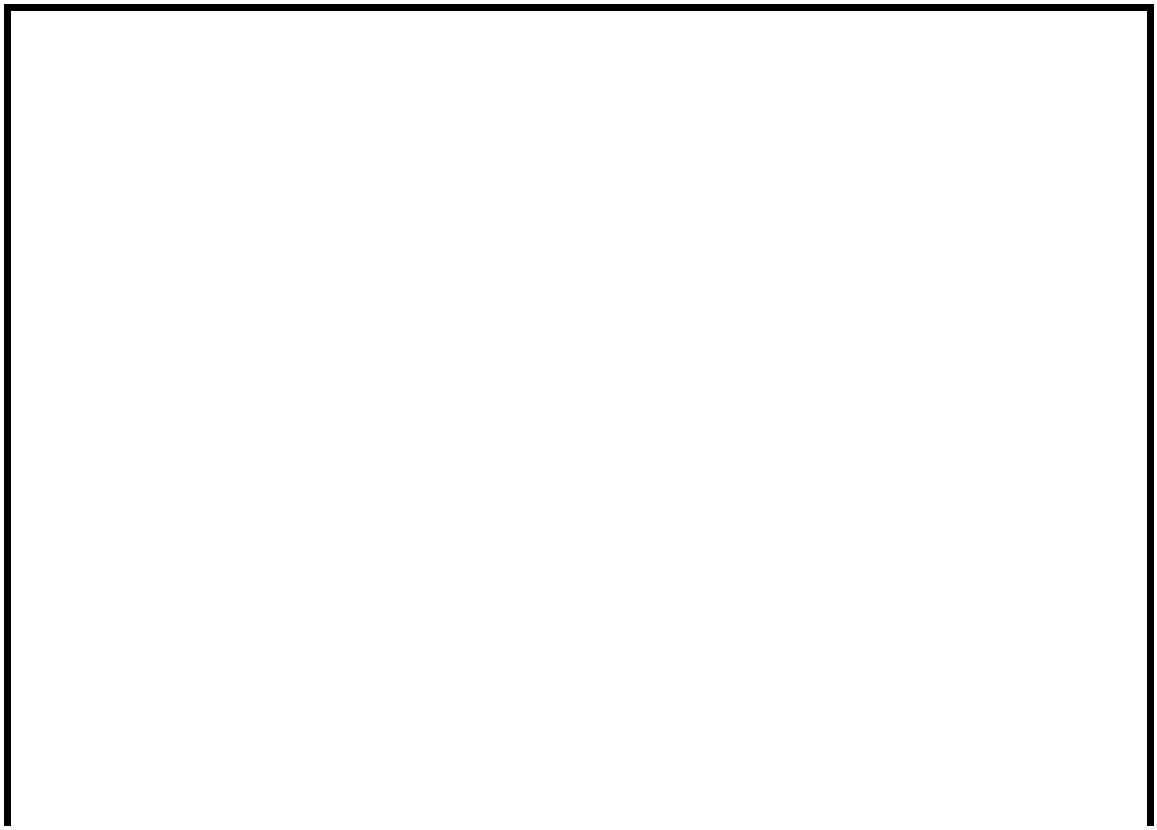
SOUTHEND-ON-SEA BOROUGH COUNCIL

SOUTHEND-ON-SEA SHORELINE STRATEGY PLAN

VOLUME ONE



FEBRUARY 1997

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DOCUMENT ISSUE REGISTER

Document Title: Southend-on-Sea Shoreline Strategy Plan

Document No: 48195/R5096

Revision/Edition Final

Date: January 1997

ISSUED TO	COPY NUMBER	DATE
Southend Borough Council	1- 7	10 February 1998
Mouchel	8	10 February 1998

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ABSTRACT

Completed in April 1997, the Shoreline Management Plan for Essex recommended that the coastal management policy for the Southend-on-Sea frontage should be to 'Hold the Existing Line'. The Plan went on to determine a number of key issues and objectives that would need to be addressed in specific detail during preparation of a long term management strategy for the frontage.

In development of this shoreline strategy plan, a number of key activities have been carried out in order to determine the condition of the existing environment and the likely developing trends of the frontage if the existing policy of reactive management is continued. Analysis of the hinterland, man made and environmental assets and condition of the existing sea defences and foreshore has led to division of the Southend frontage into a number of 'Operational Units'.

In accordance with the strategic guidelines set out by Ministry of Agriculture, Fisheries and Food (MAFF) in their paper 'Practical Consideration for Strategic Planning and Appraisal of Flood and Coastal Defence Schemes', a range of potential management options have been developed and evaluated in terms of their technical, environmental and economical viability. A long term strategic management policy has been determined as a result of these analyses and an estimated cost and programme of implementation developed.

The recommended strategy for the frontage has determined that the length termed Unit 4, stretching from the eastern side of Southend Pier to Thorpe Hall Avenue, is in need of prioritised works. A policy of 'High Investment Maintenance' is recommended, which involves detailed inspection and repair of the existing stone revetment, upgrading of the timber groynes and beach nourishment. The cost of carrying out this work is estimated to be in the order of £4.0 million. A management policy has been determined in a similar fashion for each unit along the frontage.

1.0 INTRODUCTION

The need to manage the coastal environment in a coordinated, economic and environmentally sustainable way has long been recognised. This has led to a number of initiatives aimed at obtaining baseline information, increasing our understanding of coastal processes, and the subdivision of the coastline into coherent units for future studies and management.

Research undertaken on behalf of MAFF in the early 1990's suggested that the coast of England and Wales could be divided into 11 major sediment cells as shown in Figure 1.1. Each cell is defined as "a length of coastline which is relatively self-contained as far as the movement of sand or shingle is concerned and where interruption to such movements should not have a significant effect on adjacent sediment cells." These units form the starting point for an analysis of the coast, however generally they have been subdivided for practical purposes into sub-cells.

The sub-cells then form the basis for individual Shoreline Management Plans (SMP). These SMP set out the basis for sustainable coastal defence policies and the objectives for the future management of the shoreline.

The main objectives of a Shoreline Management Plan are:

- To improve understanding of the coastal processes operating within the sediment cell;
- To predict future coastal evolution;
- To identify key assets which are likely to be affected by coastal change;
- To identify environmental enhancement opportunities;
- To determine information shortfalls;
- To assess strategic coastal defence options;
- To select a preferred coastal defence strategy;
- To facilitate consultation between those bodies with an interest in the shoreline;
- To achieve a consensus over the management of the shoreline;
- To inform the statutory planning process;

The SMP process involves a review and analysis of the available data leading to the further subdivision of the sub cell into coastal process units. These are defined by coherent coastal and geomorphological processes, which are then further divided into management units dependent on the land use, defence and other characteristics. Management strategies are then assessed and identified for each of the management units, based on the four generic options defined by MAFF as:

- Do Nothing

- Hold the Existing Defence Line
- Advance the Existing Defence Line
- Retreat the Existing Defence Line.

The Southend-on-Sea study area falls into:

- Sediment Cell 3
- Subcell 3d
- Coastal Process Unit 1
- Management Unit 1g.

The most sustainable management strategy identified for the Southend-on-Sea frontage which runs from Leigh-on-Sea to Shoeburyness/Maplin Sands, has been determined in the Essex SMP as Hold the Existing Defence Line. The SMP does not however identify how this strategy is to be implemented.

To build upon the structured approach to the development of economic, environmental and practical management strategies, draft guidelines were produced by MAFF to undertake 'Practical Consideration for Strategic Planning and Appraisal of Flood and Coastal Defence Schemes" in May 1997.

The purpose of the Shoreline Strategy Plan is to build upon the appraisals undertaken during the SMP and to focus on practical means of achieving the preferred management strategy identified in the SMP. The study looks in greater detail at the engineering, economic and environmental constraints associated with various defence systems. This leads to the selection of an appropriate defence strategy which will achieve the management objective, whilst taking into consideration wider impacts and implications.

The next phase, arising out of the Shoreline Strategy Plan, will be the development of detailed proposals and the undertaking of additional targeted studies with full Environmental Assessments, as required. This will then lead to the development of schemes for construction, management and monitoring to maintain the required level of coastal defences, in line with the SMP guidelines.

2.0 PURPOSE OF STRATEGY

2.1 Introduction

The Essex SMP, completed by Mouchel Consulting Limited in April 1997 examined the physical, environmental and engineering constraints affecting each of the designated management units along the Essex coastline. Objectives for sustainable future management policies were developed and a conclusion reached for the preferred coastal defence policy within each unit.

In accordance with MAFF guidelines, the strategic approach to coastal management is a natural progression of the SMP. The Shoreline Strategy Plan will adopt the conclusions reached in preparation of the SMP and focus in more depth upon a particular management unit within the sub cell. Designed to be proactive rather than the more traditional ad hoc reactive response to flooding or breach events, the strategy will consider the coastal objectives and provide a high level basis upon which individual schemes can be based.

Following completion of the Essex SMP, Mouchel Consulting Limited were commissioned in June 1997 by Southend-on-Sea Borough Council to prepare a Shoreline Strategy Plan for the designated management unit 1g. This unit covers the extent of frontage within their jurisdiction between Leigh-on-Sea and North Shoebury and is shown in Figure 2.1.1. and 2.1.2.

This Shoreline Strategy Plan examines the extent of the problem within the unit in terms of existing conditions and considers the economic, environmental and technical viability of various possible management options. A further round of consultations has been carried out to determine key issues which may play a part in the assessment of these options. Identification of a preferred strategy comes as a result of these investigations and leads to the development of a suggested construction sequence to ensure prioritisation of the necessary improvements.

2.2 Adoption of a Strategic Approach

The Essex SMP concluded with numerous objectives for the future management of management unit 1g. These objectives are discussed in more detail in Section 3 of this report. To examine these objectives further, Southend-on-Sea Borough Council commissioned Mouchel Consulting Limited to produce a Shoreline Strategy Plan for the unit. Although the Borough Council has historically been responsible for the execution of capital works on the coastline, the Environment Agency have expressed an interest for involvement in the production and development of the plan.

A strategic approach to the unit is considered necessary for the following reasons;

- the coastline extends for a length of over ten kilometres and contains sections maintained by separate parties. Within this unit, 9.5 kilometres are maintained by Southend-on-Sea Borough Council who have expressed concern about the lowering of foreshore levels, general deterioration of the defences and the inherent consequences of these processes.

- The coastal defences protect a hinterland highly developed in terms of tourism and commerce which Southend relies on heavily for a significant proportion of its income and employment. These defences are in varying states of deterioration and will require enhancement over a long time scale.

- Rising sea levels are creating increasing pressures of coastal squeeze on the foreshore and intertidal flats, many of which lie within internationally, nationally and locally designated areas of nature conservation importance. In addition there is a conflict of interests over the mudflats, concerning the interaction between recreational users of the estuary and nature conservation interests

- The physical processes within the Thames Estuary are creating a complex interaction with the Southend foreshore.

A strategic approach to this unit will enable the production of a management plan or framework to consider the extent of these issues within a long time scale, and determine a programme for the implementation of necessary improvement works.

2.3 Development of the Shoreline Strategy Plan

In developing the Shoreline Strategy Plan the following elements of work have been carried out;

Identification of the Problem

To develop an understanding of the physical, environmental and engineering constraints facing the coastal defences in the unit, it was necessary to gather data on the existing situation. This has been done through a number of key activities;

Existing Defence Condition Survey:

The MAFF coast defence survey examined the defences and provided a basic condition assessment. This survey has been developed and supplemented with a more substantial survey, including an investigation of ground conditions at each of the locations considered critical following the initial condition survey. The survey carried out as part of this strategy plan has identified the type and condition of defence in each of the sections defined in the MAFF survey, and thus led to an understanding of the possible failure mechanism of each section. The results of these investigations have been summarised in Section 4.3 of this report, with a more detailed discussion given in Appendix A.

To complement this condition survey, a site investigation was carried out in order to more fully understand the foundations and extent of the defences. This information has also been used in the appraisal of the defence standards.

Review of Beach Movements:

The Environment Agency has been carrying out a series of twice yearly beach profile monitoring surveys along the Essex coastline since 1993. The data from these surveys has been collated and for each location merged to provide a picture of how levels in the estuary have varied over recent years. Previous coastal scheme construction drawings, indicating surveys of the Southend foreshore, have been obtained from the Borough Council archives. Where survey information from locations correlating with existing regular monitoring locations have been found, they have been converted to a common datum and added to the Environment Agency data. This provided a comparison of levels over a longer time period. Historical Ordnance Survey drawings and mud flat evolution have also been examined. The results of these investigations are discussed in Section 4.4 of this report. The graphs obtained through merging the data are contained within Appendix B.

Coastal Processes Appraisal:

In 1986 a comprehensive hydraulic study was carried out by HR Wallingford at the site of a proposed marina at Southend-on-Sea. The study was undertaken to investigate the potential impacts on the near shore processes of a large marina and land reclamation. The results of this study have been revisited and supplemented with other available research and literature on coastal processes in the inner and outer Thames Estuary. Using the results of the study and data search, an appraisal of the potential impacts of beach management options on physical processes has been produced. The results of these investigations is discussed in Section 4.5 of this report.

Extreme Wave and Tide Conditions:

To form an analysis of potential flood damage it has been necessary to assess the statistical risk of extreme sea states. Using existing wind data collected from the anemometer station at Shoeburyness, it has been possible to hindcast wave height and predominant direction, which has then been compared against existing wave data measured off Maplin Sands. This information combined with forecasts of extreme water levels (including sea level rise) has been used to provide joint probabilities of extreme conditions. This information was then used to gauge the likely failure scenario of the existing defence and determine existing defence standards. The results of these investigations are summarised in Section 4.6 of this report. The full report is included in Appendix C. Appendix D contains the calculations developed during the overtopping analysis, carried out during the appraisal of the defence standards.

Ground Levels and Property Damage Risk:

To enable an economic analysis of the potential cost of flood damage it has been necessary to consider the topography of the hinterland and develop an understanding of the low lying areas most at risk from flooding. The land use of areas within the flood zones have been determined and an assessment made of their value and the risk of flooding. This information has been used to determine the effects of adopting a "Do Nothing" policy and the consequences of a long term continuation of this policy have been examined. The results of these investigations are discussed in Section 4.7 of this report.

Evaluation of the Existing Situation:

The existing Borough Council management policy for the frontage has been examined and has led to the development of a scenario of "continuation of existing policy" or "to minimum". A discussion of the existing management policy is included within Section 5.0 of this report.

Through identification of the problem and key issues affecting the frontage, the series of objectives developed in the SMP have been re-visited and the potential for adoption or solution of these objectives within this report considered.

Appraisal of Management Options

Selection of Options:

Once the extent of the constraints affecting development of the coast have been made, a range of management options can be determined. These options are selected to cover a range of investment levels (Do Nothing, Do Minimum, Minimum Investment Maintenance etc.) and consider potential solutions for protection of the coast in line with the objectives developed in the SMP. The selection of these options is discussed in Section 7 of this report and considered with regard to the following elements;

Engineering Appraisal of Options:

The engineering practicalities or 'buildability' of each option is considered and an outline cost of capital construction and maintenance developed. To determine maintenance costs, an appraisal of the likely impact of the works on beach movements is made. The engineering appraisal of these options is discussed in Section 8 of this report.

Strategic Environmental Assessment/Public Consultation:

The Essex SMP gave consideration to the environmental constraints affecting the Essex coastline and focussed briefly on the Southend management unit, 1g. Key parties involved in the development of the foreshore were consulted and offered an opportunity to comment on the future management strategies.

This consultation process has been complemented with a further strategic consultation designed to focus in more depth on the Southend foreshore. The consultation process selected the parties with particular interest in the management and development of the shoreline and requested further comments and views on the management options suggested, together with any further issues of particular relevance to the Southend frontage. The result of these assessments has been used to assist in the process of identification of the preferred options.

In addition to this, a Strategic Environmental Assessment has considered the Southend foreshore in detail, highlighting the particular constraints and key issues. This assessment has been used in determining the management options and examining the potential impact of each of the scheme options upon key environmental interests. The impact of the preferred strategy on the local environment has also been examined and outline mitigation measures to offset potential adverse inputs identified.

The strategic environmental assessment of the management options is discussed in summary in Section 6 of this report. The full strategic environmental assessment is contained within Appendix F.

Economic Analysis of Options:

An estimation of scheme costs including an element for maintenance has been made for each of the management options over the designated period of fifty years. In accordance with MAFF's Project Appraisal Guidance Note (PAGN), scheme costs for a range of defence standards have been compared against the value of damage avoided. The result of this analysis has led to the identification of the most economically advantageous scheme option and the most appropriate defence standard. This economic analysis is discussed in Section 7 of this report, whilst the full cost build up is included in Appendix G.

Identification of Preferred Strategy

Full economic appraisal of each of the management options and defence standards in accordance with PAGN has led to identification of the preferred strategy. This identification has taken into account the engineering and environmental aspects of the analysis and is considered to represent the optimum solution to the shoreline strategy. Implementation of this strategy is likely to take a number of years and consequently a construction sequence has been developed. This sequence has taken into account the periods required for monitoring the impacts of the early implementation works and considered the available budgets and grant monies.

3.0 ESSEX SHORELINE MANAGEMENT PLAN

3.1 Introduction

In January 1995 Mouchel Consulting Limited were commissioned by Tendring District Council, as lead authority in partnership with the Environment Agency (Anglian Region), Maldon District Council, Rochford District Council and Southend-on-Sea Borough Council, to produce a Shoreline Management Plan for the Essex coastline sub-cell. The final published version of the SMP was completed by Mouchel in April 1997. Figure 3.1 shows the extent of coastline covered by the SMP and the management units within it.

The Essex sub-cell extends over 440 kilometres from Mardyke in the Thames Estuary to the River Stour near Harwich, and forms part of the Anglian coastal cell (number three) extending from the River Thames to the Wash.

The Essex sub-cell 3d was divided further into management units. Management unit 1g was defined as the length of coastline between Leigh-on-Sea and North Shoebury/Maplin Sands. This length covers the Southend-on-Sea frontage, the subject of this Shoreline Strategy Plan. The SMP considered the physical, environmental and engineering constraints of future management policies within this length and concluded with a preferred coastal defence policy.

Issues discussed within the SMP concerning Coastal Processes/Coastal Defences and the Natural, Human and Built Environment, are considered in depth within Sections 4 and 6 of this report respectively. The following points provide a summary of further constraints and key issues highlighted within the SMP affecting the Southend-on-Sea frontage.

3.2 Planning

The principal planning issues within the unit are contained within the Southend-on-Sea Borough Local Plan. In particular the Borough Council see the promotion of recreation and tourism facilities as a key aspect within the regeneration of the seafront and the revitalization of the Pier. Any development of the frontage would consequently need to consider existing facilities and the means by which these facilities could be maintained or upgraded. A discussion of the particular planning issues concerning the foreshore is contained within Appendix F, the strategic environmental assessment.

3.3 Land Use

The principal land use within the unit is centred around commerce and tourism. The population of Southend has grown to 167,500, making it the largest town in Essex. It provides shopping facilities for over 320,000 people living in south-east Essex. The Central Seafront Area is located within the centre of the frontage and contains most of Southend's tourism facilities, including the Pier.

The majority of the frontage is open esplanade used for tourism and smaller commercial outlets catering for tourism. Facilities include bowling greens, toilet blocks, launching slipways for water crafts, cafes and open lawns areas.

3.4 Consultation Issues

The following issues were collated on a unit by unit and a county wide basis through five stages of consultation during preparation of the SMP. It should be recognised that although these issues represent the concerns, perceptions and ideas of the consultees regarding the coastal zone, some of the issues raised cannot be directly addressed by the SMP; such issues may be more appropriately addressed through Catchment Management Plans (LEAPs) or Estuary Management Plans (EMPs).

The first part of the following list of key issues consider the points directly relating to the Southend frontage and foreshore; the second part covers the Thames more generally and they are reproduced here to enable a wider view of the issues concerning the unit.

A further consultation was carried out as part of this Shoreline Strategy Plan. A summary of the results of this consultation can be found within Section 6 of this report, whilst full collation of the results is contained within Appendix E.

- The Southend foreshore, part of which is a Local Nature Reserve (LNR), is particularly subject to intense recreational pressure and despite the introduction of controls on water use, there remains the potential for conflicts with nature conservation interests. There is a need to reconcile the needs of the economy of the area with nature conservation interests.

- A fire seriously damaged Southend Pier in the summer of 1995. Proposals for replacement buildings are currently being discussed.

- South Essex Natural History Society feel that water sports and deepwater berthing would be unsuitable at Southend within the SSSI area.

- Leigh Seafront Action Group have identified a number of issues along the Thames:

  - prevent foreshore development and intrusion into the sea and mudflats;
  - restore eroded saltings;
  - provide a cycle route from Benfleet station to Shoeburyness;

- The Shellfish Association of great Britain suggests that suction dredging for cockles is not always damaging to the grounds, particularly mobile sands in exposed sites, as demonstrated in the Thames where this has been practised for twenty years.

- There are concerns regarding the commercial harvesting of fish which may deplete stocks and the pollution problems experienced by shell fisheries particularly on the Southend oyster beds.

- All sections of the fishing industry, based at Leigh-on-Sea, are encountering increasing seaward access difficulty relating to a continual build up of silt in Leigh Creek.

- The Port of London Authority Chief Harbour Master is developing a recreation strategy and should be consulted about any proposals related to increased activity in the Thames.

- The Thames Estuary Management Plan makes recommendations for a greater understanding of physical processes in the Thames.

3.5 **Objectives**

Increasing pressures from channel dredging and the rising sea levels have led to considerable erosion of the intertidal flats west of Southend Pier. Furthermore, saltmarshes to the west of this unit are being lost through coastal squeeze. The stabilised sands at Gunners Park at Shoeburyness (TQ930840) are a critical asset within the Southend frontage and are defined as an area of Critical Natural Capital. A principal objective of any development within this unit is to protect such valuable areas.

Defined in the SMP, the principal objectives for this unit are:

- Provide effective defence for people and property (including agricultural land) against flooding and erosion, where economically, technically and environmentally justifiable and sustainable.

- Defend urban and developed areas.

- Defend Critical Natural Capital such as the sand dunes at Gunners Park.

Secondary objectives are:

- Seek to sustain Constant Natural Assets such as saltmarshes and intertidal flats, ensuring conservation of the overall habitat resource of Constant Natural Assets within the Thames estuary.

- Assist and promote the development of a long term sustainable dredging policy for the Thames which sustains critical processes and meets environmental objectives.

- Support tourism and leisure at Southend-on-Sea.

- Seek to minimise recreation and conservation differences (eg. Boat movements and speed) in areas such as the Southend foreshore.

- Continue to safeguard all Conservation areas, Grade 1 listed buildings and scheduled Ancient Monuments.

- Continue to support the fisheries at Leigh-on-Sea and Southend-on-Sea.

- Continue to support the cockle industries at Leigh-on-Sea and Southend-on-Sea providing that harvesting methods do not prejudice the integrity of intertidal habitats and sea defences.

3.6 **Preferred Coastal Defence Policy**

The coastal defences along the Southend frontage protect the urban areas of Southend-on-Sea from Leigh-on-Sea to Shoeburyness from erosion and flooding and to a certain extent retain the beaches for which Southend is famous. A breach in these defences would result in flooding of a considerable area, causing damage to property and

disruption to services. Furthermore there would be a disruption to the tourist industry, an industry upon which Southend bases a large extent of its income and employment. The defences also protect Gunners Park, which is classified as an area of Critical Natural Capital. There is consequently a large enough benefit to ensure that the existing defences can be justified in the long term.

The four generic coastal defence options were tested and ranked against the unit objectives using the Strategic Coastal Defence Options Matrix. It was found that the preferred option for the frontage was to "Hold the Existing Defence Line".

3.7 Future Development

The recommended defence policy for management unit 1g is to "Hold the Existing Defence Line". Consequently the long term sustainability of the defences will be subject to the development of a sufficient understanding of the morphodynamics of the Thames Estuary. It was recommended that numerical models of the estuary be developed, requiring measured wave, current, water level, sediment and bathymetric data for calibration and for the provision of boundary conditions.

Coastal squeeze as a result of rising sea levels will mean that the inter tidal flats are put under increasing pressure. It is well documented that the long term natural response of estuaries to sea level rise is to widen and shallow. The hard defences along either side of the estuary in this area will prevent this natural process from happening.

Along with nearby Maplin Sands, the Southend flats (now designated a Local Nature Reserve) provide sufficient areas for waterfowl to rank this as one of the most important in the country. Whilst the mudflat areas to the west of the pier have suffered significant erosion over the past century, there is some evidence available to suggest that to the east they are accreting. As a consequence, this scenario may mean that the total area of mudflat available to the wildfowl will be sustained in the short term.

It is recommended that sufficient monitoring of these flats be carried out to enable analysis of the rate of change to be made. The present bathymetric monitoring of the flats by the Environment Agency should be supplemented with regular aerial photography and monitoring of the wild fowl populations.

3.8 Conclusions

In conclusion, the Essex SMP determined that for management unit 1g the preferred option for the frontage was to "Hold the Existing Defence Line". In accordance with this policy, the SMP highlighted a number of key issues which should be considered as integral to the development of a strategic plan for this frontage.

The issues that can be directly addressed within this Strategy Report are summarised as follows:

- the need for effective defence for people and property against flooding and erosion.
- the need for protection of the existing natural and man made assets and measures to induce restoration of lost assets where possible.
- the need to address the problem of Leigh Creek silting up.
- the need for additional studies to further understand the natural processes within the estuary and monitoring of the existing situation.

The following issues raised in the SMP should be addressed as a consequence of scheme plans to improve the standard of defences, taking opportunities of development to enhance the local environment and resolve outstanding issues;

- the promotion of recreation and tourism facilities along the frontage.
- the need for a reconciliation of differences regarding the use of the foreshore for the economy of Southend and nature conservation issues.
- the need to support the sustainability of the fishing industry where good practice is carried out.
- promotion of the development of a long term sustainable dredging policy for the Thames.

4.0 IDENTIFICATION OF PROBLEM

4.1 Introduction

In order to develop a thorough understanding of the environmental, physical and engineering constraints facing development of the shoreline at Southend, it was necessary to carry out an assessment of the existing conditions. This assessment has examined the following aspects:

- history of the frontage including details of any recent flooding events.
- condition survey of the existing defences, including examination of ground (foundation) conditions and crest level, and a general examination of the beach management systems.
- strategic appraisal of coastal processes in the Thames Estuary and Southend foreshore.
- a statistical assessment of extreme wave and water level conditions affecting the frontage.
- an outline strategic environmental assessment of the constraints facing development options on the Southend foreshore.

These investigations have been used to determine failure mechanisms and the likelihood of failure for each section of defence, and ultimately the defence standard for the different lengths along the front.

4.2 History of Southend-on-Sea frontage

Sea defences along the Southend frontage have been in existence for at least the past hundred years with timber groynes and breastwork preceding even that. Figure 4.2.1 appears to show that the existing pitching stone revetment and promenade were already established alongside the old Palmeira Towers in May 1905.

It is known that the current seawall defences were constructed along Chalkwell and Westcliffe esplanades by the Victorians around the turn of the century. Figures 4.2.2 and 4.2.3 show the actual construction of the seawall, whilst Figures 4.2.4 and 4.2.5 show the seawalls and beach in use and the typical foreshore levels at the time. In particular, Figure 4.2.5 indicates that the foreshore levels were three blocks, or approximately 0.9 metres from the top of the coping level. At present the levels are about six blocks or 1.9

metres below the coping, indicating a drop in levels over approximately 100 years of nearly one metre.

Over the past century there have been two major flood events that have received particular recognition. Figure 4.2.6 shows the approximate extent of flooding in the Essex area on the night of 29th November 1897.This figure indicates that flooding occurred in the areas around Old Leigh, along Western Esplanade and at East Beach. In 1952 the great flood of the east coast also caused flooding to the Southend area, causing more extensive flooding to Old Leigh and Western Esplanade once again, but also relatively far in land at Southchurch and Shoeburyness. The extent of this flood can be seen in Figure 4.2.7.

In recent years there have been several flood events of a relatively minor nature along the frontage but that have been consistent with previous flood events. Old Leigh and sections of the Cinder Path and the revetment fronted length of Western Esplanade occasionally overtop and cause flooding to restricted areas. The defences along the Southchurch/Thorpe Bay frontage have now been raised to a height sufficient enough to prevent overtopping on all but the most extreme of events.

The pitching stone revetment along Eastern Esplanade to the east of Southend Pier is in very poor condition and has suffered collapses of varying degrees in the past decade. The last collapse in 1995 exposed a series of columns and arches supporting the crest wall. Should a collapse in this area occur again it is likely that erosion could remove the fill material beneath the arches and provide a direct link with the low lying land to the rear of the defences. The exposure of these arches and the collapse in general, indicating the voids beneath the revetment, can be seen in Figure 4.2.8.

In 1994 a collapse of the brick faced wall along Western Esplanade occurred, exposing the early form of precast concrete blockwork behind. Whilst this collapse was in no way as serious as the collapse in the revetment, it does indicate the fairly fragile nature of this and other similar sections of wall along the front. Photographs of this collapse can be seen in Figure 4.2.9.

4.3 **Condition Survey**

4.3.1 Introduction

The MAFF Coast Protection Survey carried out in the early 1990s and subsequently updated in 1996, provided a brief assessment and categorisation of the coast protection works maintained by Southend-on-Sea Borough Council. The survey divided the frontage into sections, each section covering one length of a particular form of protection works, and provided information on the type and construction of protection works within each section and the condition and residual life of the works. It also made an assessment of the condition and level of the foreshore.

To enable a thorough understanding of the current situation along the frontage, an extensive condition survey was carried out to supplement and update the MAFF survey. This survey comprised of a visual inspection of the defences to examine the structural integrity of the works, the extent of erosion or undermining to the toe of the structure, and the condition of the foreshore including any timber groynes. To supplement this inspection, a review of all available Borough Council engineering design drawings for the frontage was made. This review enabled a more comprehensive understanding of how and when the structures had been constructed, which in turn helped in the assessment of why the structure had deteriorated in a particular manner.

4.3.2 Survey Boundaries

Within the stretch of coastline covered by the management unit 1g, several lengths are maintained by different agencies: the Ministry of Defence (MOD) are responsible for the coastline to the north east of the Borough Councils section known as ÖEast BeachÖ (the south western boundary delineated by the piled structure known locally as 'the Boom'), and also maintain a stretch around the point at Shoebury Ness. The MOD land is strictly inaccessible to members of the public without special permission and consequently these sections have not been considered as part of this survey.

To the west of Southend-on-Sea, Rail Track maintain the length of frontage adjacent to the railway line known as Öthe Cinder PathÖ. There is a public footpath along this section of the frontage and so although not part of the responsibilities of the Borough Council, an assessment of the frontage along this section was made for completeness.

4.3.3 Visual Inspection

The visual inspection of the defence works was carried out at low water on 10 and 11 July 1997. To supplement this inspection, on 24 and 25 September 1997 a further investigation was made to inspect the ground and foundation conditions at susceptible locations along the front, highlighted following the initial survey.

Photographs and cross sections taken during the investigation have been included within Appendix A.

To provide additional information on the crest level of the defences, a levelling survey was carried out along the frontage. The results of this survey are shown in Figure 4.3.1. and in more detail in Appendix A.

The following discussion is a general summary of the defence condition found. Whilst Appendix A considers the frontage in similar terms to the MAFF survey, for simplicity here the frontage has been divided into three sections:

i) East Beach

The East Beach section covers the length of frontage between the MOD sections east of Shoeburyness and can be divided into three distinct parts:

· Remnant dune systems of sand and shingle with brick debris form the frontage along five hundred metres of this section. There are isolated areas suffering from erosion, but on the whole the existence of a stable floral environment suggests that retreat of the line is minimal. The foreshore fronting the remnant dunes is predominantly sandy with shingle but also contains a significant quantity of waste brick rubble from the former local brickworks. The foreshore levels are relatively high, reducing exposure of the dune face to wave action only during extreme events.

· A two hundred metre long rock revetment forms the protection to an exposed dune system west of the exposed dunes. The revetment is stable and appears to be encouraging the build up of beach levels.

· The George Street/Rampart Street frontage consists of concrete and sheet piling defences for approximately one hundred metres of the frontage. The defences have been constructed at different times and consequently are in varying states of repair. On the whole the concrete capping beams are in good to moderate condition. A short flight of five concrete steps has suffered major pitting and

exhibits some cracks. Some of the sheet piling exposed to regular wave action is showing signs of moderate corrosion. Fronting Rampart Street is a concrete bastion which helps to protect the front face of a steep dune face. The seaward toe of this concrete bastion has been undermined through lowering of the foreshore, exposing the supporting piles beneath. West of the bastion between the bastion and the MOD. fence is a short length of rock revetment which again protects the toe of the dune face and is in good condition. There are two relatively new timber groynes in this section, built when the concrete bastion was repaired following a previous collapse. These groynes are in good condition but do not appear to be having much effect,

Conclusions

At the western end of this section the foreshore is at a much lower level than at the eastern end, most probably due to the hard reflective nature of the defences combined with the location on the eastern tip of Shoeburyness. This lowering of the foreshore has led to undermining of the toe of the bastion and exposure of some of the pile tops. The bastion is in good condition at present but will deteriorate and become increasing more unstable if the lowering of foreshore levels continues.

The rock revetment will adjust to fluctuations in beach level, possibly leading to a destabilisation of some rock units.

The dunes along the eastern section are protected only by the relatively high level of the foreshore. No data is available at present to determine the rate of erosion, although this rate will ultimately determine the level of protection required along the dunes.

ii) *East of Southend Pier*

This section covers the length of frontage between Shoeburyness Point and Southend Pier, a distance of approximately five kilometres. This length can be broken into four sections:

· Nine hundred metres of frontage to the west of Ness Road slipway is protected by a reinforced concrete crest wall, which is fronted with a sloping revetment inset with precast concrete slabs. The wall and revetment are both in good to as-built condition. At the eastern (down drift) end of the section the foreshore levels are high. Further west this level drops, exposing the toe wall of the revetment. For one short length, a line of rock armour has been placed seaward of the toe wall and the top of this rock is exposed in places.

- The majority of this length, comprising 1200 metres, is protected by a near vertical concrete wall, topped by precast concrete coping blocks. The exposed vertical height on the seaward side ranges from 2 to 3 metres and the foundation piling is exposed for short lengths. The surface of the wall has been rendered at some point and this is now cracking away from the wall, although this does not detract from its integrity. The foundations of this wall were investigated and found to extend up to 1.5 metres below the present foreshore. Despite the low foreshore levels at present, the depth of the foundations, the general form of construction and the condition of the wall generally indicate that the structure is stable. A cross section of the wall taken during the site investigation can be seen in Figure 4.3.2.

- Between the Stone Bastion at Lynton Avenue and the Corporation Loading Pier, the frontage is protected by a revetment comprising large cobble stones jointed using tar pitching. Over time, the jointing material has weathered and receded from the surface of the stones, allowing water and wave action to work some cobble stones loose. Further weathering of the stones has allowed water to penetrate behind the stones and remove fine bedding material. This has led to a general deterioration of the revetment and repairs are now carried out on a regular ad hoc basis as collapses occur. The toe of the revetment is generally buried beneath the foreshore but is exposed at certain locations. The extent of voids present beneath the revetment is unknown but is considered to be a major factor in determining the integrity of the defence.

- Between the Corporation Loading Pier and Southend Pier, the frontage is protected by an Essex block revetment. Although the revetment is generally in good condition with minor weathering to the top surface of the revetment, there are several areas where missing Essex blocks have been replaced by mass concrete. Furthermore, there are areas where settlement or loss of the fill material within the embankment, or consolidation of the foundation, has led to deformations in the surface of the blocks. These deformations occur within the upper half of the revetment where the blocks are not bedded on concrete. As with the previous section, it is considered that voids are likely to exist beneath the surface of the revetment.

There are timber groynes along the full length of this section and on the whole they are in good condition, tending to deteriorate further westwards. In places the groynes/bays are full to capacity yet the low level of the groyne crests prevents the build up of a significant beach level. In other locations there are missing planks and split king piles etc, allowing sediment to pass freely along the foreshore.

Conclusions

To the eastern (down drift) end of this section the foreshore levels are high, protecting the defences. The concrete wall defences at this end of the section are in a good to as-built condition. Towards the centre of the section where the defences are provided by the near vertical concrete walls, the foreshore has lowered, leading to increasing exposure of the wall to wave attack. At present however, it is considered that the wall is in good condition and is stable.

The revetment defences to the western end of the section are in a poor state of repair. Concrete and asphalt repairs to the surface of the revetment have spalled away, loose stones have been removed and are allowing removal of fine material from beneath the revetment. The presence of large areas of voids is anticipated (although their extent is unknown) and it is considered that these will lead to a more rapid deterioration over time. The Essex block revetment is also suffering from consolidation of its foundation and loss of fill material. This has led to minor collapses in the past and there are many signs of deterioration of the surface of the revetment where settlement has occurred.

The timber groynes along this section are suffering from undersizing and general deterioration at the western end, both cases are allowing too much sediment movement along and away from the beach.

iii) *West of Southend Pier*

This section covers the frontage around Southend Pier and from the west of the pier to the cockle industry yards in Leigh-on-Sea. In general the defences are of similar construction to that on the east of the pier and can also be divided into four main sections;

· Around the landward base of Southend pier and for approximately 1500 metres west of the pier, the defences are provided primarily by a sloping revetment topped with a crest wall.

  Around the base of pier the revetment consists of concrete blockwork at an approximate slope of 1:2.5. The slope is topped by a brick flood wall in good condition. The blockwork in particular has been subject to several large areas of block removal and minor collapse, indicated by the number of different patches applied to the surface of the revetment. The toe of the revetment enters the mud flats directly, there being no beach/foreshore of any description around the base of the pier.

Westwards along Western Esplanade the revetment consists of stone pitching in particularly poor condition. The asphalt jointing material has weathered significantly allowing wave action to work a number of blocks loose, leading to their eventual removal. Wave draw down will also lead to the removal of fines from beneath the surface of the revetment, ultimately leading to collapse. Large areas of the revetment surface are covered with emergency repairs of mass concrete.

A ground investigation trial hole along this length determined that the revetment extends for a total length of 12 metres, including 2.5 metres beneath the current foreshore levels. Figure 4.3.3 shows the cross section and ground conditions at the trial hole location.

- Between Holland Road and Chalkwell station, for a distance of approximately 1600 metres, the defence line is provided by a precast blockwork sea wall. The sea wall has been in place since at least the early 1900's and despite having collapsed in one location, is generally in good condition.

  Along the eastern section of this length, the foreshore levels are low, on average 2 metres beneath the wall crest. A trial hole dug at Crowstone Point found there to be a depth of sand/shingle of only 0.5 metres above the clay stratum. Other sections taken along this length found the sand/shingle layer to be only 0.3 metres thick. These sections are shown in Figure 4.3.4.

  The crest level along this section of wall is at a general level of 4.1 metre ODN.

  Further west towards Chalkwell station the foreshore levels rise to within 0.9 metres of the wall crest, yet in this location the sand layer was still found to be only 0.5 metres thick.

- West of Chalkwell station, maintenance of the defences becomes the responsibility of Railtrack, where the main London Tilbury and Southend railway line skirts the edge of the estuary. This length extends for 1050 metres between Chalkwell station and Bell Wharf at Leigh-on-Sea.

  Along this length the defences comprise pitching stone revetment, mostly covered in asphalt following Railtrack's last maintenance programme. In exposed locations, the pitching stone revetment is in poor condition, with numerous areas of loose or missing stones. Furthermore, in certain locations the foreshore levels have dropped beneath the toe revetment, exposing the sublayer to erosion.

The crest level of the revetment is approximately 4.4 metres ODN, yet flooding of the railway line is reputed to be rare.

A number of boat clubs have their timber frame decked storage facilities along this length and the foreshore contains a large number of moorings.

· At Leigh-on-Sea the defences become hard vertical structures of concrete or steel sheet piling to facilitate boat movement and mooring along Leigh Creek. The defences along this section are generally in good condition. The crest level of some of the defences is at 4.7 metres ODN, although occasional flooding of the old town has been reported.

4.4 Review of Beach Movements

4.4.1 Introduction

Since 1993 the Environment Agency have been carrying out a series of twice yearly beach profile monitoring surveys. This is part of their continual appraisal of foreshore levels along the Essex coastline. The surveyed profiles consist of a series of points for which the national grid reference and reduced level are given. The datum for the reduced levels is the Ordnance Datum at Newlyn and the front face of the sea defence structure is the zero chainage for the profiles. The profiles give information on levels for varying distances both behind the sea wall, and out across the foreshore. When plotted, the points provide a cross section of the foreshore at the profile location.

Within the Southend-on-Sea Borough Council frontage, regular profiles are taken at 13 locations as indicated in Table 4.4.1, where ÖSectionÖ refers to the length of protection works as designated in the MAFF Coast Protection Survey.

At all locations, beach levels for the periods September 1993, August 1995 and January 1997 have been compared to provide a representative picture of fluctuating foreshore levels in the estuary. At locations 4,6,7, and 9-11, the EA profiles have been complemented with cross sections taken from Council drawings. Although the Council's sections are not complete across the full width of the foreshore, the profiles available allow present day beach levels to be compared with those from the 1960s and 1970s. In most cases however, an exact location for the Council drawings is not provided, and their inclusion within the EA profiles must be taken only as indicative. Table 4.4.2 provides information on coincidental EA and Council cross sections. A full set of merged profiles is included in Appendix C.

To analyse the beach movements, the Southend foreshore has been divided into three sections, East Beach, East of Southend Pier and West of Southend Pier. For each section the movement has been considered at three locations; adjacent to the seawall, up to 100 metres offshore of the seawall and the full extent of the survey profile across the estuary.

The following points result from the merged profiles within each of these sections.

Whilst these graphs can be used to compare profiles at different snap-shots in time, the overall time frame provided by these graphs is insufficient to enable the trends to be confidently deduced. Furthermore, it is to be noted that the survey profiles were taken independent of meterorolgical conditions and the results may therefore have been misled by earlier storm events for example. It has therefore been borne in mind that these profiles and the fluctuations shown can only be taken as indicative.

4.4.2 East Beach

Three sections are regularly taken in the section known as East Beach, which covers the length between the MOD sections east of Shoeburyness Point.

Analysis of these sections show that at locations E3A4 and E3A5 there has been a lowering in the level of the foreshore, out to approximately thirty metres from the defence. Further offshore the levels have generally risen. This lowering in the level of the foreshore may be attributable to the Council's policy of removing the brick rubble strewn about the surface of the foreshore in this area.

4.4.3 East of Southend Pier

The east of Southend pier section covers the frontage between Shoeburyness Point and Southend Pier.

Throughout the section it was found that there has been a general increase in the level of the estuary, the increase starting from between 300-440 metres offshore and increasing in longitude with distance out. Furthermore, the graphs indicate a general levelling of the mudflats, perhaps through infilling of the mudflat creeks. The foreshore levels closer inshore indicate minor fluctuations in level towards Shoeburyness Point with a general lowering of levels immediately down drift of Southend Pier. This would indicate that material is generally being forced seaward to pass the end of the pier and does not then return to shore until much further eastwards towards the point. The foreshore to the immediate east of the pier is being starved of sediment and consequently eroding.

4.4.4 West of Southend Pier

The section west of Southend pier covers the length between Southend Pier and Leigh cockle yards.

Analysis of the graphs shows that across the mud flats known as Marsh End Sands between the frontage and Ray Gut, levels show minor fluctuations but have on the whole remained relatively constant.

Section E4B3 is taken close to Crowstone Point and the comparison of levels shows that the thirty metre width of foreshore along this section of wall has suffered a reduction in level of between 0.4-0.5 metres. The beach profile from 1964 indicates that whilst levels have lowered in recent years, its similarity to the levels of 1995 indicate that there has not been an overall significant loss of level. From forty metres offshore the levels have remained relatively constant.

Section E4B1 is taken immediately west of Southend Pier. This area has been regularly re-nourished by the Council and this is reflected in the higher levels in the latest survey. The graphs indicate that in this location the sand and shingle foreshore is approximately forty metres wide and that beyond this the mud flats have remained at a relatively constant level until further out into the estuary where they show a recent increase.

There are two sections taken near to the eastern end of Hadleigh salt marshes. These sections indicate that levels close to the seawall are relatively constant. Leigh Creek is shown to have made a slight progression inland. Whilst the profile of the creek has remained constant, it appears that the depth of the creek has increased slightly.

Table 4.4.1 Location of Environment Agency Beach Profile Monitoring Locations

Section of foreshore	Location Number	E.A. reference	Grid Reference of profile on defence works	
			Northings	Eastings
East Beach	1	E3A5	594297.305	184943.702
	2	E3A6	593673.355	184212.463
East of Southend Pier	3	E4A1	593179.197	183954.290
	4	E4A2	592490.790	184195.120
	5	E4A3	591562.330	184602.010
	6	E4A4	590588.960	184819.570
	7	E4A5	589525.870	184809.250
West of Southend Pier	8	E4B1	588211.130	185080.000
	9	E4B2	587208.630	185131.590
	10	E4B3	586220.880	185282.590
	11	E4B4	585208.000	185559.000
	12	E4B5	584215.310	185607.000
	13	E4B6	583188.130	185699.590

Table 4.4.2 Coincidental EA and Council Information

Location	EA Section	EA Dates used	Council Dates
4	E4A2	Sept 1993	Aug 1982
		Aug 1995	
		Jan 1997	
6	E4A4	Sept 1993	Aug 1982 Aug 1971
		Aug 1995	
		Jan 1997	
7	E4A5	Sept 1993	Aug 1982
		Aug 1995	
		Jan 1997	
9	E4B2	Sept 1993	1969 (no date available)
		Aug 1995	
		Jan 1997	
10	E4B3	Sept 1993	May 1966
		Aug 1995	
		Jan 1997	
11	E4B4	Sept 1993	Aug 1979
		Aug 1995	
		Jan 1997	

4.5 Strategic Appraisal of Coastal Processes

4.5.1 Introduction

When considering the physical processes in the Thames Estuary it is often divided, for convenience, into two sections; the Inner Estuary extending landwards of a line between Southend-on-Sea and Sheerness, and the Outer Estuary, lying between this line and one between Orford Ness and North Foreland.

The most comprehensive studies of the coastal processes in the Thames Estuary were carried out for:

- the proposed new Maplin Airport in the 1970's.
- an Island Marina on the foreshore at Southend-on-Sea in 1986.
- a review of the sediment transport mechanisms of the southern North Sea in 1996.

The early investigations concentrated on the impact of a major reclamation for the new airport on the hydraulics of the outer estuary. Hydraulics Research Limited (now HR Wallingford,) was commissioned by Brent Walker to conduct a hydraulic investigation into the implications of a new marina offshore of the pier at Southend. The southern North Sea study again concentrated on the outer estuary seaward of Southend. Of the three, the HR Wallingford study provides the most relevant information. The investigation was carried out in two stages; the first to assess the constraints of the present hydraulic environment on the general design of the marina and the second to predict how the completed development would itself modify hydraulic conditions both locally and in the Thames estuary generally.

HR Wallingford carried out a series of exercises:

- Data searches to examine existing wind and wave data and used this to determine the wave climate at the end of the pier.
- Material samples extracted from various locations on the foreshore were analysed to determine particle sizes.
- Float tracks were observed to determine the tidal streams at various locations across the estuary.

- A physical model of the area was built and tested to examine the potential effect of the marina on the sediment transport in the estuary.

- Other investigations relevant to the design of the marina but not of direct relevance to this study.

An additional data search has been carried out at the Institution of Civil Engineers' library and the British Library to compliment the data gained from the other studies. They have all been evaluated, with pertinent information being extracted to form a general appraisal of the coastal processes in this area, including the Southend foreshore, the Thames Estuary and its interaction with the southern North Sea.

4.5.2 Thames Estuary

The Thames is classified as a macro-tidal estuary, having a mean tidal range of 4.7m at Herne Bay rising to 6.6m at London Bridge. It is an important area for water and sediment exchanges between the land and sea. The whole of the estuary is generally at depths of less than thirty metres.

A large number of sandbanks occur in the Outer Thames Estuary which comprise accumulations of sand around pre-existing features. Some suggestions are that because of the pre-existing features there is no significant migration of the banks. Other research concludes that due to the net movement of sediment into the estuary, the banks are migrating landwards, causing a general infilling and increase in level of the estuary. Further monitoring of the banks is however required before a definite conclusion can be reached. The presence of sandbanks at the mouth of the estuary serves to reduce the height of waves entering the estuary from the southern North Sea through the process of shoaling.

Sediment samples were taken at 9 different locations in the estuary local to Southend, as part of the HR study, as shown in Figure 4.5.1. They indicated that the material in the inter-tidal zone is principally 'fine to very fine' sand, with a median grain size of about 0.11 to 0.13mm. At Leigh Sands and along the Westcliff foreshore the material however contains up to 30% silt and clay. These upper layers of sands overlie cohesive glacial tills.

Material within the estuary is in general related to that input from eroding coastlines. In the Thames Estuary, recognised erosion is taking place along the edge of the saltmarshes in the Dengie Peninsula and the lower Medway Estuary, whilst closer to Southend, tidal mudflats and saltmarshes have generally been receding around Canvey Island since 1820. West of Southend, at Maplin Sands, the foreshore is also suffering erosion, exerting pressure on the saltings along the shoreline.

The general response of estuaries to sea level rise is to widen and shallow. This can be attributed to either a redistribution of sediment (material eroded from the upper inter tidal areas and deposited within the sub-tidal) or by an increase in the net sediment inputs from marine sources. The current rate of sea level rise relative to the land at Southend is 6 mm/year and is considered typical for the Thames Estuary as a whole. The tendency would therefore be for the Thames Estuary to widen and shallow. However, the presence of hard defences along vast lengths of the Thames restricts this natural evolution. Consequently water depths in the deep-water channels are likely to increase at the expense of the intertidal areas which will accrete. The deeper tidal channels will produce an increase in tidal velocities and larger variations in level, which will in turn lead to increased sediment movement. Any material eroded from the beach areas is liable to be either transported further upstream or deposited in the intertidal zone.

4.5.3 Southend Foreshore

The shoreline at Southend-on-Sea consists of a narrow sand and shingle strip varying in width between virtually nothing and forty metres, running along the full length between Leigh-on-Sea in the west and Shoeburyness in the east. The existing beaches face south to south-south-west as a result of the combined effects of waves and tidal currents. At East Beach the alignment of the beaches is south - easterly. Seaward of this strip the foreshore slope shallows into the inter-tidal flats that extend up to two kilometres to the main river channel. These flats are cris-crossed by a series of creeks and channels that periodically change location and direction. The number of waterfowl using both these flats and those at nearby Maplin Sands rank the site one of the most important in the country.

Although there is some evidence to suggest that the tidal flats have eroded west of Southend pier since 1940, there is also evidence of a gradual increase in level at other locations. The conclusion is therefore that in general the flats have remained relatively stable in recent history. This is typified by the current level of the Victorian hardways in relation to the adjacent flats. Constructed around the turn of the century, the hardways were intended to provide pedestrian access across the flats to boats moored adjacent to the Ray Gut. Four of these hardways were originally constructed and only the two most western hardways remain. They however are still visible and at a level that would appear to suggest that levels on the flats at this location have not changed since their construction.

4.5.4 Flood/Ebb Tide Processes

Analysis of the tidal currents along the Southend-on-Sea frontage indicate the following circulation features throughout the tidal cycle; times are relative to tidal times at Southend:

LW:	Low Water, flow reverses in the estuary as flood tide commences.
LW +2h:	Flood flow established in the estuary, a weak flow enters Ray Gut.
LW +3h:	Water begins to flood the inter-tidal sandbanks.
LW +4h	Flow continues along Ray Gut into Leigh Creek.
	At Westcliff, tide veers shorewards from Ray Gut and reverses to an easterly ebb flow parallel and along the shoreline of Southend-on-Sea.
LW +5h:	Entire foreshore flooded.
	West of Southend-on-Sea, flow continues along Ray Gut into Benfleet creek.
	East of Southend-on-Sea, flow recirculation continues from Ray Gut eastwards parallel with the shoreline.
HW:	Flow continues up the estuary along Leigh channel and across Leigh Sands.
HW +1h:	Flow changes to an ebb direction from Leigh-on-Sea to Shoeburyness running parallel to the shoreline and progressively increasing in velocity with distance eastwards.
HW+2h:	Parts of Leigh Sands begin to dry.
	Flow over the foreshore no longer parallel to the shoreline but angled towards the main river.
	Drainage flow seawards continues in Leigh Creek and Ray Gut.
HW+3h:	Foreshore now dry and flow confined to drainage in Leigh Creek and Ray Gut.
HW +7h:	Slack water, the flow in the creeks becoming progressively weaker.

The strength of currents flowing over the foreshore was greater during times of large tidal range, i.e. spring tides, the general direction of flow was constant throughout the spring-neap cycle.

Tide directions indicate the direction of transportation of sediment by alongshore and onshore/offshore movement. For the Southend frontage, it can be seen that the flood tide waters entering the estuary will initially pass up Ray Gut and begin to enter Leigh Channel. At approximately four hours after low water, the tidal floodwaters begin to

divert away from the channel towards the coastline causing recirculation of the flow with water being transported eastwards parallel to the shoreline. This situation continues until a couple of hours after high water, whereupon the flow tends to be away from the shoreline, towards the main river channel across the flats. The flats are dry at three hours after HW and remain in that state until between nine to eleven hours after HW, depending upon the tidal range.

4.5.4 Sediment Movements

Sediment transport along the coastline ie. littoral drift, is a function of the wave climate, current regime and the nature and availability of material to be moved. The combination of tidal and wave induced currents will drive the sediment transport, whether suspended load or bed load, while the action of waves on the sediment is mainly responsible for the entrainment of sediments into the flow, making it available for transportation. Tidal currents have already been discussed. Wave induced, alongshore currents can be produced by wave set up, edge waves or oblique wave approach. The entrainment of particles into the flow is achieved through the elliptical motion of water at the sea bed driven by shoaling. At Southend the alongshore movement of material is generally caused by tidal currents, while onshore/offshore movement is due to the wave climate.

It is generally recognised that in the southern North Sea suspended sediment transport is the dominant process for transporting material. Onshore northerly winds and southward longshore currents create a predominant flow from north to south and from east to west causing material to enter estuaries on the east coast of southerly England along their north banks.

In the outer Thames Estuary the sandbanks tend to create a barrier to the seaward movement of sediment, and although the exact quantity of sediment passing through both the inner and outer estuary mouths is unknown, it is recognised that there is a net accumulation of sediment in this area. Licensed dredging of sand and gravel at a number of offshore locations in the outer Thames Estuary is carried out with little noticeable effect on the sediment transport system as a whole.

As discussed above, material accumulating within the estuary is derived from two main sources: sediment transported in a southerly direction from the eroding east Coastline of England and taken into the estuary by tidal currents, and sediment from further upstream. The fluvial sediment, however, is a relatively small proportion of the total and is considered to be negligible. Net sediment movement within the estuary appears to be in balance despite dredging activity, extensive reclamation of inter-tidal areas and sea level rise. On average, mudflats within the estuary have experienced an increase in level of about 1 mm/year, over the past 100 years.

A further source of potential sediment supply to the outer estuary as a whole is the dredged spoil from maintenance dredging deposited within the outer estuary at approved spoil disposal grounds. Studies have shown that deposition of this material has resulted in the accumulation of clays and muds on the seabed. These materials are, however, transported further offshore and southwards, rather than being returned by currents and waves to affect the Southend frontage.

It has been suggested that certain areas of the estuary act as temporary stores of sediment, accreting under normal circumstances and releasing accumulated sediment when reached by the higher spring tides and wave action.

4.5.5 Southend

The foreshore is generally in a state of dynamic equilibrium with a small net easterly drift of sediment. This is verified by the general appearance of the foreshore and by analysis of historical charts and maps.

Sediment movement on the Southend lower foreshore is initiated as the tide begins to ebb, movement occurring river wards of a line joining Shoeburyness with Canvey Point at about HW +1h. Material in Ray Gut begins to move at about HW +1.5h and continues through to HW+5. During a spring tide sediment is moved along the northern banks of Leigh Channel and Ray Gut, whilst little movement across the foreshore is evident on the neap tide cycle.

The gradient of the foreshore can have a significant effect on sediment movement. West of Southend pier, where the foreshore is at a gradient of 1:2500 or less, rapid movement of the tide across the foreshore results in a higher rate of sediment transportation. At Westcliff and westwards, the steeper foreshore results in a slower advance and retreat of the tide, therefore reducing sediment movement.

Sand of the grain size present on the Southend lower foreshore requires a near-bed current strength slightly in excess of 0.3m/s to initiate movement; the sand and mud mixtures evident at Leigh-on-sea and Westcliff require slightly more.

4.5.6 Waves and Water Level Data

Research has found that between 1881 to 1960 there was a gradual decrease in the storm index, since when there has been a gradual increase. Further research has noted that this correlates with an increase in gale frequency, both of which have produced a more severe wave climate over the past 20-30 years.

Wind data collected over 14 years at Shoeburyness between 1970 and 1983 was analysed by HR Wallingford for the 1986 study, to forecast wave conditions at a point near the end of Southend pier. These measurements were compared with wave measurements taken at Maplin Sands over one year. The dominant directions for wave generation will be from the south east (23% of the time from 90°N to 180°N) and the south west (40% of the time from 180°N to 270°N). The largest waves at the site will come from south of east as shown in Table 4.5.1 for a range of return periods.

Table 4.5.1 Return Periods (years) of extreme waves (H_s metres) from east and west

Return Period	H_s East	H_s West
1	1.4	0.8
5	1.6	0.9
20	1.8	1.0
50	1.9	1.0
100	2.0	1.0
200	2.1	1.1
500	2.2	1.1
1000	2.3	1.1

The calculation of wave heights was based on the assumption that severe storms would last for at least one tidal cycle, so that high water would occur with the largest waves.

Hourly measurements of water levels have been recorded at Southend since 1929. These were analysed by HR Wallingford for this study for the years 1929 to 1983 and predicted levels for various return periods made as shown in Table 4.6.2.

There are an infinite number of combinations of water level and wave height, each with the same joint probability of occurrence. Some combinations of water level and wave height for a range of return periods have therefore been calculated as shown in Table 4.6.3.

4.5.7 Effect of Obstructions on Coastal Processes

HR investigated the effects of structures built perpendicular to the foreshore for the proposed marina in 1986. The effects on local and estuarine processes are summarised as follows:

It is unlikely that any structure built along the Southend frontage to control local littoral processes would affect the tidal Thames west of Canvey Point, east of Shoeburyness or south of the Leigh Channel, therefore creating no attributable regime changes on the navigation channels.

Sediment transport potential offshore of the structures would be reduced. Inshore, flow would be intercepted and provide conditions conducive to the formation of inshore beaches. Ebb flow would be diverted riverward earlier, producing lower flow velocities inshore and inducing the build up of beach levels. On a spring tide, sediment movements in Ray Gut would remain largely unchanged.

4.5.8 Development of Beaches

The HR report considered the potential for constructing and maintaining beaches by the use of shore-connected structures. They considered that the only locations where sediment was likely to build up, and be stable, would be at the landward junction of the structures and the existing sea wall. Any material temporarily deposited offshore of the beach would either be removed by tidal currents accelerating around the seaward end of the structure, or pushed to the shoreline by wave action. To maintain beaches at other locations it would be necessary to either continuously feed the beach with sediments, or use large sediments that would only be moved by the action of exceptionally severe waves and tidal currents. Wave heights greater than about 0.5 metres are required to move shingle, whilst sand can be moved even under very small wave conditions.

The following details were included in the HR report as initial considerations for beach design:

- The exact beach profile will depend largely on whether a sand or shingle beach is to be formed. In either case the top of the beach would probably need to be set at an elevation of at least 3.5m OD and preferably at about 4.0m OD. At beach

levels lower than this, wave reflections off the seawall would tend to remove beach material.

- At the top of the beach a crest berm of at least 10 metres wide would probably be necessary to allow for beach erosion during storms.
- The seaward face of the beach would probably adopt a slope of about 1 in 7 if it was formed of shingle, or about 1 in 15 if formed of sand.
- Typically, the full beach width from the seawall to the toe of the beach would therefore be about 90 metres for a sandy beach or 50 metres for a shingle beach.
- To be fully effective the groynes would need to extend the full width of the beach and to stand between 0.5m and 1.0m above the surface of the beach.
- The distance between groynes would need to be similar to their length.

4.5.9 Conclusions

- The net sediment budget of the Thames Estuary appears generally to be in balance with an average increase of 1mm/year over the past one hundred years for the inter-tidal banks.
- The intertidal banks along the Southend frontage appear to be generally stable, with some evidence of minor erosion and other evidence of minor accretion.
- Sediment from sections of the eroding Anglian coastline enters the estuary along the north bank of the Thames due to the wave and tidal current action in the southern North Sea.
- Flood tides carry material into the Ray Gut and onto the Southend lower foreshore on a spring tide cycle. At about four hours after low water the flow reverses close inshore and runs eastwards parallel to the shoreline.
- Additional sediment is transported from eroding banks further upstream in the Thames, although this quantity is considered small in comparison with that entering from offshore.
- The largest waves to effect the Southend foreshore are from the south-east and range from 1.4m to 2.0m with return periods of 1 and 100 years respectively.

- The predominant wave directions are from the south-west (40%) and from the south-east (23%).

- The principal sediment size range on the lower foreshore is 0.11 to 0.13mm; material of this size requires a current of the order of 0.3m/s to be moved.

- Introduction of structures perpendicular to the coastline would only affect hydraulic processes locally and would intercept sediments moving along the coast. In addition, the structures would cause an early diversion riverward of the ebbing tide, producing areas of low flow inshore where material would consequently be deposited.

- Stable beaches could be formed by the introduction of suitable structures and additional sand and/or gravel.

4.6 **Wave Climate and Water Levels**

4.6.1 Introduction

To form the basis for determining the standard of the existing defences and the potential flood damage caused by a breach in these defences, a study was carried out to determine extreme wave conditions, extreme water levels and the joint probability of occurrence of these extremes for a site just offshore of Southend. These extreme conditions were then propagated inshore to the toe of the sea defences and used to examine the level of overtopping predicted at each of the defence locations. This information was then used to determine the defence standard.

This section summarises the methodology employed in the determination of extreme wave and water levels and the joint probability of these extremes. The full report can be found in Appendix D.

4.6.2 Determination of Extreme Conditions

To determine the wave climate at the prediction point off Southend Pier, wind data recorded at the Shoeburyness anemometer station over the 14-year period from 1970-1983 was used. Analysis of this data showed that winds in the Southend area are predominantly south - westerly, with the greatest wind speeds also from this direction. A numerical model was used to develop an hourly wave condition at a prediction point off Southend Pier. The results of this analysis were compared with measured wave data off Maplin Sands and for wave heights greater than about 0.4 metre were found to be similar. It is recognised that sand banks of varying crest height and length scattered across the mouth of the outer Thames estuary have an effect on waves from this direction. As a

general rule for calculating the energy loss due to waves breaking over natural seabed slopes, the significant wave height on the leeward side of the bank is taken as 55% of the water depth over the bank's crest. Waves breaking over the banks will then be subject to subsequent energy input in the intervening distance from the bank to the prediction point.

The extreme wave height predictions have been adjusted to incorporate this affect on a fetch by fetch basis, according to whether or not the energy arriving from a particular direction would have passed over a bank on its way to Southend.

Having established the wave climate at the prediction point, a statistical analysis was used to determine the extreme wave climate from both easterly and westerly directions. The results of this analysis are shown in Table 4.6.1.

Table 4.6.1 Extreme Wave Conditions

Return Period (years)	East		West	
	H_s (m)	T_m	H_s (m)	T_m
1	1.4	4.7	0.8	3.6
10	1.7	5.2	0.9	3.8
20	1.8	5.4	1.0	4.0
50	1.9	5.5	1.0	4.0
100	2.0	5.7	1.0	4.0

Calculation of water levels can be predicted with more certainty, both because of the large quantities of tide gauge data around the UK and because the astronomical component is deterministic. A Proudman Oceanographic Laboratory publication, which gives extreme conditions, based on measured water level data collected at Southend between 1929 - 1983, was used to determine the extreme water levels at the prediction point.

Consideration was given to the effect of sea level rise on extreme conditions. The anticipated rate of sea level rise at Southend is 6mm/year and with no evidence to the contrary, it is taken that the effect on extreme water levels over the next fifty years will be a proportional rise. Consequently the result is an increase in extreme levels by 0.3m with the subsequent effect on wave heights at Southend being an increase of 5-10%. The extreme water levels at the Southend pier prediction point are given for a number of return periods in Table 4.6.2.

Table 4.6.2 Extreme Water Levels

Return period (years)	Water Level (m ODN) 1997	Water Level (m ODN) 2047
1	3.5	3.8
10	3.9	4.2
20	4.1	4.4
50	4.3	4.6
100	4.5	4.8

4.6.3 Joint Probability of Occurrence of Extreme Conditions

Having established the extreme wave climate and extreme water levels independently, an analysis to determine the joint probability of occurrence of these extreme conditions was then carried out based on the established concept of a 'correlation factor' between the wave and water level variables. Once established, many different combinations with the same return period can be determined, with any one of them being a potential worst case scenario for design. A summary of different combinations is shown in Table 4.6.3.

Table 4.6.3 Joint Probability Combinations

Joint Return Period (years)	Water Levels (1997)		Wave Conditions			
	ret. Pd.	Actual	Easterly		Westerly	
	years	m ODN	years	Hs m	years	Hs m
10	0.1	3.2	4	1.6	7	0.9
	1	3.5	0.4	1.3	1	0.8
	10	3.9	0.04	0.9	0.1	0.7
20	0.1	3.2	10	1.7	16	0.9
	1	3.5	2	1.5	2	0.8
	10	3.9	0.2	1.2	0.2	0.7
	20	4.1	0.06	1.0	0.1	0.7
50	0.1	3.2	30	1.8	45	1.0
	1	3.5	5	1.6	6	0.9
	10	3.9	0.5	1.3	0.6	0.8
	20	4.1	0.2	1.2	0.3	0.7
	50	4.3	0.1	1.1	0.13	0.7
100	0.1	3.2	80	1.9	100	1.0
	1	3.5	10	1.7	14	0.9
	10	3.9	1	1.4	1.4	0.8
	20	4.1	0.6	1.3	0.7	0.8
	50	4.3	0.2	1.2	0.28	0.7
	100	4.5	0.1	1.1	0.14	0.7

4.7 The Existing Environment

4.7.1 Introduction

This section provides a general description of the existing environment along the study frontage and identifies key designations, assets and constraints. Specific details on individual environmental features are outlined in Appendix F. This section also makes reference to other key documentation which contains information on the study area in the context of the whole shoreline and estuary.

A plan of the existing frontage, is contained in Section 1 of this report.

4.7.2 Description

i) *Intertidal Zone*

The whole of the frontage between Leigh on Sea and the Pigs Bay area of Shoebury Ness is fronted by extensive sand and mudflats with areas of shingle forming the northern boundary of the Thames estuary. Leigh Sands and the Southend Flat area are however, subdivided by a number of channels and 'inlets', some such as Leigh Creek retaining water at a low level throughout the tidal cycle.

ii) *Beach and Sea Frontage*

The constituent materials making up the beach area change along the frontage, however they generally consist of sand and shingle with high proportions of shells at certain locations. Moving from East Beach to the south and west the beach materials are:

- East Beach - Sand and shingle with brick, fronting a remnant dune system, with block stone armour in the George Street area.
- Shoebury Ness - Sand and shingle, with the proportion of shingle increasing in the coastguard look out area. The beach is divided by timber groyne fields with a variety of hard concrete revetment systems protecting the back-shore.

- Thorpe Esplanade - Shingle, sand and a high cockle shell content particularly in the Shoebury Common area. The beach is again divided by timber groyne fields, with the back-shore protected by concrete seawalls. This frontage is also characterised by numerous multi-coloured bathing huts built on timber piles.

- Eastern Esplanade/ Marine Parade - The beach is primarily made up of sand with some shingle material retained by timber groyne fields. The Esplanade is protected by concrete seawalls and stone pitched revetments in a varying state of repair.

- Western Esplanade - The rounded pitched stone revetment around Southend Pier demarcates a change to a primarily sand dominated frontage, again retained by timber groyne fields. The graded pitched stone revetment gradually gives way to vertical concrete and masonry block work walls in the Grosvenor Road area. This vertical wall, fronted by relatively high sand beach levels, then extends to the Chalkwell Station frontage.

- Chalkwell - The width and height of the sand and shingle beach reduces moving westwards, with the frontage lined by a pitched stone revetment in various states of repair, covered by tar. Approaching Leigh on Sea three timber groynes marginally raise the sand beach levels against a concrete seawall.

- Leigh on Sea - Beach areas in this section are severely restricted by a combination of commercial fisheries harbour facilities and the proximity of the main Leigh Creek Channel.

Other structures located in the beach zone of the frontage include a number of concrete paddling pool structures, numerous concrete outfalls (many no longer functional), some beach huts on timber piles and a number of sailing club access ramps and platform structures.

The above division of the shoreline of the study area is based on environmental, land size and land use considerations and differs in detail slightly from the engineering sub-division. There is, however, generally a close correlation, with the following relationship:

East Beach	-	Unit 1 East Beach.
Shoebury Ness	-	Unit 2 (George Street to Maplin Way) (incorporating the MOD section and a short section of Unit 3).
Thorpe Esplanade	-	Unit 3 Maplin Way to Thorpe Hall Avenue.
Eastern Esplanade/ Marine Parade	-	Unit 4 Thorpe Hall Avenue to east of the pier and Unit 5 Southend Pier area.
Western Esplanade	-	Unit 6 West side of Pier to Grosvenor Road and Unit 7 Grosvenor Road to Chalkwell Station.
Chalkwell	-	Unit 8 Cinder Path (Railtrack length).
Leigh on Sea	-	Unit 9 Leigh on Sea.

iii) *Defences*

The nature, condition and height of the various seawalls, pitch stone work, bastions and timber groynes is described in more detail in Section 4.3. A detailed condition assessment of the defences is described in Appendix A.

iv) *Hinterland*

The vast majority of the hinterland of the frontage is under some form of urban development including residential, hotel, commercial, leisure and MOD facilities. In many locations this development extends up to the immediate esplanade frontage. The characteristic land use and development patterns along the frontage are briefly outlined below:

- East Beach - A grass car park and caravan and camping site lies adjacent to the frontage with residential properties further inland. In the George Street area residential properties extend to the frontage adjacent to the MOD site boundary.

- Shoebury Ness - The area is under MOD control and contains a number of low barrack and other buildings, with large areas of open space and remnant dune systems, particularly near the coastguard look-out.

- Thorpe Esplanade - Beach hut and leisure facilities line the immediate frontage, with areas of worn degraded coastal grassland formerly part of Shoebury Common. Large areas of maintained grasslands, planting beds and sports facilities line the esplanade giving way to residential properties further inland.

- Eastern Esplanade/ Marine Parade - Mixed built development lines the Esplanade frontage with Marine Parade residential and hotel accommodation, giving way to commercial and leisure development approaching the Southend Pier Leisure Complex. Facilities include the Sea Life Centre, the Pier Museum and the Southend Environmental and Outdoor Education Centre.

- Western Esplanade - The Esplanade is fronted by an ornamental landscape area of planting and grasslands backed by residential and hotel accommodation located on higher ground. Approaching Chalkwell Station car parking, boundary and other leisure facilities line the immediate seawall frontage.

- Chalkwell - The Station building and railway track dominate the frontage in this area with residential and parkland areas lining the higher ground which rises steeply behind.

- Leigh on Sea - Commercial whelk fishing, harbour storage and processing facilities line the immediate frontage, along with the railway track. Residential properties then contour the landform as it rises to the Belton Hills area.

4.7.3 **Environmental Designations**

Most of the environmental designations located within or adjacent to the Southend on Sea study area frontage are associated with the immediate frontage and intertidal zones. These include:

- Benfleet and Southend Marshes Special Protection Area and Ramsar Site designated in 1994 because of its international and nationally important wintering populations of waterfowl.
- Foulness Special Protection Area and Ramsar Site designated due to its internationally and nationally important wintering populations of waterfowl and nationally important breeding populations of Avocet, Sandwich and Little Terns.
- Benfleet and Southend- on- Sea Marshes Site of Special Scientific Interest (SSSI), originally designated in 1955 and the Leigh National Nature Reserve, declared under Section 19 of the National Parks and Access to the Countryside Act 1949.
- Foulness SSSI, originally designated 1956.
- Southend-on-Sea Local Nature Reserve, formally designated in 1996 and incorporating the important coastal sands at Gunners Park declared under Section 21 of the National Parks and Access to the Countryside Act 1949.
- Local Authority designated Sites of Importance for Nature Conservation.
- Areas, generally within the above designations, managed by the Essex Wildlife Trust as reserve areas at Shoebury Ness and Leigh Marshes.

Many of the above ecological designations are coincident and all underline the significance of the estuarine flats in providing a habitat for bird life. For further information on the above designations refer to Appendices F and I.

Other environmental designations include those regulating the important estuary fisheries operations, which are largely based at Leigh on Sea:

- Thames Cockle Fishery Order 1994 to manage the important commercial fishery administered by the Kent and Essex Sea Fisheries Committee and MAFF.
- EU agreed Total Allowable Catches to regulate other fisheries such as Bass and Mullet, again administered through the Kent and Essex Sea Fisheries Committee and MAFF.

NB: Freshwater fisheries, largely upstream of the study area are administered by the Environment Agency (EA).

The EA is also the competent authority to implement EC Directives on water quality, specifically:

- EU Bathing Water Directive (76/160/EEC), which requires sampling of bathing waters in accordance with Department of Environment requirements at three points along the study area namely; Shoebury Ness, Thorpe Bay and Westcliff.
- Urban Waste Water Directive (91/271/EEC), aimed at reducing pollution of fresh water estuaries and coastal waters.

Within the Southend-on-Sea study area there are thirteen Conservation Areas, 42 Listed Buildings and two scheduled Ancient Movements within the developed framework of the town. These are however, generally located within the town, behind the sea defence and immediate esplanade areas.

Planning coverage within the study area is provided by a number of statutory and non-statutory documents including:

- The Essex Structure Plan
- The Southend on Sea Local Plan
- The Essex Coastal Strategy
- The Thames Estuary Management Plan
- The Essex Shoreline Management Plan.

The above documents, particularly The Essex Shoreline Management Plan and The Thames Estuary Management Plan are a useful data source covering a wider range of issues for the local area and beyond the study boundary, covered by this document.

4.7.4 Strategic Environmental Assessment

Through a review of existing data and a consultation exercise the potential impacts of the various defence strategies were assessed in outline terms. Details of this scoping exercise are set out in the Strategic Environmental Assessment document in Appendix F. Conclusions, with initial comments on possible mitigation of potentially adverse imports are set out in Section 4.7.6, Outline Mitigation.

The concluding section below briefly draws together the results of the assessments made under each of the section headings, leading to the selection of the environmentally preferred option or options. The variation in types of existing defences, their current condition and level of service, however, suggests that no one solution is applicable to the whole of the Southend on Sea frontage.

4.7.5 Preferred Options

From this outline assessment of the Recreation and Tourism, Landscape, Ecology, Geomorphology, Land Use and Planning and Construction impacts potentially associated with the various scheme options, the following general conclusions can be made:

- The preservation and enhancement of the existing environment of the frontage of Southend and the mud and sand flats is essential for recreation; tourism; ecological; fisheries; landscape; geographical and planning reasons.

- The use of inappropriate materials and defence features 'alien' to the frontage would potentially create adverse impacts physically, visually, in planning terms and for recreational (navigation), ecologically and commercial fisheries interests.

- Any options which extend into the ecologically important mud and sand flats may reduce or detrimentally impact on this resource and would be environmentally unacceptable. These areas have been recognised as of local, national and international importance and also support the local and nationally important cockle fishery.

- Detailed assessment of the sediment movements within the estuary and down the east coast toward Shoebury Ness is also essential to ensure that the integrity of these intertidal areas is maintained, retaining the ecological importance of both designated and non-designated sites within our study area and associated areas.

- Works requiring extensive construction inputs, whilst 'temporary' in duration, could detrimentally impact on the recreational, tourism and commercial interest

of the resort for a longer period than options requiring minimum maintenance works or monitoring.

The above suggest that the environmentally preferred options, given the varying requirements along the frontage include:

- Do nothing; i.e. stoppage of all maintenance and intervention works on the foreshore.
- Do minimum; i.e. confirmation of existing management policy.
- Minimum investment maintenance; i.e. low level investment to provide minor enhancement of the defence standard.
- High investment maintenance; i.e. high level investment to provide substantial enhancement of the defence standard.

The above systems encompass the range of strategies required to monitor and maintain the defences at Southend, improve and retain local beach levels and environmentally improve the frontage from landscape, recreation and ecological perspectives. Section 4.7.6 below briefly outlines some draft mitigation measures which may be adopted pending further detailed studies, to mitigate against any adverse impacts associated with the above strategies.

4.7.6 Outline Mitigation

Whilst it is not possible to provide detailed mitigation measures at this stage, the following generic measures and recommendations should be applied to the development of future schemes.

Scheme Design

Whilst many of the adverse impacts associated with the scheme will arise during the construction phase and, by definition, will be temporary in nature, the long term impacts of the scheme will require careful consideration and detailed design. To mitigate some of the adverse impacts of the scheme and to integrate it into the local landscape, the following measures are recommended for incorporation into the detailed design process:

i) The construction of new structures to reflect the surrounding area in terms of scale, style and materials.

ii) Detailed attention to improving public access points, steps ramps, handrails, surface finishes and the provision of disabled persons access would enhance the landscape of the frontage and the public's perceptions of the scheme.

iii) The use of anti-corrosion, visually recessive or tonally complementary paint finishes to exposed metal work.

iv) The shingle used for recharging of the beach areas should reflect as closely as possible the existing materials. The engineering requirements for the material would have to be given due consideration during the detailed design process.

v) Native or ornamental grass seed mixes should be used, as appropriate, to reinstate areas affected by construction work.

vi) The provision of access facilities for increased recreational use of the frontage at appropriate points to minimize conflict with beach use and ecological interest.

vii) The protection and retention of existing beach features and architectural features such as the beach huts, where possible, to maintain the unique character of the frontage.

viii) The re-utilization, extension and improvement of existing beach management structures, where possible, in any new management or construction scheme.

Construction Measures

The application of the outline measures below, pending further refinement following detailed scheme development should help to minimize temporary adverse impacts.

i) Deliveries of bulk materials, e.g. shingle should where possible be made by sea.

ii) Any barge movements should be notified to the public and to the sailing clubs by site notices and the local press. Local fishermen will also be informed and consulted.

iii) Areas used during construction should be reinstated using native or ornamental seed mixes.

iv) No vehicles or plant are to be allowed to cross the most sensitive part of environmentally sensitive areas, such as the vulnerable residue dune ecosystems Shoebury.

v) Archaeological monitoring by an approved regulator is to be undertaken during construction.

vi) Movement of vehicles/plant and activities which generate noise, when undertaken within 100m of the facade of residential property, should not be carried out between the hours of 2200 hours and 0600 hours.

vii) Any vehicle storage area/site compound should be carefully designed in relation to its location and layout, in order to minimise noise nuisance from this source. Early starting of machinery and running of engines for prolonged periods in such compounds should be avoided. Attention should also be paid to public safety in relation to fencing of compounds and movement of vehicles along the promenade and beach.

viii) Acoustic screening should be erected between the vehicle storage area and adjacent properties if found to be necessary.

ix) The Environmental Health Department is to be consulted regarding any piling works at least one month beforehand in order that methods and noise control can be discussed.

x) A programme of proposed working, including vehicle delivery routes, is to be submitted to the Environmental Health Department at least one month before work starts.

xi) Adequate liaison with local residents is to be maintained so that there is wide public awareness of the work being carried out and the hours of operation.

xii) In general, all plant used on site should be fitted with suitable acoustic silencers, acoustic covers and mufflers. Should noise still cause complaints from properties along the frontage, consideration is to be given to erecting a temporary acoustic barrier along the north side of the promenade.

xiii) All traffic routes should be agreed with the local authority and notified to local residents.

xiv) A condition survey of access routes should be undertaken prior to construction and used as the basis for reinstatement and/or compensation. Verges, roads and footpaths on construction routes should be temporarily capped during construction and access routes and working areas are to be cleaned as required.

xv) Adequate liaison should be maintained with local fishermen regarding the programme for all marine and intertidal works which may affect beach access and/or fishing gear.

xvi) Secure site fencing should be maintained around all working areas.

xvii) A footpath diversion order should be obtained before the promenade is used by construction traffic.

xviii) Seaweed deposited on the beach should be removed before shingle nourishment is added.

4.7.7 *Recommendation*

Prior to the development of detailed scheme options and construction control mechanisms, it is, however, essential that a full environmental impact assessment is carried out for the frontage. This should address all the areas identified above in Section 4 with particular attention paid to the assessment of sediment dynamics in relation to beach management and possible implications on the ecologically significant mud flat areas. Other areas requiring detailed assessment include:

- The potential impact on tourism and recreational facilities and uses on the frontage;
- Potential conflict and co-ordination with the fisheries interests;
- The development of a co-ordinated approach to monitoring, beach management and any subsequent construction along the frontage, but particularly as key areas such as Leigh on Sea, the Central Sea Front Area and East Beach;
- The detailed assessment of key fisheries area and phases of operation;
- The detailed assessment of the sand and mud flat ecosystem in terms of particular use of areas by birds, sensitive locations and time periods to minimise ecological impacts (particularly during construction).

4.8 Evaluation of Do Nothing Policy

4.8.1 Introduction

The previous sections of this report have sought to gather together sufficient data about the Southend frontage to enable assessments of the residual life and probability of failure of the defences to be made. Studies have also examined the hinterland to the rear of the defences and assessed the value of existing assets, including conservation areas..

To determine the level of investment that can be justified, a 'Do Nothing' scenario has been developed. This scenario considers the effect of ceasing all maintenance works on the defences and groynes with no intervention works being carried out in the event of storm or flood damage. In particular, the following aspects have been considered;

Technical: A failure scenario for each of the units have been developed to examine the likely mode and location of failure and the effects of allowing this initial breach to go unrepaired.

Environmental: The impact of a Do Nothing policy on the natural and human environment highlighted and a view taken on the non-financial effect on the environment of a loss of this asset.

Financial: The financial impact on society of a breach in the defences. It has been assumed that once the defences have breached, flooding will occur on a regular basis to an annual flood level of 3.5 metres OD. Within this section the following elements have been considered:

Damage to residential properties
Damage to commercial properties
Traffic disruption
Loss of amenity value.

The present value cost of damage to each of these elements has been calculated using discounted cash flow techniques. Different failure scenarios have been considered to test the sensitivity of these present value costs, to the timing of failure.

At this strategic level of analysis the purpose of the cost benefit analysis has been to focus on the general level of investment that can be justified, rather than to provide a comprehensive appraisal. The level of investment has then been used rather broadly to identify the type of scheme for each of the operational units. It is envisaged that a more comprehensive economic appraisal would be carried out prior to submission of an individual engineer's report for a particular scheme.

The analyses have been carried out using the following principles;

Damage to Residential

For the purposes of calculating the value of residential properties that would be lost, should breach of the defences occur, the annual return period still water level (SWL) was used. The number of properties below this level (3.5 metres OD) was then determined from examination of the local topography, and value of each of these properties was obtained from the Borough Council tax offices. A full list of properties in this boundary and the total cost within each of the operational units can be seen in Appendix H.

Commercial Properties

A similar technique was used for determining the value of commercial properties.

Traffic Analysis

The traffic analysis was carried out to determine the loss to the nation incurred as a result of traffic rerouting, following breach and loss of sections of the Southend-on-Sea frontage. Breach of the defences in the Thorpe Esplanade area in the 'Do Nothing' scenario would eventually result in the loss of the main road along on the front. The scenario adopted considers that excessive damage would render the road unusable, thus requiring all traffic to be redirected elsewhere. In Appendix H it can be seen that traffic travelling to Thorpe Bay or further along the coast towards Shoebury Ness would be required to detour inland to avoid the breached section. Traffic survey data has been used to assess the number of vehicles using the road, thus allowing the cost of diversion of these vehicles around the section to be calculated. These calculations can be seen in Appendix H.

At this strategic level of appraisal the location and value of infrastructure services (such as gas and electricity mains) has not been investigated, and consequently not included in the benefits.

The capital value of the land lost due to breach has not been used in the cost benefit analysis.

Amenity Value

Loss of the beaches along the Southend-on-Sea frontage would result in a cost to the nation. This element would arise as a result of members of the public who would normally travel to Southend for their vacation or recreation, having to travel to an area of similar standard. The financial value of this alternative can be quantified by assessment of the number of travellers and the additional distance travelled. For the purposes of this analysis, the alternative area that was considered to be of a similar standard to Southend was Margate.

It has been assumed that the majority of visitors to Southend-on-Sea come from London or further afield. Using figures from the Southend tourism study of 1995 it has been possible to calculate a conservative amenity value. This is based on the numbers of train passengers and parked cars associated with day trippers to Southend.

The extra distance that would have to be travelled to Margate instead of Southend, by car from London, was calculated to be 67.2 km. Using this figure in conjunction with an assumed average vehicle speed of 50 mph, a cost per km per vehicle was calculated. This figure was then multiplied by the number of parked cars associated with day trip visits to the Southend beach. The method of calculation did not take into consideration the visitors to Southend by car, that stayed for longer than one day.

The number of day trip train passenger visiting Southend for recreational purposes, was also stated in the 1995 tourism study. By calculating the difference in cost between a day return to Southend from London and a day return to Margate from London, the loss to the nation and thus the amenity value was calculated. These calculations are included in Appendix H.

4.8.2 Definition of Operational Units

The data collection and assessment exercises determined that along the Southend foreshore there exist certain divisions based on topographical or man-management divides that may require protection at different levels of defence standard. Whilst these divisions, are all inter-dependant in terms of experiencing the same hydraulic and physical processes, the benefits to be gained through investment vary significantly along the frontage.

Consequently, the frontage has been divided into a series of nine operational units. The extent of these units has been determined through an appreciation of the situation along the Southend frontage, taking into account factors such as the topography of the hinterland (including the likely flood zones), the different defence lengths and the condition of these defences and physical features such as the pier and MOD boundaries. The location of each of these units is summarised in Table 4.8.1 and can be seen in Figure 4.8.2.

Table 4.8.1 Description of Operational Units

Operational Unit	Description of Unit
1	East Beach
2	Shoeburyness (MOD length)
3	Maplin Way to Thorpe Hall Avenue
4	Thorpe Hall Avenue to East of the Pier
5	Southend Pier Area
6	West Side of the Pier to Grosvenor Road
7	Grosvenor Road to Chalkwell Station
8	Cinder Path (Railtrack length)
9	Leigh on Sea : Commercial whelk fishing harbour and processing facilities.

4.8.3 Application of 'Do Nothing' policy

The 'Do-Nothing' policy has been applied to each of these operational units and the effect of flooding examined. A brief discussion on the findings for each unit follows;

Unit 1 East Beach

Unit one extends from the MOD boom north of Shoeburyness to the MOD fence near to George Street.
The length of frontage contained within this unit has been sub-divided into three lengths;

- the eastern frontage, which consists of an area of parkland designated as Critical Natural Capital and fronted by a series of remnant dunes;

- the central frontage, comprising rock revetment protection to the front face of the dunes;

- the western frontage, higher level dunes protected by a series of hard defences such as piled and concrete vertical walls.

It is considered that through an application of the 'Do Nothing' policy in this unit, the eastern and western frontages would experience the most noticeable deterioration. In the east the dunes would continue to retreat slowly as a result of rising sea levels. The rate of retreat of the dune crest has not been determined through this strategy. Assuming that a breach through the defences would occur, flood waters would soon erode either side of the dunes and cause a more rapid loss of foreshore material, allowing flood waters to enter the low lying land to the rear.

The impact of this policy would be a loss of Critical Natural Capital, protection of which was deemed to be a principal objective in the Essex SMP.

On the western frontage the low foreshore levels have already exposed the toe of the concrete bastion. A policy of 'Do Nothing' would lead to continuing lowering of the foreshore, resulting in an eventual collapse of the bastion, exposing the cliffs behind. A far longer period of time would be required before sufficient erosion would enable a breach in this area.

Consequently, a breach of the defences in this unit through a policy of 'Do Nothing' was assumed to occur at the eastern end of the unit in year 20, although the sensitivity of the costs incurred to year of failure was also tested for the 30 and 50 year scenarios. The principal calculable losses would be as a result of loss in the amenity value of the beach. It is recognised that the low lying land to the east of this unit contains MOD properties which may succumb to flooding in an annual event, but the value of the MOD properties is unknown and a detailed appraisal has not been carried out as part of this strategy. Furthermore, the economic evaluation of loss of environmental capital has not been taken into account. The present value cost of damage through flooding in this zone has been conservatively determined as follows;

Table 4.8.2 Cost of 'Do Nothing' Policy in Unit One

Assumed year of failure	20	30	50
Present Value Cost (£ M)	0.59	0.28	0.01

The discounted flow spreadsheets are shown in Appendix H.

Unit 2 Shoeburyness (MOD Property)

The MOD commissioned a study of the defences by Sir William Halcrow and Partners who reported earlier this year. It is understood that they recommended extensive remedial works but that the MOD are preparing to sell their land in the near future without carrying out any of the works. A detailed assessment of this unit is presented in the Halcrow report.

Unit 3 Maplin Way to Thorpe Hall Avenue

The frontage along the full extent of this unit, extending for 1200 metres from Maplin Way in the east to Thorpe Hall Avenue, is provided by concrete seawalls which are generally in good condition. The hinterland to the rear is primarily residential land, the majority of which is above the five metre contour. The foreshore along this length varies; the eastern end the foreshore is primarily shingle and cockle shells and extends to a width of 30 metres; at the western end the foreshore is lower yet still reasonably healthy. The timber groynes along this section are in good to moderate condition.

Left to deteriorate naturally, a breach in this unit would come as result of the timber groynes allowing more sediment to be transported along and away from the defences.

It is envisioned that a rotational collapse failure of the defences would occur, resulting in loss of the main road link along the front and allowing flood waters to penetrate the land to the rear causing flooding to a total of 64 properties (this figure will increase to 123 properties if sea level rise over the fifty year life of the scheme is included). Collapse of the road would cause substantial traffic disruption and loss of the beach would result in a loss of amenity value of the frontage.

The economic analysis of the 'Do Nothing' policy for this unit considered the financial effect of a failure of the defences in years 20, 30 and 50. The result of this analysis is shown in Table 4.8.3.

Table 4.8.3 Costs of 'Do Nothing' Policy in Unit Three

Year of failure	20	30	50 Without SLR	50 with SLR
PV Damage (£ M)	3.0	1.58	0.36	0.79

Note: The Present Value (PV) of damage increases dramatically in the fifty year failure scenario due to sea level rise (SLR) bringing a further band of properties into the flood contour.

Unit 4 Thorpe Hall Avenue to East of the Pier

This unit covers the length of frontage between Thorpe Hall Avenue and the east side of Southend pier.

The defences in this section consist of a pitching stone revetment topped with a short concrete crest wall. The revetment is in poor condition, having suffered several collapses in the past and it is now suspected that cavitation has occurred beneath the blockwork armour layer. The timber groynes fronting the revetment are in poor condition with missing waling planks allowing sediment to pass straight through them. Furthermore, the groynes are too short and in places too low.

It is considered that if all maintenance was to cease in this section there would be a steady deterioration of the defences. Under continual wave attack the timber groynes would continue to lose waling planks due to deterioration and splitting of the king piles, leading to general ineffectiveness and thus allowing an increase in sediment transportation along and away from the defences. Erosion of the underlying clay beds would result in a permanent lowering in foreshore levels, leading to increased water levels and consequently larger and more frequent wave attack on the defences.

Bearing in mind the condition of the existing revetments and the history of collapses, it is considered that eventually under extreme conditions there would be a serious collapse in the pitching stone revetment leading to increased erosion, collapse of the seawall and eventual overtopping and breach of the defences. A collapse of the pitching stone revetment along the Eastern Esplanade in 1995 revealed the existence of a series of brick arches and columns supporting the crest wall. It is presumed that these tunnels were constructed as part of the reclamation works along the frontage, the revetment built seaward to protect them from erosion. It is considered that a collapse in the revetment would allow a channel to be eroded beneath the esplanade leading to collapse and disruption. Erosion of the subsoil beneath the road would allow a direct link with the low lying land to the rear of the defence.

Under these conditions a collapse would result in flooding to approximately 1.9 square kilometres of primarily residential land in the Southchurch area (involving all properties beneath the 3.5 metre contour). Further to this there would be disruption to the main coastal road link along the front, placing increased pressure on the A13 to the north, disruption and damage to commercial properties along the front and loss of the foreshore amenity.

The level and condition of the defences in this section has led to the estimation of a present 1 in 50 year defence standard, which is likely to deteriorate rapidly with failure estimated to occur in 20 years. To test the sensitivity of the present value cost of damage to the failure scenario, the cost of failure in years 20, 30 and 50 was evaluated. A summary of these costs is shown in Table 4.8.4 below.

Table 4.8.4 Costs of 'Do Nothing' Policy in Unit Four

Year of failure	20	30	50
PV Damage (£ M)	20.37	11.35	3.71

It can be seen from this table that the level of damage is significant. It is considered that the 'Do Nothing' policy does not therefore satisfy the requirement for providing a technically, economically and environmentally viable option for defence in the long term.

Unit 5 Southend Pier Area

This section covers the short length of revetment around the Peter Pan playground at the landward end of Southend Pier.

The revetment itself is in poor condition having suffered numerous collapses and removal of the defence armour layer in the past it also shows signs of the various patching up attempts that have been made over the years. At the top of the revetment is a short brick wall providing flood protection to the playground behind. The wall is in good condition and has a crest level of 5.8 metres ODN. Although not examined during the site investigation, the evidence gained through adjacent trial holes would suggest that the toe of the revetment extends for some metres below mud flat level and consequently undermining of this toe is not a cause for immediate concern. No details are available as to the underlying material beneath the revetment but it is assumed to be similar to that beneath the other forms of revetment.

Left to maintain itself naturally the revetment armour layer would continue to lose armour stones, allowing further loosening of the revetment leading to collapse. The mudflat levels around the toe of the revetment appear to be stable, perhaps showing marginal accretion. Depending on the foundation material, it is envisaged that a serious

collapse would allow the formation of a channel straight through the wall into the playground behind, which is situated at a level below that of the defences. It is considered that the area of flooding would be restricted to the playground as the land to the west and north of the pier head rises, and to the east a rise in the road has been introduced as a barrier to prevent flood waters spreading to the low lying Southchurch area.

The primary benefits to be protected in this unit comprise the pier base itself and the contents of the Peter Pan playground. Whilst an arbitrary figure for the value of the amusements and property can be determined, the pier itself is more complicated. To include in this benefit is the loss of amenity involved in tourism to the pier and the value of the pier's heritage.

It is estimated that if left to maintain itself naturally, a breach would occur within 20 years. To test the sensitivity of the present value cost of damage to the failure scenario, the cost of failure in years 20, 30 and 50 were evaluated. A summary of these costs is shown in Table 4.8.5 below.

Table 4.8.5 Costs of 'Do Nothing' Policy in Unit Five

Year of failure	20	30	50
PV Damage (£ M)	0.49	0.27	0.09

Unit 6 West Side of the Pier to Grosvenor Road

This length of frontage extends from the western side of Southend pier to Grosvenor Road on Western Esplanade, a distance of approximately 2000 metres.

To the west of the pier the seawall is provided by a pitching stone revetment, which extends below the foreshore surface for up to 5 metres. The revetment is in a similar poor state of repair to that in Unit 4. There is no real crest wall to the revetment, simply a capping beam, providing a finishing detail to the crest of the revetment and to the edge of the pavement that runs along the top of the revetment. Immediately to the west of the pier is an extensive groyne system which appears to be having some effect on the beach levels but not enough to encourage build up of levels to a reasonable standard.

According to reports, the defences along this section are overtopped yearly, allowing major flooding of the Western Esplanade road behind. The cliffs to the rear of this road limit the extent of potential flooding to the seafront road; to the east, a rise in the road level has been introduced to prevent flood waters from this section spreading.

Left to maintain itself naturally, it is envisaged that due to general deterioration and a loss of foreshore material fronting the revetment, there would be a significant collapse which would lead to increased erosion of the wall and eventually a collapse in the road running along the front. Due to the presence of other usable roads at higher elevations in the system, the cost of traffic disruption would be minimised.

There are a number of properties along this frontage but it was found that the majority of these properties are above the 3.5 metre OD annual flood level and consequently will not form part of the benefits.

It was therefore found that the benefits to be gained from investment along this section would be limited to protection of the beach front amenity. The present value cost calculations for loss of these amenities assuming loss in years 20, 30 and 50 are shown in Table 4.8.6

Table 4.8.6 Costs of 'Do Nothing' Policy in Unit Six

Year of failure	20	30	50
PV Damage (£ M)	0.59	0.28	0.01

Unit 7 Grosvenor Road to Chalkwell Station

This unit extends for a distance of 1100 metres from Grosvenor Road in the east to Chalkwell railway station at the western end of Chalkwell Esplanade.

The defences along this length comprise a seawall formed from precast blocks with concrete capping slabs. The defence is generally in reasonable condition. The foreshore levels in front of the defences are relatively low, a consequence of the poor condition of the timber groynes along this length. The flood defence level in this section is set at a retired line to the rear of the gardens which lie immediately landward of the defences.

Adoption of a 'Do Nothing' policy along this length would lead to a continued lowering of the foreshore levels through general deterioration of the groynes. Collapse of the seawall would result in a breach of the defences, but flooding to land other than the gardens (which contain WC facilities, a bowling green, children's amusements etc.) is unlikely. Furthermore, the recently completed Anglian Water Storm and Foul Water Storage Works are located behind the defences in this unit. The capital value of these works is estimated as £1.3M.

The benefits to be gained through investment are consequently limited to loss of the storage tanks and the beach front amenity. The present value cost calculations for loss of these aspects assuming failure of the defences in years 20, 30 and 50 are shown in Table 4.8.7.

Table 4.8.7. Costs of 'Do Nothing' Policy in Unit Seven

Year of failure	20	30	50
PV Damage (£ M)	1.03	0.52	0.09

Unit 8 Cinder Path (Railtrack length)

The 'Cinder Path' is the name given to the length of frontage extending between Chalkwell railway station and Bell Wharf at Leigh-on-Sea. This unit has a frontage length of approximately 1050 metres and is maintained by Railtrack.

The pitching stone revetment along this frontage is in poor condition and has received several coats of asphalt as remedial works to the loose stones. Lowering of the foreshore in isolated locations has led to undermining of the revetment toe with potential loss of fines. There are no timber groynes along this length.

Termination of maintenance would lead to a continued deterioration of the revetment, leading to collapse and rapid erosion. Breach of the defences would come as a consequence, leading to potential flooding and eventual loss of the railway line to the rear, but would certainly result in a loss of the footpath from Leigh to Southend. Furthermore, loss of the footpath would restrict access to the large number of yacht mooring facilities situated along this length. A 'Do Nothing' policy would therefore represent a reversal on the 'encouragement of sporting and leisure facilities' objective developed in the Essex SMP.

The benefits to be gained from investment in the defences in this unit can be solely attributable to the number of users of the railway and the fair income received, and the capital value of the railway line itself. Beyond the line the land rises steeply to form Leigh cliffs. All residential properties at relatively high levels on the cliffs.

Unit 9 Leigh on Sea : Commercial Whelk Fishing Harbour and Processing Facilities.

The Leigh-on-Sea frontage extends from Bell Wharf in the east to the Leigh boat yards in the west. Beyond these yards to the west there are substantial areas of salt marshes, which lie beyond the scope of this strategy study.

Leigh Creek passes very close to the frontage of this unit and consequently the defences primarily consist of vertical concrete or sheet piled walls to enable mooring of fishing vessels at high tide. In general these defences are in good condition and considered sufficient to withstand the reduced wave climate at this location.

Although there are reports of minor flooding this area, it would seem likely that this is due to insufficient flood barriers.

5.0 EXISTING MANAGEMENT POLICY

5.1 Existing Maintenance Policy

At present the Borough Council management policy of the Southend frontage is simply to maintain the defences in a serviceable condition. Maintenance is generally carried out on a reactive response basis. Foreshore Inspectors employed by the Council report any failures or damage to the Borough Council Engineers who then prepare an order for work to be carried out by a contractor. Generally minor work requirements are recorded until sufficient work is required to provide a cost effective order for the contractor.

The maintenance work can be divided into three categories, which are summarised below, along with approximate expenditures on each category;

i) *Sea Defences*

Of the two main forms of sea defence along the frontage, vertical or near vertical seawalls and revetment, maintenance work over the past few years has generally tended towards the patching up of failed or damaged sections of pitching stone or Essex block revetment. The vertical walls themselves along the frontage are in reasonable condition.

Failure of the revetment is initiated by stones being worked loose by continual wave action. Eventually a stone is plucked from the revetment leaving a void which allows movement and eventual removal of adjacent stones leading to an increase in the size of void. Erosion of the underlayer then accelerates as the hole becomes larger, leading to eventual collapse of a section of revetment. Similarly, wave impact and subsequent drawdown of the water leads to removal of the fine material underlayer through gaps in the revetment, which in turn leads to cavitation and eventual collapse.

Consequently repairs to the revetment have generally taken one of two forms; those required to resurface the revetment with mass concrete poured over the surface, and those required to refill a hole formed by a collapse in the revetment.

The Borough Council expenditure on seawall repairs in recent years is as follows;

Year	Expenditure (£)
1992 / 93	33,510
1993 / 94	11,320
1994 / 95	23,054
1995 / 96	30,220
1996 / 97	23,063
Total	**121,167**

The average expenditure per year on the sea defences is £24,233.

ii) *Timber Groynes*

Along the frontage the total length of existing timber groynes is approximately 4800 metres, spread fairly evenly along the full 9500 kilometres of frontage maintained by Southend Borough Council. These groynes are responsible for reducing alongshore sediment transportation and consequently holding the foreshore in place. In turn, the foreshore helps to protect the sea defences by dissipating wave energy and reducing wave impact on the defences. Council expenditure on maintenance of the groynes over the past few years can be summarised as follows;

Year	Expenditure (£)
1992 / 93	£10,639
1993 / 94	£9,417
1994 / 95	£9,509
1995 / 96	£8,347
1996 / 97	£7,478
Total	**£45,390**

The average expenditure on the groynes per year is £9, 078

iii) *Beach Renourishment*

In the past, the Council has renourished certain sections of the foreshore to improve the amenity value rather than to protect the defences. This nourishment has been deposited in places where there is generally already some form of beach, the material selected to match that existing (coarse sand). The expenditure involved in beach renourishment has been included in the sea defence section in Item (i) above.

At Three Shells Beach to the west of Southend Pier:

Year	Quantity (tonnes)
May 1991	100
April 1992	100
July 1993	100
April 1994	100
July 1995	100
March 1996	140
May 1997	100
Total	**740**

The following quantities have also been placed:

Date	Location	Quantity (tonnes)
April 1995	East Beach Paddling Pool Area	1200
November 1995	Thorpe Bay Slipway	200
November 1995	Westcliff Jetty	250
November 1995	Leigh Beach	750
Total		**2,400**

These figures can be summarised as follows:

Year	Quantity (tonnes)
1991	100
1992	100
1993	100
1994	100
1995	2,500
1996	140
1997	100
Total	**3,140**

The average nourishment quantity per year is generally approximately 100 tonnes, although the extra quantity in 1995 has led to a statistical average of 500 tonnes.

The total expenditure per year on maintenance is then:

Item	Expenditure (£)
Sea Defences	24,233
Timber Groynes	9,078
Average per year	33,311

5.2 Capital Schemes

In recent years the following capital schemes have been carried out;

i) Shoeburyness, East Beach Raising of dune levels
ii) Shoeburyness, East Beach Remedial Works to Rampart Street Bastion etc.
iii) Shoeburyness, East Beach Construction of rock revetment

Works additional to this have centred around local raising of existing defence levels and construction or replacement of timber groynes.

5.3 Estimate of Expenditure Per Unit

To estimate the approximate proportion of maintenance money spent within each of the operational units, the proportional length of each unit was calculated and multiplied by a weighting based on the current condition and standard of the defences. These calculations were made as follows;

Operational Unit	Length of Frontage (metres)	Proportion of Frontage Length (%)	Weighting	Total	% of Total Expenditure	Maintenance Expenditure (£)
1	700	8	3	24	8	2,664
2	Not included in calculation of predicted Council expenditure					
3	1,200	15	2	30	12	3,997
4	2,200	26	4	104	37	12,325
5	600	7	3	21	7	2,331
6	2,000	24	3	72	25	8,327
7	1,100	13	2	26	9	2,997
8	Not included in calculation of predicted Council expenditure					
9	600	7	1	7	2	666
Total	**8,400**	**100**	**18**	**284**	**100**	**33,311**

6.0 CONSULTATION

6.1 Introduction

In accordance with MAFF''s 'Practical Consideration the Strategic Planning and Appraisal of Flood and Coastal Defence Schemes', and to complement the SMP consultations, a further consultation process was carried out as part of this Strategy Plan to focus more on the concerns and issues facing development of the Southend shoreline. In particular, the consultation was carried out to satisfy the following objectives:

- To gather together, understand and take account of the long term plans, published by the various official bodies, for the development of the Southend shoreline.

- To take account of the specialist knowledge available regarding environmental, recreational and commercial aspects to determine key issues and individual concerns about the foreshore and surrounding areas

The comprehensive list of consultees developed for the Essex SMP was revisited and parties with particular interests and involvement in the shoreline selected. The consultees were asked to provide their views on possible management options and development of the shoreline in general.

Whilst a summary of the main responses is included here, a full list of parties consulted and their responses can be found in Appendix E.

6.2 Responses

Comments returned from the consultation addressed various issues facing the shoreline. A summary of the responses is as follows:

- management and further research into coastal processes is required to understand the natural systems at work on the foreshore, principally involving transportation of sediment.

- the strategy should consider sustainable schemes; there are existing concerns about exacerbation of 'coastal squeeze' through holding the line and these will need to be addressed.

- a detailed Environment Impact Assessment is required before any construction work carried out, to ensure compatibility with adjacent units.

- importance of ongoing consultation between interested parties.

- The need for improvement of flood protection to Southend pier and the surrounding area.

- Access to/from the RNLI station on the pier should be maintained at all times.

- dredging of Ray Gut should be considered in order to maintain access to Leigh Creek.

In particular, the following more specific concerns were raised;

Conservation

- there are concerns regarding the impact of construction or management works on the Benfleet and Southend marshes SSSI, SPA and Ramsar site and the Southend Foreshore Local Nature Reserve. Impacts such as the disturbance to internationally important bird populations at certain times or areas during construction work will need to be incorporated into future management works.

Sport and Leisure

- Access to the water should not be restricted, diminished or made dangerous, the effect on moorings should be considered, launching facilities should be improved and supervised and a continued expansion of sporting and tourism facilities supported.

- The implications of these objections are wide ranging. The general principles summarised here are achievable either at this strategic level or through a review of the principle outlined in this strategy, or through development of the individual scheme recommended. A further assessment will be carried out in Section 8 of this report.

7.0 MANAGEMENT OPTIONS

7.1 Introduction

The previous sections of this report have defined the existing situation on the Southend frontage and considered the objectives developed by the SMP for Essex. In accordance with MAFF's Project Appraisal Guidance Notes (PAGN) it is necessary to consider a range of potential management options, and carry out an economic appraisal to determine the level of investment that can be justified and the best means of implementing this level of investment.

PAGN suggests that for a large scheme such as a strategy plan, the following options should be considered as a minimum;

- 'without project' or 'do nothing'
- a minimum level of investment such as filling in low spots in an embankment or replacement of a revetment etc.
- a low level of investment, but offering a performance significantly higher than the minimum level of investment
- a higher level of investment
- other genuine alternatives such as managed set back

This section describes the selection of suitable options in accordance with the above list.

7.2 Summary of Problem

The principal problems affecting the shoreline at Southend are those of general deterioration of the defences combined with a gradual lowering of the immediate foreshore and the consequences of sea level rise. The most likely failure scenario will be through a breach in the defences, pre-empted by a failure in the pitching stone revetment east of Southend pier.

In Section 4 the extent of the existing problem was examined and led to the development of a series of nine operational units based on condition of the defences, foreshore levels, defence crest levels, level of development, relief of the hinterland etc. These units are as shown in Table 7.1.

Table 7.1 Designation of Operational Units

Operational Unit	Description
Unit 1	East Beach
Unit 2	Shoeburyness (George Street to Maplin Way) (incorporating the MOD section)
Unit 3	Maplin Way to Thorpe Hall Avenue
Unit 4	Thorpe Hall Avenue to East of the Pier
Unit 5	Southend Pier Area
Unit 6	West side of the Pier to Grosvenor Road
Unit 7	Grosvenor Road to Chalkwell Station
Unit 8	Cinder Path (Railtrack length)
Unit 9	Leigh on Sea : Commercial whelk fishing harbour and processing facilities.

Whilst it is recognised that further research into coastal processes in the Thames Estuary is required before the complex interaction with the Southend foreshore can be more fully understood, the limited research to date has been used to develop general conclusions allowing a formation of outline designs and potential options at this stage. The following provides a summary of the constraints that have been determined;

Engineering Constraints

Historical analysis of foreshore evolution noted that whilst an average increase in estuary level of 1mm/year has been calculated, the intertidal banks of the Thames along the Southend frontage appear to be in balance, some experiencing minor erosion whilst others are experiencing minor accretion. It is suggested that the introduction of suitable structures along the front could be used to encourage the formation of stable beaches, which would intercept sediment moving along the coast and by early riverward diversion of the ebb flow, produce areas of low flow that would encourage the build up of material. Furthermore, structures introduced along the shoreline would only affect local hydraulic processes.

The largest waves reaching Southend will be from the south-east, with a range of 1.4m to 2.0m for return periods of 1 and 100 years respectively. The predominant wave direction is from the south-west.

Environmental Constraints

Areas to be considered in development of options include:

- the potential impact on tourism, fisheries and recreation.
- the potential impact upon the sand and mudflat ecosystem through effects on the coastal processes.
- the potential for enhancement of the local environment through improved facilities etc.
- the use for appropriate materials and techniques of beach management.
- the effect of temporary impacts during construction..

7.3 Selection of Options

The Essex SMP determined that for the Southend frontage the recommended management policy should be to Hold the Existing line . This strategy has been reconsidered and found to provide the most effective solution for each of the operational units. Management options involving a retired defence line or managed retreat have consequently been ruled out.

The previous sections of this report have examined the condition of the existing defences and management policy of the Southend frontage and considered the engineering and environmental constraints affecting future improvement works. This information has been used in development of possible management options in accordance with MAFF's PAGN. From the list described in Section 7.1 above, the following options have been considered:

i) Do Nothing
ii) Do Minimum
iii) Minimum Investment Maintenance
iv) High Investment Maintenance
v) Capital Investment.

Although in reality the economic analysis of the options will be the predominant factor in deciding the preferred scheme, a strategic environmental assessment of each option was carried out to assess the likely impacts, both positive and negative, in addition to an assessment of the engineering practicalities or buildability of each scheme. This assessment is discussed in Section 8 of this report.

7.3.1 Do Nothing

The Do Nothing option assumes that there will be no further intervention works to the foreshore and that the shoreline will be left to maintain itself. Should a breach or collapse occur, there will be no maintenance or repair work; the situation will be left to deteriorate naturally.

This option has been used as the basis on which to compare the economic benefits of investment works.

The implementation of this management strategy over the whole length of the study area would impart negative impacts on the environmental quality and assets of the Southend frontage. Deterioration of the coastal defences, the promenade and beach access points will in the medium to long term reduce the visual amenity, tourism and recreational potential and impact on the socio-economic basis of the area. Continuation of erosional processes will, in time, also impact on the areas of Coastal Natural Capital at Shoeburyness, and may also impact on the long term maintainability of the intertidal areas of national and international ecological importance. Furthermore this strategy offers no opportunity for the enhancement or maintenance of the human and built or natural environmental assets along the Southend frontage.

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A more detailed discussion of the effects of adopting this policy in each of the management units was provided in section four of this report.

7.3.2 Do Minimum

This option assumes that there would be a continuation of the existing policy of maintenance on a reactive response basis, providing no improvement in the existing situation. Collapses of the revetment or loss of or damage to the timber groynes would be repaired by the Borough Council's contractors as and when an order for the work was placed. It is recognised that this policy has been successful for many years and would prolong the life of the defences slowing, but not halting, the general deterioration until a more significant collapse occurs.

Minimum maintenance of the defences, whilst continuing to make the defences serviceable, is not addressing the more significant problem of general deterioration. A serious collapse is likely to occur due to extreme wave and water level conditions and this would eventually lead to a breach and flooding as discussed above. It is considered that, because the Borough Council does not maintain its own emergency work force, significant damage/flooding could occur before repairs to the wall could be carried out.

The environmental implications of this management strategy are almost identical to the Do Nothing option, with the only variable relating to the timeframe for the deterioration or loss of assets.

The average annual expenditure on maintenance of the defences and groynes is approximately £33,300.

7.3.3 Minimum Investment Maintenance

This option considers the policy of carrying out sufficient maintenance to maintain the current standard of defences over the next fifty years. The policy will require an initial capital investment to carry out necessary repairs and then incorporate a regular sum of maintenance spending over the next fifty years.

It is considered that prior to any subsequent works to the foreshore, a comprehensive survey of the existing defences and timber groynes is required. This survey would aim to locate the extent of existing voids in the revetment/seawall, enabling an informed decision to be made on the level of investment required to strengthen the existing defences. The use of a ground penetrating radar survey is suggested, although it is recommended that a trial section be carried out first to determine the effectiveness of this survey on the revetment in question.

Once the condition of the defences has been more reliably assessed, methods of improvement can be developed. These methods may involve one of the following;

Revetment Repairs

Short sections of revetment may be stripped and the foundations improved by removal of the existing material and replacement with new material, properly laid and compacted. A decision could be made whether the existing revetment could be replaced or a new form introduced, using seabees, rock, Essex blocks etc.

Seawall Repairs

Similarly, if large voids behind the seawall, or fractures within the block work are found, it may be desirable to remove sections of the existing wall, refill the backfilled area and rejoint the blocks.

The survey of the groynes will seek to develop a more detailed understanding of the condition and effectiveness of the groynes. This survey will seek to detect reusable timber and highlight lengths that will need prioritised attention.

These surveys will enable a programme of maintenance investment to be established to provide proactive maintenance of the defences, once the condition has been stabilised. This option will consider low level investment in repairing known voids in the revetment and repairing damaged groynes, split king piles etc.

In addition to carrying out these repairs it is considered prudent to continue the existing policy of introducing nominal amounts of nourishment into the system. This nourishment can, as at present, be used to maintain the areas of beach amenity that help maintain Southend's attraction as a tourist resort.

Whilst this option will seek to maintain the current status quo, it does not address the problem of general deterioration through lowering of foreshore levels and rising sea levels.

The implementation of this strategy, which basically maintains the 1997 level of defences, whilst reducing the rate of deterioration and loss of assets will eventually have similar environmental impacts to the Do Nothing and Minimum Maintenance options. The time frame for deterioration may be extended, barring a major collapse, but the end results will be the same. Similarly, this strategy only offers a severely restricted opportunity for environmental benefit associated with the local maintenance and improvement of existing defence structures, maintaining the current visual quality of the frontage. The potential is however, severely restricted.

7.3.4 High Investment Maintenance

This option was developed to consider an investment level sufficient to enable the strengthening, raising and lengthening of the existing groynes, provision of beach nourishment and high level investment revetment maintenance.

It is recognised that groyne systems have been effective to date on the Southend frontage, at the locations where they are well maintained, high and long enough to reduce longshore sediment transportation; problems arise where groyne bays are working and full to capacity

yet the beach is still insufficient to provide protection to the defences. This option looks at making the groynes larger to enable them to trap more sediment. The majority of the existing timber groynes have fallen into disrepair, some with missing waling planks that allow the movement of sediment through the groynes, others with split king piles leading to rapid further deterioration.

To complement this upgrading of the groynes, this option will include beach nourishment within the groyne bays. A typical profile for nourishment has been developed, based on the beach design guidance given by HR Wallingford in their 1986 report.

This strategy offers opportunities for the upgrading of the existing defence systems environmentally as well as levels of service. The physical upgrading of the groynes with associated beach recharge will unify the visual appearance of the frontage whilst improving beach access and stability. This will protect and enhance the tourism, recreational and built assets along the frontage along with ensuring the integrity of areas of nature conservation intact. These works will, however, result in construction impacts with associated positive and negative effects. Adherence to the outline mitigation measures set out in section 5 of the Stregic Environmental Assessment document in Appendix F, will however, minimise any adverse impacts.

7.3.5 Capital Investment

A series of higher level or capital investment options have also been considered. These are as follows:

Option One: New Timber Groynes
Beach Nourishment

This option considers incorporation of the structural groynes and revetment survey and revetment/defence repair element into the provision of new management works on the foreshore.

It is considered that to provide only timber groynes, or beach nourishment would be an insufficient solution as the physical processes acting on the Southend foreshore are linked. Provision of new timber groynes would not address the issue of insufficient foreshore material; provision of beach nourishment would be ineffectual on a long term basis if there was no means of arresting alongshore transportation.

Consequently this option considers the provision of new timber groynes to a higher standard than those existing at present, supplemented with beach nourishment. It is recognised that groyne systems have been effective to date on the Southend frontage at the locations where

they are well maintained, high and long enough to reduce longshore sediment transportation. Timber groynes would also maintain the existing visual quality/character of the front. The use of timber groynes was therefore considered to be a viable option.

The environmental consequence of implementing this strategy are broadly similar to the High Investment Maintenance option, however, construction impacts may be more extensive and take place over a longer time period.

The design of new groynes would be carried out using numerical modelling techniques which would optimise the alignment, location, length and height of the groynes in such a manner as to increase their effectiveness in restricting alongshore sediment transportation whilst minimising their environmental impact. Structural design would be carried out with a view to reusing as much of the existing timber as possible.

To supplement the groynes, the beach would be selectively nourished higher and wider, increasing the defence standard and providing protection to the existing defences. Figure 7.1 shows the layout of a typical profile on existing topographically surveyed sections. Consideration was given to the recycling of material from the down drift (eastern) end of the frontage but it was concluded that the material, predominantly cockle shells and fine sand, would be too light/fine and the more coarse shingle fraction was not present in sufficient quantities.

The numerical modelling and design would be required to determine an appropriate grain size and consequently a suitable profile for the nourishment. Beach nourishment of a coarser grading would need to be brought to the site from a borrow area. The Borough Council have indicated that road transportation is impractical as a means of delivery. Consequently transportation by sea has been considered and found to be practicable and financially viable.

Option Two Rock Groynes
Beach Nourishment

Carried out in conjunction with beach nourishment, rock groynes are effective in their dissipation of wave energy, have a longer effective life and require less maintenance than timber groynes. Numerical modelling techniques can be used to determine the alignment, length and height of the groynes so as to be most effective in the prevailing hydraulic conditions. Typical construction details and layout of rock groynes can be seen in Figures 7.2 and 7.3.

Rock groynes will, however require a higher initial capital investment and the delivery of sufficient quantities of rock to site may prove impractical. The shallow water flats of

Southend foreshore would minimise the draft available, leading to an increased number of deliveries. This would increase the environmental impact and potentially cause damage to the foreshore, which is a designated conservation site.

Alternatively there is the option of bringing rock to the front by road. The quantities estimated would require a large number of wagon loads, producing a great impact upon the local community, traffic congestion and potentially damaging local roads.

Furthermore, the construction of rock groynes will have a significant visual impact and would also have health and safety implications in areas of high amenity value. It is recognised that rock groynes could be effective in reducing longshore sediment transport, however it is also considered that the impact of bringing sufficient quantities of rock to site would produce too great an environmental impact to make this a viable option.

Option Three Rock Breakwaters
Beach Nourishment

Rock breakwaters are effective in their dissipation of wave energy and can help to reduce offshore currents and consequently reduce longshore sediment transportation. At Southend they would need to be constructed in conjunction with some form of groyne system and would therefore probably not prove cost effective. Their introduction would also cause a reduction in amenity in an area of high active water sport usage. Furthermore, the location of breakwaters within the intertidal zone may have negative impacts on both the integrity of the flats as a national and internationally important ecological resource, and the important cockle fishing which relies on these areas. Once again, delivery of a large quantity of rock to site would impart a high environmental cost upon Southend. Figures 7.4 and 7.5 provide typical details of layout and construction.

Rock breakwaters are not therefore considered a viable option for the improvement of the foreshore.

Option Four Rock Strong points
Beach Nourishment

Rock strong points act by combining the actions of both groyne systems and breakwaters, retaining beach material and diffracting longshore currents. Although they are constructed at less frequent intervals along the coast, their relatively gentle side slopes require large areas of foreshore and at Southend they would consequently create too much of an impact, both visually and on alongshore physical processes. Again there is also the impact of material delivery to site. Figures 7.6 and 7.7 provide typical details of layout and construction.

Option Five Seawall/Revetment Improvements
Beach Nourishment

To overcome the physical process constraint at Southend, a new seawall or revetment would have to be constructed much larger than those at present to meet the required defence standards. Due to rising sea levels, the crest level of the seawall would have to be raised locally to provide a uniform level across the extent of the frontage. Lowering foreshore levels would need to be addressed by providing deeper toe piling to prevent undermining.

Sea level rise is already having consequences on the areas of mudflat and salt marsh (through coastal squeeze), and the construction of an larger seawall would lead to increased wave reflection leading to further beach loss. The SMP determined that a sustainable management policy should be adopted for the frontage; the construction of a new seawall would not fulfil this requirement.

7.4 Typical Costs of Selected Options

To provide the basis for assessing the cost of each of the different options, a typical capital cost per metre of frontage has been determined (detailed calculations are included within Appendix G of this report).

7.4.1 Do Minimum

This policy will involve continuation of the existing management strategy, that is, repair of the defences and groynes on an ad hoc reactive basis. The current average yearly expenditure on these two items is approximately £33,000. This sum represents the total expenditure along the whole of the frontage maintained by Southend Borough Council. The condition and type of defence works along the frontage vary, resulting in variations in the maintenance expenditure. The table in section 5.3 provides an estimate of expenditure with each of the operational units.

7.4.2 Minimum Investment Maintenance

The likely cost per metre of frontage for this option can be estimated as follows;

	£
Structural Survey of Revetment/Seawall (per metre of frontage)	2
Revetment/Seawall Repairs (low level)	100
Structural Survey of groyne (per metre of frontage)	1
Groyne Repairs (low level)	106
Preliminaries, Contingencies @ 20%	42
Supervision, Consultants fees etc. @ 10%	25
Total Cost per metre of frontage	**276**

7.4.3 High Investment Maintenance

	£
Structural Survey of Revetment/Seawall (per metre of frontage)	2
Revetment/Seawall Repairs (high level)	133
Structural Survey of groyne (per metre of frontage)	1
Groyne Upgrading (high level)	265
Beach Nourishment	720
Preliminaries, Contingencies @ 20%	224
Supervision, Consultants fees etc. @ 10%	134
Total Cost per metre of frontage	**1,500**

7.4.4 Capital Investment

The likely cost per metre of frontage for this option can be estimated as follows:

Structural Survey of Revetment/Seawall (per metre of frontage)	2
Revetment/Seawall Repairs (high level)	133
Structural Survey of groyne (per metre of frontage)	1
Removal of existing beach management structures	106
Provision of new groyne systems	300
Beach Nourishment	900
Preliminaries, Contingencies @ 20%	289
Supervision, Consultants fees etc. @ 10%	173
Total Cost per metre of frontage	**1,900**

7.5 Conclusions

The particular constraints affecting the Southend foreshore can be summarised as follows;

- location on the Thames Estuary, leading to current driven hydraulic processes
- inaccessibility across the foreshore and full development of the hinterland
- proximity of areas of local, national and international conservation importance
- importance of the foreshore area in terms of local amenity, tourism, watersports and fisheries.

Consequently the variation in possible management options available for consideration is limited. Whilst rock is recognised as an effective means of dissipating wave energy and reducing alongshore sediment transportation in any one of a number of different forms, the provision of rock in beach management structures is considered impractical simply in terms of environmental impact, both visually and aesthetically, and practically considering the options open for delivery of the material across the mudflats.

The management options developed for further consideration in Section 8 of this report vary in terms of the level of investment. The options can be summarised as follows:

Do Nothing	Allow deterioration without interference of existing situation
Do Minimum	Continuation of existing policy
Minimum Investment Maintenance	Maintain existing 1997 standard
High Investment Maintenance	Upgrade existing groynes to a higher standard
Capital Investment	Provision of new beach management systems

The preferred management option for each of the individual operational units is determined in Section 8.

8.0 SELECTION OF MANAGEMENT OPTION FOR INDIVIDUAL UNITS

8.1 Introduction

The standard and priority of the operational units were determined in Section 4, and possible management options were examined and developed in Section 7. This section examines each operational unit in detail, in terms of the environmental, financial and technical constraints, with a view to determining the optimal management option recommended for each unit.

To determine the present value costs for each of the options, the typical costs per metre of frontage, developed in Section 7, have been multiplied by the length of frontage to determine the approximate investment required. For the High Investment maintenance and Capital Investment options it has been assumed that where this figure is less than £1 million, the work involved would be carried out as part of a single contract. Where the figure has run into several millions, it has been assumed that the work would be split into phases to defer payment (to facilitate cash flow) and minimise impact (particularly through the summer season). For the Minimum Investment Maintenance option, the capital sum determined has been spread over a 25 year cycle, the 25 years taken as an estimate of the working life of a timber groyne. The sum has been split to enable a series of programmed works to be carried out to ensure that the current standard of defence is maintained.

For the 'Do Minimum' option, the current average level of expenditure on the defences has been calculated and continued for the fifty year period covered by this strategy plan on a similar basis. In addition to this, a capital sum of £50K has been included every ten years to simulate the cost of carrying out emergency works.

The present value cost of each of these options has been calculated on a discounted flow spreadsheet. These spreadsheets have been included within the individual unit sections.

8.2 Determination of Strategy For Operational Units

8.2.1 Unit 1 - East Beach

Introduction

The length of frontage contained within this unit has been sub-divided into three lengths:

- the eastern frontage, which consists of an area of parkland designated as Critical Nature Capital and fronted by a series of remnant dunes;
- the central frontage, comprising rock revetment protection to the front face of the dunes;
- the western frontage, protected by a series of hard defences such as piled and concrete vertical walls.

Whilst this unit has been considered as a whole in terms of the economic analysis, recommendations for each of these sub-divisions have been developed individually to reflect their different management requirements and objectives.

The 'Do Nothing' evaluation in Section 4 determined that the benefits protected by the defences in this length centre on the amenity value of the beach, the dunes in the eastern section and the area of parkland behind. The economic evaluation of environmental capital such as these areas is an inexact science and suitable methods of analysis are still being sought. Nevertheless, one of the primary objectives of the Essex SMP was to continue protection for the dunes in the eastern section and the means for doing so effectively and justifiably must therefore be considered carefully. The area of low lying land east of this section contains MOD properties, the value of which is unknown and consequently have not been included in this analysis.

The limited range and means of valuing the benefits to be gained through investment in this length has consequently led to a limited range of options for further analysis.

Conclusions and Recommendations

Appraisal of the various constraints affecting this unit has led to the conclusion that at present and with the current levels of knowledge, the preferred management policy should be to 'Do Minimum', that is, to continue the existing management policy of carrying out repairs to the defences as required. This decision has been examined to appraise the effect of this policy on each of the three sub-divisions of the unit, leading to the following conclusions and recommendations;

For the Eastern Frontage

- Although the rate of retreat of the dunes has not been determined through this strategy, the condition survey and subsequent appraisal concluded that the front line of the dunes does not appear to be eroding rapidly. The quite heavily vegetated front face and high level of the foreshore would appear to provide sufficient protection from flooding.

- The Essex SMP determined that protection of areas such as the eastern frontage of East Beach should be considered a principal objective under subsequent development plans. This policy has been borne in mind whilst appraising this management decision. Protection of this frontage must involve minimising the impact of any management policy and consequently more information about the processes at work are required before a confident strategy can be proposed.

- To provide a true reflection of the impact through loss of Critical Natural Capital, it is necessary to be able to put the loss into perspective by establishing an effective means of economically valuing the capital. To date this method is unavailable and consequently a value for the loss of this frontage has not been included within these calculations.

- In order to provide a means of determining the physical processes and the rate of retreat of the dunes, it is recommended that at this strategic stage a regular means of monitoring the crest level of the dunes be initiated. It is recommended that a base line be developed along the rear of the dune crest and a series of offsets from the baseline to the crest taken at three monthly intervals. The results of this monitoring will form the basis for a more informed decision to be made on management of this length.

For the Central Frontage:

- The rock revetment itself is stable and in good condition, the foreshore in front of the revetment relatively high. The defence standard at present is sufficient and breach of this unit through the rock revetment is considered unlikely. Consequently it is considered that a policy of 'Do Minimum' is appropriate in this instance, maintenance work simply involving monitoring of beach levels to try and determine future problems.

For the Western Frontage:

- The western section of this frontage is composed of hard vertical defences in the Rampart Terrace/George Street area and requires a different perspective. The defences themselves, which front a low cliff/dune face, are at present in good to as-built condition. However, the foreshore levels along the majority of this section are low and have led to undermining of the more exposed extremes of the concrete

bastion. The timber groynes in the bastion vicinity are in good condition but appear to be completely ineffectual due to a lack of sediment feed.

- The low cliff/dune face behind the defences mean that overtopping is negligible. Consequently it is considered that maintenance of the bastion and adjacent hard vertical defences is not cost effective as they provide only an ineffectual means of protecting the toe of the cliff/dunes from erosion and are not sustainable.

- It is therefore recommended that a policy of 'Do Minimum' or 'managed deterioration' be adopted until collapse occurs. Upon collapse, a scheme to provide a more sustainable form of defence should be promoted. In order to predict the time scale of this unit more confidently, it is recommended that a regular monitoring programme be initiated to determine the rate at which the toe of the bastion is being undermined and provide feedback on the fluctuations of the foreshore in general.

8.2.2 Unit 2 - Shoeburyness (George Street to Maplin Way)

This length is the responsibility of the MOD who have indicated that they will not be carrying out any works to this length.

8.2.3 Unit 3 - Maplin Way to Thorpe Hall Avenue

Introduction

The frontage along the full extent of this unit is provided by concrete seawalls which are generally in good condition. The hinterland is primarily residential land, the majority of which is above the five metre contour. The foreshore along this length varies; at the eastern end the foreshore is primarily shingle and cockle shells with a crest width of about 30 metres; at the western end the foreshore is lower yet still reasonably healthy. The timber groynes along this section are in good to moderate condition.

The economic analysis of the 'Do Nothing' policy for this unit was considered in Section 4 of this report across the entire length of frontage. It was found that the benefits protected in the short term centre on the road link along the frontage, the loss of a limited number of properties and the loss of the beach front amenity. This level of damage costs has therefore limited the number of options available for consideration in the benefit cost analysis.

Whilst it has been determined that in the long term, sea level rise has a significant effect on the number of properties within the flood contour, for the purposes of this appraisal sea level rise has not been considered. It may be assumed therefore that the figures calculated are conservative.

Benefit Cost Analysis

Using the cost estimates per metre of frontage developed in Appendix G, the following costs for this unit, which has a frontage of 1200 metres are:

Option	Cost/metre (£/m)	Total (£ k)
Do Minimum (per year)	3.33	4
Minimum Investment Maintenance	276	330
High Investment Maintenance	1,500	1,800

To develop an estimate of the costs that would accrue over a fifty year period, a present value cost stream was determined for each of the options. These cost streams can be seen in Appendix H. The present value costs of each of these options have been used in Table 8.2.1.

Table 8.2.1 Economic Analysis of Unit 3

	Options			
	Do Nothing	**Do Minimum**	**Minimum Investment Maintenance**	**High Investment Maintenance**
Standard (1997) (yr)	200	200	200	200
Standard (2047) (yr)	50	50	100	100
PV Costs (£M)	-	0.12	0.78	2.16
PV Damages (£M)	0.79	0.36	0.02	0.00
PV Damages (£M) Avoided	-	0.42	0.77	0.79
PV Benefits (£M)	-	0.42	0.53	0.79
NPV (£M)	-	0.30	-0.01	-1.38
B/C ratio	-	3.42	0.99	0.36
Incremental B/C Ratio	-	-	0.53	0.01

Conclusions and Recommendations

It can be seen from Table 8.2.1. that the benefit/cost ratio for the 'Do Minimum' option is substantially greater than unity, whilst the 'Minimum Investment Maintenance' option is marginally less than unity. The incremental benefit/cost ratio for this latter option was substantially less than unity, rending the option unviable. The net present value for the 'Minimum' option was found to be positive. It is therefore proposed that the 'Do Minimum' option be adopted for this unit. The condition survey and subsequent appraisal of this unit have found that on the whole the defences are in good condition and the foreshore reasonably high. Beach huts line the seaward side of the defences which rarely suffer from wave attack. Consequently there is little need at present for higher levels of investment.

On the whole, the standard and deterioration rate of the defences are dependent upon the level of the foreshore, which in turn is dependent upon the condition of the timber groynes. At present the groynes are in good condition and it is anticipated that with continued maintenance of the groynes, the foreshore levels will remain high. Further to this, the recommended management policy for unit four to the west will be to improve the standard of groynes and supplement them with beach nourishment. The alongshore drift of this nourished material will then feed this unit and consequently, the condition of the groynes permitting, the levels of the foreshore should rise.

In the short term, it is recommended that a detailed condition survey of the groynes be carried out. This information when entered into a database will provide the basis for informed decisions on those lengths of groyne requiring further investment.

In the long term however, the policy decision should be reviewed, taking the condition of the defences, groynes and foreshore levels and the impact of construction works to the west in Unit 4 into account.

8.2.4 Unit 4 - Thorpe Hall Avenue to East of the Pier

Introduction

Stretching for approximately 2.2 kilometres from the eastern side of Southend Pier to Lynton Road Stone Bastion, the low level of the foreshore and poor condition of the revetment make this section a priority in terms of management works. Furthermore this length of frontage is in part responsible for providing flood defence for the low lying Southchurch area. A breach of these defences would allow flooding of up to approximately 1.9 square kilometres of primarily residential land, containing 711 properties within the annual flood contour.

The 'Do Nothing' economic analysis in Section 4 determined that the present value of damages accrued through breach of these defences would be approximately £50 million. Consequently a full range of management options has been considered.

Benefit Cost Analysis

Using the cost estimates per metre of frontage developed in Appendix G, the following costs for this unit, which has a frontage of 2200 metres, are:

Option	Cost/metre (£/m)	Total (£ k)
Do Minimum (per year)	5.60	12.3
Minimum Maintenance Investment	276	607
High Maintenance Investment	1500	3300
Capital Investment	1900	4180

To develop an estimate of the costs that would accrue over a fifty year period, a present value cost stream was determined for each of the options. These cost streams can be seen in Appendix H. These values have then been fed into Table 8.2.2 below.

Table 8.2.2 Economic Analysis of Unit 4

	Options				
	Do Nothing (M)	**Do Minimum (M)**	**Minimum Investment Maintenance (M)**	**High Investment Maintenance (M)**	**Capital Investment (M)**
Standard (1997)(yr)	50	50	50	200	200
Standard (2047)(yr	less than 5	5 - 10	50	100	200
PV Costs (£M)	-	0.26	1.51	4.05	5.07
PV Damages (£M)	20.37	11.35	3.71	0.20	0.00
PV Damages Avoided (£M)	-	9.02	16.66	20.17	20.37
PV Benefits (£M)	-	9.02	16.85	20.17	20.37
NPV (£M)	-	8.76	15.15	16.12	15.29
B/C ratio	-	34.40	11.07	4.98	4.01
Incremental B/C Ratio	-	-	6.14	1.38	0.20

Conclusions and Recommendations

It can be seen from Table 8.2.2. that each of the three investment options have benefit/ cost ratios greater than unity. The 'High Investment Maintenance' option attracts a marginally higher net present value than the other two options. Furthermore, whilst the benefit cost ratio is higher for the 'Minimum Investment Maintenance' option, the table shows that additional benefit is to be gained through providing a higher level investment, the incremental benefit/cost ratio being marginally greater than unity. The 'High Investment Maintenance' option will also provide the indicative standard of protection recommended by MAFF for the level of an urban development in the hinterland of this unit. The recommended policy decision for this unit is therefore for 'High Investment Maintenance.'

In addition to the revetment repair work to be carried out in this option, the timber groynes are to be upgraded to a higher standard and the foreshore then renourished with suitable material. The design of these works will require numerical modelling techniques to optimise the proposals. This modelling work will cost approximately £50K but would be used to consider the hydraulic processes acting along the full length of the foreshore and would lead to a greater understanding of the developing trends. The cost of this modelling work will be included with the scheme costs for this unit.

Further to the proposed beach management works, an initial appraisal has determined that in order to facilitate construction of the works and in order to comply with the SMP objectives and conclusions of the consultation carried out as part of this Strategy Plan, additional elements of work involving improvement of the foreshore's facilities and accesses will have to be considered as part of any scheme in this unit.

8.2.5 Unit 5 - Southend Pier Area

Introduction

The primary benefits to be protected in this unit comprise of the landfall of the pier itself and the contents of the Peter Pan playground. Whilst an arbitrary value for the value of the amusements and property can be determined, the pier itself is more complicated. The loss of amenities arising through tourism generated by the pier and value of the pier's heritage are to be included in the benefits.

Following the 'Do Nothing' evaluation in Section 4, it was judged that due to the low level of present value damages incurred through breach, the range of investment options that could be justified was restricted to the 'Do Minimum' and 'Minimum Investment' options. This section will then examine these options in order to determine the level of justifiable investment. The economic appraisal of this section can be seen in Table 8.2.3.

Benefit Cost Analysis

Using the cost estimates per metre of frontage developed in Appendix G, the following costs for this unit, which has a frontage of 700 metres, are:

Option	Cost/metre (£/m)	Total (£K)
Do Minimum	3.3	2.3
Minimum Maintenance Investment	276	193

Table 8.2.3 Economic Analysis of Unit 5

	Options		
	Do Nothing	**Do Minimum**	**Minimum Investment Maintenance**
Standard (1997) (yr)	100	100	100
Standard (2047) (yr)	less than 5	5 - 10	100
PV Costs (£M)	-	0.1	0.45
PV Damages (£M)	0.49	0.27	0.09
PV Damages Avoided (£M)	-	0.21	0.40
PV Benefits (£M)	-	0.21	0.40
NPV (£M)	-	0.12	0.06
B/C ratio	-	2.24	0.88
Incremental B/C Ratio	-	-	0.51

Conclusions and Recommendations

It can be seen from Table 8.2.3 that of the two options appraised, only the 'Do Minimum' option achieved a benefit cost ratio of greater than unity and acheived a positive net present value. However, support of tourism and leisure in Southend was deemed to be an objective of the Essex SMP and Southend pier has and will continue to play an integral part in maintaining Southends' attraction to seasonal visitors. The heritage value of the pier is incalculable in economic terms. The structure has been the focus of tourism in Southend for

over a century, generating income through the industry and employment that it creates. In addition, the RNLI station at the seaward head of the pier is in an essential location for overseeing the high level of watersports activities that take place on the Southend foreshore. The continuation of this service is essential for continuation of these watersports and the subsequent employment generated.

Consequently it is considered that the existing policy of 'Do Minimum' is not sufficient to enable continued protection to the pier head, and it is recommended that a policy of 'Minimum Investment Maintenance' should be adopted.

The revetment around the pier is in poor condition and has experienced a number of minor collapses to date through removal of the revetment armour layer. Although not examined during the site investigation, the evidence gained through adjacent trial holes would suggest that the toe of the revetment extends for some metres below mud flat level and consequently undermining of the toe is not a cause for immediate concern.

It is therefore recommended that as a precursor to any maintenance works, a structural survey of the revetment be carried out with a view to repairing the voids and replacing loose blocks. The coping stone blocks along the top of the revetment will need to be examined in order to determine a more effective means of protecting the edge of the footpath.

8.2.6 Unit 6 - West Side of the Pier to Grosvenor Road

Introduction

The frontage within this unit extends for a length of approximately 2000 metres from the west side of Southend pier to Grovesnor Road on Western Esplanade. The defence along this frontage is provided by pitching stone revetment with a precast concrete crest capping beam. Western Esplanade runs along the top of the defences; the land rises steeply to the landward side of the road, forming Southend cliffs and consequently limiting the potential for spread of flood waters and restricting the damage sustained during a flood event to traffic disruption. It is recognised that overtopping of this section occurs occasionally on extreme events but is limited to ponding on the seaward side of the carriageway.

Evaluation of the 'Do Nothing' damages for this unit in Section 4 of this report gave an indication of the level of investment that could be justified. Consequently the options that have been further investigated are as follows; 'Do Minimum', 'Minimum Investment Maintenance' and, 'High Investment Maintenance.'

Benefit Cost Analysis

Using the cost estimates per metre of frontage developed in Appendix G, the following scheme costs for this unit, which has a frontage of 2000 metres, are:

Option	Cost/metre (£/m)	Total (£K)
Do Minimum	4.15	8.33
Minimum Maintenance Investment	276	552
High Maintenance Investment	1,500	3,000

Table 8.2.4 Economic Analysis of Unit 6

	Options			
	Do Nothing	Do Minimum	Minimum Investment Maintenance	High Investment Maintenance
Standard (1997) (yr)	50	50	50	100
Standard (2047) (yr)	less than 5	5 - 10	50	50
PV Costs (£M)	-	0.2	1.38	3.63
PV Damages (£M)	0.59	0.28	0.01	0.00
PV Damages Avoided (£M)	-	0.31	0.59	0.59
PV Benefits (£M)	-	0.31	0.59	0.59
NPV (£M)	-	0.12	-0.73	-3.04
B/C ratio	-	1.61	0.44	0.16
Incremental B/C Ratio	-	-	0.24	0.00

Conclusions and Recommendations

The result of this analysis indicates that the 'Do Minimum' option has achieved the only benefit cost ratio greater than unity and the only positive net present value. However, it is estimated that the standard of protection provided by this management policy will reduce to between 5-10 years by 2047 and consequently is not sufficient for Southend Borough Council's social objective for a length of frontage of this prominence (in terms of location within the Central Seafront Area).

The benefit cost ratio for the 'Minimum Investment Maintenance' option is less than zero and the net present value negative. This option is therefore unjustifiable in economic terms. However, it is considered that to maintain Southend's attraction as a tourist resort, minimum maintenance must be provided along this essential link in the town's defences. This unit contains the West Cliff Sports Centre, Esplanade car parking facilities, watersport and recreational facilities and is adjacent to the tourist attractions of Southend Pier and Peter Pans Playground (Unit 5). Consequently it is recommended that minimum maintenance works be carried out, justifiable on a social and political basis.

8.2.7 Unit 7 - Grosvenor Road to Chalkwell Station

Introduction

This unit extends for a distance of 1100 metres from Grosvenor Road in the east to Chalkwell railway station at the western end of Chalkwell Esplanade. The seawall defences along this length are generally in reasonable condition although the foreshore levels in front of the defences are relatively low, a consequence of the poor condition of the timber groynes along this length. The flood defence level in this section is set at a retired line to the rear of the gardens which lie immediately to the rear of the defences.

There are a number of properties the cliffs along this frontage but it was found that the majority of these properties are above the 3.5 metre OD annual still water level and consequently have not been included in the benefits. The recently completed Anglian Water storm and foul sewer storage tanks are located landward of the defences along this length and an estimated value of £1.3M has been included in the benefits.

Benefit Cost Analysis

Using the cost estimates per metre of frontage developed in Appendix G, the following scheme costs for this unit, which has a frontage of 1100 metres, are:

Option	Cost/metre (£/m)	Total (£ K)
Do Minimum	2.73	3.0
Minimum Maintenance Investment	276	304

Table 8.2.5 Economic Analysis of Unit 7

	Options		
	Do Nothing	**Do Minimum**	**Minimum Investment Maintenance**
Standard (1997)(yr)	200	200	200
Standard (2047)(yr)	100	100	200
PV Costs (£M)	-	0.11	0.70
PV Damages (£M)	0.52	0.24	0.09
PV Damages Avoided (£M)	-	0.28	0.44
PV Benefits (£M)	-	0.28	0.44
NPV (£M)	-	0.18	-0.26
B/C ratio	-	2.64	0.62
Incremental B/C Ratio	-	-	0.26

Conclusions and Recommendations

The results of the benefit cost analysis shown in Table 8.2.5 indicate that only the 'Do Minimum' option achieves a benefit/cost ratio of greater than unity, and has a net present value of marginally greater than zero. It is therefore recommended that the 'Do Minimum' option be adopted for this unit.

8.2.8 Unit 8 - Cinder Path (Railtrack Length)

Introduction

The benefits to be gained from investment in the defences in this unit can be solely attributable to the value and use of the railway line itself. Beyond the line the land rises steeply to form Leigh cliffs. All further properties are situated on top of the cliffs. The value of benefits derived come from the loss of passenger fares due to a loss of service.

During discussions with Railtrack, it was indicated that at present and for the foreseeable future their management policy for this length would be to continue as at present, providing maintenance works on a reactive basis.

A full benefit cost assessment has not therefore been considered necessary.

8.2.9 Unit 9 - Leigh on Sea: Commercial Whelk Fishing Harbour and Processing Facilities

Introduction

Within this unit are the properties of Leigh-on-Sea, the cockle fishing industry and the railway line.

Conclusions and Recommendations

The benefits to be gained through investment in this unit are very limited. The vertical defences along the creek are in good condition making a breach unlikely. The crest level of the flood wall is sufficient for the 1 in 100 year still water level event, although it is reported that limited flooding has occurred through overtopping of the lower level defence near to Bell Wharf.

Consequently it is recommended that a policy of 'Do Minimum' be adopted for this unit. Although difficult to justify economically at present, maintenance of the frontage is essential for enabling continuation of the fishing and cockle industries at Leigh.

It is recommended that a programme of monitoring of Leigh Creek be established with a view to investigation of long term evolution and realignment of the creek. The close proximity of the vertical defences to the Creek mean that any possible landward movement as a response to sea level rise could have serious repercussions on the stability of these defences. Likewise, the monitoring could be used to assess long term siltation of the Creek. These results can be used to address the secondary objectives of support of fisheries and cockling at Leigh.
Furthermore, it is recommended that a detailed topographic survey of the unit be carried out with a view to determining the low lying defence lengths that allow occasional overtopping

events to flood limited areas of Leigh. Once this information has been obtained, a further assessment of the benefits of carrying out minor flood mitigation works may be made.

Further information from and monitoring of the cockle industry yards is required. Historically, the industry have dumped their unused shells seaward of their properties, leading to a widened area of compacted reclaimed land. It is possible that continuation of this policy is having repercussions on the hydraulic conditions of the creek, in that additional material is being fed into the system and that the width of the creek has been artificially reduced. This may have led to increased flow rates and potentially increased erosion of the mud flats in this vicinity. Studies are required to examine the impact of these works on Leigh creek and the implication for the Southend foreshore as a whole. Methods and details of the level of dredging required in the creek can then be determined in an attempt at satisfying the SMP objective relating to this issue.

9.0 SHORELINE MANAGEMENT STRATEGY

9.1 Strategy Objectives

The Southend-on-Sea Shoreline Strategy study has been carried out with the following objectives borne in mind;

- The Borough Council engineers' concerns about the long term effects of loss of foreshore material and general lowering of foreshore levels, rising sea level and general deterioration of the sea defences and the need for a long term sustainable policy of justifiable management. The requirement for an outline programme and cost estimate for implementation of this policy.

- The need for a long term management plan which has considered the fundamental issues affecting the foreshore and provides the higher level basis on which individual schemes can be based.

In addition to these objectives, site specific objectives developed during preparation of the Essex SMP and further clarified in preparation of this plan can be summarised as follows;

· The need for effective defence of people and property (including agricultural land) against flooding and erosion, where economically, technically and environmentally justifiable and sustainable.

· The need for defence of Critical Natural Capital such as the sand dunes at Gunners Park.

Secondary objectives are:

· Seek to sustain Constant Natural Assets such as saltmarshes and intertidal flats, ensuring conservation of the overall habitat resource of Constant Natural Assets within the Thames estuary.

- Assist and promote the development of a long term sustainable dredging policy for the Thames which sustains critical processes and meets environmental objectives.

· Support tourism and leisure at Southend-on-Sea.

· Seek to minimise recreation and conservation differences (eg. Boat movements and speed) in areas such as the Southend foreshore.

· Continue to safeguard all Conservation area, Grade 1 listed buildings and scheduled Ancient Monuments.

- Continue to support the fisheries at Leigh-on-Sea and Southend-on-Sea.

- Continue to support the cockle industries at Leigh-on-Sea and Southend-on-Sea providing that harvesting methods do not prejudice the integrity of intertidal habitats and sea defences.

The development of this strategy plan has sought to achieve the fundamental objectives of protection to properties and people and provide the basis for long term protection of the Critical Natural Capital. Furthermore, impacts of the recommended strategy have been considered carefully and are considered to be in accordance with and not detrimental to, the requirements of the secondary objectives. Where possible, individual schemes arising as a result of recommendations in this strategy plan, will be used to address these objectives further.

9.2 Strategy Recommendations

This strategy study has determined and justified the following management policies for each of the operational units;

Operational Unit	Description of Unit	Management Policy
1	East Beach	Do Minimum
2	Shoeburyness (MOD length)	--
3	Maplin Way to Thorpe Hall Avenue	Do Minimum
4	Thorpe Hall Avenue to East of the Pier	High Investment Maintenance
5	Southend Pier Area	Minimum Investment Maintenance
6	West side of the Pier to Grosvenor Road	Minimum Investment Maintenance
7	Grosvenor Road to Chalkwell Station	Do Minimum
8	Cinder Path (Railtrack length)	- -
9	Leigh on Sea : Commercial whelk fishing harbour and processing facilities.	Do Minimum

9.3 Strategy Costs and Programme

9.3.1 Scheme Costs

Detailed Revetment Condition Survey

It is considered that prior to an investment in management works on the foreshore, a more detailed condition survey of the revetment lengths is required. This investigation would involve use of Ground Probing Radar surveying techniques. The cost of such a survey is as follows:

Length of revetment requiring assessment	4200 metres
Length of revetment to be surveyed per day	approx. 800 metres
Approximate cost of survey	£1000/day
Total cost of survey	**Approx. £5250**

Structural Survey of Groynes

It is recognised that the existing groynes are in varying states of repair and consequently it is considered that a detailed condition survey will need to be carried out, initially to evaluate the state of disrepair and level of effectiveness of each of the groynes. This survey will be incorporated in to the cost build up to enable a more accurate cost programme to be developed;

The likely cost of a condition survey can be estimated as follows;

Provision of a graduate engineer for survey	Ö250/day
Interpretation/reporting etc	Ö500/day
Supervision @ 10%	Ö75/day
Length of groyne surveyed/interpreted	600 metres/day
Approximate cost / metre of groyne	Ö1.40
Total length of existing groynes	4796 metres
Total cost of survey	**Approx £7000**

Unit 4 - Thorpe Hall Avenue to East of the Pier

In order to facilitate cash flow and construction programming, it is recommended that this section be broken into three phases of management;

- Phase One covering a length of approximately 750 metres between Southend Pier and the Corporation Loading Pier;
- Phase Two covering the 520 metre length between the Corporation Loading Pier and the slipway/paddling pool at Chelsea Avenue;

- Phase Three covering the 920 metre length between the slipway and Lynton Road Stone Bastion.

At this stage the costs suggested here are based on an outline design developed using limited knowledge to date of physical processes at work on the foreshore, engineering judgement and experience. Further studies and numerical modelling of the processes are required before detailed design of the beach can be carried out.

The outline design proposes the use of 50 metre long timber groynes, constructed at a spacing of 75 metres. These groynes would then be supplemented by a nourished beach profile comprising of a crest width of 5 metres at a level of 4.5 m ODN, and with a front slope of 1:10. This slope is based on the use of a coarse sand or fine gravel.

The costs for these three phases are summarised as follows;

Phase One:		**(£ K)**
Length	*750 metres*	
Timber Groynes	9 No. @ £800/m, 25% reuse of existing	280
Improvement of Revetment (high level repairs)	750 metres @ £133/metre	100
Beach Nourishment	40,000m^3 @ £12/m^3	480
Provisional sum for mobilisation		250
Construction of new access/ permanent launching facility		100
Preliminaries, Contingencies	@ 20%	242
Consultants fees	@ 10%	145
Total Cost		**£1,600**

Phase Two:		**(£ K)**
Length	*520 metres*	
Timber Groynes	6 No. @ £800/m, 40% reuse of existing	168
Improvement of Revetment (high level repairs)	520 metres @ £133/metre	70
Beach Nourishment	28,600m^3 @ £12/m^3	343
Provisional sum for mobilisation		250
Refurbishment of existing slipways at Camper Road and Chelsea Road, refurbishment of paddling pool		150
Preliminaries, Contingencies	@ 20%	200
Consultants fees	@ 10%	120
Total Cost		**£1,300**

Phase Three:		**(£ K)**
	920 metres	
Timber Groynes	14 No. @ £800/m, 40% reuse of existing	168
Improvement of Revetment (high level repairs)	920 metres @ £133/metre	122
Beach Nourishment	50,600m^3 @ £12/m^3	607
Provisional sum for mobilisation		250
Construction of new access/permanent lasting facility		100
Preliminaries, Contingencies	@ 20%	250
Consultants fees	@ 10%	150
Total Cost		**£1,650**

The total cost of the three phases would be of the order of £4.6 million.

Unit 6 West Side of the Pier to Grosvenor Road

Following completion of the three phases of Section four above, Unit six has been highlighted for further works. This length has been divided into two phases as follows.

- Phase One, stretching from Grosvenor Road to the Westcliff sports centre, a distance of approximately 1200 metres.

- Phase Two, from Westcliff sports centre to the west side of the pier, approximately 700 metres

The management option determined for this length was for 'Minimum Investment Maintenance'. In line with development of this option in section seven, improvement works in this unit would follow completion and appraisal of the groyne and revetment condition surveys. These would determine the full extent of works required. The following tables provide an estimate of the likely costs; it has been assumed that both surveys will be carried out independent of individual schemes in order to maximise economies of scale, the cost of these surveys has not therefore been included in these estimates:

Phase One:		**(£ K)**
Length	*1200 metres*	
Improvement of Timber Groynes	600 metres of groyne @ £200/metre	180
Improvement of Revetment (low level repairs)	1200 metres @ £100/metre	120
Beach Nourishment (nominal)	1000m^3 @ £25/m^3	25
Preliminaries, Contingencies	@ 20%	65
Consultants fees	@ 10%	39
Total Cost		**£430**

Phase Two:		**(£ K)**
Length	*800 metres*	
Improvement of Timber Groynes	300 metres of groyne @ £200/metre	60
Improvement of Revetment (low level repairs)	800 metres @ £100/metre	80
Beach Nourishment (nominal)	1000m^3 @ £25/m^3	25
Preliminaries, Contingencies	@ 20%	33
Consultants fees	@ 10%	20
Total Cost		**£220**

The total cost of works in this unit would be in the order of £650,000.

Unit 5 Southend Pier Area

Works in this area would commence following completion of the works to the west in unit 6. An estimate of the cost for this unit can be determined as follows;

	700 metres	**(£ K)**
Improvement of Revetment (low level repairs)	700 metres @ £100/metre	70
Preliminaries, Contingencies	@ 20%	15
Consultants fees	@ 10%	8
Total Cost		**£95**

Unit 3 Maplin Way to Thorpe Hall Avenue

Once the entirety of the works to unit four are complete, specific maintenance works to the timber groynes in unit three may be considered. The existing condition of the defences is such that immediate works are not required. However, continued deterioration of the groynes maintaining the foreshore will allow increased sediment transportation away from the defence. The beach nourishment carried out to unit four will, through longshore drift, lead to an increase in sediment feed to unit three. Consequently, an improvement in the standard

of groynes will serve to reduce the rate of transportation and help prolong the life of the defences.

Minimum maintenance of the groynes will seek to strengthen and raise the general standard. The likely cost of this operation is as follows;

Length	*1200 metres*	**(£ K)**
Improvement of Timber Groynes	500 metres of groyne @ £100/metre	50
Preliminaries, Contingencies	@ 10%	5
Total Cost		**£55**

Unit 7 Grosvenor Road to Chalkwell Station

Similarly, it was found that groynes in this unit, particularly those to the west of this unit, were relatively full at the time of inspection. Consequently it is considered that upgrading of these groynes would lead to an increase in the level of the beach, leading to increased protection to the defences. The likely cost of carrying out these works is as follows;

Length	*1050 metres*	**(£ K)**
Improvement of Timber Groynes	600 metres of groyne @ £100/metre	60
Preliminaries, Contingencies	@ 10%	6
Total Cost		**£66**

9.3.2 MAFF Grant Aid

Grant Aid from the Ministry of Agriculture, Fisheries and Food (MAFF) is payable on eligible flood defence and coast protection schemes. In order to be eligible a scheme must satisfy a number of criteria. These include:

- capital works or major improvements to existing (maintenance works are excluded);
- failure of the existing works must not be due to lack of maintenance;
- the works are necessary for existing developments, not future proposals;
- the works are essential for flood defence or coastal protection, no additional issues will be paid for;

- the works must be part of a long term strategic approach to flood defence and/or coast protection;
- the works must be environmentally sound, technically feasible and economically worthwhile;
- the costs must be reasonable and the benefits sufficient to justify the whole scheme irrespective of whether grant aid is payable or not.

The basic rate of grant aid for coastal schemes is currently about 45% although this varies depending upon the cost of the scheme. Until about a year ago the rate was higher: of the order of 75%. It is however possible that the remainder of the eligible costs may be covered by a Supplemental Credit Approval (SCA) from the Department of the Environment, if no other forms of funding are available. The availability of SCA is dependant upon a number of factors including:

- the ability of the Council to raise sufficient funds by other means;
- the annual expenditure of the Council on coast protection works;
- whether the Council is rate capped or not;
- how many other schemes elsewhere around the country also apply for SCA;

Other potential sources of funding include the Environment Agency, either directly through the LFDC or more probably through their increased rate of MAFF grant, which can at present be up to 85%.

9.4 Implementation

In developing a programme for implementation of the strategy plan, the following aspects have been taken into account;

- the need to spread the cost of implementation works over a long time period;
- Southend's value as a centre for tourism and the need to restrict the impact of construction works to the low season periods in terms of visitor numbers;
- the requirement for collation and interpretation of data concerning the condition surveys of the groynes and revetment;
- the ongoing requirement for monitoring of the foreshore, as a consequence of sea level rise and in response to initial construction works;
- the need for further consultation with parties interested in development of the foreshore, in particular those concerned with protection of the sites of high environmental value.

The suggested programme is included as Figure 9.1 and indicates a construction period approaching seven years for the main capital and investment maintenance works. Table 9.1 below provides an estimated cost stream to cover the period of this construction period.

Table 9.1 Strategy Implementation Cost Stream

	1999 (£ K)	2000 (£ K)	2001 (£ K)	2002 (£ K)	2003 (£ K)	2004 (£ K)	2005 (£ K)	(£K)
Maintenance, Monitoring and Data Collection								**Totals**
Monitoring	7	7	7	7	7	7	7	49
Condition Surveys	12							12
Minimum Maintenance	33	33	33	33	33	33	33	231
Capital Works								
Unit 4 Phase 1	873	727						1600
Unit 4 Phase 2	120	590	590					1300
Unit 4 Phase 3	150		750	750				1650
Unit 6 Phase 1		40		195	195			430
Unit 6 Phase 2		20			100	100		220
Unit 5		8				43	44	95
Total Cost	**1,195**	**1,425**	**1,380**	**985**	**335**	**183**	**84**	**5587**

10.0 MONITORING AND MAINTENANCE

10.1 Recommendations for Further Monitoring

In order to develop a thorough understanding of the condition of the defences and use this understanding to allocate prioritisation of 'Do minimum' investment, the following recommendations are given:

- to provide ready access to information on the existing defences and beach management structures, it is recommended that a sea defence database be set up to incorporate information from the full extent of management unit 1g. This database would require regular feedback of information from the regular monitoring and surveys conducted on the foreshore and provide interaction between the various levels of management.

To further this concept and provide information on where investment should be prioritised, the following surveys are recommended:

- to ensure a uniform recording of condition and best use of economies, the structural survey of the existing timber groynes should be designed to incorporate the full extent of the Southend frontage. The survey should make a full recording of the dimensions and structural components involved and base an assessment of the general condition of the groyne on individual assessments of these components. This survey would also enable an estimate of the proportion of existing timber that could be reused in any subsequent groyne upgrading contracts.

- similarly, a structural survey of the defences should be carried out along the full length of both the pitching stone revetments in units 4, 5 and 6, and the Essex block revetment in unit 4. Investigations into the level of cavitation beneath the revetment could be carried out by 'Ground Probing Radar Survey'. This system works by feeding an antenna (containing a transmitter and receiver) down the surface of the revetment and applying a pulse of energy through it. The pulse will penetrate the revetment surface and can detect the location of an interface (air/clay for example) by measuring a change in velocity of the pulse; some energy from the pulse is lost and some energy reflected back to the receiver. The location of interfaces within the revetment can therefore be detected by changes in pulse velocity and a profile of the wall can be produced.

  Due to the conductivity of salt water and the potentially misleading results that this may produce, it is recommended that a one day trial survey be carried out initially to determine the effectiveness of the methodology for the defences under consideration.

  Once the extent of voids beneath the revetment has been determined, a strategy for repair of lengths of revetment suffering form large areas of cavitation could then be developed.

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SOUTHEND-ON-SEA STRATEGY PLAN

Title	Level (m)
Shoebury Common Road opposite Maplin Way	wall= 5.174
Thorpe Esplanade opposite St. Augustine Avenue	wall= 6.816
Thorpe Esplanade opposite The Broadway	kerb = 6.901
Thorpe Esplanade opposite Thorpe Hall Avenue	kerb = 6.147
Eastern Esplanade opposite Burgess Terrace	kerb = 5.564
Eastern Esplanade opposite Lynton Road	wall= 5.692
Eastern Esplanade opposite Cleveden Road	kerb = 4.980
Eastern Esplanade opposite Warwick Road	kerb = 4.843
Eastern Esplanade opposite Plas Newydd	kerb = 4.583
Eastern Esplanade opposite Bryant Avenue	wall= 5.715
Eastern Esplanade opposite Elizabeth Road	wall= 5.692
Eastern Esplanade opposite Chelsea Avenue	wall= 5.678
Eastern Esplanade opposite Chester Avenue	wall= 5.689
Eastern Esplanade opposite Camper Road	wall= 5.684
Eastern Esplanade opposite Victoria Road	wall= 5.678
Eastern Esplanade opposite Beach Road	path= 5.007
Marine Parade opposite South Church Avenue	path= 4.974
Chalkwell Esplanade opposite Chalkwell Avenue	wall= 5.793
Chalkwell Esplanade opposite Crowstone Avenue	wall= 5.778
Chalkwell Esplanade opposite Grosvenor	kerb = 5.897

Avenue	