

Annex 30.2

Preliminary Identification of  
Alternative Sites for Habitat  
Compensation

*(Black & Veatch)*





## **Able Marine Energy Park**

### **Preliminary Identification of Alternative Sites for Habitat Compensation**

September 2010



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**ABLE MARINE ENERGY PARK****PRELIMINARY IDENTIFICATION OF ALTERNATIVE SITES FOR HABITAT  
COMPENSATION****CONTENTS**

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## ABLE MARINE ENERGY PARK

### PRELIMINARY IDENTIFICATION OF ALTERNATIVE SITES FOR HABITAT COMPENSATION

#### 1. INTRODUCTION AND BACKGROUND

##### 1.1 Introduction

1.1.1 Able UK Ltd (Able) proposes to construct a major new deep water facility on the south bank of the Humber at Killingholme Marshes. This will involve developing some of the internationally designated intertidal areas of the Humber Estuary for industrial use. If the development is approved, compensation of intertidal habitat, principally mudflat, is expected to be required as a condition of the consent. Natural England has advised Able that any habitat compensation should be provided in the middle estuary.

1.1.2 Accordingly, Black & Veatch (B&V) has been asked to carry out a site selection process to identify the most suitable area for the creation of the compensatory habitat at Sunk Island, and to present the results as soon as possible to allow the necessary ecological investigations of the recommended site to be undertaken.

##### 1.2 Background

1.2.1 The selection of alternative sites has focussed on Crown Estate land in the middle estuary. Crown Estate own approximately 4,500 ha of land around Sunk Island, on the north bank of the Humber, from Paull Holme Strays to Welwick, as shown in Figure 1 and Figure 2 in Appendix A.

1.2.2 Able's informal consultation document, issued to consultees on 8 July 2010, envisages the reclamation of 52 ha of the estuary. A portion of this reclamation is existing intertidal mudflat that is designated as part of the Humber Estuary Special Protection Area (SPA). Subject to an Appropriate Assessment in accordance with the requirements of the Habitat's Directive, it is likely that this loss will require compensation habitat to be created in order to maintain the integrity of the SPA. The quantum of compensation required is subject to discussion with Natural England, but at this stage a requirement for 100 ha compensatory habitat is assumed.

#### 2. METHODOLOGY AND PROCESS FOR SELECTING SITES

##### 2.1 Data Collection

###### *(a) Mapping*

2.1.1 To enable the study to proceed, B&V purchased digital mapping data as follows:

2.1.2 Consideration was given to the purchase of LiDAR aerial survey information from the Environment Agency for this study. This was rejected at this stage of the investigation as the cost of LiDAR data for the whole search area would have been in the order of 20 times greater than that for the OS Nextmap

product. The LiDAR data would have provided more accurate information but was not considered to be essential for this preliminary investigation. LiDAR data is recommended for purchase at the next stage of the project once the site has been selected and the area of interest is more defined.

**Table 1 - Data Purchased by B&V**

Product	Purpose
OS Mastermap	Identification of all properties and other features in the area requested
OS 1:10,000 and 1:50,000 colour raster	Background mapping for the search area
Address Layer 2	Provides the address and property type for all buildings within the search area
Nextmap Britain 5m DTM	Provides indicative ground level data

*(b) Constraints Data*

2.1.3 In order to identify potential constraints, the available statutory, non-statutory and planning datasets from Natural England, English Heritage, East Riding of Yorkshire Council and the Royal Society for the Protection of Birds (RSPB) were used. The constraints information collected provided details on topics such as environmental designations, habitat inventories, land classifications and rural designations.

2.1.4 The extent of Crown Estate owned land and tenancies was taken from the plans supplied by Carter Jonas LLP to Able. The outline was digitised and added to the B&V figures.

2.1.5 Other sources of information included: The Humber Flood Risk Management Strategy (March 2008), and the Flamborough Head to Gibraltar Point Shoreline Management Plan – Consultation Draft (November 2009).

## 2.2 Identification of Exclusion Areas

2.2.1 Certain factors have been determined as being prohibitive to introducing a compensation area. These factors have therefore been used to identify areas that been excluded from future investigation for the selection of potential sites. These exclusion areas include:

- Land not owned by Crown Estates;
- Land with ground levels > 3.4mAOD;
- Terrestrial environmental designations such as SSSI, SPA, SAC;
- Scheduled Ancient Monuments;
- Listed Buildings;
- Dwellings;
- Public Highways;
- Other critical infrastructure (e.g. the radar mast at Stone Creek);
- Main watercourses; and
- Locations of previous pollution incidents.



2.2.2 Figures 3, 4 & 5 show the locations of the identified exclusion areas and where planning or construction considerations may apply, which may have an influence in selecting suitable sites (see Appendix A).

2.2.3 An additional consideration is that Natural England has stated a preference that the compensation site should be located within the Middle Humber Estuary. This is a division of the estuary based on geomorphology and ecology considerations. The Humber Coastal Habitat Management Plan has identified the Middle Estuary as the part of the Humber between the Humber Bridge and a line between Hawkin's Point and Grimsby. For this site selection process the boundary between the Middle and Outer estuary at Hawkin's Point is particularly relevant.

2.2.4 A ground level of 3.4mAOD was selected as a constraint as this level is the level of Mean High Water Springs (MHWS) from the Admiralty Tide Tables for Immingham on the south bank of the Humber opposite the western part of Crown Estate at Sunk Island. Land at this level or higher would be most likely to develop as saltmarsh and would only be occasionally exposed to tidal flooding.

2.2.5 Development of mudflat habitat would require land that is exposed at low water on the majority of tides, but also submerged on the majority of high tides. The boundary between saltmarsh and mudflat habitat is not fixed, but depends on a variety of factors including the exposure of the site, elevation, slope, the frequency of inundation, and other factors (National River's Authority R&D Technical Report W208). For site selection purposes, the assumption has been made that the compensation habitat is likely to require ground levels that are below the level of Mean High Water Neaps (MHWN) which Admiralty Tide Tables quote as 1.9mAOD for Immingham and 1.8mAOD for Grimsby.

2.2.6 In identifying potential areas for compensation habitat, we have ensured the site encloses 100ha and then applied a nominal 50m buffer all around the site to allow for construction of the new flood defence, drainage ditch and access. We have attempted to maximise the distance of the site from nearby residential property, scheduled monuments and environmental designations.

## **2.3 Limitations of Data Used**

2.3.1 The Nextmap topographic data has a quoted vertical accuracy of +/- 1m. Flying completely at night the data was acquired using airborne radar, at an altitude of 20,000-28,000ft.

2.3.2 The constraints datasets are updated on an intermittent basis by the relevant provider. The last update to the data was on 3 August 2010.

## **3. DESCRIPTION OF POTENTIALLY SUITABLE SITES**

### **3.1 Site Location Plan**

3.1.1 Using GIS as a decision-making tool, the various constraints were weighted, by environmental and planning specialists, based on their potential restriction to the creation of a compensation area. Analysis of the cumulative effect of the various restrictions allowed five potential compensation sites to be identified. Sites A and B are located to the north west of Stone Creek, whilst Sites C, D and E are located to the east. Figure 6 shows the location of the sites (see Appendix A).

### 3.2 Site A

3.2.1 Site A is the westernmost of the five sites. The site area is bounded by an area of Coastal Floodplain Grazing Marsh identified within the BAP Habitat data to the north-west, Cherry Cobb Sands Road to the east and the existing flood defence embankment to the south-west. The site is classified as Grade 2 agricultural land.

3.2.2 The area of Coastal Floodplain Grazing Marsh is not apparent from ground level or aerial photography available on the internet. A more important constraint is the presence of a Scheduled Monument on the saltmarsh seaward of the flood defence immediately to the north of the site. This monument is a set of ponds constructed as a World War II decoy on the saltmarsh, and we have assumed that the whole length of the existing flood defence between the saltmarsh embayment and the land behind would need to be maintained to prevent erosion of the existing saltmarsh, which would be likely to threaten the foundations of the ponds that form the monument.

3.2.3 There is one residential property within 250m of the embankment, 'Fairview' on Cherry Cobb Road near Long Plantation. The embankment runs about 115m from 'Fairview' on the opposite side of the road.

3.2.4 Data supplied on behalf of the Crown Estate indicates that land within Site A is occupied by two tenants, with a 70% / 30% split.

3.2.5 The length of new embankment required is estimated to be 3,239m. This includes the 450m length of existing flood defence that separates Site A from the existing saltmarsh. The average level of land within the site is 3.0mAOD according to the Nextmap data.

3.2.6 The majority of this site has been identified as a potential habitat creation area by the Environment Agency in The Humber Flood Risk Management Strategy (March 2008).

3.2.7 Apart from the northern part of this frontage, where the scheduled monument is located, the mapping shows little or no saltmarsh along the remainder of the frontage where breaches in the existing defences would need to be made to allow tidal inundation of the site (see Figure 7 in Appendix A).

3.2.8 Site A is west of Hawkin's Point and so within the Middle Humber Estuary preferred by Natural England.

### 3.3 Site B

3.3.1 Site B is to the east of Site A, although they partially overlap to the south-west of Long Plantation. The site area is bounded by Cherry Cobb Sands Road to the east, the Crown Estate land boundary to the south-east (close to the radar mast and outfall for Keyingham Drain) and the existing flood defence embankment to the south-west. The site is classified as Grade 2 agricultural land.

3.3.2 There is one residential property within 250m of the embankment, 'Fairview' on Cherry Cobb Road near Long Plantation. The shape of Site B has been adjusted in the vicinity of 'Fairview' to keep the proposed embankment at least 290m away from this property, on the opposite side of the road.

3.3.3 The length of new embankment required is estimated to be 3,126m. The average level of land within the site is 3.1mAOD according to the Nextmap survey (See Figure 8 in Appendix A).

3.3.4 The radar mast near Stone Creek is not on Crown Estate land and we assume that access and utilities required by this site do not cross the Crown Estate land. These assumptions would require verification if this site were chosen.

3.3.5 This site has been identified as part of a potential future habitat creation area by the Environment Agency in The Humber Flood Risk Management Strategy (March 2008).

3.3.6 The mapping shows little or no saltmarsh along the site frontage where breaches in the existing defences would need to be made to allow tidal inundation.

3.3.7 Data supplied on behalf of the Crown Estate indicates that land within Site B is occupied by one tenant.

3.3.8 Site B is west of Hawkin's Point and so within the Middle Humber Estuary preferred by Natural England.

### **3.4 Site C**

3.4.1 Site C is located between Stone Creek and the Coastal Battery, on Sunk Island. The site is bounded by the existing flood defence embankment to the south, and to the north by Stone Creek Road. The site is classified as Grade 2 agricultural land, though the north east boundary of the site comes within 250m of an area of Grade 1 land.

3.4.2 Data supplied on behalf of the Crown Estate indicates that land within the site is occupied by four tenants with a 44% / 14% / 41% / 1% split. It is feasible for the site to be amended to limit the effects to three tenants with the largest share of the plot, the exact changes to the site boundaries can be investigated in the next stage of the project.

3.4.3 The length of new embankment required is estimated to be 3,751m. The average level of land within the site is 3.1mAOD according to the Nextmap data.

3.4.4 The boundaries of the site are set back 250m from Stone Creek Road with its three residential properties to minimise the effect of the embankment on these properties. Two of the three properties are on the opposite side of the road, while Crown Farm at the east end of the site is on the same side of the road at the crossroads. Opposite the eastern embankment 100m down a side turning there is a residential property (South Farm Cottages) that is Grade 2 listed. Altogether there are five residential properties within 250m of the embankment.

3.4.5 The southern boundary of the site is alongside the wooded area that contains the remains of a coastal fortification that is believed to date from the First World War. This site, however, is not a Scheduled Monument nor designated for its heritage value in any other way. This area is also unusual in Sunk Island as one of the very few wooded areas, though it has not received any environmental designation.

3.4.6 Site C is wholly within the Sunk Island Built Conservation Planning Area in the East Yorkshire local plan. Proposed works within the area would need to

apply for Conservation Area Consent from the Local Planning Authority. Works are more likely to be consented if they are in keeping with the character and setting of the Conservation Area. For example, works to remove trees or buildings are unlikely to be approved as these are protected by the Conservation Area status. Early discussions with the Local Planning Authority would be required to determine the acceptability of substantial changes in the setting of the Conservation Area.

3.4.7 The seaward boundary of Site C is separated from the mudflat of the Humber Estuary by 110m of saltmarsh. One or two channels would need to be excavated through this saltmarsh to allow tidal water to flood and drain the site each tide. A similar approach was adopted when ABP developed the Welwick site as a mudflat compensation for their port development at Immingham.

3.4.8 Site C is west of Hawkin's Point and so within the Middle Humber Estuary preferred by Natural England.

### 3.5 Site D

3.5.1 Site D is bounded to the south by the existing flood defence embankment and to the north by Old Hall Road and to the east by Spragger Drain, which discharges into the estuary. The extent of the site is heavily influenced by existing dwellings. There are 12 residential properties including two grade 2 listed buildings within 250m of the Site D embankment. The site is classified as Grade 2 agricultural land, though the north boundary of the site comes within 250m of an area of Grade 1 land.

3.5.2 Data supplied on behalf of the Crown Estate indicates that land within the site is occupied by three tenants with a 51% / 48% / 1% split. It is feasible for the site to be amended to limit the effect to two tenants; the exact changes to the site boundaries can be investigated in the next stage of the project.

3.5.3 The length of new embankment required is estimated to be 3,065m. The average level of land within the site is 3.1mAOD according to the Nextmap data.

3.5.4 Site D is wholly within the Sunk Island Built Conservation Planning Area in the East Yorkshire local plan. As described above for Site C, proposed works within the area would need to apply for Conservation Area Consent from the Local Planning Authority. Works are more likely to be consented if they are in keeping with the character and setting of the Conservation Area. For example, works to remove trees or buildings are unlikely to be approved as these are protected by the Conservation Area status. Early discussions with the Local Planning Authority would be required to determine the acceptability of substantial changes in the setting of the Conservation Area.

3.5.5 There is a narrow band of saltmarsh separating the site from the Humber which widens out to 225m at the eastern end of the site. One or two channels would need to be excavated through this saltmarsh to allow tidal water to flood and drain the site each tide. A similar approach was adopted when ABP developed the Welwick site.

3.5.6 Just to the east of this site is Hawkins Point, which with the Grimsby port reclamation on the opposite bank of the estuary, acts as a local narrowing of the estuary. While Hawkins Point is less prominent than other geological controls in the estuary, it probably still influences the morphological development of the estuary, being situated at the apex of one of the major bends in the Humber.

Disturbance to the geological features at Hawkins Point would be unwise without a good understanding of how any changes might affect the long term evolution of the estuary; especially with the risk any change might affect the navigability of the Humber.

3.5.7 Site D is west of Hawkin's Point and so within the Middle Humber Estuary preferred by Natural England.

### 3.6 Site E

3.6.1 Site E is the easternmost of the five sites. The site area is bounded by an access track from East Bank Farm to the east, the existing flood defence embankment to the south, and access tracks from The Old Hall to the west and north. The site is classified as Grade 2 agricultural land.

3.6.2 Data supplied on behalf of the Crown Estate indicates that land within the site is occupied by two tenants with a 71% / 29% split

3.6.3 There are no residential properties within 250m of the embankment; the closest residential property is 285m from the proposed embankment.

3.6.4 The length of new embankment required is estimated to be 3,183m. The average level of land within the site is 2.9mAOD according to the Nextmap data.

3.6.5 Site E is wholly within the Sunk Island Built Conservation Planning Area in the East Yorkshire local plan. As with Sites C and D, proposed works within the area would need to apply for Conservation Area Consent from the Local Planning Authority. Works are more likely to be consented if they are in keeping with the character and setting of the Conservation Area. For example, works to remove trees or buildings are unlikely to be approved as these are protected by the Conservation Area status. Early discussions with the Local Planning Authority would be required to determine the acceptability of substantial changes in the setting of the Conservation Area.

3.6.6 The Environment Agency owns a narrow coastal strip of land at the east end of the site, and in our assessment, we assume all this land would need to be defended from tidal inundation. To do this requires a short return embankment of approximately 350m length to ensure the frontage of the site is limited to land owned by the Crown Estate.

3.6.7 There is a narrow band of saltmarsh separating the east part of the site from the Humber which widens out to approximately 170m at Hawkins Point and about 100m in the part of the site west of Hawkins Point. One or two channels would need to be excavated through this saltmarsh to allow tidal water to flood and drain the site each tide. A similar approach was adopted when ABP developed the Welwick site.

3.6.8 Just to the south of this site is Hawkins Point, which with the Grimsby port reclamation on the opposite bank of the estuary, acts as a local narrowing of the estuary. While Hawkins Point is less prominent than other geological controls in the estuary, it probably still influences the morphological development of the estuary, being situated at the apex of one of the major bends in the Humber. Disturbance to the geological features at Hawkins Point would be unwise without a good understanding of how any changes might affect the long term evolution of the estuary; especially with the risk any change might affect the navigability of the Humber.

3.6.9 Site E, being east of Hawkins Point is within the Outer Humber Estuary geomorphology zone and so less favoured as a compensation site by Natural England who have stated a preference for the site to be located within the Middle Humber Estuary area.

### 3.7 Qualitative Assessment of Benefits / Disbenefits

3.7.1 Table 2 below records the relative benefits / disbenefits of each of the five potential sites.

**Table 2 – Benefits / Disbenefits for Each Site**

Site	Benefits	Disbenefits
A	<p>No saltmarsh will be disrupted when existing embankment is breached</p> <p>Can be combined with Site B to provide a site &gt;100ha</p> <p>The nearest residential property to the site is 100m from the embankment and the nearest non-residential property is 315m away</p> <p>The site is within the Middle Humber estuary</p>	<p>Land has already been earmarked by the Environment Agency as a planned habitation creation site</p> <p>Overtopping of the new embankment could cause damage to Cherry Cobb Sands Road</p> <p>The Public Right of Way running along the existing embankment will have to be permanently diverted when the embankment is breached</p>
B	<p>No saltmarsh will be disrupted when existing embankment is breached</p> <p>Can be combined with Site A to provide a site &gt;100ha</p> <p>Is used by a single tenant, which may assist with future negotiations, when compared with the other sites</p> <p>The nearest residential property to the site is 240m from the embankment and the nearest non-residential property is 380m away</p> <p>The site is within the Middle Humber estuary</p>	<p>Land has already been earmarked by the Environment Agency as a planned habitation creation site</p> <p>Overtopping of the new embankment could cause damage to Cherry Cobb Sands Road</p> <p>The Public Right of Way running along the existing embankment will have to be permanently diverted when the embankment is breached</p>
C	<p>The nearest residential property to the site is 160m from the embankment and the nearest non-residential property is 110m away</p> <p>The site is within the Middle Humber estuary</p>	<p>Located in a Built Conservation Planning Area</p> <p>Saltmarsh seaward of the existing flood defence will need to be excavated to construct drainage channel</p> <p>Has longest embankment length of the five sites</p> <p>Access to Coastal Battery will become elongated, when accessing from the west</p>

Site	Benefits	Disbenefits
		Is used by four tenants, which would complicate future negotiations, when compared to the other sites
D	<p>Has shortest embankment length of the five sites</p> <p>The nearest residential property to the site is 170m from the embankment and the nearest non-residential property is 150m away</p> <p>The site is within the Middle Humber estuary</p>	<p>Located in a Built Conservation Planning Area</p> <p>Saltmarsh seaward of the existing flood defence will need to be excavated to construct drainage channel</p> <p>Construction may upset the stability of Hawkins Point and might affect the morphology of the Humber Estuary</p>
E	<p>The nearest residential property to the site is 285m from the embankment and the nearest non-residential property is 150m away</p>	<p>Located in a Built Conservation Planning Area</p> <p>Saltmarsh seaward of the existing flood defence will need to be excavated to construct drainage channel</p> <p>The site is within the Outer Humber Estuary</p> <p>Construction may upset the stability of Hawkins Point and might affect the morphology of the Humber Estuary</p>

### 3.8 Initial Estimate of Development Costs

3.8.1 To prepare an indicative cost for constructing a new flood defence embankment at each site, we need to assume certain design criteria. For estimating purposes, it is assumed that the embankments will be constructed to the standard Environment Agency design. That specifies a 4m crest width and 1 in 3 side slopes.

3.8.2 It is believed that the existing flood defences have a crest level of approximately 6mAOD. Making an allowance for sea level rise and settlement of the embankment after construction, we have assumed that the new embankment for each site be constructed to a crest level of 6.75mAOD to maintain the same standard of protection as currently provided after about 50 years of sea level rise. From the topographic data, average ground levels at each site are approximately 3mAOD, giving an embankment height of 3.75m. For individual sites the average level ranges from 2.9 to 3.1mAOD. Such small differences are well within the reliability of the data suggesting that there are no significant differences in ground level between the sites.

3.8.3 With a ground level of 3.0mAOD, which is only 0.4m below MHW level at Immingham, there is a significant risk that the site will not develop as mudflat, but as saltmarsh. If that is unacceptable to Natural England, the level of the site will need to be reduced over the entire area to ensure mudflat development. We have assumed for the purpose of estimating quantities that the average ground level of the site will need to be reduced to 1.9mAOD, or lowered by an average of 1.1m

over the whole site. If we assume material from within the site can be used to construct the embankment, the remainder will need to be taken outside the site for use in other parts of the development or disposed of. Table 3 indicates the typical volume of material to be taken from the site in order to reduce ground levels, the amount required for embankment construction and the amount to be removed from the site. The amount requiring removal dominates for all sites if the average site ground level is 3mAOD.

**Table 3 - Volumes of Material Required for Each Site**

Site	Embankment length	Volume to reduce ground level by 1.1m (1000 m <sup>3</sup> )	Embankment volume (1000 m <sup>3</sup> )	Volume requiring disposal (1000m <sup>3</sup> )
A	3239	1100	185	915
B	3126	1100	179	921
C	3751	1100	215	885
D	3065	1100	175	925
E	3183	1100	182	918

3.8.4 Table 4 shows how the volume balance for the site changes with ground level using Site B as an example. The results for other sites are very similar if the ground levels are similar. The range of ground levels chosen is  $\pm 0.5$ mAOD, which covers the most probable range of uncertainty in ground levels. While embankment volumes fall as ground levels rise, the amount requiring disposal increases very rapidly.

**Table 4 - Effect of Ground Level on Material Quantities for Site B**

Average ground level (mOD)	Reduction in ground level(m)	Volume to reduce ground level (1000 m <sup>3</sup> )	Embankment volume (1000 m <sup>3</sup> )	Volume requiring disposal (1000m <sup>3</sup> )
3.5	1.6	1600	140	1460
3.0	1.1	1100	179	921
2.5	0.6	600	223	377

3.8.5 Costs for constructing embankments have been taken from the Environment Agency Flood Risk Management Estimating Guide – Update 2010. The costs have been increased by 60% as a contingency, to allow for erosion protection and unquantified risks such as ground conditions, material transport etc. The magnitude of the contingency is based on experience across public sector procurement that has shown that out-turn costs are typically around 60% greater than initial estimates based on outline quantities. This has been applied here as no design studies have taken place to quantify the risks. Indicative costs are shown in Table 5 for a range of ground levels.

3.8.6 The cost of excavating the material required for the embankments is included within the embankment cost, but there will be additional costs for the extra excavation required to lower ground levels. Spon's 2010 Civil Engineering Price Book gives cost estimates for general excavation, which have been used to estimate the cost of this additional excavation. Again Optimism Bias has been added to the figures and included in Table 5.

3.8.7 The overall construction costs for the embankment and the costs of excess excavation more or less balance out as illustrated on Table 5, with a slight increase in overall cost if the ground level of the site is higher.



**Table 5 - Embankment Construction and Site Excavation Costs**

<b>Ground Level mAOD</b>	<b>Embankment construction £M</b>	<b>Excess excavation £M</b>	<b>Contingency (60%) £M</b>	<b>Overall cost £M</b>
3.5	5.5	4.6	6.1	16.2
3.0	7.1	2.9	6.0	16.1
2.5	8.8	0.9	5.8	15.5

3.8.8 The costs in Table 5 exclude any additional costs associated with disposal of excess material. The cost of disposal of the excess material will depend greatly on uses that can be found for the material. Some of this material could probably be utilised within the site on landscaping and on providing berms to protect the main embankment from wave attack, so avoiding the costs of wave protection. The remaining material will either need to be used to raise ground levels around the site, requiring the use of additional land or be removed from site.

3.8.9 We have, for the purpose of this estimate, assumed all material will be disposed off site up to 15km away by lorry, including the associated landfill tax on inert material. Costs of disposal are set out in Table 6 including 60% contingency. The costs of disposal of excess material, if incurred, seem likely to dominate the other costs of developing the compensation site. Means to reduce the volume that needs to be disposed will be important for the economic development of the site. As expected, the cost of disposal increases very rapidly as the average ground level of the site rises, hence an accurate assessment of site ground levels is of critical importance.

3.8.10 The cost estimates do not allow for land purchase or landowner compensation

**Table 6 - Estimated Costs of Disposal of Excess Excavation for Site B**

Ground Level mAOD	Disposal cost £M	Contingency (60%) £M	Overall cost £M
3.5	73	44	117
3.0	46	28	74
2.5	19	11	30

#### 4. CONCLUSIONS AND RECOMMENDATIONS

##### 4.1 Conclusions

4.1.1 The site selection exercise has identified five potential sites within the Crown Estate on Sunk Island where 100ha intertidal compensation could be developed without coming closer than 100m to any residential property, using Grade 1 farmland or affecting Scheduled Monuments or their setting. The ground level at each site is similar according to the Nextmap topographic information, so does not favour one site over another.

4.1.2 Sites A and B to the north west of Stone Creek appear to have fewer constraints to development as a mudflat compensation habitat than Sites C, D & E to the south and east of Stone Creek. Those three sites are all within the Sunk Island Built Conservation Area, which would need to be considered in any planning application.

4.1.3 Sites A, C and D are closer to residential property than the other two sites.

4.1.4 Sites A, B, C and D are within the Middle Humber Estuary geomorphology and ecology zone that is preferred by Natural England.

4.1.5 Sites D and E are close to the headland at Hawkins Point in the Humber where the Humber changes direction. Any changes to the way currents flow around Hawkins Point may have long term effects on the morphology and navigation of the Humber. This would not prevent their development, but is likely to require more extensive hydrodynamic and sediment studies to demonstrate that they would not have an adverse effect on the morphology of the estuary.

4.1.6 All sites except B and part of A are fronted by saltmarsh, which would need to be excavated to allow tidal access to the compensation site.

4.1.7 Sites A, C and E each require return embankments close to the coast to protect adjacent land. For Sites A and C the adjacent land contains fortifications and defensive works built during the two world wars so might be sensitive on that account. The works near Site A are protected as a Scheduled Monument while those near Site C are not. The return embankment at Site E is required to protect an adjacent narrow strip of Environment Agency owned land.

4.1.8 At this stage of the assessment there is little to choose between sites on construction costs. The key issue is likely to be the amount of material requiring disposal off site. This quantity is extremely sensitive to the ground level of the site and the ground level that is required within the site to allow appropriate habitat to develop. Although Site C has almost 20% longer embankment than the other sites, this would only be likely to become an issue if off-site disposal of excess material was required.

- Overall, we recommend Site B as having fewest constraints to constructing the required habitat compensation area.

- Costs for embankment construction and removal of excess material are likely to be around £16M including 60% Optimism Bias. If disposal of significant quantities of material are required to landfill, the disposal costs are likely to greatly exceed the costs of construction and excavation.

## 4.2 Recommendations

4.2.1 The present report and study has been prepared using readily available sources of information. Particularly in the case of topographic data, more accurate and detailed, but more costly, LiDAR aerial surveys are available from the Environment Agency as these surveys have been flown at lower level than the OS Nextmap data. We recommend the following actions be undertaken during the next stage of the study:

- a) Purchase LiDAR data to develop a more accurate indication of ground levels. Like all aerial survey techniques, LiDAR can only measure to the top of the surface visible from the air. Where standing crops are present at the time of flying an assessment needs to be made of the height of the crop at the time of survey. Software is routinely used to make adjustments for vegetation such as trees and man-made objects such as buildings, but our experience is that while very helpful, these routines cannot be relied upon to provide an accurate estimate of bare ground field levels without confirmatory topographic survey.
- b) We also recommend that the accuracy of aerial mapping should be confirmed by undertaking a topographic survey of selected locations within the chosen site.
- c) Discuss required finished land level and other habitat constraints for the site with Natural England.
- d) Carry out a Ground Investigation to identify foundation conditions for the embankments and locate sites where suitable material to construct the embankments can be won.
- e) Discuss requirements for hydrodynamic field data collection and model testing with relevant parties to establish the size and location of breaches, and any environmental effects to allow inundation of the site and understand how the site will interact with the geomorphology of the Humber Estuary.

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## **APPENDICES**

### **APPENDIX A: FIGURES**

Figure 1 – Location Plan

Figure 2 – Crown Estate Owned Land

Figure 3 – Ecological Designations and Important Habitats

Figure 4 – Heritage and Planning Constraints

Figure 5 – Properties and Infrastructure

Figure 6 – Location of Potential Compensation Sites

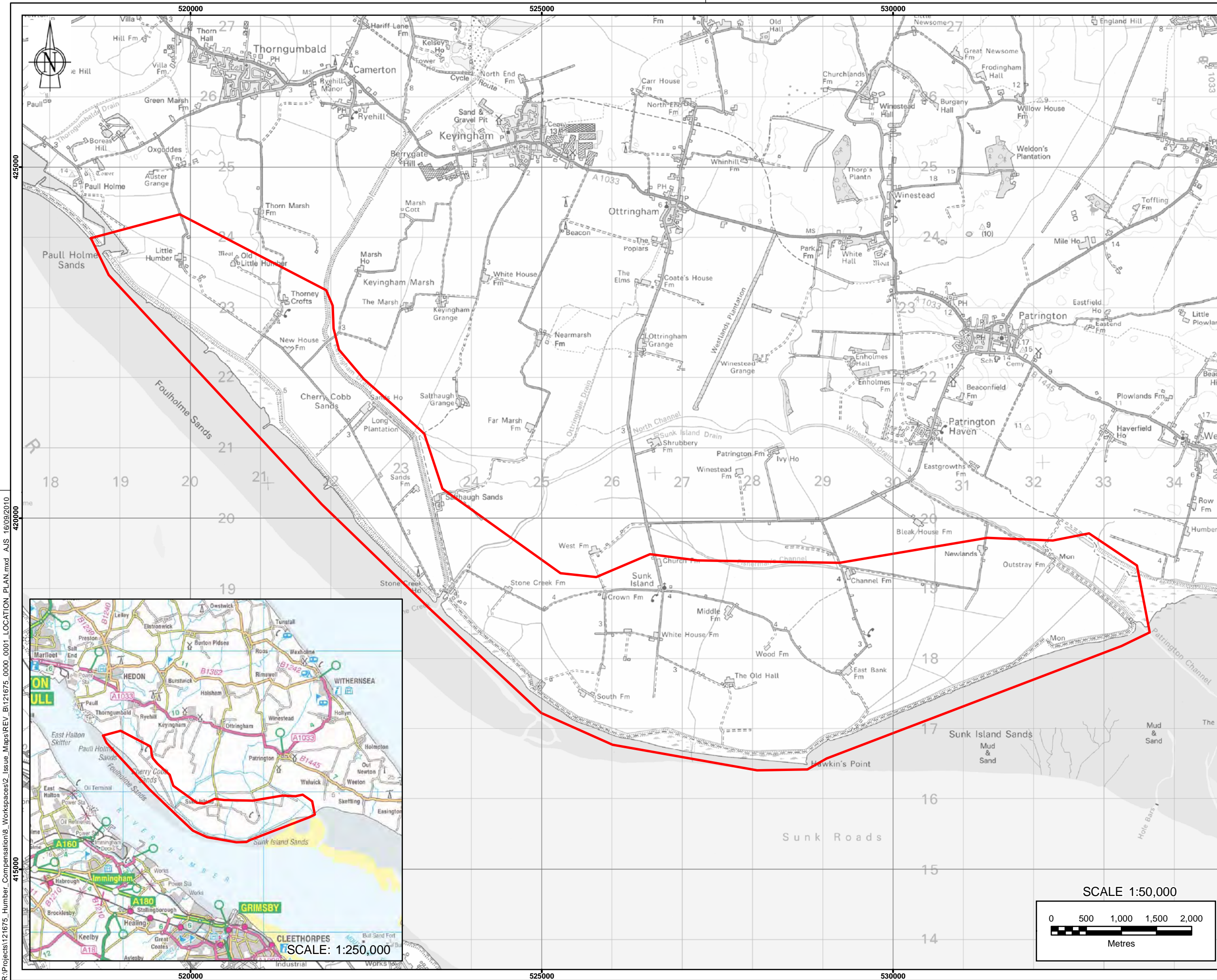
Figure 7 – Site A

Figure 8 – Site B

Figure 9 – Site C

Figure 10 – Site D

Figure 11 – Site E



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Legend  
 Study Area Boundary

**Safety Health and Environment Information**  
 In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

<b>Construction.</b>
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<b>Decommissioning / Demolition.</b>

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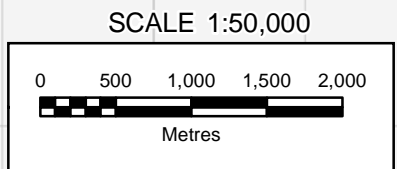
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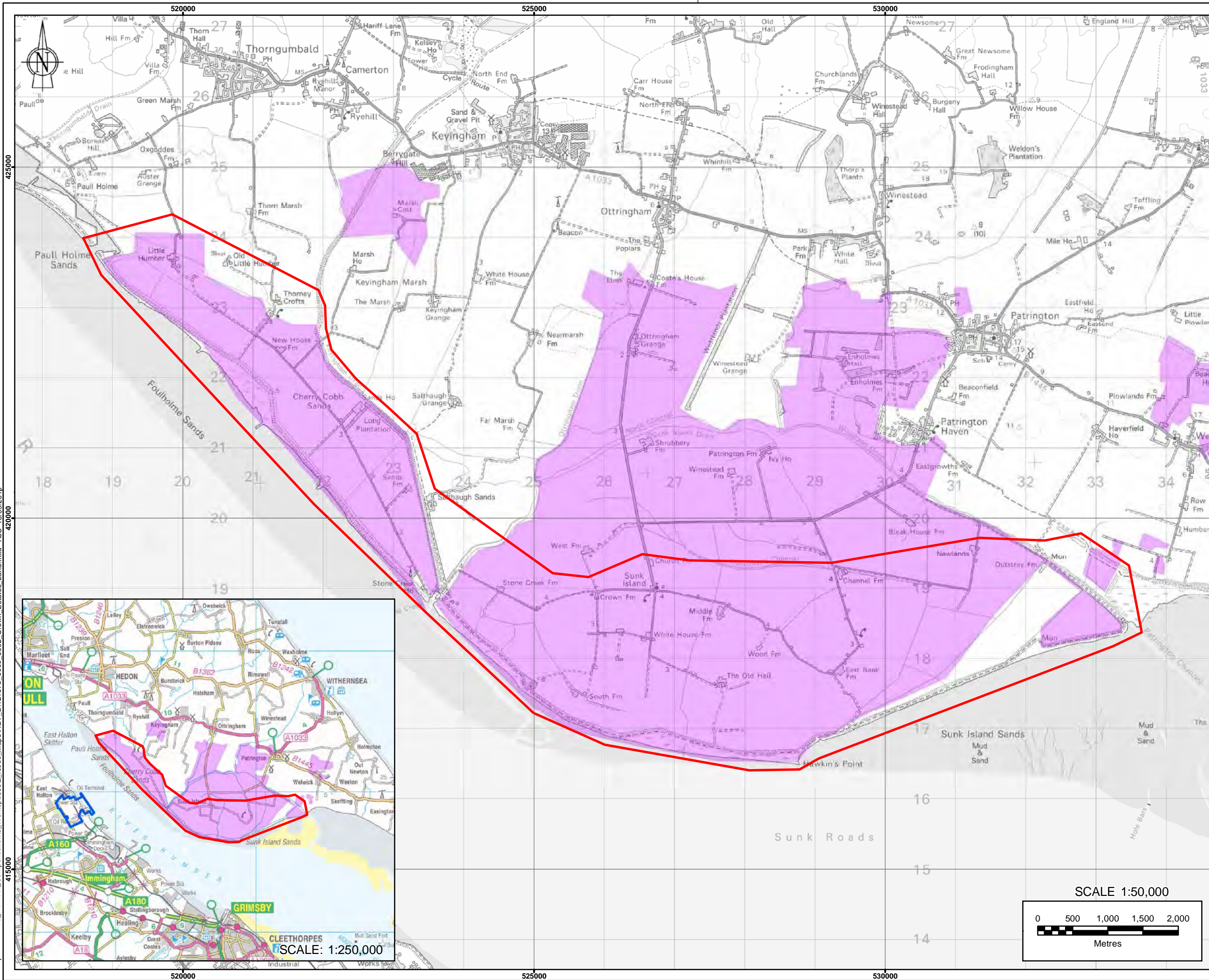


Project:  
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 Drawing title:

LOCATION PLAN

Drawing scale: SCALE | Sheet size: A3  
 Drawing no: 121675-0000-0001 | Revision: B





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- Legend**
- Study Area Boundary
  - Crown Estate Land
  - Proposed Humber Marine Energy Park

Note:  
 - Crown Estate Owned Land data sourced from Carter Jonas LLP.

**Safety Health and Environment Information**

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

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**Maintenance / Clearing / Operation.**

**Decommissioning / Demolition.**

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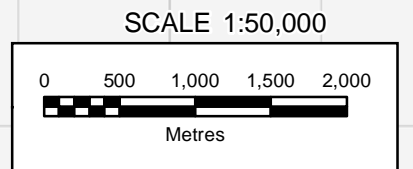


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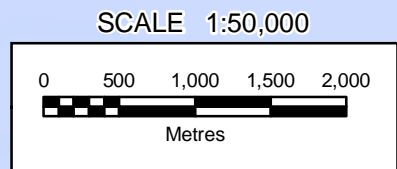
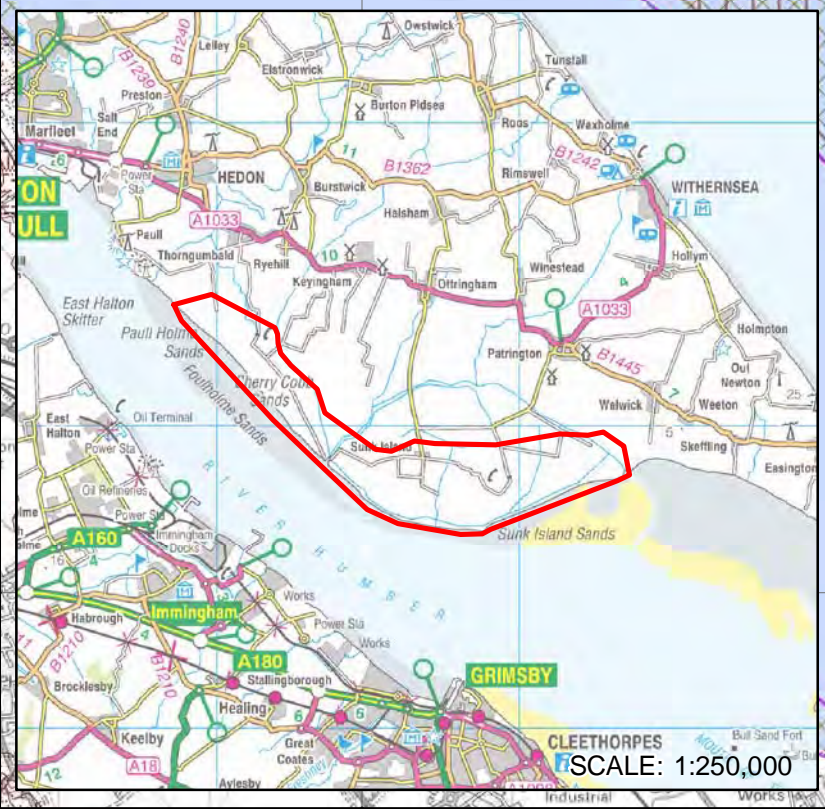
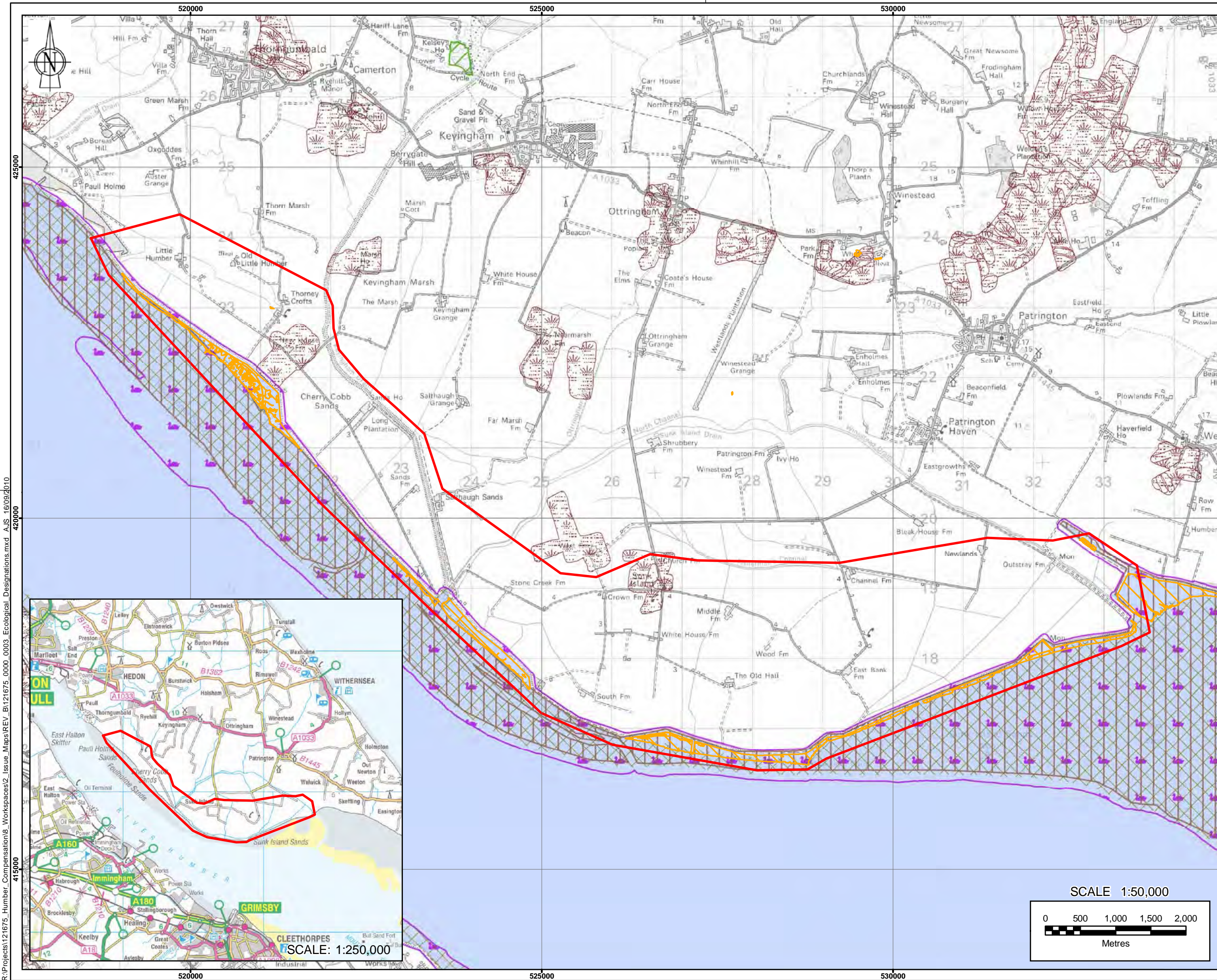
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- Legend**
- Study Area Boundary
  - Humber Estuary International and National Nature Conservation Designations\*
  - Site of Special Scientific Interest
  - Site Of Nature Conservation Importance
  - Important Bird Area
  - Saltmarsh
  - Coastal Floodplain Grazing Marsh
  - Mudflat

\*Note: Humber Estuary is designated as a Ramsar Site, Special Area of Conservation, Special Protection Area and Site of Special Scientific Interest

**Safety Health and Environment Information**

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

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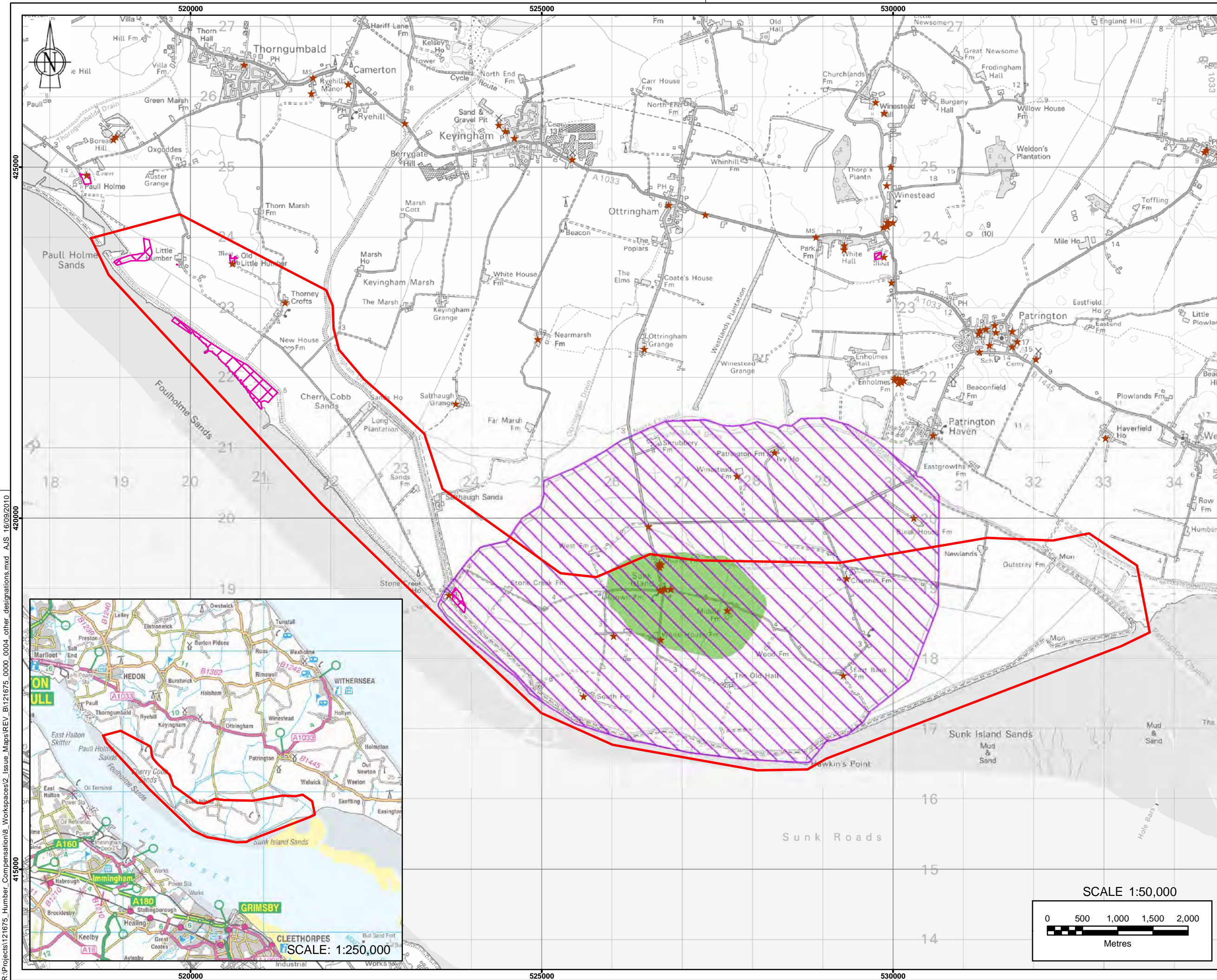
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**Legend**

- Study Area Boundary
- ★ Listed Building
- Scheduled Monument
- Grade 1 Agricultural Land
- Built Conservation Planning Area

**Safety Health and Environment Information**

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

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<b>Decommissioning / Demolition.</b>

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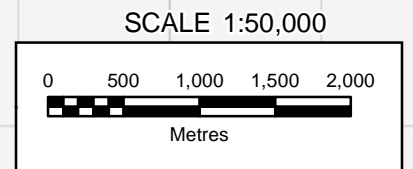
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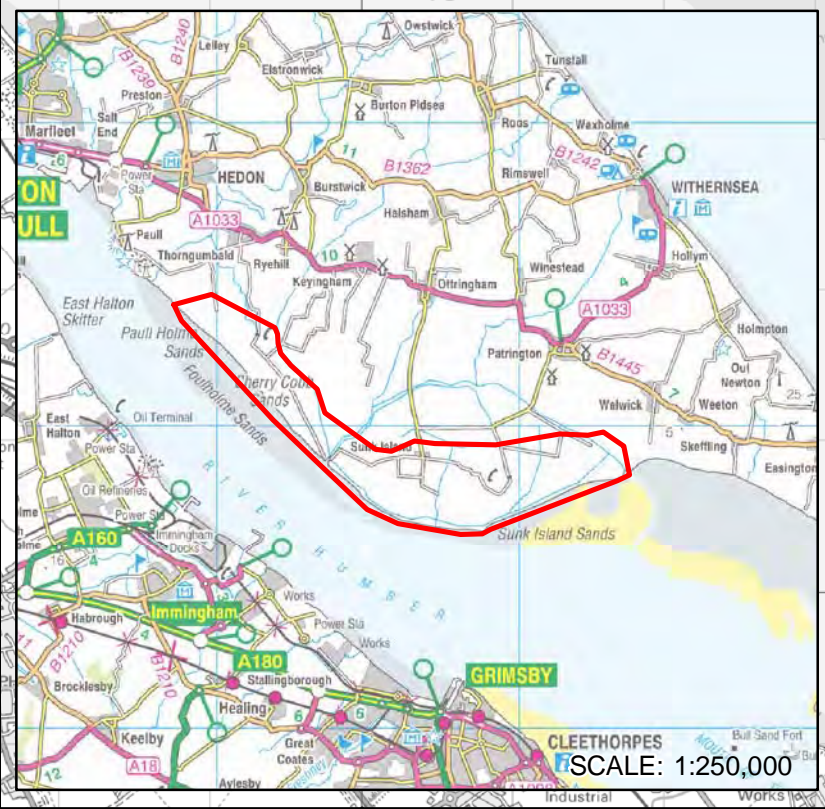
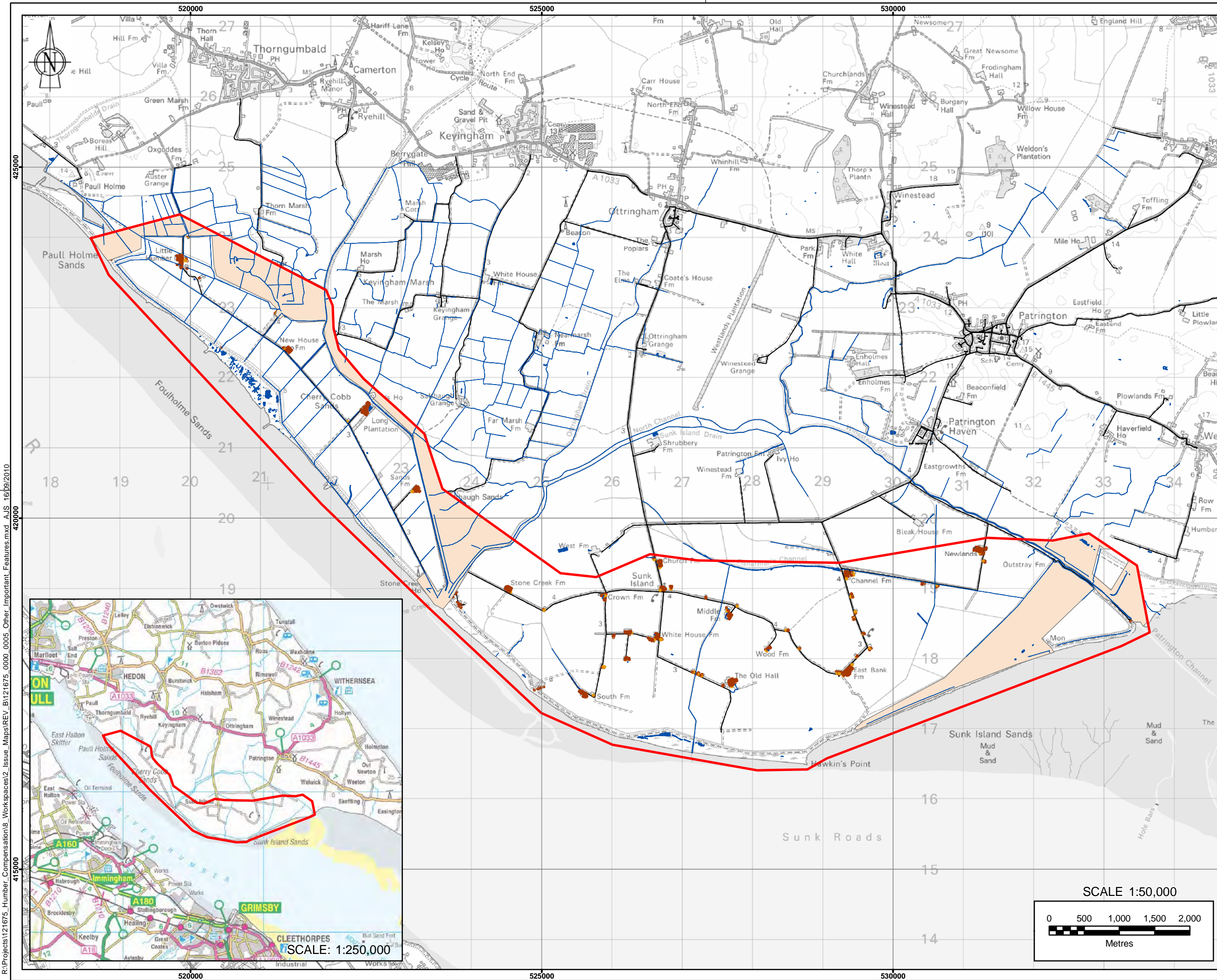
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- Legend**
- Study Area Boundary
  - Watercourse
  - Non-Crown Estate Land
  - Dwelling
  - Other Building
  - Road

**Safety Health and Environment Information**

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

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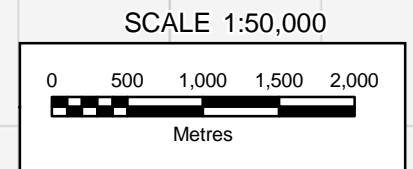


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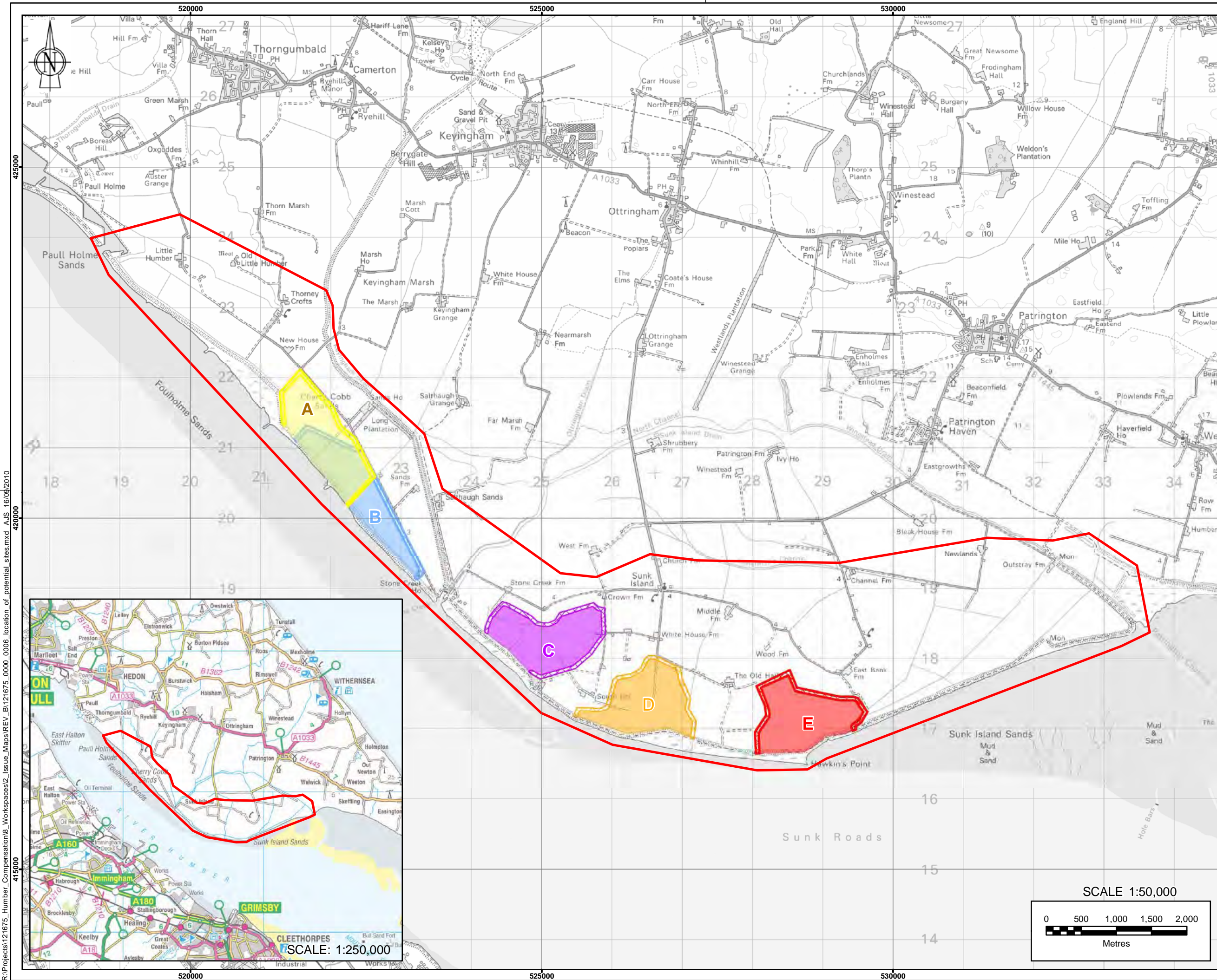
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**Legend**

- Study Area Boundary
- Site A
- Site A Embankment
- Site B
- Site B Embankment
- Site C
- Site C Embankment
- Site D
- Site D Embankment
- Site E
- Site E Embankment

**Safety Health and Environment Information**

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

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<b>Decommissioning / Demolition.</b>		

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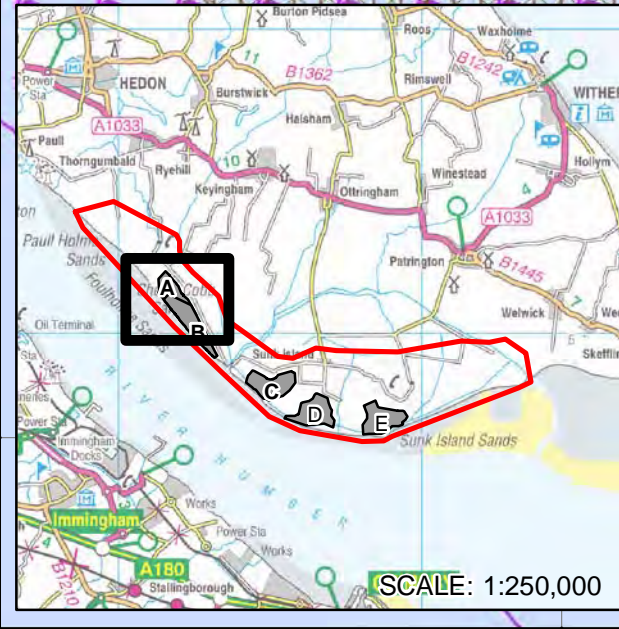
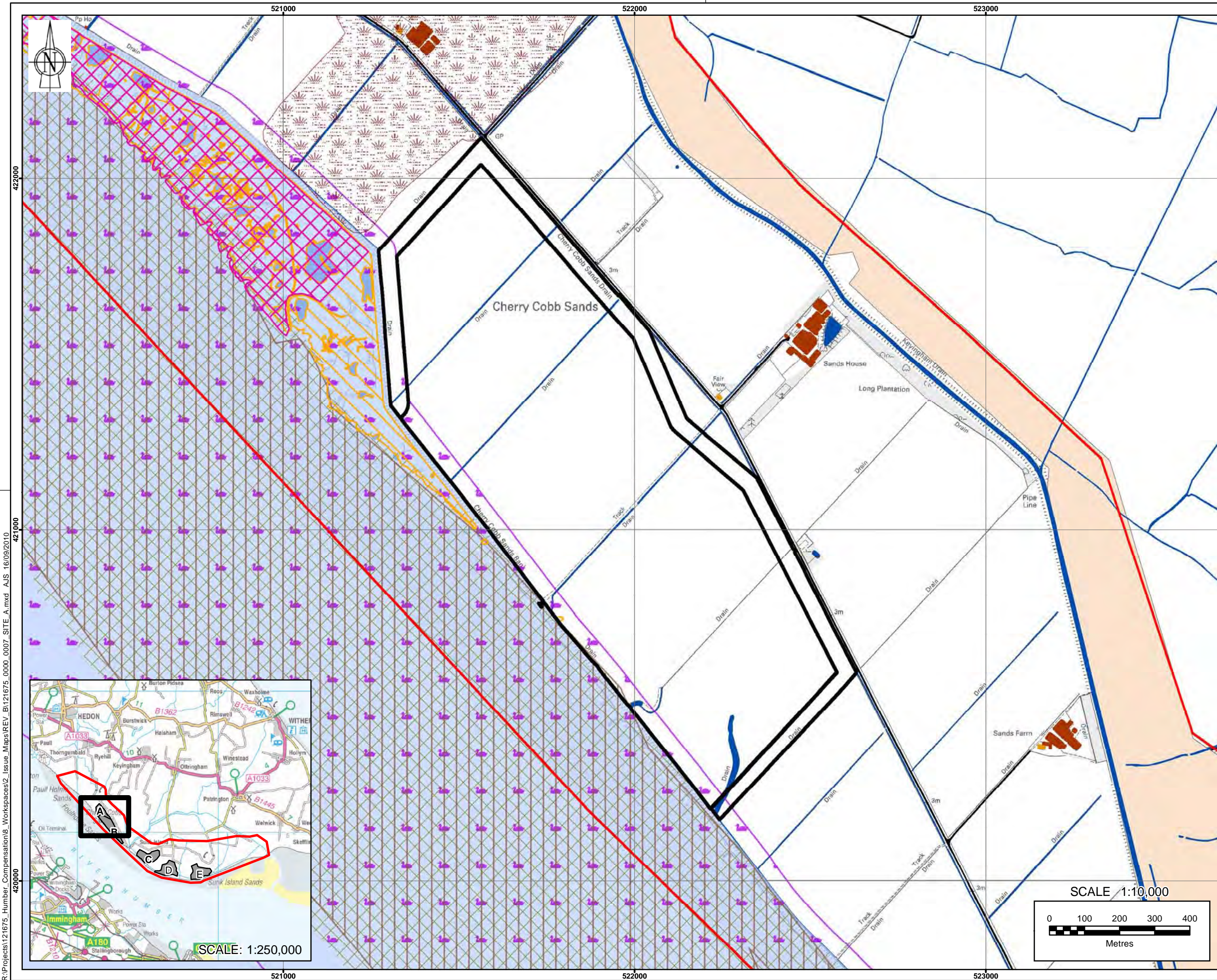
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Drawing no: 121675-0000-0006 Revision: B

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- Legend**
- Study Area Boundary
  - Potential Site A
  - Humber Estuary International and National Nature Conservation Designations\*
  - Site of Special Scientific Interest
  - Site Of Nature Conservation Importance
  - Important Bird Area
  - Saltmarsh
  - Coastal Floodplain Grazing Marsh
  - Mudflat
  - ★ Listed Building
  - Scheduled Monument
  - Grade 1 Agricultural Land
  - Built Conservation Planning Area
  - Watercourse
  - Non-Crown Estate land
  - Dwelling
  - Other Building
  - Road

\*Note: Humber Estuary is designated as a Ramsar Site; Special Area of Conservation; Special Protection Area and Site of Special Scientific Interest

**Safety Health and Environment Information**

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

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<b>Maintenance / Clearing / Operation.</b>					
<b>Decommissioning / Demolition.</b>					

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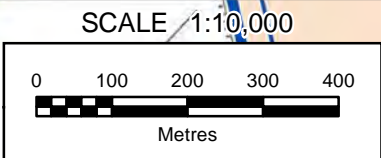
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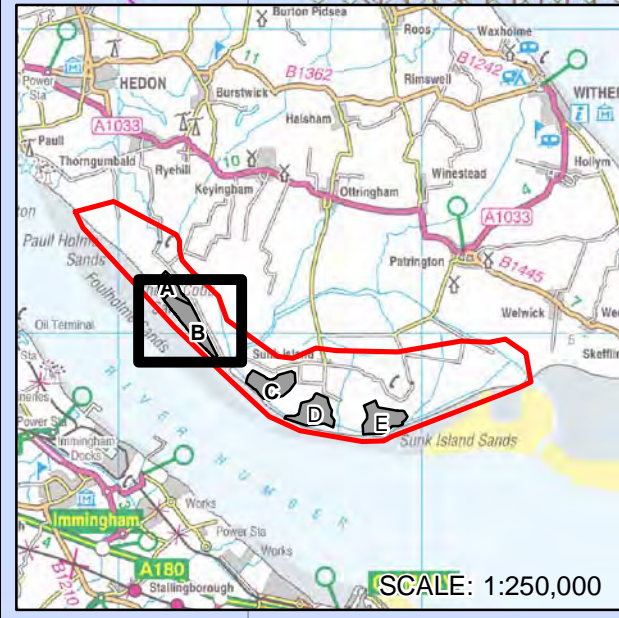
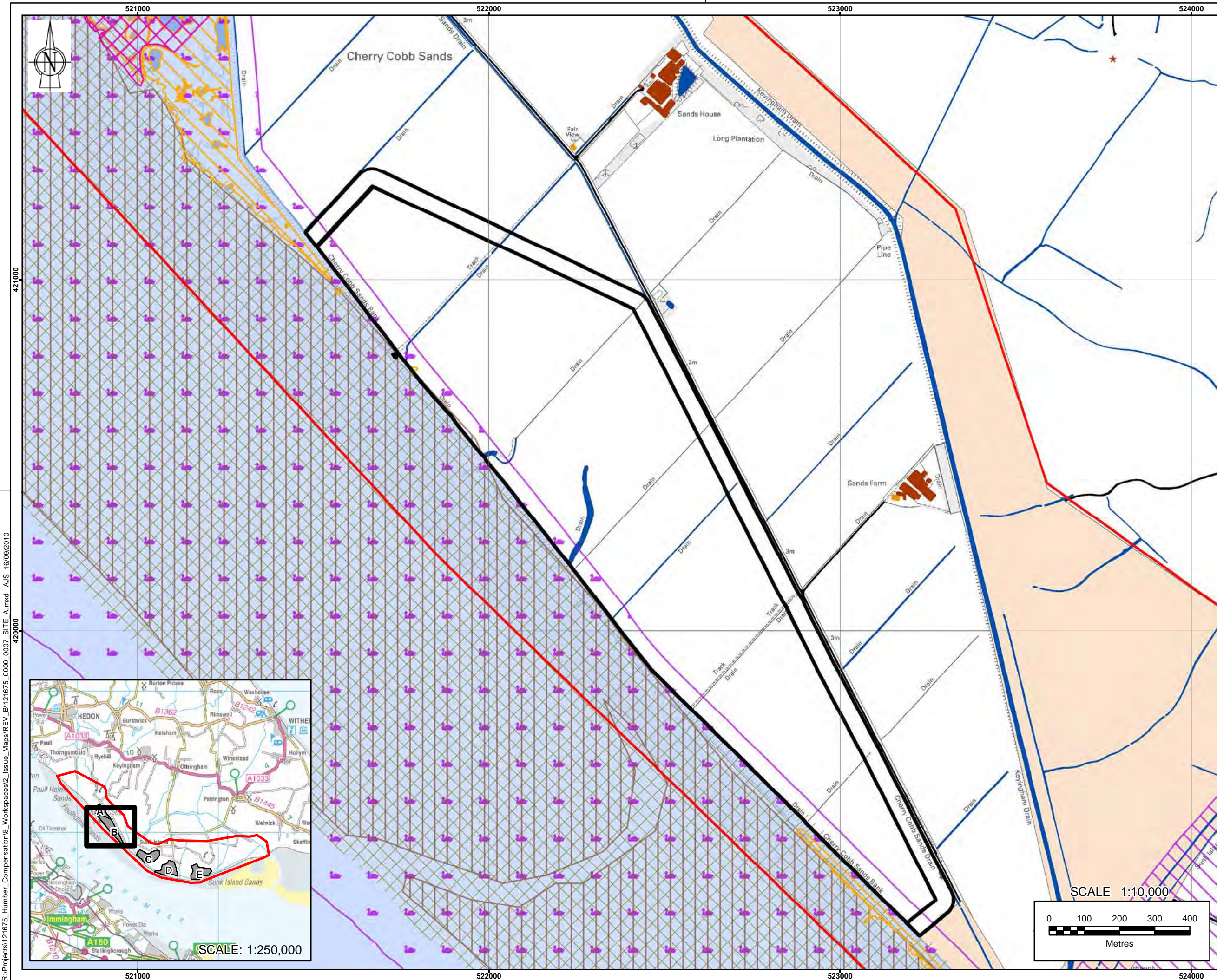


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Drawing scale: SCALE Sheet size: A3  
 Drawing no: 121675-0000-0007 Revision: B





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- Legend**
- Study Area Boundary
  - Potential Site B
  - Humber Estuary International and National Nature Conservation Designations\*
  - Site of Special Scientific Interest
  - Site Of Nature Conservation Importance
  - Important Bird Area
  - Saltmarsh
  - Coastal Floodplain Grazing Marsh
  - Mudflat
  - ★ Listed Building
  - Scheduled Monument
  - Grade 1 Agricultural Land
  - Built Conservation Planning Area
  - Watercourse
  - Non-Crown Estate land
  - Dwelling
  - Other Building
  - Road

\*Note: Humber Estuary is designated as a Ramsar Site; Special Area of Conservation; Special Protection Area and Site of Special Scientific Interest

**Safety Health and Environment Information**

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**Decommissioning / Demolition.**

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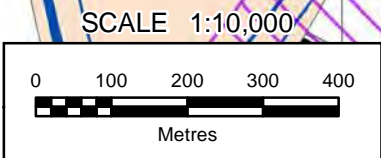
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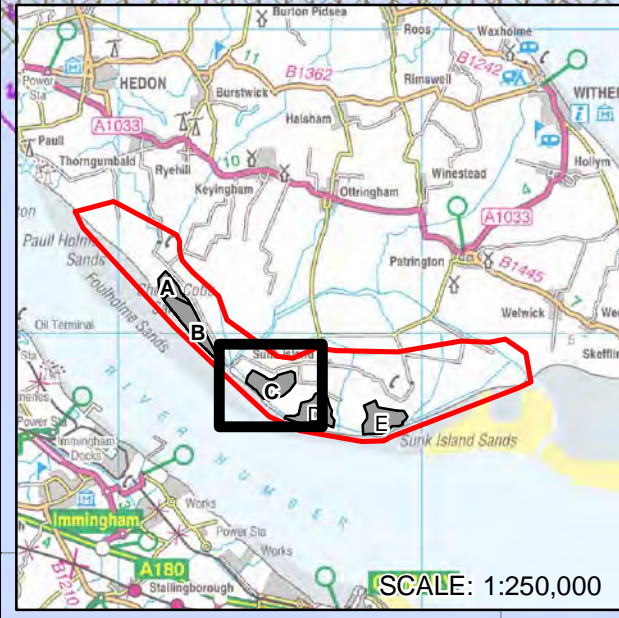
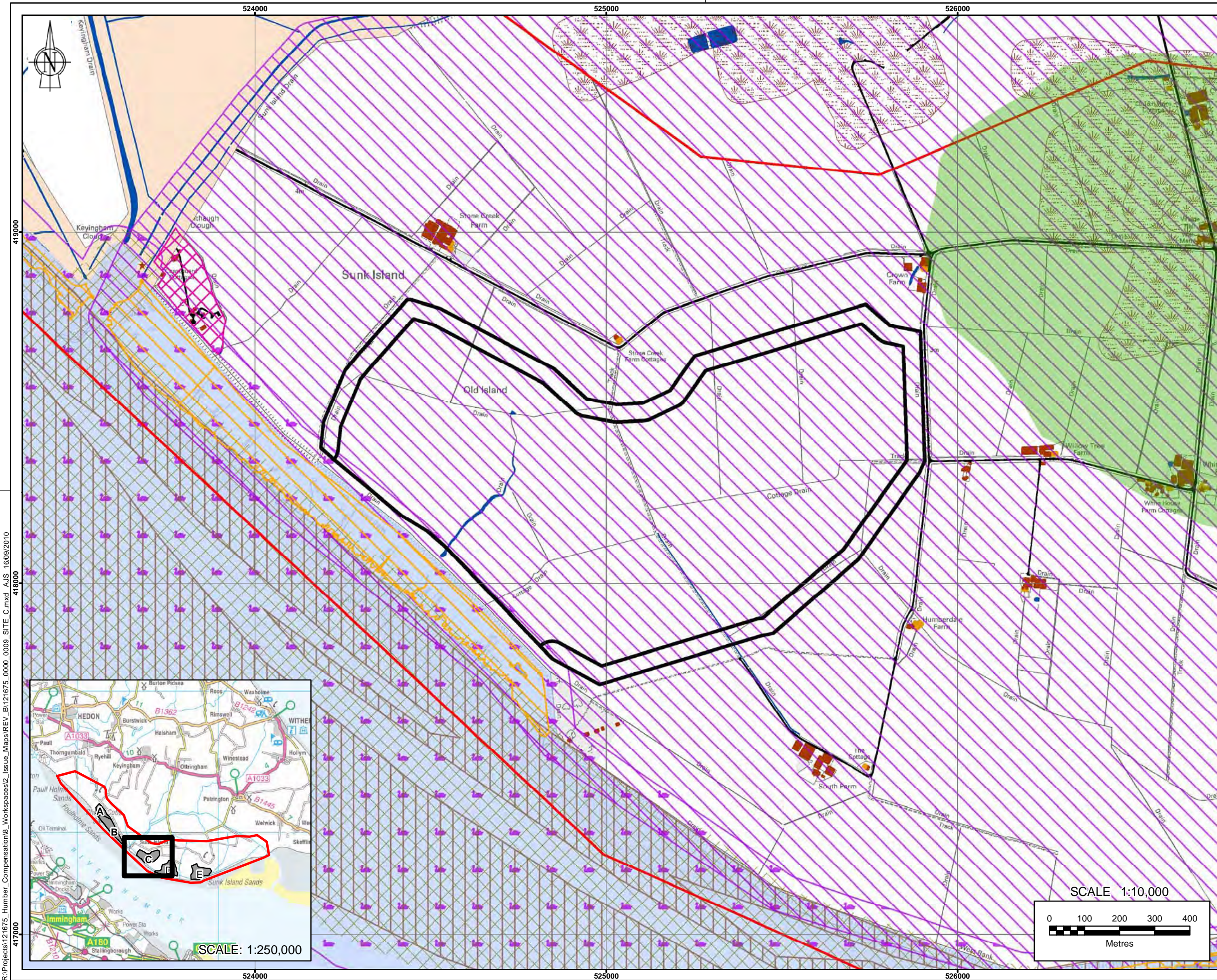
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Drawing scale: SCALE Sheet size: A3

Drawing no: 121675-0000-0008 Revision: B



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- Legend**
- Study Area Boundary
  - Potential Site C
  - Humber Estuary International and National Nature Conservation Designations\*
  - Site of Special Scientific Interest
  - Site Of Nature Conservation Importance
  - Important Bird Area
  - Saltmarsh
  - Coastal Floodplain Grazing Marsh
  - Mudflat
  - ★ Listed Building
  - Scheduled Monument
  - Grade 1 Agricultural Land
  - Built Conservation Planning Area
  - Watercourse
  - Non-Crown Estate land
  - Dwelling
  - Other Building
  - Road

\*Note: Humber Estuary is designated as a Ramsar Site; Special Area of Conservation; Special Protection Area and Site of Special Scientific Interest

**Safety Health and Environment Information**

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

**Construction.**

**Maintenance / Clearing / Operation.**

**Decommissioning / Demolition.**

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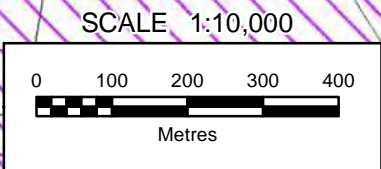


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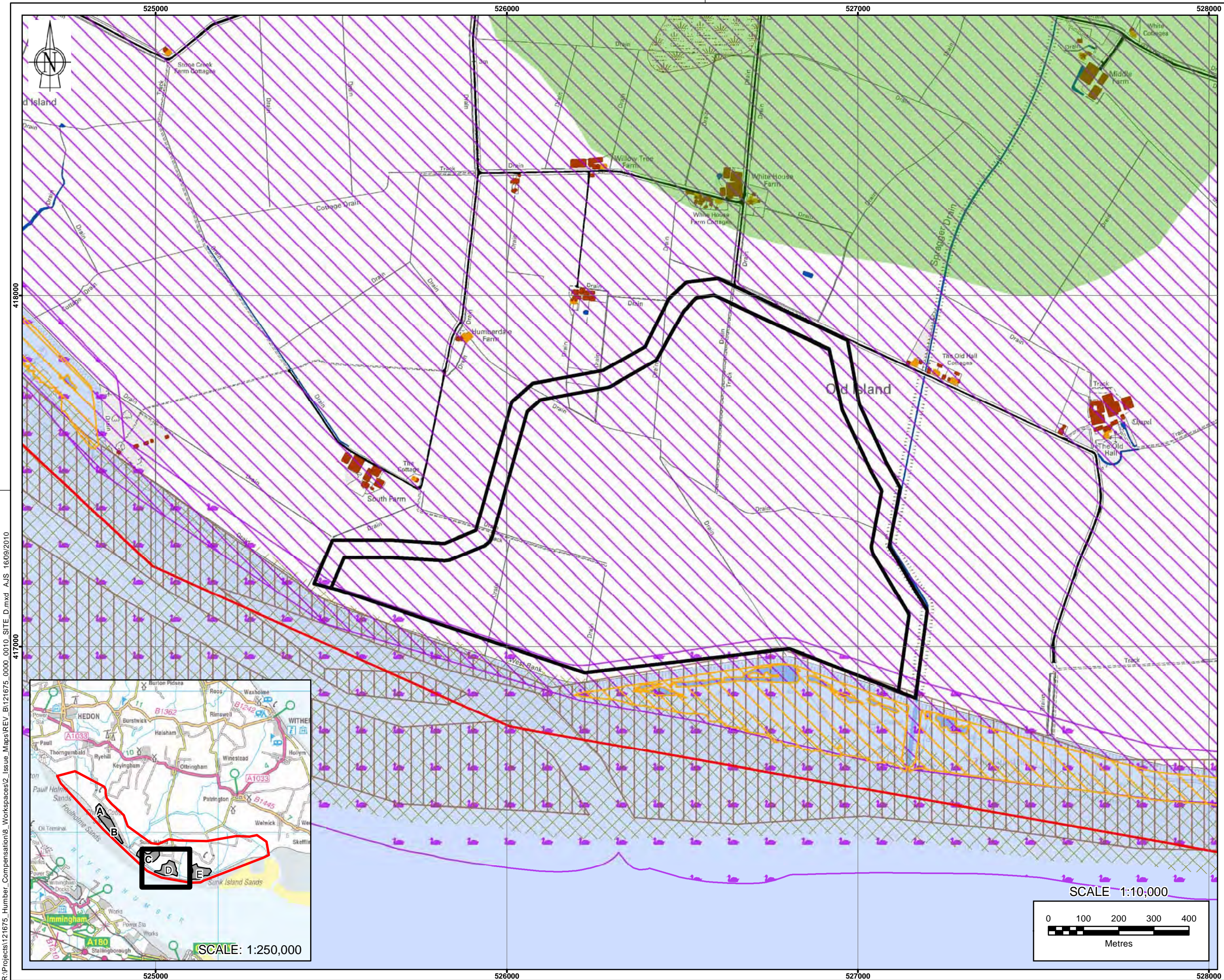
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- Legend**
- Study Area Boundary
  - Potential Site D
  - Humber Estuary International and National Nature Conservation Designations\*
  - Site of Special Scientific Interest
  - Site Of Nature Conservation Importance
  - Important Bird Area
  - Saltmarsh
  - Coastal Floodplain Grazing Marsh
  - Mudflat
  - ★ Listed Building
  - Scheduled Monument
  - Grade 1 Agricultural Land
  - Built Conservation Planning Area
  - Watercourse
  - Non-Crown Estate land
  - Dwelling
  - Other Building
  - Road

\*Note: Humber Estuary is designated as a Ramsar Site; Special Area of Conservation; Special Protection Area and Site of Special Scientific Interest

**Safety Health and Environment Information**

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

<b>Construction.</b>
<b>Maintenance / Clearing / Operation.</b>
<b>Decommissioning / Demolition.</b>

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Rev	Drawn	Chkd	Rev'd	Apprv'd	Date	Description

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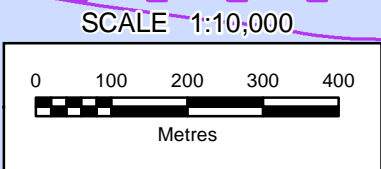
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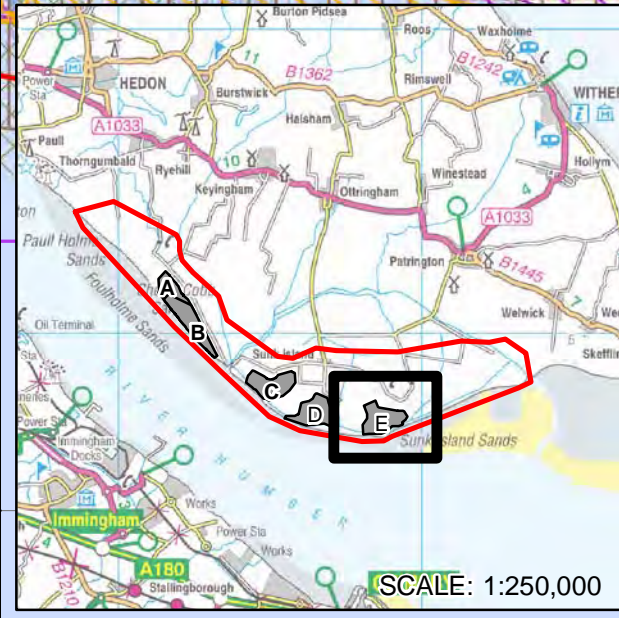
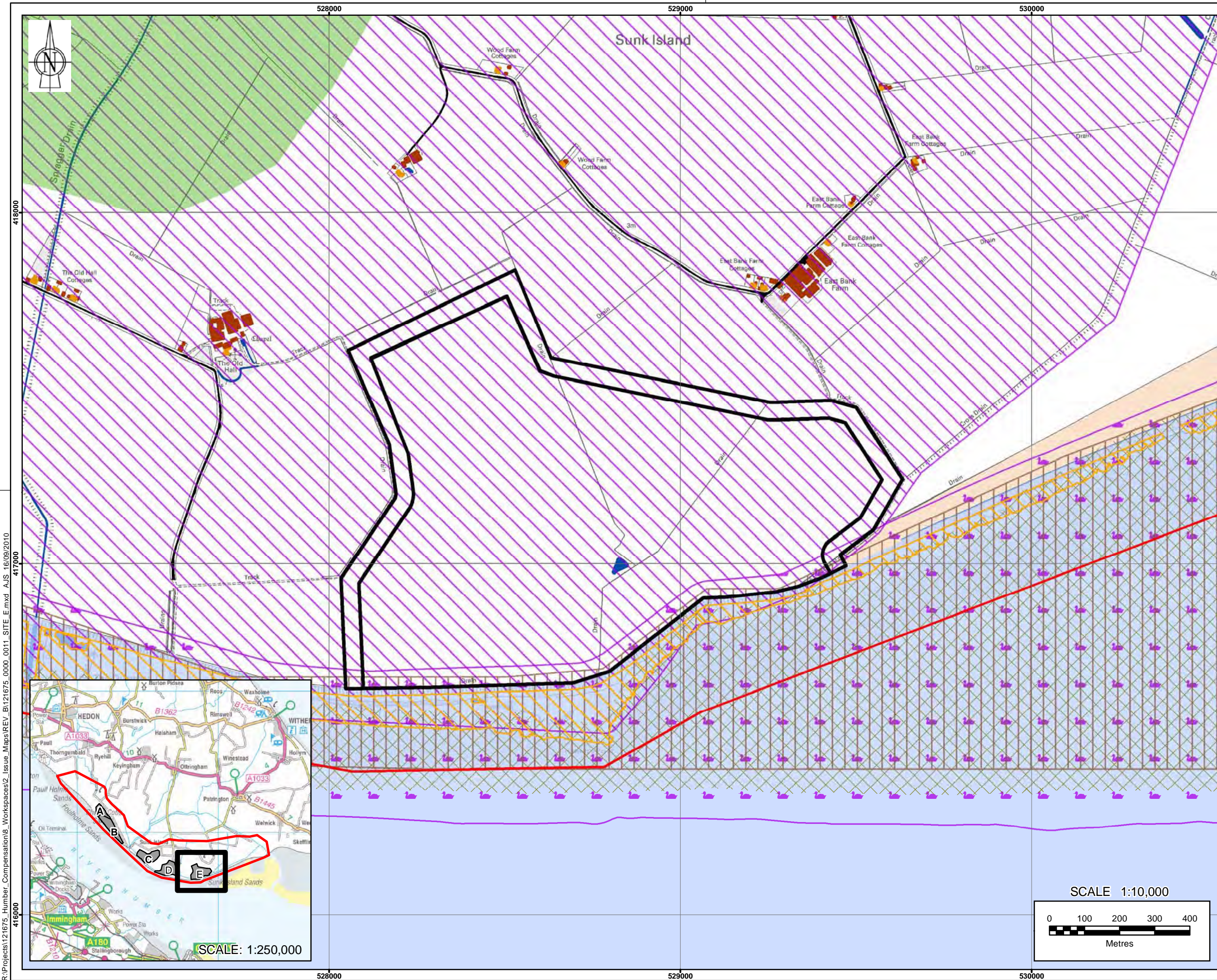
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Drawing scale: SCALE	Sheet size: A3
Drawing no. 121675-0000-0010	Revision B



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Note: The limits, including the height and depths of the Works, shown in this drawing are not to be taken as limiting the obligations of the contractor under Contract.  
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- Legend**
- Study Area Boundary
  - Potential Site E
  - Humber Estuary International and National Nature Conservation Designations\*
  - Site of Special Scientific Interest
  - Site Of Nature Conservation Importance
  - Important Bird Area
  - Saltmarsh
  - Coastal Floodplain Grazing Marsh
  - Mudflat
  - ★ Listed Building
  - Scheduled Monument
  - Grade 1 Agricultural Land
  - Built Conservation Planning Area
  - Watercourse
  - Non-Crown Estate land
  - Dwelling
  - Other Building
  - Road

\*Note: Humber Estuary is designated as a Ramsar Site; Special Area of Conservation; Special Protection Area and Site of Special Scientific Interest

**Safety Health and Environment Information**

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

**Construction.**

**Maintenance / Clearing / Operation.**

**Decommissioning / Demolition.**

B	AJS	LVI	DK	DK	16/09/2010	FOR ISSUE
A	AJS	LVI	PLR	DK	31/08/2010	DRAFT FOR COMMENT
Rev	Drawn	Chkd	Revd	Apprvd	Date	Description

Designed by: PH Date: 23/08/2010



Client Drawing No: 73242 - 0011 Revision: B

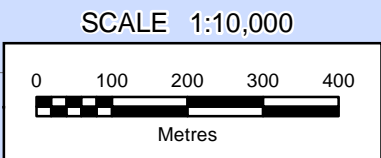


Project: ABLE MARINE ENERGY PARK PRELIMINARY IDENTIFICATION OF ALTERNATIVE SITES FOR HABITAT COMPENSATION

Drawing title: SITE E

Drawing scale: SCALE Sheet size: A3

Drawing no. 121675-0000-0011 Revision: B



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