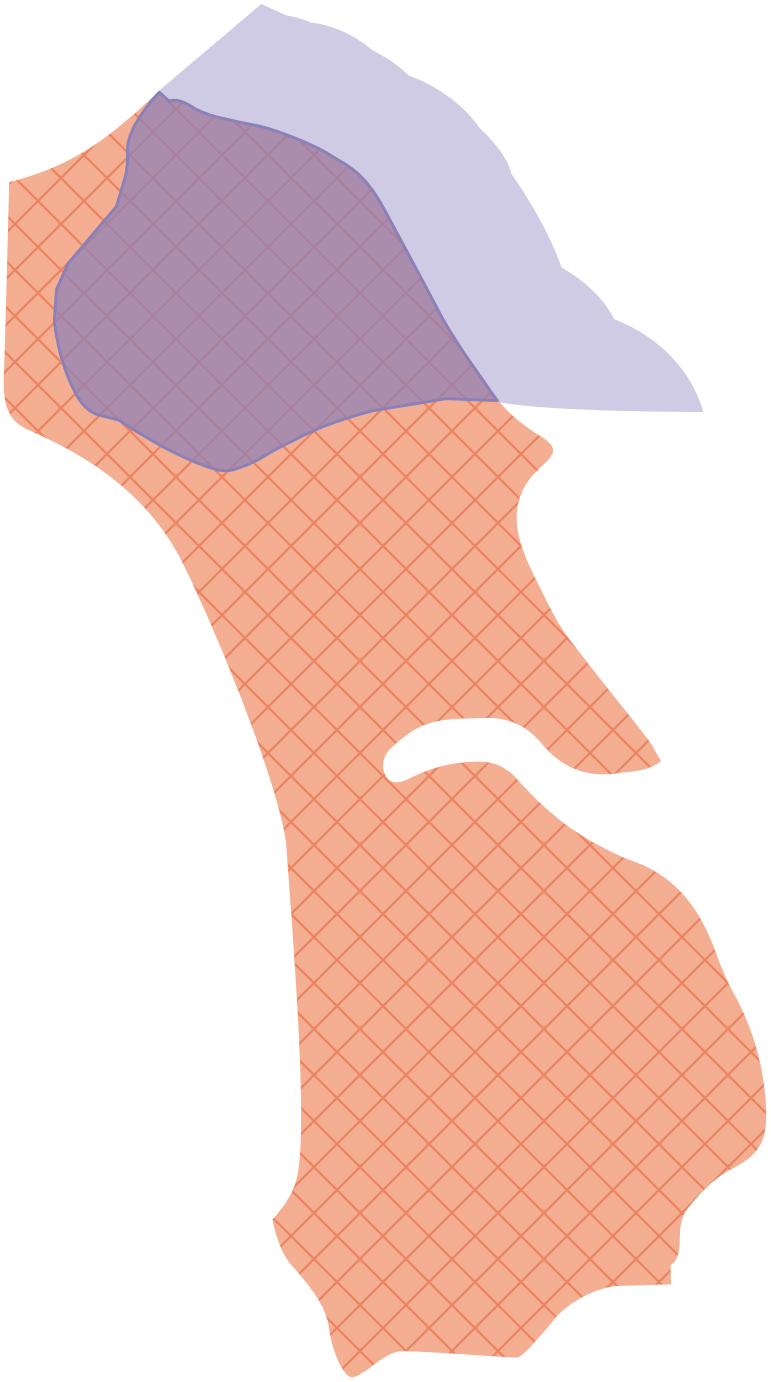
Radioactive Waste Management



Eastern England

SUBREGION 1

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 can be seen at the surface in some of this subregion such as the sea cliffs, cliffs in the North York Moors and in man-made excavations such as quarries or road cuttings. Combined with numerous deep boreholes and some geophysical investigations, this gives us an understanding of the rocks present and their distribution.

There are clay-rich rock layers under most of the subregion in which we may be able to site a GDF. There are also layers of rock salt under most of the eastern coastal half of the subregion and extending off the coast, in which we may be able to site a GDF. 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 contribute to the safety 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.

Parts of the subregion, south-west of Whitby and south of Pickering in particular, have known oil and gas resources and the area between Whitby and Middlesbrough has been mined for iron ore. In these areas the 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.

Parts of this subregion, either side of the Vale of Pickering, in particular, and extending 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 the subregion which are mined for potash and rock salt, south of Middlesbrough, 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 comprises the largely upland part of the Eastern England region east of Thirsk, south to Malton and including the adjacent inshore area which extends to 20km from the coast.

Rock type

Figures 1a to 1c show where in the subregion there are likely to be Rock Types of Interest for the development of a GDF within the depth range of interest. The geology of this subregion comprises a well-known and predictable sequence of sedimentary rocks throughout the depth range of interest including sandstones, limestones, mudstones and evaporites. There are 2 Lower Strength Sedimentary Rock (LSSR) units present in the depth range of interest under the subregion (Figure 1b): the Lias Clay and the Mercia Mudstone.

- The Lias Group reaches thicknesses in excess of 100m in the depth range of interest in the east of the subregion but thickness is variable and greatest to the north-east of the subregion. The mudstone dominated Lias Group predominantly comprises mudstones and shales, but also contains frequent layers of sandstone or limestone. It is unlikely that individual mudstones are thick enough to act as a host rock, but the Lias Group provides an effective barrier to movement of groundwater from depth towards the surface.
- The thick mudstone units within the Mercia Mudstone Group are known to act as a barrier to groundwater movement in other regions and have the potential to act as LSSR host rocks where they are sufficiently thick.

Further information on the characteristics of the Lias and Mercia Mudstone Groups at depth under this subregion would need to be obtained to determine whether they have the potential to host a GDF. 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.

There are also 2 potential Evaporite host rocks present below the subregion (Figure 1c). The Esk Evaporite Member of the Mercia Mudstone Group is approximately 50m thick below Whitby extending off the coast but thinning to the west and north. It comprises crystalline rock salt (halite) with occasional mudstone and siltstone layers and therefore a better understanding of the exact distribution of the layers would be needed to ascertain its potential as a host rock. The highest evaporite cycle in the Zechstein Group, the Sneaton Halite Formation, is likely to occur at the bottom of the depth range of interest under the subregion reaching 55m thickness below Whitby. Deep boreholes have shown that this formation contains rock salt, potash, anhydrite and mudstone although there are not enough deep boreholes in this area to know whether the size and shape of the rock salt bodies would be suitable for an Evaporite host rock.

A summary of the geological attributes of the Eastern England 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

There is major faulting in the south of the subregion between Thirsk, Malton and Scarborough (Figure 2) which would need to be considered in the siting of a GDF in this subregion. However, most of the rocks in this subregion have not been significantly affected by folding. Faults may act as barriers to or pathways for groundwater movement, depending upon their characteristics, and these would need to be considered during the siting of a GDF[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. Two principal aquifers are present within 400m of the surface in this subregion: the Sherwood Sandstone Group and the Corallian Group. The Sherwood Sandstone Group is widely used for public water supply, agriculture and industry to the west of the subregion, but is confined by the Mercia Mudstone Group and dips to the east with evidence of increasingly saline water as it becomes deeper. The Corallian Group occurs at the surface in the Hambleton, Howardian and Tabular Hills and the North York Moors, where it is fed by rainwater, and provides drinking water for much of Scarborough and the Vale of Pickering. Two other rock types which are principal aquifers in other regions, where they occur at shallow depths, also occur below this subregion. The numerous LSSRs in this subregion are likely to act as barriers to vertical flow between deep and shallow groundwater even where they are not thick enough to host a GDF. The presence of groundwater in the deeper units, which is older, more saline water than the fresh groundwater in the shallower units, provides evidence that there is hydraulic separation between them. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK[2].

There are some areas in the subregion, around Whitby in particular, where 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

The area between Whitby and Middlesbrough has been mined for iron ore (centred on Upsall mine) (Figure 4a). There are producing gas wells between Pickering and Malton, including sites at Kirkby Misperton, Malton, Ebberston Moor, and Marishes, as well as 10 small gas fields (Figure 4b). 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. These known resources would be taken into account in the siting of a GDF.

The southern part of the subregion, either side of the Vale of Pickering extending to the coast, has been identified as a prospective shale gas area and several Petroleum Exploration and Development Licences[3] are currently held both onshore and inshore in this subregion (Figure 4b). It is not known whether oil or gas in these licence areas will be exploited, but they would need to be considered during the siting process.

An area south of Middlesbrough has been mined for potash and rock salt (halite) (Boulby mine) as shown in Figure 4c and polyhalite mining is currently being considered both at Boulby and in the north part of the North York Moors National Park. 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, the presence of any excavations in these rocks would need to be considered in the siting of a GDF.

Areas of historic iron ore mining are also shown in Figure 4c but are not relevant to the siting of a GDF as they are shallower than 100m.

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 Eastern England subregion 1 where any of the 3 rock types of interest are present between 200 and 1,000 m below NGS datum.

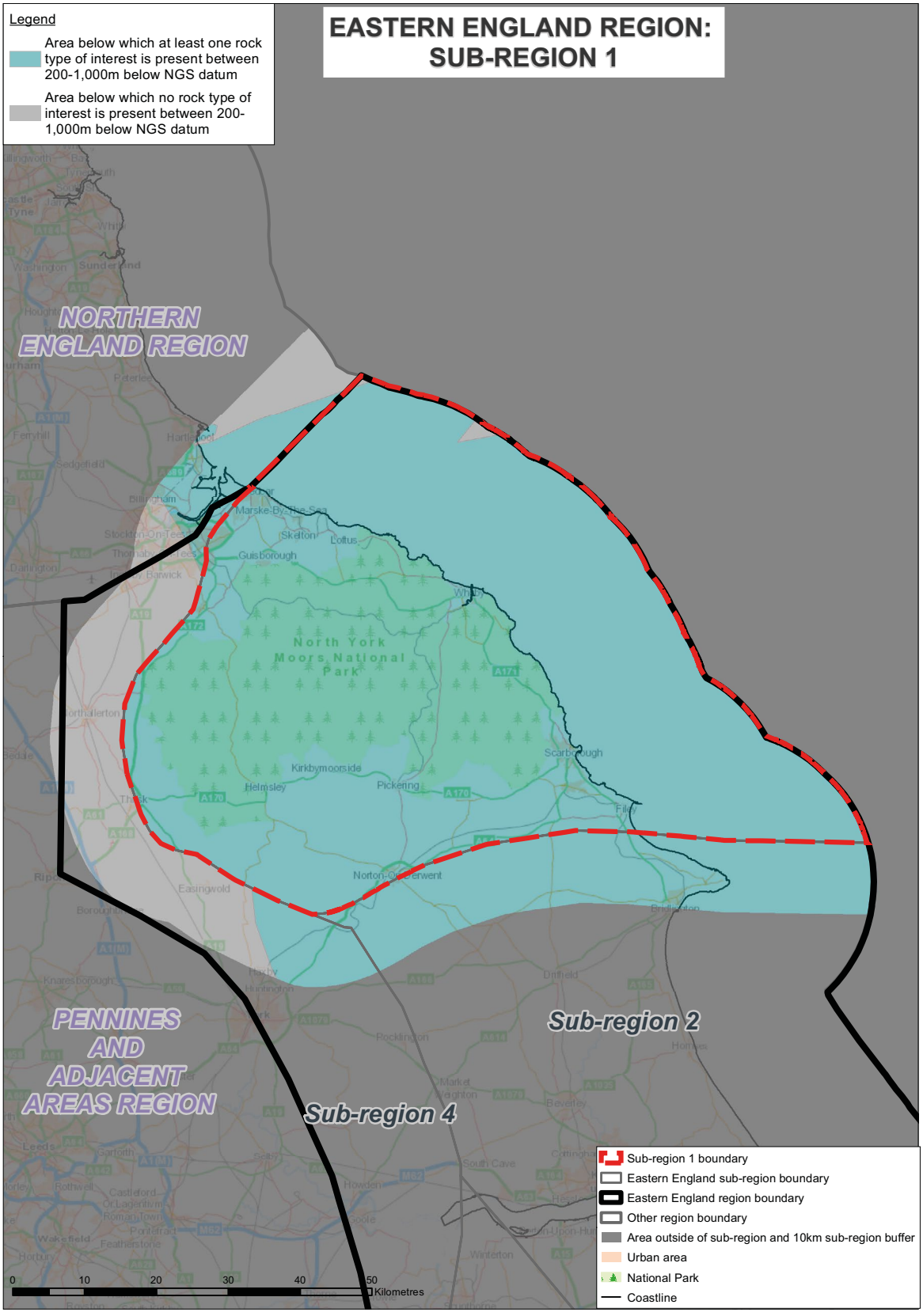


Figure 1b The areas of the Eastern England subregion 1 where Lower Strength Sedimentary rock types of interest are present between 200 and 1,000 m below NGS datum.

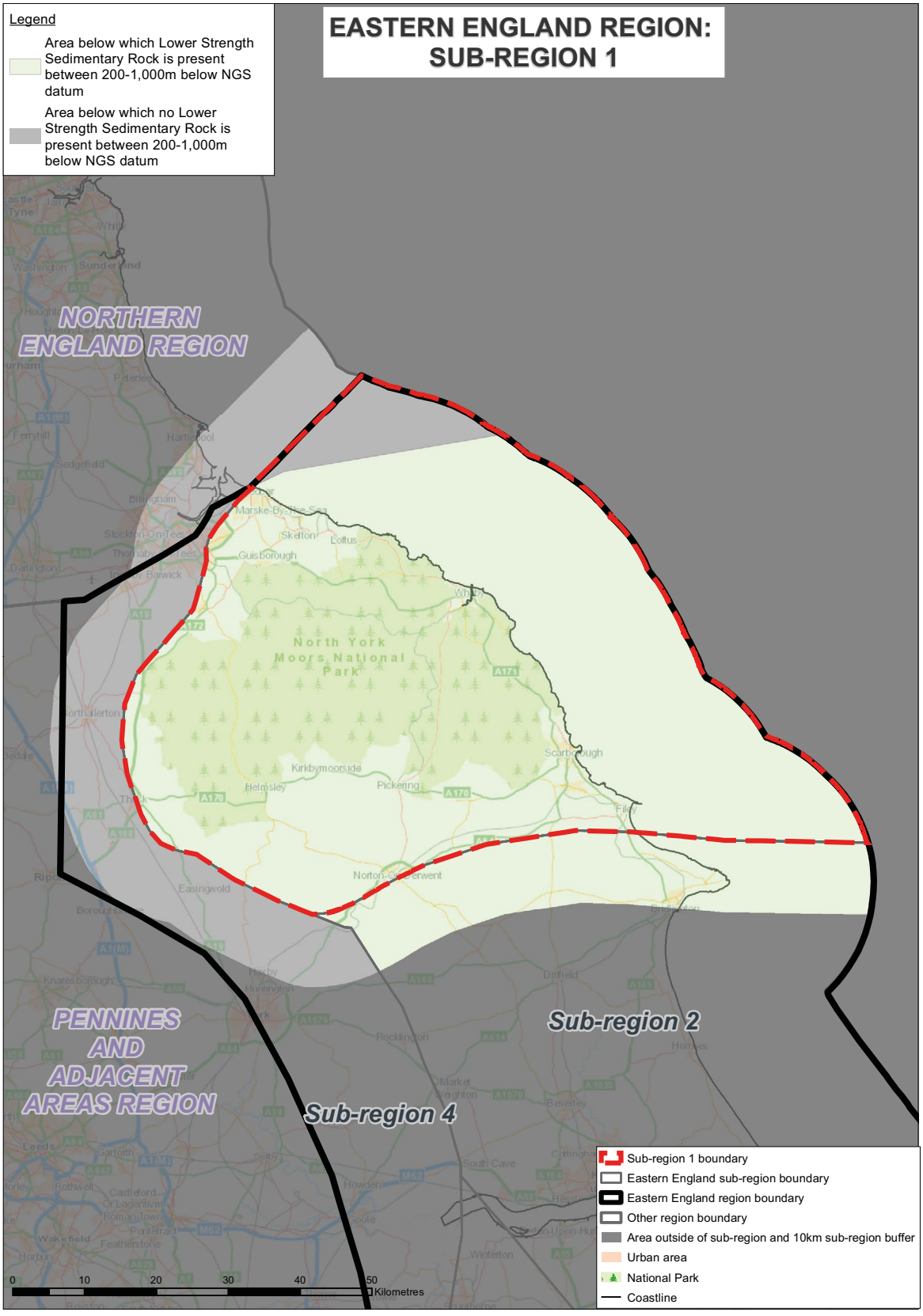


Figure 1c The areas of the Eastern England subregion 1 where Evaporite rock types of interest are present between 200 and 1,000 m below NGS datum.

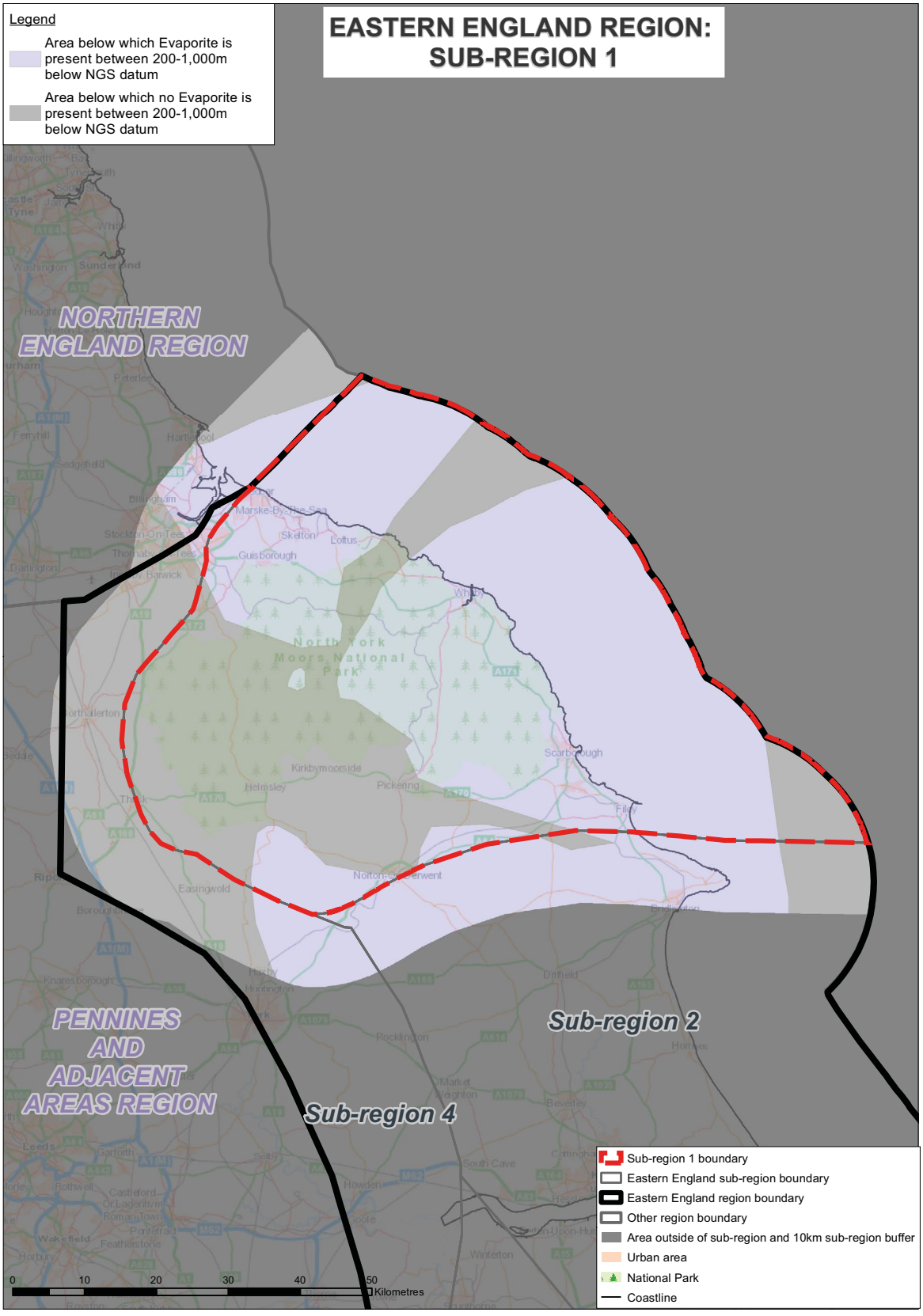


Figure 2 Location of major faults in the Eastern England subregion 1.

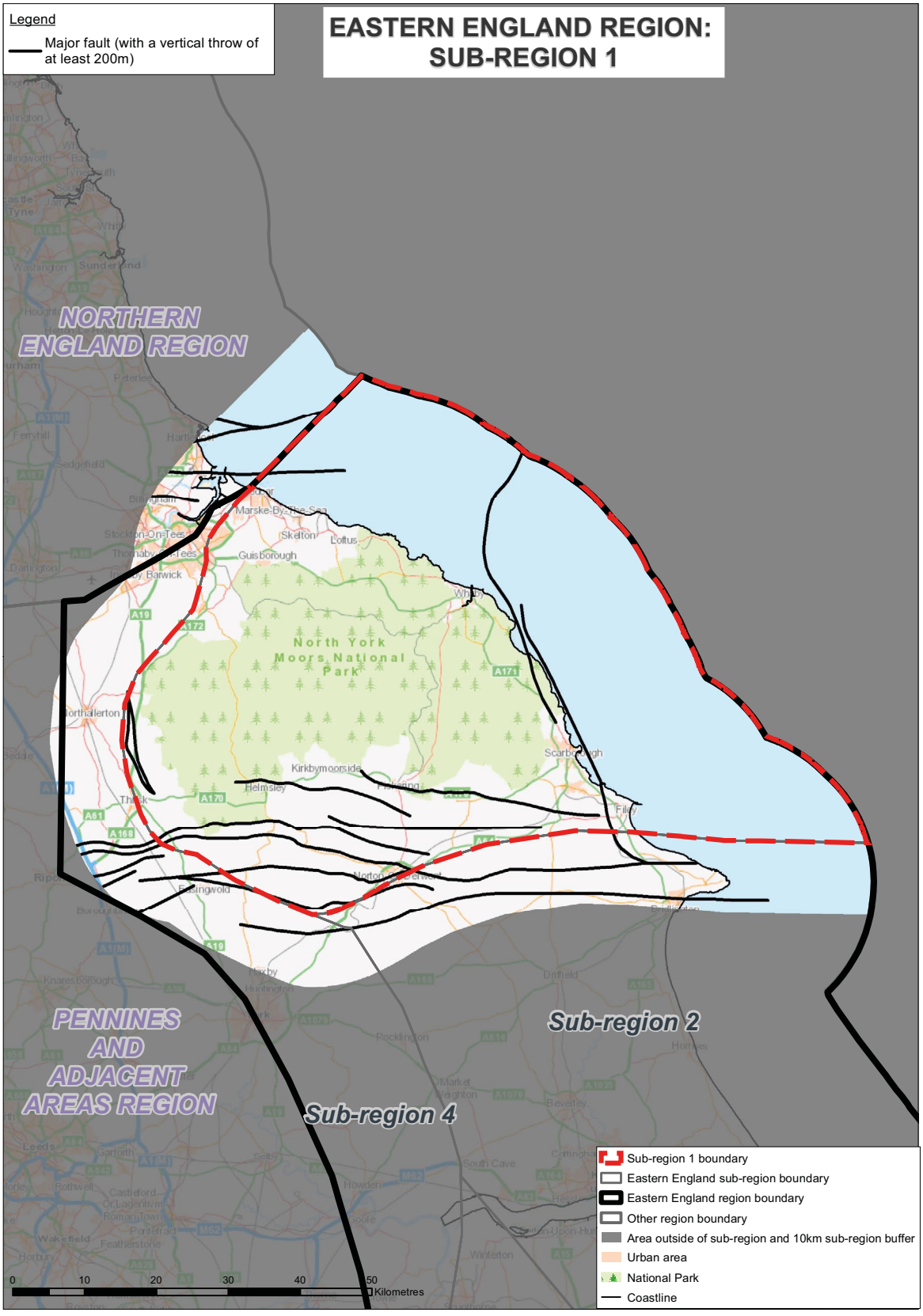


Figure 3 Areas in the Eastern England subregion 1 with concentrations of deep exploration boreholes.

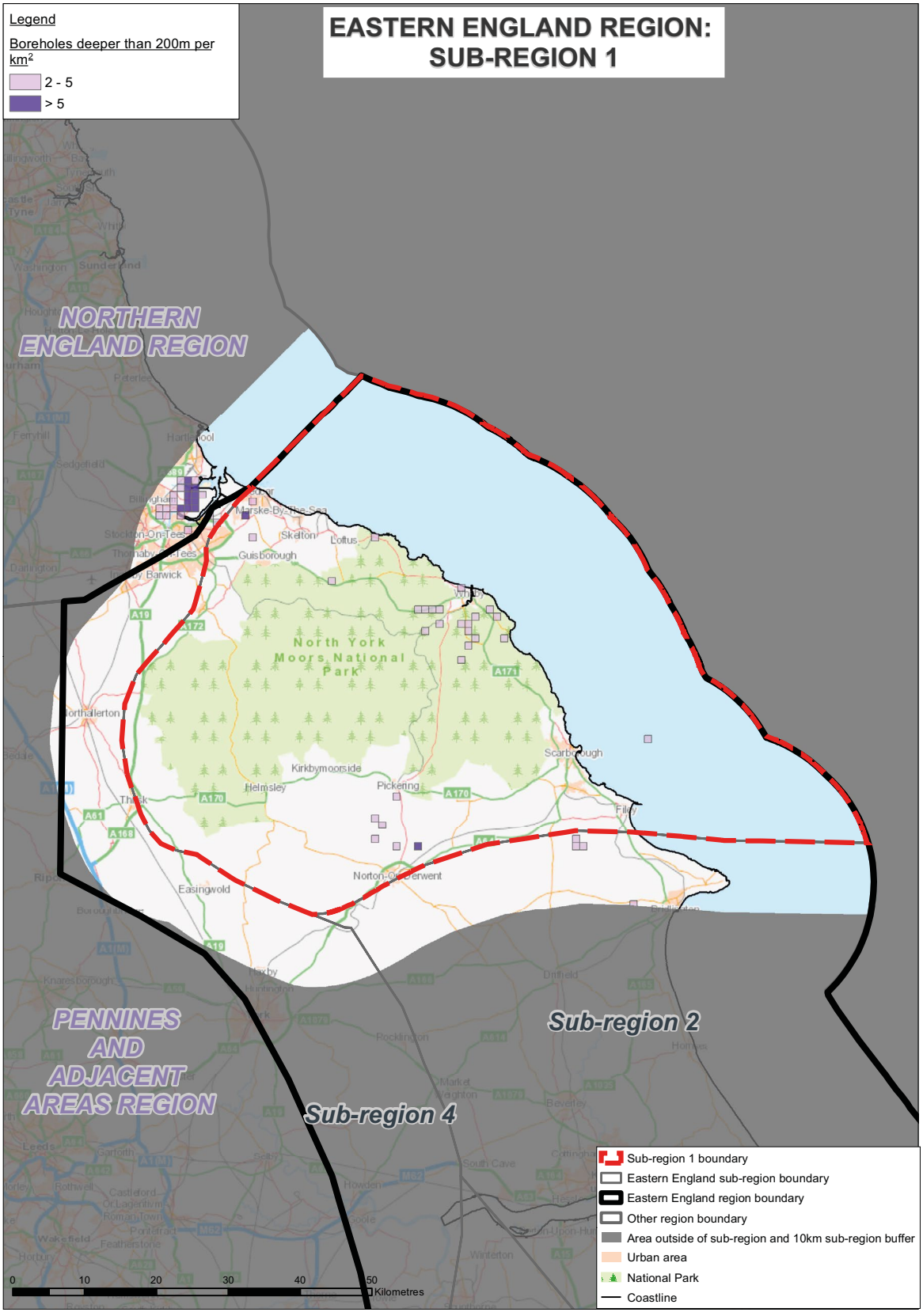


Figure 4a Areas of the Eastern England subregion 1 with iron ore mines present below 100m.

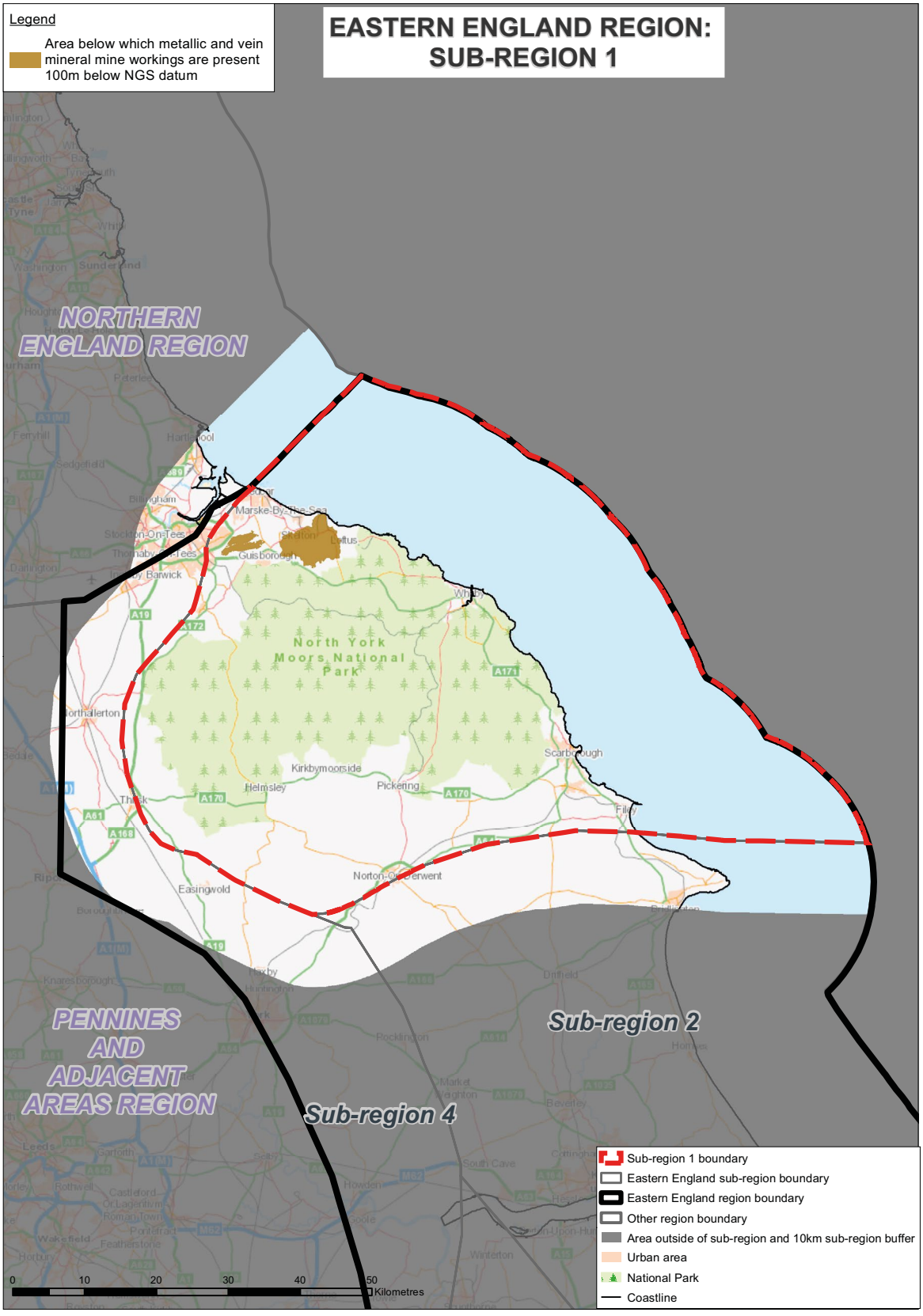


Figure 4b Areas of the Eastern England subregion 1 with oil and gas fields and Petroleum Exploration and Development Licences.

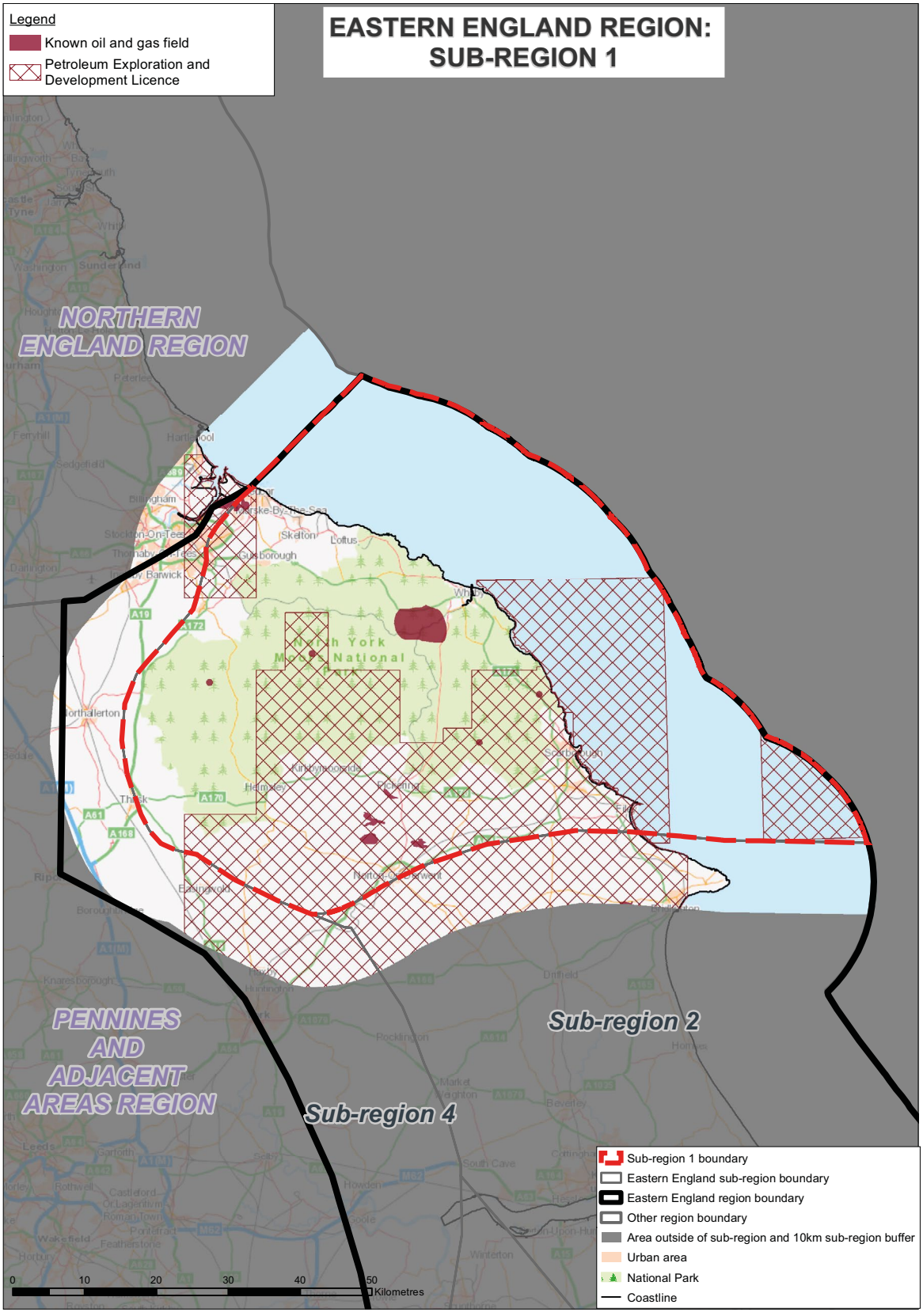
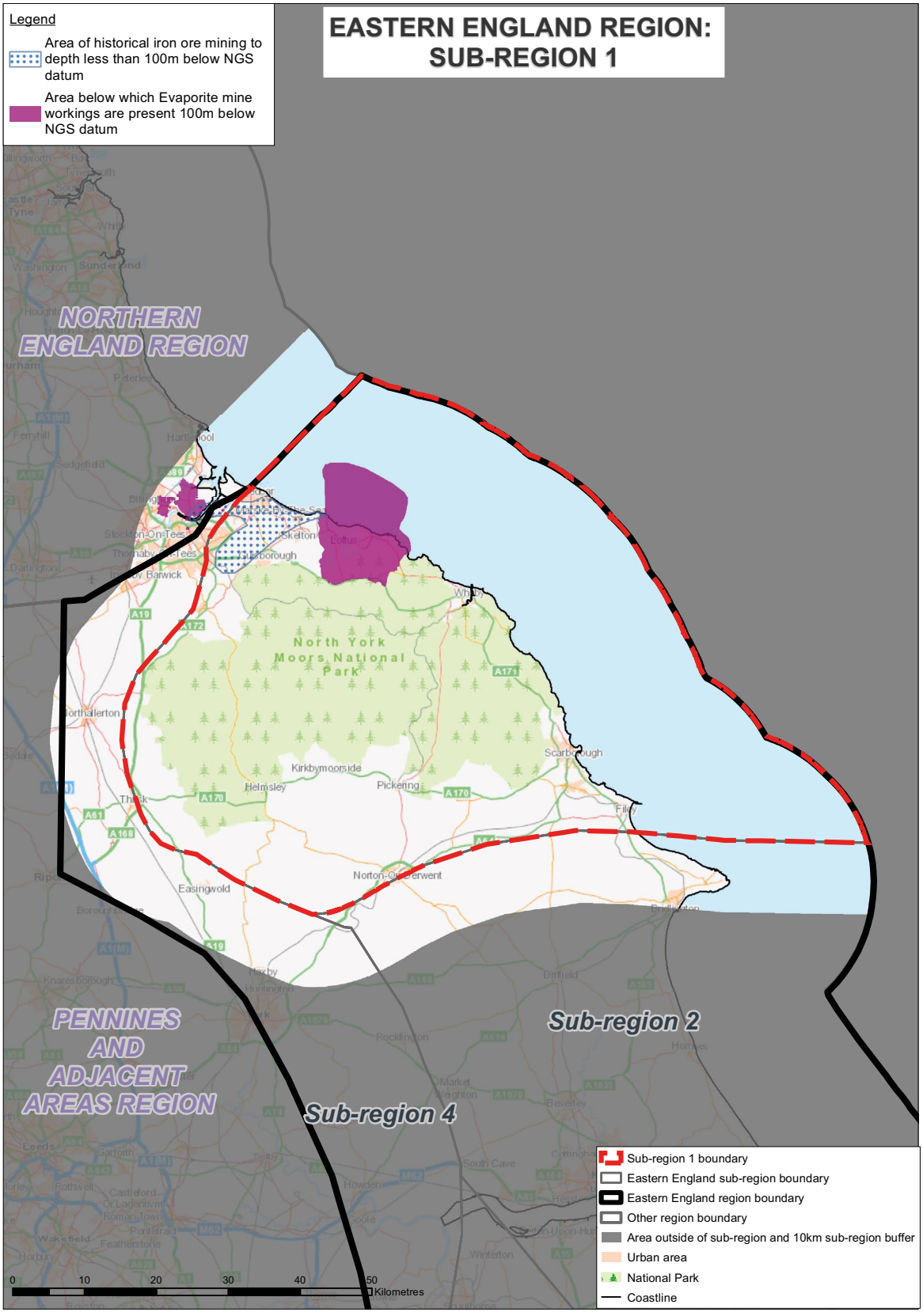


Figure 4c Areas of the Eastern England subregion 1 with historical iron ore mines less than 100m deep and evaporite mines present below 100m.



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.

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.

Evaporite cycle
An evaporite cycle is a sequence of rocks left behind after a body of salty water has evaporated Often this cycle is repeated numerous times within a sequence.

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

Polyhalite
An evaporite mineral that forms from the reaction of anhydrite or gypsum with potassium and magnesium rich fluids.

Potash
The collective term for potassium-bearing evaporite minerals. Potash is mined in the UK for use in fertilizer.

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.

Saline
Containing salt (e.g. seawater is saline).

Sedimentary
A type of rock resulting from the consolidation of material that has accumulated in layers to form gravel, sandstone, mudstone and limestone. The layers may be built up by movement from erosion (e.g. by rivers, the sea or wind) or by chemical precipitation. Generally, the material that accumulates has originated from the weathering of other rocks. Sedimentary rocks constitute one of the three main classes of rocks identified by geologists, the others being igneous and metamorphic.

Shales
A very fine-grained and strongly layered sedimentary rock in which the grains are not visible to the naked eye. Consists of clay grains and tiny fragments of other minerals such as quartz and mica.

Shale gas
Gas that is naturally generated and trapped within shales that contain a high amount of organic material. Shale gas can be extracted for use as a fuel in heating or power generation by a technique known as hydraulic fracturing or 'fracking'.

Radioactive Waste Management

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