

Draft Final Report

R&D Project 446

Scoping report for the proposed  
Beach Management Manual

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May 1993

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## FORWARD

Active beach management techniques, such as periodic nourishment, recycling of longshore drift and sediment by-passing of structures or channels, have been successfully tried and accepted as effective long term coast defence methods. Despite the increasing trend towards these "soft" engineering solutions, and away from traditional structural solutions, there are no comprehensive guidelines available to assist coastal managers in design and implementation of suitable management programmes. In recognition of this lack of guidance the National Rivers Authority, in conjunction with the Ministry of Agriculture Fisheries and Food and other members of the CIRIA Project Steering Group, propose to produce a Beach Management Manual, incorporating current best practice and research developments.

Production of the manual has been separated into two phases. The first phase is to determine the scope of the manual, to identify existing and ongoing research relevant to beach management and to identify future research areas. The second phase is the production of the manual. This report presents the results of the first phase.

The report has been prepared by members of the Coastal Group at HR Wallingford. The proposed contents of the manual have been reviewed and agreed by members of the CIRIA Project Steering Group coordinated by Dr Judy Payne. The authors gratefully acknowledge the assistance of various organizations who have contributed information to the review of existing research projects.

## **SUMMARY**

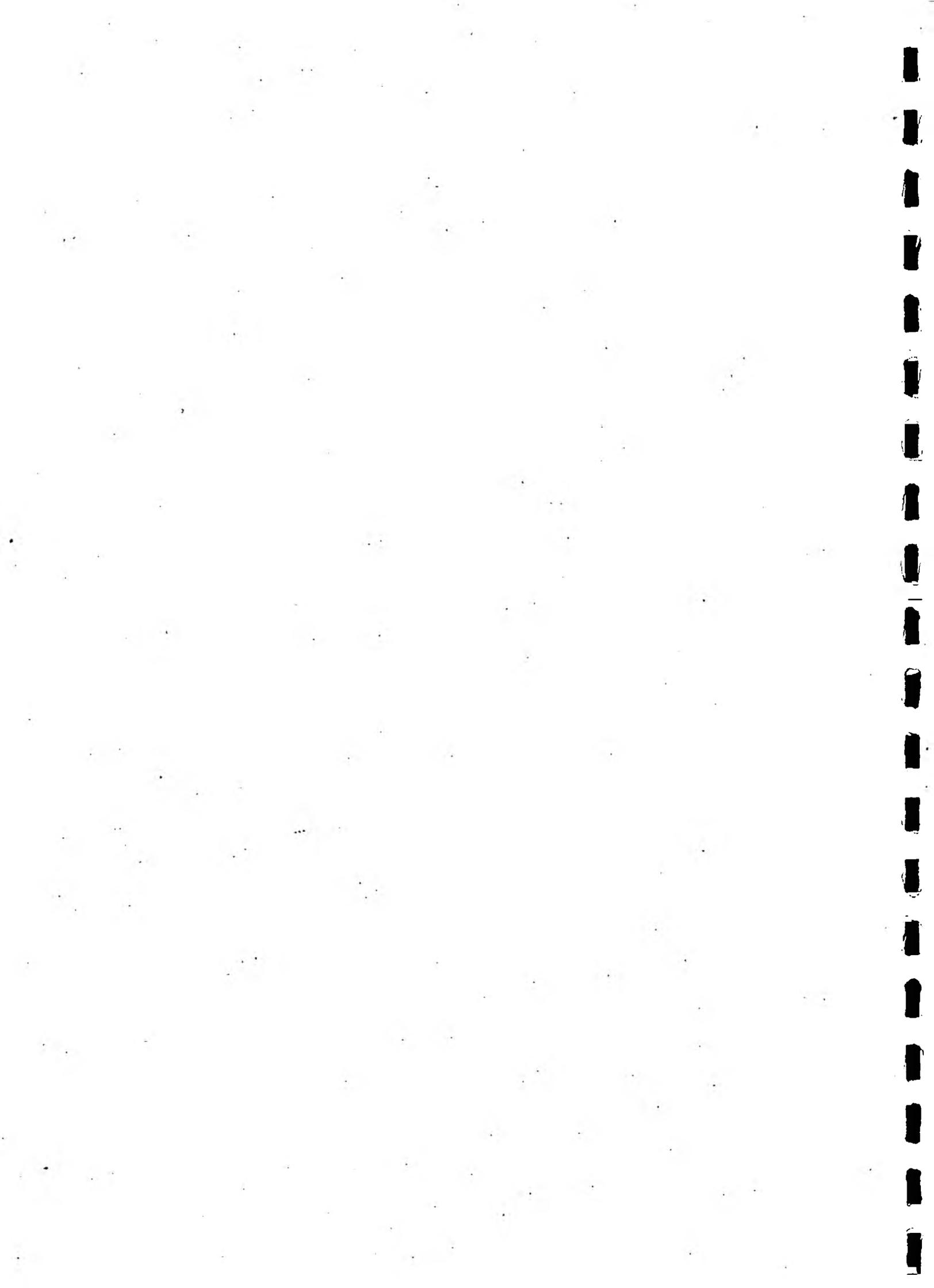
This report outlines the scope of the proposed Beach Management Manual, reviews relevant current and ongoing research, and identifies future research areas. The report has been prepared by HR Wallingford for the National Rivers Authority under research project CO6(92)2, Phase 1.

The scope of the Beach Management Manual is presented as a contents list with explanatory text. The contents list has been reviewed by members of the Steering Group under the auspices of CIRIA.

The research review provides outline information on all major current and ongoing research projects in the UK which are relevant to the Manual. Information is also included on projects of interest from other European countries and from North America. Research organizations, funding bodies and publications are recorded for each project in order that further information may be obtained.

## **KEY WORDS**

Beach management, research



## **1. INTRODUCTION**

### **1.1 Background**

This scoping report has been produced by HR Wallingford (HR) for the National Rivers Authority (NRA) under research project CO6(92)2 Phase 1. The report presents the results of the first phase of a project to produce a Beach Management Manual. It details the scope of the proposed manual, as reviewed and agreed by members of the Project Steering Group under the auspices of CIRIA, outlines existing research relevant to the manual and identifies future research needed to improve the current level of understanding of beach processes and beach management techniques.

The proposed Beach Management Manual is intended to address the need for comprehensive and practical guidance for coastal engineers in order that cost effective and environmentally acceptable beach management programmes are developed in the future. It will be produced by CIRIA and will be funded primarily by the NRA with contributions from the Ministry of Agriculture, Fisheries and Food and other interested bodies. The manual will incorporate current best practice and recent research results, and will be updated regularly to include the results of future research and site experience.

### **1.2 Terms of reference**

The NRA terms of reference for this phase of the project are:

- (a) To detail the content of the manual
- (b) To establish the aspects addressed by research commissioned by other funding bodies
- (c) To identify the gaps/areas in knowledge for investigation to be funded by the NRA and others
- (d) To produce a draft final report and Project Record on the project findings.

### **1.3 Framework of the report**

Section 2 of this report discusses the scope of the proposed manual and expands on the intentions and details of the various headings of the contents list which appears in Appendix A. The contents list was proposed initially by members of the HR project team and was then reviewed, modified and agreed with members of the Project Steering Group under the auspices of CIRIA.

Section 3 outlines recent and ongoing research projects which are relevant to the manual. The projects and, where relevant, funding bodies, contractors, publications and completion dates are presented in Appendix B and are discussed in the text. A reference for each of the publications is presented in Appendix C of the report. The section also presents a brief outline of future research areas which are needed to improve the current level of understanding of beach processes and of beach management techniques.

Section 4 presents the conclusions and recommendations of the first phase of the Beach

Management Manual project and includes a likely schedule for updating the manual.

## **2. PROPOSED CONTENT OF THE BEACH MANAGEMENT MANUAL**

This section discusses the content of the proposed manual and expands on the intentions and details of the various headings in the contents list, which is presented in Appendix A. It should be noted that the italic contents are intended for guidance only.

Briefly, the manual is set out as follows:

- introduction to beach management and to the manual
- detailed discussion of beach processes, morphology and attributes of beaches
- guidelines for measuring and appraising the processes, morphology and attributes
- guidelines for defining the aims and objectives of beach management
- detailed description of the design process necessary to achieve the aims and objectives
- detailed discussion of the options available
- guidelines for implementing the selected strategy.

Chapter 1 is intended as an introduction to both the manual and to the concept of beach management. It is intended that the chapter should be brief, though Section 1.1 should provide sufficient information to allow a non-specialist engineer or planner to understand the functional differences between traditional hard sea defences and the soft solutions which are presented in the manual; reference should be made to site examples and to beach management in other countries.

Section 1.2 defines the objectives of the manual which are essentially to provide UK coastal managers with guidelines to plan, design and implement cost effective and environmentally acceptable beach management programmes. It should be made clear that the manual covers a wide range of management options and is not restricted to beach recharge schemes. The manual will not attempt to address salt marsh/sand dune management or detailed design of beach structures. It should be compatible with the 1991 CIRIA/CUR "Manual on the use of rock in coastal and shoreline engineering".

Section 1.3 will act as a guide to the manual. In brief, it is intended that the reader can either be led through the entire manual or look up specific information. In order to achieve this each section must be able to stand alone without the need for constant cross referencing to other sections and should present information in a style which will not deter the non-specialist. Full use should be made of illustrative figures, tables and photographs, while complex information should be presented in text boxes. Text boxes should also be used to present case study information, though these should be kept brief and relevant to the main text.

Chapter 2 describes the processes affecting beaches, local and regional beach morphology and the attributes of beaches. It is anticipated that this chapter will be extensive as it will guide the reader towards a better understanding of the physical and socio-economic factors affecting the shoreline. Particular care should be taken in Section 2.1 and Sub-section 2.2.3 to ensure that processes and mechanisms are dealt with at both an introductory and more detailed level.

Care is also required in Section 2.4 to ensure that differing views as to the function of a beach are presented, allowing the beach manager to develop an appreciation of the requirements of various interested groups.

Chapter 3 discusses the methods of measuring, analysing and appraising the processes, morphology and attributes of a beach. It is intended to be a guide to the available methods and the results that may be expected, rather than a comprehensive guide to survey and data processing techniques. Particular care should be taken with the discussion of appraisal in Section 3.9 to ensure that the reader understands the limitations of field measurements, the potential for seasonal and long term variations and the development of the beach in a regional and historical context. The reader should be made aware of the benefits of long term monitoring for effective beach management, as well as the need for design data.

Chapter 4 guides the reader towards formulating a long term strategy of aims and objectives for beach management. It is intended that the reader should be led from considering what is required from a beach in broad terms, through an appreciation of the current situation and the likely future developments, and then on to defining specific objectives for coastal defense and for environmental/socio-economic issues. There are several areas of this chapter, such as risk assessment and future climatic change, which are not well defined at present, but which will be clarified by ongoing research.

Having defined a beach management strategy, Chapter 5 then leads the reader through the design process. Section 5.3 is intended to introduce the options available; a detailed discussion of each option is left to Chapter 6. Section 5.4 will need particular attention to provide an introduction to the expanding array of numerical and physical modelling tools available to the engineer.

Chapter 6 expands on the management options introduced in Section 5.3. The manual should give sufficient weight to the non-recharge methods to ensure that the reader is made aware of all the available options. Section 6.1 covers beach recharge and is intended to include both general subjects, such as materials availability and future demand, as well as information required for detailed design; reference will be made to Appendix A of the manual which will present the summary of the CIRIA beach recharge resources project. Most recharge schemes will require some form of control works to retain material at the required location; Section 6.2 covers the range of structures and techniques that may be considered. Other management options are discussed in Sections 6.3 to 6.5. Many of the topics in the chapter are the subject of recent or ongoing research which should be included where possible.

Finally Chapter 7 discusses the implementation of management programmes, including legal, contractual, construction and post-construction aspects. Attention should be paid to the long term management and maintenance aspects and to the post-project appraisal of all the management objectives. The reader should be made aware of the continuous nature of beach management; implementation of a management programme should lead back to monitoring, appraisal and modification where necessary.

Appendices A and B are intended to provide further details of beach recharge material

resources and acquisition. Appendix A will comprise the summary of the CIRIA beach recharge material demand, resources and availability project which will run in parallel with the production of this manual. Further appendices may also be included to cover other aspects of beach management which might be considered too detailed to fit within the main text and too lengthy for inclusion as a text box.

### **3. RESEARCH REVIEW**

#### **3.1 Recent and ongoing research**

The following section briefly outlines recent and ongoing research projects and technical publications which are relevant to the Beach Management Manual. Appendix B lists the projects and/or publications which have been considered. The table is set out in accordance with the proposed chapters of the manual and indicates the sub-sections which are relevant to each item, along with the funding body, the contractor or author, the completion date and the publication reference. References for the publications are listed in Appendix C of the report.

The majority of the research considered has been, or will be, undertaken in the UK. Projects and publications from other European countries and from the USA are also reviewed where they may have direct relevance to the UK in terms of physical or economic conditions. No attempt has been made to outline recent work in the development of field measurement equipment, the prediction of offshore wave conditions, salt marsh or sand dune management, detailed structural design, construction management or amenity planning.

Chapter 1 of the Manual introduces the general philosophy of beach management. There is little point in introducing any detailed research to the introduction; however it may be an appropriate point to reference recently published guidelines concerning various aspects of beach management. The Dutch 'Manual on Artificial Beach Nourishment' (CUR, 1987) covers many of the proposed topics for the UK manual but is written from the Dutch perspective; it concentrates only on sand beaches and does not address other beach management options. Similarly, a recent publication, 'Short Course on the Principles and Applications of Beach Nourishment' (Campbell et al, 1990), presents the current design situation in America. The Dutch publication 'Effectiveness of Coastal Defence Measures' (Zeidler et al, 1992) concentrates on sand beach situations and considers the design and function of structures as well as beaches. Coastal structures are the subject of the UK/Dutch publication 'Manual on the Use of Rock in Coastal and Shoreline Engineering' (CUR/CIRIA, 1991) which is of interest for its sections on coastal processes and risk assessment as well as for its coverage of beach control structures; the proposed manual and the existing CUR/CIRIA manual should form the basis for much of the future coastal engineering in the UK. Also of relevance to this introductory section is the ongoing controversy in the USA regarding the long term viability and cost-effectiveness of beach nourishment schemes and the difficulties of post-project appraisal; these discussions commenced with a paper by Pilkey and Clayton (1987), which questioned current American design practices and continued with contributions from Pilkey (Pilkey and Leonard, 1991) and Houston (Houston, 1991a and b). Though the details on the American situation may not be directly applicable to the UK, the principles of the controversy are important to effective beach management worldwide and should be considered.

Chapter 2 describes the morphodynamic processes which affect the coastline and the attributes of beaches. This chapter is an appropriate point to discuss much of the state-of-the art research which is not yet generally available to practising engineers. Recent research has

tended to concentrate on wave processes and morphodynamics, but other areas have also received some attention. HR Wallingford are involved in ongoing MAFF sponsored research into inshore wave transformations, fundamental beach morphodynamics, wave-structure interaction and the development of numerical models to simulate these processes. Research reports have been published over a number of years with several recent reports describing the current state-of-the-art (Hawkes, 1992; Ewing and Hawkes, 1993; Chesher et al, 1993; Lowe, 1993; Southgate and Nairn, 1993; Nairn and Southgate, 1993). This work will continue over the coming years and will result in preparation of a catalogue of synthetic wave data for the UK coast and further developments to existing 2D and 3D numerical coastal models which are, or will be, available to practising engineers and beach managers.

In addition to this HR research there are a number of other projects which are also relevant to coastal processes. MAFF have sponsored a study by IOS Deacon on wave set-up on beaches (King and Bacon, 1993; Bacon and King, 1993). SERC have sponsored several ongoing university studies relating to the measurement, description and modelling of nearshore processes. Two morphodynamics projects have been sponsored by MAST, known as G6M and G8M; the former is now complete, and many of the results have been integrated into the ongoing HR work, while the latter is due for completion in 1995. G6M papers comparing various 2D and 3D coastal morphodynamic models have been prepared by Hedegaard (1993) and de Vriend (1993). NERC are undertaking research through POL and their university collaborators into inshore wave transformations, wave statistics and prediction of extreme sea conditions; much of this work will be available in 1994.

NERC are also involved in coastal research through their Land Ocean Interface Study (LOIS) and the British Beach and Nearshore Dynamics (B-BAND) programme. The three elements of the LOIS project are all relevant: the North Sea Modelling Study (NORM) considers long term morphodynamics, the Land Ocean Evolution Perspective Study (LOEPS) considers long term geological development of the coastline, biological influences on coastal processes and the sources and sinks of coastal sediments, while the River-Atmosphere-Coast Study (RACS) considers the flux of materials, including sediments, into and out of the coastal zone. The work is ongoing and, though it will concentrate on the North Sea coast, should be of general interest; no results have yet been published. The B-BAND programme is concentrating on obtaining field measurements of wave induced sand transport processes in the surf zone which will provide important calibration data for the developing numerical models; the importance of infra-gravity waves in sediment transport has been identified and interim results have been published (ie. Russel et al, 1991). The final report for the project will be published later this year. The LOIS study of long term and large area morphodynamics has a European counter part in the Dutch GENESIS programme, the aims of which are described by Terwindt and Battjes (1990).

SCOPAC, in association with Crown Estates, have sponsored a study of onshore shingle transport from offshore sources along the south coast; this study provides guidelines to determine potential onshore transport at other sites (HR Report EX 2597, 1993). SCOPAC have also sponsored the preparation of a literature review of published material relevant to the south east coast (Bray et al, 1991) which provides background material for beach managers in that area. Similar information is available for the Anglian coastline from the well publicized

Anglian Sea Defence Management Study. Other coastal groups also have databases of published literature relevant to their frontage.

Other recent and future publications and projects that are of importance to this chapter are the MAFF sponsored document on English and Welsh coastal cells (Motyka, 1993), the MAFF guidelines on coastal defence and the environment (Pethick and Burd, 1993), the MAFF sponsored Coast Protection Survey of England, the Sports Council report on the recreational use of coastal areas (Masters, 1992) and the ongoing preparation of the English Heritage Register of Maritime Sites and Monuments. In addition, both the Ordnance Survey and the British Geological Survey are considering production of coastal zone map series which should be of considerable interest.

Chapter 3 of the Manual discusses field measurement of environmental data. Much of the development of field equipment is undertaken by commercial manufacturers and is not reviewed here; the major development of recent years is in the use of GPS equipment which has transformed the establishment of survey control set-up, particularly in remote areas, and is likely to take over from traditional methods for detailed survey work in the near future. Research into improved, non-invasive, measurement of waves, currents, water levels and sediment transport is being undertaken by POL under NERC funded projects. This work includes: the use of the OSCAR system to measure nearshore waves; development of acoustic systems to measure currents and suspended sediments; and the use of GPS to monitor long term land movements to improve the determination of global sea level changes. Other non-invasive measurement projects include the development of the radio pebbles for sediment tracking at Southampton University and the use of a "tell-tale" monitor to measure toe-scour along sea walls. The NRA have contracted a methodology study on the collation of existing data on water levels and on the establishment of coastal management databases following the experience of the Anglian study, which are nearing completion, and are about to start work on the establishment of a national beach monitoring database. An HR study has been completed which discusses existing beach survey data for the UK (Brampton, 1992a), and finally, HR and Halcrows are collaborating on the development of an interactive beach data system which will provide a useful management tool for appraising data in relation to specific problems; this system will be completed during 1993.

Chapter 4 provides a guide to assessing existing beach situations and to setting the standards to be attained by a beach management programme. Recent relevant research concentrates on the derivation of wave and water level climates (Hague, 1992), the impact of climate change (Hawkes, 1991a; Hawkes, 1991b; Diserens, 1991; Diserens et al, 1992), assessment of the performance of existing renourished beaches (Moller and Swart, 1987; Strine and Dalrymple, 1989; Houston, 1991b), the ecological and socio-economic aspects of beach nourishment (Lankford and Baca, 1989; Townend and Flemming, 1991) and the potential for variability in natural longshore drift of beach material (Brampton, 1992b).

Ongoing and future projects will continue to investigate the potential impact of climatic change (MAFF-HR), develop inshore wave and joint probability prediction methods with guidelines for their use (MAFF-HR; NERC-POL), develop risk assessment and performance/conservation criteria measurement methods (DoE/NRA - HR/Halcrows), develop

public safety guidelines (NRA) and develop conservation guidelines (NRA).

Chapter 5 sets out the design processes necessary to achieve the beach management requirements. Several useful publications have already been referred to within the paragraph on Chapter 1. Recent developments in design have been in the areas of numerical modelling of beach response, including the introduction of probabilistic techniques (Vrijling and Meijer, 1992), and in the economic and environmental evaluation of beach management schemes.

Basic research on the processes and principles of beach response plus several models which are still undergoing development have been mentioned in the discussion of Chapter 2. Models which are currently in use are included in this design chapter. These include:

- parametric beach profile response models for orthogonal wave attack (Powell, 1990; Van der Meer, 1988; Larson and Kraus, 1989 & 1990; Vellinga, 1986; Steetzel, 1991) and for angled wave attack (Coates and Lowe, 1993).
- 2D morphodynamic models of nearshore profile development (Southgate and Nairn, 1993; Nairn and Southgate, 1993; Hedegaard et al, 1991);
- beach planshape models including longshore transport around groynes and beach development in the lee of offshore breakwaters (Hanson and Kraus, 1989; Graven, 1992; Brampton, 1991; Brampton and Goldberg, 1991)

Economic and environmental evaluation of beach management schemes in the UK have been addressed in the MAFF sponsored documents "Economic approaches to Environmental Evaluation" (Coker and Richards, 1992) and "The Economics of Coastal Management" (Penning-Rowse et al, 1992). Socio-economic considerations are also addressed by Townend and Flemming (1991), while English Nature have commissioned a guide to selecting schemes appropriate for environmentally sensitive areas, in particular geological SSSI's (HR EX 2112, 1990). Socio-economic considerations from an American viewpoint are discussed by Black et al (1988).

Chapter 6 discusses the options available for beach management. Much of the recent work relating to renourishment has been discussed previously, however there are several further publications and projects of note. BGS and Crown Estates have published the "Marine Aggregates Survey" (BGS 1988-93) in several volumes which indicate the distribution of the main aggregate sources for UK waters; the final volume has yet to be commissioned. CIRIA have published "Non-aggregate marine materials for beach recharge - Stage I" (CIRIA, 1992) which discusses the use of materials that are not available to the aggregate industry and also covers other subjects of importance to the Manual; Stage II of this study, which has yet to be commissioned, will investigate the demand and availability of recharge materials around the UK coast. MAFF funded research on the use of material which does not match the existing beach sediment is nearing completion at HR; some aspects of the work have been discussed by Powell (1992). Work is also under way on the use of harbour dredged material through a DoE sponsored project at Harwich Harbour.

Recent and ongoing research relating to beach control structures is extensive. The impact of groynes on shingle beaches has been investigated using physical models at HR and is discussed in Coates and Lowe (1993). This work is being continued, and extended to include offshore breakwaters, under contracts to MAFF and will result in further development of existing longshore transport models. Development of numerical modelling of offshore breakwaters is also under way at HR and has resulted in several publications (ie. Smallman et al, 1991). The stability of rock armoured groynes has been investigated through physical models tests (Allsop and Jones, 1993). All of this work will result in a set of guidelines for the design of beach control structures. Field work and numerical model development is also being carried out under a SERC contract to Plymouth and Brighton Universities.

Developments in the design and impact of seawalls are covered by a variety of MAFF and NRA sponsored projects. Publications to date cover work on shingle beach profile response to sea walls (Sayers, 1992; Powell, 1993). Future work and publications will cover modelling and field measurement of toe scour of sand beaches, further investigations of permeable revetments and rock armouring of sea walls and other structures (Jones and Allsop, 1992; Allsop and Jones, 1993), the design of armourstone foundations (NRA), the use of timber in sea defences (NRA) and the rehabilitation of existing structures (NRA).

The use of beach drainage systems has been under development in Europe, Australia and the USA for several years and is discussed by Davis (1992). At present there is a proposed installation at Newquay in Devon. Managed retreat is also a relatively new concept to the UK and is currently regarded as a possible option for saltmarshes and estuaries, which are not covered by the manual. The proceedings of a recent (March, 1993) seminar cover the present state of this subject in the UK. Managed retreat has been accepted as an option in the USA for some time as the only economically viable solution to coastal erosion in areas of low economic value. A recent French study (Manoha and Teission, 1990) discusses retreat of a shingle beach on a exposed shoreline as a means of establishing a new equilibrium shoreline.

Non-structural and low cost beach control operations are currently under review by HR for both MAFF and the NRA; the reports will cover subjects such as beach scraping, use of vegetation, perched beaches, artificial seaweed, beach drainage, retreat and recycling. Earlier studies by HR on low cost structures are summarised in Motyka and Welsby (1986).

Finally, a workshop on "Litter on the undeveloped coast" has recently been run by English Heritage. A report will be available shortly which should be of interest to planners and engineers responsible for leisure beaches.

Chapter 7 covers the legal, contractual, maintenance and monitoring requirements of beach management programmes, however current research projects only cover monitoring and appraising the physical response of beaches. Several projects are under way to monitor replenished beaches and to relate their performance to sea conditions. HR is investigating several UK shingle beaches, while a European project, NOURTEC, is investigating beaches in Denmark, Germany and the Netherlands. An American publication on monitoring guidelines for beach schemes (Stauble and Hoel, 1986) is also of interest.

### **3.2 Suggested future research**

The brief outline above indicates that many of the important areas of beach management have been, or are being, investigated. However, there are still areas which need further attention. These include:

- development of beach monitoring and appraisal guidelines for natural and managed beaches, to include appraisal of conservation, amenity and commercial aspects;
- development of guidelines for specifying the required standards of performance for beaches;
- field studies of managed retreat on exposed UK shorelines to supplement existing work on estuaries/saltmarshes;
- field studies of differential transport of material placed outside the surf zone, with particular reference to dredged spoil;
- field and model studies of beach drainage systems;
- development and field calibration of a UK dune face erosion model;
- model studies of the impact of beach control structures on sand beaches, with field calibration;
- investigation into the probability of sequential storm events as worst case scenarios for design of beach management schemes;
- development and field calibration of numerical models of fine sediment deposition in the lee of coastal structures;
- further development of the understanding of wave-structure-beach interactions resulting in design models;
- investigation of ground water flow through natural and replenished beaches;
- further development of methods to reduce toe scour of structures using models and field studies;
- further development of guidelines for safety procedures and reduction of downtime on coastal construction projects;
- investigation of the impact of beach management schemes on local property values (and therefore taxable values), road use, local employment and other socio-economic considerations;

- investigation of the environmental impact of beach management ie. nesting, growth of backshore vegetation, benthic species, shoreline fishing;
- further investigation on selecting schemes for environmentally sensitive beaches;
- application of probabilistic techniques to beach modelling.

Many of these topics will require relatively long term programmes. They have not been set out in any order of priority. It is hoped that future editions of the manual will include results from these research initiatives.

#### **4. CONCLUSIONS AND RECOMMENDATIONS**

This report details the scope of the proposed Beach Management Manual, outlines relevant recent and ongoing research and suggests further research topics. It is recommended that the proposed manual is written in accordance with the scope and that the suggested research topics are addressed in the near future and are included in subsequent editions of the manual.

In order to facilitate the updating of the manual it is further recommended that it is produced in the form of separate volumes for each of the proposed Chapters, or in a loose binding. This will allow re-printing costs to be kept as low as possible. Using the framework for the manual proposed in Appendix A an updating schedule could be as follows:

	<b>Update frequency</b>
Chapter 1	As necessary to introduce changes in other sections.
Chapter 2	10 years, to include sea level rise and new beach process research.
Chapter 3	5 years, to include new survey techniques.
Chapter 4	10 years, to include sea level rise, changes in government policies etc.
Chapter 5	5 years, to include changes in modelling technology. 10 years, to include changes in government policies.
Chapter 6	10 years, to include new innovations and changes in recharge material availability and demands.
Chapter 7	10 years to include new innovations and government policy.

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**APPENDIX A**

**Beach Management Manual contents list**

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**APPENDIX A Beach Management Manual contents list**

1. INTRODUCTION
  - 1.1 Beach management
    - General philosophy of beach management*
    - Historical context*
  - 1.2 Objectives and scope of manual
  - 1.3 Structure and use of manual
2. BEACHES : PROCESSES, MORPHOLOGY AND ATTRIBUTES
  - 2.1 Physical processes affecting beaches
    - 2.1.1 Wave dynamics
      - Wave generation*
      - Wave transformation in shallow water*
      - Wave action in the surf zone*
    - 2.1.2 Tidal dynamics
      - Tidal wave propagation*
      - Meteorological effects*
      - Tidal currents in shallow water*
    - 2.1.3 Wind effects
      - Modification of wave conditions*
      - Aeolian transport of sediments*
    - 2.1.4 Sea level rise and climate change
  - 2.2 Beach morphology and sediment transport
    - 2.2.1 Description of beach types
    - 2.2.2 Geological evolution of UK beaches
    - 2.2.3 Present day sediment transport mechanisms
      - Longshore transport*
      - Cross-shore transport*
    - 2.2.4 Sediment sources and sinks
    - 2.2.5 Dune mechanisms
    - 2.2.6 Interaction with natural structures
      - Cliffs*
      - Clay beds*
      - Rock platforms*
    - 2.2.7 Impact of sea level rise and climate change
  - 2.3 Regional description of the UK coast

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2.4 Beach attributes

2.4.1 Coastal defence

2.4.2 Conservation

*Geological*

*Ecological (marine and terrestrial)*

*Landscape*

*Built heritage*

2.4.3 Amenity

*Public safety*

*Water quality*

*Recreation*

2.4.4 Commercial

*Fishing*

*Tourism*

*Others (beach extraction, water intakes, outfalls, jetties, land reclamation, etc)*

3. MONITORING AND DATA COLLECTION

3.1 Establishing a monitoring programme

3.1.1 General approach

3.1.2 Site inspection

3.2 Wave and tidal climate data collection

3.2.1 Wind climate

3.2.2 Wave climate

*Deepwater*

*Nearshore*

*Surf zone*

3.2.3 Water levels

3.2.4 Currents

3.2.5 Historic extreme events

3.3 Nearshore data collection

3.3.1 Seabed contours

3.3.2 Sediment distribution

3.3.3 Bed forms and sediment pathways

3.4 Beach data collection

3.4.1 Beach plan shape changes

3.4.2 Beach profile changes

- 3.4.3 Establishing a sediment budget
- 3.4.4 Beach material sampling
- 3.4.5 Environmental data collection
  - Upper beach and dunes*
  - Lower beach and nearshore seabed*
- 3.5 Geotechnical data collection
  - 3.5.1 Site investigations
  - 3.5.2 Methods
- 3.6 Monitoring near structures
  - 3.6.1 Seawalls
  - 3.6.2 Shore normal structures
    - Groynes*
    - Shore connected breakwaters*
    - Harbour arms*
    - Piers*
    - Outfalls*
  - 3.6.3 Shore parallel breakwaters
- 3.7 Monitoring amenity and commercial factors
  - Water quality*
  - Public use of the shoreline*
  - Local property values*
  - Commercial use*
  - impact on local economy*
- 3.8 Data storage and analysis
  - 3.8.1 Databases
  - 3.8.2 Data analysis methods
- 3.9 Appraisal of monitoring results
- 4 ESTABLISHING BEACH MANAGEMENT STRATEGIES
  - 4.1 General philosophy
  - 4.2 Identifying needs and priorities
    - 4.2.1 Coastal defences
    - 4.2.2 Conservation
    - 4.2.3 Amenity
    - 4.2.4 Commercial

- 4.3 Derivation of hydraulic loadings
- 4.4 Present day beach status
- 4.5 Predicting future beach behaviour
  - 4.5.1 Assessing response to severe events
  - 4.5.2 Assessing gradual long term changes
  - 4.5.3 Sensitivity to climate change
- 4.6 Defining performance criteria
  - 4.6.1 Design life of defence
  - 4.6.2 Acceptable failure probabilities
    - Relation to design life*
    - Extreme events (based on joint probability)*
    - Fatigue loading*
  - 4.6.3 Acceptable flood risk
    - Overtopping volumes*
    - Other factors*
  - 4.6.4 Acceptable land loss
  - 4.6.5 Relationship to adjacent coastlines
  - 4.6.6 Maintenance requirements
- 4.7 Defining environmental and socio-economic criteria
  - 4.7.1 Conservation interests
    - Geological*
    - Ecological*
    - Landscape and built heritage*
  - 4.7.2 Amenity
    - Effect on shoreline recreation and public safety*
    - Beach access*
    - Noise*
    - Pollution*
  - 4.7.3 Commercial activities
    - Effect on local property values and economy*
    - Fishing*
    - Marine traffic*
    - Land based traffic*
    - Others*

- 4.8 Formulation of management strategy
  - 4.8.1 Management framework
    - Defining aims and objectives*
    - Legislative and administrative framework*
  - 4.8.2 Constraints
    - Regulation and planning issues*
    - Policy issues*
    - Economic and environmental constraints*
  - 4.8.3 Response options
  - 4.8.4 Consultation and education
    - Regulation and planning issues*
    - Policy issues*
    - Publicity and community relations*
- 4.9 Problem identification
- 5 DESIGN PROCESSES
  - 5.1 General approach
  - 5.2 Establishing design constraints
    - 5.2.1 Physical constraints
      - Hydraulic boundary conditions*
      - Ground conditions*
      - Materials resources*
    - 5.2.2 Conservation constraints
    - 5.2.3 Amenity constraints
    - 5.2.4 Socio-economic constraints
      - Local commercial interests*
      - Local politics*
      - Legislative requirements*
    - 5.2.5 Financial constraints
    - 5.2.6 Construction constraints
      - Access to site*
      - Noise*
      - Pollution*
      - Timing*
  - 5.3 Generation of management options
  - 5.4 Prediction of effectiveness and effects of beach management

- 5.4.1 Beach modelling
  - Numerical*
  - Physical*
  - Interactive modelling*
- 5.4.2 Response in extreme conditions
- 5.4.3 Gradual changes in beaches
- 5.4.4 Reaction of adjacent coastlines
- 5.4.5 Prediction of maintenance requirements
  
- 5.5 Economic appraisal
  - 5.5.1 Preliminary cost estimation
    - Construction and weather risk assessment*
    - Scheduling of works*
    - Budget costing*
  - 5.5.2 Assessment of benefits
  - 5.5.3 Benefit-cost analysis
  
- 5.6 Environmental appraisal
  - 5.6.1 Construction impacts
  - 5.6.2 Geomorphological impacts
  - 5.6.3 Ecological impacts
  - 5.6.4 Impact on built heritage
  - 5.6.5 Socio-economic impacts
  - 5.6.6 Consultative procedures
  - 5.6.7 Presentation of environmental statement
  
- 5.7 Comparison and selection of preferred design
  
- 6 BEACH MANAGEMENT OPTIONS
  - 6.1 Beach recharge
    - 6.1.1 Availability of materials
      - Sources - dredged, quarried*
      - General licensing procedures*
    - 6.1.2 Anticipated future demand
    - 6.1.3 Importance of material size, grading and mineralogy
    - 6.1.4 Determination of replenishment volume and profile
    - 6.1.5 Specification and testing of material
    - 6.1.6 Winning of material
    - 6.1.7 Transportation to site
    - 6.1.8 Measurement and cost aspects
    - 6.1.9 Construction aspects
      - (including placement methods)*

6.1.10 Environmental considerations

6.2 Beach control works

6.2.1 Groynes

*Types of structure*

*General design considerations (spacing/length ratios, profile materials)*

*Effectiveness and cost optimization*

*Environmental considerations*

*Construction/maintenance aspects*

*Downdrift effects*

*Safety aspects*

6.2.2 Shore connected structures

*Types of structure*

*General design considerations (spacing/length ratios, configuration of head, materials, deposition of silt)*

*Effectiveness and cost optimization*

*Environmental considerations*

*Construction/maintenance aspects*

*Downdrift effects*

*Safety aspects*

6.2.3 Shore parallel breakwaters

*General design considerations (elevation, length, spacing, orientation, location relative to the shore line, materials)*

*Effectiveness and cost optimization*

*Environmental considerations*

*Construction/maintenance aspects*

*Downdrift effects*

*Safety aspects*

6.2.4 Sills

*General design considerations (elevation, width, length, materials)*

*Effectiveness and cost optimization*

*Environmental considerations*

*Construction/maintenance aspects*

*Downdrift effects*

*Safety aspects*

6.2.5 Modified seawalls

*General design considerations (reduction of reflectivity, reduction of overtopping, impact on beach levels)*

*Effectiveness and cost optimization*

*Environmental considerations*

*Construction/maintenance aspects*

*Downdrift effects*

*Safety aspects*

- 6.2.6 Beach drainage systems
  - Concept*
  - General design considerations*
  - Effectiveness and cost optimization*
  - Environmental considerations*
  - Construction/maintenance aspects*
  - Downdrift aspects*
  - Safety aspects*
  
- 6.3 Managed retreat
  - 6.3.1 Concept
  - 6.3.2 Effect on adjacent frontages
  - 6.3.3 Special design considerations
  - 6.3.4 Special environmental considerations
  
- 6.4 Other options
  - 6.4.1 Restoration of drift or supply
  - 6.4.2 Sediment bypassing
  - 6.4.3 Use of dunes
  - 6.4.4 Use of vegetation
  - 6.4.5 Rock beaches
    - Design concept*
    - Profile response*
    - Longshore transport*
    - Amenity*
  
- 6.5 Ongoing management and maintenance works
  - 6.5.1 Periodic recharge
  - 6.5.2 Longshore recycling or bypassing
  - 6.5.3 Beach profile regrading
    - Dune management*
    - Beach scraping*
    - Beach coarsening*
  - 6.5.4 Maintaining and improving beach control structures
  - 6.5.5 Control of blown sand
  - 6.5.6 Beach cleaning
    - Litter*
    - Seaweed*
  - 6.5.7 Beach use zoning

7 IMPLEMENTATION

7.1 Planning consents and grant aid procedures

- 7.1.1 Statutory and legal considerations
- 7.1.2 Beach recharge extraction licences and procedures
- 7.1.3 Emergency works
- 7.1.4 Public advertisement and consultation

7.2 Preparation of contract documents

- 7.2.1 Conditions of contract
- 7.2.2 Technical specification
- 7.2.3 Method of measurement for payment
  - Hopper volume*
  - Beach volume*
- 7.2.4 Pre-tender discussions with specialist contractors

7.3 Tendering

- 7.3.1 Tendering processes
- 7.3.2 Evaluation of alternative designs
- 7.3.3 Evaluation of alternative construction methods

7.4 Construction

- 7.4.1 Marine operations
- 7.4.2 Land operations
- 7.4.3 Surveys and measurement
- 7.4.4 Contract management

7.5 Project completion

7.6 Post project management

- 7.6.1 Monitoring
- 7.6.2 Maintenance

7.7 Post project appraisal

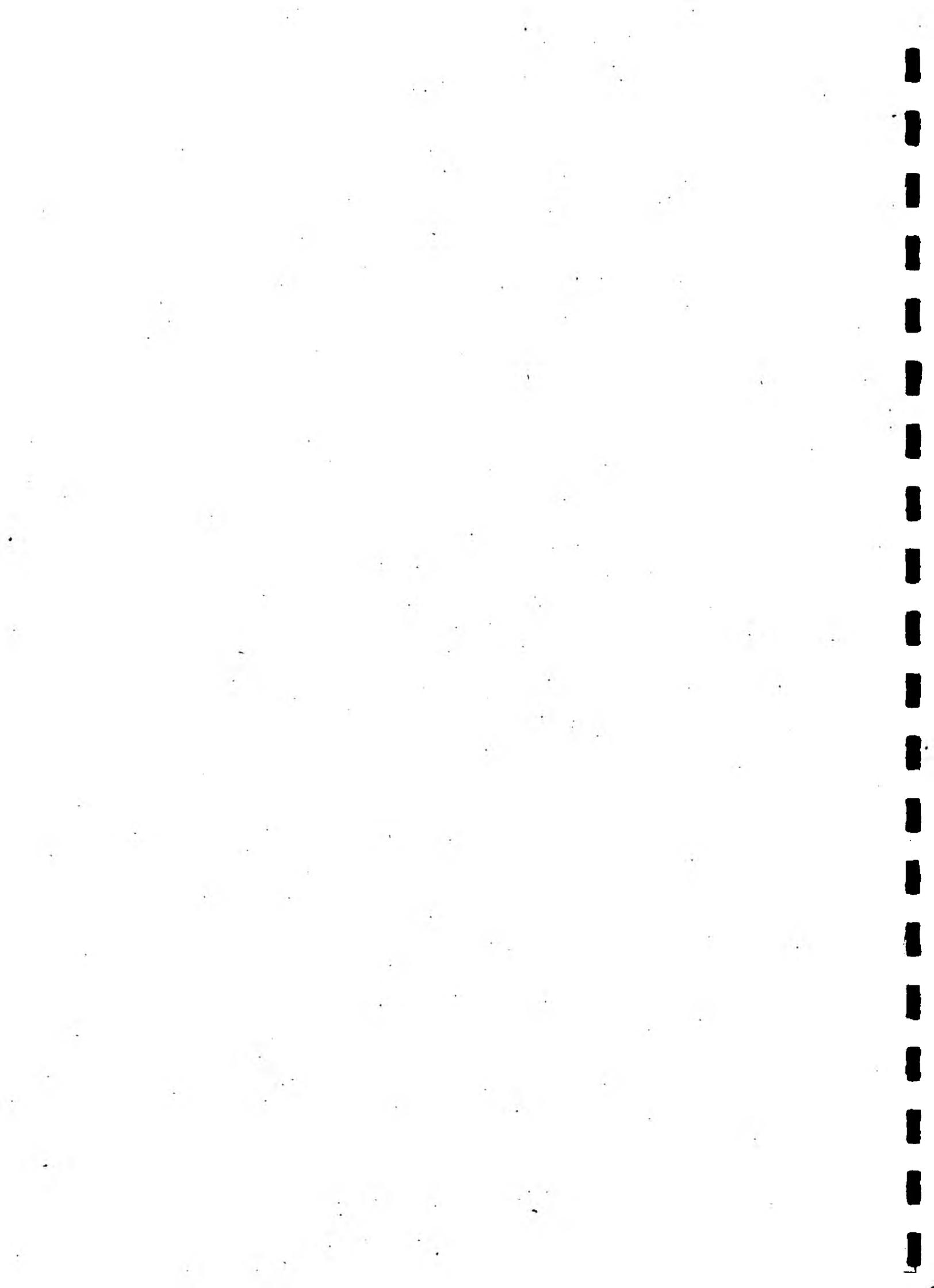
- 7.7.1 Coastal defence
- 7.7.2 Conservation
- 7.7.3 Amenity
- 7.7.4 Commercial

**APPENDICES**

- A Beach recharge material resources**
- B Procedural framework for obtaining beach recharge material**

**APPENDIX B**

**Recent and ongoing beach management research and publications**



**APPENDIX B      Recent and ongoing beach management research and publications**

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
1	Manual on artificial beach nourishment		CUR	Delft	CUR 1987
1	Manual on the use of rock in coastal and shoreline engineering		CUR/CIRIA		CUR/CIRIA 1991
1	Effectiveness of coastal defence measures: Design background for coast defence and management		Rijkswaterstaat & Delft	Polish Acad. of Science	Zeidler et al 1992
1	Short course on principles and applications of beach nourishment				Campbell et al 1990
1	Beach replenishment: the national solution? and subsequent discussions of the American situation				Pilkey et al 1987 & 1991; Houston 1991a & b
2	Physical processes of sediment transport by irregular waves	2.1.1 2.1.2 2.2.3	MAFF	HR	1994
2	Wave attenuation due to offshore banks	2.1.1 4.3	MAFF	HR	1994 Ewing & Hawkes, 1992
2	Wave model validation and comparison	2.1.1 4.3	MAFF	HR	1994 Hawkes, 1992
2	Field measurement of coastal dynamics (Phase I)	2.1	MAFF	HR	1994

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
2	Development of next generation of transformation models	2.1.1 4.3	MAFF	HR	1997
2	Project definition study for research on wave-structure interaction	2.1 6.2	MAFF	HR	1994
2	Catalogue of synthetic wave data for the UK coast	2.1.1 4.3	MAFF	HR	1995
2	The COSMOS profile model	2.2.3 5.4.1	MAFF	HR	1994 Southgate & Nairn 1993 Nairn & Southgate 1993
2	Morphodynamic coastal area model - PISCES	2.1 2.2.3 5.4	MAFF	HR	Ongoing Chesher et al, 1993
2	Sand beach dynamics	2.2.3	MAFF	HR	1994 Lowe, 1993
2	Wave set-up on beaches	2.1	MAFF	IOS Deacon	King & Bacon 1993 Bacon & King 1993
2	Modifications of breaking wave velocity fields by beach forms	2.1.1	SERC	Edinburgh Univ.	1992
2	Waves in coastal waters - development of theoretical solutions	2.1.1	SERC	Bristol Univ.	1992

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
2	Coastal Morphodynamics	2.1.1	SERC	Liverpool Univ.	1993
2	Wave kinematics and erosion in front of coastal structures	2.1	SERC	Bristol Univ. Aberdeen Univ.	1994
2	Surf zone hydrodynamics of irregular water waves and associated wave induced currents (LUCI project)	2.1.1	SERC	Imperial College	1994
2	Shear stresses and hydrodynamics of combined waves and currents (LUCI project)	2.1.1 2.2.3	SERC	University College	1994
2	G6 Coastal Morphodynamics Project	2.2.1 5.4.1	MAST	G6 Members	1993 Hedegaard et al 1993 deVriend et al 1993
2	G8M Project - Waves including transformations and low frequency impacts - Currents - Cohesive sediment transport - Beach morphology modelling	2.2.1 5.4.1	MAST	G8 Members	1995

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
2	<b>LOIS Project :LOEPS</b> - Sources and sinks of coastal sediments - Long term impacts of changes to hydrodynamic conditions - Geological development of the coastline - Biological influences on coastal processes  <b>:NORM</b> - Coastal hydrodynamic modelling over long time scales  <b>:RACS</b> - Transfer of materials, including sediment, into and out of the coastal zone	2.24 2.2.6 4.5.2 4.5.3 2.2.2 4.4  2.2   2.2	NERC	BGS         HR         POL/HR	Ongoing
2	The British Beach and Nearshore dynamics programme (B-BAND)	2.2.1 5.4.1	NERC	B-BAND Group	1993 Russel et al 1991
2	Dutch GENESIS Project: Large scale coastal behaviour	2.2 4.5.2 4.5.3	Dutch	Various	1995 Terwindt & Battjes 1992
2	<b>South Coast Mobility Study</b> - Sediment analysis and hydrodynamic conditions - Onshore transport of sediment	2.2 2.4	Crown Estate/ SCOPAC	HR	1993 EX 2597 in prep.

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
2	Literature review of South Coast processes (5 Volumes)	2	SCOPAC	Portsmouth Poly	Bray et al 1991
2	Mapping of littoral cells	2.3	MAFF	HR	Motyka, 1993
2	Coastal defence and the environment: A guide to good practice	2.4.2 4.7 5.6	MAFF	Hull Univ.	Pethick & Burd, 1993
2	Coast Protection Survey of England	2.3	MAFF		1993
2	Preparation of National Heritage Register for Maritime Sites and Monuments	2.4.2 4.6.2	Eng. Heritage		Ongoing
2	Recreational use of coastal areas	2.4.3 4.6.2	Sports Council/ Heritage Coast Forum		Masters 1992
2	Development of Coastal Zone map series	2.4 4.4 5.2	OS and Admiralty		Ongoing
2	Development of Coastal Geology map series	2.4 4.4 5.2	BGS		Ongoing
3	UK Beach survey data	3.4 3.7 3.8	MAFF	HR	Brampton, 1992a

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
3	Methodology for collating water level data	3.2	NRA	Posford Duvivier	1993
3	Development of remote instrumentation for measuring waves, currents, water levels and sediment transport inside the breaker zone		NERC (also DoE & MAFF)	POL	Ongoing
3	Development of OSCAR for nearshore wave measurements	3.1	NERC	POL	1995
3	Development of radio pebbles for shingle transport monitoring	3.4 3.6		S'ton University	Ongoing
3	"Tell-tale" instrumentation for sea wall scour monitoring	3.6	MAFF	HR	1994
3	Guidelines for beach management database studies based on the Anglian Sea Defence Study	3.7	NRA	NRA Anglian	1994
3	National database for beach monitoring data	3.7	NRA	Tender	1994
3	Development of the Beach Management System	3.7	HR/Halcrows		1993
4	Joint probability assessment (UK South Coast Shingle Study)	4.3	MAFF	HR	Hague, 1992
4	Validation of joint probability methods for high waves and high water levels	4.3	MAFF	HR	1993

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
4	Climate change and its impact on coastal management	2.1.1 4.3 4.5.3	MAFF	HR	1998 Hawkes, 1991a Hawkes, 1991b
4	Beach development due to climate change	4.5.3	NRA	HR	Diserens et al 1992
4	Global sea level rise predictions	4.5.3	MAFF	HR	Diserens, 1991
4	Sea level rise and shore nourishment: A discussion	5.6			Strive et al 1991
4	Guidelines for the use of existing wave transformation models	4.3	NRA	HR	1993
4	Extreme erosion event on an artificially nourished beach	4.5			Moller & Swart 1987
4	Beach fill at Fenwick Island, Delaware	4.6.1			Strine and Dalrymple 1989
4	Beach fill performance	4.6			Houston 1991b
4	Assessment of risks of beach recharge schemes	4.6	NRA	Tender	1994
4	Development of probabilistic risk assessment methods for sea and tidal defence schemes	4.6.1 5.6	NRA and DoE	HR, Halcrows	1995
4	Public safety of access to coastal structures	4.6.2 5.2.3 6.2	NRA	Tender	1994

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
4	Comparative environmental impacts of various forms of beach nourishment	4.6.2			Lankford & Baca 1989
4	Conservation survey and classification of inland and coastal waters	4.4	NRA	NRA	1993
4	Conservation in coastal areas	4.6.2	NRA	NRA	1993
4	Alongshore drift variability (UK South Coast Shingle Study)	4.5.2 5.4 6.1	MAFF	HR	Brampton, 1992b
5	Probabilistic coastal modelling	2.2.3 4.5.1 5.4			Vrijling & Meijer, 1992
5	Rock slopes and gravel beaches under wave attack	2.2.3 4.5 5.4 6.1		Delft	Van der Meer, 1988
5	Predicting short term profile response for shingle beaches	2.2.3 4.5.1 5.4 6.1	MAFF	HR	Powell, 1990
5	Three dimensional response of open and groyned shingle beaches	2.2.3 4.5.1 5.4 6.2	MAFF	HR	Coates & Lowe, 1993

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
5	Numerical model of groynes on shingle beaches	5.4 6.2	MAFF	HR	Brampton, 1991 Brampton & Goldberg, 1991
5	Numerical model for beach and dune erosion during storm surges	5.4			Vellinga 1986 Sleetzel 1991
5	SBEACH: Numerical model for simulating storm induced beach change (Reports 1 and 2)	5.4	CERC		Larson & Kraus 1989/90
5	American GENESIS: Generalized model for simulating shoreline change	5.4	CERC		Hanson & Kraus 1989
5	The users guide to the Shoreline Modelling Systems	5.4	CERC		Gravens 1992
5	Onshore/offshore sediment transport and morphological modelling of coastal profiles	5.4	DHI		Hedegaard et al 1991
5	Economic approaches to Environmental Evaluation	4.6 5.6 5.7	MAFF	Middlesex Poly	Coker & Richards 1992
5	The Economics of Coastal Management	4.6 5.6	MAFF	Middlesex Poly	Penning Rowsell et al 1992
5	Beach nourishment and socio-economic aspects	4.6 5.6			Townend & Flemming 1991

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
5	Guide to the selection of appropriate coast protection works for geological SSSI's	4.6.2 5.2.2 6.2	Eng. Nat.	HR	HR-EX 2112 1990
5	An economic analysis of beach renourishment for the State of Delaware	5.5 7.7	US Dept of Natural Resources and Env. Control		Black et al 1988
6	Marine Aggregate Survey: Volumes 1 - 4	6.1.1	Crown Estates	BGS	BGS 1988, 1989, 1990, 1993
6	Non-aggregate marine materials for beach recharge - Stage 1	6.1	NRA Crown Estates	CIRIA	CIRIA 1992
6	Beach recharge material demand, resources and availability	6.1	Various	CIRIA	1994
6	Beach replenishment using dissimilar sediments	6.1	MAFF	HR	1993 Powell 1992
6	Use and impact of harbour dredged material - Harwich Harbour Study	4.6.2 5.2 5.7 6.1 6.4 6.5	DoE	HR	1996
6	Effectiveness of beach control structures	6.2	MAFF	HR	1994

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
6	Behaviour of beach control structures	6.2	NRA	HR	1994
6	Guidelines for design of beach control structures	6.2	MAFF	HR	1994
6	Offshore breakwaters and beach development	6.2	MAFF	HR	1994
6	Numerical modelling of offshore breakwaters	6.2	MAFF	HR	Ongoing Smallman et al, 1991
6	The role of offshore breakwaters in coastal defence: a field measurement and computational model study	6.2	SERC	Plymouth Univ. /Univ. of Brighton	1994
6	Beach profile response in the presence of sea walls	6.2	MAFF	HR	1992 Sayers, 1993 Powell, 1993
6	2D modelling of toe scour at sea walls - Sand	6.2	MAFF	HR	1993
6	3D modelling of toe scour at sea walls - sand	6.2	MAFF	HR	1996
6	Field measurement of toe scour	6.2	MAFF	HR	1997
6	Guidelines for toe scour on sand beaches	6.2	MAFF	HR	1997
6	Rock armouring for surf zone structures	6.2	MAFF	HR	1993 Jones & Allsop, 1992 Allsop & Jones, 1993
6	Performance of permeable revetments	6.2	MAFF	HR	1993

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
6	Armourstone foundations	6.2	NRA	Posford Duvivier	1994
6	Guidelines for stability of beach structures	6.2	MAFF	HR	1994
6	Use of timber in sea defence schemes	6.2	NRA	TRADA	1993
6	Rehabilitation of structures	6.2	NRA	I Stickland	1993
6	Beach drainage	6.2			Davis et al 1992
6	Installation and monitoring of a beach drainage scheme at Newquay, Devon	6.2		MMG	
6	Seminar: 'Managed retreat: Putting theory into practice'	6.3	Various	Posford Duvivier	1993
6	Beach profile management: Literature review	6.5	MAFF	HR	1993
6	Beach profile management: Case studies and modelling	6.5	MAFF	HR	1994
6	Effectiveness of beach control operations	6.5	NRA	HR	1993
6	Novel and low cost shore protection methods	6.2	MAFF	HR	Motyka & Welsby, 1986
6	Seminar: 'Litter on the undeveloped coast'	4.6.2 6.5	Eng. Heritage	Heritage Coast Forum	1992

Chapter	Topic	Manual Sections	Main Funding Body	Contractor	Completion date and/or References
7	European beach nourishment monitoring - NOURTEC	6.1 7.7	MAST + National support	Various	1994
7	Monitoring of replenished beaches	6.1 7.6	MAFF	HR	1995
7	Physical and biological guidelines for beach restoration projects: Part II - Physical engineering	7.6 7.7			Stauble & Hoel 1986

**APPENDIX C**

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## APPENDIX C      References

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