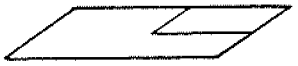
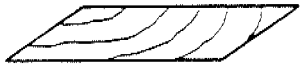
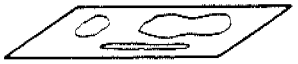
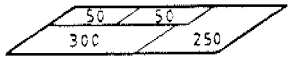
APPENDIX A1.3

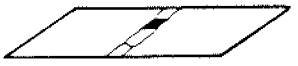
THE ROLE OF GIS

APPENDIX A1.3 THE ROLE OF GIS

A1.3.1 Geographical Information Systems, with their capacity to store and map spatial information, are well suited to investigating the impacts of sea level rise.

Figure A1.3.1

1.  Administration Boundaries
2.  Contours/Bathymetry
3.  Existing habitats
4. 

Crop/land value data
5.  Sea Defences, e.g. from Sea Defence Survey

One of the key facilities offered by most GIS software is the capacity to overlay layers of different thematic information (Figure A1.3.1).

Most GIS packages can also perform various automated calculations. Determining areas within boundaries is one important example. By overlaying maps 1. and 2. this would, for instance, enable the area below the 5m contour in a particular district to be identified.

Many GIS packages also offer more complex calculations and statistical-analysis facilities, with the potential for ecological, hydraulic or economic analysis in the context of sea level rise. Algorithms can be constructed which link stored data on land values, house types and service line distribution together with topography. This enables various "what if" scenarios to be tested, calculating the range of economic costs associated with different levels of flood. This approach is currently being investigated as part of the MAFF study on the Economic Implications of Sea Level Rise on the South Coast, carried out by the GeoData Institute of Southampton University (see Table A1.3.1). This project is still at the experimental stage but the approach has been advanced through to implementation stage elsewhere, notably in Dade County, Florida (Pryjomko, 1990).

In the latter project, a three dimensional terrain model has been mounted on the ARC/INFO GIS, giving contours at increments of one foot. Future sea levels have been modelled at six inch increments and overlaid with population distribution, urban land use, infrastructure and agriculture data. Estimates of the financial loss resulting from progressive sea incursions have then been calculated.

A1.3.2 In developing the GIS role further, experiences from other projects utilising computerised analytical techniques in the coastal zone can provide guidance. Modelling the economic and biological damage from oil spills uses systems analysis techniques, ecological and economic models, and data storage structures that can be adapted for sea level rise investigations (e.g. Grigalunas and Opaluch, 1990). Coastal Zone Management is another major focus for computerised analysis. The Louisiana Coastal GIS Network (LCGISN) is a coastal management project where, in a State that is suffering 40% of the USA's land loss, research is underway to enable the networking of relevant databases throughout Louisiana to provide a clearer picture of environmental changes that are taking place and why (David, 1990).

A1.3.3 The prioritisation of habitats for restoration or creation could also be carried out using GIS, given information on the extent and change of relevant coastal ecosystems. It might be shown, for example, that 90% of reedbeds, 60% of sand dunes and 50% of saltmarsh had been lost since a specified baseline date in a particular country. Reedbed creation might then be identified as the main priority for habitat creation and the possible locations for creating reedbeds could then be determined via a search of the sites, identified by the NRA, where maintenance of defences is currently under scrutiny.

It is clear that GIS has the potential to play a major role in sea level rise projects. The main restriction is the lack of availability of information in an appropriate digital format with associated spatial coordinates (e.g. national grid, UTM, latitude/longitude).

There is a recognised need for coordinated effort in the collection of appropriate coastal data (Clark, personal communication, 1990). The volume of data required is beyond the capacity of any one body. The need for coordination, however, is essential to ensure that accuracy is maintained, effort is not wasted by unnecessary duplication, and that the data is collected in a format which is both transferable and appropriate to the use of GIS technology.

A1.3.4 The most expensive aspect of GIS is the transfer of data from traditional sources (maps, reports) onto the computer. Any capture of data onto the computer should therefore be undertaken in such a manner that it can be used by GIS technology at some stage. This will inevitably also require an acceptance of some form of data sharing agreement, such as that being promoted by the GeoData Institute. At present this group are pursuing a regionally based approach whereby contributors of data have access to pooled computerised information held in a "system free" format (i.e. available in all the major computer compatible forms).

An interim measure towards pooled computerised information would be the establishment of a detailed record of all digital data held by organisations, as well as their immediate plans for further data capture. Coordination of effort must be made to ensure that spatial attributes are applied to data, even when its use is intended primarily within a more standard tabular database. Point data can be quite simply referenced by a grid coordinate. Spatial areas or complex linear features are less simple but equally essential. Where they correspond to a fixed boundary line then reference to that would be applicable. Otherwise an indicative spatial reference should be used, such as the coordinate of the centroid of the area. The range of information is such that data formats and structures cannot be universally applied. However, accurate spatial and temporal references should be linked to all digital data no matter what system it is to be stored on. The problem of data exchange, given

a willingness to share, is less of a problem than data capture, and is likely to become easier with time.

A1.3.5 By way of demonstrating the potential of this approach, current GIS and database work being undertaken by a range of agencies, which could potentially contribute to a retreat-for-conservation component of a coastal GIS, has been reviewed. The results of this exercise are shown in Table A1.3.1.

A1.3.6 **Recommendations in Respect of the Role of GIS**

A wide range of coastal information, much of which relates to sea level rise, is currently held on database and GIS by various academic, commercial and government organisations. There is a clear need for an inventory of these systems to be compiled, identifying in detail the attributes stored on each, the restrictions on accessibility to the data, and the potential compatibility of the various systems. Following this exercise a pilot study should then be undertaken, drawing on a range of experience both in Great Britain and overseas, to begin to combine all possible database and GIS information. An appropriate, unified means of storage, manipulation and display should then be investigated in order to produce guidelines for an integrated approach to coastal zone management using GIS as a primary tool.

Table A1.3.1 GIS and Database Projects of Relevance to Sea Level Rise

Organisation	Database/ GIS	System	Purpose	Information Contents	Status	Reference	Title
NRA, Anglian Region	GIS	Intergraph	Sea defence management	25 different datasets covering geomorphology, protected areas, ecology, recreation, infrastructure, jurisdiction, wind and wave climate, etc. All related to national grid coordinates. Previously on textual data-base currently being trans-ferred to GIS.	Pilot	NRA (1990)	Anglian Sea Defence Management System
NRA, Thames Region	GIS and Database	GFIS and SPANS	Sea defence management	Urban and rural land use, habitats, protected areas land values, etc. plus similar to above.	Under develop-ment	NRA (1990)	South Coast Sea Defence Management System

Organisation	Database/ GIS	System	Purpose	Information Contents	Status	Reference	Title
NRA	Database	Fox pro (?)	Inventory of wildlife resources associated with NRA defences	Ornithological and botanical data referenced to 500m stretches of coastline in NRA Anglian Region where NRA are responsible for sea defences.	Recently started	Prigmore D., NRA, Personal Communi-cation (1991)	Coastal Wildlife Database
NCC	Textual Database	Advanced Revelation	Estuaries management	Estuarine wildlife, conservation status, Birds of Estuary Enquiry, National Wildfowl Counts and human activities. Details spatially related to estuaries only. Some annotated field maps on archive.	Current	NCC (1991)	Estuaries Review

Organisation	Database/ GIS	System	Purpose	Information Contents	Status	Reference	Title
NCC	Textual Database	In-house	Habitat inventory	Coastal habitats, land use, and waters edge human activities. Compiled on 1:10000 maps, with key features put on in text form into database, with spatial reference to 1km squares of national grid.	Current	NCC (1990)	Coast-watch
NCC	GIS	Intergraph	Saltmarsh change	Saltmarsh monitoring between 1973 and 1988/89	Current	NCC (1990)	Saltmarsh Change in Essex and Kent
NCC	GIS	Intergraph	Irish Sea management	Coastwatch data, biblio-graphy, important and threatened conservation areas, etc.	Current	NCC (1990)	Irish Sea Project

Organisation	Database/ GIS	System	Purpose	Information Contents	Status	Reference	Title
NCC	Database	COSMOS Revelation	Saltmarsh inventory	Archive of conservation status and details of saltmarsh plant communities. Spatially referenced centre points for each marsh using national grid coordinates.	Completed	NCC (1989)	Saltmarsh Survey of Great Britain

Organisation	Database/ GIS	System	Purpose	Information Contents	Status	Reference	Title
NCC	Database and GIS	Advanced Revelation and Intergraph	Sand dune inventory	Sand dune communities using National Vegetation Classification categories spatially referred by national grid coordinates. Community also mapped at 1:10000, being transferred progressively on to Inter-graph. Started in 1987 and due for completion in 1992.	Current	NCC (1990)	Sand Dune Survey of Great Britain
NCC	Textual Database	Advanced Revelation	Shingle inventory	Shingle communities using National Vegetation Classification categories spatially referenced by national grid coordinates.	Near comple-tion	NCC (1990)	Shingle Survey of Great Britain

Organisation	Database/ GIS	System	Purpose	Information Contents	Status	Reference	Title
CEC	GIS	Arc/Info	Dredging license management	British Geological Survey core sample data, service lines, dredging areas, bathymetry, and Admiralty features, at scales from 1:5000 to 1:200000.	Near comple-tion	Posford Duvivier (1991)	Aggregate Resource Manage-ment System

Organisation	Datsbase/ GIS	System	Purpose	Information Contents	Status	Reference	Title
NRA	Database	DataEase	Sea defence management	National survey of sea defence structures including sand dunes, levels of service, properties and area at risk, plus geomorph-ological data, referenced to national grid coordinates. Phase 1 has been completed on NRA owned defences. Phase 2 covering local and district authorities and Phase 3 for private defences are both underway. Phase 4 on tidal defences due to start Spring 1991.	Current	NRA (1991)	Sea Defence Survey

Organisation	Database/ GIS	System	Purpose	Information Contents	Status	Reference	Title
SCOPAC	Database	In-house	Biblio-graphy	Bibliography material relating to coastal processes	Current	Court (1991)	Coastal Sediment Database
RSPB	GIS	Datascape	Assessment of impacts on wild-life of human activities in UK estuaries	Waters edge and adjacent land use, ecological data, habitats and water based activities, covering a total of 60 variables. A national study of 3 years duration.	Under develop-ment	RSPB (1990)	Estuaries Inventory Project
BTO	Database	Prime	Monitoring of waders	Monthly infor-mation on wader numbers, referenced to estuaries, estuary sections, or count points 1967 onwards	Current	BTO (1991) unpublished data	Birds of Estuary Enquiry

Organisation	Database/ GIS	System	Purpose	Information Contents	Status	Reference	Title
WWT	Database	Prime	Monitoring of wild-fowl	Monthly count information on wildfowl numbers referenced to estuaries, estuary sections or count points such as reservoirs. 1967 onwards.	On-going	WWT (1991)	National Wildfowl Count
DoE	Graphical Database	GIMMS	Coastal planning	Protected areas, etc.	Current	C. Hrynkiewicz, DoE, personal commun-ication (1991)	Directory of the North Sea Coastal Margin
MAFF	GIS	PC-based In-house	Broadscale North Sea management	Protected areas, outfalls, dredging, water quality, bathy-metry, etc. UK-wide coverage.	Current	J. Ramster, MAFF, personal commun-ication (1991)	Digital Marine Atlas Project

Organisation	Database/ GIS	System	Purpose	Information Contents	Status	Reference	Title
Directorate North Sea of the Dutch Public Works Department (Rijkswater-staat)	GIS	Possibly SPANS	Coastal data management and modelling system	Water quality, a range of other biolog-ical data, climatic information, jurisdictions, oil hazard analysis, eutrophication, dredging, between Straits of Dover in the South and the 58th degree latitude in the north. Project running 1988-92	Proposed	Adam Col-King (personal commun-ication 1991)	Manage-ment Analysis North Sea (MANS)
Marine Information Service (MARIS) Netherlands	Database	In-house	Commercial data bank	Water quality, physical oceanography, bathymetry, sea bed features, geology, ecology, etc.	Current	As above	Marine Infor-mation on the North Sea

Sources: Neil Pallister, NRA, personal communication (1991)
Fiona Burd, NCC, personal communication (1991)
Katherine Howard, NRA, personal communication (1991)
Tony Britton, NRA, personal communication (1991)
Amanda Rogers, NRA, personal communication (1991)
Debbie Prigmore, NRA, personal communication (1991)

APPENDIX A2.1

REVIEW OF RECENT AND ON-GOING RESEARCH OF RELEVANCE TO THIS STUDY

Review of Recent and On-Going Research of Relevance to this Study

Project	Contracted To	Funding and/or Supervising Agency
A. HABITATS		
Basic saltmarsh processes in Essex marshes in relation to predicted sea level rise	ITE - Dr. L. Boorman Monks Wood	NRA, EC, ITE, Soil Survey
Monitoring saltmarsh changes using satellite imagery.	Environmental Research Centre - University of Durham	NRA/Halcrow
Comparative studies of saltmarsh processes - assess changing patterns in the production and exchange of organic matter and exchange of mineral nutrients across the zones from mudflat to reclaimed marsh. 1990/92.	ITE - Monks Wood	NERC/EC
Studies of saltmarsh erosion in Essex. Production of maps showing changes in the area of saltmarsh vegetation, and tables showing the tidal regimes the saltmarsh plant species can withstand. 1987/92.	ITE - Dr. L. Boorman Monks Wood	Anglian Water Authority/ NRA
Saltings as a sea defence - to review research previously undertaken, and to study selected methods of saltings generation. 1990/92.	Halcrow	NRA
Restoration and protection of grazing marsh - investigate and model the recovery of soil, water and nutrient factors when arable land is returned to pasture also to produce a conservation strategy for dykes. 1990/93.	Wye College	NRA
Sand dune studies in East Anglia - studies on the vegetation communities on the North Norfolk coast. 1985/91.	ITE - Monks Wood	NERC

Project	Contracted To	Funding and/or Supervising Agency
Beach Feeding - provide guidance on the acceptable type, size and gradation of material for beach nourishment, including economic considerations. 1990/91.	MAFF and Crown Estate Commissioners	NRA
Protection of Britain's wetlands under national law and international agreements.	University College, London	WWF
B. IMPACTS OF CLIMATE CHANGE AND SEA LEVEL RISE		
Beach development due to climate change.	Hydraulics Research	NRA
Evaluation of tidal return periods in relation to climate change.		NRA
Sea level change and coastline response - changes in patterns of accretion and erosion with different rates of sea level change.	Environmental Research Centre, University of Durham	EC
Identifying areas and extent of land uplift and subsidence.	Environmental Research Centre, University of Durham	EC
Impacts of sea level rise - the use of GIS in management requirements and modelling; including coastline retreat and the environmental, social and economic aspects.	Environmental Research Centre, University of Durham	EC
Effects of sea level rise upon water resources - implications on surface and groundwater.	WRC	NRA
The Greenhouse Wales Project - to look at the implications of climate change (including sea level rise) for land and water resources in Wales.	UWIST, Cardiff	NRA, IoH, Met Office, Welsh Water

Project	Contracted To	Funding and/or Supervising Agency
Climate change, sea level rise and the English and Welsh coast. To study and predict the effects of sea level rise on coastal habitats in England and Wales. 1989/93.	ITE, Monks Wood	NERC
Modelling the effects of climatic change in species distribution. To predict species distribution at equilibrium with a changed climate and the dynamics of dispersal and population change for selected species. 1990/93.	ITE, Monks Wood	NERC, DoE
Effect of climate change and its implications for water resources. 1990/92 (Extension of DoE programme on climate change research).	Institute of Hydrology	NRA, DoE
Increasing storminess with the greenhouse effect.	UEA/CRU, Halcrow	
Climate change affecting Ireland - different issues (forestry, agriculture, fisheries, sea level rise).	DoE - Ireland (Republic) and University of Ulster	DoE
C. SEA DEFENCE STRUCTURES		
Sensitivity of sea defence structures to greenhouse effect - hydraulic performance in relation to sea level rise and storminess, and proposed methods of improving performance. 1990/91.	Hydraulics Research	NRA
Estimating Manual - examine data to estimate construction costs and develop manual for project appraisal and design of defence structures. 1990/91.	WRC	NRA

Project	Contracted To	Funding and/or Supervising Agency
Investigation of alternative methods of coast protection - to investigate coast protection methods that are effective but also safeguard geological features of interest. 1988/90.	Hydraulics Research	NCC
Current awareness review - examine relevant information on climate change research and the implications for sea defences - assess the European situation.	WRC	NRA
Unit costs for sea defence works - especially for progressive raising of defences and new constructions both inland and seaward of existing defences.	WRC	NRA
D. ECONOMIC		
Benefit/cost study on the value of coastal areas - investigate the values placed on low lying coastal areas and identify priorities for protection or sacrifice of coastal areas in a rising sea level scenario.	UEA and Middlesex Polytechnic sub contracted to WRC	NRA
Economic appraisal of the consequences of climate induced sea level rise - to examine the economics of alternative sea defence options in response to sea level rise, through case studies on the Anglian coastline. 1990/92	UEA - Mr. K. Turner	MAFF, NRA
Economic appraisal of the consequences of climate induced sea level rise - to examine the economics of alternative sea defence options in response to sea level rise, through case studies on the Southern coastline. 1990/92.	University of Southampton	MAFF, NRA

APPENDIX A3.5.1

TECHNICAL MANUALS FOR HABITAT CREATION AND RESTORATION

Table A3.5.1 Manuals and other Publications dealing with the Technical Details of Habitat Creation and Restoration

Authors & Date	Title & Notes	Publishers
Allen, H.H. & Webb, J.W. (1983)	Erosion Control with Saltmarsh Vegetation	Reprinted from the Proceedings of the Third Symposium on Coastal and Ocean Management. ASCE/San Diego, California, USA.
Allen, H.H., Webb, J.W. & Shirley, S.O. (1984)	Wetlands Development in Moderate Wave-Energy Conditions	Reprinted from the Proceedings of the Conference Dredging "84", Waterway, Port, Coastal and Ocean Division ASCE, Florida, USA.
Brooks, A. (1979)	Sand Dunes - A Practical Conservation Handbook	British Trust for Conservation Volunteers, Wallingford, UK.
Burgess, N.N. & Hirons, G.J.M. (1990)	Management Case Study - Techniques of Hydrological Management at Coastal Lagoons and Lowland Wet Grasslands on RSPB Reserves.	Royal Society for the Protection of Birds, Sandy, UK.
Countryside Commission for Scotland (1982-88)	Vegetation Management Coastal Vegetation Sheets:- 5.2.8 (1988) Sand Fencing Strained Constructions 5.2.7 (1988) Timber Panel Fencing 5.2.6 (1988) Brushwood Sand Fencing 5.2.5 (1988) Sand Fencing 5.2.4 (1982) Sand Stabilisation by Thatching 5.2.3 (1982) Sand Stabilisation by Spraying 5.2.2 (1987) Reseeding of Dune Pastures 5.2.1 (1985) Dune Grass Planting	Countryside Commission for Scotland, Perth, Scotland.
Coppin, N.J. and Richards, I.G. (1990)	Use of Vegetation in Civil Engineering	Construction Industry Research and Information Association, London, UK.
Environmental Advisory Unit (1989)	Review of Coastal Revegetation Techniques	EAU, Liverpool University, UK.

Authors & Date	Title & Notes	Publishers
Environmental Laboratory (1978)	Wetland Habitat Development with Dredged Material : Engineering and Plant Propogation.	US Army Corps of Engineers. Waterways Experimental Station, Vicksburg, MS, USA.
Gale, J.G. & Williams, P.B. (1988)	Integrating Tidal Wetland Restoration with Coastal Flood Basin Design : The Example of Shorebird Marsh, Corte Madera, California.	John M. Tettemer & Associates Limited; Philip Williams & Associates Limited, In : Proceedings of the National Wetland Syposium Urban Wetlands. June 1988, Oakland, California, USA.
Haltiner, J. & Williams, P.B. (1987)	Hydraulic Design in Salt Marsh Restoration.	Philip Williams & Associates, San Francisco, California, USA.
Kenworth, W.J., Fanesca, M.S., Hamziak, J., & Thayer, G.W. (1982)	Development of a Transplanted Seagrass (Zostera marina) Meadow in Back Sand, Carteret Country, North Carolina.	In: Cole D.P. Proceedings of the 7th Annual Conference on the Restoration and Creation of Wetlands.
Knutson, P.L., Allen, H.H., & Webb, J.W. (1990)	Guidelines for Vegetative Erosion Control on Wave Impacted Coastal Dredged Material Sites. *Chapters 3-6 evaluate the vegetative stabilisation alternatives for dredged material disposal areas using salt marsh plants.*	US Army Corps of Engineers. Waterways Experiment Station, Vicksburg, MS, USA.
Landin, M.C., Webb, J.W. & Knutson, P.L. (1989)	Long Term Monitoring of Eleven Corps of Engineers Habitat Development Field Site Built of Dredged Material 1974-87. *Chapters 2-12 discuss the technical aspects of eleven sites developed on dredged material.*	US Army Corps of Engineers, Vicksburg, MS, USA.
Morrison, J. & Williams, P. (1989)	Warm Spring Marsh Restoration	Philip Williams & Associates, San Francisco, California, USA.
Newbold, C., Honnor, J. and Buckley, K. (1989)	Nature Conservation and the Management of Drainage Channels.	Nature Conservancy Council, Peterborough, UK.

Authors & Date	Title & Notes	Publishers
San Francisco Bay Conservation and Development Commission (1986)	Guidelines for Enhancement and Restoration of Diked Historic Baylands.	SFBCDC, San Francisco, California, USA.
Saucier, R.T., Calham, C.C., Engler, R.M., Patin, T.R., & Smith, H.K. (1978)	Synthesis of Research Results Dredged Material Program - Executive Overview and Detailed Summary. Tech. Report D5-78-22. *Pages 105-150 summarise case studies of aquatic habitats developed on dredged material.*	US Army Corps of Engineers, Waterways Experimental Station, Vicksburg, MS, USA.
US Army Corps of Engineers (1976)	Dredging: Environmental Effects and Technology. Part 1. *Knutson, P.L. - Development of Intertidal Marshlands upon Dredged Material in San Francisco Bay.* *Holloway, L.F. - Biological Aspects of Marsh Development on Dredged Material.* *Reinold, R.J. - Creation of a South Eastern United States Saltmarsh on Dredged Material.*	Proceedings of World Dredging Conference 7th, San Francisco, California, USA.
US Army Corps of Engineers (1989)	Beneficial Uses of Dredged Material. *Chapters 4,5,7,8 discuss habitat development on dredged material in various aquatic habitats.*	US Army Corps of Engineers, Vicksburg, MS, USA.
US Army Corps of Engineers (1989)	Engineering and Design - Environmental Engineering for Coastal Protection. *Chapter 6. Non-structural Alternatives (saltmarsh creation).*	US Army Corps of Engineers, Vicksburg, MS, USA.

Authors & Date	Title & Notes	Publishers
US Army Corps of Engineers	Environmental Effects of Dredging. Technical Notes Volume II. *EEDP-07-01 (1986) Building, Developing and Managing Dredged Material Islands for Bird Habitat.* *EEDP-07-02 (1988) Wetlands Created for Dredged Material Stabilisation and Wildlife Habitat in Moderate to High Energy Environments.*	US Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS, USA.
Williams, G. & Lewis, G. (1984)	Rivers and Wildlife Handbook: A Guide to Practices which further the Conservation of Wildlife on Rivers.	Royal Society for the Protection of Birds, Sandy, UK and Royal Society for Nature Conservation, Lincoln, UK.
Zedler, J.B. (1984)	Saltmarsh Restoration - A Guidebook for Southern California.	California Sea Grant College Program, University of California, USA.