

# **Why West Cumbria is unsuitable for a deep geological nuclear waste facility**

**International aspects**

**Guidelines**

**What other countries do**

**History of search in Britain**

**Up to watershed of 1997 Inquiry**

**West Cumbria**

**Geology of northern Allerdale**

**Political/scientific manipulation**

**Some progress made during MRWS  
consultation:**

**Geology put centre-stage of agenda**

**Arguments reduced to two rock types:**

- **Eskdale / Ennerdale granites (Copeland)**
- **Mercia Mudstone Group (Allerdale)**

**Sellafield** now implicitly ruled out

# Evolution of international search criteria

The following organisations agree or have agreed on the same set of broad principles:

- IAEA (pre Nirex 1995 Inquiry guidelines)
- British Nuclear Fuels Ltd
- IAEA – new guidelines 2011
- European Union
- British Geological Survey
- Finnish Geological Survey

None of them put voluntarism ahead of a systematic geological search.

# Search practice abroad

# Geological search for a waste repository

Abroad:

Geology sorted before community involvement :

- Belgium
- Canada
- Finland
- France
- Sweden
- Switzerland
- USA

The 2008 White Paper misleads on:

Sweden and Finland

# Summary of fundamental criteria

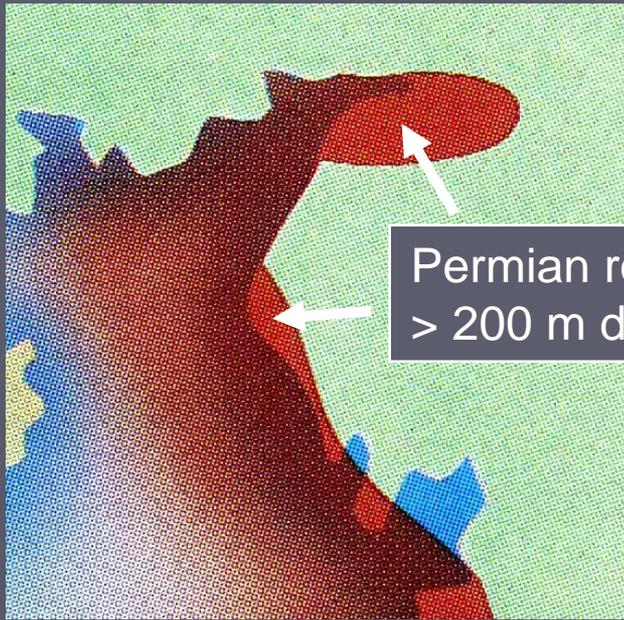
Drawn from research, experience and recommendations here and abroad since the early 1990s:

- The host rock is NOT so important at the first stage.
- The regional setting of the site IS most important.
- Long geological stability.
- Low hydraulic gradients.
- Simple geology.
- Suitable geology precedes community assent / veto.

**Every locality in West Cumbria has a problem with several of these.**

# **History of UK site search up to 1997**

# Nirex 1987: *The Way Forward*



Permian rocks at > 200 m depth

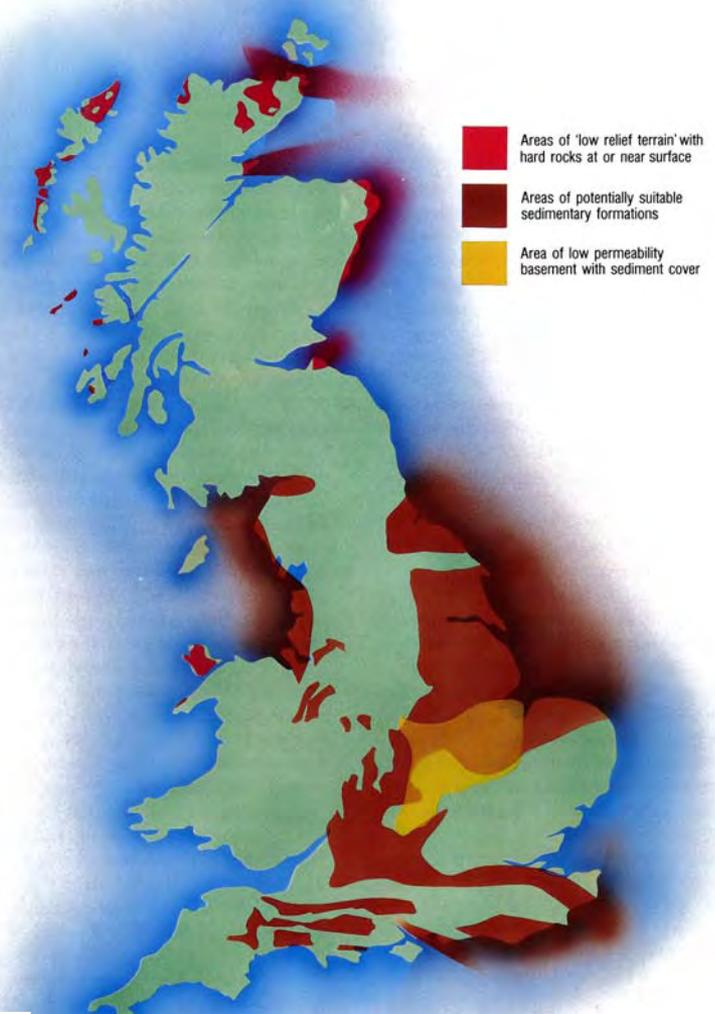
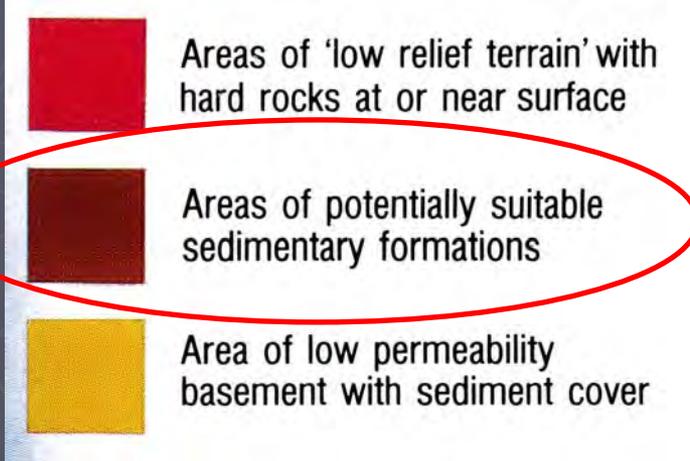


Figure 5.4 Base map showing geological environments considered to have potential for repository development.

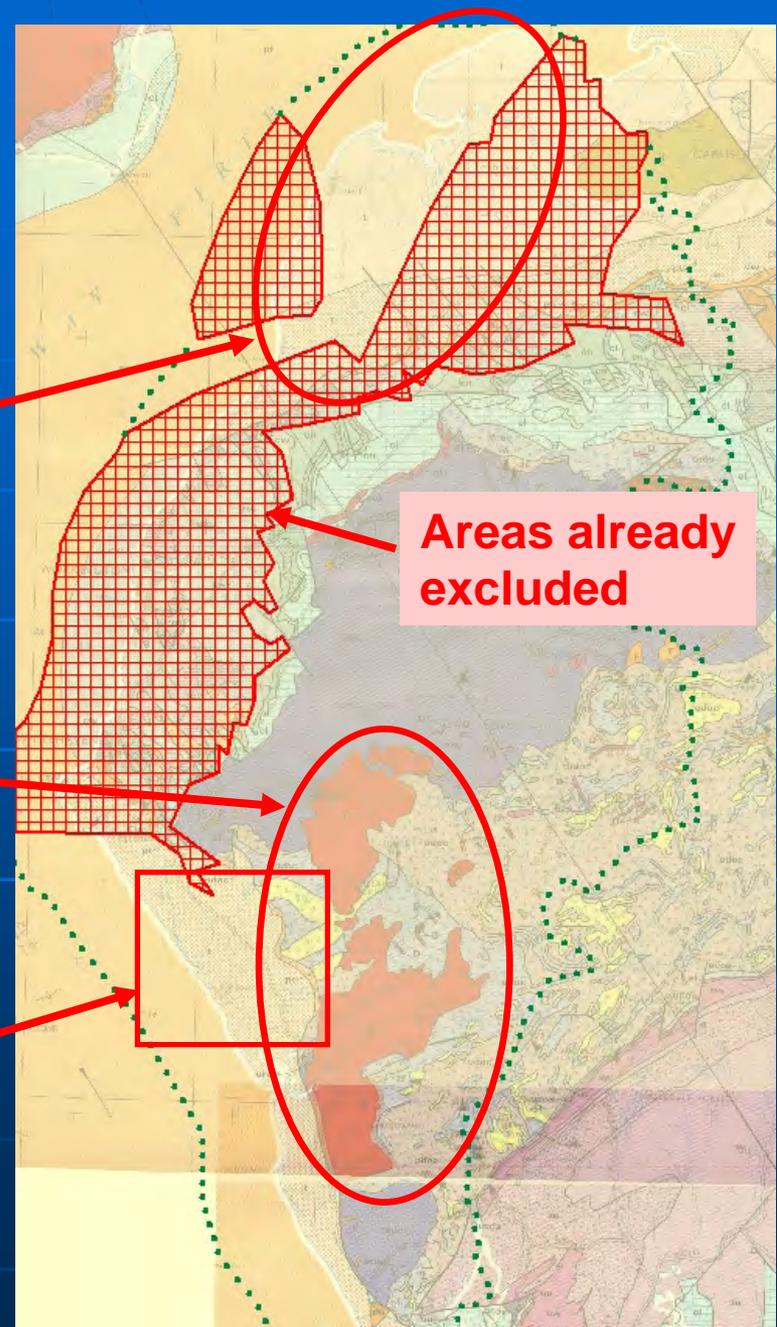
**Sediments were the only suitable formation identified in Cumbria**

# Geology of the areas left in play

Northern Allerdale –  
the Mercia Mudstone  
Group

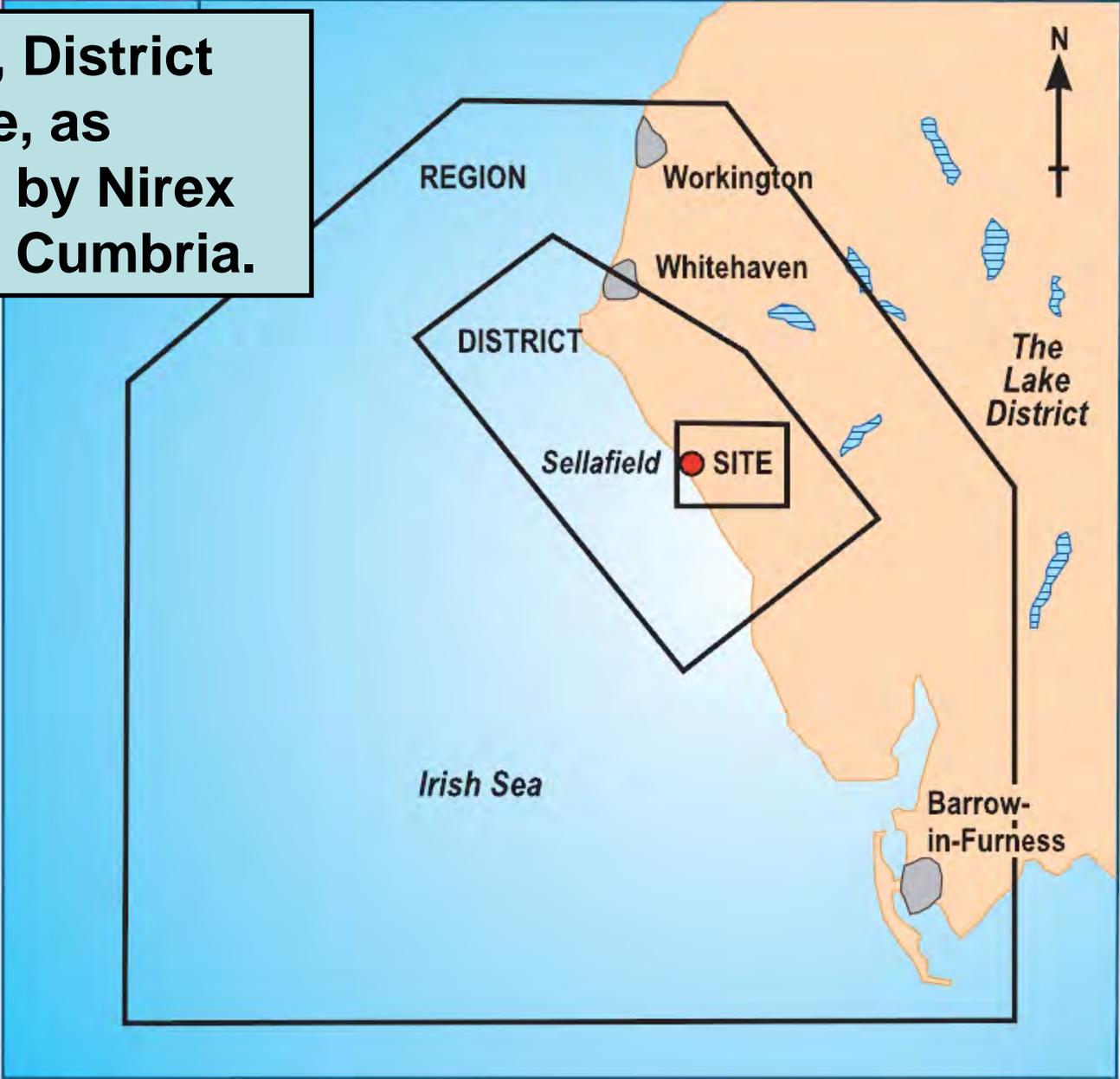
Eskdale and Ennerdale  
granites (red areas)

Sellafield / Longlands Farm  
(ancient history or not?)

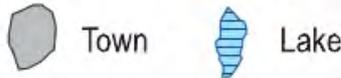


**Region, District and Site, as defined by Nirex in West Cumbria.**

**Site and repository pre-selected - but whole region now very well-understood**



Key



**Systematic search  
(international search guidance)**



CUMBRIA

North of Workington to south of Barrow - inland to Ulverston.



NIREX 1  
REGION

Whitehaven to Ravensglass and offshore 10km.



NIREX 2  
DISTRICT

Sellafield Worthy - Seascale and Gosforth.



NIREX 3  
SITE

Longlands Farm, Gosforth.



NIREX 4  
PROPOSED  
REPOSITORY  
ZONE



**Directions of Nirex studies**

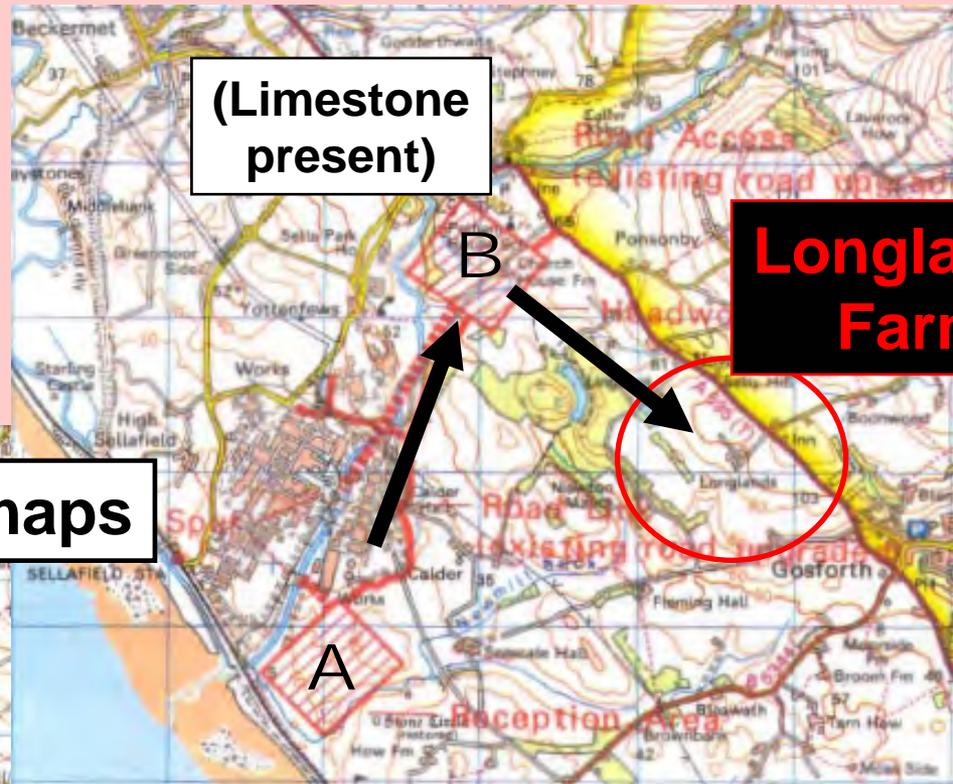
Thanks to Marianne Birkby

**Sellafield  
Longlands Farm  
Host rock:  
Borrowdale Volcanic Group**

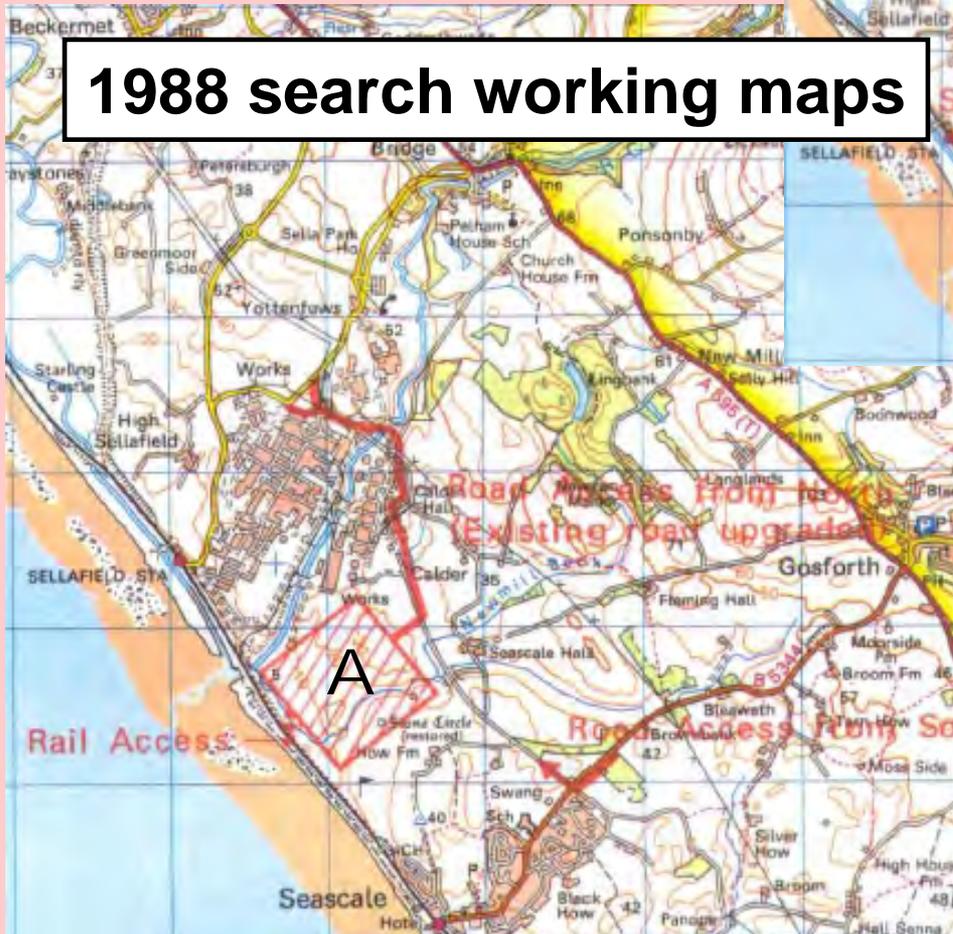
- **£400M spent**
- **Rejected by Inquiry**

**Can it be revived?  
What lessons can be learned?**

Site search:  
 'Coastal sediments'  
 at Sellafield  
 morphed into a  
 'BUSC variant'.



1988 search working maps



361	North Rona	Small island	A	420	Salisbury Farm	Ex-AOS inland	D
362	Norton Barracks	Inland	A	421	Samphrey	Small island	B
363	Norton Manor Camp	Inland	A	422	Sanda	Small island	B
364	Nuneaton	Inland	A	423	Sandhurst	Inland	A
365	Oakington	Inland	A	424	Sandray	Small island	G
366	Odiham RAF	Inland	A	425	Scalpay	Small island	B
367	Ogborne St George	Inland	A	426	Scampton RAF	Sedim. inland	C
368	Oigh Sgeir	Small island	F	427	Scarba	Small island	A
369	Old Dalby	Inland	A	428	Scarp	Small island	A
370	Old Park Barracks	Inland	A	429	Scor	Ex-AOS coastal	D
371	Old Sarum	Inland	A	430	Seathorpe USAF	Sedim. inland	E
372	Oldbury	Ex-AOS coastal	D	431	Sealand Range	Coastal	A
373	Ollerton	Sedim. inland	C	432	Seighford	Inland	A
374	Orfordness	Coastal	A	433	Sellafield (-A)	Sedim. coastal	H
375	Ornsay	Small island	A	434	Sennybridge	Ex-AOS inland	D
376	Ornsay	Small island	B	435	Shawbury	Inland	A
377	Osgodby Moor	Sedim. inland	F	436	Shellingford Afd	Inland	A
378	Ossington Afd	Sedim. inland	B	437	Shiant Islands	Small island	B
379	Otmoor	Inland	A	438	Shoeburyness	BUSC coastal	F
380	Otterburn	Ex-AOS inland	D	439	Shrivenham	Ex-AOS inland	C

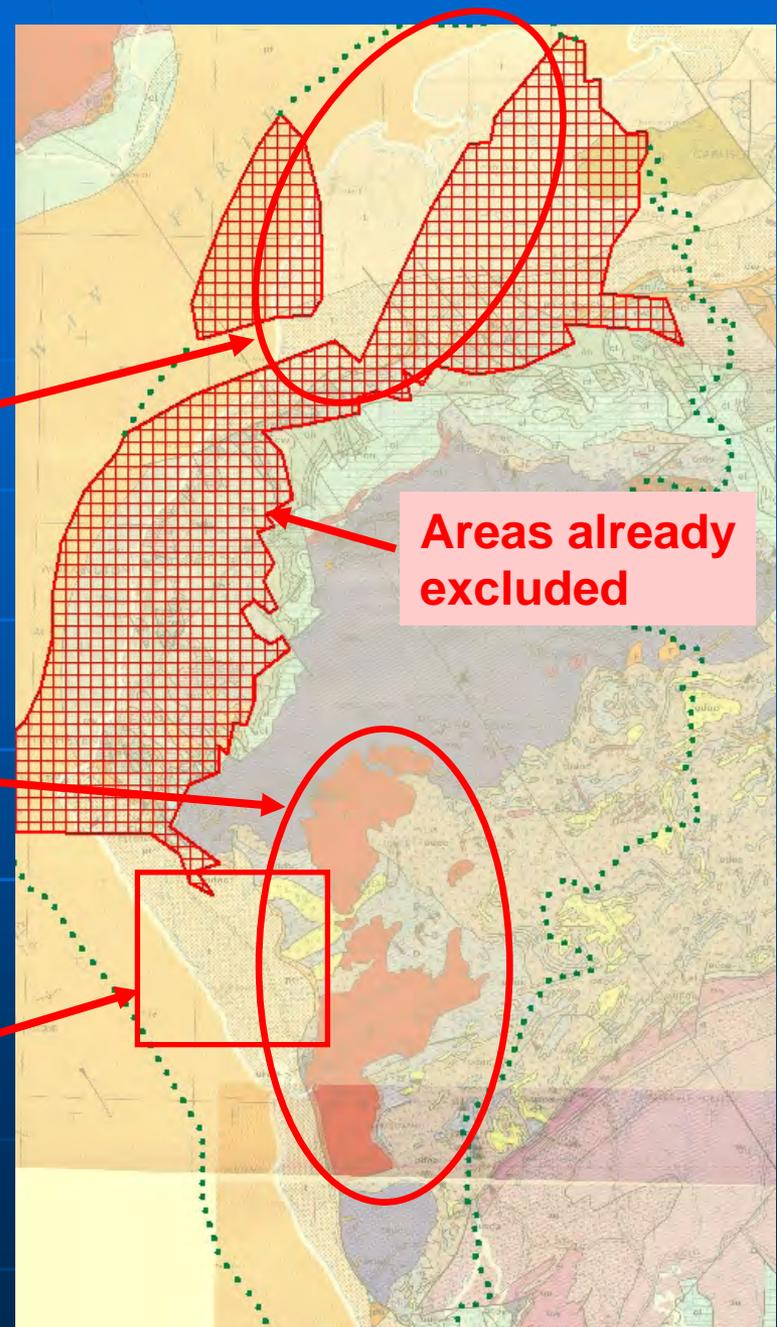
List of 437 UK potential sites

# Geology of the areas left in play

**Northern Allerdale –  
the Mercia Mudstone  
Group**

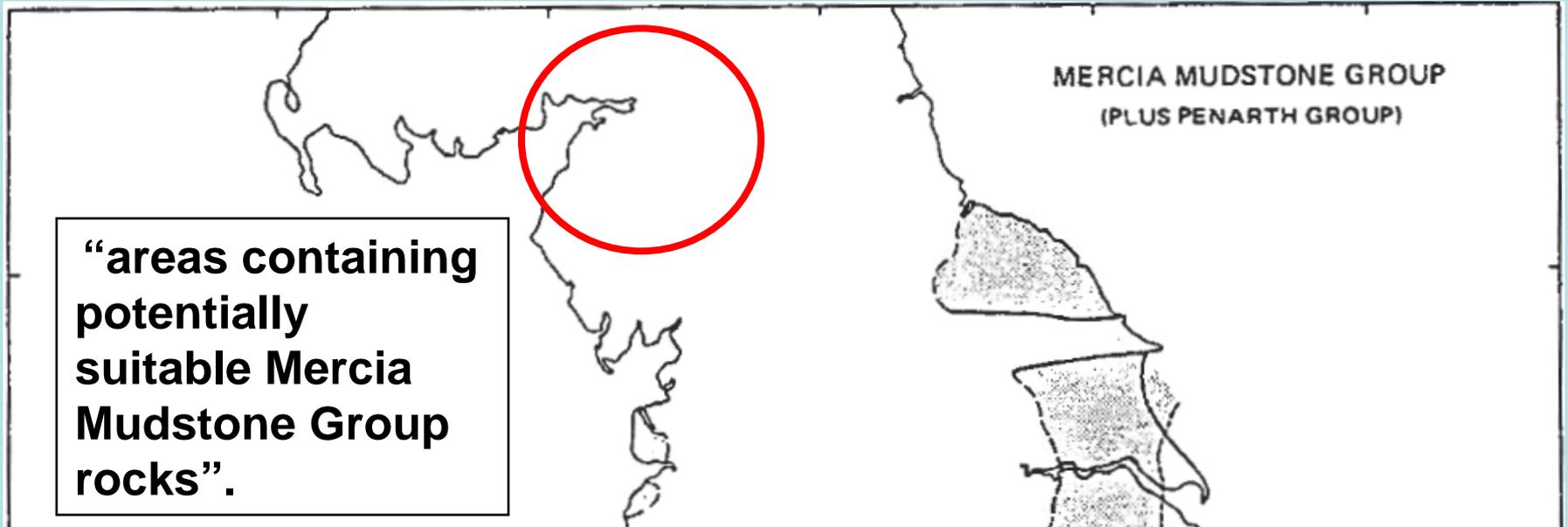
**Eskdale and Ennerdale  
granites (red areas)**

**Sellafield / Longlands Farm**



The MMG in Cumbria was excluded by the BGS as a potential host rock during the 1980s national search

# Details from the BGS review of 1986

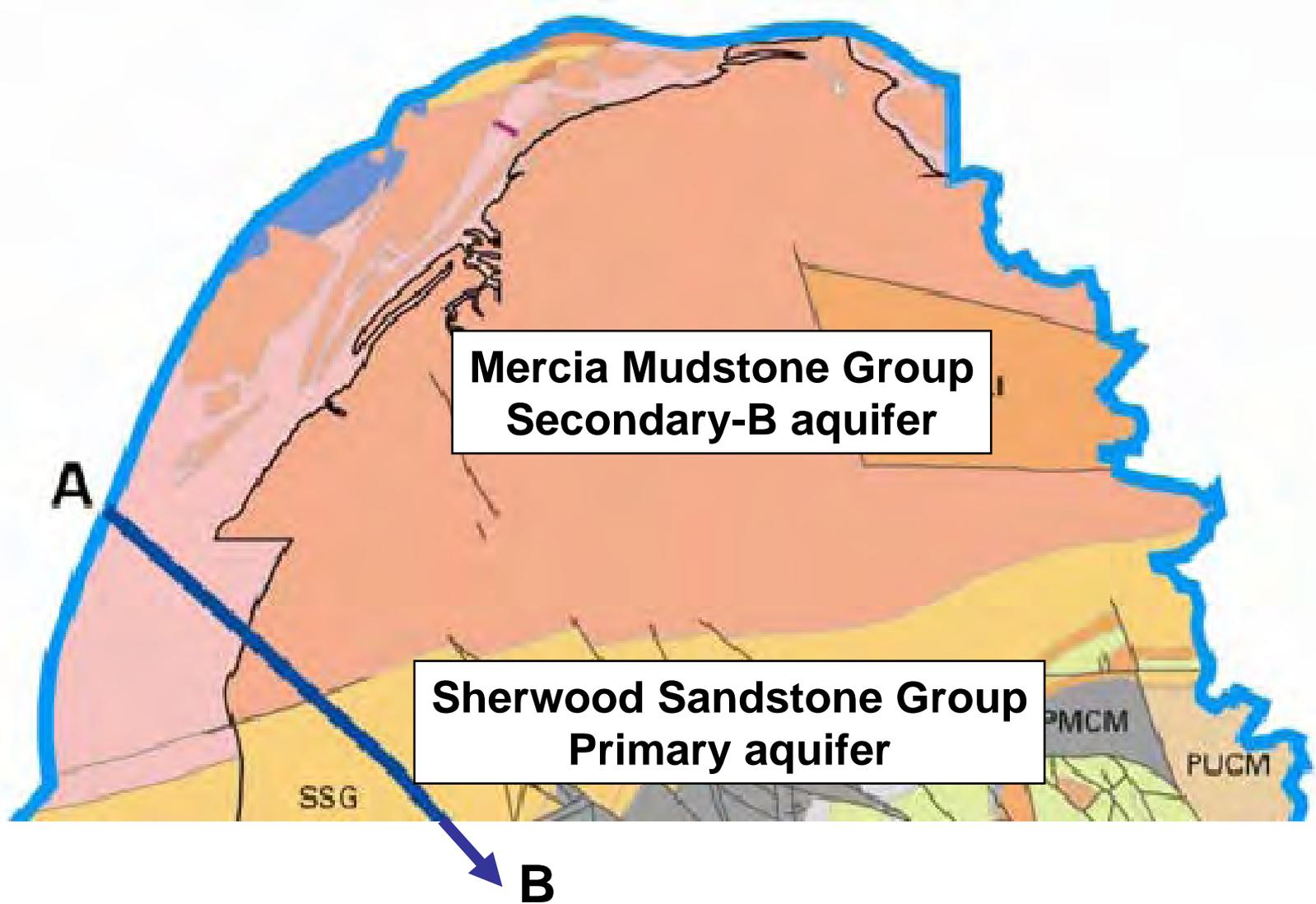


Dr Dearlove:

“Figure 2.1.1 (b) in Smythe's submission identifies **the area including the MMG** as "areas of potentially suitable sedimentary rocks" following Dr Chapman's 1986 review. Whilst an assessment **may have been made at the time** to remove this area from the search for potentially suitable sites, **additional data have since been acquired** that may, or may not, change that view. These data need to be assessed.”



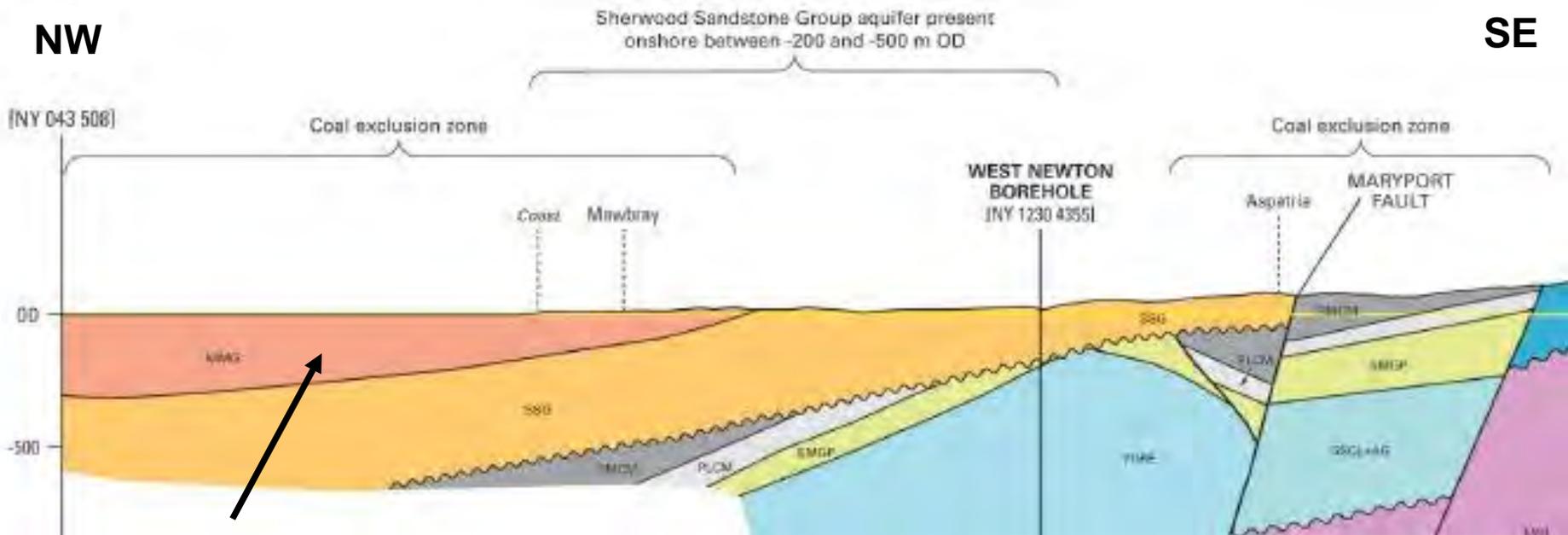
Detail of map from *The Way Forward* (Nirex, 1987), based on the BGS national search of the mid 1980s



**Sediments of northern Allerdale  
A cross-section along line AB is shown in the next  
figure.**

NW

SE



Mercia Mudstone Group

Cross-section: Aspatia to Solway Firth

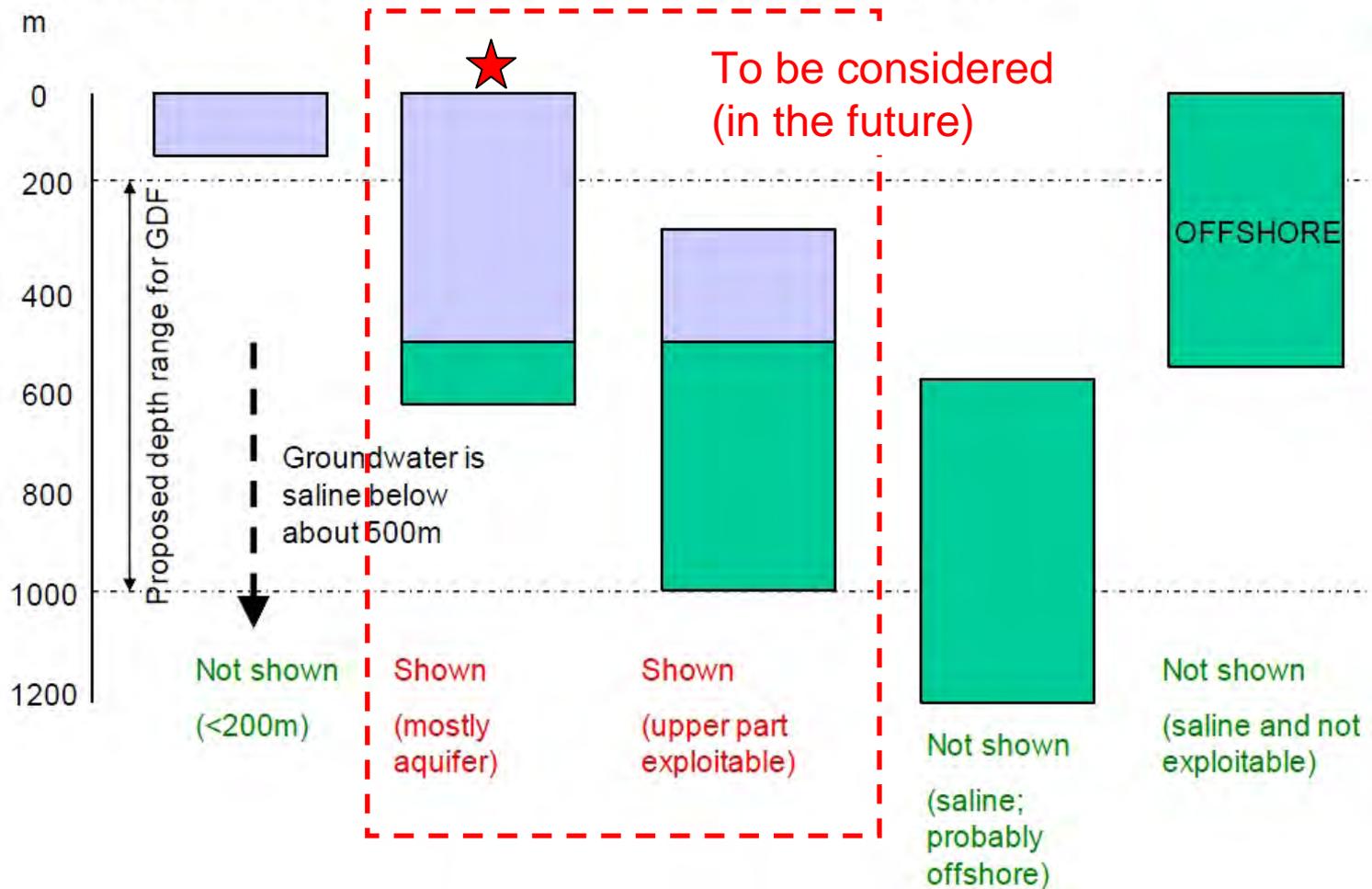
Mercia Mudstone Group

- Not previously considered as a host rock by the BGS.
- A site at Anthorn airfield was considered and rejected in 1988.
- Dr Dearlove (MRWS) has introduced the MMG: ***"I understand from brief discussions with the BGS that the Mercia Mudstones within this area would also form part of the BGS's "potentially suitable sedimentary formations"."***

**So the MMG is in play on the basis of hearsay.**

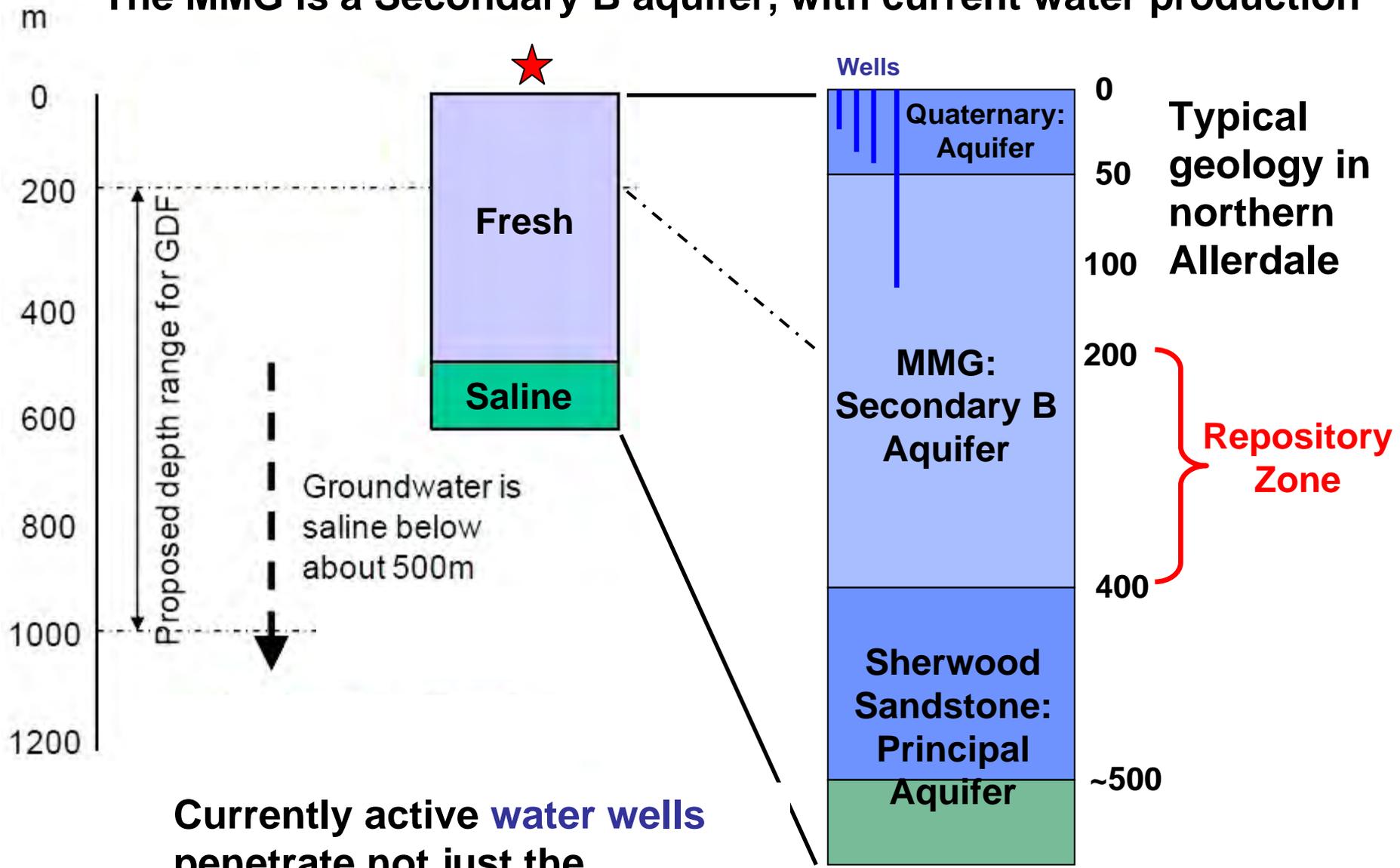
The MMG is an aquifer

# Illustrations of where 'aquifer' is marked in Figure 13 in BGS screening report

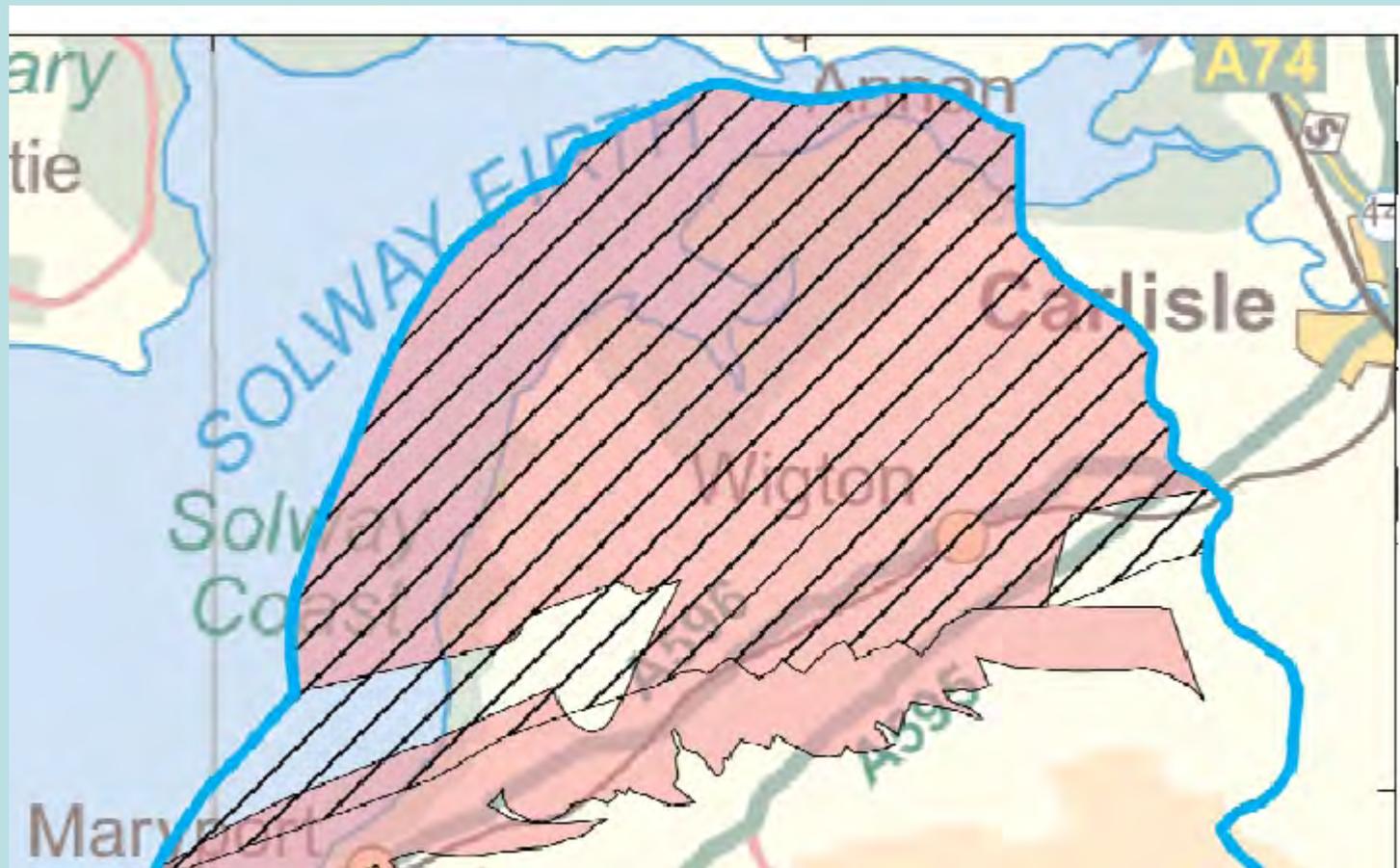


Slide from Adrian Bath: 2011 MRWS geology seminar. In the BGS screening report the MMG is not included in the category of aquifers.

# The MMG is a Secondary B aquifer, with current water production



Currently active **water wells** penetrate not just the Quaternary, but also the MMG to more than 100 m depth.

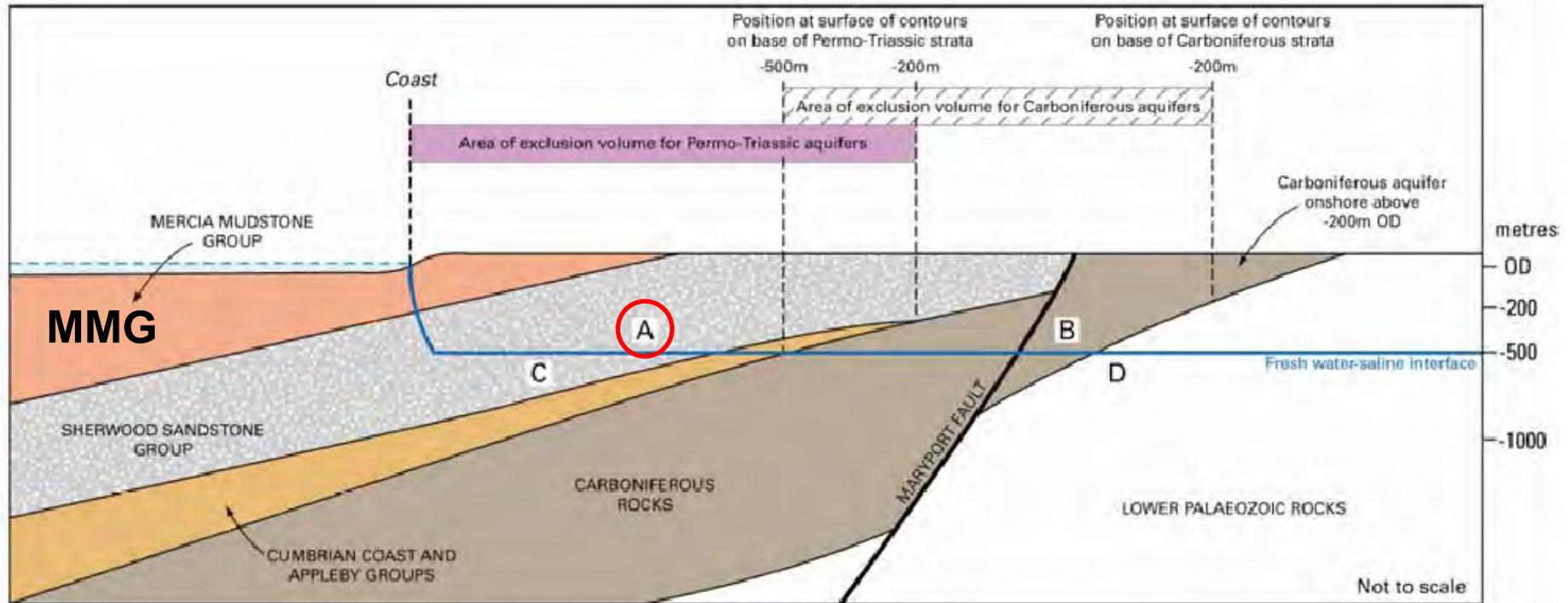


(Oil and gas, coal, etc.)

**BGS draft screening report, July 2010: all of northern Allerdale is completely excluded (minerals), AND partially excluded (groundwater).**

NW

SE

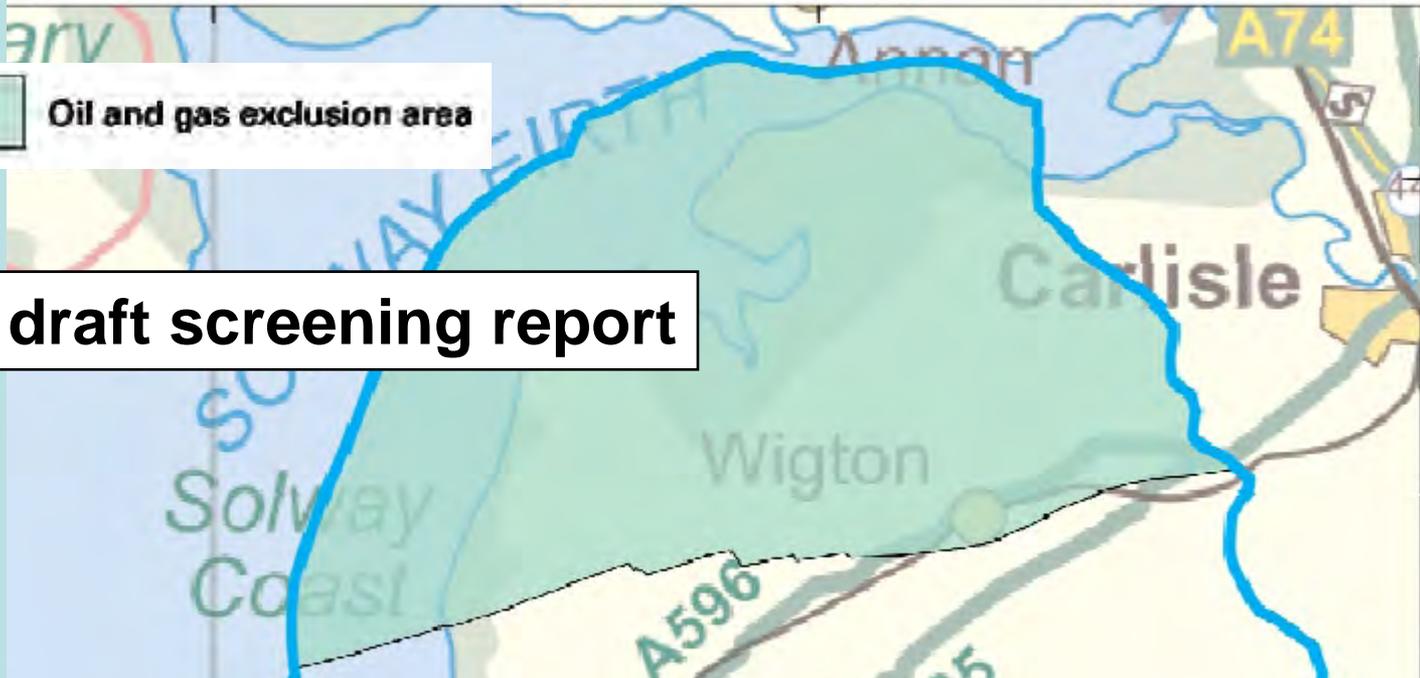


**BGS screening report:**

**Volume **A** of the Sherwood Sandstone is excluded.**

**But since the MMG is an aquifer it must also be excluded**

The MMG is in an  
oil and gas  
exploration  
province



 Oil and gas exclusion area

**BGS draft screening report**

Criteria	To be applied as exclusion criteria (Y/N)?	Reasons/explanations and qualifying comments (from Table B1, Defra, 2008)	Assessment of the geology of the Partnership area judged against the criteria
<b>Natural resources</b>			
Coal	Yes	Intrusion risk to depth, only when resource at >100m depth	Includes areas of the Cumbrian (Workington/Whitehaven) Coalfield and Coal Measures, at depth, in the Solway Basin
Oil and gas	Yes	Intrusion risk to depth	Known oil and gas fields lie to the south of the area [check Solway Basin]; some areas of the Sherwood Sandstone, at depth, might be regarded as prospective

**Table B1:** Summary table of initial sub-surface screening criteria

	To be applied as exclusion criteria?	Reasons/explanations and qualifying comments
<b>Natural resources</b>		
Coal	Yes	Intrusion risk to depth, only when resource at >100m depth
Oil and gas	Yes	Intrusion risk to depth

Defra White Paper 2008 – the only mention of oil and gas

Refers to **JOINT REPORT OF THE CRITERIA PROPOSALS GROUP (CPG) AND THE CRITERIA REVIEW PANEL (CRP)**

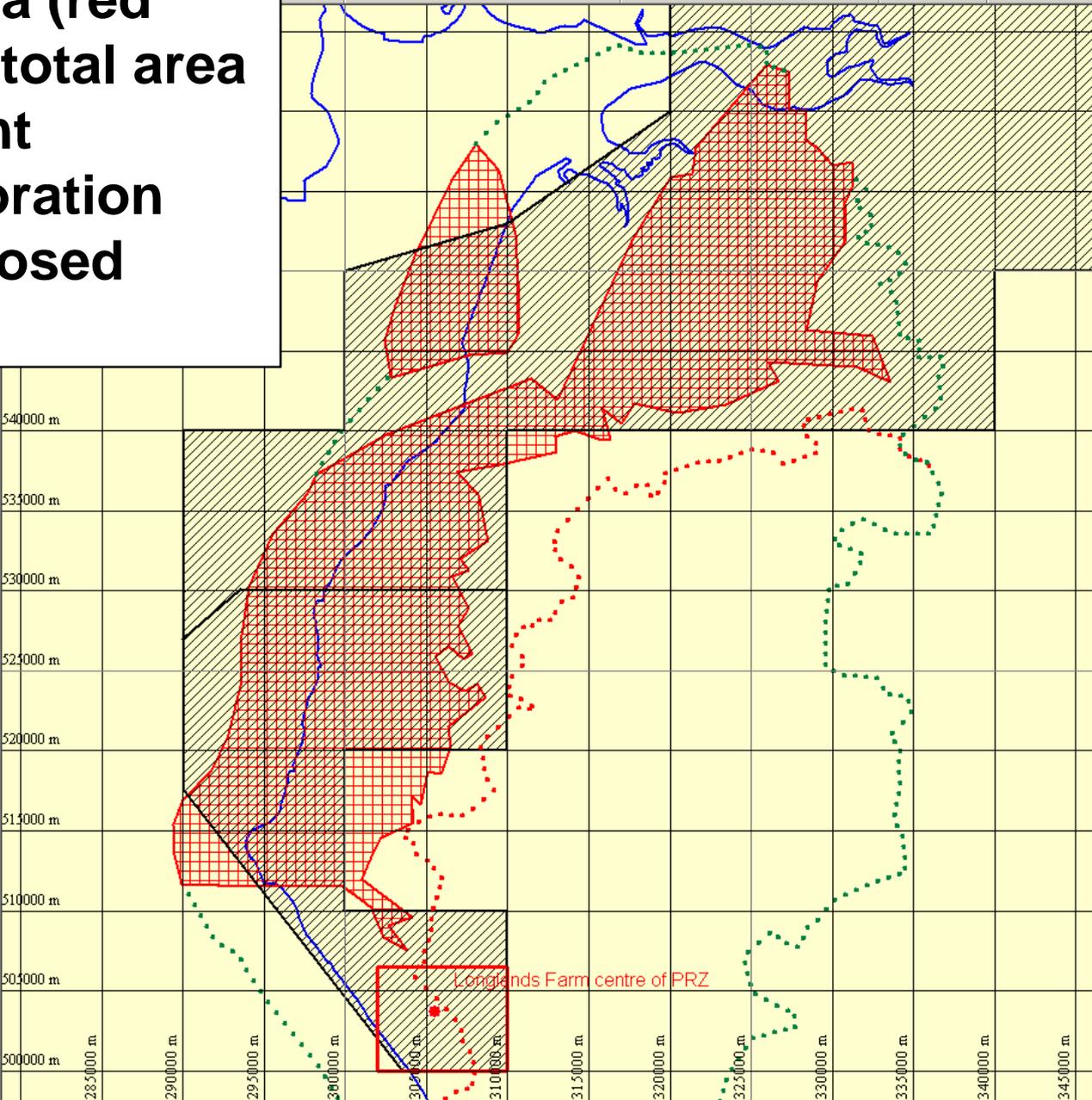
## JOINT REPORT OF THE CRITERIA PROPOSALS GROUP (CPG) AND THE CRITERIA REVIEW PANEL (CRP)

### (b) Oil and gas

The UK has been thoroughly explored for gas/oil resources, many oilfields have been developed and their distribution is well known. **The extent of future exploration and exploitation is difficult to judge and will be dependent on market prices for oil and development of new theories on oil genesis/traps that might lead to novel areas being explored in future.**

It is not feasible to predict possible future exploration areas for exclusion but it is appropriate to exclude areas from consideration based on the extent of known oil and gas fields. **It is the risk of intrusion into the repository in conjunction with the loss of future oil and gas resource that is addressed by this exclusion.**

**So the BGS draft screening report was correct to exclude northern Allerdale**



**BGS exclusion area (red hatching) with the total area of former or current hydrocarbon exploration licences superimposed (diagonal ruling).**

**So why have rational groundwater and oil/gas exclusions not been consistently applied?**

# Is the MMG well understood?

Dr Dearlove (MRWS) claims that the area still needs to be assessed – and by the BGS

# Survey data required to scope out the Mercia Mudstone Group in Allerdale

## 2D seismic programme:

100 km onshore, mainly following roads

Cost: **£800,000**

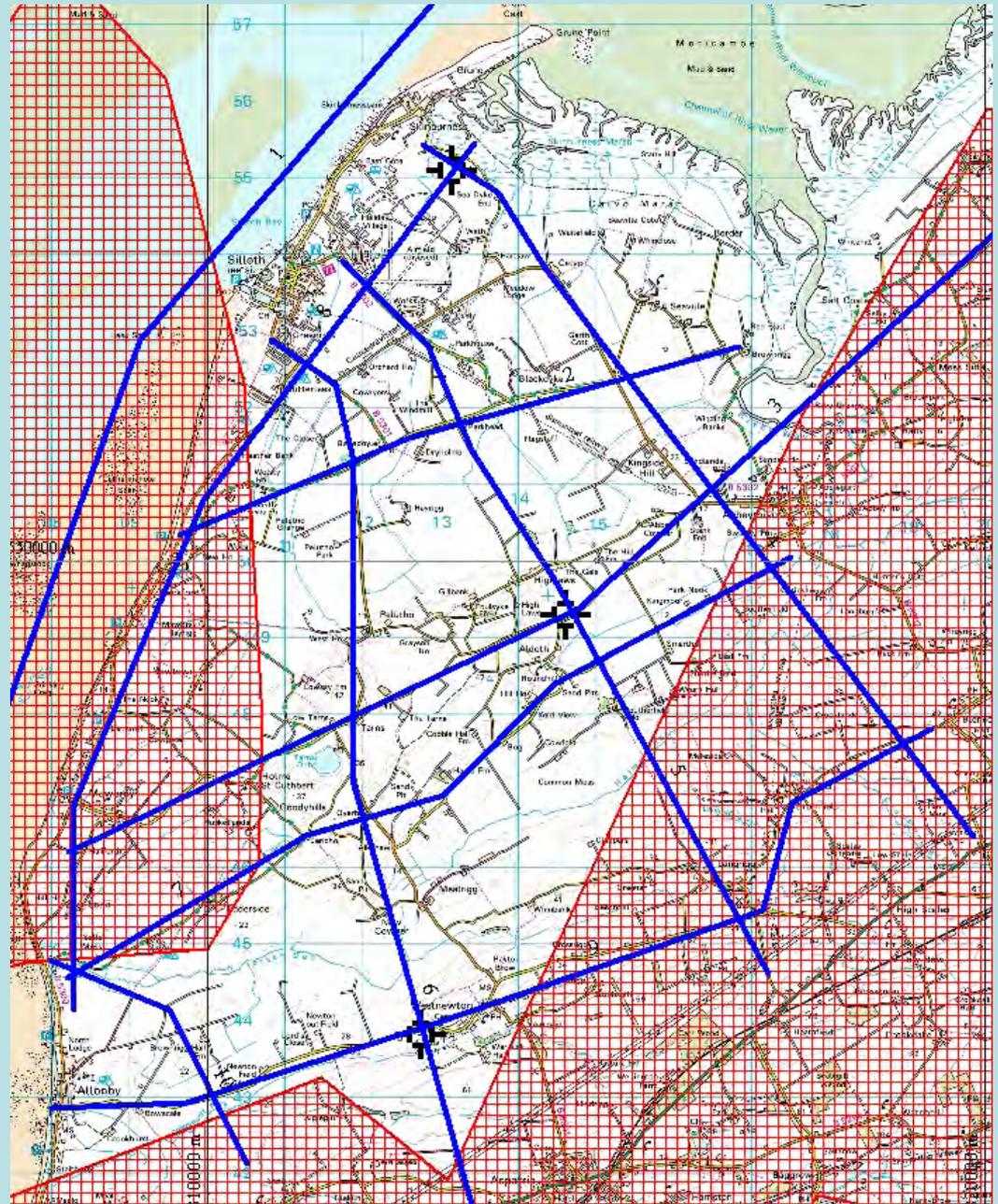
+ 15 km offshore  
(? If opportune: **£25,000**)

## Three boreholes to 500 m:

Fully cored and logged

Cost: **£1,500,000**

**Total cost (incl. interpretation): c. £2.5M**



# Existing survey data over Mercia Mudstone Group in Allerdale

## 2D seismic data:

More than 150 km onshore  
+ many km offshore

## Boreholes:

*Abbeytown* (1876)  
Geology available to 311 m

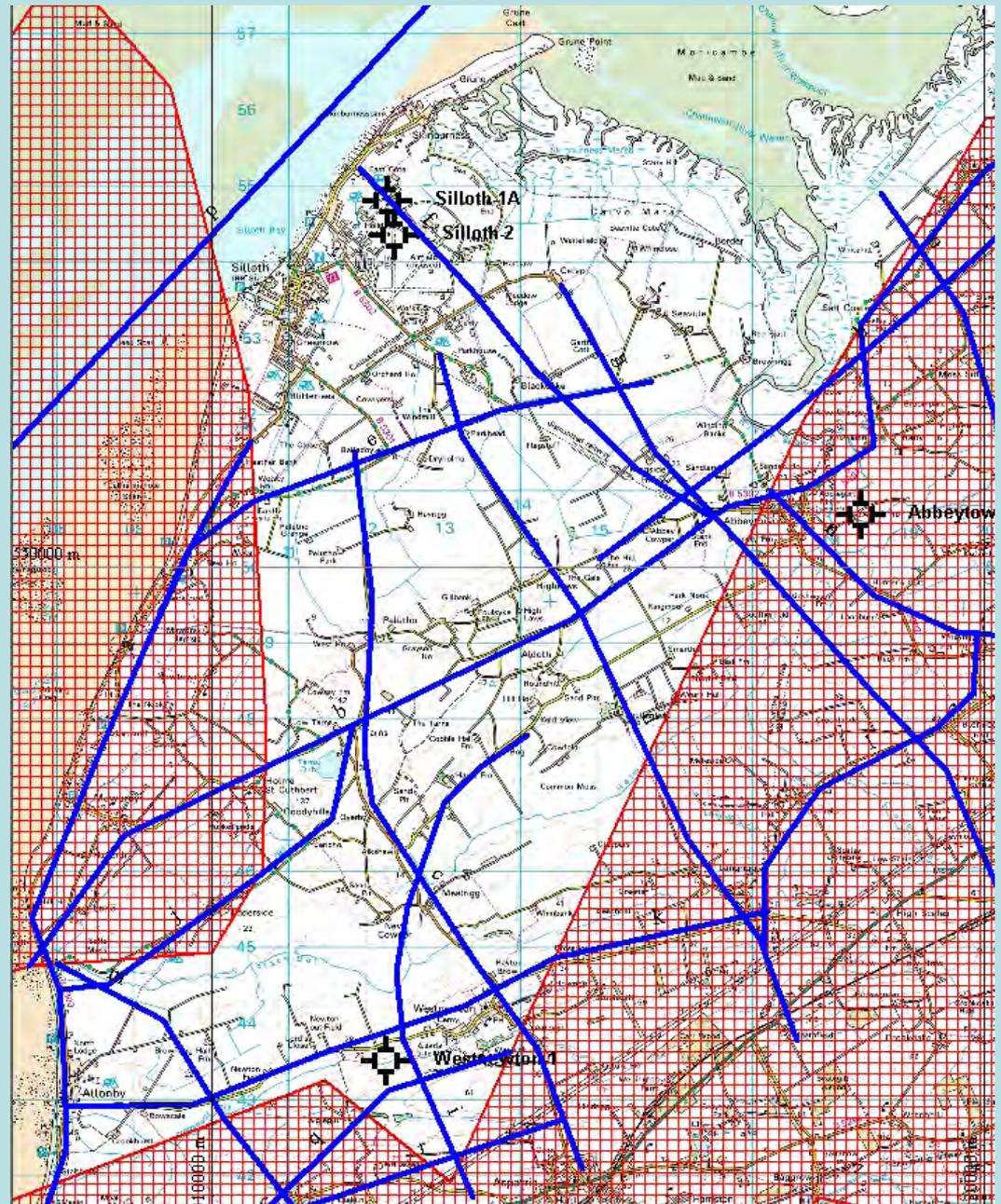
*Silloth-1A* oil well (1973)  
Fully logged to 1330 m.

*Silloth-2* geothermal well (1982)  
Fully cored and logged to 351 m.

*Westnewton-1* oil well (1983)  
Fully cored and logged to 1976 m.

+ several water wells into MMG, plus  
gravity and aeromagnetic maps etc.

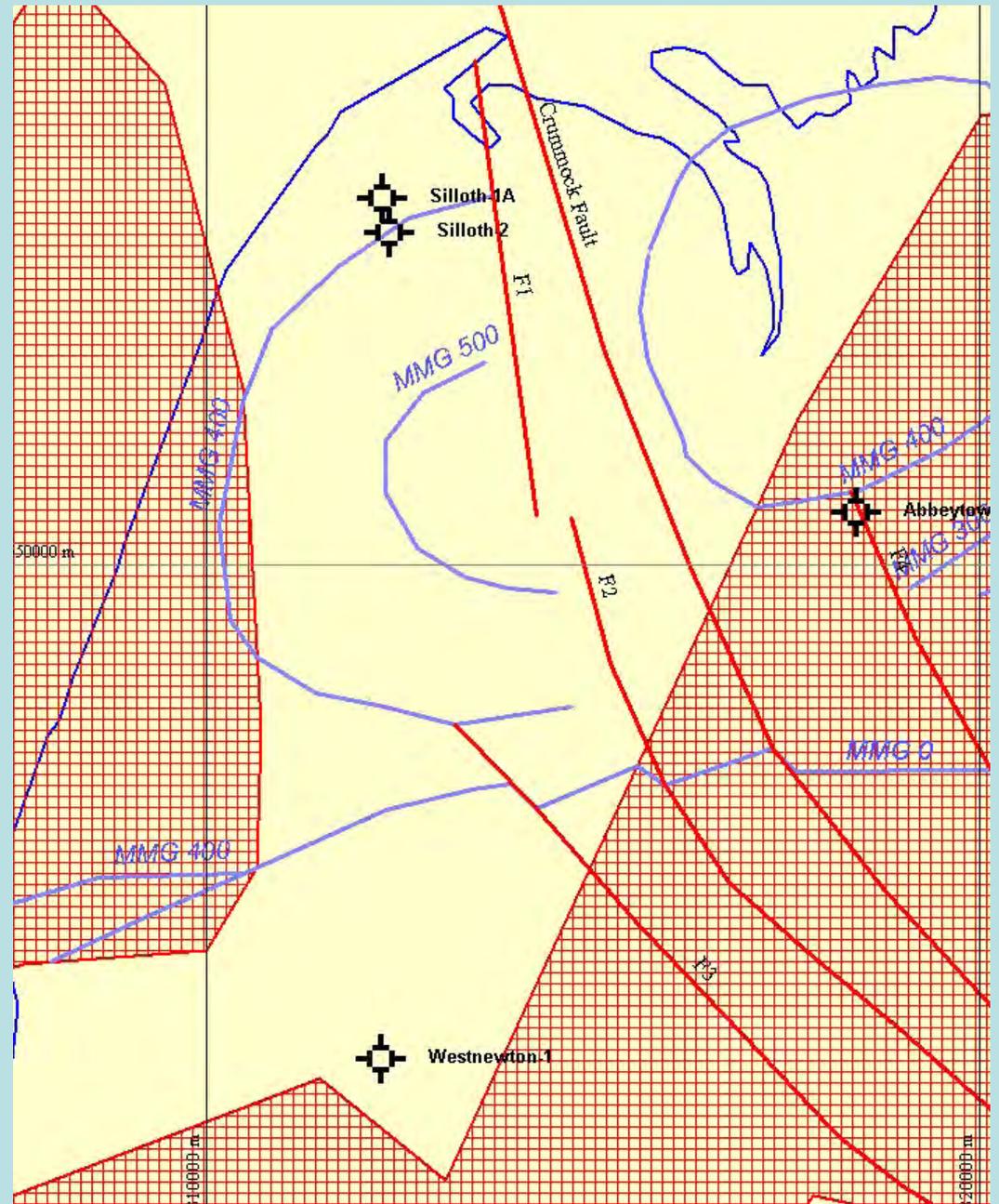
**- All interpreted and  
published by BGS before  
the 1986 national search**



Results known in time  
for the 1986  
assessment and  
**published by BGS:**

- Simple shallow basin
- Cut by large faults

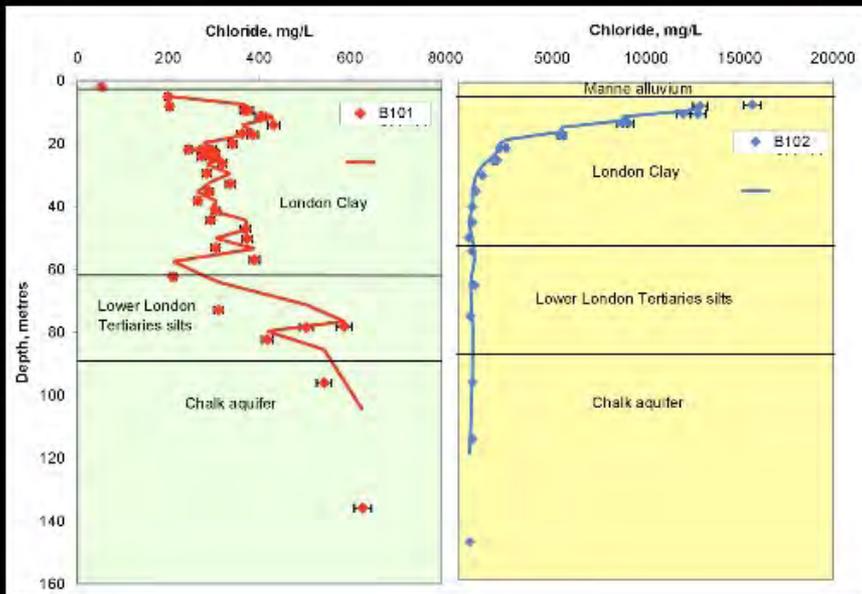
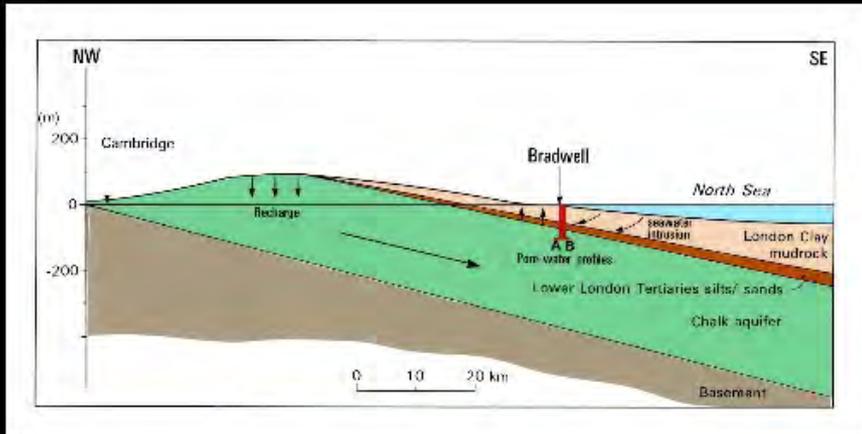
So the geological  
structure is simple, but  
fundamentally  
unsuitable



Is the MMG a good clay  
rock?

From David Savage, 2006

# The move to clay



- Internationally, there is a developing preference for clay host rocks:
  - *diffusion-controlled transport;*
  - *self-healing fractures,*
  - *preservation of past evolution;*
  - *'explorability'.*
- UK researchers developed many of the concepts and methodologies currently being applied at clay sites elsewhere.
- *However*
  - *there is a 20-year gap in our own knowledge base;*
  - *EBS designs must be tailored accordingly.*

Graphics courtesy Adrian Bath (BGS ©NERC)

## Highways Agency report on UK clays, 2006

*“strata considered to behave as ‘**stiff plastic clays**’ are generally of Jurassic age or younger. These include, for example, the*

- *Upper Lias Clay,*
- *Oxford Clay,*
- *Weald Clay,*
- *Kimmeridge Clay,*
- *Gault Clay and*
- *London Clay.*

*Older mudrocks of Triassic and Carboniferous age, such as the **Mercia Mudstone**, are usually too **indurated to be considered as clays.**”*

# Mercia Mudstone Group (MMG) Comparison with Europe

Three European countries have each found a good clay host rock.

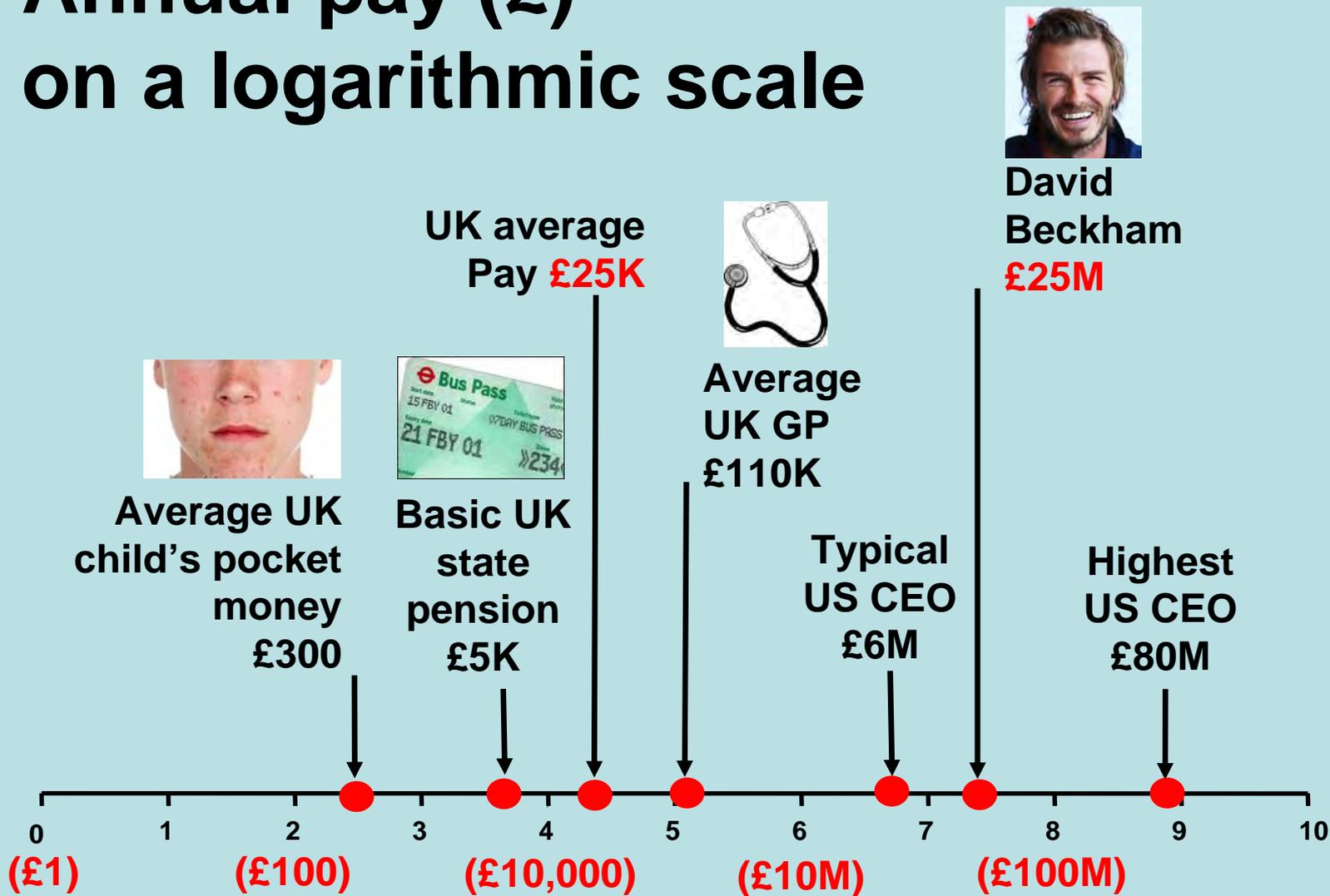
Is the MMG up to the job?

The crucial factor is the **hydraulic conductivity**

-How fast the water can flow through the rock

-First, a word on logarithmic scales ...

# Annual pay (£) on a logarithmic scale



Logarithmic scale:

Each unit of the scale is a **factor of 10** increase to the right

**Hydraulic  
conductivities:  
Synthesis**



Switzerland (Opalinus Clay)



France (Callovo-Oxfordian clay)



Belgium (Boom Clay)

Abroad

England



London Clay



Oxford Clay



Gault Clay



Lias Clay



Upper



Lower



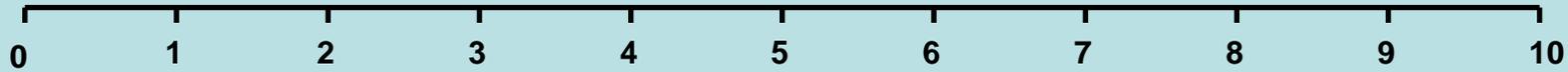
Desirable range



Mercia Mudstone

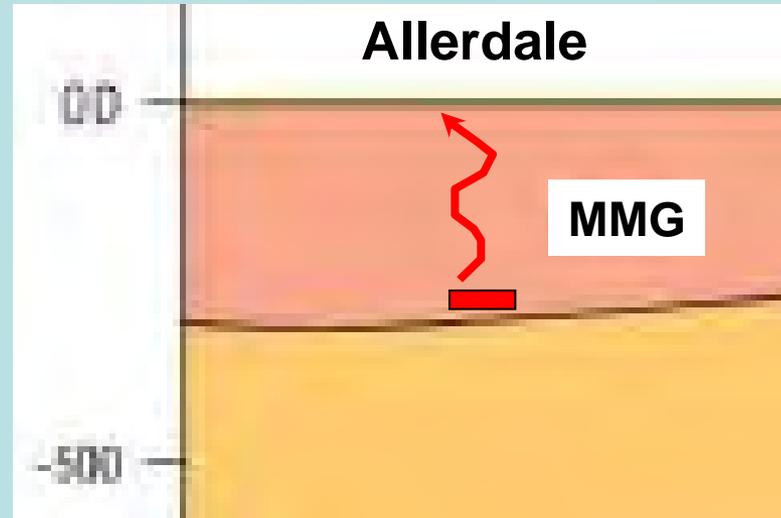
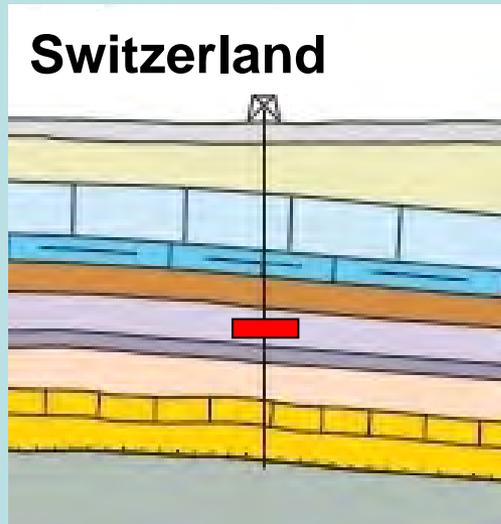


Increasing intrinsic permeability (hydraulic conductivity)



Log hydraulic  
conductivity  
(Log k) +14 m/s

# What the relatively high permeability of the MMG means



50 m Opalinus Clay above repository  
Say 1 million years to travel 50 m

Permeability 1 unit

This is a **SAFE** repository

300 m MMG above repository

Permeability 6 – 8 units

How long to reach surface ?

# What the relatively high permeability of the MMG Means for escape of toxic waste to the surface

## Switzerland

Slowness of travel: 20,000 year/m

Divided by 1

Multiplied by 50 m thick

= 1 million years

## Allerdale

Slowness of travel: 20,000 year/m

Divided by 100,000 to 10,000,000

Multiplied by 300 m thick

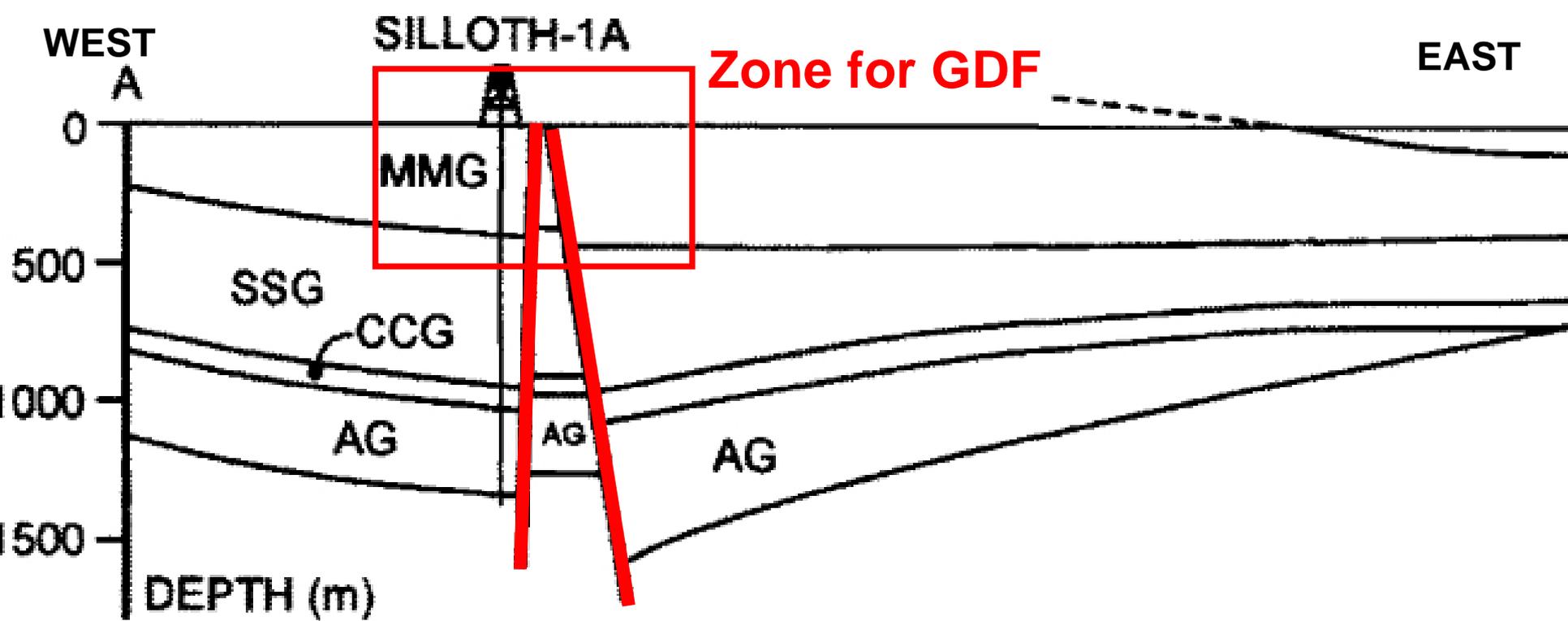
= from 60 years to 8 months

**UNSAFE**

# **Mercia Mudstone Group (MMG)**

## **Conclusions on permeability**

- **The MMG is NOT a clay rock**
- **The MMG is “poorly permeable and is classified as a Secondary B Aquifer” (BGS screening report)**
- **Its permeability is far too high**
- **So the MMG is unacceptable as a host rock**



## BGS cross-section through northern Allerdale

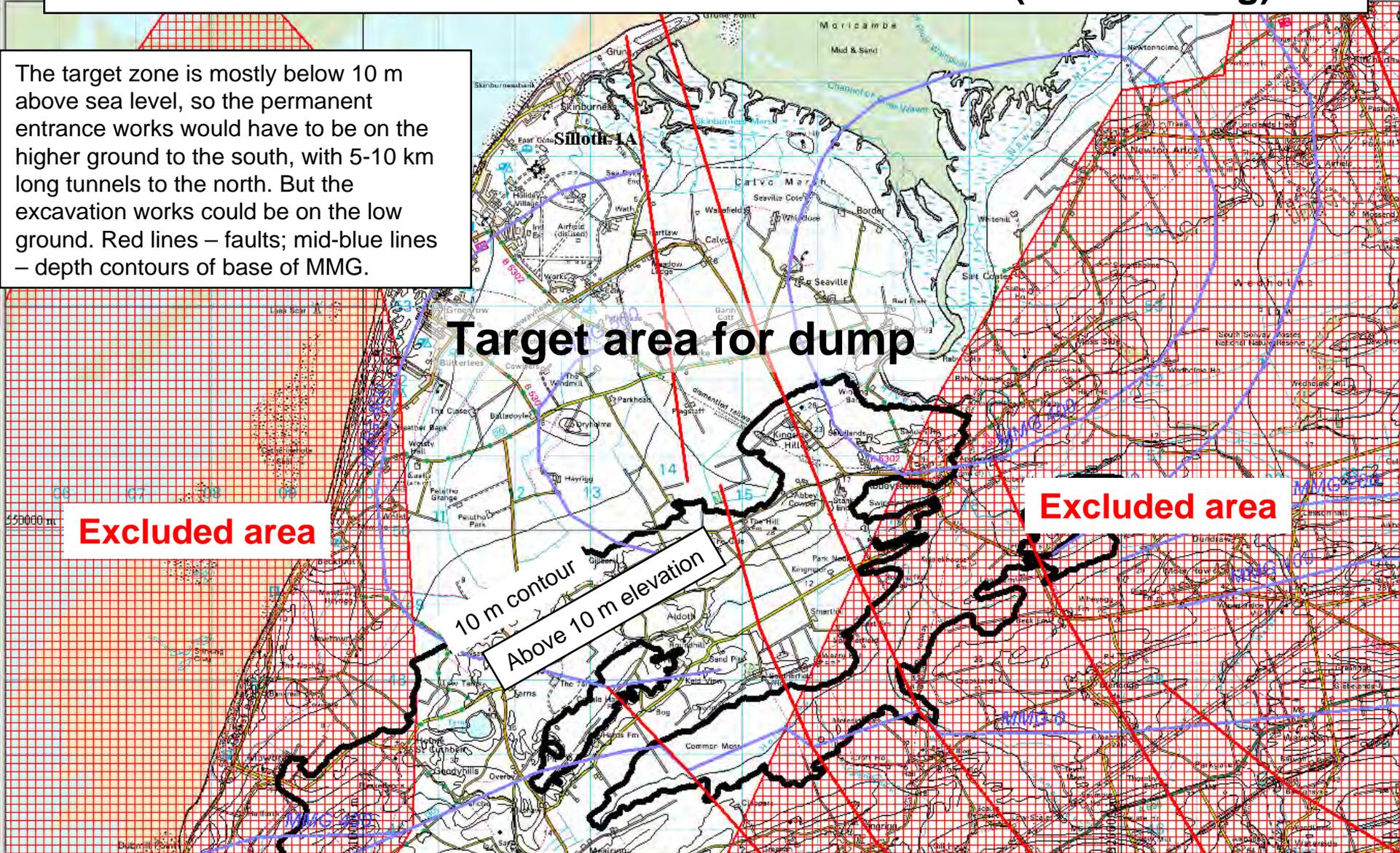
- and that is before the faulting (**red**) is taken into consideration. Only the two major faults are shown.

Where would facilities  
be sited in northern  
Allerdale?

# Mercia Mudstone Group: target rock for waste dump

## Confined to area between BGS excluded zones (red hatching).

The target zone is mostly below 10 m above sea level, so the permanent entrance works would have to be on the higher ground to the south, with 5-10 km long tunnels to the north. But the excavation works could be on the low ground. Red lines – faults; mid-blue lines – depth contours of base of MMG.



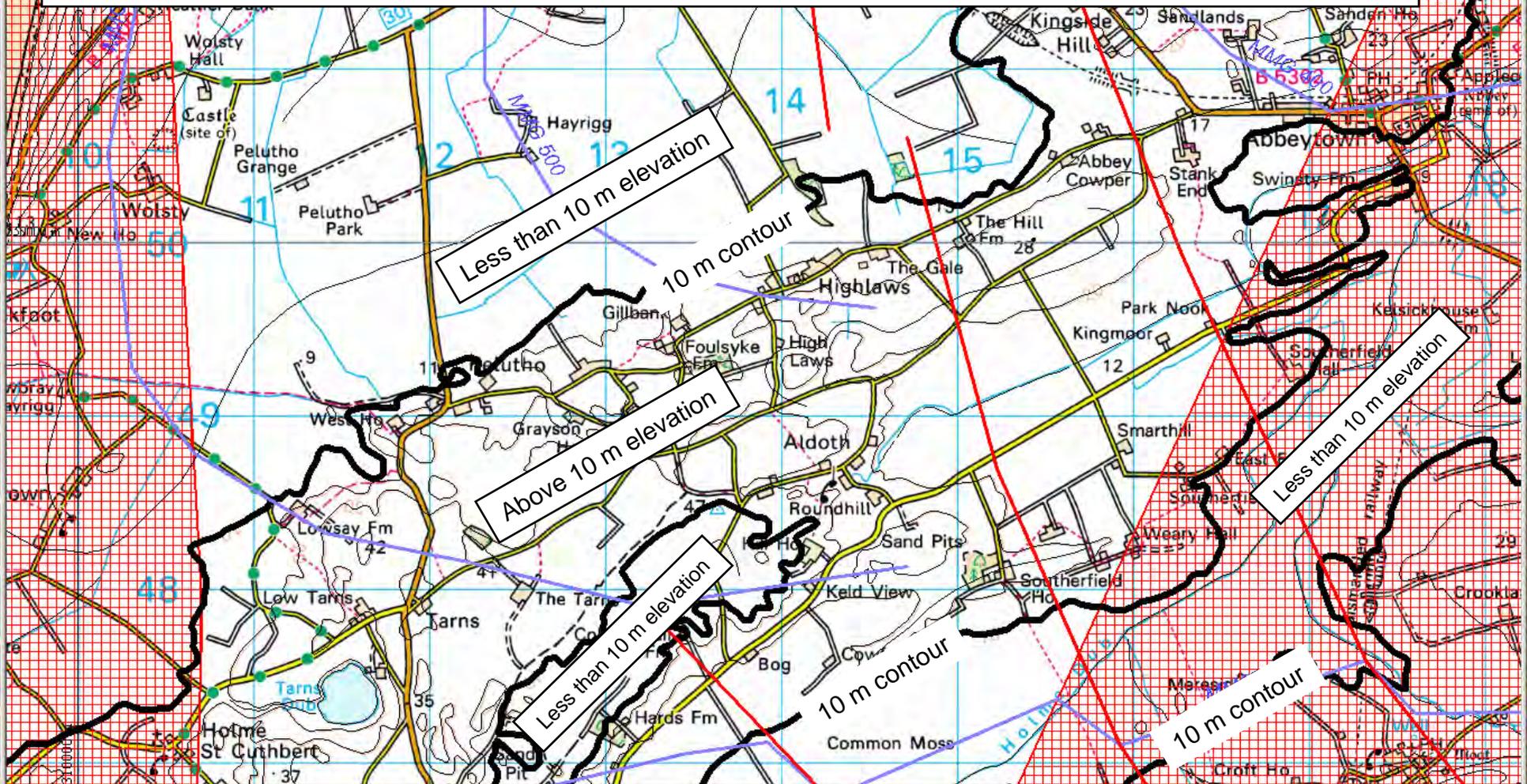
**Target area for dump**

**Excluded area**

**Excluded area**

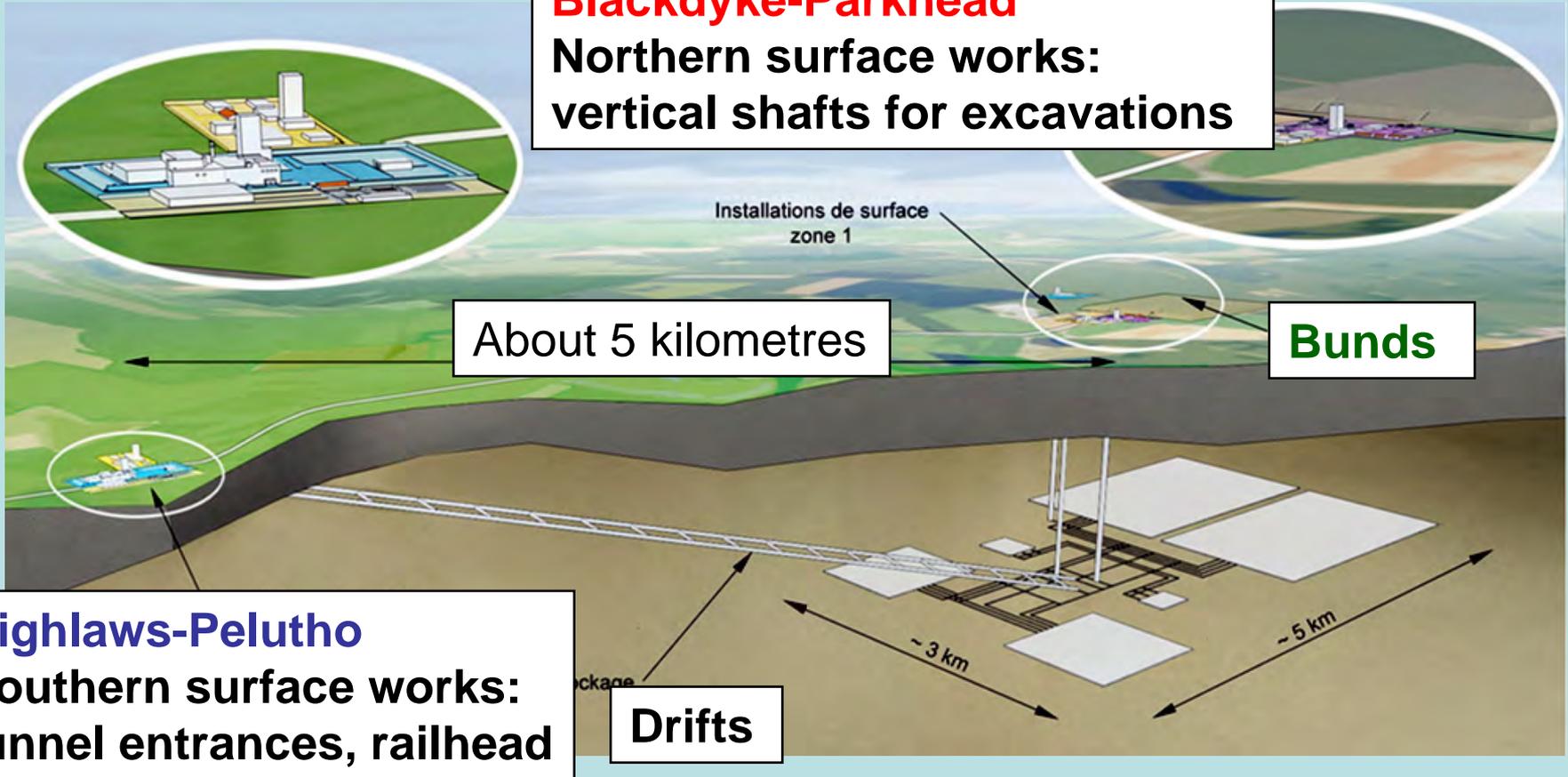
**10 m contour**  
**Above 10 m elevation**

**Permanent entrance works (?hundreds of years) on higher ground. Excavation works (? 20 years or more) on low ground, along with with resulting permanent spoil heaps.**



## Blackdyke-Parkhead

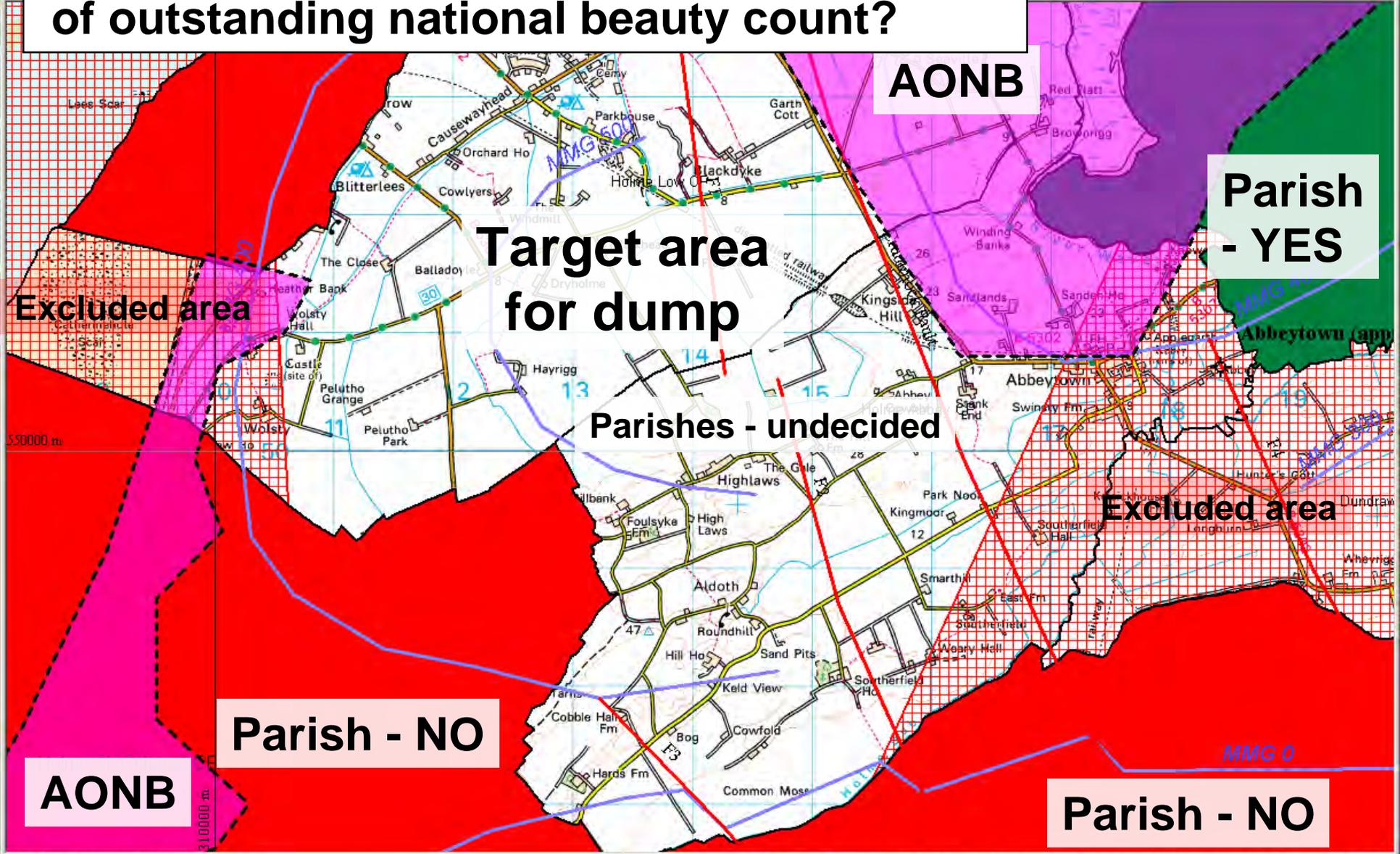
Northern surface works:  
vertical shafts for excavations



3D view of the proposed French waste repository in clay, applied to Allerdale. NB Allerdale subsurface area 20-23 km<sup>2</sup>.

**Southern works** on higher ground (greater than 10 m above sea level).  
**Northern works** sited on the very low ground (where MMG thickest).  
**Spoil heaps** stored in bunds nearby.

# Will opposing parish councils and the areas of outstanding national beauty count?



# Mercia Mudstone Group: target rock for waste dump

Confined to area between BGS excluded zones (red hatching).

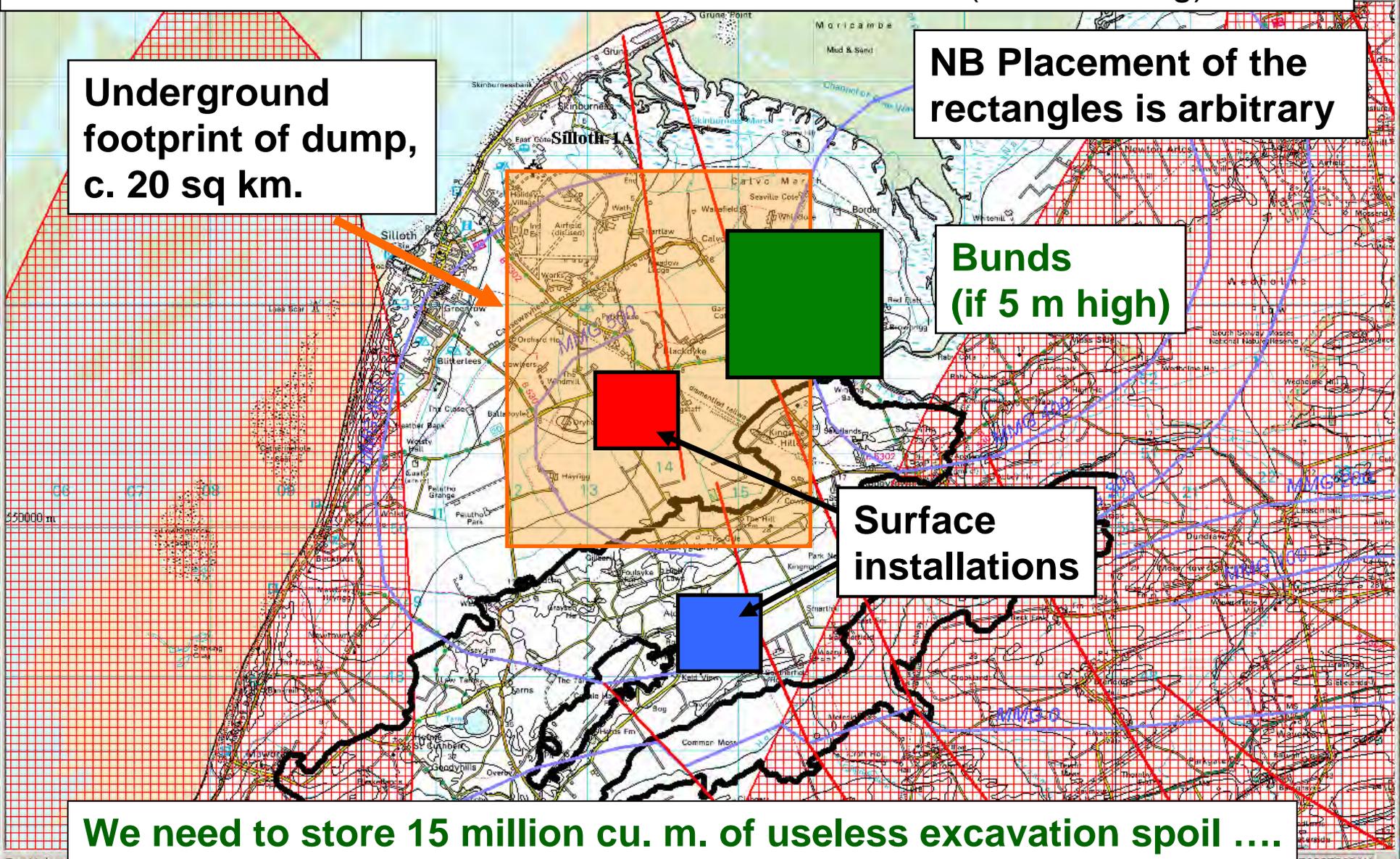
**Underground footprint of dump, c. 20 sq km.**

**NB Placement of the rectangles is arbitrary**

**Bunds (if 5 m high)**

**Surface installations**

**We need to store 15 million cu. m. of useless excavation spoil ....**



**The  
construction  
waste  
problem**



**The Great Pyramid of Cheops (or Kheops) at Giza, Egypt  
volume 2,500,000 cu. m., 140 m high.  
London Routemaster bus is shown for scale.**

**Spoil heaps will not be pyramids but flat-topped mounds called *bunds*.  
Allerdale dump will produce 6 pyramids of spoil.  
If 5 m high some 4 sq km (= 400 Ha = 1000 acres) required.**

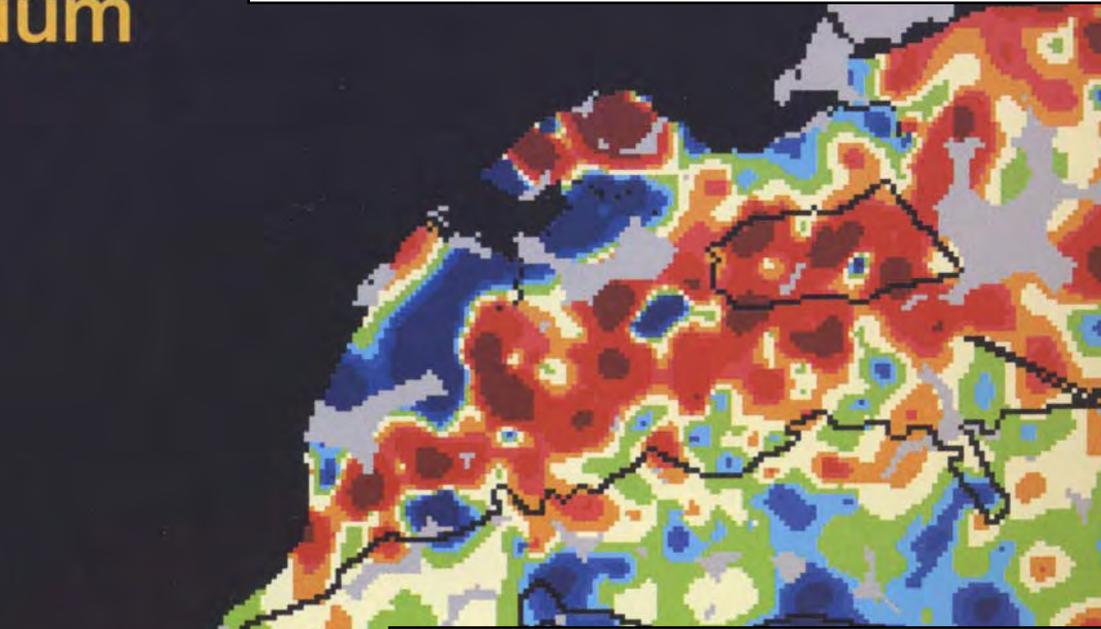
300

Managing 15 million cu. M. of spoil could be a major groundwater contamination problem

# Chromium Cr

## KEY

1550



### BGS Regional geochemistry atlas Chromium in stream sediment

*“over the Solway Plain, a marked area of high and very high Cr values ... covers much of the area, although there are areas with low Cr values ... such as between Allonby and Kirkbride, east of Silloth. ... The Triassic rocks must therefore be the main Cr source”*

# Mercia Mudstone Group

## The MRWS 'review' by Dr Dearlove

Professor Smythe appears to have misunderstood my comments that “a proper evaluation of the available data has not yet been undertaken”. In my opinion, and that of Mr Colin Knipe, only the BGS is capable of making this assessment, and until the BGS undertake and publish such a review the area must remain potentially suitable.

It is primarily on this basis that I suggest that the MMG cannot be rejected at this stage of the MRWS Partnership process as a potential GDF host rock. I also agree with Mr Knipe's comments that, whilst not currently ruled out, the prospect of finding sufficient volume of suitable rock in the MMG is not promising, it **CANNOT AT THIS STAGE BE ENTIRELY RULED OUT.**

# **Scientific conclusion**

## **Mercia Mudstone Group - unsuitable**

- 1. Not previously considered as a host rock by the BGS.**
- 2. Introduced by MRWS in 2011 on hearsay.**
- 3. Current hydrocarbon exploration - should have been excluded.**
- 4. Regional hydraulic gradient is high (but acceptable).**
- 5. Undesirably shallow depth of between 200 and 500 m.**
- 6. Geology is well understood due to oil industry exploration.**
- 7. Haematite-bearing red beds – oxidising environment.**
- 8. Very high in chromium (→toxic spoil heaps?).**
- 9. The groundwater is fresh.**
- 10. Exploited as an aquifer.**
- 11. Hydraulic conductivity is 100,000-1,000,000 times too high.**
- 12. A leaky seal (cap rock) for hydrocarbons.**
- 13. Cut by large faults which may act as water conduits.**
- 14. Geothermal anomaly – Solway area might have potential.**

**The MMG might have been introduced as a debating tactic by MRWS  
- but we cannot be sure.**

**Misinformation  
or  
Non-information?**

# British Geological Survey (BGS) - advocacy by subterfuge



British  
Geological Survey  
NATURAL ENVIRONMENT RESEARCH COUNCIL

2002: (Hearsay) BGS director supports return to Sellafield.

2006: BGS: 'rather more than 30%' of the UK is potentially suitable.

2006: BGS: high hard-rock mountains are a 'favourable' location.

2010: Crucial screening criteria (oil, water) removed.

2011: (Hearsay) MMG now considered a potential host rock by BGS.

2012: 'Geological Society of London' support for MRWS process actually emanates from one BGS board member + two employees.

2012: Richard Shaw (BGS) states on BBC radio that West Cumbria "*offers potential*".

If Stage 4 goes ahead: Can we trust the BGS ?



# Scrutiny of the process?

**Committee on Radioactive Waste Management  
(CoRWM)**

**Letter to Colin Wales, March 2012**

**Response to question about voluntarism before  
geology:**

***“It could be argued that the British process has  
also screened out unsuitable geology before  
asking communities to volunteer.***

**...**

***Your sincerely, Robert Pickard, Chair of CoRWM”***

# Committee on Radioactive Waste Management (CoRWM)

*“ ... no credible scientific case to support the contention that all of West Cumbria is geologically unsuitable.”*

**This is NOT TRUE :**

- We DO know – it's a highly studied area
- No stone has been left unturned
- NOWHERE is suitable
- MRWS stage 4 has been done

# Memo to Councils: once you're in, you're in

Councils locked in  
from here on

Govt. to BGS:  
“Within the Partnership area,  
where are the most promising  
localities?”

**2. Unsuitability screening**

**3. Decision to participate**

**4. Desk studies**

**5. Surface research**

**6. Underground**

**Point of no return -  
BGS starts drilling**

**A site is  
selected**

**Decision points – the slippery slope**

**Each step postpones the real decision: Is the area suitable?**

# NOMINATED SITES FOR NEW NUCLEAR POWER STATIONS

Allerdale:  
? National centre for encapsulation of waste before burial?



**C u m b r i a CC**

**Allerdale BC**

**Copeland BC**

**Economy**

**Environment**

**Dubious benefits**

**? National sacrifice**

*Fin*