engineered facility* deep below the ground
  - UK policy is 200 m - 1000 m below surface
  - Uses the waste form, the waste package, specially designed engineered seals and stable geology to ensure safety
  - Provides a high level of long-term isolation and containment without future maintenance

Technology to-date

13 countries currently pursuing geological disposal for a variety of waste types

- 4 sites in operation
- 3 site under construction
- 2 sites have submitted the license application
- Other sites in discussion

Safety Case

- A safety case is a *"formal compilation of evidence, analyses and arguments that quantify and substantiate a claim that the repository will be safe"*. (Nuclear Energy Authority, 2013)
- Early safety cases
  - during site characterisation
  - general assumptions about the host geology and the layout of the repository
- Safety case for authorisation of repository construction
  - sufficient factual detail to provide the necessary confidence for the regulator to determine that the repository will be safe.

Safety case

- Assessed by the independent regulators
- Post-closure safety case
  - examples of crystalline rock, clay rock and salt
- Construction and operational safety case

Environment Agency

An agency of HSE
Office for Nuclear Regulation

Sweden/Finland

KBS3 – Safety concept for fractured granite

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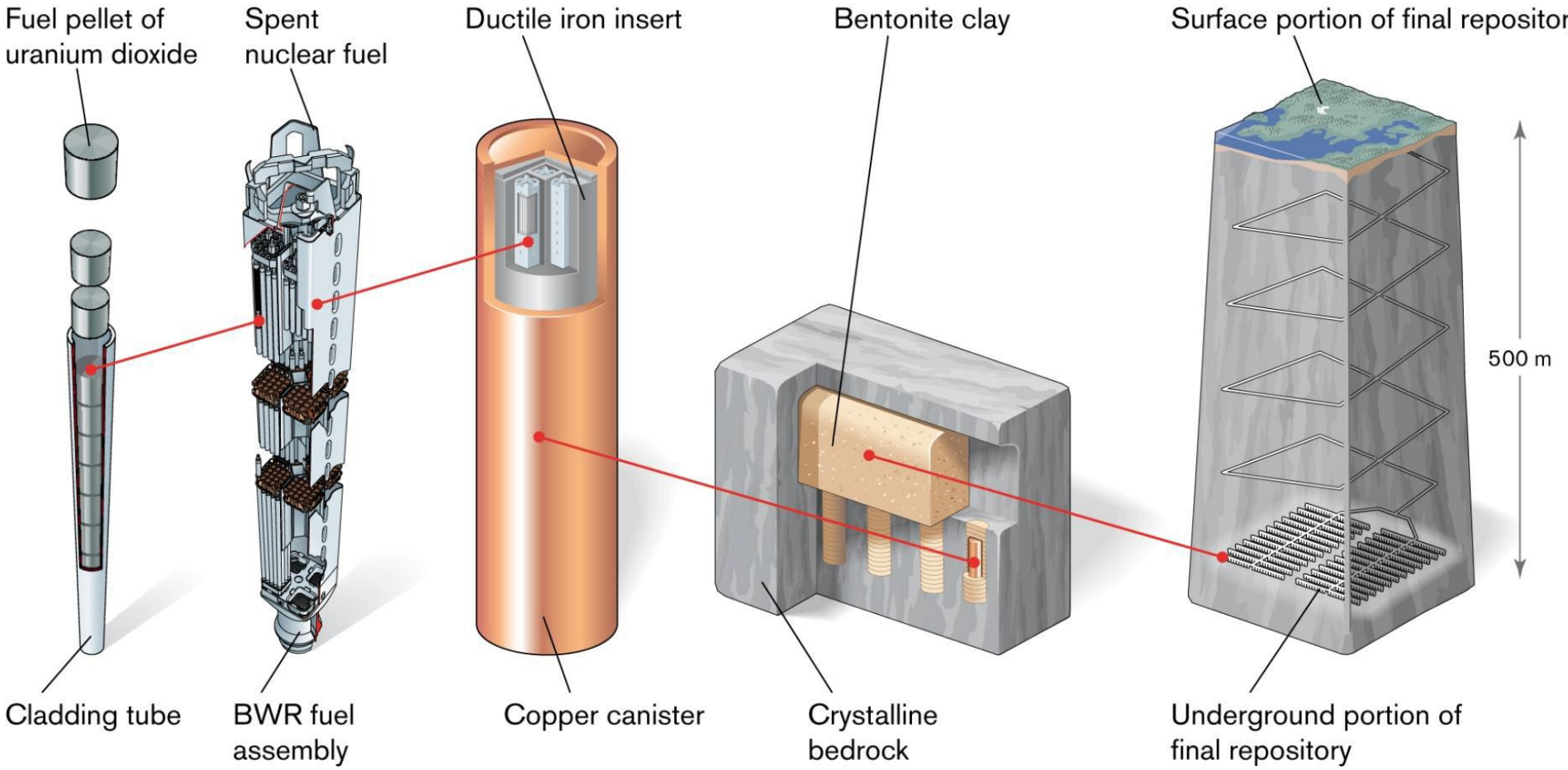
Multi-barrier approach



Sweden/Finland

KBS3 – Safety concept for fractured granite

For spent nuclear fuel

Safety criteria: Annual risk of harmful effects must be less than a one in a million chance

Safety relies on ensuring no radionuclide release from the waste cannister over first million years

- Low flow rates keep stable groundwater chemistries at repository depth – stops breakdown of engineered barriers
- Engineered barriers protect cannisters from earthquakes and from copper corrosion

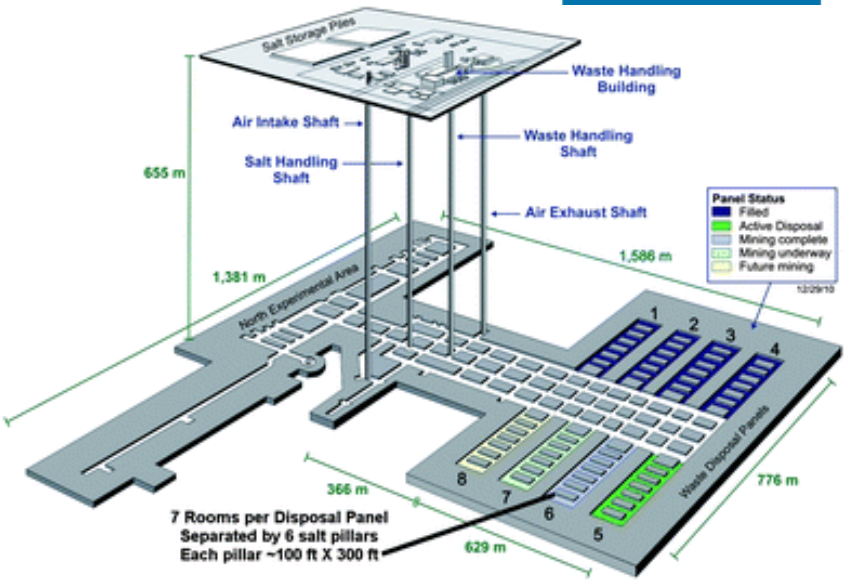
Safety case assumes ***instantaneous*** transport from depth to surface – doesn't rely long times-scales for contaminant migration through fractures

US

WIPP –Operating since 1999 in salt rock

For transuranic waste

Safety criteria: 10,000-year radionuclide containment and isolation of the waste



- Salt 'flows/creeps' so holes (and cracks) in the rock close under the weight of the rock above
- Salt is dry as no holes, but also water is incorporated into the salt
  - mobile phones!
- Water cannot flow hence waste cannot travel to the surface

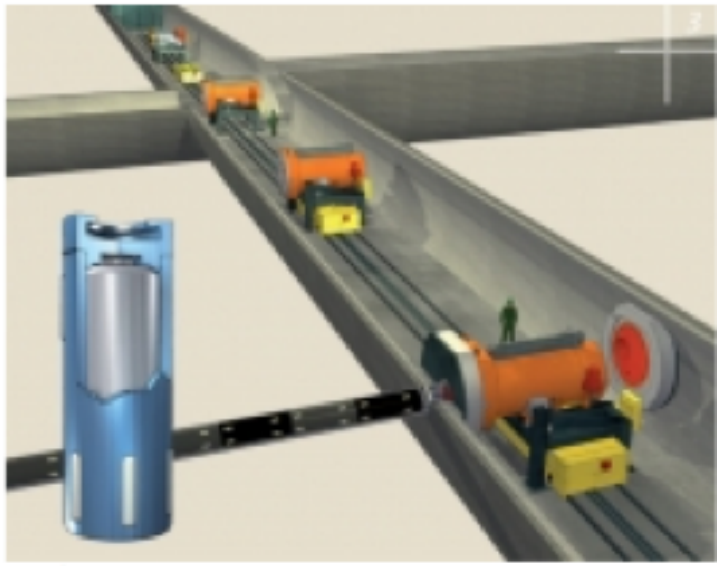
France

Andra - clay rocks

For High Level and Intermediate Level Long-Lived Waste

Safety criteria: "wastes must represent no increased risk for human beings and the environment" *Andra*

- Clay rock very impermeable to water so travel times for radionuclides to reach the surface are extremely long
- Experiments at Bure show fractures heal (close up)
- No conflict with shale-gas due to high clay content



Before being emplaced in disposal cells, HL radioactive-waste packages are conditioned in disposal containers.

UK Siting Process

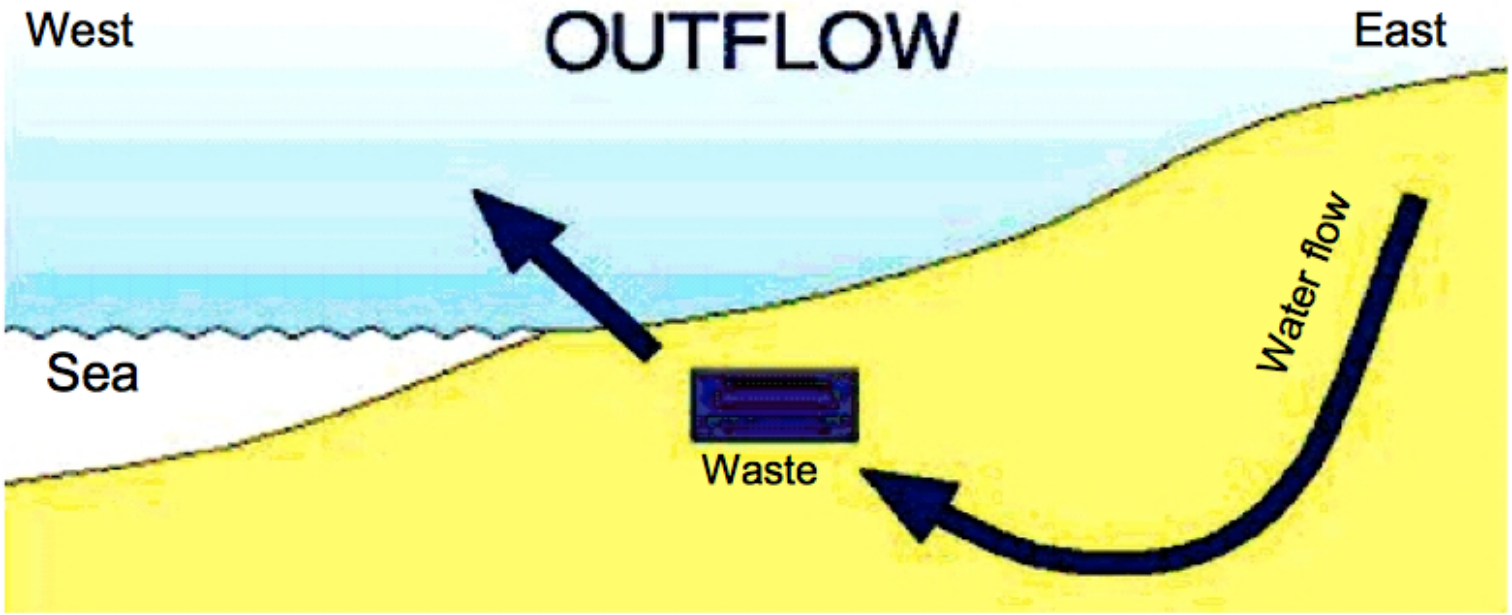
- Volunteer communities
  - Communities first express an interest
  - Local consultation
  - Decision whether to participate
- Community benefits package
- Data (including geology) not gathered until after a community decides to participate

Siting process – 2009 to 2013

- Only Cumbria County Council, Allerdale District Council and Copeland District Council express an interest
- Extensive public consultation through a siting partnership with members from each council
- Moray Poll shows **net support** within each region
- Copeland and Allerdale vote to participate,Cumbria vote against

NGO and Local Campaign Claims

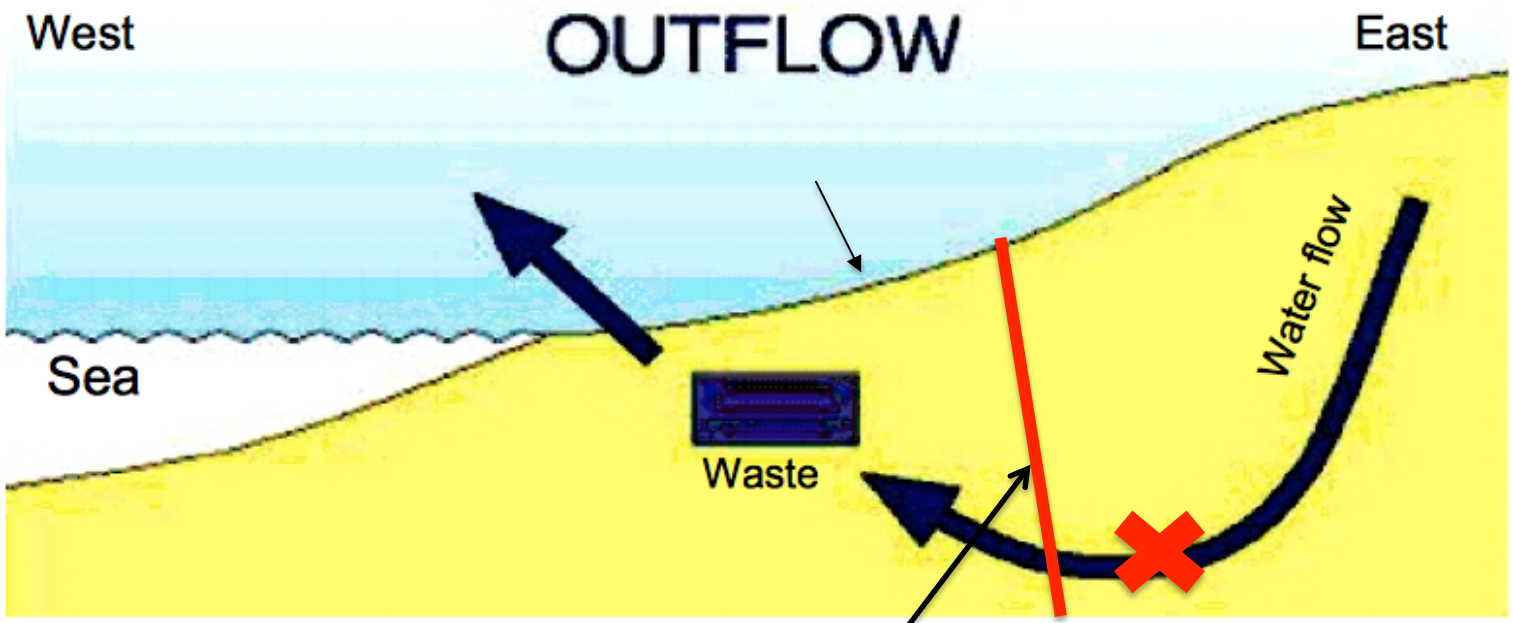
Courtesy of David Smythe's web site



– Claimed geology already known to be *unsuitable*
  - Two geologists presenting evidence for campaigners
  - misleading and simplistic arguments about groundwater flow

NGO and Local Campaign Claims

Courtesy of David Smythe's web site



Lake district boundary fault will divert flow

NGO and Local Campaign Claims

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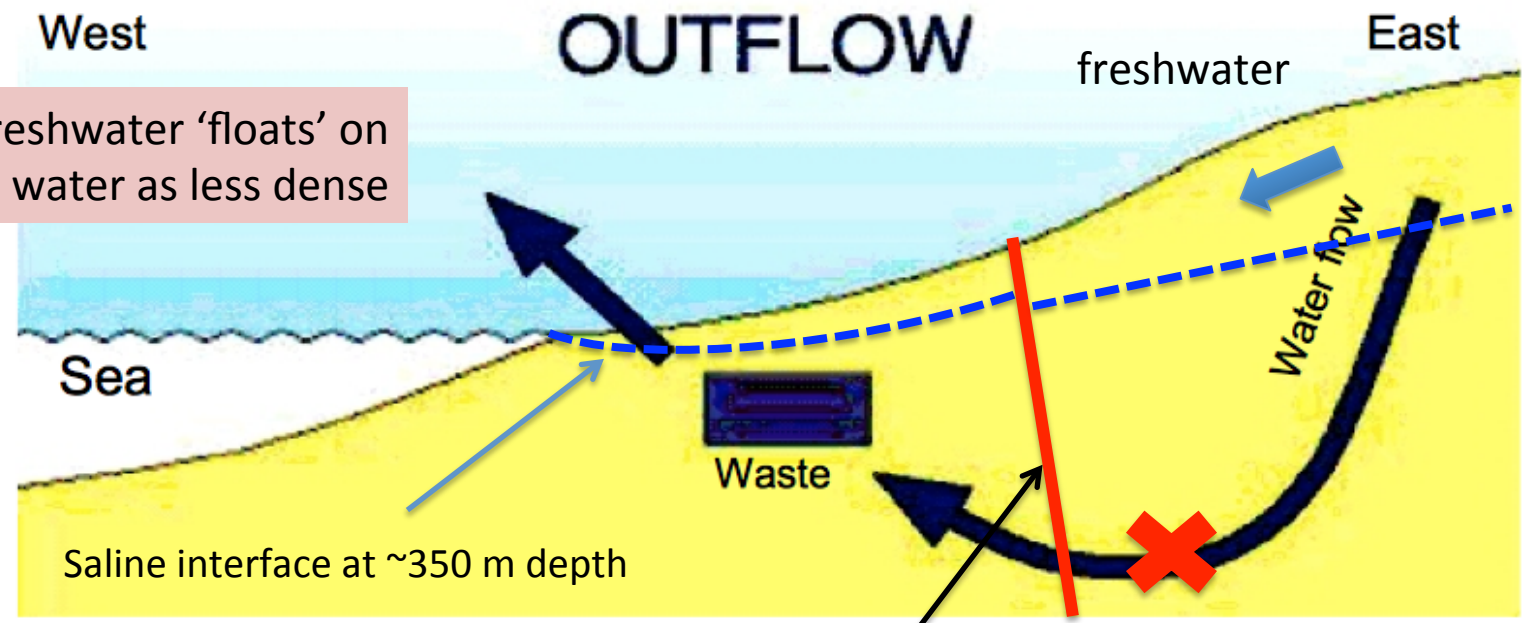

Freshwater 'floats' on salty water as less dense

Lake district boundary fault will divert flow

NGO and Local Campaign Claims

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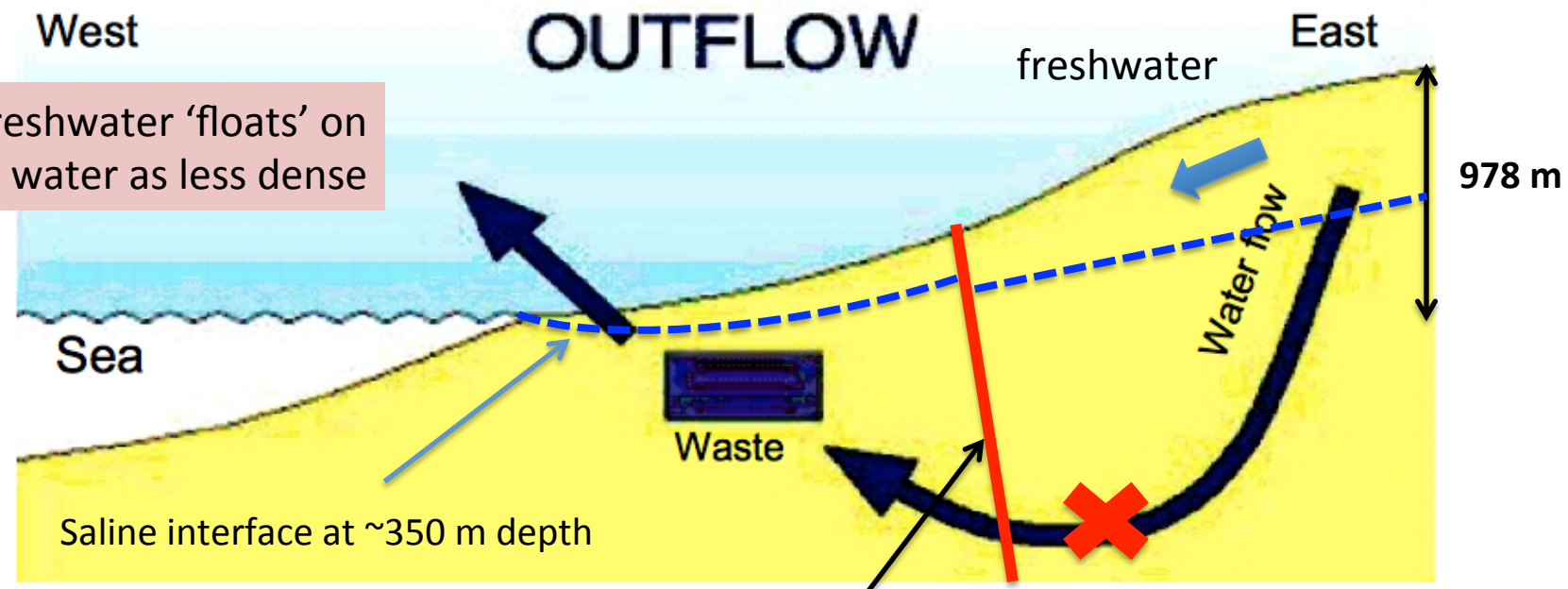

Freshwater 'floats' on salty water as less dense

- Large vertical exaggeration - Scafell Pike ~16km from the sea

Lake district boundary fault will divert flow

No plausible reason to drive flow far below sea level – what is the driving force?

NGO and Local Campaign Claims

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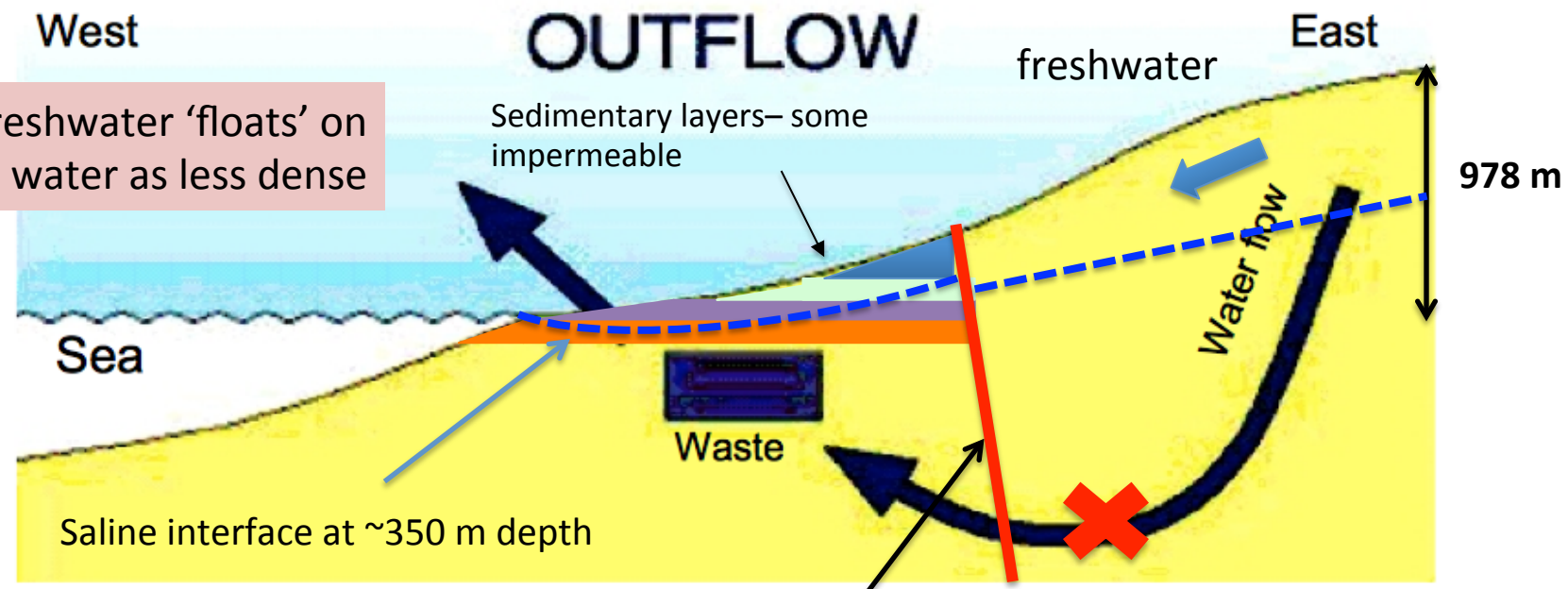


Freshwater 'floats' on salty water as less dense

- Large vertical exaggeration - Scafell Pike ~16km from the sea
- **Layers of permeable and impermeable sediments**

Lake district boundary fault will divert flow

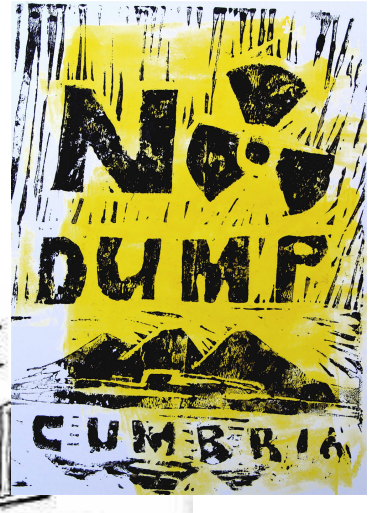
No plausible reason to drive flow far below sea level – what is the driving force?

NGOs and Local Campaign Groups

- Claims that community benefits were a *bribe*
- Claims that government always planned to return to 1995 site

- Anti new-build nuclear power
- '*Nuclear dump*' used by national and local press
  - Even *Costing The Earth (Feb 2014)* Radio 4

Don't forget Moray Poll showed public in favour!



Disclaimer: The following are my personal views and do not represent the views of the CoRWM committee

My views…

- Responsibility to minimise public risk
  - Waste at the surface is vulnerable and more hazardous
- Ethical and moral responsibility
  - Our generation used the energy, so we should pay for the solution

- Future power?
  - A tough choice between energy shortages, nuclear power and climate change
  - Carbon capture and storage technology is unproven at an industrial scale

Lessons-learned

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- News reporters are not experts and simple statements make good headlines

A safety-case takes 10-20 years to build

- Safety arguments are complex and technical
- Public cannot weigh one expert argument against another (**e.g. MMR**)

BUT… International experience shows public support is necessary for success

So how can a geological disposal siting process succeed?

New siting policy development

- Public consultation ended Dec 2013

Some key issues

- Geological screening?
  - Very sparse data at depth
  - Still need volunteers
  - Focus should be safety NOT GEOLOGY

New siting policy development

Some key issues

- *When* do we need net of public support?
  - In Sweden public confidence grew as the safety case was developed

New siting policy development

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Some key issues

- Who should the decision-making body be?
  - Previous process failed to find a site, despite substantial local support

    Copeland - YES 68%, NO 22%

    Allerdale - YES 51%, NO 37%

    Cumbria - YES 50%, NO 35%

- Who should receive community benefits?

How can we engage the public and the press in an ***informed debate***?

For legacy waste at the very least, the UK needs a siting process that delivers


GAZPROM
DON'T FOUL THE ARITIC
CUT
NO
BIOFUEL
ROCs
NO INCINERATOR
SAY NO TO WIND TURBINES
AAWT.ORG.UK
NOT HAPPENING
slaythearray
alliance against the monster
NO
SAVE LAKELAND
NO NUKE DUMP
NO
MAPPERTON
HUGE
SOLAR FARM
GEOLOGICAL
DISPOSAL
SAFE
NO FRACKING IN THE UK
Our Energy Future?!

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