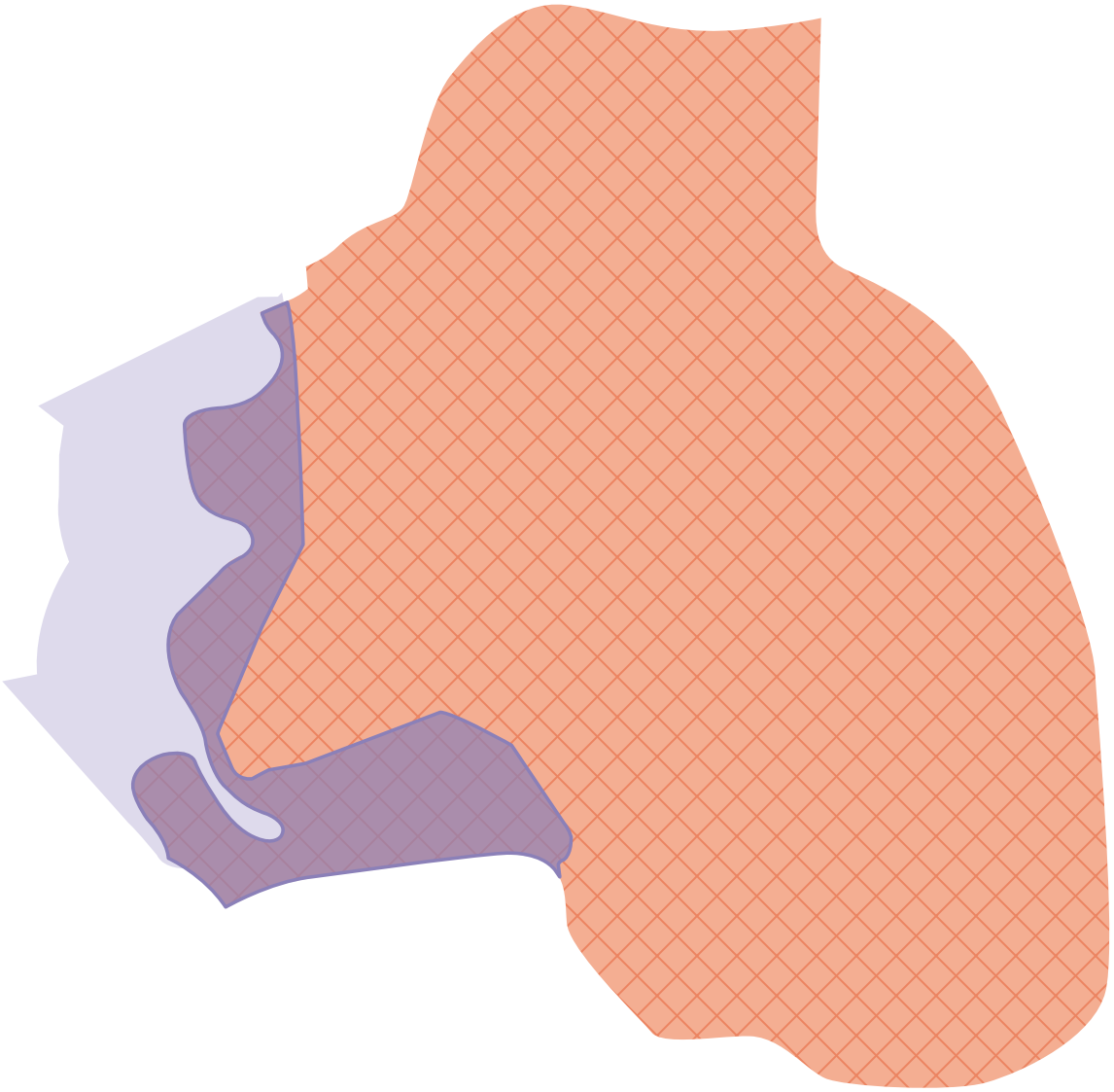
Radioactive Waste Management



Pennines and adjacent areas

SUBREGION 4

Contents

Clicking on words in green, such as sedimentary or lava will take the reader to a brief non-technical explanation of that word in the Glossary section. By clicking on the highlighted word in the Glossary, the reader will be taken back to the page they were on.

Clicking on words in blue, such as Higher Strength Rock or groundwater will take the reader to a brief talking head video or animation providing a non-technical explanation.

For the purposes of this work the BGS only used data which was publicly available at the end of February 2016. The one exception to this was the extent of Oil and Gas Authority licensing which was updated to include data to the end of June 2018.

Our work shows that we may find a suitable geological setting for a GDF in most of this subregion.

Rock cannot generally be seen at the surface in this subregion, except in man-made excavations such as quarries or road cuttings. However, numerous deep boreholes and geophysical investigations give us an understanding of the rocks present and their distribution.

There are clay-rich rock layers, in which we may be able to site a GDF, under most of the subregion. There are also layers of rock salt between Southport and Lancaster and off the coast of much of the subregion, in which we may be able to site a facility. We would need to do more work to find out whether these rocks have suitable properties and thicknesses.

Even where individual clay-rich rock layers are found not to be thick enough to host a GDF they may support the siting of a GDF in deeper rocks as they could act as a barrier to groundwater flow from depth. This is important because movement of groundwater is one of the ways in which radioactive material could be carried back to the surface.

Some of the subregion has been mined for coal to depths below 100m, around Warrington and west of Ellesmere Port and there are also known oil and gas resources, off the coast from Southport, east of Blackpool and near Warrington. In these areas the mining and drilling is likely to have affected the way in which water moves through the rock. Also possible exploration in the future in these areas means that it is more likely that future generations may disturb a facility.

Much of the onshore and parts of this subregion off the coast have Petroleum Exploration & Development Licences to allow companies to explore for oil and gas. This exploration is currently at an early stage and it is not known whether oil or gas in these licence areas will be exploited. RWM will continue to monitor how this exploration programme progresses.

Parts of this area, off the coast around Liverpool, are Coal Authority Licence Areas allowing companies to explore for coal. It is not known whether coal in these licence areas will be exploited. RWM will also continue to monitor how this exploration programme progresses.

Parts of the subregion which are mined for rock salt, such as around Fleetwood, would also need to be taken into account in the siting of a GDF, although the nature of mining in evaporites does not affect the movement of groundwater in the surrounding rocks in the same way as other mining.

Introduction

This subregion of the Pennines and adjacent areas region comprises mainly low-lying ground extending from Stockport to the Wirral, north to Morecambe and including the adjacent inshore area which extends to 20km from the coast.

Rock type

The younger sedimentary rocks include both Lower Strength Sedimentary Rock (LSSR) and Evaporite rock layers within the depth range of interest with potential to host a GDF (Figures 1a to c). The following major units have potential to host a GDF.

- The Mercia Mudstone Group is predominantly low permeability in this subregion, comprising mudstone and evaporites, although some sandstones are present and act locally as aquifers. It becomes progressively thicker to the west such that it is around 500m thick along the Lancashire coast, thickening to more than 1,000m in the inshore area. The thick, extensive mudstone units are a known barrier to groundwater movement and have the potential to act as LSSR host rocks. Rock salt (halite) layers are well developed in the Mercia Mudstone Group. In the north, near Blackpool, individual rock salt layers may be over 100m thick and continue westward off the coast. Thick rock salt layers are also present in the southern part of the subregion around Northwich. These layers have the potential to act as Evaporite host rocks.
- The Cumbrian Coast Group occurs near the southern margin of the subregion and also along the Lancashire coast. This unit becomes thicker off the coast and contains rock salt layers, locally up to 100m thick, as well as mudstones. In the south, sandstones are more abundant. Although the Cumbrian Coast Group generally acts as a barrier to groundwater movement, the calcareous nature of some of the mudstones and the presence of anhydrite and gypsum may affect its potential as an LSSR host rock.

At the top of the Carboniferous sequence, the Warwickshire Group includes some beds of mudstone interlayered with sandstones and siltstones. They are unlikely to form a sufficiently thick and homogeneous body to act as a LSSR host rock but may provide hydraulic separation between shallow and deep groundwater where these have not been disrupted by mining.

Subsurface engineering in mudstones can be challenging because they are relatively weak. Where these mudstones occur in the lower part of the depth range of interest the constructability of a GDF would be considered during the siting process.

A summary of the geological attributes of the Pennines and adjacent areas region can be found here, including a simplified rock column showing the oldest and deepest rocks at the bottom, with progressively younger rock units towards the top.

Rock Structure

The younger sedimentary rocks in this subregion are faulted but not significantly folded (Figure 2). Many rock units thicken off the coast with an abrupt increase in thickness on the western, downthrown sides of the north-south aligned faults. As a result of this, the potential LSSRs are likely to be thicker in the inshore to the west of these faults than they are onshore to the east. Faults may act as barriers to or pathways for groundwater movement, depending upon their characteristics, and the siting of a GDF would need to take account of them[1].

Groundwater

There is very little information on groundwater in the depth range of interest for a GDF, 200 to 1,000m below NGS datum, although there is information on groundwater in aquifers above 200m. There are several principal aquifers within 400m of the surface in this subregion including the Sherwood Sandstone Group and sandstones of the Appleby Group. Where these rocks are present off the coast, the water present in the pores of rocks beneath the seabed is saltwater rather than fresh and they are not therefore used as aquifers.

The LSSR and Evaporite layers in this subregion are likely to act as barriers to vertical flow between the various more permeable units described here, even where they are not thick enough to host a GDF. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK[2].

In parts of the subregion deep exploration boreholes may influence the connectivity between shallow and deep groundwater which would need to be considered during the siting process (Figure 3). There are no thermal springs in this subregion to suggest rapid flow of deep groundwater to the surface.

[1] Faults occur on a diverse range of scales, from centimetres to kilometres, and the subsurface is criss-crossed by networks of numerous individual faults. However our work includes only those faults identified by the BGS with throws (vertical offset) of 200m or more. This is because the data available to the BGS are not able to resolve all faults consistently, across all thirteen regions, with throws less than 200m. We recognize the potential importance of smaller scale faults to the integrity of a GDF and will need to survey them in detail as part of the site evaluation process.

[2] Water Framework Directive UK TAG. Defining and reporting on groundwater bodies, 2012.

Resources

Coal has been mined below 100m, mainly in the area around Warrington (Figure 4a), and there are several small oil and gas fields off the coast from Southport, east of Blackpool and around Warrington (Figure 4b). In these areas the mining is likely to have affected the way in which water moves through the rock. Also possible exploration in the future in these areas means that it is more likely that future generations may disturb a facility. These known resources would be taken into account in the siting of a GDF.

A number of Petroleum Exploration and Development Licences[3] are currently held in the subregion (see Figure 4b). There are also Coal Authority Licence Areas off the coast around Liverpool (Figure 4a). It is not known whether coal, oil or gas in these licence areas will be exploited, but they would need to be considered during the siting process.

Rock salt has been extracted from the Cheshire and Lancashire plains for many years, primarily by solution mining, and many of the known salt layers have been exploited extensively to depths of around 500m (Figure 4c). There are plans to develop gas storage facilities in solution-mined cavities in the deeper parts of the salt layers near Fleetwood and there is potential for similar storage at the southern margin of the subregion. Although the nature of mining in salt does not affect the movement of groundwater in the surrounding rocks in the same way as other mining, the presence of any excavations in these rocks would need to be considered in the siting of a GDF.

Natural Processes

Earthquakes and glaciations are unlikely to significantly affect the long-term safety of a GDF in the UK. Therefore, whilst a GDF would need to be sited and designed to take account of natural processes which may occur during its lifetime, they are not considered further as part of this screening exercise.

[3] This also includes other licences awarded by the Oil and Gas Authority to allow companies to explore for hydrocarbons.

Figure 1a The areas of the Pennines and adjacent areas subregion 4 where any of the 3 Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

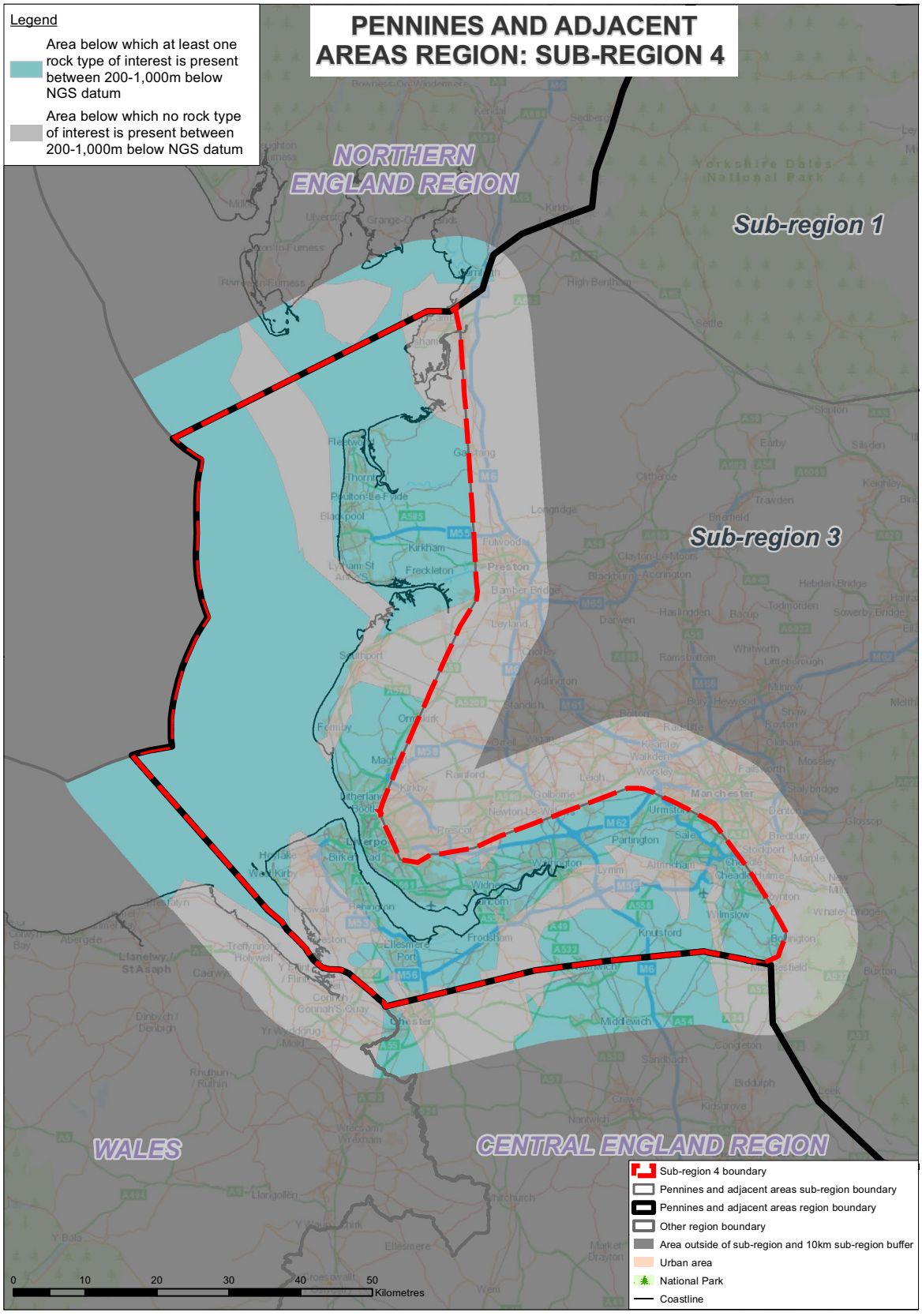


Figure 1b The areas of the Pennines and adjacent areas subregion 4 where Lower Strength Sedimentary Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

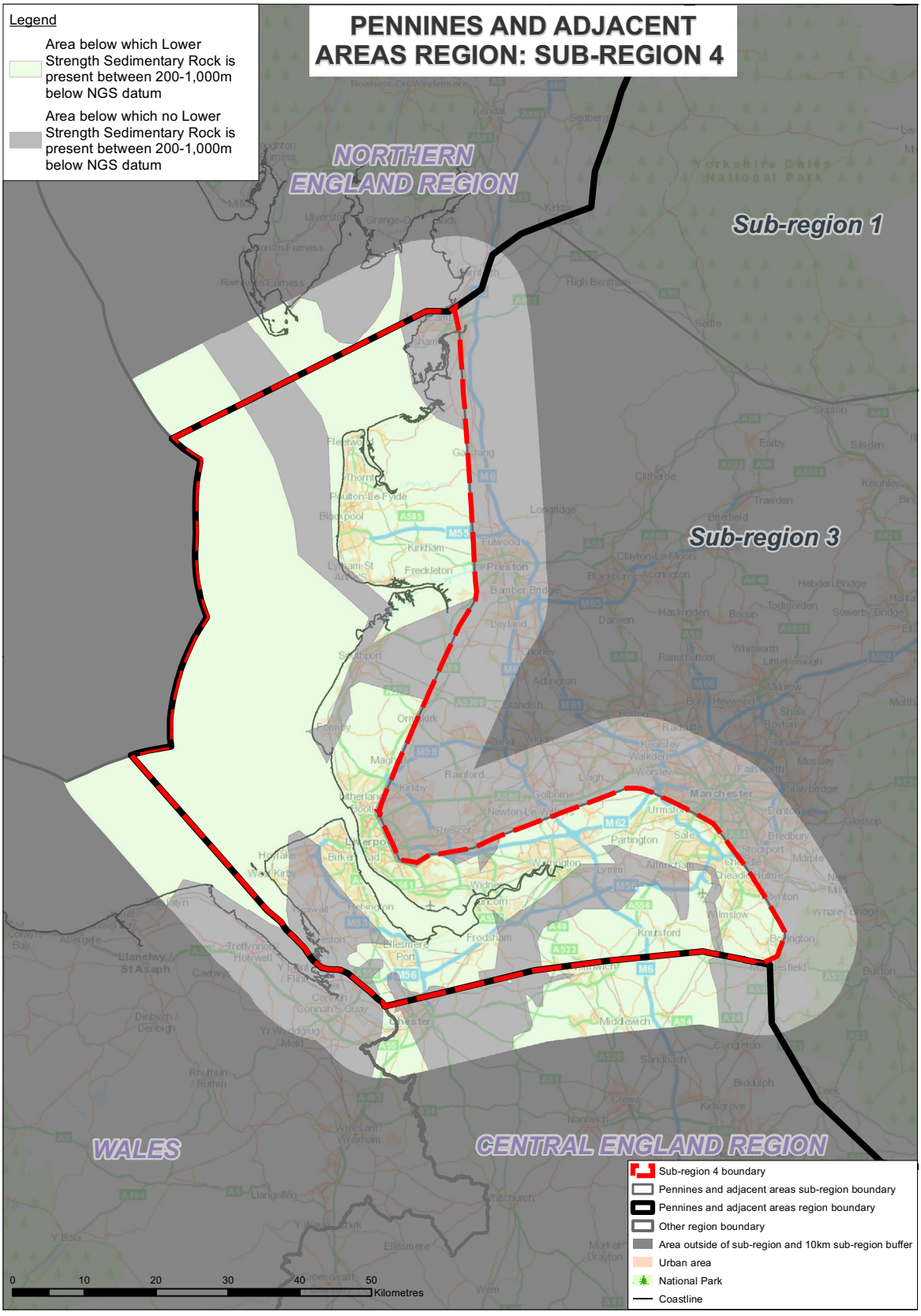


Figure 1c The areas of the Pennines and adjacent areas subregion 4 where Evaporite Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

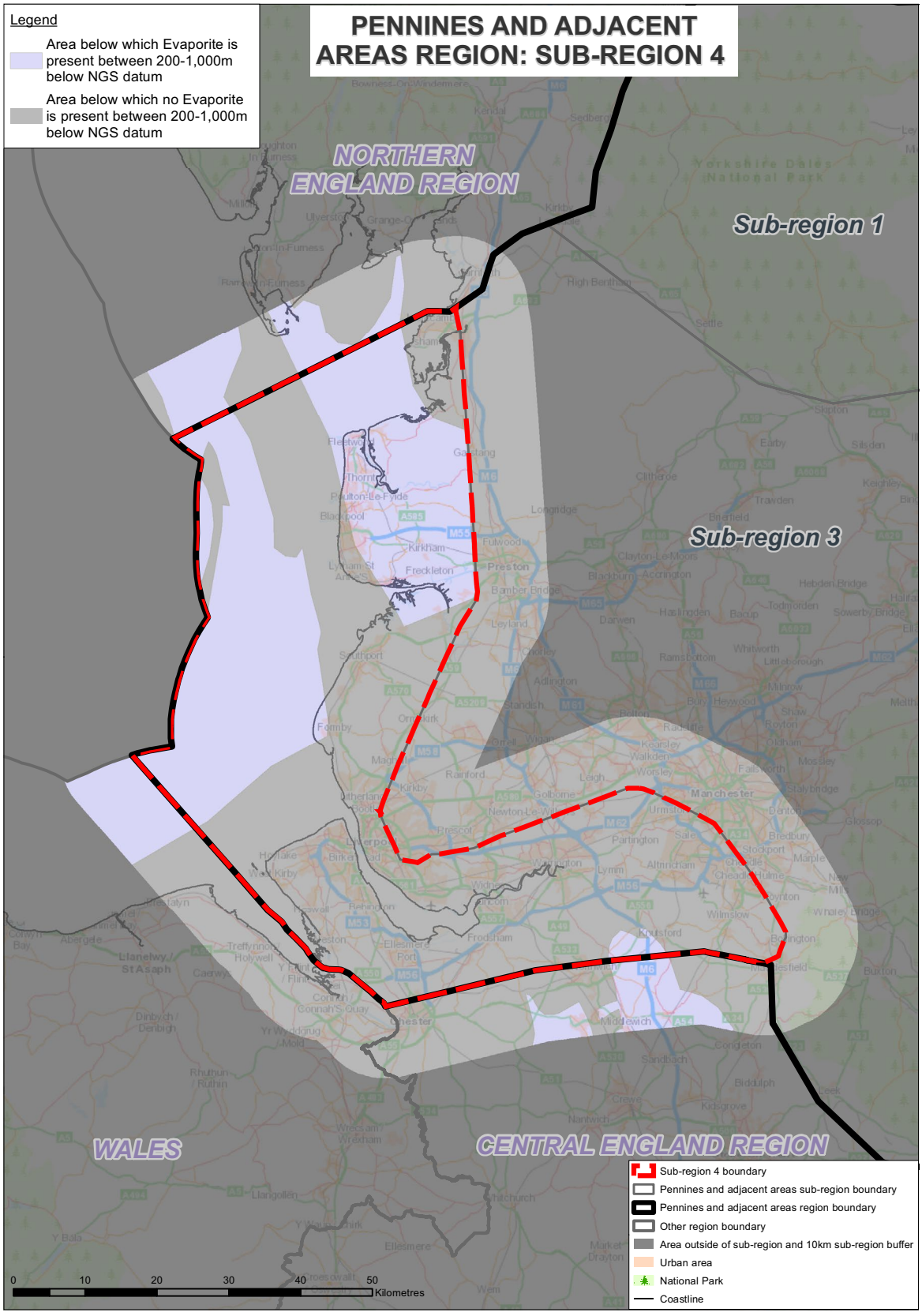


Figure 2 Location of major faults in the Pennines and adjacent areas subregion 4.

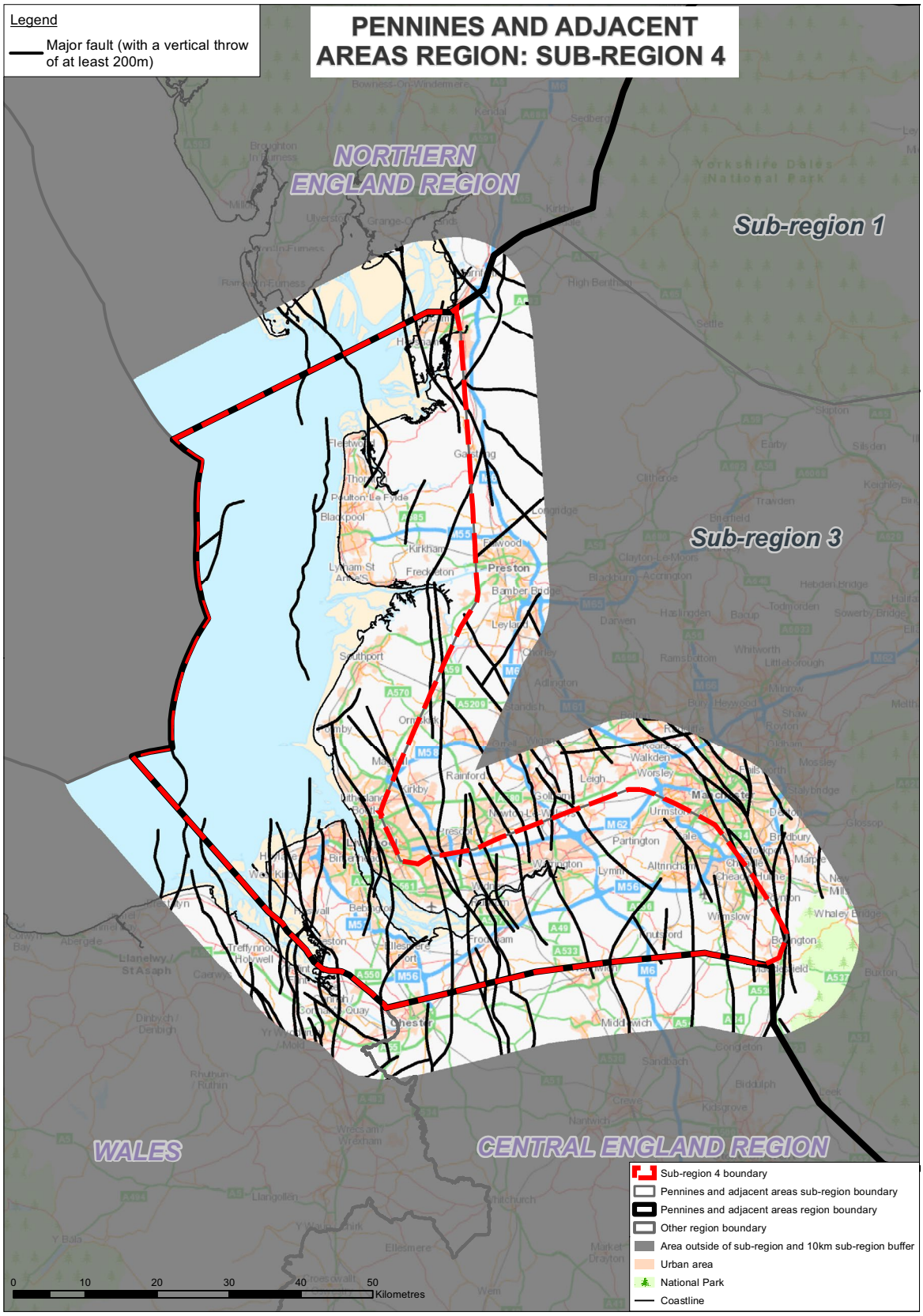


Figure 3 Areas in the Pennines and adjacent areas subregion 4 with concentrations of deep exploration boreholes.

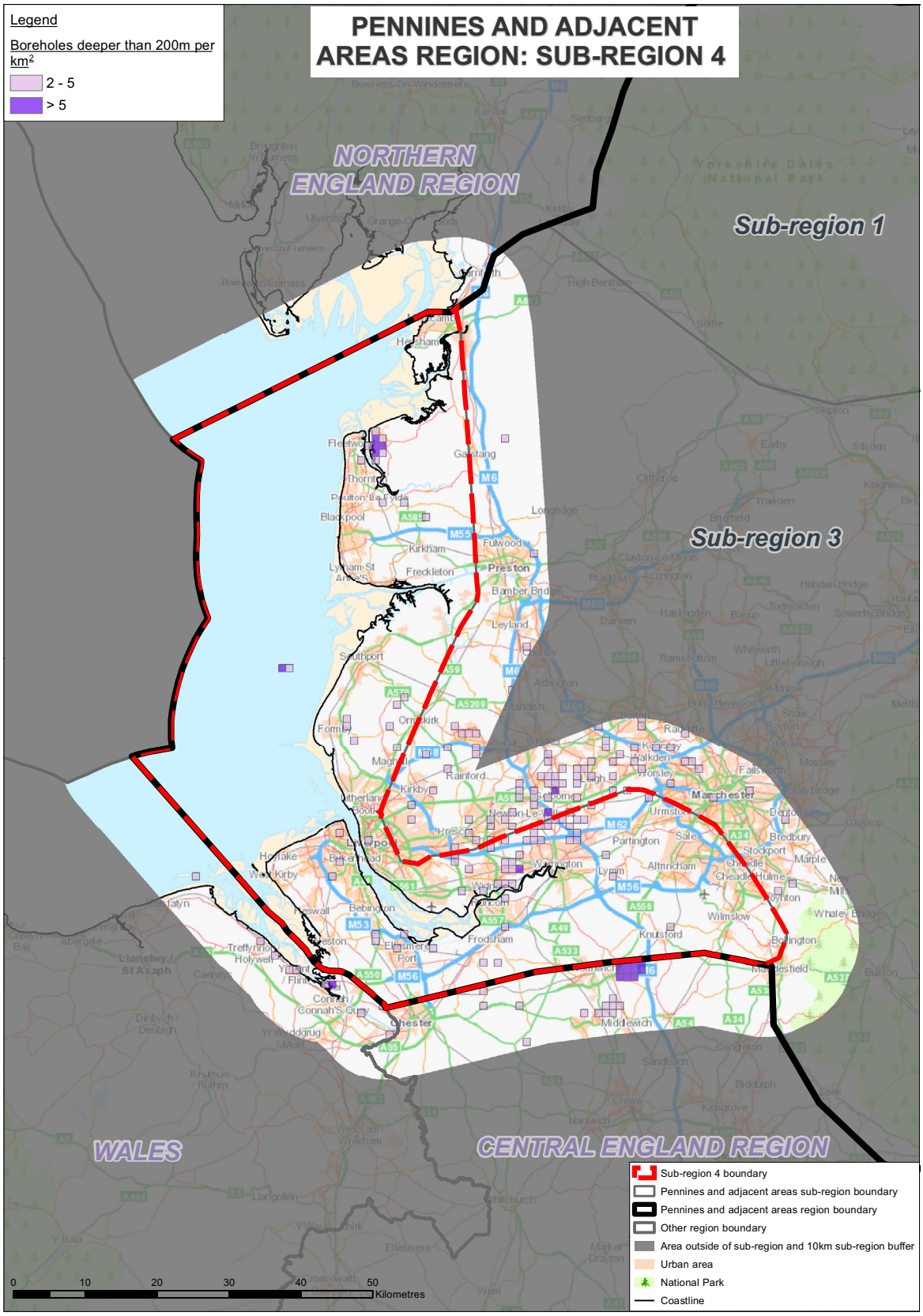


Figure 4a Areas of the Pennines and adjacent areas subregion 4 with coal mines present below 100m and Coal Authority Licence Areas.

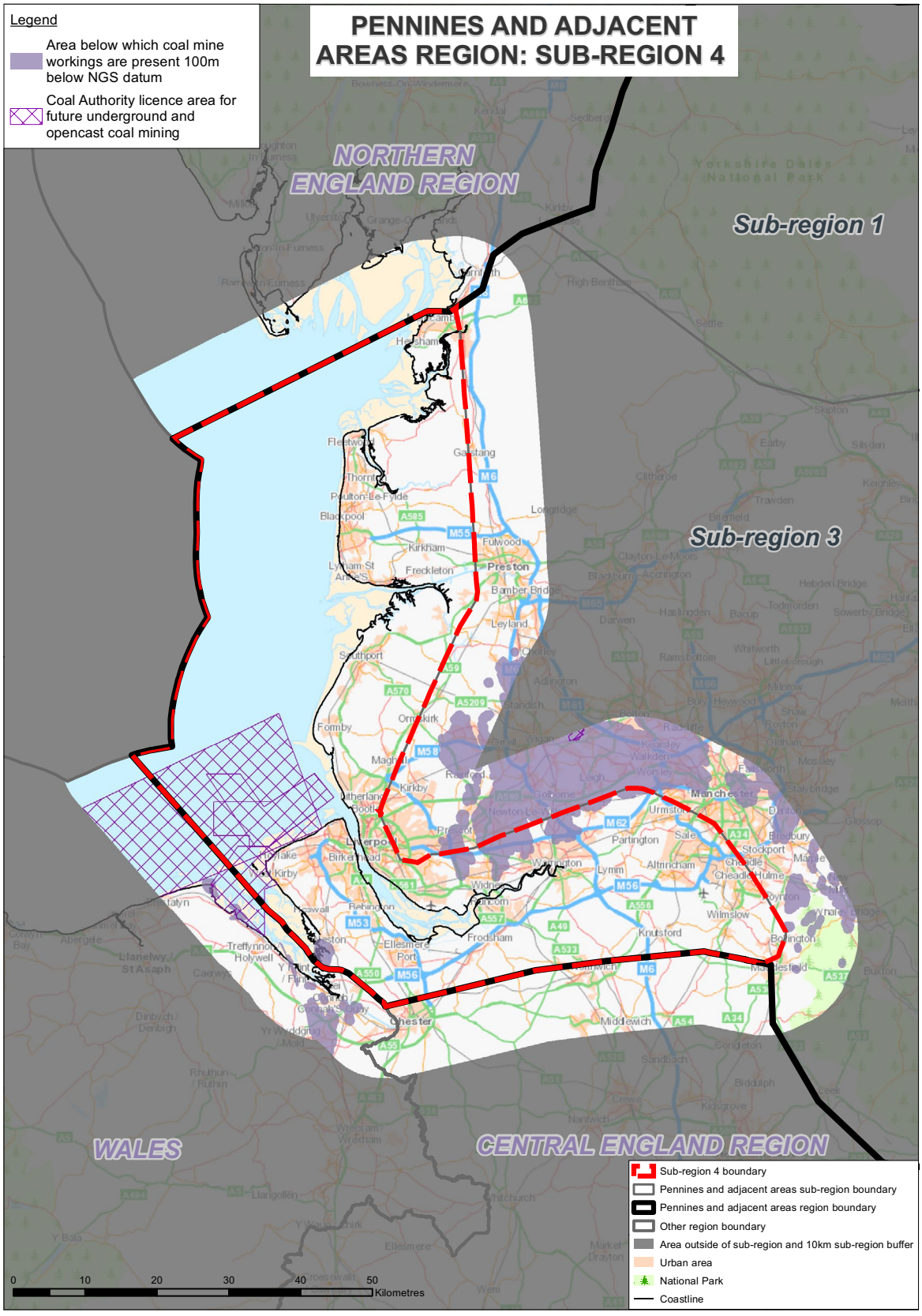


Figure 4b Areas of the Pennines and adjacent areas subregion 4 with oil and gas fields and Petroleum Exploration and Development Licenses.

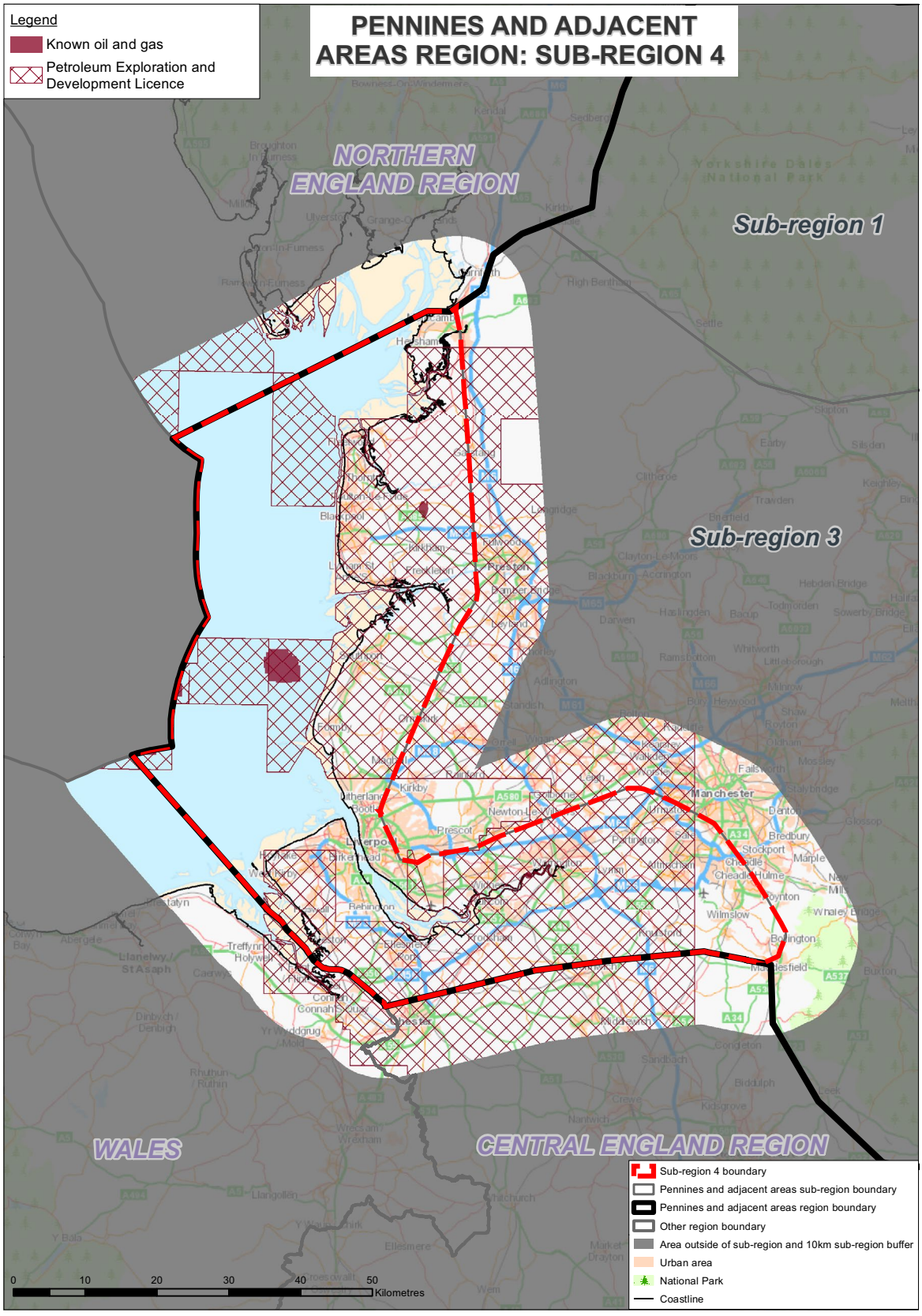
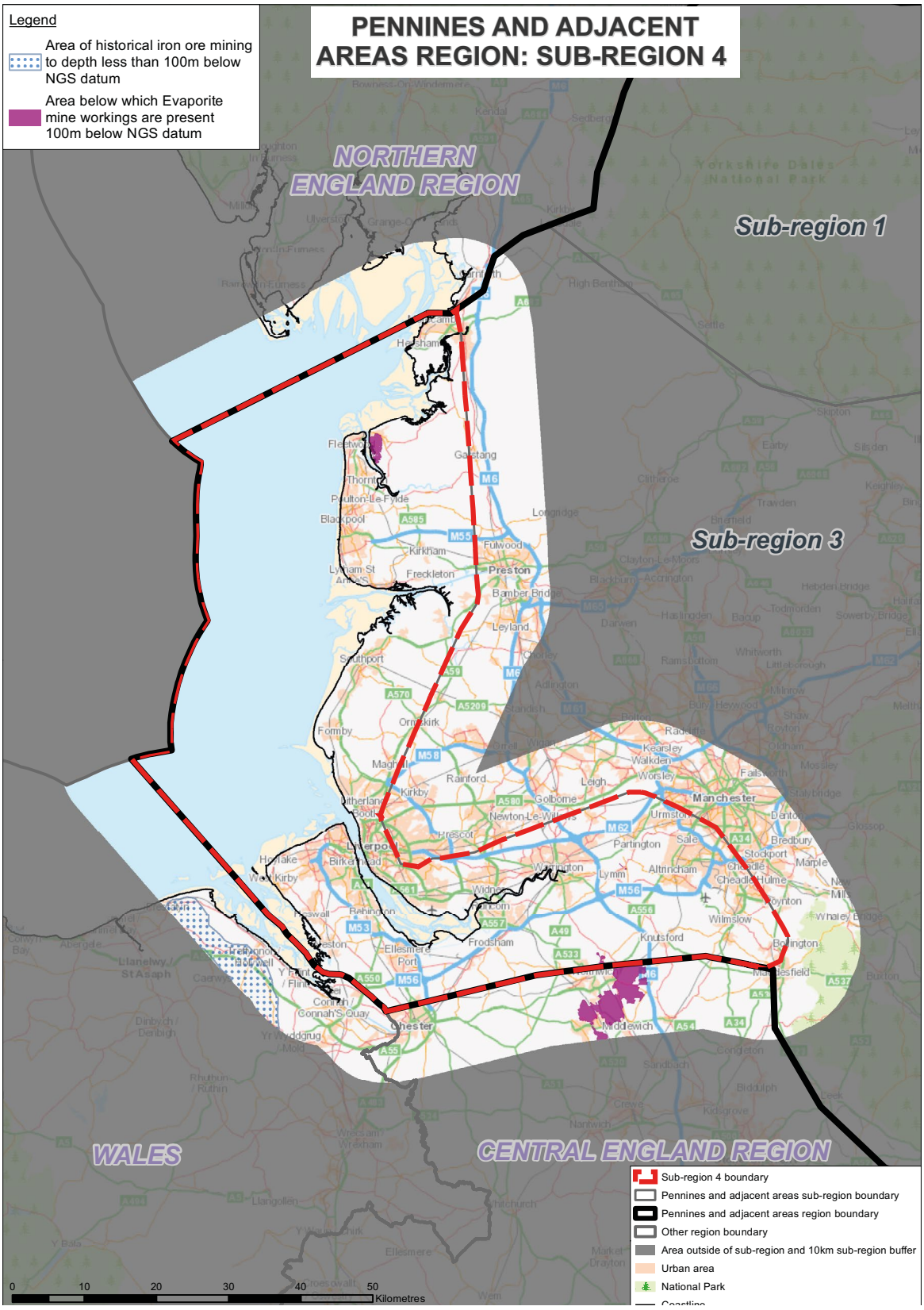


Figure 4c Areas of the Pennines and adjacent areas subregion 4 with evaporite mines present below 100m.



Glossary

Anhydrite
A calcium sulphate mineral that forms from the evaporation of salty seas. It contains no water and occurs at greater depths and higher temperatures than gypsum.

Aquifers
Aquifers are rocks that contain freshwater in pores and/or fractures and whose porosity and permeability are sufficiently high to make the extraction of groundwater possible.

Calcareous
A rock or sediment that contains the mineral calcium carbonate.

Downthrown side
The side of a fault where the rock layers cut by the fault have dropped lower.

Evaporite
The generic term for rock created by the evaporation of water from a salt-bearing solution, such as seawater, to form a solid crystalline structure. Gypsum, anhydrite and halite are all types of evaporite.

Fault
A fracture in the earth's crust across which the rock layers each side of it have been offset relative to one another.

Gas storage facilities
Underground facilities where gas can be pumped and stored under pressure. These can be within man-made caverns in salt deposits or by pumping gas into depleted oil and gas reservoirs. The gas can then be extracted again when demand is high.

Gypsum
A calcium sulphate mineral that forms from the evaporation of salty seas. It contains water and occurs at shallower depths and lower temperatures than anhydrite.

Halite
A sodium chloride evaporite mineral that forms when salty water dissolves. Also known as rock salt, or just 'salt'.

Principal aquifers
An aquifer classified by the Environment Agency as: "rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage." They represent the most important aquifers in terms of water supply or base flow.

Solution mining
A technique to extract soluble minerals out of the ground by pumping liquids into a deposit, dissolving the target minerals, returning the water to surface and reprecipitating the mineral. Solution mining for rock salt is carried out in the UK and for other commercially valuable minerals around the world.

Radioactive Waste Management

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