# *Executive Summary (copy)*

Southern North Sea Sediment Transport Study Phase 2

Sediment Transport Report

Report produced for Great Yarmouth Borough Council by HR Wallingford, CEFAS/UEA, Posford Haskoning and Dr Brian D'Olier

Report EX 4526
August 2002

## 1. Study Context

Sediment movements in the southern North Sea influence the eastern English coastline through supplying or removing beach material. It is important to understand these movements thoroughly so as to improve the data on which Shoreline Management Plans (SMPs) and the assessment of dredging licence applications are based. A fuller understanding of sediment movements will facilitate a greater awareness of issues affecting management of beaches and coastal defences, the coastline and sediment resources offshore.

The Southern North Sea Sediment Transport Study Phase 2 was designed to provide the broad appreciation and detailed understanding of sediment transport along the eastern coastline of England between Flamborough Head in Yorkshire and North Foreland in Kent, on the south side of the Thames Estuary (Figure 1). The study was undertaken between 2000 and 2002 by a consortium comprising of HR Wallingford, CEFAS Lowestoft Laboratory and UEA Norwich, Posford Haskoning and independent consultant Dr Brian D'Olier.

The study was commissioned by a group of nine local authorities, together with the Environment Agency and English Nature and the dredging industry. It built on the earlier Phase 1 study completed in 1996 (ABP Research & Consultancy, 1996a, 1996b and 2000). The present study was part funded by the Department for Environment, Food & Rural Affairs (DEFRA). The client project manager was Julian Walker of Waveney District Council on behalf of Great Yarmouth Borough Council, the client group leader. The consultant team was led by Richard Whitehouse of HR Wallingford.

The study is described below and where appropriate links to the report Appendices and Sections are indicated to enable the reader to follow up specific information.

## 2. Summary of outputs

The outcomes of the study have been presented in the Sediment Transport Report (HR Wallingford, 2002) which is supported by 15 Appendices containing detailed information on various facets of the study. A database, field data and various map data is available for use within a Geographical Information System.

It is expected that the report will be of use to engineers and scientists with roles in managing, regulating or working within the coastal and seabed areas encompassed by the study area (Figure 1). At a generic level it will be relevant to those undertaking research into coastal and seabed processes.

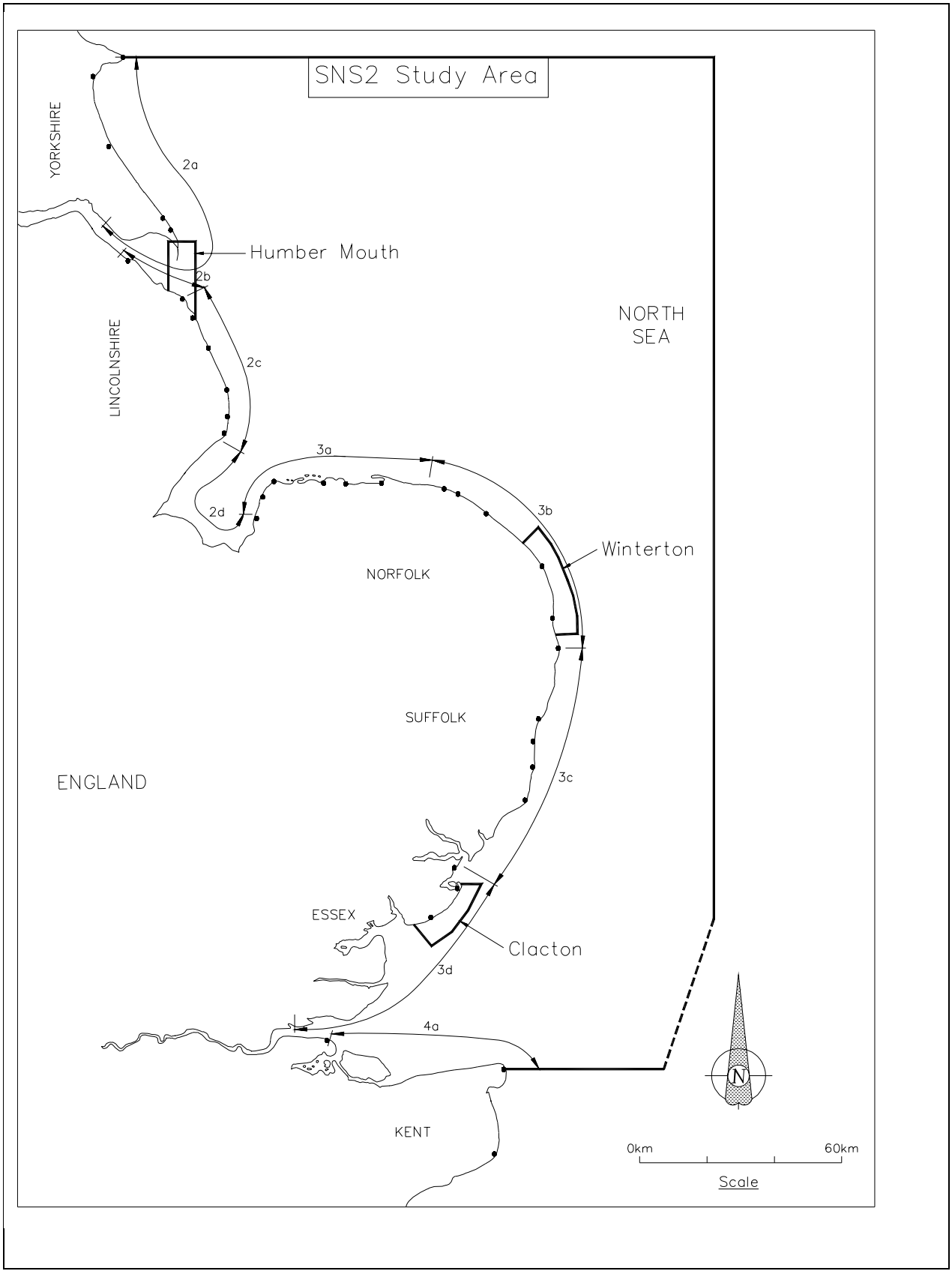


**Figure 1Location map showing the study area, the extent of the coastal subcells used for coastal management (numbered 2a to 4a), and the location of the sites for new data collection (Humber mouth, Winterton, Clacton)**

## 3. Objective

The study addressed the broad objective detailed in Box 1.

**Box 1**

To obtain an improved understanding of the Southern North Sea sediment transport system, and its links with the eastern England coastline between Flamborough Head and the River Thames.

To include:

- Identification of sediment sources, transport pathways, volumes of sediment transport and areas of deposition, across the complete range of particle sizes and temporal scales
- Identification of the location, size, variability and evidence of offshore features, and their influence on and interaction with waves and tidal current climates
- Provision of the information that is required for the updating of SMPs, and which enables a more informed assessment to be made of the influence of offshore dredging on the eastern coast of England

## 4. Methodology

To deliver the objectives and address the issues the study team planned and executed a series of interdisciplinary activities: identification of key strategic issues; data/knowledge review, collation and capture; computational modelling of sediment transport in coastal and seabed areas; new field data collection of hydrodynamics and sediment transport; mapping of information including seabed sediment transport indicators, and expert analysis and interpretation. A flow chart of these activities is presented in Figure 2. The activities under each of the headings will be described briefly.

### *4.1 Identification of key strategic issues with respect to sediment transport*

An important part of the study was to determine the strategic issues with respect to sediment transport along the study coastline. A key step in identifying these issues was a focussed consultation process with maritime local authorities from the whole of the study region, the Environment Agency and English Nature, as well as representatives of the dredging industry (Appendix 4). In parallel the eight existing Shoreline Management Plans for the study coastline were reviewed for sediment transport related issues (Appendix 3). The combined outcome of this process was the identification and reporting of key strategic issues, strategy level issues and local issues in an Inception Report (HR Wallingford, 2001). The study then focussed on tackling the strategic issues where it was felt the most significant gains could be made and an improved coherence in the sediment transport understanding could be delivered.

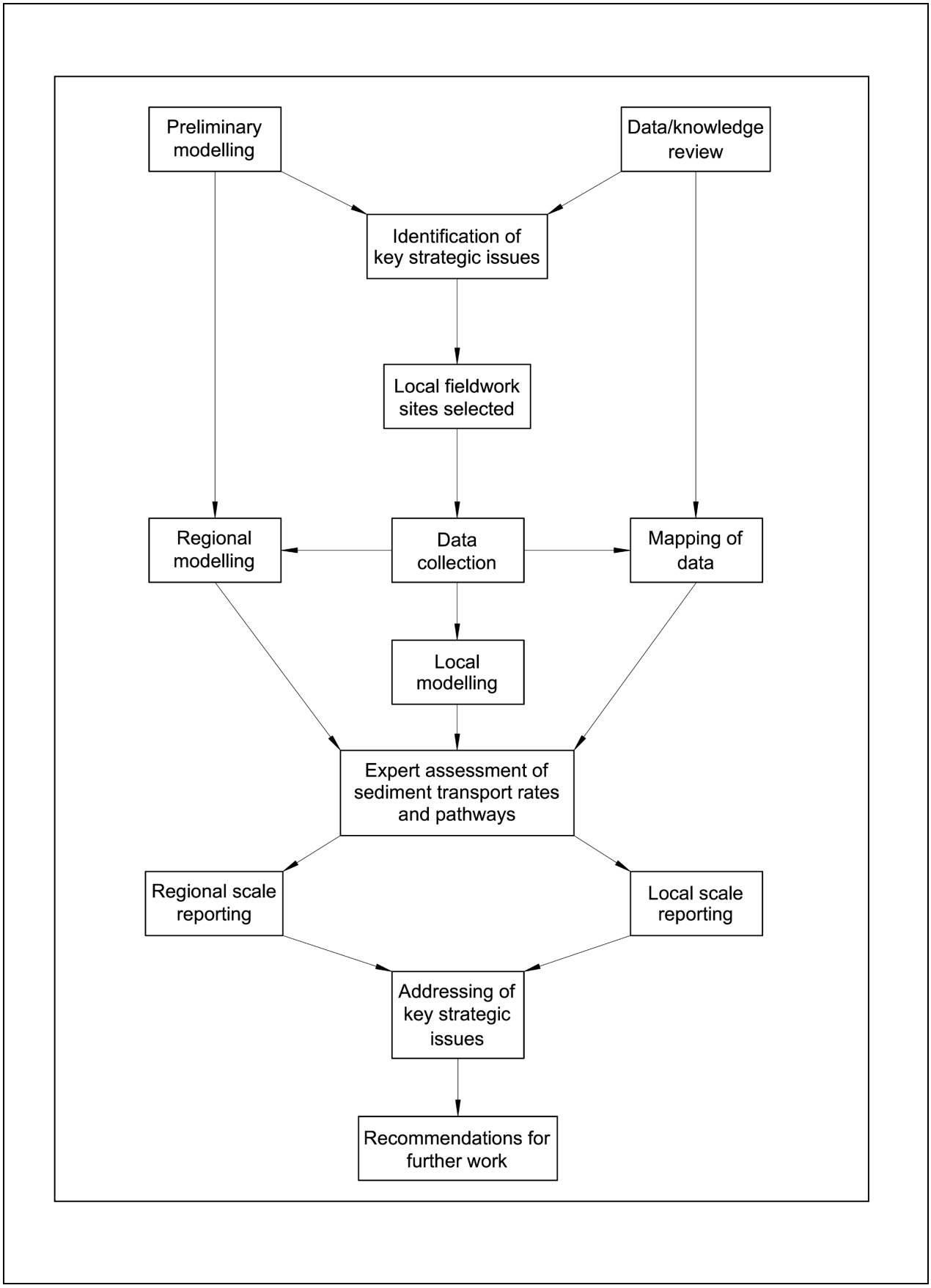


**Figure 2Project methodology**

The strategic issues were encompassed in the following headings:

- Issue A – Northern Boundary
- Issue B – Role of Holderness
- Issue C – The role of the Wash
- Issue D – Nearshore banks
- Issue E – North Norfolk drift divide
- Issue F – Sediment circulation Cromer to Benacre Ness
- Issue G – The role of the Sizewell-Dunwich Banks
- Issue H – Suffolk Coastline
- Issue I – Clacton
- Issue J – North Kent coast and nearshore
- Issue K – Thames Estuary

*4.2 Data/knowledge review, collation and capture*

The knowledge capture and collation (summarised in Appendix 8) involved building on the earlier Phase 1 studies completed in 1996 by identifying and consulting the results of relevant studies and published material in the fields of maritime civil engineering and hydraulics, oceanography, physical geography/geomorphology, and geology. New information was listed in a web browser based sediment transport database which has been distributed to the client group and funders (Appendix 5); this was consistent with and included all the information from the Phase 1 database. New knowledge brought to the study was input and correlated through expert assessment at study workshops designed to address the key strategic issues. The new knowledge included a summary of sediment processes (Appendix 2), results from sediment transport modelling studies carried out as part of coastal strategy or scheme studies, field measurement and modelling of flows and sediment transport in the study area, mapping of seabed features (primarily the larger sedimentary features called sandwaves and megaripples), and a synthesis of the geological context including sediment sources, pathways and sinks (Appendix 10, 14). The latter was supported for the Holderness coast, Humber and north Lincolnshire by an appraisal of previously collected mineralogical data (Appendix 9). The development of aggregate dredging and disposal activities at a practical and policy level was also reviewed (Appendix 1).

An extensive amount of modelling of longshore sediment transport (littoral drift) has been completed since the 1970s. This has been undertaken by different organisations at various times with different objectives. The volume of available information has been brought together for the first time to form a catalogue of predicted longshore sediment transport rates (Appendix 11). Where possible the rates and direction of sediment transport have been specified, at other locations it has only been possible to determine the net direction (e.g. from observed coastal features).

*4.3 Computational modelling of sediment transport*

A key aspect of the study was the computational modelling of sediment transport by waves, tides and an extreme water level event (North Sea surge) (Appendix 12). This provided consistent information over the entire study area using a calibrated depth-averaged tidal flow model (TELEMAC) and a calibrated and validated total load (bedload and suspended load, SANDFLOW) sediment transport module. The model validation showed that a high degree of confidence could be placed in the results. The results were plotted both at the scale of the whole study area and for 11 local areas:

- Flamborough Head to the Humber
- Humber Entrance and Lincolnshire
- Lincolnshire and the Wash
- North Norfolk

- East Norfolk
- North Suffolk
- Suffolk and Essex
- South Essex
- Outer Thames
- North Kent
- East Kent

The computational modelling could not represent and explain all the complexities of the actual sediment transport processes in the Southern North Sea. This was because within the limitations of the study it was not possible to consider all possible tidal ranges, all possible surges/wind/wave conditions and the fine detail of seabed sediments over such a large area. Rather the approach was to carry out a modest number of hypothetical situations that could provide potential answers to specific results for fine sand (0.1 mm size), medium sand (0.4 mm size) and fine gravel (2 mm size) under neap and spring tides, spring tides with increasing levels of wave activity (1 to 5 m significant wave height), and an extreme North Sea surge event (20 year return period). The reader has been provided with guidance as to the relevance of each of the scenarios that have been run (Appendix 13). The role of surge events in modifying flow and sediment transport patterns was identified (Appendix 7), and the dominating effect of an extreme surge on the coastal currents and sediment transport was confirmed by the model results.

Refined tidal modelling of sediment transport was undertaken at Clacton and detailed modelling of wave and current sediment transport was completed at Winterton Ness. This was undertaken in parallel with the field data collection activity at these sites (see 4.4 below).

The large number of modelling results were collated into a report (Appendix 12) describing predicted sediment transport rates which forms an "atlas of synthetic data" showing the way in which sediment transport rates and patterns are altered by different levels of tidal and wave forcing. These results have been used as one of the inputs to the expert analysis by which the strategic issues have been answered. They also form a source of information that can be turned to when future specific questions are asked (e.g. what will happen to fine sand dumped from dredging operations at a specific location in a particular area of seabed?).

In addition, the local longshore sediment transport by waves and tidal currents was modelled to fill a data gap on the Holderness coastline and the results were input into the longshore sediment transport catalogue (Annex to Appendix 11).

*4.4 New field data collection*

To support the strategic objectives new field data was collected at three key locations in the study area (Figure 1 of this summary and Appendix 6). The sites were chosen in conjunction with the client group to fill data gaps (HR Wallingford, 2001):

- Between Happisburgh and Winterton Ness on the Norfolk coast (April 2001): Calibrated measurements of waves, currents, water depths and sediment concentrations (fines and sands) were made over a 14 day period with a number of seabed mounted instrument packages. In addition nearshore transects were completed to map out the vertical structure and tidal time variation of the coastal tidal current. Off Winterton Ness and south through the bank complex off Great Yarmouth the seabed features were mapped to determine sediment transport pathways. A sand sediment tracer study was completed at Winterton Ness itself and surface water samples were taken over a large area to characterise the background sediment concentration of fine material.

- Clacton in Essex and the adjacent Gunfleet Bank (September 2001): Calibrated measurements of waves, currents, water depths and sediment concentrations (fines and sands) were completed over a 14 day period with a number of seabed mounted instrument packages. A transect was run between the shore and the Gunfleet Bank to map out the vertical structure and tidal time variation of the coastal tidal current. The seabed features were mapped to determine sediment transport

pathways. Surface water samples were taken over the nearshore area to characterise the background sediment concentration of fine material.

- The mouth of the Humber Estuary (December 2001): The seabed features were mapped to determine sediment transport pathways. Surface water samples were taken over the nearshore area to characterise the background sediment concentration of fine material and water salinity.

The process measurement results have been used to validate the computational model with which the sediment transport predictions have been made. The seabed features have been interpreted and mapped as part of the analysis of seabed sediment transport. The data collected within the study is available for use in support of subsequent studies in conjunction with the field data report (Appendix 6).

### *4.5 Mapping of seabed sediment transport indicators*

Sediment transport features such as sandwaves and megaripples have been observed on seabed surveys made using acoustic sidescan sonar equipment since the 1960s. Once the observations are interpreted they provide good indications as to the presence (or not) and dimensions of seabed features at the time of the survey (or the last sediment transporting event). Sandwaves and megaripples are the primary features indicating sediment transport activity as they travel predominantly in the direction of the prevailing tidal flows, i.e their crests lie perpendicular to the tidal flow axis. The asymmetry in cross-section of these features can be used to provide a clear indication as to the net direction of sediment transport at the time the image was captured. Both published information from the literature and unpublished information provided through contacts with the dredging industry have been combined with the new interpreted data collected in this study to produce a comprehensive and detailed map of sediment transport indicators for the entire study area. The concentration of information is mainly within 20 km of the coastline, except off North East Norfolk in the sandbank complex and offshore of the Outer Thames Estuary. The data has been mapped with two levels of indication (Appendix 15): firstly, a net transport direction was determined for those locations where the asymmetry of seabed features could be determined with certainty; and secondly, no-net direction where the axis of transport could be determined with certainty, but the net direction could not. The latter case arises where bedforms have no clear asymmetry in cross-section but can also be obtained from the orientation of other flow parallel seabed features including sand ribbons and sand streaks, comet marks and wreck marks. The sand ribbons are low amplitude features which are oriented parallel to the predominant tidal currents, they can be seen extending over otherwise essentially immobile seabeds of gravel and clays. Sand streaks are seen at the outer extents of sand patches and indicate transport into or out of the sand patch. Comet marks and wreck marks are the pattern of erosion and deposition seen around seafloor obstacles and wrecks, once again these are oriented parallel to the main flow direction.

## 5. Expert assessment of sediment transport rates and pathways - addressing key strategic issues

The sediment transport knowledge, modelling, field data and interpreted seabed sediment transport indicators have all been brought together in an expert analysis of sediment transport pathways in the study area. The expert analysis has generated improved understanding and certainty to be able to address the key strategic issues A to I listed above (Section 5 and 6 of main report), and the sediment transport context of the licensed aggregate dredging areas. To convey the information to the reader the understanding has been portrayed schematically on a series of maps covering the whole of the study coastline (contained in Section 6 of the main report), e.g. as shown for the Wash on Figure 3. These maps show the “every-day” transport situation and for comparison the interpreted sediment transport situation for the extreme water level (storm surge) condition that was modelled. The causes of variability in sediment transport and timescales for sediment transport have also been discussed (Section 7 of main report).

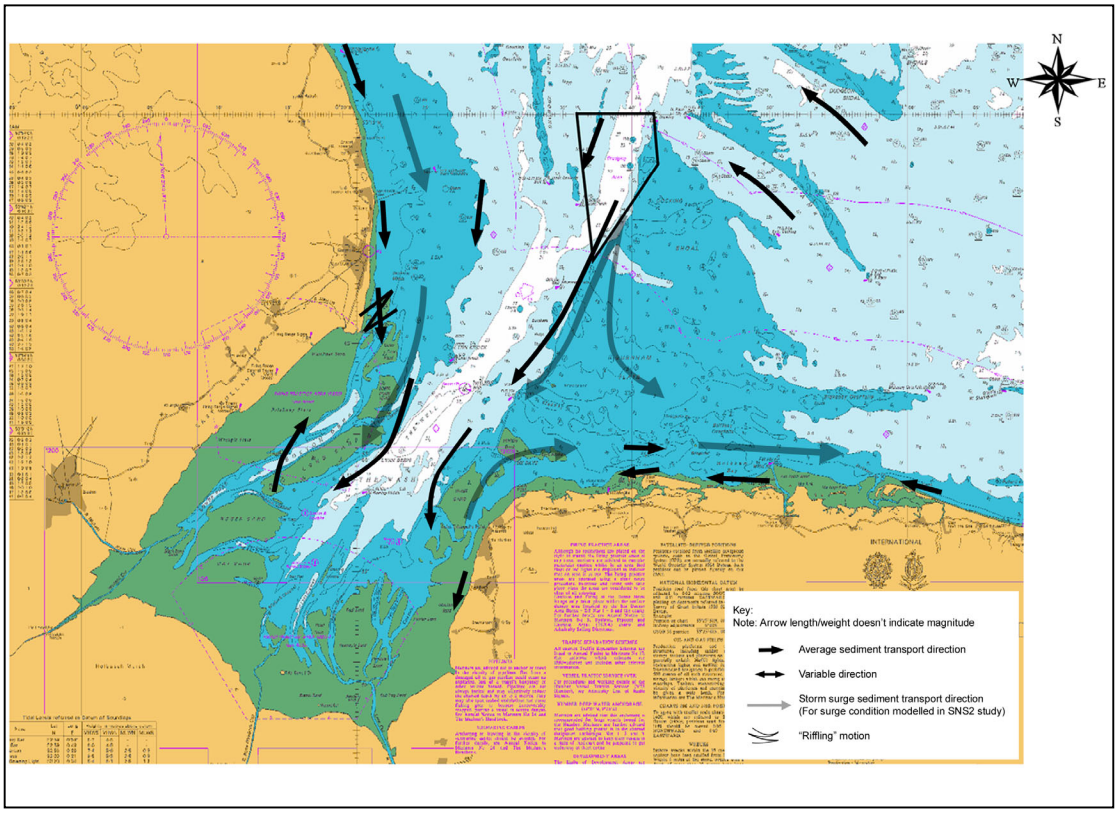


**Figure 3Schematic sediment transport pathways for average conditions and interpreted for the extreme water level (surge), wind and wave event modelled in this study (overlain on Admiralty Chart 1408)**

## 6. Report Usage and Study Outcome

Section 8 of the report contains a description of how the report can be used to assess sediment transport in the study area. It also describes how the project objectives have been met, the limitations on the material presented and the links with other ongoing projects which has provided added value towards the design/sustainability of coastal/sea defence works, seabed works and the assessment of dredging activities.

## 7. Recommendations for further work

Finally, the findings of the study have been used in a consideration of the boundaries for SMPs and to derive recommendations for further studies and research (Section 9 of the main report) which are required to fill gaps in knowledge or data

## 8. References

ABP Research & Consultancy (1996a). Southern North Sea Sediment Transport Study: Literature Review & Conceptual Sediment Transport Model. Report No R.546, May 1996.

ABP Research & Consultancy (1996b). Southern North Sea Sediment Transport Study: Recommendations for Phase II Study. Annex to Report R.546, June 1996.

ABP Research & Consultancy (2000). Southern North Sea Sediment Transport Study: Phase 1 Update. Report No. R.845. January 2000.

HR Wallingford (2001). Southern North Sea Sediment Transport Study – Phase 2. Inception Report. Prepared for Great Yarmouth Borough Council by HR Wallingford in association with CEFAS/UEA, Posford Duvivier and Dr B D'Olier. Report EX4341, HR Wallingford, March 2001.

HR Wallingford (2002). Southern North Sea Sediment Transport Study – Phase 2. Sediment Transport Report. Prepared for Great Yarmouth Borough Council by HR Wallingford in association with CEFAS/UEA, Posford Haskoning and Dr B D'Olier. Report EX4526, HR Wallingford, August 2002.

For **further information** about the study contact either Richard Whitehouse at HR Wallingford (Telephone: 01491 835381, Email: rjsw@hrwallingford.co.uk) or Julian Walker at Waveney District Council (Telephone: 01502 562111, Email: julian.walker@waveney.gov.uk). The field data is hosted by the Environment Agency, Anglian Region, contact Jane Rawson (Telephone: 01733 371811, Email: jane.rawson@environment-agency.gov.uk).

This Executive Summary is available from the project web site: www.sns2.org