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- European Wildlife Division

Wallasea Island
North Bank Realignment:
Proposed Monitoring Programme

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Non-Technical Summary

Project Background

The European Wildlife Division of the Department for Environment Food and Rural Affairs (DEFRA-EWD) is proposing to undertake a coastal realignment project on the north bank of Wallasea Island in the Crouch Estuary (Essex). The aim of this scheme is to create new mudflat and saltmarsh in compensation for losses of these habitats, and associated impacts to SPA-designated bird populations, following port developments at Lappel Bank (in the Medway Estuary) and Fagbury Flats (in the Orwell Estuary). This project is being pursued with the support and assistance of the landowner, Wallasea Farms Ltd., who were responsible for the submission of the Planning Application and the commissioning of the Environmental Impact Assessment (EIA) which accompanied this application. The whole development is being overseen nationally by the Lappel Bank Project Management Group (PMG) which includes representatives from DEFRA-EWD, English Nature (EN), the Environment Agency (EA), the Royal Society for the Protection of Birds (RSPB) and Wallasea Farms Ltd.

Planning approval for this scheme was secured in February 2005 and the proposed realignment is scheduled to take place in the June/July 2006. To accompany this proposal DEFRA-EWD are required to carry out monitoring work in order to evaluate the success of the site (i.e. whether it meets its compensation targets) and to verify whether any physical and ecological changes which occur in the adjacent Crouch and Roach Estuaries are within the limits predicted within the EIA. This report sets out a proposed monitoring programme that is designed to meet these objectives.

This monitoring programme is to commence prior to the realignment work (in order to ensure that a full baseline dataset is in place) and will continue for five years subsequently. The results of the monitoring work will be reviewed regularly by the Wallasea Project Management Team (WPMT) who will be overseeing this monitoring programme locally. The WPMT (which includes local representatives of the above-listed authorities) will meet on a regular basis throughout the five-year programme and after five years of post-realignment monitoring they will agree the requirements for, and scope of, further monitoring work.

The programme outlined in this report was developed by Associated British Ports Marine Environmental Research (ABPmer) with input and advice from members of the Lappel Bank PMG and the WPMT as well as from specialists who carried out relevant aspects of the baseline monitoring work for the EIA.

Monitoring Proposal

In summary, the proposed monitoring scheme will involve the following elements: -

(1) Overwintering Bird Populations (Site Success): - The realignment site will be divided up into 9 'Count Areas' and records of the abundance and behaviour of birds in each of the different habitats within each of these areas will be made over the winter months (October to March). In the first winter after realignment these surveys will be undertaken once per month but in subsequent winters there will be two such surveys per month.

(2) Spring/Breeding Bird Populations (Impact Verification): - To check on the ecological development of the mitigation habitats (i.e. the islands in the realignment site and the borrow dyke/grassland habitat on the landward side of the new sea wall) monthly walkover bird surveys will be carried out in May and June each year. The surveyor will identify breeding pairs and farmland bird species on mitigation habitats within each of the 9 Count Areas.

(3) Benthic Invertebrates (Site Success): - To describe the development of invertebrate communities in the realignment site and therefore the abundance of waterbird prey species, qualitative benthic ecology investigations will be made in Years 1, 2 and 4 after realignment. These will involve in-situ examinations of the infauna and epifauna as well as the retrieval of 0.01m^2 core samples for simple laboratory-based taxonomic analysis and cumulative biomass measurements. In Years 3 and 5 the same in-situ examinations and sample retrieval work will be undertaken but the retrieved samples will be subject to more detailed quantitative examination which will include species-level identification, enumeration, biomass measurement and statistical analysis according to standardised methodologies.

(4) Benthic Invertebrates (Impact Verification): - To confirm the absence of any impacts to invertebrate communities on habitats outside the realignment, quantitative benthic core sampling will be carried out at four locations on the surrounding mudflat. Three replicate core samples will be retrieved from each site and these will be subject to species-level quantitative analysis as described above. This survey will be carried out in Years 1 and 5 after realignment and can be undertaken at the same time as the Site Success benthic monitoring. In the event of any adverse impacts being identified in Year 1 the subsequent surveys in Years 2 and 3 may be required to clarify the characteristics and duration of any identified effects.

(5) Aquatic and Terrestrial Invertebrates (Impact Verification): - To test whether the new borrow dyke mitigation areas provide suitable habitat for aquatic and terrestrial invertebrates (especially Ramsar-cited species), appropriate surveys will be carried out across these habitats in June during Years 1, 3 and 5 after realignment. At the same time, and to provide valuable extra information on the functioning of the realignment site at low cost, it is recommended that extra sampling of aquatic habitats within the

realignment site is undertaken to assess the development of the 'ponded' areas. This will be undertaken to confirm whether specialist saline lagoon species develop in these areas.

(6) Protected Species (Impact Verification): - To check whether the borrow dyke and adjacent grassland mitigation areas support protected species (and especially common lizard and adder that have been translocated from within the realignment site), a series of basking mat surveys will be undertaken in the spring months of Year 3. Once deployed, these mats will be visited on 7 occasions in the spring and early summer to check for reptiles and amphibians. During these visits surveyors will also look for signs of other protected species (especially water voles in the borrow dyke). If reptiles are not recorded during this survey, then a repeat visit will be carried out in Year 5.

(7) Fish Populations (Site Success): - There is no requirement for DEFRA-EWD to undertake fish monitoring work. However, surveys of fish populations will be undertaken at the Wallasea site by the EA and these will help to describe the overall ecological value of the site. The results from these surveys should be integrated into the annual monitoring reviews for the realignment work.

(8) Intertidal Morphology within the Realignment Site (Site Success): - To measure the rate and pattern of sediment accretion, LiDAR flights will be made in Years 1 and 5 after realignment. These will need to be preceded by a baseline LiDAR flight in the summer of 2006 (Year 0) as there is a need to update the existing 1999 data set and obtain an accurate and contemporary understanding of the topography within the realignment site prior to breaching of the sea wall. On each occasion the data will have to be 'ground truthed' by in-situ theodolite-based work. Annual topographic and sediment shear strength surveys will also be undertaken on the recharge area to establish the rate of settlement and consolidation of the deposited sediments.

(9) Intertidal/Subtidal Morphology (Impact Verification): - To show whether or not the realignment causes any change to the morphology of the estuary, the LiDAR surveys (see above) will also be used to map intertidal habitats and these will be complemented by surveys of the subtidal bathymetry around the realignment site. These studies will be made in Years 1 and 5 after realignment but extra surveys in Year 3 may be needed if significant change is identified in the first year. These surveys will also be complemented by fixed-point photography surveys of intertidal areas, as viewed from the new and exiting sea walls. These fixed-point photography surveys will be carried out before breaching and annually thereafter.

(10) Saltmarsh Vegetation (Site Success): - To monitor the rate and character of the saltmarsh development in the realignment site (and specifically across the recharge area) the LiDAR surveys in the Years 1 and 5, will be accompanied by CASI work. This imaging should be complemented by annual transect surveys on the recharge area that will carried out at the same time as the settlement studies (see above) as well as the fixed-point photography work.

(11) Saltmarsh Vegetation (Impact Verification): - To check that the extent of saltmarsh habitat outside the realignment is not adversely affected, the LiDAR/CASI data will also be used to map these habitats (especially the two large saltmarsh areas on the north bank of Wallasea Island). This will be complemented by annual transect surveys of these areas. These saltmarshes are known to be eroding and the baseline rate of this erosion will be obtained by comparing the baseline LiDAR to be obtained in 2006 with the previous LiDAR data collected by the EA in 1999. Also, this information can be obtained by comparing the aerial photographs of the site which were taken by the Environment Agency in 1997 and again in the summer of 2004.

(12) Current Monitoring (Impact Verification): - To confirm that the rate of water flow through the breaches and the changes to current speeds in the middle of the estuary are as predicted in the EIA, current monitoring will be undertaken. Static meters will be placed at Breaches 2 and 4 to measure flows through these areas after breaching (static turbidity recorders will also be placed at these points to provide an indicative measure of the net suspended sediment flux into and out of the site). An additional static current meter will be placed outside the realignment site at Wallasea Ness (an area used by locals for recreation) to determine whether there is any detectable change that could alter the morphology and amenity value of this feature. To measure levels in the estuary, current meters will be deployed from a survey boat that will navigate three major zones. These zones will be: in front of Breach 3 (Zone 1); in front of Breach 4 (Zone 2); and downstream, at the confluence of the Roach and Crouch (Zone 3). Further boat-based monitoring will also be carried out in a smaller area (Zone 4) which will be seaward of the Burnham-on-Crouch boat yard. This will be designed to determine whether the operations of this yard are affected and it will also operate as a control location. In these estuary zones the flow regime will be monitored on a neap and a spring tide both before and after the breaching has taken place.

(13) Tidal Height (Impact Verification): - Information on tidal levels can be obtained from existing gauges and from the water level readings that will have to be taken as part of the subtidal bathymetry surveys (scheduled for Years 1 and 5 after realignment). The data obtained during these bathymetry surveys will be compared against available baseline data and used to confirm that there is no detectable change to tidal height in the estuary. In addition, a graduated tidal board and digital recorder have also been placed alongside Breach 2 (in order to inform decisions being made on site during the construction work) and this will remain in place after realignment to provide data on tidal levels in this area.

(14) Breach Stability and Integrity (Impact Verification): - There is a need to describe how the breaches and breach-channels develop in response to the tidal flows through them after realignment. This will be done using the outputs from the LiDAR/CASI surveys and by annual measurements of the breach widths in-situ. Also, the subtidal bathymetry surveys (in Years 1 and 5) will be extended into the breach areas to map the subtidal channel morphology (and check on siltation in the Breach 2 sluice).

(15) Sea Wall and Clay Bund Integrity (Impact Verification): - To check whether there is any erosion of the internal walls and clay bunding from internally-generated waves or from water flows within the realignment site, visual inspections and photographs of the internal sea walls and clay bund will be carried out. These can be undertaken at the same time as the annual fixed-point photography work, the measurements of breach widths and the testing of the recharge compaction (see above).

(16) Recreational Use (Site Success): - To seek views from locals and tourists about the amenity value of the realignment site it is recommended that interested parties and local groups are formally consulted in Year 3. To cover any day-to-day issue that may arise information boards will be placed along the sea wall and appropriate contact numbers will be included on these.

Annual reporting will be required throughout the monitoring programme and DEFRA is committed to ensuring that there is full dissemination of the information throughout the life of this project. To facilitate this dissemination, a web-site will be set up which will be regularly populated with site information, progress reports and monitoring reports.

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1. Introduction

1.1 Project Background

The European Wildlife Division of the Department for Environment Food and Rural Affairs (DEFRA-EWD) is undertaking a managed coastal realignment project on the north bank of Wallasea Island in the Crouch Estuary, Essex. This is being pursued to create new intertidal mudflat and saltmarsh habitat in compensation for impacts arising from port developments that were carried out during the late 1980s and early 1990s at Lappel Bank in the Medway Estuary (Kent) and at Fagbury Flats in the Orwell Estuary (Suffolk). The location of these sites is shown in Figure 1.

In addition to providing compensation habitats, this proposal will also improve the levels of coastal protection afforded to Wallasea Island. Many of the existing sea walls on the north bank of the island are in poor condition and the creation of a new sea wall fronted by a large expanse of new intertidal habitat will enhance the protection afforded to the existing land holdings on the island. The defence benefits of this proposal are indicated by the Environment Agency's (EA's) Draft Flood Management Strategy for the Crouch and Roach Estuaries (Halcrow/EA, 2003) which recommended coastal realignment in this area of the island.

This realignment proposal is being undertaken with the support and assistance of the landowner, Wallasea Farms Ltd, who were responsible for the submission of the Planning Application for this work. To support this Planning Application, and also to underpin applications for other relevant legal consents/licences, ABP Marine Environmental Research Ltd (ABPmer) carried out an Environmental Impact Assessment (EIA) as required under the Town and Country Planning Act (EIA) Regulations 1999 (ABPmer, 2004a). This EIA was informed by a numerical modelling study which was carried out to predict the effect of the scheme on the hydrodynamic conditions (water flows, tidal heights etc.) and sedimentary movements both across the adjacent estuary and within the new site itself (ABPmer, 2004b).

This modelling work was also used to refine the design of the scheme which will be divided into three hydrodynamically separate sites (Site A (west), Site A (east) and Site B) and will have six breaches in the existing sea wall. The design also includes seven 'island' features that are located within the realignment site and new borrow dyke and grassland habitats that will be created landward of the new sea walls. These habitats are to be created as mitigation for impacts to existing terrestrial and aquatic habitats on the island (including Ramsar-cited aquatic invertebrate populations within the borrow dyke). The scheme design layout is illustrated in Figure 2.

1.2 Report Background and Content

On behalf of DEFRA-EWD, this report identifies the details of the monitoring work that will need to be undertaken as part of this proposal in order to assess the success of the site in terms of its habitat creation objectives and also to verify the physical and ecological effects that it has on the estuary. The scope of this monitoring work is set out in broad terms within the Environmental Statement (ES) but, as a first stage in the process of defining the monitoring requirements, a more detailed scope has been prepared for this report. This detailed scope considers the planning conditions and the results of subsequent consultations with interested parties (including the EA) and is summarised in Section 2.1 and then presented in Table 1 as a series of individual questions that need to be answered by the monitoring. Section 2.2 additionally highlights a number of issues that will need to be considered (e.g. health and safety and method standardisation) and Section 2.3 presents summary details about other monitoring on the site that is being carried out by other parties and which could be used for this monitoring programme.

In response to the details monitoring scope, Section 3 sets out what ABPmer consider to be the most effective overall monitoring strategy for robustly addressing the relevant issues. These methods have been derived from: the established outline programmes that are set out in the original ES; the results of consultations with DEFRA, EA and RSPB as well as ABPmer's in-house experience of survey work, realignment schemes and numerical model interpretations. Section 4 presents an outline of the monitoring programme and also sets out contingency arrangements (measures to be taken in the event of significant impact being observed) and reporting requirements.

2. Monitoring Requirements

2.1 Monitoring Scope

As noted above, the monitoring can be divided into two distinct categories as follows:

(1) Site Success Monitoring: - This will be needed to determine whether the habitats created by the realignment will attain an ecological value that is sufficient to compensate for the habitats losses and waterbird impacts at Lappel Bank and Fagbury Flats. The findings will need to be tested against Compensatory Targets that are to be identified and agreed separately by the Project Management Group (PMG).

(2) Impact Verification Monitoring: - This will be needed to confirm the findings of the EIA work and show that the physical and ecological changes within the estuary are within the limits predicted in the ES. In particular there will be need to check: that there are no significant impacts to nationally or internationally designated sites (Crouch and Roach Estuaries SPA/Ramsar/SSSI and Ramsar and Essex Estuaries SAC); that existing coastal defences are not compromised and that there is an effective development of habitats created to mitigate for those that are lost/changed through tidal inundation.

A provisional scope for the Site Success monitoring work has been identified by the Wallasea Project Management Team (WPMT) and the outline requirements of the Impact Verification monitoring work was identified within the ES in response to the findings of the EIA. As they are currently proposed and presented in the ES, the outline scopes of these programmes show some overlap with the provisional site success monitoring programme including requirements that are more relevant to the impact verification objectives. For instance, the former includes work to assess the success of brackish water borrow dyke habitats but, because these are to be created in mitigation for losses (following tidal inundation) of equivalent Ramsar-designated habitats, they are technically impact verification objectives (although the mitigation habitats will also contribute to the success of the site by providing additional bird roosting, feeding and nesting areas). Similarly, the provisional Site Success programme includes requirements to monitor the impacts to protected terrestrial species as well as effects on the physical stability of the breaches. Again, both of these aims are more closely related to impact verification objectives. While some overlap between the monitoring objectives will always remain there is a requirement here to rationalise the scope of the two monitoring programmes as far as is possible and therefore ensure that their objectives are as clearly defined as possible.

In addition to rationalising the scope of these programmes, there are also extra requirements for monitoring that were not included in the ES but were identified during the planning process and following subsequent consultations. These extra elements are:

(1) Consider success of mitigation areas for providing water vole habitat - As a planning condition the EA requested additional baseline water voles and evidence of this species' presence has been found. The Management Plan for the Wallasea realignment site therefore includes measures to address the impacts to water vole from the breaching work and the new borrow dyke mitigations habitats have already been designed to provide suitable replacement habitat for this species. Although a requirement to monitor the new borrow dyke for water vole was included in the ES, a greater emphasis on this element will be needed to check that this species does re-establish in this mitigation area.

(2) Future integrity of the landward side of the existing sea wall - Following consultations with the owners of Priors Boat Yard (Burnham-on-Crouch) concerns were expressed that internally generated waves could lead to erosion of the internal part of what is the existing sea wall, especially at its north east corner (Mark Dixon pers. comm.). This effect will be mitigated by the creation of an internal 'beach' feature in the north-east corner of the site using recharge sediment. However, the monitoring will include inspections to test the effectiveness of this recharge and determine whether there are any such signs of internal wall erosion as part of the impact verification process.

(3) Flow Regime in front of Burnham-on-Crouch. Also following the consultations with the owners of Priors Boat Yard (Burnham-on-Crouch) current monitoring will be extended include sections of the estuary in front of their yard. This is to allay their specific concerns about potential effects on their operations.

In view of these additional elements and need to ensure that works undertaken is appropriately allocated to either the Impact Verification or the Site Success objectives, the outline scope of these programmes has been refined and is presented in Table 1. In this table the scope is described as a series of questions that the monitoring programme will be designed to address.

2.2 Issues to Consider

As part of this monitoring work consideration will have to be given to the following aspects:

(1) Health and safety - For all work, the safety of the surveyors will be of paramount importance and the monitoring work will need to take account of the risk to those undertaking investigative work on site. In particular surveyors are unlikely to be able to access areas between the breaches (as shown in Figure 3) on foot and risk assessments will have to be produced for all field surveys. This aspect will be addressed as part of the tender/procurement process.

(2) Standardisation - The survey methods should use standard protocols wherever possible and in particular, it should adhere to DEFRA guidance on 'Habitat Quality Measures and Monitoring Protocols' which was specifically produced to ensure that there is a level of standardisation for all future realignment proposals (DEFRA/EA, 2004).

(3) Integration of two monitoring programmes - There will be a need to consider how the two monitoring elements (Site Success and Impact Verification) can be integrated to maximise the value of the information, the standardisation of survey methods and the cost-efficiency of the overall programme.

(4) Minimising intrusion - Wherever possible the survey work should be carried out using remote techniques in order to minimise the amount of physical intrusion into the site and especially into areas such as developing or retreating saltmarsh where excessive numbers of movements by surveyors or survey vehicles could have an adverse effect.

(5) Use of other relevant data - Where possible, and relevant, existing and future surveys by other parties (including baseline data collected during the EIA) should be included in the monitoring programme (see Section 2.3).

(6) Scheduling - The initial phases of the monitoring will clearly need to be scheduled so that it links in with the proposed construction timescales and particularly, any extra baseline work that is needed (to provide a context for the Impact Verification monitoring) will have to be completed before breaching in June/July 2006. After realignment most of the survey work should be scheduled such that there is an even spread of programmed events (with the exception of the current monitoring where there will be a need for intense monitoring immediately around the time of the realignment). In some cases the surveys will be annual but other surveys should to be carried out in the first, third and/or fifth years to allow time for significant and detectable habitat change.

(7) Contingencies - The proposed programme sets out the monitoring requirements for the months prior to realignment (January to June/July 2006) and the five years thereafter. The programme has been prepared based on our current understanding of the potential physical and ecological effects of the scheme however, it must be recognised that this programme may need to be adapted should unexpected findings emerge. Some examples of possible contingency arrangement are set out in Section 4.2.

(8) Effect of natural variability - Where necessary the monitoring work includes control sampling locations to provide information on natural variability however it is likely that additional data (for instance on weather patterns) may be needed to explain temporal changes within the estuary or in the realignment that are not directly attributable to the proposed scheme (e.g. the effects of prolonged drought periods).

(9) Review/reporting and information dissemination - The initial monitoring programme will cover the first five years after realignment during which time there will be annual reporting of the findings. A final five-year report will then be produced at the end of this period which will include recommendations for subsequent monitoring work. DEFRA-EWD is committed to full dissemination of the information obtained and, to achieve this, a web-site will be set up to allow result and reports to be reviewed throughout the life of the programme.

2.3 Other Proposed and Completed Monitoring

The monitoring work that is set out in the preceding section and the interpretation and reporting work that accompanies it should, for the most part, be seen as stand-alone work and should not be reliant on other national or regional monitoring programmes. However, it will clearly be valuable, wherever possible, to try and use any relevant data that are collected as part of other established monitoring programmes. This includes:

(1) Five-Year Strategy Monitoring - Monitoring work will be that carried out as part of the 5-year review for the Roach and Crouch Flood Management Strategy. There will be a need to liaise with the EA's Shoreline Management Group (SMG) staff on this issue throughout the monitoring programme.

(2) Environment Agency Topographic Surveys - On a biennial basis the EA carries out cross-estuary topographic surveys to describe the profile and extent of intertidal habitat along the length of the Crouch and Roach. The next such survey is scheduled for Summer 2007 (Clive Flanders EA Pers. Comm.) and the results of this work (as they are presented in EA reports) should be integrated into the Wallasea monitoring programme and linked to LiDAR/CASI survey undertaken in the same year.

(3) Baseline Bird Data for Estuary - For the WeBS programme the BTO undertake and oversee high tide (core count) and low-tide ornithological surveys of the Crouch and Roach (a recent low water survey was competed in 2004/2005). The results obtained will provide a context for the assessment of all the ornithological survey results.

(4) LiDAR/CASI and Aerial Photographic Surveys - The EA carries out LiDAR/CASI and aerial photographic surveys. At the present time no LiDAR/CASI survey is scheduled but an aerial photographic survey was carried out in Summer 2004 and the next one is scheduled for 2007 (Clive Flanders EA Pers. Comm.).

(5) Fish Populations Studies for PhD Research Study - As part of the European INTERREG IIIB-funded ComCoast project, investigations are being carried out into the fish populations that are supported by realignment site in the Blackwater (Abbotts Hall, Orplands and Tollesbury). This work is the focus of a PhD study that will include monitoring in the Wallasea island realignment site as a case-example.

(6) Ground Elevation and Tidal Data Collected During Construction - A lot of data will be collated as part of the construction works some of which may be useful for this monitoring work. These data include ground elevation information although such information will be confined to areas such as the new sea wall and the recharge areas. It also includes information on the tidal heights because a tide recorder and graduated tidal board has been installed adjacent to Breach 2 (Grassland Point) and this will remain in place after realignment to provide data on tidal levels in this area.

The above data may be useful but will not be relied upon. Instead, the monitoring programme that is proposed here should be seen as stand-alone. The only exceptions are those projects that will definitively go ahead. These are the annual WeBS surveys (which provide valuable a background for the interpretation of the bird survey results) and the Environment Agency aerial photographic work in 2007 (which will provide very useful information on habitat development within the site).

Table 1. Objectives and outline scope of the Wallasea realignment monitoring programmes

Subject/Issue	Site Success Monitoring	Impact Verification Monitoring
Bird Populations	Survey - How do the abundance and diversity of overwintering (October to March) bird populations develop within the site? How do these overwintering birds use the site (i.e. for feeding, roosting and/or loafing) and what disturbance effects are observed? Data Interpretation - How does bird usage of adjacent estuarine habitats and the abundance of the SPA/Ramsar populations change during the winter months when compared with the established baseline?✳	Survey - How do breeding bird populations develop within the borrow dyke and island mitigation habitats?
Benthic Invertebrates	Survey - How do the abundance and diversity of benthic communities within the realignment site develop over time?	Survey - Do the abundance and diversity of benthic communities outside the realignment site change over time?
Aquatic/terrestrial Invertebrates		Survey - How do the aquatic invertebrates populations and water salinity conditions in the new borrow dyke mitigation habitats develop? How do the aquatic invertebrate populations within lagoon/scrape habitats of the realignment site change over time?★
Protected Species		Survey - How effectively do populations of protected species (including translocated reptiles, amphibians and water voles) establish themselves in the borrow dyke mitigation habitats? ◈.
Terrestrial Plant Species		Survey - How do coastal plant species become established in the new borrow dyke and island mitigation habitats?
Fish Populations	Data Review - How valuable is the site for fish populations?▣	
Intertidal/Subtidal Morphology	Survey - What are the sediment accretion characteristics (i.e. depth over time, spatial extent, grain size) within the realignment site?⊙ What is the sediment flux through the breaches? and What is the shrinkage of the recharge area?	Survey - Do the morphology of subtidal and intertidal habitats outside the realignment site change over time?
Saltmarsh Vegetation	Survey: - How do the extent and diversity of saltmarsh communities develop within the realignment site over time?	Survey -Is there any change to the rate of erosion of the saltmarsh areas on the north bank of the island outside the realignment site? ◘
Current Monitoring		Survey - Are the flow speeds through the breaches as predicted by the modelling work? Do the changes to the flow speeds within the estuary occur as predicted by the modelling work? Is there any change to water flows either in front of the Burnham-on-Crouch boat yard or at Wallasea Ness that could affect the operations of the former or the amenity value of the latter?
Tidal Height		Data Review - Do the water levels within the estuary under a range of tidal conditions show no significant change as predicted by the modelling work? ○
Breach Integrity		Data Review – How do the breaches and the breach-channels develop in response to the tidal flows through them after realignment?
Sea Wall/Bund Integrity		Survey - Are currents or internally-generated waves promoting erosion of the existing sea wall or the clay bund?
Recreational Use	Questionnaire - How often and for what activities (angling, bird watching, walking etc.) is the site used by locals and tourists and what are the views of these visitors about the value of the site?	

NB1 Summary details of the survey and data interpretation requirements are set out in Table 2
NB2 Unless otherwise stated all works are to be compared against baseline data as presented within the ES.
✳ = This is not a survey requirement for DEFRA but data that is collected as part of the WeBS programme will need to be considered to provide a context for the assessment of bird populations within the realignment site (NB baseline data are in the ES but an additional WeBS low-water survey of the Crouch and Roach was undertaken in 2004/05 after completion of the EIA).
◈ = As part of the pre-breach preparation work, a protected species monitoring and translocation programme (especially for common lizard, adder and water vole) will have been carried out according to agreed Method Statements.
◘ = Details about the baseline erosion rates are available from the ES and the Roach and Crouch Flood Management Strategy as well as from the aerial photographic surveys of the site that were taken by the Environment Agency in 1997 and 2004.
★ = Addressing this second question is not an essential requirement of the impact verification monitoring work but it will contribute valuable information on the impacts of the realignment scheme on the aquatic invertebrates and on its potential benefits in terms of supporting saline-lagoon specialist species. This information can be collected as part of the mitigation habitat aquatic/terrestrial invertebrate sampling work.
⊙ = Surface sediment samples will also be taken for Particle Size Analysis as part of the benthic invertebrate community studies.
▣ = This is not a survey requirement for DEFRA but surveys to address this issue will be undertaken separately by the EA and their reports and findings should be considered to contribute to the overall understanding of the site's ecological value (e.g. for piscivorous bird species)
○ = There is no need for a specific survey of water level changes but information on tidal height conditions will be collected during the subtidal bathymetric surveys and from the permanent tide gauge that is in place near Breach 2. These data and those from other relevant sources should be reviewed.

3. Monitoring Recommendations

3.1 Overwintering Bird Populations (Site Success)

3.1.1 Rationale and Objectives

The main objective of the proposed realignment is to create feeding and roosting habitat for overwintering birds species and, in so going, to contribute to the wider Natura 2000 network of designated sites. There is a need therefore, to assess the ornithological value of the site and to evaluate its development as a waterbird habitat against a set of compensatory targets that are to be agreed separately.

3.1.2 Methods

The overwintering bird survey work at Wallasea should be carried out using the same monitoring methods that have been, and are being, used at other realignment sites. This standardisation of approach will ensure that direct comparisons can be made between the datasets collected from different sites and that the findings can then feed into future assessments and strategic evaluations of such schemes. To ensure that there is such standardisation, the monitoring programme that is proposed here has been prepared with advice from Chris Tyas (RSPB) who is undertaking the Abbotts Hall and Tollesbury monitoring work and has also been undertaking the bird monitoring of Site A at Wallasea since December 2002.

The overwintering bird monitoring should be carried out from October to March during each of the five winter periods after breaching (i.e. 2006/07 to 2010/11) after which there will be an evaluation of the future monitoring requirements, as will be the case for all other parts of the monitoring programme. For the first winter, when the site will just be starting to develop (October 2006 to March 2007), the surveys should be carried out once per month but in the four subsequent winters, when the site is likely to increase in ecological value, two surveys per month should be undertaken.

Each individual survey should be carried out over 6 hours extending either from High Water (HW) to Low Water (LW) or from LW to HW (i.e. on ebbing or flooding tides respectively). The surveys should also be carried out under a range of different tidal conditions between neap and spring. In this way the monitoring will provide a better and more comprehensive description of bird abundance and behaviour than would be the case if the surveys were carried out under the same tidal state and same tidal regime each time.

The birds counts should be made across a series of nine count areas that are labelled A to I and are shown in Figure 4. Within the realignment site the boundaries between these count areas are marked by existing field drainage ditches that traverse the area and these will act as visible boundary markers for the surveyors. The boundaries on

the new sea wall will not be so clearly visible so they may need to be marked by placing posts or information signs at appropriate locations on the sea wall.

Ideally, the surveyors should aspire to make two counts in each hour during each six-hour survey (i.e. 12 counts in total) and, given the large size of the site, it is recommended that three surveyors are on site for each survey. Each surveyor can then make counts across one of three parts of the site as defined by Count Areas A to C; D to F; and G to I.

Within each of the nine count areas, records should be made of the bird numbers and behaviour in each of the key habitats that are present. These habitats are as follows:

(1) The tidal water (i.e. the waters flooding and ebbing across the site).
(2) The new and developing mudflat.
(3) The new and developing saltmarsh (recharge area).
(4) The old sea wall.
(5) The new sea wall.
(6) The island features that are present in Areas B, C, D, F, G, H and I.
(7) The water-filled scrapes and internal borrow dyke areas within the site.
(8) Any new shallow scrape areas that do not have impounded water.
(9) The new external borrow dyke mitigation areas landward of the new sea wall.

To survey each of these individual areas it will be best to use pre-prepared maps of the survey areas on which to record the results. This will help to clarify the spatial patterns of bird usage and the differences between separate parts of each habitat (e.g. individual scrapes and/or borrow dyke features). With respect to the counts that are made on the external/landward borrow dyke mitigation habitat, it is recognised that the bird interest here may well be affected by disturbance from the surveyors moving along the sea wall. This disturbance is inevitable but it will not compromise the survey results overall because the monitoring of these habitats is not an essential part of the overwintering monitoring. Instead it represents additional information that can be collected to provide added value to the survey findings.

For each count area, behavioural notes will be taken to show whether birds are feeding, loafing or roosting. Also records of the occurrence and effects of disturbance events (including, if relevant, any disturbance that is induced by the surveyors themselves) should be included. Further notes about birds over-flying the site and particularly, of any clear flight movements between feeding areas and roosting sites should also be made.

No impact verification monitoring or control location monitoring is required for these surveys but for the interpretation and reporting, comparisons will have to be made to the results from baseline and future bird surveys of the estuary. The main source of information on bird numbers within the estuary will be the annual WeBS/BTO core counts (showing the numbers of birds in the estuary at high water) and the BTO low-

water surveys that were undertaken in 1995/96 and 2004/05 (showing the abundance and distribution of birds at low tide). Ultimately, this information will show how the realignment site has affected bird abundance within the Crouch and Roach SPA and Ramsar sites.

3.2 Spring/Breeding Bird Populations (Impact Verification)

3.2.1 Rationale and Objectives

Additional ornithological surveys should be carried out during the spring months to assess the success of the mitigation habitats (i.e. the islands in the realignment site and the borrow dyke/grassland habitat on the landward side of the new sea wall) in terms of their value for nesting and farmland bird species.

3.2.2 Methods

These surveys do not need to be undertaken according to the methods that are usually applied for detailed breeding bird survey (which includes transect sampling and habitat mapping work) as this level of detail is not required in this case. Instead, to obtain qualitative or semi-quantitative descriptions of the mitigation habitats' ornithological value during the spring months they should be undertaken following the methods that are currently being used by RSPB for the monitoring of Site A (Chris Tyas RSPB pers. comm.).

This work will involve a single walkover survey that is undertaken in May and June (i.e. one visit per month) by an experienced ornithologist. The surveyor makes a circuit of the whole site along an agreed path (in this case along the new sea wall) and identifies breeding pairs and farmland bird species on the island and new borrow dyke mitigation habitats within the nine count areas described in the preceding section.

3.3 Benthic Invertebrates (Site Success)

3.3.1 Rationale and Objectives

To check that the new mudflat habitat in the site is developing as required, there is a need to evaluate the compositions of benthic invertebrate communities that it supports. This is important for showing that the emergent habitats are providing a suitable, and sufficient, amount of prey species for feeding waterbird species (especially in the months prior to the overwintering period). It is also an effective mechanism for measuring the functionality and 'naturalness' of the site as this will be reflected in the abundance and species composition of the invertebrate assemblages that it supports.

3.3.2 Methods

The benthic survey work should be carried out by experienced surveyors using Phase 2 level Marine Nature Conservation Review (MNCR) habitat mapping techniques (Hiscock, 1996) supported by benthic core sampling work. The core sampling should be carried out using a standardised approach as set out in the JNCC Marine Monitoring Handbook (Davies et al., 2001). This involves taking samples of surface sediment (15cm deep) using a 0.01m^2 core and retaining these samples for sieving (using a 500µm (0.5mm) mesh size sieve) and preservation followed by laboratory-based sorting, species identification and biomass recording. The laboratory analyses should adhere to guidelines of the National Marine Biological Analytical Quality Control programme (NMBAQC).

As the communities are expected to develop relatively slowly it is considered that the core samples are only subject to qualitative analysis in Years 1, 2, and 4. This qualitative analysis will involve processing the samples as described above and then making simple identifications and enumerations 'by-eye' of key taxa (especially those that are important waterbird prey species such as *Corophium* sp. *Macoma balthica*, *Hediste diversicolor* and *Hydrobia* ulvae) and recording the biomass of these and the total biomass of all organisms in each sample. This information will describe the general character of the benthic communities. To also provide detailed and statistically-robust information, quantitative analyses of the samples will are undertaken in Years 3 and 5. This will involve identification to the lowest taxonomic-level (species-level wherever possible) with enumeration and measurements of biomass for each of the taxa recorded. The results of the quantitative core sampling should be analysed with multivariate statistics to identify and describe any spatial and/or temporal trends (i.e. differences between different sample areas and different surveys respectively) in the invertebrate community data.

These surveys should be undertaken in the autumn months (when productivity and invertebrate abundance is highest), as this will show the amount of food that is available to overwintering/passage birds. The option of carrying out a second annual survey in the spring to describe the impacts of the bird feeding or the invertebrate resource was considered. However, it will be difficult to divorce the impacts of bird feeding on the benthos from the effects of natural species variability and seasonal mortality. Therefore, it is recommended that the behavioural notes which are taken during the ornithological surveys (see above) are used to assess the extent and location of bird feeding activities and that additional spring surveys are only included if a specific need is identified during the monitoring programme.

When considering the sampling strategy (i.e. the number and location of sampling locations and the number of replicate cores taken at each location) it is important to ensure that it will be statistically robust enough to ensure that the data from the different surveys can be quantitatively compared. It is also important that, given the large area of the site, the sampling strategy is flexible and dynamic enough to allow

individual investigations to be made across different areas of the site over the five-year period. The sampling scheme also needs to be comparable with work that has been undertaken at other realignment sites (such as Abbotts Hall and Tollesbury) and beach recharge trials sites (such as Shotley). It is recommended therefore, that the sampling is based around the nine Count Areas that were identified above for the bird survey work (i.e. the areas between the existing field drainage channels) and that within each area, five replicate core samples are taken from random locations across the mudflat. A further five samples should also be taken from recharge/saltmarsh habitats. Thus there will be 50 samples in total and the locations can scattered across the sites and do not need to be aligned in a cross-shore transect arrangement (as is usually the case for intertidal surveys). This is because the land at Wallasea is relatively flat and there are unlikely to be clear spatial changes along a cross-shore gradient and therefore there is no particular value in a transect arrangement.

The use of variable locations in discrete areas of a site is an approach that is used by CEFAS in their surveys of the recharge work at Shotley (Stefan Bolam pers. comm.). It is also an approach that will allow direct comparisons to be made with the results of the bird surveys because the sampling areas are the same for both studies. The use of single replicates will also maximise the spatial coverage of the survey while the separation of the sites into discrete areas will allow the results from different areas and different years (i.e. Years 3 and 5) to be statistically compared.

In addition to the core sampling work, surface sediment samples should be taken from all the sampling locations for Particle Size Analysis (PSA) and for organic content/Loss on Ignition (LOI) tests and at all locations surveyors should take the following:

(1) Notes about obvious surface features (casts, algal cover etc.) and details about their frequency and coverage over an average m^2 area.
(2) Photographs of the site to show the main features.
(3) Notes about the character and composition of the surface sediments.
(4) A record of the anoxic depth with photographs of the sedimentary profile to facilitate inter-annual comparisons.
(5) Measurements of the sediment Redox potential.

These additional notes will be crucial in the event that benthic communities do not develop as expected, in which case it will be important to understand what physical or chemical factors might have constrained development.

As the surveyors move across the site to access the core sampling points, they will also need to record target notes describing the broad-scale habitat characteristics of the site and identifying distinct changes to the extent of the visible epibenthic communities (e.g. algal/faunal settlement and growth on islands). Wherever possible these habitat developments and inter-annual changes should be recorded using fixed-point photography. It is not recommended that all individual habitats, such as individual patches of emergent saltmarsh, are mapped for each survey because this

will require too much invasive work which may itself damage the developing habitats. Overall invasive work and surveyor movements across the site should be kept to a minimum. Instead, the final habitat maps should be created by using survey results to ground-truth the aerial photography and LiDAR/CASI survey images that will be collected separately (see Sections 3.8 to 3.11). This habitat mapping should be based on agreed MNCR biotope codes although it is recognised that this may not be straightforward in this case because these are developing habitats (especially during the early stages of the five-year monitoring period) as opposed to natural and established habitats that form the basis for MNCR biotope coding.

3.4 Benthic Invertebrates (Impact Verification)

3.4.1 Rationale and Objectives

In addition to understanding the ecological development that takes place within the realignment site, there is also a need to monitor areas outside the site to confirm that the scheme does not have an ecological effect on mudflats in front of Site A. In view of the limited ecological value of this foreshore, this sampling needs only to be sufficient to identify significant effects.

3.4.2 Methods

For the purposes of impact verification monitoring, four of the locations that were sampled outside the realignment site during the baseline survey work should be revisited and sampled during Years 1 and 5. If any changes are observed over this time then additional surveys in Years 2 and 3 should be undertaken to check whether the observed changes reflect a persistent trend.

Of the four proposed sampling points (as shown in Figure 5), two are 'control' positions that are located upstream (B1) and downstream (B6) of the realignment site and are outside any zone of potential direct impacts from the scheme. The other two locations are located immediately adjacent to Breach 1 (B2) and Breach 3 (B4) on the narrow strip of the intertidal mudflats that lies in front of Site A. The control locations will be used to describe natural community variability and thus set the context for the interpretation of the survey data. The results from locations B2 and B4 will show whether the breaching works have indirectly affected the ecological value (albeit limited at present) of the adjacent mudflat habitat. The sampling methods will be the same as those undertaken for the baseline surveys with three 0.01m^2 core samples being taken from each site which will be subject to quantitative or species-level analysis (see preceding section) of the infauna. In total therefore, 12 core samples will be taken from these four locations. This monitoring should be carried out in September at the same time as the Site Success benthic surveys.

3.5 Aquatic and Terrestrial Invertebrates (Impact Verification)

3.5.1 Rationale and Objectives

Baseline surveys of the existing borrow dyke habitats showed that they support many notable and rare brackish/freshwater invertebrate species (including species cited in the Ramsar designations) so that these habitats are important in a national context. These habitats will become fully saline after realignment and to mitigate for this change the borrow dyke areas behind the new sea walls are designed to support comparable brackish/freshwater invertebrate populations. There is a need for monitoring of the aquatic invertebrates to be carried out to check that these populations do develop effectively in the mitigation areas. These surveys could also be accompanied by small-scale investigations of the terrestrial invertebrate in the mitigation areas and of the aquatic invertebrate populations within the scrape and borrow dyke habitats in the realignment site itself. The terrestrial invertebrate survey work will contribute to the overall assessment of the value of the mitigation habitats and will inform the measures that are used for their management. The study of the aquatic habitats within the realignment site, although not an essential monitoring requirement, will help to evaluate the impact of the scheme on the designated borrow dyke areas while also contributing to an understanding of the site's overall ecological development.

3.5.2 Methods

The sampling methodology for this survey work should be the same as that employed for the baseline surveys that were carried out for the EIA (Godfrey, 2004, ABPmer, 2004a). These methods are outlined below and a provisional set of sampling locations for this work is presented in Figure 6 and can be compared against the baseline survey locations that are shown in Figure 7. In summary, the number and location of the survey points and the sampling objectives are as follows:

(1) Twelve aquatic locations in borrow dyke mitigation habitat. These 12 locations will be sampled to assess the effectiveness of the mitigation habitat creation. Most of the locations (eight) are located in Borrow Dyke B which, unlike Borrow Dyke A, will be designed to have a relatively variable topography with extended shallow areas which should enhance invertebrate interest. Therefore, extra samples are required in this area to assess the success of these design measures.

(2) Three terrestrial locations in grassland/berm mitigation habitat. These five locations will be sampled to asses the value of the grassland/berm habitats alongside the new borrow dyke habitats. One sample point will be located adjacent to Borrow Dyke A and two will be located in Borrow Dyke B area.

(3) Five aquatic locations in realignment site. These locations will be sampled to assess the impacts of tidal inundation on the existing aquatic habitats within the realignment area as well as monitoring the establishment of new saline-tolerant aquatic fauna (possibly saline lagoon specialists) in these habitats.

In total therefore there will be 17 aquatic samples and 3 terrestrial samples collected from within the borrow dykes, field drains, flooded scrapes and grassland areas of the mitigation areas and the realignment site. A specialist invertebrate surveyor should undertake this work during the summer months (June) and the methods for the survey should be the same as those that were applied for the baseline monitoring (Godfrey, 2004) to allow direct comparisons to be made with this preceding survey. The aquatic sampling at each location should be carried out over a 3-minute period using a standard hand net with 1mm apertures. The net should be passed along the sides and bed of the channels or waterbodies and through submerged vegetation. The sample should then be gently washed and sieved in the field using 1cm and 500µm sieves. Coarse material that is retained by the 1cm sieve should be examined for large invertebrates and put back when this had been done. The bulk of the sample should then be examined in the field in a white tray for a period of at least 45 minutes or until no new taxa are recorded. Abundances of taxa should be estimated in the field. Voucher samples would be placed in 5-10% formalin or alcohol in the field to avoid decay and to preserve material in good condition.

As with the benthic invertebrate sampling work, a recording form should be completed in the field for each sample location. This should record physical features such as channel width, water depth, water flow, as well as the sample position, water temperature, pH and salinity. The main taxa of interest will be water beetles, water bugs and lagoon species (e.g. *Gammarus* spp, sea slugs). To complement these surveys it is recommended that, where possible, additional qualitative sampling work is carried out any by relevant groups of experts (e.g. the Dipterists Forum or other entomological specialists) that might be interested in studying certain taxa on site (Roger Morris EN pers. comm.). This would cost-effectively enhance the value of the information obtained overall, although the number and frequency of such visits would have to be controlled to avoid undue habitat impacts.

Terrestrial invertebrates should be sampled using a sweep net. A period of about one hour should be spent at each location and locations should be selected in the field on the basis of these being potentially of value to invertebrates and representative of the terrestrial habitats on the site. Vouchers should be removed from the net using an aspirator. Distinctive invertebrates that are observed in the field should also be noted and the annual reports would need to highlight the presence of species that are: protected, National BAP, Local BAP and Red Data Book and Nationally Scarce.

These surveys of the aquatic and terrestrial invertebrate populations should be undertaken in Years 1, 3 and 5 to describe how these habitats become established over the full five-year monitoring period.

3.6 Protected Species (Impact Verification)

3.6.1 Rationale and Objectives

The baseline survey work showed that the existing borrow dyke and breach areas support species that are protected under Section 9 of the Wildlife and Countryside Act 1981 as amended (especially adder and common lizard). Therefore, before breaching, a translocation exercise for these species will be carried out and the receptor site will be the on the east bank of Wallasea Island (where the new sea wall behind Area B joins the existing sea wall on the west bank of the Roach). There is a need to monitor this habitat after realignment to test the success of this translocation and mitigation work.

3.6.2 Methods

The surveys for reptiles and amphibians should be the same standard methodology as baseline the surveys which were carried out to inform the EIA. This involves the deployment of artificial basking mats at selected locations across the mitigation area and revisiting these to check for basking adder and common lizard. In accordance with guidelines recommended by the Herpetofauna Groups of Britain and Ireland and supported by English Nature, these mats should be visited on seven separate occasions during late spring and early summer (April/May). Survey visits should be timed to coincide with cool but warming early morning conditions, when reptiles should have been basking, before they are "up to temperature" and begin foraging. It is estimated that around 200 basking mats should be used and placed at a range of different locations and habitat types across the back of the new sea wall (Antony Muller EN pers. comm.). The decision about where these are placed should be made by an experienced surveyor in consultation with EN. During the deployment, revisiting and collection of the basking mats the surveyors should make target notes of any signs of protected species. In particular there will need to be an examination of Borrow Dyke habitats for water vole.

This work will be carried out in Year 3 after the mitigation areas have had time to develop. In the event that there are no signs of protected reptile species then a follow-up survey will be undertaken in Year 5.

3.7 Fish Populations (Site Success)

3.7.1 Rationale and Objectives

There is no requirement for DEFRA-EWD to undertake fish monitoring work. However surveys of fish populations will be undertaken at the Wallasea site by the Environment Agency either as part of the ComCoast project, which includes a PhD study into the value of realignment sites for fish species, or as part of other statutory monitoring work. The results of these studies will be presented in reports that will be separately

produced by the EA and these results should be integrated into the annual monitoring reviews for the realignment work.

3.7.2 Methods

It is recommended that the findings of the EA studies and associated publications (e.g. scientific papers) at Wallasea are integrated into the reporting and interpretation work for the DEFRA-EWD monitoring programme. This information will contribute to the overall understanding of the site's ecological development and will particularly, help to show whether the developing saltmarsh and mudflat habitats are providing feeding and nursery areas for demersal fish species.

3.8 Intertidal Morphology Within the Realignment Site (Site Success)

3.8.1 Rationale and Objectives

To show how the site is functioning and also predict its long-term functionality there is need to measure the rate and spatial pattern of sediment accretion over the five-year period. There is also a need to describe the settlement of the dredge arisings within recharge area as this may be important for understanding the subsequent patterns of saltmarsh development across this area.

3.8.2 Methods - Sediment Accumulation Within the Site

The most cost-effective method for monitoring the sediment accretion characteristics within the site will be to use remote sensing Light Detection and Ranging (LIDAR) imaging techniques (that will be accompanied by Compact Airborne Spectral Imaging (CASI) where vegetation also needs to be mapped - see Sections 3.10 and 3.11). The area to be covered by these LiDAR/CASI surveys (which will also be used for impact verification) is shown in Figure 8.

These imaging surveys have the advantage of covering large areas and this will be important at Wallasea because of the large size of the site and the fact that the rates of accretion are expected to be low and may well be patchy (especially in the short term). Therefore, walkover survey techniques such as theodolite levelling or measurements of sediment deposition over accretion plates or alongside vertical posts/canes are unlikely to be provide sufficient spatial coverage for this work. Another disadvantage of the walkover techniques is that they are invasive and they involve surveyors regularly walking across large areas of the site.

There will still however be a need to carry out some theodolite-based work to 'ground truth' the information provided by the LiDAR images. To achieve this a series of fixed points should be set up across the site and marked by 'Control Plates'. They should be 'levelled in' against established bench-marks. These should be placed at a range of high and low elevation points. In this case, the low elevation locations will be on the

mudflat and the recharge areas and the high elevation points will be the tops of the sea walls and islands. These sea wall points could also be used as locations for fixed-point photography (see below). A provisional set of Control Plate locations is shown in Figure 9. Elevation levels will also be taken across the recharge areas on an annual basis and these data can also be used for the ground-truthing (see Section 3.8.3).

Before breaching takes place, it will be necessary to do a new LiDAR flight of the area and also do a levelling survey to set up the Control Plate positions and ground truth this LiDAR. LiDAR data already exists for this area but this was collected in 1999 (upstream regions of the Crouch to the west of North Fambridge were updated in 2002/2004 but the rest of the Crouch and Roach was last surveyed in 1999) and there will have been changes in land elevation since that time. Therefore, ground-truthing of the 1999 data is not expected to provide the necessary accuracy in terms of the baseline land elevations.

A LiDAR survey will therefore be carried out prior to breaching (early summer 2006) and then combined LiDAR/CASI surveys will be carried out in the first and fifth years after realignment. However, if after the first survey after realignment indicates substantial change outside the site (see next section) there will be a need to include an extra LiDAR survey in the third year after realignment. The EA does undertake its own LiDAR flights however, none are scheduled for the Crouch and Roach at present (Alison Mathews EA pers. comm.) and even if they are undertaken during the five-year monitoring period it will not be possible for the EA to guarantee a flight under the correct tidal conditions. Therefore, these surveys will have to be specifically commissioned for this project.

On each occasion that LiDAR flights are carried out, the elevation of the Control Plate points should be measured (especially because there may be some subsidence at those points which are positioned on the new sea wall, island and recharge areas) so that they can be used adjust and calibrate the LiDAR images.

In addition to the LiDAR imaging work, a fixed-point photographic survey of the area should be conducted on an annual basis. This should be done at the same time as the benthic survey work (September each year) and should include panoramic views of the realignment area and, where relevant, adjacent intertidal areas (see next section). The intertidal benthic surveys will also, on an annual basis, include the collection of surface sediments for Particle Size Analysis at 50 locations across the site and the information from these analyses can be linked to the findings of these investigations into site accretion.

The possibility also exists that an outline sediment 'budget' for the site could be produced using the results of the flow metering at the breaches (see Section 3.12.4) allied to additional studies of sediment movements in the incoming and outgoing tidal waters.

3.8.3 Methods - Settlement of the Sediment Recharge Area

The information collected from LiDAR and Control Plate levelling work will also be used to measure the vertical settlement of the recharge sediments. To compliment this it is recommended that additional levelling work and soil strength (bed shear stress) measurement surveys are taken on an annual basis. It is envisaged that readings will be taken at 200m intervals along the length of the recharge area and a provisional sampling regime is shown in Figure 10. The levelling will measure the annual rate of settlement and the shear strength readings will describe the changes in the quality of these sediment and the rates of consolidation. This information will show whether they are continuing to settle or move. In the event that there are any problems in terms of the rate of the saltmarsh development on these habitats such qualitative description of the sediments, allied to the quantitative information from the levelling and LiDAR work, will help to show whether such problems are attributable to the sediment character. This levelling and shear stress work can be done at the same time as the benthic sampling work (which will include 5 benthic and PSA sampling sites in the recharge area) and the fixed photography surveys.

3.9 Intertidal/Subtidal Morphology (Impact Verification)

3.9.1 Rationale and Objectives

The monitoring programme will need to show whether or not the realignment causes any change to the morphology of the estuary. This will need to include both subtidal areas and intertidal areas. The former is required to indicate whether the subtidal habitats or the general navigability of the estuary have been affected and the latter is required to show, particularly, whether the extent of designated intertidal habitats or levels of coastal protection have changed.

3.9.2 Methods

To monitor the potential changes to both subtidal and the intertidal habitats the survey work will involve the following three elements:

(1) The LiDAR surveys (as described in the preceding section) will also be used to describe any changes to the intertidal topography outside the site (across the area shown in Figure 8). Therefore, the flights will have to be carried out at low water on a spring tide to ensure maximum intertidal exposure (they will also have to be undertaken in daylight hours for the purposes of the CASI imaging work as discussed in next section).

(2) Boat-based bathymetric surveys will be carried out across regions of the Crouch and Roach that immediately surround the site, as well as areas immediately upstream and downstream (see Figure 11) to obtain information on the subtidal bathymetry.

(3) Fixed point photographic surveys of the intertidal habitats surrounding the realignment site (on the north and east sides of Wallasea Island).

The first two of these surveys will be conducted in the first and fifth years after realignment (in addition to the baseline LiDAR undertaken before breaching in 2006) although if substantial changes are detected after the first survey, an additional survey in the third years should be added to the programme. On each occasion the data from these surveys should be integrated into a single GIS bathymetric plot which can be used to compare the result from different years and calculate the changes arising from accretion or erosion. The first year's results will be compared against the baseline bathymetry from the 2006 baseline LiDAR survey and the sub-tidal bathymetric survey that was carried out for the EIA in 2004.

To additionally describe the extent and character of the foreshore around the realignment site (mainly in front of Site A and at Wallasea Ness), fixed-point photographs should be taken before realignment and thereafter on an annual basis from safely accessible areas (location of Control Plates as discussed in previous section). The results (allied to the LiDAR/CASI results) should be used to confirm that there are no significant changes to the intertidal habitats.

3.10 Saltmarsh Vegetation (Site Success)

3.10.1 Rationale and Objectives

As part of the assessment of the site's ecological development it is necessary to monitor the rate and character of the saltmarsh development on the recharge area and, if relevant, in other areas of the realignment site.

3.10.2 Methods

Once again, the main source of information needed to describe changes in the extent of the saltmarsh will be the LiDAR/CASI images (especially the CASI) that will be collected in the first and fifth year of the monitoring programme. However additional information should be collected on an annual basis (at the same time as the annual benthic invertebrate surveys and recharge settlement surveys). Surveyor intrusion into the area should be kept to a minimum and therefore the approximate extent of saltmarsh should be mapped visually from the sea wall and these maps should be supported by fixed-point photographic work from the sea wall. Survey transects should be placed at locations where surveyors already have to enter the area to test the quality of the recharge sediments (see Section 3.8.3 and Figure 10) and on an annual basis the extent of saltmarsh should be measured along these transects and quadrat samples should be taken in the immediate vicinity of the bed shear stress reading points to record the percentage coverage and species composition of the emergent marsh. The quadrat points and locations of the transect alignments should therefore

be identical to the locations for the bed shear stress measurements (see Figure 10). The annual fixed-point photography surveys of the recharge area will also be used to describe the extent of saltmarsh across the recharge area.

3.11 Saltmarsh Vegetation (Impact Verification)

3.11.1 Rationale and Objectives

In addition to considering whether the extent and morphology of the intertidal habitats outside the realignment site is altered by this proposal, there is a need to determine whether such changes alter the erosion rate of saltmarsh habitats in the estuary and particularly the rate of retreat of the two large areas of saltmarsh on the north bank of Wallasea Island.

3.11.2 Methods

The LiDAR/CASI images that are to be used to map morphology and vegetation changes inside and outside the realignment sites can also be used to assess the changes to the saltmarsh habitats for this impact verification monitoring. To supplement this information (which will be collected in the first and fifth year of the five year monitoring programme) two cross-shore transect surveys will be undertaken on an annual basis across each of the two large saltmarshes in front of the existing sea wall in order to accurately measure the extent of the saltmarsh. The extent limits will be defined as the distance from fixed points on the sea wall back to the furthest limit of the 'last living plant'. These transect surveys should be carried out in September (at the same time as the benthic survey work) and once again every effort should be made to minimise the extent to which surveyors intrude into these saltmarsh habitats.

To underpin this monitoring, an indication of the baseline levels of erosion of these areas should be made because it is already known from personal observations and the results of a review in the Flood Management Strategy document (EA/Halcrow, 2003, ABPmer, 2004a) that these saltmarsh areas are retreating. This baseline rate of erosion should be measured using the pre-realignment LiDAR/CASI surveys undertaken in 2006 and comparing them against the LiDAR images that were collected in 1999. It can also be estimated by comparing the aerial photos taken by the EA in 1997 and again in 2004 can be used for this analysis. These images should provide a detailed description of the erosion rate over the 7-year period preceding realignment.

3.12 Current Monitoring (Impact Verification)

3.12.1 Rationale and Objectives

There is a need to confirm that the rate of water flow through the breaches and the changes to current speeds in the middle of the estuary are as predicted within the EIA and the supporting hydrodynamic studies.

3.12.2 Methods - Flow Speeds Through the Breaches

It is recommended that the current monitoring at the breaches is undertaken by mounting static meters on floating buoys attached to stakes or piles that are set into the mud on either side of the breach areas. This equipment should be put place as soon as possible after the breaching. Not all the breaches need to be surveyed as the objective of this work is only to confirm the predictions detailed in the EIA. Therefore, it is recommended that this monitoring takes place at Breach 2 (a 100m wide breach in Site A East) and Breach 4 (the 210m wide breach in Site B) to provide an indication of the conditions at these two differently sized breaches.

The breaching work will be carried out on a neap tide but the monitoring should include flow measurements under the worst-case conditions (i.e. the periods of maximum flow on spring tide). Therefore, it is recommended that the current meters are mounted on the buoys as soon as possible after breaching and then left for a period of 8 days so that they describe conditions on the next spring tide.

An additional static current meter will be placed outside the realignment site at Wallasea Ness (an area used by locals for recreation) to determine whether there is any detectable change that could alter the morphology and amenity value of this feature.

3.12.3 Methods - Flow Speeds in the Estuary

To monitor the flows in the estuary and test whether the realignment has detectable effects on the current regime, it is recommended that a boat-based monitoring programme is undertaken using a mobile Acoustic Doppler Current Profiler (ADCP). The alternative use of static equipment in the estuary has been rejected because, while it might provide a good temporal dataset, it would only provide localised point-specific information and it would probably have to be placed outside the main navigable areas (which is the main area that needs to be investigated).

For this survey work, the boat will need to follow a rectangular course (i.e. both 'along shore' and 'cross estuary') over four parts ('zones') of the estuary as shown in Figure 12. These zones are: in front of Breach 3 (Zone 1); in front of Breach 4 (Zone 2), downstream of whole realignment site at the confluence of the Roach and Crouch (Zone 3) and in front of the boatyard at Burnham (Zone 4). Zones 1 to 3 are areas in which the hydrodynamic model predicted maximum change and Zone 4 is an area that needs to be surveyed to allay concerns that the scheme may affect the operation of the Burnham boat yard. Zone 4 will also act as a control site because it is located in an upstream area where no flow speed changes are predicted.

In Zones 1 and 2 the along-shore movements will provide extra information on the flows in and out of the breaches which will complement the findings from the buoy-

mounted current meters at Breaches 2 and 4. The cross-estuary sections will provide information on the through-estuary flow conditions.

In all zones sampling will be carried out at 30-minute intervals for any single point along the rectangular course. The monitoring should be undertaken on a neap and a spring tides before realignment and again on comparable tides after all the breaching work has been completed.

3.12.4 Methods - Sediment Budget

To complement the current monitoring work, it is recommended that static turbidity meters are deployed at the breaches alongside the static current meters. The aim of this would be to combine the flow and suspended sediment readings and obtain a measurement for the rate of sediment flux into and out of the realignment site. This will provide a general description of the suspended sediment movements during the 8 days over which static monitors will be in place. It will also help to show whether, in the period immediately following realignment, there is any evidence of turbidity plume formation (in which event the requirement for water quality monitoring will be triggered - see Section 4.2).

3.13 Tidal Height (Impact Verification)

3.13.1 Rationale and Objectives

There is no expectation that the tidal heights within the Crouch or Roach estuaries will be affected by the realignment however, there is a need to ensure that any concerns from locals and interested parties (e.g. Baltic Wharf and the Crouch Harbour Authority) are addressed. Therefore, information on tidal height conditions after realignment will need to be collated, reviewed and compared against baseline information.

3.13.2 Methods

For this study information on tidal heights will be available from two principal sources:

(1) Data collected for bathymetry survey calibration. For the subtidal bathymetry surveys, tidal information has to be collected to describe the spatial changes in tidal height along the estuary so that this can be taken into account when processing the readings taken during the survey. For the baseline survey that was carried out in 2004, tidal readings were taken from gauges specifically deployed at Holliwell Point and Baltic Wharf and also Havengore Island. For the post realignment subtidal bathymetry surveys (in the first and fifth year after realignment) tide gauges will have to be placed at the first two of these locations to calibrate the survey results (see Section 3.9.2). These data can be compared directly against the 2004 baseline results.

(2) Data collected for breaching work. As part of the construction and breaching work a tide gauge has been placed on the north bank of Wallasea Island (near Breach 2) to measure the tidal heights in an area that is as close as possible to the proposed wall breach areas. The data collected will help the contractors to accurately predict the time windows within which they are able to work for the wall breaching. Thus gauge will provide a continuous set of tidal height data before and after the realignment.

These sources of information as well as others (such as the tide gauge at Burnham-on-Crouch) can be reviewed as part of the annual reporting work to compare the baseline and post-realignment water levels in the estuary.

3.14 Breach Stability and Integrity (Impact Verification)

3.14.1 Rationale and Objectives

As part of the impact verification monitoring it is necessary to assess the development of the breaches and breach channels after realignment. There is also a requirement to test the rate of siltation at the sluice which is located at Breach 2 (Mark Dixon pers. comm.).

3.14.2 Methods

The width of the breaches will be measured from the LiDAR/CASI surveys that are undertaken in the first and fifth years after realignment. At the same time as both these LiDAR/CASI flights are carried out (and the contemporaneous subtidal bathymetric survey of the estuary), a high water subtidal survey of the channel areas between the breaches will be undertaken (at all six breaches). These surveys will be used to map the morphology of the channel and to test whether it has changed in the year following realignment and at the end of the five-year monitoring period. This work will also be used to measure the rate of siltation within the sluice that is located at Breach 2. The area to be covered at this breach will extend from the sluice gate in front of the existing sea wall to the seaward face of the 'internal' sluice which is currently located some 20-30m on the landward of the existing sea wall.

On an annual basis the location of the accessible outer edges of the breaches can also be calculated based on distance measurements from fixed points (e.g. safety notice signs, Control Plates and/or photography locations). As parts of the wall are not safely accessible (see Figure 3) only the following sides of the following breaches can be measured on each occasion: Breach 1 (both sides), Breach 2 (west side), Breach 3 (east side) Breach 4 (west side), and Breach 6 (east side).

3.15 Sea Wall and Clay Bund Integrity (Impact Verification)

3.15.1 Rationale and Objectives

As well as examining the effects on the foreshore outside the site there is a need (based on concerns expressed by the owners of Priors boat yard) to check whether there is any erosion of the internal walls and bunding from internally-generated waves or water flows within the realignment site.

3.15.2 Methods

In tandem with the annual fixed-point photography work, the measurements of the outer limits of the breaches (see Section 3.14) and the testing of the recharge compaction (see Section 3.8.3) visual inspections and photographs of the internal sea walls and clay bund will be carried out to check for erosion.

3.16 Recreational Use (Site Success)

3.16.1 Rationale and Objective

Although not an essential requirement for the proposed DEFRA-EWD monitoring programme, it will be of value for this and future realignment schemes, to seek views from locals and tourists about the amenity value of the realignment site. This will help to identify measures that might be taken to enhance the value of the site (for angling, bird watching, walking etc.).

3.17 Methods

To obtain the views of those that use the site it is recommended that interested parties and local groups (e.g. wildfowlers, ornithologists, bass fishermen and oyster fishermen) are formally consulted towards the middle of the five-year monitoring programme (in the third year after realignment). This allows time for accommodating, where possible, any problems or recommendations that arise and then assessing their effectiveness within the five-year life span of this monitoring programme. To cover any day-to-day issue that may arise, information boards will be placed along the sea wall and appropriate contact numbers will be included on these. The views expressed via this approach can then be reviewed within the annual reports.

Table 2. Proposed methods for the Wallasea realignment monitoring programmes over the first five years

Subject/Issue	Site Success Monitoring	Frequency	Impact Verification Monitoring	Frequency
Bird Populations	Survey of overwintering bird abundance and behaviour from October to March across nine survey count areas. Counts once/month in first year after breaching then twice/month in subsequent years. Each survey for 6 hours (ideally two counts per areas per hour) either on the ebb (HW to LW) or flood (LW to HW) and under a range of different tidal conditions (neap to spring). Count areas to be divided into separate habitat types (each surveyed individually) and over-flying species also to be noted. Compare results against data collected by WeBS/BTO for Crouch and Roach estuaries.	Annually	Walkover surveys in May and June (i.e. one visit per month). The surveyor makes a circuit of the whole site along an agreed path (on sea walls) and identifies breeding pairs and farmland bird species (especially those on the island and new borrow dyke mitigation habitats) within the nine different count areas	Annually
Benthic Invertebrates	Phase 2-level Marine Nature Conservation Review (MNCR) habitat mapping supported by qualitative or quantitative benthic core sampling work across the realignment site. Core sampling will be at five locations within each of the nine bird count areas and at five locations in the recharge area (50 sample sites in total)	Annually (Qualitative sample analysis in Years 1,2 and 4; Quantitative analysis in Years 3 and 5)	Benthic core sampling at four sample points (with 3 replicate cores per site) on mudflat around Wallasea Island. Two of these sample points are 'Control' locations outside the immediate influence of the realignment and two are located immediately adjacent to breaches.	Years 1 and 5 (and again in Year 2 and 3 if any significant changes is detected in Year 1).
Aquatic/terrestrial Invertebrates			Surveys of: aquatic invertebrates at 12 sample points in the new borrow dyke mitigation habitats, terrestrial invertebrates at 3 sample points in new grassland/berm mitigation habitat and aquatic invertebrates at 5 sample points within the realignment site	Years 1, 3 and 5
Protected Species			Basking mats to be deployed in spring early summer and to be revisited on seven occasions to check for amphibians and retiles. During these visits signs of protected species to be notes (especially signs of water voile sin Borrow dyke mitigation habitats).	Year 3 (and again in Year 5 if no reptiles recorded)
Fish Populations	Review of interpretative reports produced separately either as part of the ComCoast project (which includes a PhD study into the value of realignment sites for fish species) or as part of other statutory EA monitoring work.	As reports become available		
Intertidal/Subtidal Morphology	LiDAR/CASI imaging surveys carried out in the autumn and 'ground truthed' against measurements at a set of Control Plates locations positioned at a range of tidal heights (mudflat, recharge area, sea walls and islands). The plate locations on the sea wall will also be used as locations for undertaking annual fixed-point photography surveys of the realignment site. Additional levelling work and soil strength (bed shear stress) readings will be taken annually along the recharge areas to measure shrinkage and compaction of the deposited sediments	Year 0 for LiDAR only Years 1 and 5 for LiDAR/CASI Year 0 and Annually for photography Annually for recharge levelling	The LiDAR/CASI imaging surveys used for the site success monitoring should also be used to map intertidal habitats in estuary. They must be undertaken on a low water spring tide in daylight. At the same time a boat-based subtidal bathymetry survey of an area from Baltic Wharf to the confluence of the Crouch and Roach will be undertaken. Also fixed point photography surveys of the intertidal areas around the realignment site to be carried out on an annual basis.	Year 0 for LiDAR only Years 1 and 5 for LiDAR/CASI and bathymetry Year 0 and Annually for photography
Saltmarsh Vegetation	LiDAR/CASI imaging surveys used to describe extent of saltmarsh in the recharge area. This information to be supported by fixed point photography well as transect/quadrat sampling at pre-defined locations on an annual basis.	Years 1 and 5 for LiDAR/CASI Annually for photography and & transect/quadrat sampling	LiDAR/CASI imaging surveys can be used to describe the extent of saltmarsh outside the realignment site and to measure the rate of erosion of the two large saltmarshes on the Wallasea north bank. This information is to be supported by in-situ transect measurements over the two large saltmarshes on an annual basis.	Years 1 and 5 for LiDAR/CASI Annually for transect sampling
Current Monitoring			Flow through breaches to be measured using static meters mounted on floating buoys that will be attached to stakes or piles within Breach 2 and Breach 4. Flows within estuary to be measured at 4 zones using mobile measurements from a survey vessel boat. The boat surveys to be undertaken on neap and spring tides before and after realignment.	Year 0 – shortly before and after breaching
Tidal Height			Measurements on tidal heights will be obtained from gauges deployed as part of the subtidal bathymetric surveys and from a gauge that is already in place near Breach 2. The data obtained from these sources will be reviewed.	Years 1 and 5 for bathy survey Continuous for Breach 2 tide gauge.
Breach Integrity			LiDAR/CASI survey will describe width of breaches, a high water subtidal survey of the channel areas between the breaches will be used to map the morphology of the channel. On an annual basis the location of the accessible outer edges of the breaches will be measured from fixed points.	Years 1 and 5 for LiDAR/CASI and bathy Annually for fixed point references
Sea Wall/Bund Integrity			Visual inspections and photographs of the internal sea walls and clay bund will be carried out to check for erosion.	Annually
Recreational Use	Interested parties to be formally consulted towards in the middle of the five-year monitoring programme. For day-to-day issues, information boards will be placed along the sea wall and appropriate contact numbers will be included on these.	Year 3 for consultation		

4. Scheduling, Contingencies and Reporting

4.1 Scheduling - Key Monitoring Events

To describe the overall schedule of events throughout the proposed monitoring programme, a schedule of the monitoring events is presented in Figure 13. In summary the key 'staging posts' for the monitoring are as follow:

(1) Project Start (Early 2006). Project commissioning and survey scheduling.

(2) Baseline Monitoring Year 0 (Spring 2006). LiDAR survey to map intertidal topography outside the realignment site and measure baseline elevations within the site. Fixed-point point photography to establish baseline conditions within and immediately outside site. Review of historical aerial photographs and other information to agree baseline rates of saltmarsh erosion outside the site prior to breaching. Current monitoring to be undertaken in the estuary on a neap and a spring tide before breaching. As the breaching is scheduled for the first week of June 2006 all this baseline monitoring will need to be completed by the end of May 2006.

(3) Post Breach Monitoring Year 0 (August/September 2006). Current monitoring at breaches and in estuary on a neap and a spring tide shortly after breaching.

(4) Post Breach Annual Surveys Years 1 to 5 (2007 to 2011). Annual surveys of the benthic communities in the realignment site, fixed-point photography, surveys of recharge elevation and compaction, surveys of the extent of saltmarsh both within and outside the site, inspections of breaches, sea wall and clay bund integrity.

(5) Post Breach Surveys in Years 1, 3 and 5 (2007, 2009 and 2011). Surveys of aquatic and terrestrial invertebrates in mitigation area.

(6) Post Breach Surveys Years 1 and 5 Monitoring (2007 and 2011). Surveys of the benthic communities outside the realignment site, LiDAR/CASI flights, subtidal bathymetry surveys of estuary and breach channels.

(7) Protected Species Year 3 (2009. Survey of receptor site (east side of realignment site behind new sea wall) to check for presence of adder and common lizard populations.

(8) Post Breach Consultation Year 3 (2009. Questionnaire/Consultation to clarify recreational use and amenity value.

4.2 Contingency Arrangements

The monitoring programme and especially the impact verification work has been developed on the basis of what is expected to happen using the results of the impact assessment process. There will be a need for those undertaking the survey and interpretation work to consider where changes to this programme might need to be made if different or unexpected impacts arise. Examples of such theoretical contingencies are as follows: -

(1) Water quality sampling - If there is evidence of significant erosion of the breach channels and sediment export from the realignment site (especially immediately after breaching) additional water quality measurements may be required to asses the spatial extent and duration of the changes arising (see Section 3.12.4).

(2) Extra surveys if there is substantial morphological change outside the realignment site - At present estuary morphology surveys work (including sub-tidal bathymetry surveys and LiDAR/CASI surveys) are to be carried out in the first and fifth years of the five-year monitoring programmes. However, if substantial physical change is identified after the first of these surveys then an additional survey should be conducted (perhaps in the third year). This extra survey will provide additional information to show whether the changes that were observed in the first survey were temporary or are more persistent (i.e. whether there is consistent intertidal retreat or accretion at any point in the estuary).

(3) Extra surveys if there is high level of accretion in the realignment site - Similar to the previous point, if there is significant accretion in the site, there may be a need to carry out extra survey or expand the scope of those that are currently proposed in order to identify the provenance of this sediment and/or establish whether high levels of erosion are occurring in the estuary.

4.3 Review and Reporting

Regular reporting and information dissemination will be required throughout the monitoring programme: -

(1) Annual Report - Reports of findings to be produced annually with the data on site success monitoring to be compared against compensation targets (to be produced separately by the Project Management Group) and impact verification work against predictions made in the ES (ABPmer, 2004a) and Hydrodynamic Modelling reports (ABPmer, 2004b).

(2) Regulator Reviews - Meetings of the Wallasea Project Management Team (WPMT) to be held on an annual basis to review findings and agree the way forward.

(3) Five-Yearly Report - To be produced at the end of 2011 presenting an overview of the five-year monitoring programme and highlighting any requirements for further monitoring based on findings and the views of the WPMT. All the data will be collated digitally and will include weather records (especially extreme wind/storm events that might affect ecological development).

(4) Web-site Set Up and Management - DEFRA is committed to ensuring that there is full dissemination of the information obtained throughout the life of this project. Therefore, to facilitate this, a web-site will need to be set up which will then be populated throughout the monitoring programme with details about the progress being made as well as final copies of the reports that are produced. It should also include links to the EA's site for the Roach and Crouch Flood Management Strategy.

5. References

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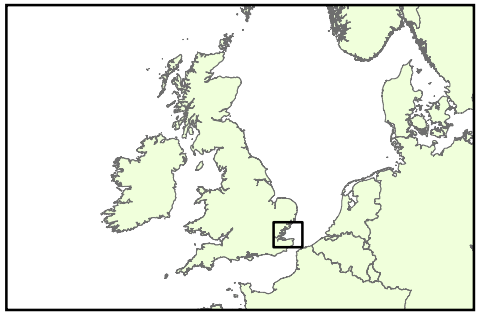
Figures



- Wallasea Island
- Site of port developments at Lappel Bank and Fagbury Flats

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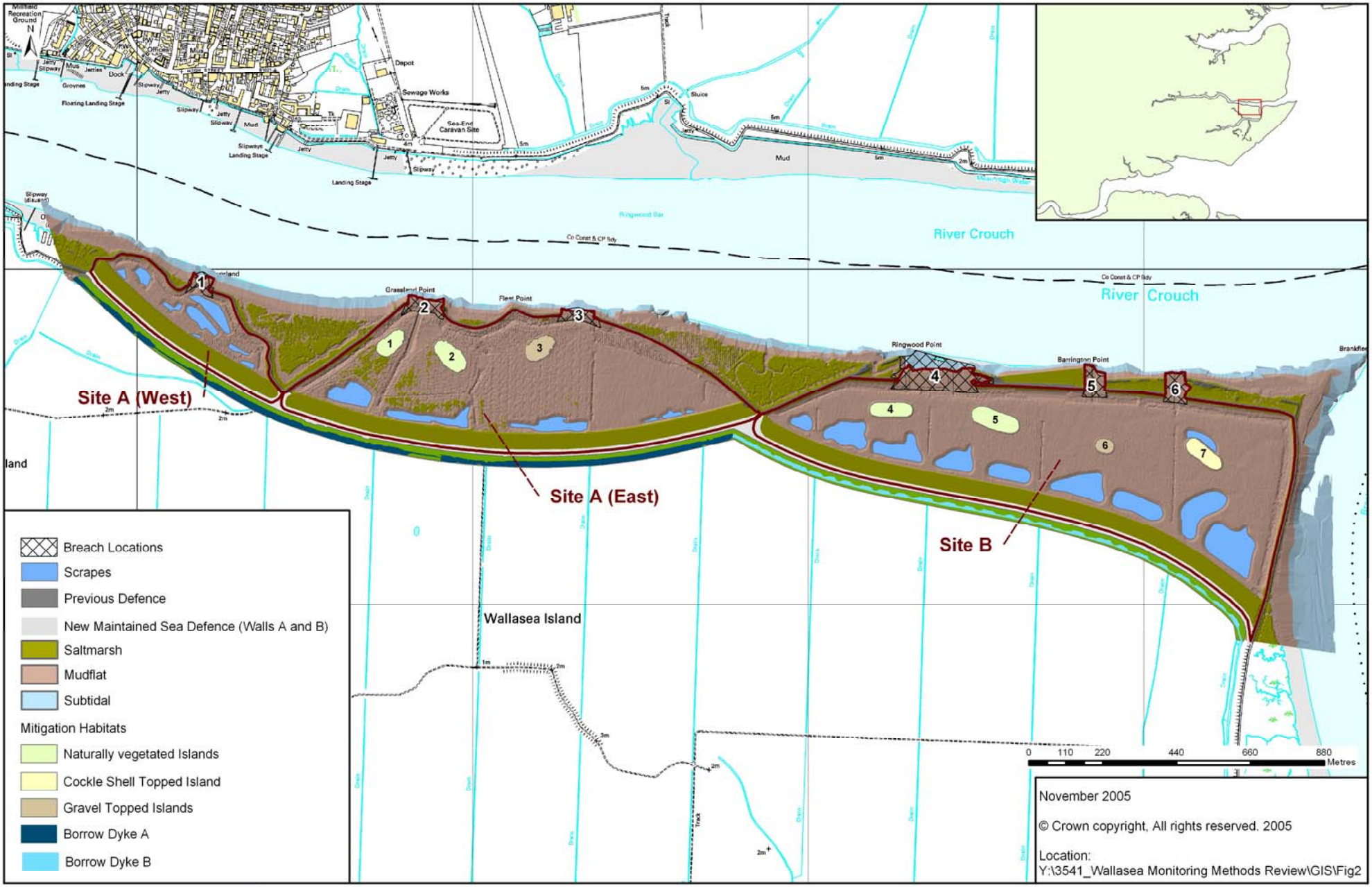
Location map showing the position of Wallasea Island, Lappel Bank and Fagbury Flats

Figure 1



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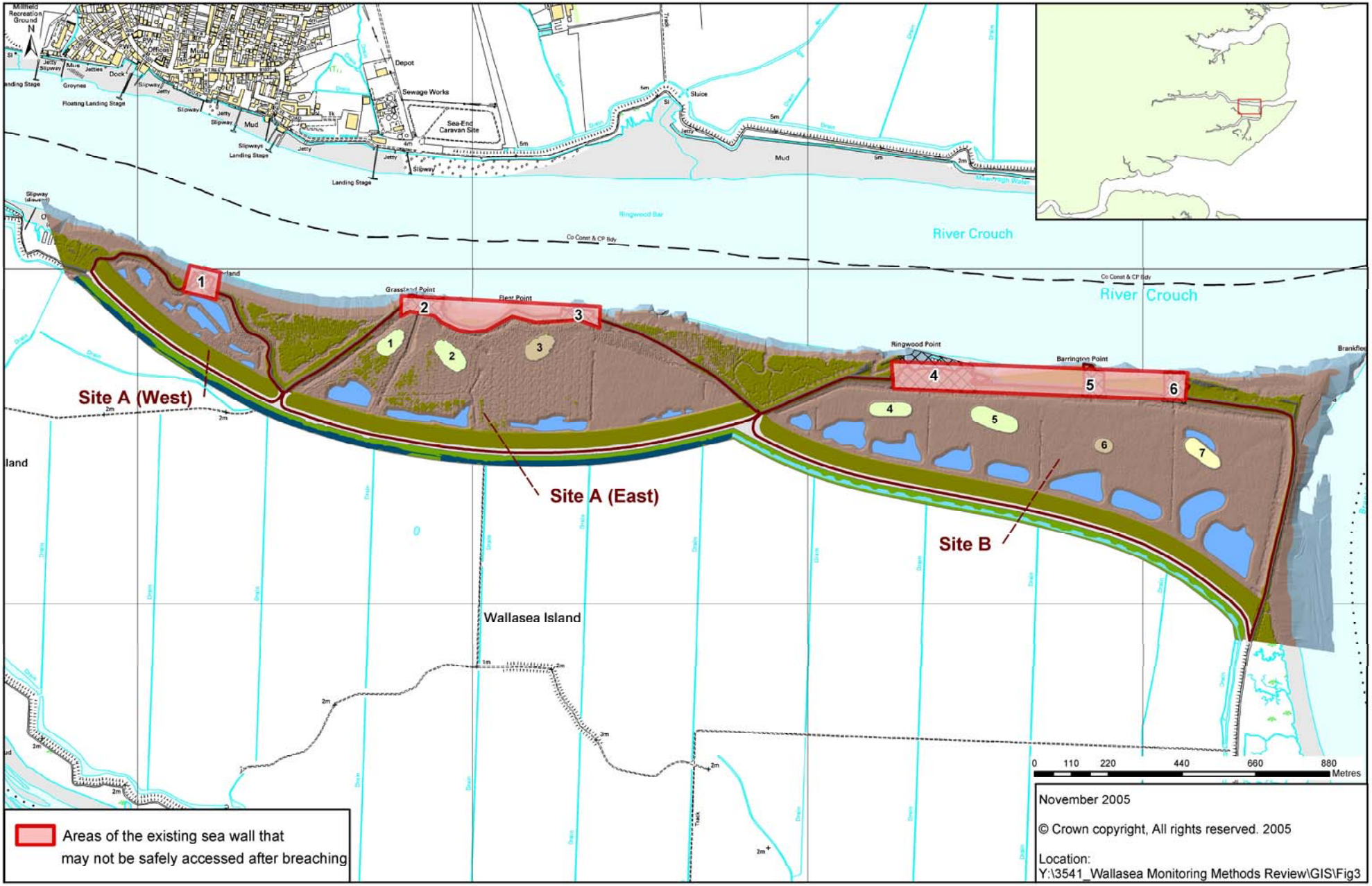
Schematic description of the Wallasea realignment scheme

Figure 2



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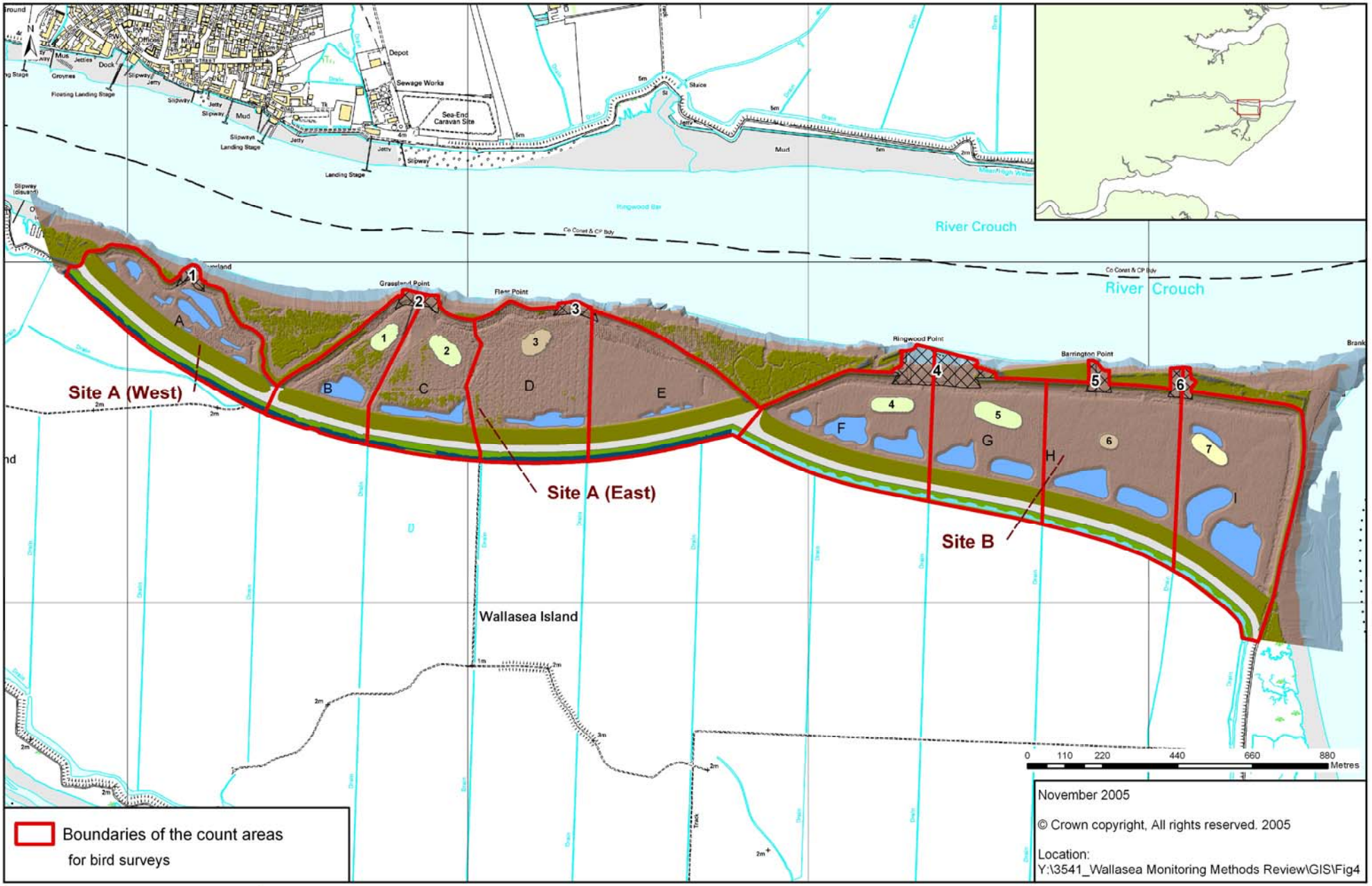
Areas of the site that cannot be safely accessed after realignment

Figure 3



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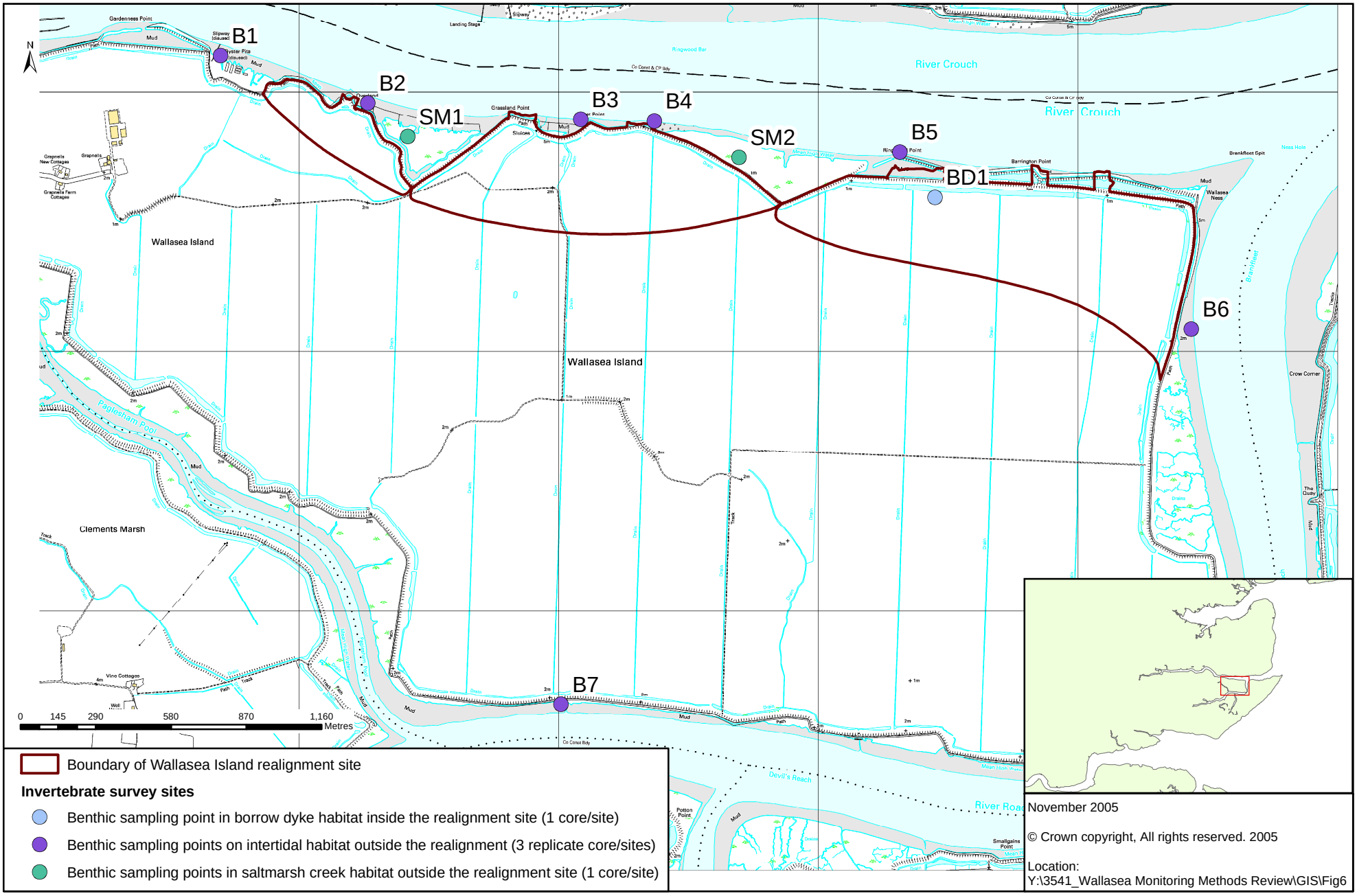
Count areas for the bird surveys

Figure 4



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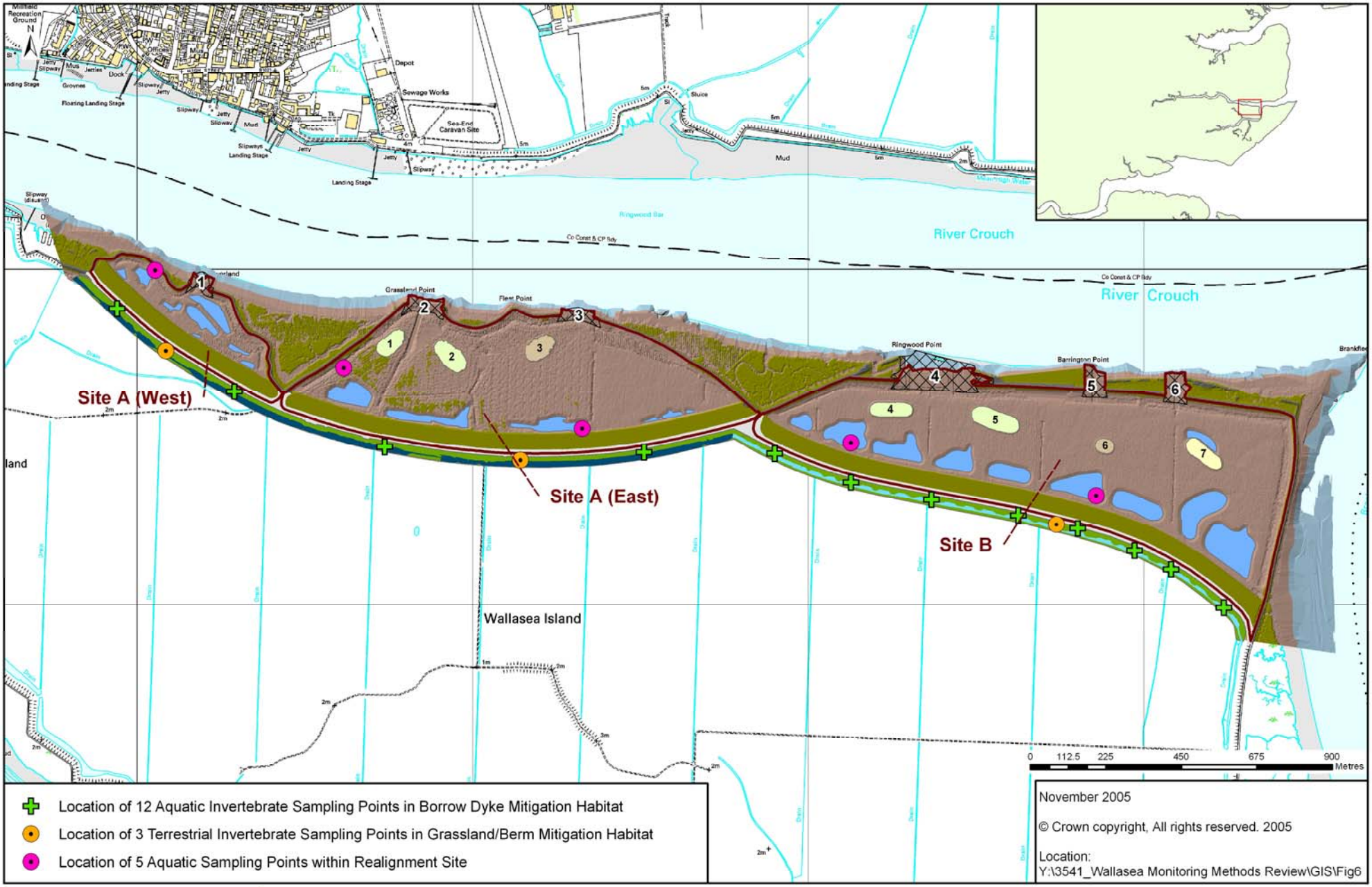
Sampling locations for the baseline benthic invertebrate survey

Figure 5



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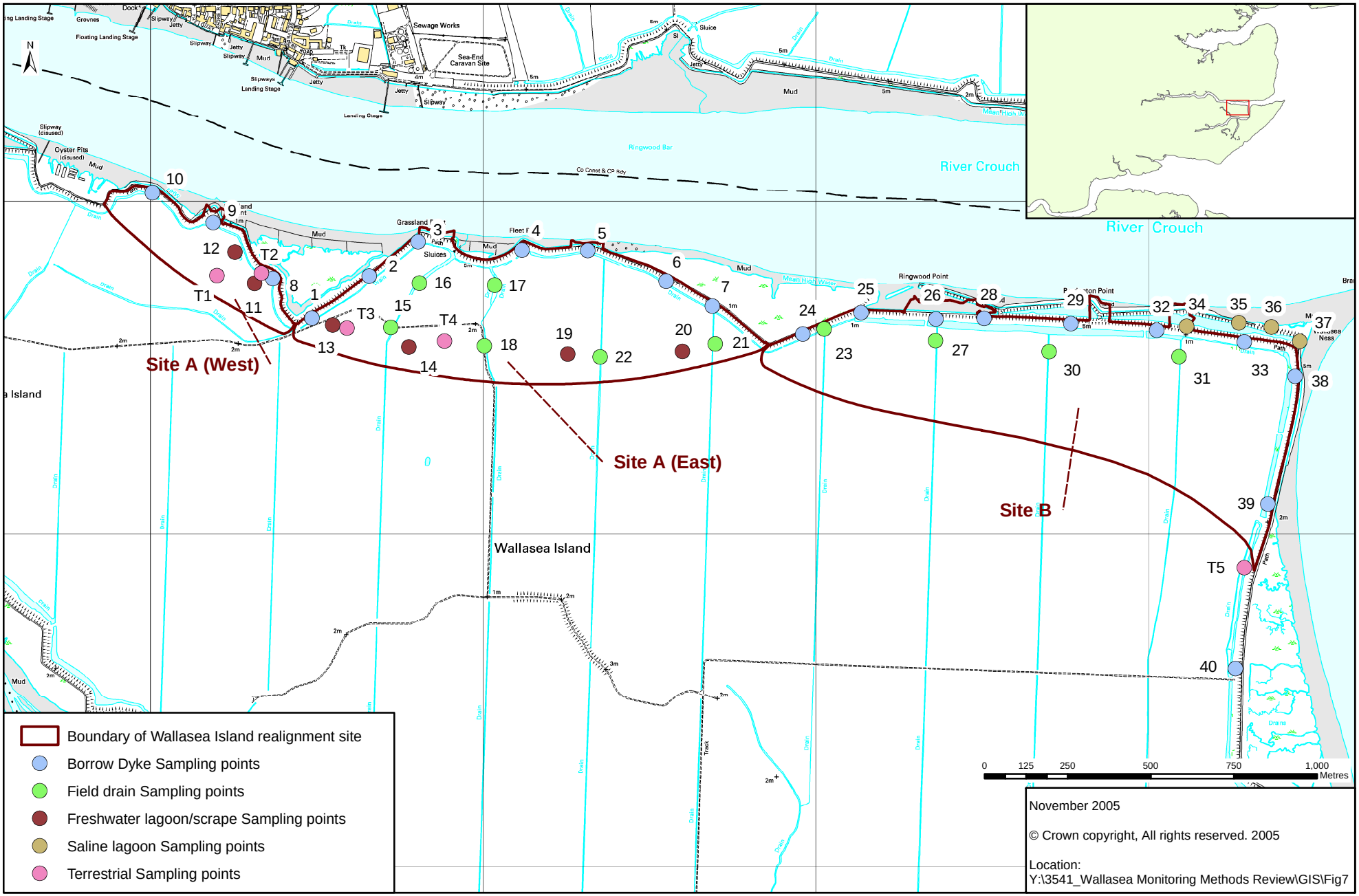
Possible sampling Locations for Aquatic and Terrestrial Invertebrate Surveys

Figure 6



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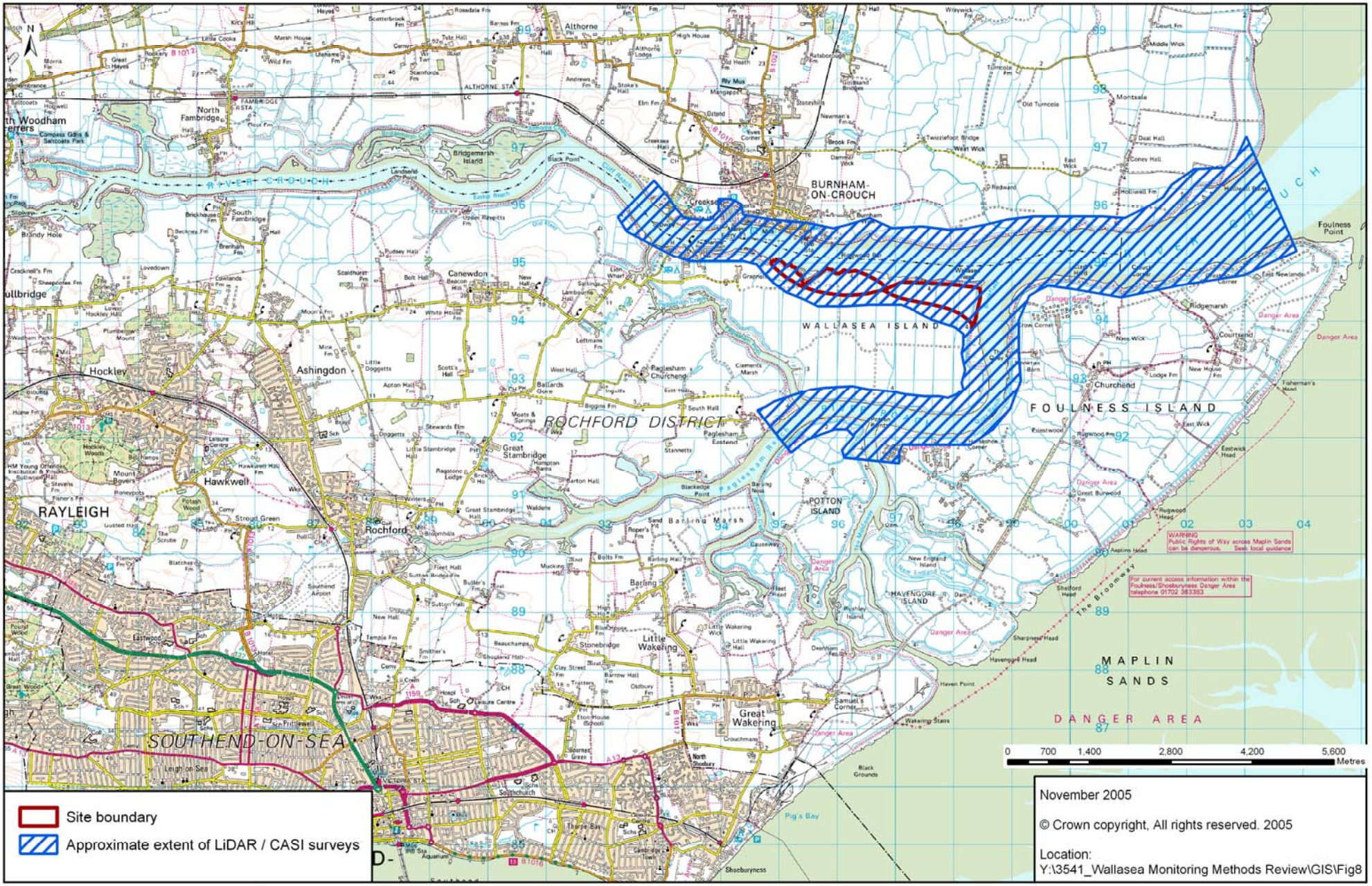
Sampling locations for the baseline aquatic & Terrestrial invertebrate surveys

Figure 7



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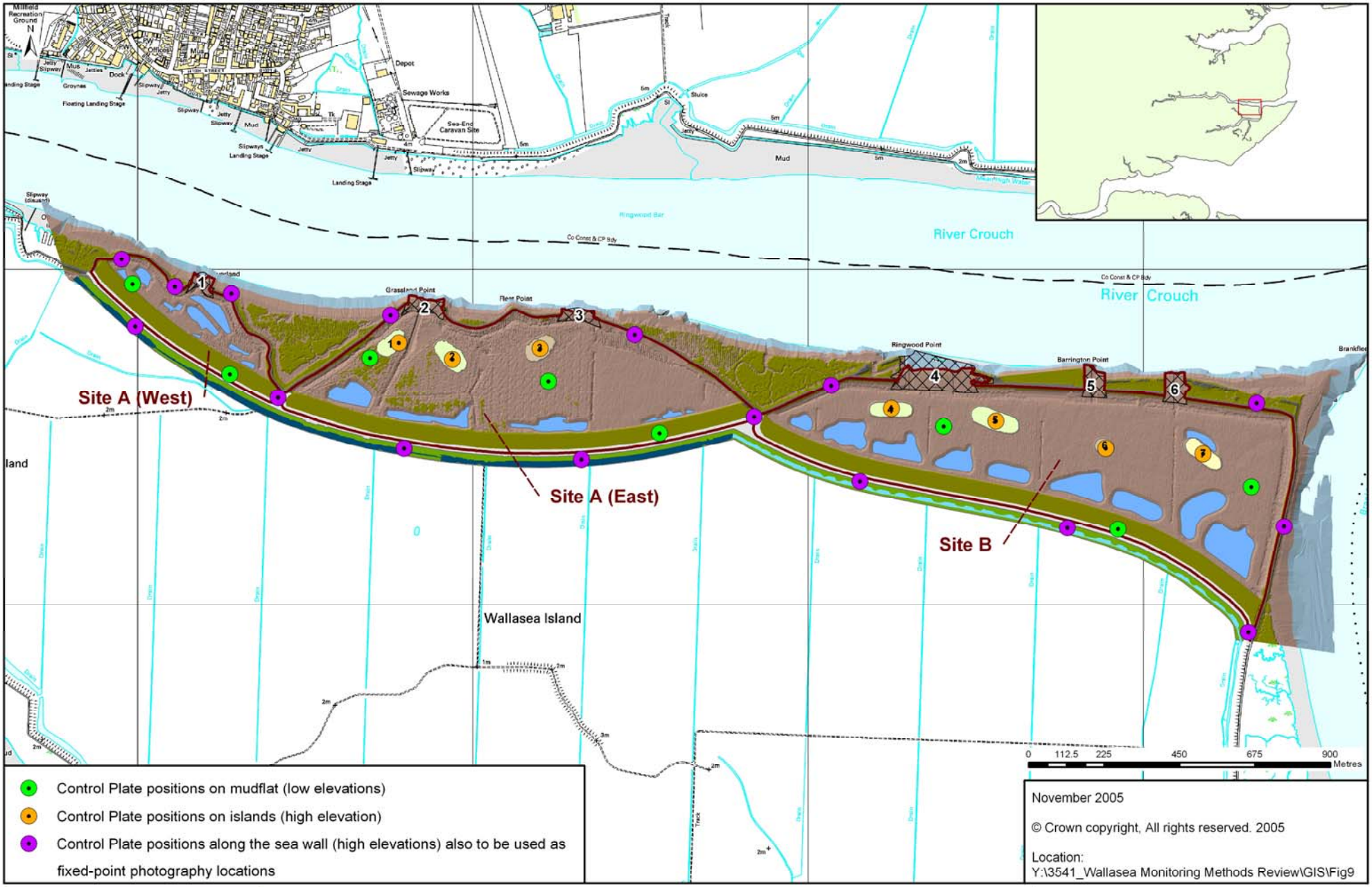
Approximate extent of LiDAR / CASI surveys

Figure 8



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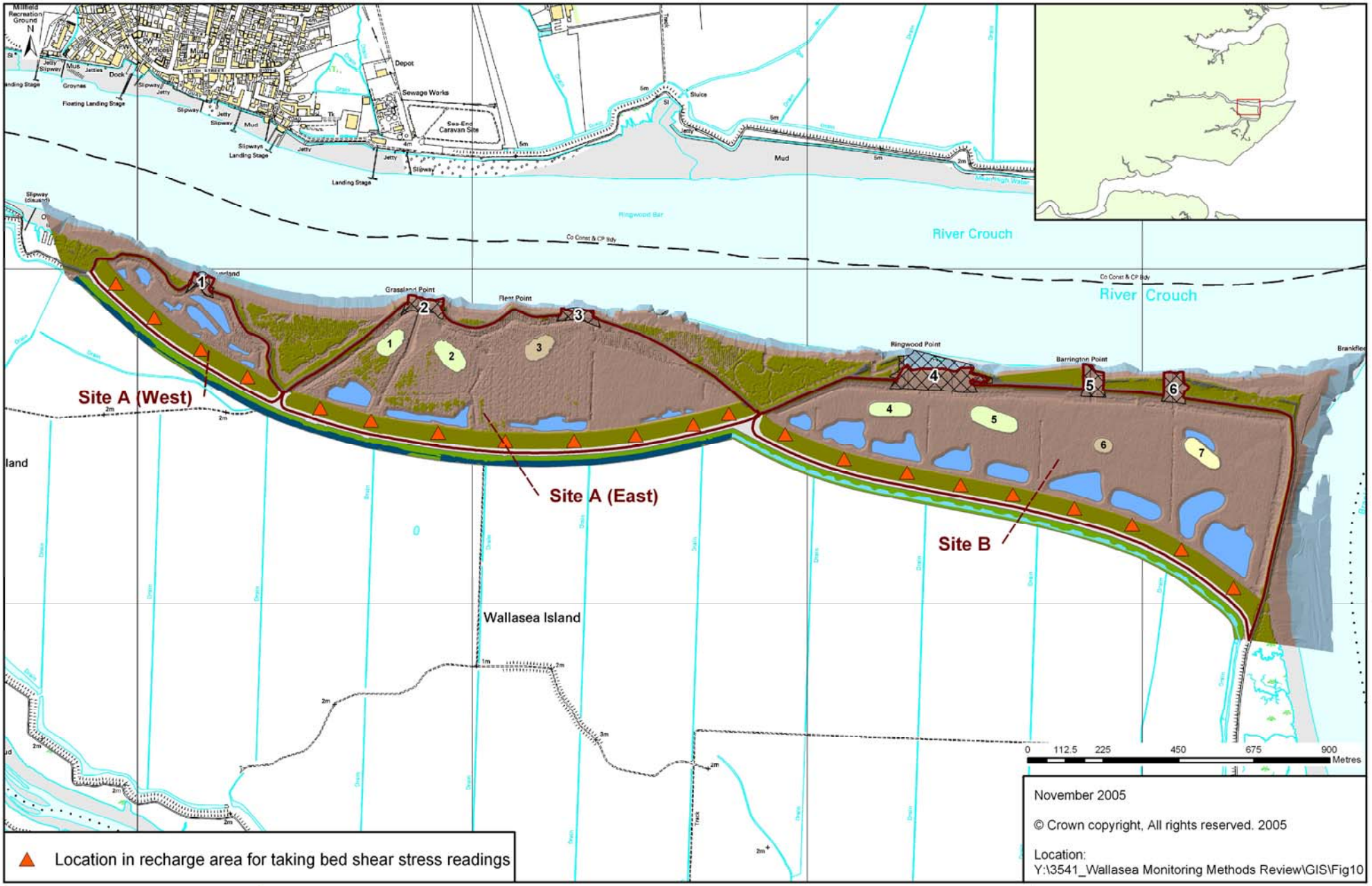
Proposed Locations for the Positioning of Control Plates

Figure 9



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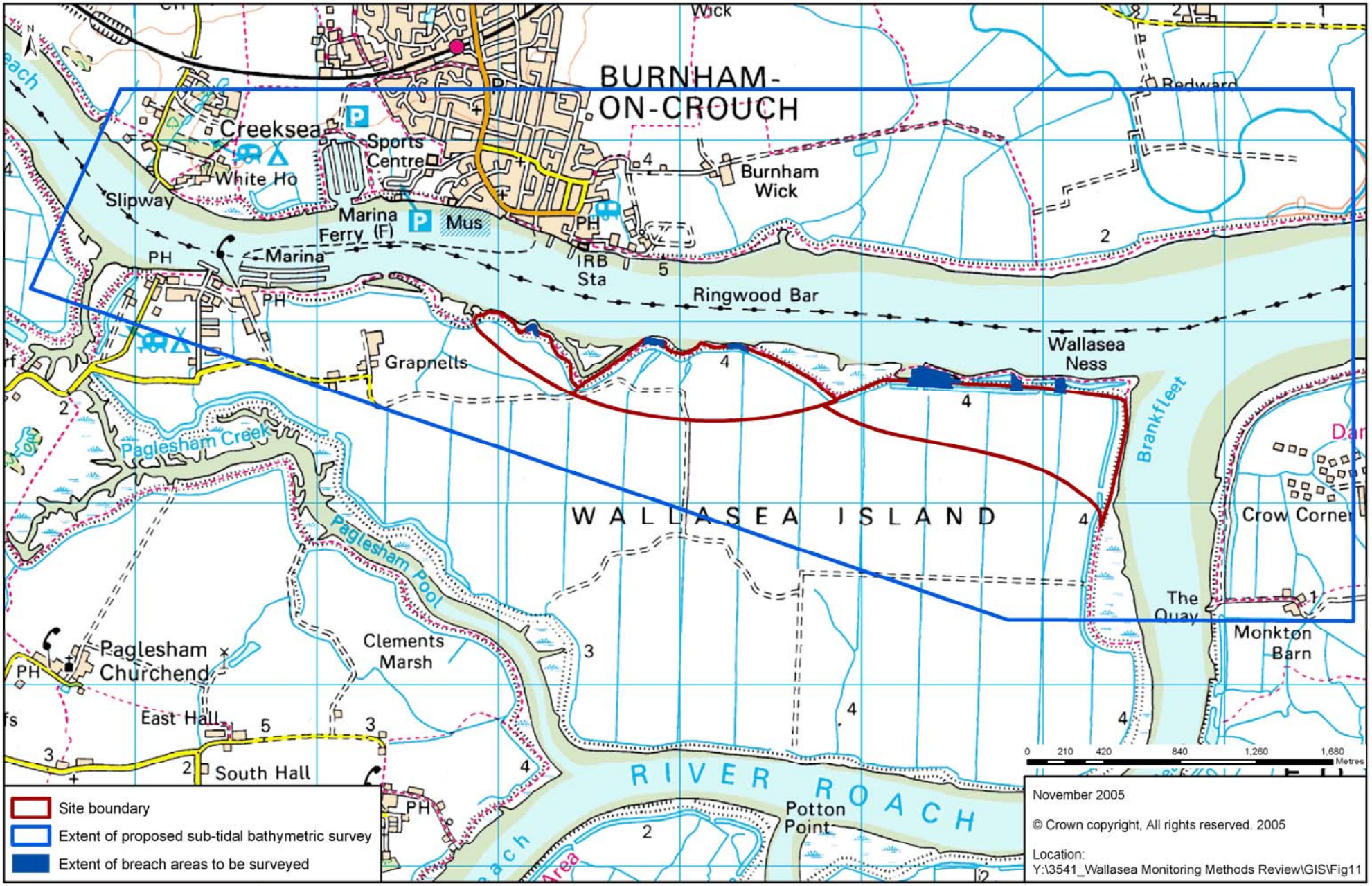
Locations for bed shear stress readings and saltmarsh monitoring in the recharge area

Figure 10



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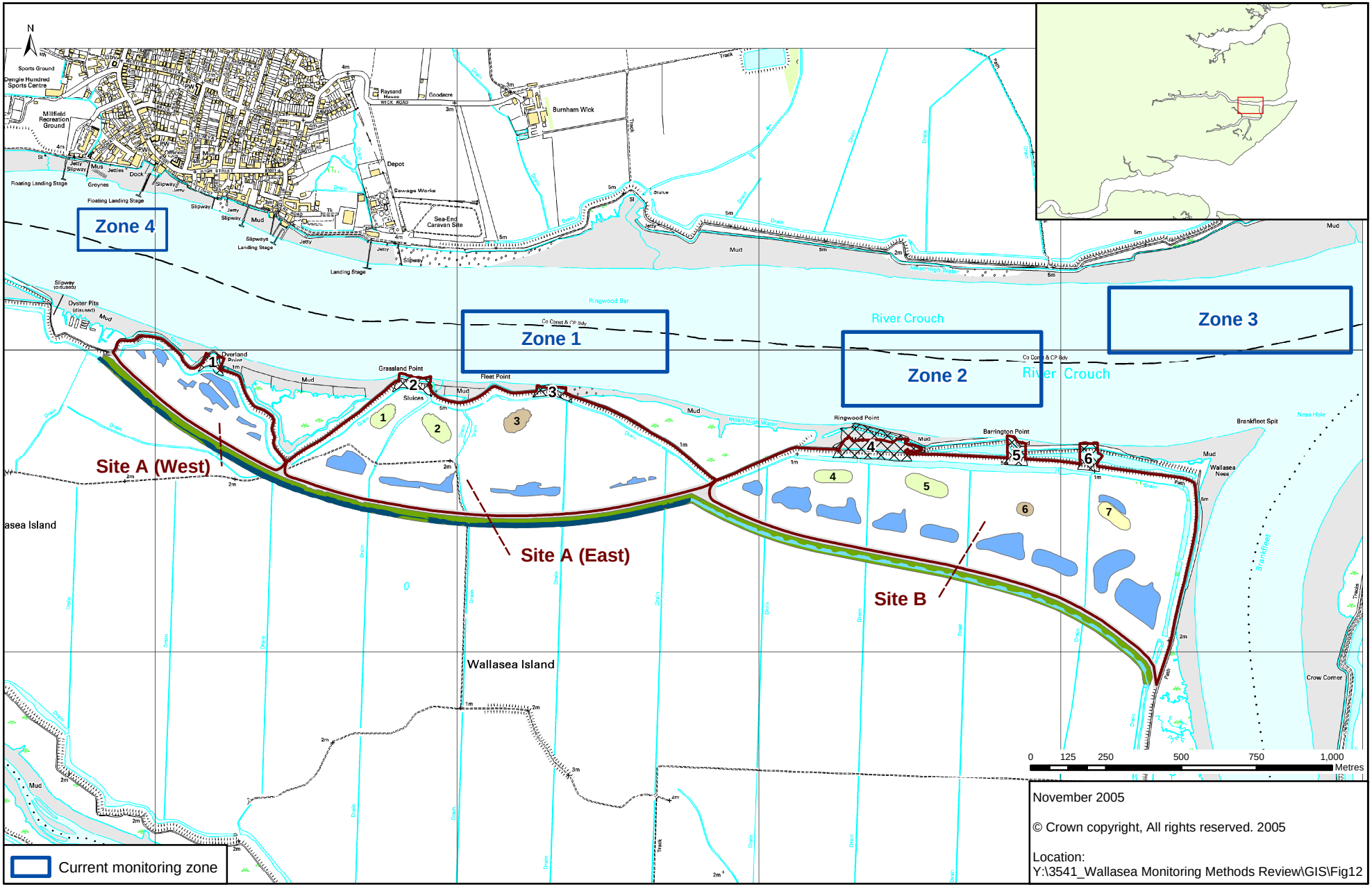
Approximate extent of the subtidal bathymetry surveys

Figure 11



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Zones in which baseline & post-realignment current monitoring is to be undertaken

Figure 12

Baseline (Year 0)	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06
Overwintering birds										a	a	a
Intertidal Morphology - LiDAR					l							
Fixed Point Photography					l							
Current Monitoring					p			p				
Reporting											PT	
Post Realignment (Year 1)	**Jan-07**	**Feb-07**	**Mar-07**	**Apr-07**	**May-07**	**Jun-07**	**Jul-07**	**Aug-07**	**Sep-07**	**Oct-07**	**Nov-07**	**Dec-07**
Overwintering birds	a	a	a							b	b	b
Spring/Breeding birds					c	c						
Benthic Inverts (Site Success)									d			
Benthic Inverts (Impact Verification)									f			
Aquatic and Terrestrial Invertebrates						g						
Intertidal Morphology and vegeation (LiDAR/CASI									j			
Bathymetry surveys									k			
Fixed Point Photography									l			
Saltmarsh Recharge settlement									m			
Saltmarsh (internal)									n			
Saltmarsh (external)									o			
Breach Stability & Integrity (breach width measurements)									q			
Sea wall and Clay Bund integrity									r			
Reporting					AR						PT	
Post Realignment (Year 2)	**Jan-08**	**Feb-08**	**Mar-08**	**Apr-08**	**May-08**	**Jun-08**	**Jul-08**	**Aug-08**	**Sep-08**	**Oct-08**	**Nov-08**	**Dec-08**
Overwintering birds	b	b	b							b	b	b
Spring/Breeding birds					c	c						
Benthic Inverts (Site Success)									d			
Benthic Inverts (Impact Verification)*									f			
Fixed Point Photography									l			
Saltmarsh Recharge settlement									m			
Saltmarsh (internal)									n			
Saltmarsh (external)									o			
Breach Stability & Integrity (breach width measurements)									q			
Sea wall and Clay Bund integrity									r			
Reporting					AR						PT	
Post Realignment (Year 3)	**Jan-09**	**Feb-09**	**Mar-09**	**Apr-09**	**May-09**	**Jun-09**	**Jul-09**	**Aug-09**	**Sep-09**	**Oct-09**	**Nov-09**	**Dec-09**
Overwintering birds	b	b	b							b	b	b
Spring/Breeding birds					c	c						
Benthic Inverts (Site Success)									e			
Benthic Inverts (Impact Verification)*									f			
Aquatic and Terrestrial Invertebrates						g						
Protected Species (reptiles)				h	h							
Intertidal Morphology and vegetation (LiDAR/CASI)*									j			
Bathymetry surveys*									k			
Fixed Point Photography									l			
Saltmarsh Recharge settlement									m			
Saltmarsh (internal)									n			
Saltmarsh (external)									o			
Breach Stability & Integrity (breach width measurements)									q			
Sea wall and Clay Bund integrity									r			
Recreational/Amenity Value Consultation					s							
Reporting					AR						PT	
Post Realignment (Year 4)	**Jan-10**	**Feb-10**	**Mar-10**	**Apr-10**	**May-10**	**Jun-10**	**Jul-10**	**Aug-10**	**Sep-10**	**Oct-10**	**Nov-10**	**Dec-10**
Overwintering birds	b	b	b							b	b	b
Spring/Breeding birds					c	c						
Benthic Inverts (Site Success)									d			
Fixed Point Photography									l			
Saltmarsh Recharge settlement									m			
Saltmarsh (internal)									n			
Saltmarsh (external)									o			
Breach Stability & Integrity (breach width measurements)									q			
Sea wall and Clay Bund integrity									r			
Reporting					AR						PT	
Post Realignment (Year 5)	**Jan-11**	**Feb-11**	**Mar-11**	**Apr-11**	**May-11**	**Jun-11**	**Jul-11**	**Aug-11**	**Sep-11**	**Oct-11**	**Nov-11**	**Dec-11**
Overwintering birds	b	b	b									
Spring/Breeding birds					c	c						
Benthic Inverts (Site Success)									e			
Benthic Inverts (Impact Verification)									f			
Aquatic and Terrestrial Invertebrates						g						
Protected Spp*				h	h							
Intertidal Morphology and vegeation (LiDAR/CASI									j			
Bathymetry surveys									k			
Fixed Point Photography									l			
Saltmarsh Recharge settlement									m			
Saltmarsh (internal)									n			
Saltmarsh (external)									o			
Breach Stability & Integrity (breach width measurements)									q			
Sea wall and Clay Bund integrity									r			
Reporting					AR					PT		5R

Key

Survey Type	Code	Survey Objective
Overwintering bird surveys once per month	a	Site success evaluation
Overwintering bird surveys twice per month	b	Site success evaluation
Spring/Breeding bird survey once per month	c	Impact Verification
Benthic invertebrate site success surveys (qualitative)	d	Site success evaluation
Benthic invertebrate site success surveys (quantitative)	e	Site success evaluation
Benthic invertebrate impact verification surveys (quantitative)	f	Impact Verification
Aquatic and Terrestrial Invertebrate surveys	g	Impact Verification
Protected Species (reptiles)	h	Impact Verification
Intertidal Morphology (LiDAR)	l	Site Success evaluation and Impact Verification
Intertidal Morphology and vegetation cover (LiDAR/CASI)	j	Site Success evaluation and Impact Verification
Subtidal morphology (boast based bathymetry surveys)	k	Site Success evaluation and Impact Verification
Intertidal Morphology - Fixed Point Photography	l	Site Success evaluation and Impact Verification
Saltmarsh Recharge settlement rate studies	m	Site success evaluation
Saltmarsh vegetation internal (transect surveys)	n	Site success evaluation
Saltmarsh vegetation external (transect surveys)	o	Impact Verification
Current Monitoring at breaches and in estuary	p	Impact Verification
Breach Stability & Integrity (breach width measurements)	q	Impact Verification
Sea wall and Clay Bund integrity inspections	r	Impact Verification
Recreational/Amenity Value Consultation	s	Site success evaluation
Contingency surveys*		Undertaken if preceding surveys indicate change requiring further investigation.

Main Programme Milestones

Approximate Start of monitoring programmes	DATE
Breaching/Realignment	DATE

Reporting and Interpretation

Annual Reporting	AR
Five Year Reporting	5R
Meetings of the Wallasea Project Management Team	PT

Some surveys by other parties that will be useful

Environment Agency Shoreline Management Group - Aerial photo surveys undertaken in Summer 2004 and scheduled next one scheduled for Summer 2007
Environment Agency Shoreline Management Group - Topographic surveys scheduled for Summer 2007;
WeBS/BTO - High tide (core count) ornithological surveys of the Crouch and Roach undertakem annually
WeBS/BTO - Low-water ornithological surveys of the Crouch and Roach competed in 2004/2005.
Environment Agency/ComCoast - Fisheries PhD study (Wallasea included as case example)

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Gantt chart showing proposed monitoring timetable

Figure 13

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