

Annex 31.1

Summary Desk Study and Site Investigation Design Report

(Black & Veatch)



Able Marine Energy Park

Summary Desk Study and Site Investigation Design Report

December 2010



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SUMMARY DESK STUDY AND SITE INVESTIGATION DESIGN REPORT

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SUMMARY DESK STUDY AND SITE INVESTIGATION DESIGN REPORT

1. INTRODUCTION

1.1 Background

Able UK Ltd (Able) propose to construct a major new deep water facility on the south bank of the Humber Estuary 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.

Black & Veatch (B&V) were commissioned by Able to undertake a site selection process to identify suitable areas for the creation of compensation habitat. In this study it was assumed that the area of compensation habitat required would be around 100ha. The assessment (B&V, 2010) identified a number of potential sites, and one of these areas, shown on Figure 1, is now being considered for more detailed appraisal.

B&V were commissioned by Able in Nov 2010 to carry out a desk study and site investigation design for the proposed area of compensation habitat, and this report is a summary of the findings of these investigations. An appraisal of the proposed deep water facility works at Killingholme Marshes is beyond the scope of this assessment.

1.2 Site Location

The area of compensation habitat (the site) is located adjacent to the north bank of the Humber Estuary, opposite the proposed new deep water facility at Killingholme Marshes. The eastern boundary of the site is west of Stone Creek (NGR TA 233192) and the western boundary is at Cherry Cobb Sands (NGR TA 213218). The southern boundary of the site is the existing flood defences adjacent to the Humber Estuary and the northern boundary is Cherry Cobb Sands Road, the minor public highway between Cherry Cobb Sands and Stone Creek.

The location of the proposed compensation habitat site is shown on Figure 1.

1.3 Objectives

The following desk study is an assessment of readily available site information, including topographic, geological and hydrogeological data.

The objectives of the desk study are to:

- Determine whether the ground conditions in the area are suitable for the proposed development.
- Evaluate the suitability of spoil for re-use in the construction of earth embankments and other earthworks at the site.
- Evaluate risks associated with potential land contamination.

2. CONSTRUCTION WORKS

The development of the site is likely to require a range of construction works. Typically these will involve the excavation, movement and placement of soil to form new flood defence earth embankments and other earthworks.

2.1 Construction of New Flood Defence Embankments

It will be necessary to construct a new flood defence at the landward boundary of the compensation site and it is anticipated that this will be an earth embankment. The new embankment will be approximately 3km long and around 4.0m high.

2.2 Creation of New Habitat

It is anticipated that the required compensation habitat will largely comprise tidal mudflat. However, currently the ground elevation is typically 2.5mAOD across the site and so it may be necessary to reduce ground levels by around 0.5m in some areas. This could create a significant volume of spoil and it is proposed that, where possible, this is re-used on site in earthworks.

Additional earthworks and landscaping may also be necessary in some parts of the site to create pools and raised areas.

2.3 Breaching of Existing Embankments

After the construction of the new flood defence and other site development works, the existing flood defence will be breached in one or more locations. This will involve excavating through the embankment to allow water ingress and it may be necessary to protect the land adjacent to the breach points to control localised scour and erosion.

3. SITE CONDITIONS

3.1 Topography

A detailed topographic survey of the site was undertaken by Able in October 2010. This indicated that the site is relatively flat and low lying with a typical ground elevation of 2.5mOD.

3.2 Geology

The assessment of the geology of the site and the ground conditions has been inferred from available information. No assurance is given to its accuracy.

The summary of geology given below is based on the BGS 1:50 000 Sheet 81 for Patrington, 1991, and the BGS geological memoir, Geology of the country around Grimsby and Patrington, HMSO 1994.

The site is underlain by Marine and Estuarine Alluvium over Till over Cretaceous Chalk.

The geological map for the area (BGS, 1991) indicates that the site is located in an area of land that has been reclaimed by natural and anthropogenic processes since the eighteenth century. A more detailed discussion of the movements of the shoreline in this area are given in a East Yorkshire Local History Society book entitled The Draining of the Marshes (Sheppard, 1966).

(a) Marine and Estuarine Alluvium.

The Marine and Estuarine Alluvium at the site is likely to be around 20m to 25m thick. In this part of the Estuary these deposits are generally granular and comprise fine grained sands, silts and gravels with shell fragments. These granular soils are thought to be part of an ancient sand bank which extends across much of Sunk Island.

The granular soils are overlain by a 1m to 5m thick stratum comprising laminated silty clays and sands with organic layers. These cohesive strata were probably deposited in the last 400 years or so as a result of land reclamation, estuarine tidal deposition and saltmarsh development.

(b) Glacial Till

Glacial Till is likely to comprise stiff gravelly clay and, due to the thickness of Marine and Estuarine Alluvium, is unlikely to be encountered during the proposed construction works at the site.

(c) Cretaceous Chalk

Cretaceous Chalk bedrock is unlikely to be encountered during the proposed works.

Glacial Till and Cretaceous Chalk will not be discussed further in this site assessment.

3.3 Hydrogeology

The Marine and Estuarine Alluvial deposits at the site are recorded as a non-aquifer on the Groundwater Vulnerability Map of the area (NRA, 1994). From 1 April 2010, aquifer designations were adopted in England and Wales that are consistent with the Water Framework Directive and, in accordance with the Directive, the Marine and Estuarine Alluvial deposits in this area are likely to be classed as unproductive strata.

The foreshore and saltmarsh areas on the seaward side of the existing flood defences at Cherry Cobb Sands (NGR TA 210220) and to the east of Stone Creek (NGR TA 240185) are recorded on the Groundwater Vulnerability Map as being minor aquifers comprising soils with a high leaching potential. In accordance with the Water Framework Directive these areas would be classed as Secondary Aquifers, although, due to the likely brackish water and limited thickness of the strata, it appears unlikely that they could support groundwater supply.

Whilst the Marine and Estuarine Alluvial deposits are not expected to be an aquifer with potential as a groundwater resource, they are likely to be water bearing. The groundwater is likely to be in hydraulic continuity with the adjacent River Humber and so groundwater levels and pore water pressures may fluctuate as river water levels vary due to tidal and other influences.

3.4 Conceptual Site Model

Figure 2 is a two dimensional diagrammatic representation of the ground conditions at the site based on the findings of this desk study. This conceptual site model will be reviewed and updated as further site specific information becomes available.

4. ENGINEERING ISSUES

4.1 Bearing Capacity

The surficial cohesive Marine and Estuarine Alluvial deposits are normally consolidated and contain organic rich layers. These soils are likely to be very soft to soft and could deform and fail as a result of the loads imposed by the new flood defence, assumed to be around 70kN/m² to 80kN/m² for a 4.0m high embankment. As a result, it may be necessary to stabilise the ground forming the foundation of the proposed embankment prior to construction by improving the soils, or by incorporating a ground strengthening geo-textile at the foundation level.

The granular Marine and Estuarine Alluvial deposits are likely to be loose and, unless they are very silty, are unlikely to fail as a result of the load imposed by the new embankment.

4.2 Consolidation and Settlement

The surficial cohesive Marine and Estuarine Alluvial deposits are probably both very soft to soft and organic rich, and are likely to consolidate as a result of the load imposed by the new embankment. The total amount of settlement will be related to the thickness of the underlying compressible soils and could be as much as 20% to 25% of the cohesive strata thickness. Therefore, if the cohesive strata are 2m thick, then the settlement of the embankment crest could be as much as 500mm in some areas.

Differential settlement is also likely to occur as a result of natural variations in the thickness and composition of the compressible strata.

The granular Marine and Estuarine Alluvial deposits are likely to consolidate during embankment construction and are therefore less likely to be subject to ongoing settlement.

4.3 Embankment Fill

(a) Marine and Estuarine Alluvial Soil

Cohesive Soil

It seems likely that the preferred option will be to construct the embankment from cohesive soil won from the site and the only likely on site source is the cohesive Marine and Estuarine Alluvium. However, these soils are likely to be silty, contain organic matter and have a high moisture content making their suitability for use as fill marginal at best. Therefore, if it is proposed that these soils are used as fill in the construction of the new embankment, then remedial measures may be required to ensure constructability and embankment stability.

Such measures may involve one or more of the following:

- Treatment of the soils using lime to reduce the moisture content.
- Treatment of the soil using cement to improve the geotechnical properties of the soil.
- Natural drying of the soils in stockpiles.
- Use of an appropriate embankment design geometry allowing low gradient shoulders and a wide crest.
- Construction of the embankment over a period of years to allow slow consolidation of the embankment fill and underlying foundation stratum.

Groundwater is likely to be encountered near to the ground surface in borrow excavations. This will reduce the stability of the excavation side wall potentially leading to collapse.

Also soils excavated from beneath the groundwater table are likely to be too wet for use as embankment fill without significant drying.

Granular Soil

Granular Marine and Estuarine Alluvial strata may be encountered at a relatively shallow depth in borrow excavations. It may be possible to use these fine grained granular soils as embankment fill if they are relatively dry, contain a suitable fine content or are mixed with cohesive soils. However, they are probably present at depths of greater than 1.0m and are therefore less likely to be encountered during the general re-grading of the site. Wet fine grained granular soils, and in particular wet silts, are difficult to work and would require drying before use.

These soils are also likely to be water bearing and very unstable during excavation leading to side wall instability.

(b) Glacial Till

The Glacial Till deposits beneath the site are likely to be suitable for use as embankment fill but are too deep to make on-site excavation viable. However, Glacial Till is likely to be exposed at the ground surface at a number of locations around 5km to the north of the site in the areas to the north of Keyingham (NGR TA 250255) and Ottringham (NGR TA 270245).

4.4 Embankment Stability

Long term embankment stability during normal operation and short term embankment stability during a flood event will need to be analysed to ensure that the embankment is stable. Geotechnical soil properties and the likely embankment geometry are required to carry out this analysis.

4.5 Embankment Geometry

The cohesive Marine and Estuarine Alluvial soil is not likely to be an ideal embankment fill material and, if used, one method of improving embankment stability is to construct an embankment with low gradient shoulders and a wide crest. This could require a shoulder gradient that is as low as 1V:5H and a crest width of around 4m. It may also be appropriate to improve stability by constructing a suitably wide berm on the seaward face of the defence.

A low gradient seaward embankment face and the construction of a seaward facing berm will cause wave energy to dissipate, protecting the toe of the embankment from erosion. The berm would also protect the embankment toe if it becomes necessary to breach the existing defences before the grass and vegetation has had time to develop on the new embankment.

The soils beneath the new embankment may be sand rich and could represent a preferential flow path for surface and groundwater leading to excessive seepage. As a result it may be necessary to increase the flow path by widening the embankment, and constructing a ditch close to the landward toe to collect water and allow it to flow away from the embankment in a controlled manner. The drainage ditch will need to be connected into the existing drainage network and the water collected must be able to flow or be pumped back into the Estuary.

A number of land drains are present at the site and some of these are likely to cross the line of the new flood defence embankment. These could also represent a preferential flow path, again leading to excessive seepage, and so it will be necessary to remove or break the drainage network during the development of the site.

5. PRELIMINARY MASS BALANCE CALCULATION

The following is a preliminary estimate of the volume of spoil created during construction and the volume of fill needed to complete the works.

The preliminary mass balance calculation is an initial high level estimate and a more detailed understanding of spoil creation and re-use will be required for planning purposes and the detailed design of the works. This will require a detailed appraisal of the physical and chemical suitability of the spoil for re-use and an understanding of groundwater elevation. It will also require further consideration of embankment geometry, embankment alignment, the requirement for other earthworks, the relative proportion of different types of habitat required and the ground levels needed to achieve these.

5.1 Spoil Produced During the Works

The topographic survey for the area suggests that the site is relatively level and that the typical ground elevation is around 2.5mOD. It has been assumed initially that the ground elevation will need to be reduced to around 2.0mOD to allow the site to develop as a mudflat, although the need for this or any reduction in average site ground levels has not been confirmed.

It is assumed that the compensation area required is around 100ha (1,000,000m²) and therefore the total volume of spoil created during operations to reduce the ground elevation to 2.0mOD is around 500,000m³.

5.2 Fill Required During Embankment Construction

The development will require the construction of a flood defence at the northern boundary of the site and it is assumed that this will be an earth embankment. The crest of the existing embankment is at an elevation of around 6.0mOD and the ground elevation is around 2.5mOD. Therefore, the new embankment will need to be around 3.5m high to achieve the current standard of protection. However, the new embankment will also require an allowance for sea level rise and settlement and will probably need to be constructed to a height of around 4.0m above the final ground level, an elevation of 6.5mOD.

The length of the new embankment will depend on the area and shape of the site ultimately selected for development. However, at this stage it has been assumed that the new embankment is around 3.0km in length.

A typical flood defence embankment of this type may have a 3m crest width and 1V to 3H side slopes. A 4m high, 3km long embankment with this geometry will require approximately 180,000m³ of fill.

Given the likely ground conditions and poor quality fill material available on site, it may be necessary to modify the embankment geometry to improve stability. If it is assumed that the embankment crest width is 4m and the side slopes have a gradient of 1V to 5H, then a 4m high, 3km long embankment with this geometry will require approximately 288,000m³ of fill.

A berm constructed on the seaward face of the embankment would also increase stability and reduce the potential for erosion at the embankment toe. If it is assumed that the berm is 15m wide and the crest is 2m above the final ground level, then an additional 90,000m³ of fill is required in its construction.

Therefore, a 3km long, 4m high embankment with a crest width of 4m and side slopes at 1V to 5H and a 15m wide seaward facing berm will require around 378,000m³ of fill.

5.3 Surplus Spoil

Surplus spoil will be classed as waste and so it is important to minimise surplus spoil production.

The volume of spoil created during the works could be around 500,000m³ and the volume of fill required to construct the new embankment could be as much as 378,000m³.

Therefore, the works could potentially produce a surplus of around 122,000m³ of spoil and consideration should be given to ways of reducing spoil production and the identification of additional re-uses of spoil on site to improve the ecological diversity of the habitats that develop.

Waste issues are discussed in more detail in Section 7 of this report.

6. LAND CONTAMINATION

6.1 Potentially Polluting Land Uses

(a) General

The site is composed of agricultural land and there is no evidence of any recent industrial activity. Contaminants related to the agricultural use of the land may be present in the soils at the site and these could include pesticides, fertilisers and other agricultural chemicals. Such contaminants, if present, are likely to be relatively uniformly distributed.

(b) Decoy Site

The site was used as a decoy site during World War II. This involved the excavation of a series of ditches and pools on the seaward and also probably on the landward side of the defences. Lights were erected in the area so that the pools and ditches resembled Hull Docks. Oil could also be pumped into some of the pools and ignited to resemble burning buildings.

A number of the pools and ditches are still present on the seaward side of the existing flood defences at Cherry Cobb Sands (NGR TA 210218). The linear pools on the landward side of the defences at NGR TA 222203 may also have been part of the decoy and resemble Hedon Haven and Lords Clough at Salt End to the east of Hull (NGR TA 160275).

Given the historic use as a World War II decoy site, it is recommended that a detailed unexploded ordnance survey and risk assessment is carried out prior to the commencement of detailed design works.

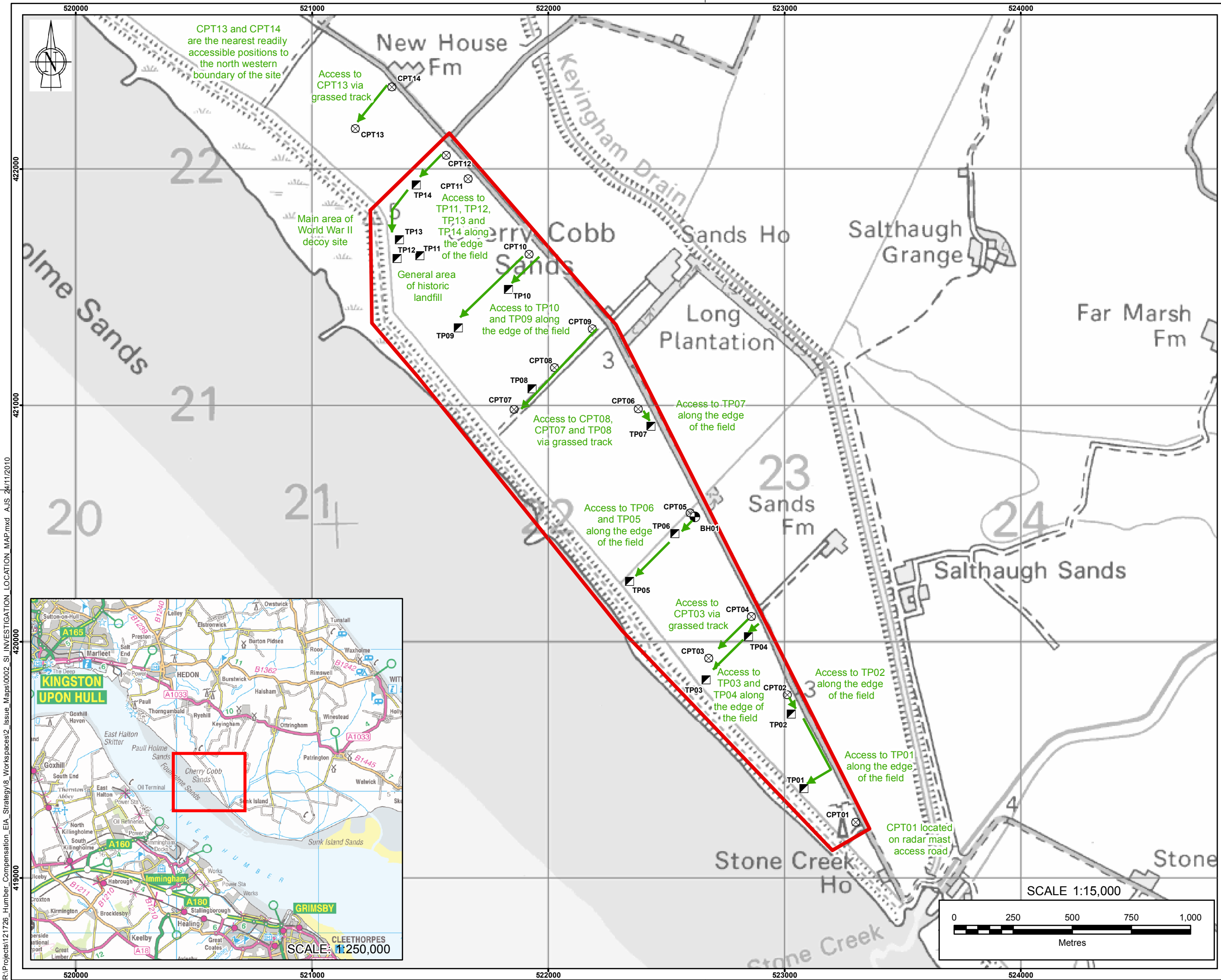
(c) Landfill

The Environment Agency website (viewed 12 November 2010) identified one historic landfill site (Land West of Cherry Cobb Sands Road) within the site boundary at Cherry Cobb Sands (NGR TA 214214). The website does not contain any further information about the landfill but it is close to the main part of the World War II decoy site and may be associated with this historic activity. Landfills can contain polluted soil and groundwater and so further investigation of this area is required.

No other active or historic landfills are recorded on the Environment Agency website within 1km of the site. However, the geological map of the area (BGS, 1991) does record a back filled quarry or pit at NGR TA 220227, around 600m north of Cherry Cobb Sands and the northern boundary of the site.

The Environment Agency website also reports a minor pollution incident involving a spillage of contaminated water close to Stone Creek (NGR TA 235190). No further information is provided.

Finally, the Environment Agency website records one company with a licence to discharge potential pollutants at Saltaugh Grange (NGR TA 239217) around 1.5km northeast of the site. The licence allows the discharge to the atmosphere of particulate matter, ammonia and methane and the site was also used as a waste transfer station for used oils and food waste.



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
- Borehole
- Trial Pit
- Cone Penetration Test
- Site Access Route

Able UK are to confirm access routes with the landowners and tenants. Access routes shown are indicative only and may be subject to change.

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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FIGURE 3:
SITE INVESTIGATION LOCATIONS

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6.2 Preliminary Qualitative Risk Assessment

Land contamination is considered in the planning process. Potentially contaminated land needs to be identified and the risks associated with such land assessed. Planning Policy Statement 23 (PPS23) Planning and Pollution Control requires a precautionary approach to land contamination and planning permission can be refused if risks to receptors are deemed to be unacceptable.

Part IIa of the Environmental Protection Act 1990 complements the planning process and provides a statutory regime for the identification of historically contaminated land. Again this is based on risk and it adopts the source-pathway-receptor approach to the identification of potentially significant linkages between contaminants and receptors. For a risk to exist there must be a source of contamination, a receptor capable of being affected by the contamination and a pathway between the two. This is often referred to as a pollutant linkage.

DEFRA and the Environment Agency guidance, Model Procedures for the Management of Land Contamination (CLR11) emphasises the need for a tiered approach to risk assessment. An initial preliminary qualitative risk assessment is normally carried out and, if needed, this will be followed by a generic quantitative risk assessment and finally a detailed quantitative risk assessment.

The following is a preliminary qualitative risk assessment and it should be developed as the further site specific data become available.

The following preliminary qualitative risk assessment (Table 1) identifies and assesses the risk of complete potential pollution linkages i.e. those where there is a source of pollution that can migrate via a pathway to a receptor. The probability of occurrence, the severity and the assessed risk are quantified in the following way:

Probability of Occurrence:

VL= Improbable: unlikely to occur

L= Remote: unlikely but possible

M= Occasional: possible at some time

H= Probable: likely to occur several times

VH = Frequent: likely to occur many times

Severity:

1 = Negligible: No impact likely

2 = Marginal: Minor environmental impact, no lasting damage

3 = Serious: Environmental impact, damage in short term. Minor illness

4 = Critical: Major environmental impact, damage medium/long term. Serious illness

5 = Catastrophic: Permanent environmental damage. Serious illness or death

UA = Unacceptable

UD = Undesirable

A = Acceptable

N = Negligible

Assessed risk:		Severity				
		1	2	3	4	5
Probability	VL	N	N	A	A	UD
	L	N	A	A	UD	UA
	M	A	A	UD	UA	UA
	H	A	UD	UD	UA	UA
	VH	UD	UD	UA	UA	UA

Table 1: Qualitative Risk Assessment for Complete Potential Pollution Linkages

1	2	3	4	5	6	7	8
Source	Pollutant	Receptor	Potential Pathway	Consequence	Probability of Occurrence	Severity	Assessed Risk
World War II Decoy Site	UXO Oils	Site construction workers	Exposure of UXO during construction works leading to explosion and severe injury or death. Inhalation of dust or dermal contact with polluted soil or groundwater during site construction works	Harm to human receptors	L	5	UA
Historic Landfill at Cherry Cobb Sands	Organic and inorganic pollutants	Site construction workers	Inhalation of dust or dermal contact with polluted soil or groundwater during site construction works	Harm to human receptors	M	3	UD
Historic Landfill at Cherry Cobb Sands	Organic and inorganic pollutants	Surface Waters in the Humber Estuary	Polluted soils used as fill in embankment construction. Contaminants leached by rainfall infiltration which seep into the Estuary or ditches leading into the Estuary	Pollution of surface water	M	3	UD
Agricultural Pollution	Pesticides, Fertilisers and Agricultural Chemicals	Site construction workers	Inhalation of dust or dermal contact with polluted soil or groundwater during site construction works	Harm to human receptors	M	2	A
Agricultural Pollution	Pesticides, Fertilisers and Agricultural Chemicals	Surface Waters in the Humber Estuary	Polluted soils used as fill in embankment construction. Contaminants leached by rainfall infiltration which seep into the Estuary or ditches leading into the Estuary	Pollution of surface water	L	2	A

7. WASTE

Waste is defined in Article 1(a) of the European Waste Framework Directive as, “any substance or object....which the holder discards or intends or is required to discard”.

Waste is carefully controlled in the UK and the costs associated with the management and disposal of waste spoil can be high. Therefore, wherever possible, it is important to ensure that spoil created during construction work is not classed as waste.

Current industry best practice relating to earthworks and the generation of waste is provided in the CL:AIRE guidance document, The Definition of Waste: Development Industry Code of Practice (CL:AIRE, 2008). It is recommended that the works are designed and managed in accordance with the CL:AIRE CoP. This states that spoil produced during construction works would not normally be classed as waste providing that the following criteria apply:

- There must be a re-use and the re-use must be certain.
- Only the quantity necessary for the specified works can be used.
- The soil is chemically and physically suitable for re-use without treatment.

Therefore, it is essential to identify all potential re-uses of spoil on site. Detailed mass balance calculations are required to confirm volumes of spoil created and volumes required in each re-use. Finally all re-uses should be detailed in the planning application to ensure that they are considered integral to the development of the site.

Surplus spoil and spoil that is either physically or chemically unsuitable for a defined re-use is waste and waste can not be re-used on site without an Environmental Permit or Waste Exemption. Environmental Permits are usually time consuming and costly to obtain and, given the volumes of spoil created during the works, an Exemption is unlikely to be available.

However, the preliminary mass balance calculation in Section 5 of this report suggests that the works have the potential to create surplus spoil. It may be possible to minimise the creation of surplus spoil by reducing the depth of the required excavations or by limiting excavation works to certain areas. Additional earthworks may also be required to improve the ecological diversity of the habitats that develop on the site, and these may require the use of more spoil.

However, if the works create surplus spoil then this will be waste and disposal options need to be considered. Disposal to landfill is expensive and unsustainable and should always be considered to be a last resort. Other disposal options should also be evaluated and these could include disposal to a site with a waste exemption or sites with a licence for recycling or reprocessing.

It should be noted that the total organic carbon (TOC) threshold for waste being disposed to an inert landfill is 3%. The near surface soils at this site are likely to be organic rich and could contain a TOC content in excess of 3% and, if this is the case, they would not be suitable for disposal to an inert landfill.

Finally, it is a legal requirement to pre-treat waste before disposal to landfill to reduce its volume, reduce its hazardousness, improve handling or enhance recovery. The pre-treatment may cause the cost of disposal to be reduced, off-setting the expense of the treatment. Pre-treatments include sorting of excavated spoil into stockpiles for re-use and disposal, screening, drying and chemical treatment and it is important to select the most appropriate methodology for the excavated soils.

8. SITE INVESTIGATION

8.1 Objectives

The proposed site investigations are designed to obtain sufficient data for the outline design of the flood defence and other development works at the site. Further investigations may be needed for detailed design in certain parts of the site depending on the findings of this first phase of investigation.

The site investigation is designed to:

- Determine the soil stratigraphy across the site.
- Determine the depth to the groundwater table and establish its variation.
- Evaluate relevant soil properties for each stratum encountered. These include plasticity, moisture content, organic matter, undrained shear strength, relative density, consolidation and compaction.
- Identify areas of potential land contamination.

8.2 Methodology

The proposed site investigations are in accordance with the requirements of BSEN 1997-2:2007 Eurocode 7 Geotechnical Design. A range of technically appropriate and cost effective geotechnical investigation techniques are recommended including cone penetration tests (CPT), trial pits (TP) and a borehole (BH).

CPT is particularly appropriate for the likely ground conditions at the site which are expected to comprise soft and loose alluvial strata over Glacial Till. CPT can be carried out rapidly, allowing the collection geotechnical data over a large area at relatively low cost. CPT (fitted with a combined magnetometer/piezo cone) can also be used to check for UXO, ensuring that the investigations are carried out safely.

In general accordance with Eurocode 7, an approximate investigation spacing of around 200m-250m has been adopted for the proposed earth embankment. CPT are regularly spaced along the northern boundary of the site running parallel to Cherry Cobb Sands Road. The locations selected are adjacent to existing field access routes and the CPT are positioned at the field entrances for ease of access and to minimise ground damage. It is also recommended that a borehole is formed next to one of the CPT positions to allow the calibration of the CPT data.

Additional CPT are proposed on or adjacent to access tracks that run between Cherry Cobb Sands Road and the existing flood defence embankment. Again the precise location of each CPT position can be modified to minimise ground damage.

TP are located across the site to determine the near surface stratigraphy and to evaluate the potential for the soil to be used as embankment fill. The TP are located at the edges of fields and adjacent to access tracks to minimise ground damage and it is recommended that a tracked excavator is used. TP11, TP12 and TP13 are located in the area of an historic landfill to identify its location and evaluate the composition of the fill material.

Soil samples will be collected from BH and TP and tested in the laboratory to determine a range of geotechnical and chemical properties.

The site investigation positions are shown on Figure 3. No discussions have been held with the landowners or tenants in the area regarding the site investigation, access routes or any other matters relating to the proposed site investigation works.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Geology and Hydrogeology

The ground conditions at the site are likely to comprise Marine and Estuarine Alluvium to a depth of 20m to 25m, over Glacial Till. The Marine and Estuarine Alluvial soils are likely to consist of 1m to 5m of organic, soft, silty clay over around 20m of fine sand and silt with layers of gravel.

The groundwater table is likely to be near to the ground surface across much of the site and may vary in response to changes in the tide cycle and rainfall. The near surface soils at the site are likely to be classed as unproductive strata and are unlikely to be used for groundwater supply.

9.2 Engineering Issues

The near surface soils at the site are likely to be soft where cohesive and loose where non-cohesive. The design of the proposed flood defence embankment will need to account for the poor ground conditions to ensure that the risk of failure is minimised.

The near surface soils in the foundation of the proposed embankment are also likely to consolidate under the load imposed by the new embankment, and this could lead to significant amounts of both total and differential settlement.

The near surface cohesive Marine and Estuarine Alluvium is likely to be the most readily available site won soil for use as fill in the new embankment and other earthworks. These soils are likely to be soft, wet and contain organic matter and may not be suitable for re-use as fill without treatment or drying. If these soils are used, it may be appropriate to increase the width of the proposed embankment and to decrease the gradient of the embankment shoulders to improve stability.

It may also be possible to use granular Marine and Estuarine Alluvium in earthworks if it is dry, contains a suitable fine content or is mixed with cohesive soils. However, these soils are likely to be present at depths of greater than 1.0m and are therefore less likely to be encountered during the general re-grading of the site.

Groundwater is likely to be encountered near to the ground surface and could restrict the depth of excavation to obtain soil.

The primary local off-site source of embankment fill material is likely to be Glacial Till, which is present at the ground surface at numerous locations around 5km north of the site.

9.3 Preliminary Mass Balance Calculations

Site re-grading works could produce around 500,000m³ of spoil. It may be possible to re-use some of the fill in the construction of the new embankment and volumes required vary from 180,000m³ to 378,000m³ depending on the embankment geometry and the requirement for a seaward facing berm.

Therefore, the works have the potential to produce significantly more spoil than can be used on site. Consideration should be given to ways of reducing spoil production and the identification of additional uses of spoil on site, for example for use in environmental enhancement.

Surplus spoil is waste and disposal options should be considered. Disposal to landfill can be expensive and should be considered to be a last resort. Other options should be

considered including disposal to a site with an appropriate Environmental Permit or Waste Exemption and disposal to a recycling or reprocessing facility.

9.4 Land Contamination

The foreshore adjacent to Cherry Cobb Sands was used as a decoy site during World War II and may have been bombed. Therefore, the risk of encountering unexploded ordnance (UXO) during site investigation and site development is considered to be unacceptable and further assessment and mitigation measures are needed.

A small historic landfill has also been identified near to the western end of the site and this could represent a source of soil and groundwater pollution. These soils may be unsuitable for use as embankment fill and further investigation is needed to determine whether they pose a risk to human and environmental receptors.

9.5 Waste

Waste can be expensive and time consuming to manage and so the works should be designed to minimise waste production.

The earthworks should be managed in accordance with the CL:AIRE Code of Practice (CL:AIRE, 2008). This provides a mechanism for ensuring that excavated spoil is used appropriately and ensures that the spoil used is very unlikely to be classed as waste.

Surplus spoil is waste and needs to be managed accordingly. Various waste disposal options should be considered including off-site re-use at a site with an Environmental Permit or Waste Exemption. However, if disposal to landfill is determined to be the most appropriate disposal option, it should be noted that the surplus soils may have a high organic content which could make them unsuitable for disposal to an inert landfill.

9.6 Site Investigation

Site investigations are needed to enable the design of the new flood defence earth embankment and other development works at the site. Information required includes a detailed understanding of the soil stratigraphy and soil properties including plasticity, strength, compressibility and density. An evaluation is also needed to determine whether spoil created during the site development is likely to be suitable for use as embankment fill. Finally, the investigation should establish the elevation of the groundwater table and identify areas of potential land contamination.

The proposed site investigations are in general accordance with Eurocode7 and include a mix of cone penetration tests (CPT), trial pits (TP) and a borehole (BH). CPT is appropriate for the likely ground conditions and allows a number of investigation positions to be carried out rapidly and at low cost. CPT can also be used to ensure that there are no UXO in the area of the investigation position, allowing the work to be carried out safely. The BH is used to calibrate the CPT data and record groundwater levels and variation.

The TP are used to evaluate the near surface soil stratigraphy across the site and to enable an assessment of the suitability of site won soil for use as fill in embankment construction. Trial pits will also be excavated in the area of an historic landfill to evaluate the likelihood of soil contamination.

10. REFERENCES

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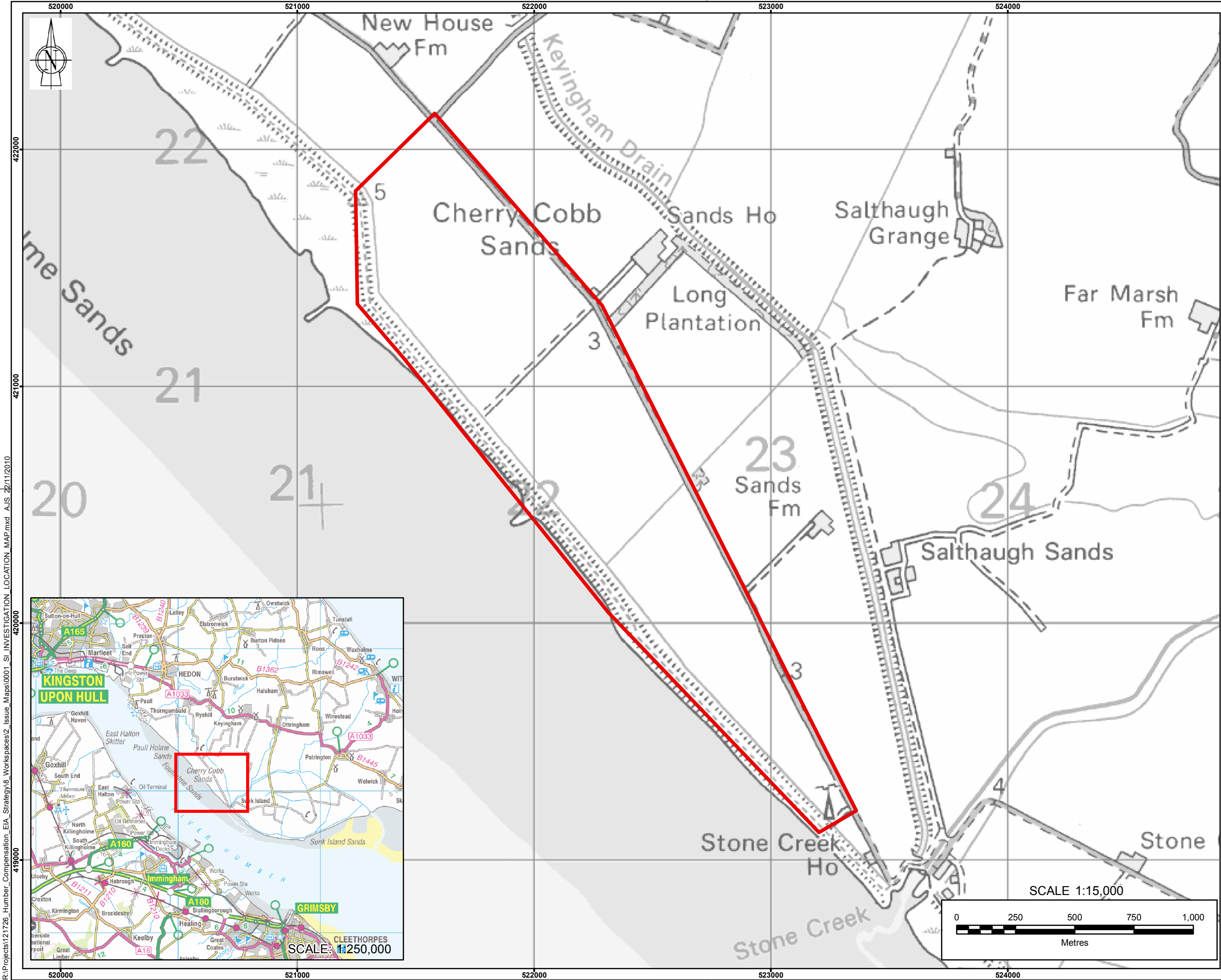
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Note: The limits, including the height and depths of the Works, shown in this drawing are not to be taken as limiting the obligations of the contractor under Contract.

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Legend

 Study Area

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.

A	AJS	LVI	MB	JLP	24/11/2010	DRAFT FOR COMMENT
Rev	Drawn	Chkd	Rvwd	Apprvd	Date	Description

Designed by: AJS Date: 24/11/2010

Client



Client Drawing No. Revision
A



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Project:

CHERRY COBB SANDS COMPENSATION SITE

Drawing title:

**FIGURE 1:
LOCATION PLAN**

Drawing scale: SCALE Sheet size: A3

Drawing no. 121726-7000-0001 Revision
A

**FIGURE 2: CONCEPTIONAL SITE
MODEL FOR THE PROPOSED
HABITAT CREATION SITE AT
CHERRY COBB SANDS**

