

Royal Haskoning

**North East
Coastal Authorities Group
SMP2: Estuaries Assessment**

Date: May 2006

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Abbreviations

ABPmer	ABP Marine Environmental Research Ltd
NECAG	North East Authorities Coastal Group
SMP	Shoreline Management Plan
SMP2	Second Generation Shoreline Management Plan
eSMP	Estuary Shoreline Management Plan
CFMP	Catchment Flood Management Plan
EGT	Estuary Guidance Table
Defra	Department for Environment Food and Rural Affairs

North East Coastal Authorities Group SMP2: Estuaries Assessment

Contents

	Page
Abbreviations.....	i
1. Introduction.....	1
1.1 Report Aims	1
1.2 Report Structure.....	1
2. Shoreline Management Plans: Integration of Estuaries.....	2
2.1 Overview of Guidance	2
2.1.1 Open Coast - Estuary Interactions.....	2
2.1.2 Should the Estuary Be Included in the SMP Process?	3
2.1.3 How Should the Estuary Be Included in the SMP Process?	3
2.1.4 How Far Upstream Should the Estuary Be Included?.....	3
2.1.5 Estuary Guidance Tables.....	4
3. Tyne Estuary Assessment.....	5
4. Wear Estuary Assessment	7
5. Tees Estuary Assessment.....	9
6. Esk Estuary Assessment.....	12
7. Summary	14
8. References	14

Appendix

- A. Estuary Guidance Tables (Extracts from Procedural Guidance for Production of Shoreline Management Plans, Appendix F: Integration of Estuaries)

Tables

1.	Tyne estuary assessment.....	5
2.	Wear estuary assessment	7
3.	Tees estuary assessment.....	9
4.	Esk estuary assessment.....	12

Figures

1.	Location of four assessed estuaries within the SMP area
2.	Tyne Estuary
3.	Wear Estuary
4.	Tees Estuary
5.	Esk Estuary

1. Introduction

ABP Marine Environment Research Ltd (ABPmer) was commissioned by Royal Haskoning in November 2004 to undertake a number of tasks in support of the production of the second generation Shoreline Management Plan (SMP) for the length of coast from the Tyne to Flamborough Head. This project is being led by Royal Haskoning, on behalf of the North East Coastal Authorities Group (NECAG), with Scarborough Borough Council as lead authority.

One of the key tasks being undertaken by ABPmer is an Estuaries Assessment. This document reports the results of this assessment.

1.1 Report Aims

The main objective of this report is to assess the need (or otherwise) for the inclusion of the estuaries in the study area within the SMP process. An assessment has been undertaken and conclusions provided for four estuaries:

- (1) The Tyne;
- (2) The Wear;
- (3) The Tees;
- (4) The Esk.

A plan showing the location of each of the estuaries is provided in Figure 1. Each estuary has been assessed to address three key questions relating to the inclusion of an estuary in the SMP process, as follows:

- Should the Estuary be included in the SMP process?
- If so, how should the estuary be included?
- How far upstream should the estuary be included?.

The conclusions and answers to each of these questions for each estuary informs the overall SMP development process. To address these questions Defra's 2004 Guidance for the Production of SMP's (Defra, 2004) has been followed.

1.2 Report Structure

The report is divided into the following sections:

Section 2: Provides an overview of the Defra's Guidance for the production of SMPs, with particular reference to the contents and approach outlined in its Appendix F: Integration of Estuaries;

Sections 3-6: Provides an assessment for each of the four estuaries;

Section 7: Provides a summary of the conclusions of the assessment of each estuary.

2. Shoreline Management Plans: Integration of Estuaries

The estuary assessment has been produced in accordance with Defra's 2004 Guidance for the Production of SMP's (Defra, 2004). This guidance updates the 2001 guide for local defence authorities (Defra, 2002) specifically for second (and later) generation plans. The guide overall is aimed at those responsible for the definition, management and production of SMP's, providing procedural guidance on SMP production complying with specific requirements. Volume 3 of the guidance consists of technical appendices outlining a number of tools and techniques to be used in support of SMP production.

Appendix F: Integration of Estuaries provides guidance regarding the incorporation of estuarine shores into the SMP process. The guidance enables the scale of water and sediment exchanges between an estuary and adjacent areas of open coast to be considered, along with the scale of management intervention, to feed into the decision as to whether or not an estuary should be included in the SMP process.

2.1 Overview of Guidance

This section provides a brief overview of the guidance contained in Appendix F to provide background and context to the remainder of this report.

2.1.1 Open Coast - Estuary Interactions

The inclusion of an estuaries assessment within the SMP process has arisen in recognition of the importance of understanding physical processes in providing effective flood and coastal management. The interaction of, and exchanges between, the open coast and estuaries mean management policies in one environment have the potential to affect the other.

The interactions between the open coast and estuaries may take a number of forms, as follows (after Defra, 2004):

- **Sediment Supply:** The open coast may provide a significant supply of sediments to the estuary and the estuary may supply sediment to the coast. Therefore any management policy that acts to alter this supply may have an impact on the estuary;

- Alteration to Longshore Drift: Water flows from estuary can act to block longshore sediment transport across the mouth of the estuary. In addition, high river flows can drive sediment from the longshore transport system offshore;
- Flood and Ebb Tidal Deltas: Sediment within the longshore transport system can be transported into the estuary mouth and stored on flood tide deltas before being transferred to the downdrift coastline. Similarly, ebb tide deltas may store sediments. Ebb tide deltas also serve a natural coastal defence function to the estuary mouth and adjacent stretches of the open coast; and
- Tidal Prism Changes: A change in the tidal prism of the estuary may alter process to the extent that changes also occur to erosion / deposition patterns and / or changes in the dominance of the flood or ebb tide and hence the import or export of sediment. This will have implication for the sediment budget along adjacent coastlines.

2.1.2 Should the Estuary Be Included in the SMP Process?

This is the first stage of the assessment process. The guidance states that this question is to be addressed by considering:

- The type and scale of physical interactions and their significance;
- Management Issues, and their significance.

2.1.3 How Should the Estuary Be Included in the SMP Process?

If a decision is made to incorporate the estuary in the SMP, then there are two options for inclusion:

- The estuary could be included in the open coast SMP;
- The estuary could have its own 'estuary SMP' (eSMP).

2.1.4 How Far Upstream Should the Estuary Be Included?

To completely cover any potential interactions, the estuary should be theoretically incorporated to the tidal limit, however this is not practical in many cases due to the tidal length of an estuary. The practical alternative is to determine an upstream limit beyond which no change in shoreline management policy is assumed (Defra, 2004). Defra (2004) provide a number of criteria that could be used to determine the upstream limit of inclusion of an estuary within an SMP. These are:

- Approximate limit of tidal influence;
- Approximate limit of wave influence;
- Approximate limit of non-cohesive sediment exchange;
- Limit of continuity of habitats, development or risk zones;
- Limit of existing Catchment Flood Management Plan (CFMP) boundaries;
- Limit as defined by existing Schedule IV Boundary (Defra, 2004).

2.1.5 Estuary Guidance Tables

The guidance does not provide a prescriptive method for assessing estuaries and their inclusion in an SMP. However, a series of Estuary Guidance Tables (EGTs) have been produced that provide consistency in the approach. These EGTs are reproduced in Appendix A of this report for information.

The Procedural Guidance recommends assessments of the 'significance' of water and sediment exchanges between the estuary and open coast and of the management issues within the estuary. In undertaking this assessment, the term 'insignificant' has been difficult to apply since clearly any physical interaction or management issue is significant at some, perhaps very local, scale. Consequently, in undertaking this assessment, the term 'insignificant' has been interpreted as being of no, or low, significance to the regional (i.e. cell-wide) coastal processes. This may mean that some locally important processes or issues do need to be considered, but where these exist they have been highlighted in the following assessments.

3. Tyne Estuary Assessment

The following table presents the assessment of the Tyne. The Tyne estuary is illustrated in Figure 2.

Table 1. Tyne estuary assessment

Estuary	Tyne
Location	North East England
Classification	Origin: Drowned River Valley; Type: Ria; Sub-type: No spits
Main Characteristics	Macro-tidal, medium sized estuary. Relatively long, narrow estuary with steep banks. Large degree of industrial and urban activity along the banks of the estuary leaving only a narrow intertidal zone. Estuary confined at the mouth by breakwaters
Data Availability	<ul style="list-style-type: none"> River Tyne to Seaham Harbour Shoreline Management Plan, Sub Cell 1B (Babtie, 1997); Futurecoast Estuaries Assessment (Halcrow, 2002); An Inventory of UK Estuaries (JNCC, 1997);
Stage 1: Step 1: Significance of water exchange (EGT2)	<p>Total Area: The Tyne is considered to be of medium size in terms of the total estuary area within the whole range of estuaries in England and Wales.</p> <p>Intertidal Area: The estuary has a small intertidal area relative to its total area. It is anticipated that this intertidal area would have been considerably larger, before the heavy industrialisation that now exists along the banks. In the present day the estuary is dominated by subtidal area with patches of mudflat along the southern shore and a small area of saltmarsh. Inside the breakwaters in the outer estuary, there are also stretches of sandflat and rocky shore. The small intertidal area suggests a relatively small tidal exchange.</p> <p>Channel Length: The length of the estuary is considered to be high.</p> <p>Mouth Width: The estuary has a moderate width at the mouth (Note: The mouth is constrained by the presence of the breakwaters).</p> <p>Tidal Range: The tidal range in the estuary is moderate.</p> <p>Mean Freshwater Flows: Freshwater flows within the estuary are considered to be relatively high as are maximum flows.</p> <p>% Area: The estuary has a relatively low % area.</p>
	<p>Verdict on Significance: The estuary is of medium size. The mouth width is considered low in relation to the channel length, indicating a deep channel at the mouth. The ratio of tidal range to freshwater flows is low due to the high input of freshwater flows. The system is also highly stratified indicating there may be density circulations driving sediment movement.</p> <p>Therefore in accordance with EGT2, in terms of water exchange the estuary is assessed as "Insignificant".</p>

Stage 1: Step 2: Significance of sediment exchange (EGT3)	<p>Tidal Asymmetry: The estuary is strongly ebb dominant according to Dronkers' Gamma.</p> <p>Morphological features: The outer estuary is confined by the north and south pier, within which lie areas of accumulation of sandy sediments. The high level of development has restricted the amount of intertidal although mudflats are present.</p> <p>Source / Sink Relationships: Evidence would suggest that the estuary is a net sink for sediments (inferred from dredging figures). It has been suggested that the estuary is a weak sink for fine sediment derived from the seaward side (driven into the estuary by the density currents) in addition to deposition of some of the fluvially derived sediments.</p> <p>Potential for plume generation: A plume is likely to be present on the ebb and potentially on the flood as well. This may prevent fluvially derived sediment being deposited within the estuary.</p>
	Verdict on Significance: "Marginal".
Stage 1: Step 3: Relevance of process issues	<p>Verdict on Relevance of Process Issues:</p> <p>Step 1 - "Insignificant" water exchange;</p> <p>Step 2 - "Marginal" sediment exchange;</p> <p>Step 3, therefore, from EGT5, process issues are assessed as Grade C.</p>
Stage 1: Step 4: Significance of management issues	<p>Historical Reclamation: Industrialisation along the banks of the estuary has led to a high degree of reclamation in the past resulting in the noted reductions in the intertidal area.</p> <p>Presence or Absence of Jetties: Two prominent breakwaters (North and South Pier) exist at the mouth of the estuary. These structures are likely to exert a significant control on the open coast and within the estuary in terms of their role in tidal and wave process and associated sediment dynamics. In addition, the structures exert an important control on the nature of the interaction between the coast and the estuary.</p> <p>Maintenance Dredging: Some degree of dredging is undertaken to remove sediments from within the main estuary channel, thereby maintaining suitable navigational access.</p> <p>Future Intervention Potential: It is considered that the opportunity for large-scale anthropogenic intervention in the form of re-alignment or reclamation is limited.</p>
	Verdict on Significance: "Marginal".
Stage 1: Step 5: Recommendation on whether the estuary should be included in the SMP process (EGT5)	<p>Step 3 - Process issues assessed as Grade C;</p> <p>Step 4 - Management Issues assessed as "Marginal"</p> <p>Therefore, from Step 5 of EGT5, the Tyne scores 3 in terms of overall significance and need not be included in the SMP process</p>
	<p>Verdict: The Estuary need not be included in the SMP.</p> <p>It is considered that the Fish Quay provides an appropriate limit for the inclusion of the Tyne on the open coast SMP. This location allows the physical interaction to be represented along with the important influence of the outer breakwaters. This is also the existing Schedule IV boundary under the Coast Protection Act (1949).</p> <p>Upstream of this point the estuary narrows considerably. To some extent a change to processes will occur between the embayed outer estuary and the narrow upper estuary. Accordingly the largest degree of non-cohesive sediment exchanges with the open coast are likely to occur in the outer embayed area, with the confined channel likely to be dominated by finer sediments. This is reflected in the accumulation of sandy sediment in the area confined by the breakwaters.</p>

4. Wear Estuary Assessment

The table below presents an assessment of the Wear. The Wear estuary is illustrated in Figure 3.

Table 2. Wear estuary assessment

Estuary	Wear
Location	North East England
Classification	Origin: Drowned River Valley; Type: Spit Enclosed; Sub-type: Double spit
Main Characteristics	Macro tidal, medium sized estuary. A long narrow channel with a large degree of industrial and urban development along the shore, enclosed by two breakwaters at the mouth.
Data Availability	<ul style="list-style-type: none"> River Tyne to Seaham Harbour Shoreline Management Plan, Sub Cell 1B (Babtie, 1997); Whitburn Bay to Ryhope Strategy (Scott Wilson, 2001) Futurecoast Estuaries Assessment (Halcrow, 2002); An Inventory of UK Estuaries (JNCC, 1997);
Stage 1: Step 1: Significance of water exchange (EGT2)	<p>Total Area: The Wear is a moderate sized estuary relative to the England and Wales dataset, but is at the lower end of the moderate scale;</p> <p>Intertidal Area: The estuary has a moderately sized intertidal area.</p> <p>Channel Length: The length of the estuary is also moderate.</p> <p>Mouth Width: The estuary has a low to moderate width at the mouth, although it should be noted that mouth is constrained.</p> <p>Tidal Range: The estuary has a moderate tidal range.</p> <p>Mean Freshwater Flows: Flows in the Wear are moderate.</p> <p>% Area: The ratio of total area to intertidal area is high.</p>
	<p>Verdict on Significance: The estuary is of moderate size although falls at the lower end of this size scale. The mouth width is narrow in relation to the channel length, suggesting a deep mouth. This could be due to either dredging over-deepening the mouth or the constriction to the mouth width. River flows are marginally high in relation to water volume.</p> <p>Overall, in accordance with EGT2, in terms of water exchanges the estuary is assessed as "Insignificant".</p>

Stage 1: Step 2: Significance of sediment exchange (EGT3)	<p>Tidal Asymmetry: The estuary is strongly ebb dominant according to Dronkers' Gamma.</p> <p>Morphological features: Inside the two breakwaters, the estuary is enclosed by two spits. These former spit features have now been reclaimed and are fixed in position. However, their presence does indicate a degree of longshore transport along the coast prior to the reclamation and the construction of the breakwaters. This indicates a natural unconstrained tendency for an interaction between the estuary and the open coast. Upstream of the former spits, the estuary opens into a small embayed area. Sediments within this area are non-cohesive forming beaches. In the middle estuary, strips of mudflat bound the subtidal channel. Sandflats occur in the lee of the breakwaters in the outer estuary.</p> <p>Source / Sink Relationships: The ebb dominance of the estuary suggests that significant quantities of fine sediments are unlikely to accumulate within the estuary. The estuary is likely to be a source of fine sediments. The accumulation of coarser sediments in the lee of the breakwaters, seaward of the former spit features suggests some sedimentary interaction with the open coast in this area of the mouth.</p> <p>Potential for plume generation: Plume formation is likely during the whole of the tide.</p>
	<p>Verdict on Significance: "Insignificant". Interactions between the coast and the estuary, in terms of sediment exchanges, do occur but are localised in nature.</p>
Stage 1: Step 3: Relevance of process issues	<p>Verdict on Relevance of Process Issues:</p> <p>Step 1 - "Insignificant" water exchange;</p> <p>Step 2 - "Insignificant" sediment exchange;</p> <p>Step 3, therefore, from EGT5, process issues are assessed as Grade C.</p>
Stage 1: Step 4: Significance of management issues	<p>Historical Reclamation: Industrialisation along the shoreline of the Wear has led to reclamation of the upper intertidal areas. In addition the entire South Docks area was reclaimed in the 18th century from mudflats and sandflats at the estuary mouth.</p> <p>Presence or Absence of Jetties: Two breakwater structures exist enclosing the natural mouth of the estuary (as defined by the two former spits). These structures exert an influence on local coastal processes through their interaction with the wave regime and their effect on longshore sediment transport.</p> <p>Maintenance Dredging: Some maintenance dredging is undertaken in the estuary to maintain appropriate navigable depths with material dumped at sea.</p>
	<p>Verdict on Significance: In terms of management issues, the interaction between the estuary and the open coast is insignificant with the exception of the presence of the breakwaters, which do represent a potentially important interaction.</p> <p>Therefore due to the importance of the breakwaters in terms of coastal processes, in accordance with EGT 4, management issues are assessed as "Marginal".</p>
Stage 1: Step 5: Recommendation on whether the estuary should be included in the SMP process (EGT5)	<p>Step 3 - Process issues assessed as Grade C;</p> <p>Step 4 - Management Issues assessed as "Marginal"</p> <p>Therefore, from Step 5 of EGT5, the Wear scores 3 in terms of overall significance.</p>
	<p>Verdict: The estuary need not be included in the SMP.</p> <p>It is recommended that a boundary across the two former spits at the mouth of the estuary is appropriate for the Wear. This boundary essentially provides a continuation of the natural line of the coastline and allows the SMP to take account of the significance of the breakwaters in interacting with coastal processes and any sediment exchange with the area directly inside the breakwaters.</p>

5. Tees Estuary Assessment

The table below presents an assessment of the need to include the Tees in the open coast SMP. The Tees estuary is illustrated in Figure 4.

Table 3. Tees estuary assessment

Estuary	Tees
Location	North East England
Classification	Origin: Drowned River Valley; Type: Spit Enclosed; Sub-Type: Double spit.
Main Characteristics	A macro-tidal moderate sized estuary. A long narrow estuary with a wide embayment at the mouth. Heavily industrialised along its entire length and modified by a variety of management intervention.
Data Availability	<ul style="list-style-type: none"> Seaham Harbour to Saltburn, Shoreline Management Plan, Sub-Cell 1C (Babtie, 1999); Futurecoast Estuaries Assessment (Halcrow, 2002); An Inventory of UK Estuaries (JNCC, 1997); Teesmouth Sediment Study (HR Wallingford, 2002).
Stage 1: Step 1: Significance of water exchange (EGT2)	<p>Total Area: The Tees is of moderate size in terms of total area when compared to the England and Wales dataset of estuaries. However, this is one of the largest estuaries in the North East;</p> <p>Intertidal Area: The estuary also has a moderate sized intertidal area. It is expected that the intertidal area would have been considerably larger prior to the reclamations that would have accompanied the development of the estuary for the docks and other facilities.</p> <p>Channel Length: The Tees has a notably long channel length, extending some 38km inland.</p> <p>Mouth Width: The estuary is also of moderate size in terms of the mouth width.</p> <p>Tidal Range: The tidal range of the estuary is moderate.</p> <p>Mean Freshwater Flows: Mean freshwater flows in entering the estuary are low to moderate.</p>
	<p>Verdict on Significance: The estuary is of medium size with a hydrodynamic regime that has been altered by the construction of the barrage. The mouth width to channel length ratio shows a reasonable balance but this has been altered by the barrage and the mouth dimensions are likely to alter in response.</p> <p>In accordance with EGT2, in terms of water exchanges the estuary is assessed as "Insignificant".</p>

<p>Stage 1: Step 2: Significance of sediment exchange (EGT3)</p>	<p>Tidal Asymmetry: The estuary was ebb dominant prior to the construction of the barrage and is now flood dominant.</p> <p>Morphological features: The estuary is enclosed by spits on both banks, extended by breakwater structures (North and South Gare breakwaters). The coast either side of the estuary mouth is composed of sandy beaches backed by dunes. These beaches would once have been part of the estuary mouth prior to reclamation activity. Inside the breakwaters is an embayed area dominated by sandy sediments. On the northern side is North Gare Sands and to the south, Bran Sands. Upstream of the embayed area is Seal Sands. This predominantly muddy intertidal area is bounded by man-made defences. The middle part of the estuary narrows considerably and is canalised. The upper part of the estuary was separated from tidal influence by the construction of the barrage in 1995.</p> <p>Source / Sink Relationships: The estuary is likely to be a sink for sediments. Coarser sediment transported in via longshore transport processes are liable to be deposited in and around the mouth area in the lee of the breakwaters structures. Fine sediments on the other hand are likely to be despotised further upstream. It is also noted that high fluvial flows have the potential to reverse this process and remove sediments from the estuary on a periodic basis.</p> <p>Potential for plume generation: Evaluation of flows would suggest that there is likely to be a plume during the ebb tide.</p> <p>Estuary Specific Knowledge</p> <p>Longshore transport along the adjacent coast has a net direction to the south east. Sediment is therefore likely to be driven towards and into the estuary from Seaton Sands to the north. In addition studies have shown that during easterly storm events there is potential for high magnitude drift reversals to occur. Such events have the potential to result in quantities of sediment being driven in a north westerly direction along Coatham Sands and into the area of the estuary mouth from the south. Waves are therefore the primary driver for transporting sediments from the longshore system into the estuary.</p> <p>Sand and silt sized sediment is driven into the estuary from Tees Bay. These sediments then become trapped within the estuary due to the flood dominance and the lack of flushing ability within the estuary. This lack of flushing ability is likely to be due to the low tidal flows caused by the over deepening of the channel. Coarser sediments are likely to be deposited in the lower estuary, while finer sediments will be deposited upstream. In addition, a small amount of fluvially derived sediment is introduced and deposited within the estuary.</p>
	<p>Verdict on Significance: "Marginal". There is undoubtedly some degree of sediment interaction between the estuary and the open coast. However, this exchange can be considered to be localised in terms of region wide sediment transport (i.e. these exchanges are primarily confined to the embayed area inside the estuary mouth and the coastline immediately either side of the estuary mouth). Such exchanges are important to the functioning of the local sedimentary system but are unlikely to affect larger scale shoreline management policy.</p>
<p>Stage 1: Step 3: Relevance of process issues</p>	<p>Verdict on Relevance of Process Issues:</p> <p>Step 1 - "Insignificant" water exchange;</p> <p>Step 2 - "Marginal" sediment exchange;</p> <p>Step 3, therefore, from EGT5, process issues are assessed as Grade C.</p>

Stage 1: Step 4: Significance of management issues	<p>Historical Reclamation: The Tees has been the subject of large scale change due to land reclamation in the past. The original estuary shape was much wider than the present day confined channel. This loss of intertidal area has led to the estuary now being dominated by subtidal areas bounded by narrows strips of mudflat.</p> <p>Presence or Absence of Jetties: The north and South Gare Breakwaters at the mouth of the estuary alter the way in which the estuary interacts with the adjacent areas of open coast.</p> <p>Maintenance Dredging: The estuary is regularly dredged to maintain navigable depths.</p> <p>Barrage Construction: The barrage (1995) is located 18km from the mouth (approximately half the length of the estuary) and has resulted in an alteration to tidal volume and hence tidal currents. However, at the mouth the change to tidal currents is not large. Further upstream (9km from the mouth) currents have reduced by approximately 50%. The barrage has also importantly altered the tidal asymmetry from ebb to flood dominant.</p> <p>Potential for Future Intervention: Given the already heavily industrialised and canalised nature of the Tees, it is unlikely that there is significant opportunity for any future large-scale reclamation or realignment that may alter the tidal prism (with the exception of Seal Sands).</p>
	<p>Verdict on Significance: "Marginal". It is recognised that the jetties at the mouth of the estuary, the construction of the barrage and the deepening of the channel alter the way in which the estuary and adjacent coast interact. However, the assessment indicates that this influence is only on the local regime as opposed to at a regional level.</p>
Stage 2: Step 5: Recommendation on whether the estuary should be included in the SMP process (EGT5)	<p>Step 3 - Process issues assessed as Grade C; Step 4 - Management Issues assessed as "Marginal"</p> <p>Therefore, from Step 5 of EGT5, the Tees scores 3 in terms of overall significance and should not be included in the SMP process.</p>
	<p>Verdict: The Estuary need not be included in the SMP.</p> <p>However, the above assessment has identified a number of important influences of estuary processes and management intervention that control the estuary - coast interactions. These are particularly relevant around the mouth of the estuary. Therefore it is recommended that the boundary of the SMP allows the mouth of the estuary to be incorporated. This would specifically involve including two areas, as follows:</p> <p>The sandy embayed area inside the outer Breakwaters (i.e. North Gare Sand and Bran Sands). These areas interact in sedimentary terms with the coast and are an important component of the local sediment cell. In addition the management policy within the stretch has implications both within and outside of the estuary.</p> <p>Also it is recommended that Seal Sands be included in the SMP. This muddy intertidal area will play an important role in terms of water exchanges due to the volume of intertidal water held over the flats on each tide. In addition, from a management perspective, this area plays an important role in the overall shape and functioning of the mouth of the estuary.</p>

6. Esk Estuary Assessment

The table below presents an assessment of the inclusion of the Esk in the open coast SMP. The Esk estuary is illustrated in Figure 5.

Table 4. Esk estuary assessment

Estuary	Esk
Location	North East England
Classification	Origin: Drowned River Valley; Type: Ria; Sub-Type: No Spits
Main Characteristics	Macro tidal, small estuary. Relatively short and narrow with small catchment. The mouth is constrained by breakwaters with a harbour in their lee.
Data Availability	<ul style="list-style-type: none"> Huncliffe (Saltburn) to Flamborough Head Shoreline Management Plan, Sub-Cell 1D (Mouchel, 1997); Futurecoast Estuaries Assessment (Halcrow, 2002); An Inventory of UK Estuaries (JNCC, 1997); River Esk and Coast Catchment Management Plan (NRA, 1994); Whitby Coastal Strategy (HR Wallingford, 2002).
Stage 1: Step 1: Significance of water exchange (EGT2)	<p>Total Area: The Esk is one of the smallest estuaries in the UK in terms of total area.</p> <p>Intertidal Area: Relative to the total size, the intertidal area is of a moderate size. However, in absolute terms, the intertidal area is small and is assessed as low in terms of significance. This implies only a small exchange of water with the sea on each tidal cycle.</p> <p>Channel Length: The estuary is relatively short.</p> <p>Mouth Width: The estuary mouth is relatively narrow, although it is noted that the mouth is constrained.</p> <p>Tidal Range: The tidal range is moderate.</p> <p>Mean Freshwater Flows: Freshwater flows are assessed as low.</p> <p>% Area: The estuary has a relatively low % area.</p>
	Verdict on Significance: The estuary is small, with a narrow width relative to the length of the channel. Due to the small magnitude of water exchanges, in accordance with EGT2, the Esk is assessed as "Insignificant".
Stage 1: Step 2: Significance of sediment exchange (EGT3)	<p>Tidal Asymmetry: The estuary is strongly ebb dominant according to Dronkers' Gamma.</p> <p>Morphological features: The estuary is confined by breakwaters at the mouth (West and East Piers). To the west of the West Pier lies Whitby Sands beach. Sandflats are located immediately inside the breakwaters, on the eastern shore in the harbour area. Sandflats also occur on the western shore in the middle reaches. The estuary is bounded by higher ground in places with area of cliff.</p> <p>Source / Sink Relationships: The estuary is likely to be a sink of cohesive sediments derived from the adjacent Whitby Sands.</p> <p>Potential for plume generation: There is potential for a plume to occur on the ebb tide.</p> <p>Estuary Specific Knowledge</p> <p>Longshore drift along the coast to the west of the mouth is west to east directed, acting to drive material along the beaches towards the Esk. The harbour breakwaters therefore hold the beach in position with some sandy sediment entering the estuary and being deposited in the lower harbour area.</p>

	<p>The breakwaters are critical in holding the beach in place and preventing greater accumulation of sediments in the estuary.</p> <p>There is a fluvial sediment supply, the majority of which settles in the upper harbour. Although some of this material is transported offshore by tidal processes.</p>
	Verdict on Significance: In general, sediment exchanges between the coast and the estuary are weak and assessed as "Marginal".
Stage 1: Step 3: Relevance of process issues	Verdict on Relevance of Process Issues: Step 1 - "Insignificant" water exchange; Step 2 - "Marginal" sediment exchange; Step 3, therefore, from EGT5, process issues are assessed as Grade C.
Stage 1: Step 4: Significance of management issues	<p>Presence or Absence of Jetties: Two breakwater structures exist at the mouth of the estuary. The West Pier in particular plays a role regarding the interaction of the estuary and the adjacent coast at Whitby Sands.</p> <p>Maintenance Dredging: Maintenance dredging is undertaken in Whitby lower harbour to remove accumulations of sand sized sediments.</p> <p>Coastal Defences: Within the harbour the town of Whitby is protected by harbour walls and defences.</p> <p>Future Intervention Potential: Opportunities for future large scale intervention in the estuary in the form of reclamation or realignment are limited as, in common with many Ria type estuaries, the Esk is bounded by higher ground. It is therefore unlikely that significant changes to the tidal prism will occur in the future.</p> <p>Flood Risk: Studies have shown some element of flood risk from overtopping of defences in the upper harbour. This risk is the result of high sea levels as opposed to high river levels.</p>
	Verdict on Significance: Overall there is very little management activity in the estuary that affects the interaction of the estuary and the open coast and based on this an assessment of "Insignificant" would be appropriate. However, the role of the West Pier in controlling the interaction between the coast and the estuary is important, as are the defences around the harbour protecting the town of Whitby. For these reasons, therefore, management issues are assessed as "Marginal".
Stage 1: Step 5: Recommendation on whether the estuary should be included in the SMP process (EGT5)	Step 3 - Process issues assessed as Grade C; Step 4 - Management Issues assessed as "Marginal" Therefore, from Step 5 of EGT5, the Esk scores 3 in terms of overall significance.
	<p>Verdict: The estuary should not be included in the SMP.</p> <p>It is recommended that the lower harbour area immediately inside the breakwaters be included within the SMP. This would allow the incorporation of the breakwaters structures at the mouth and the harbour immediately inside the mouth.</p> <p>The Coastal IV boundary is situated along a line between the southern edge of Tate Pier and the southern edge of Scotch Head at Whitby.</p>

7. Summary

An assessment has been made of the Tyne, Wear, Tees and Esk estuaries to determine the requirement to include each estuary in the second generation NECAG SMP. This assessment has been undertaken in accordance with Defra's Procedural Guidance for the Production of Shoreline Management Plans (Defra, 2004).

The assessment has revealed that all four estuaries exhibit a number of similar characteristics in terms of physical processes and management intervention. In particular the Tyne, Tees and Wear are remarkably similar estuaries, albeit at different scales, and as such the assessment, conclusions and recommendations for the limits of the SMP show similarities.

The recommendations for each of the estuaries are as follows:

- The Tyne: The estuary need not be included in the SMP. The limit of the SMP should be the Fish Quay;
- The Wear: The estuary need not be included in the SMP. The limit of the SMP should be the two former spits at the mouth of the estuary;
- The Tees: The estuary need not be included in the SMP. However, it is recommended that the limits of the SMP are set to allow the inclusion of the areas immediately inside the breakwaters (North Gare Sands and Bran Sands) and Seal Sands;
- The Esk: The estuary should not be included in the SMP. The limit of the SMP should be the Lower Harbour, immediately inside the breakwaters.

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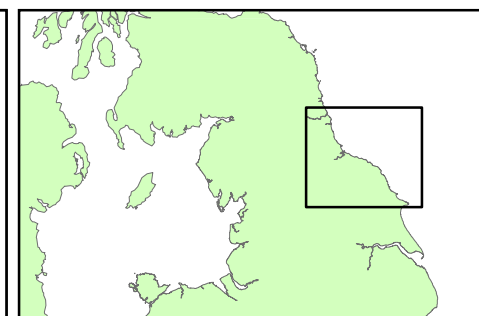
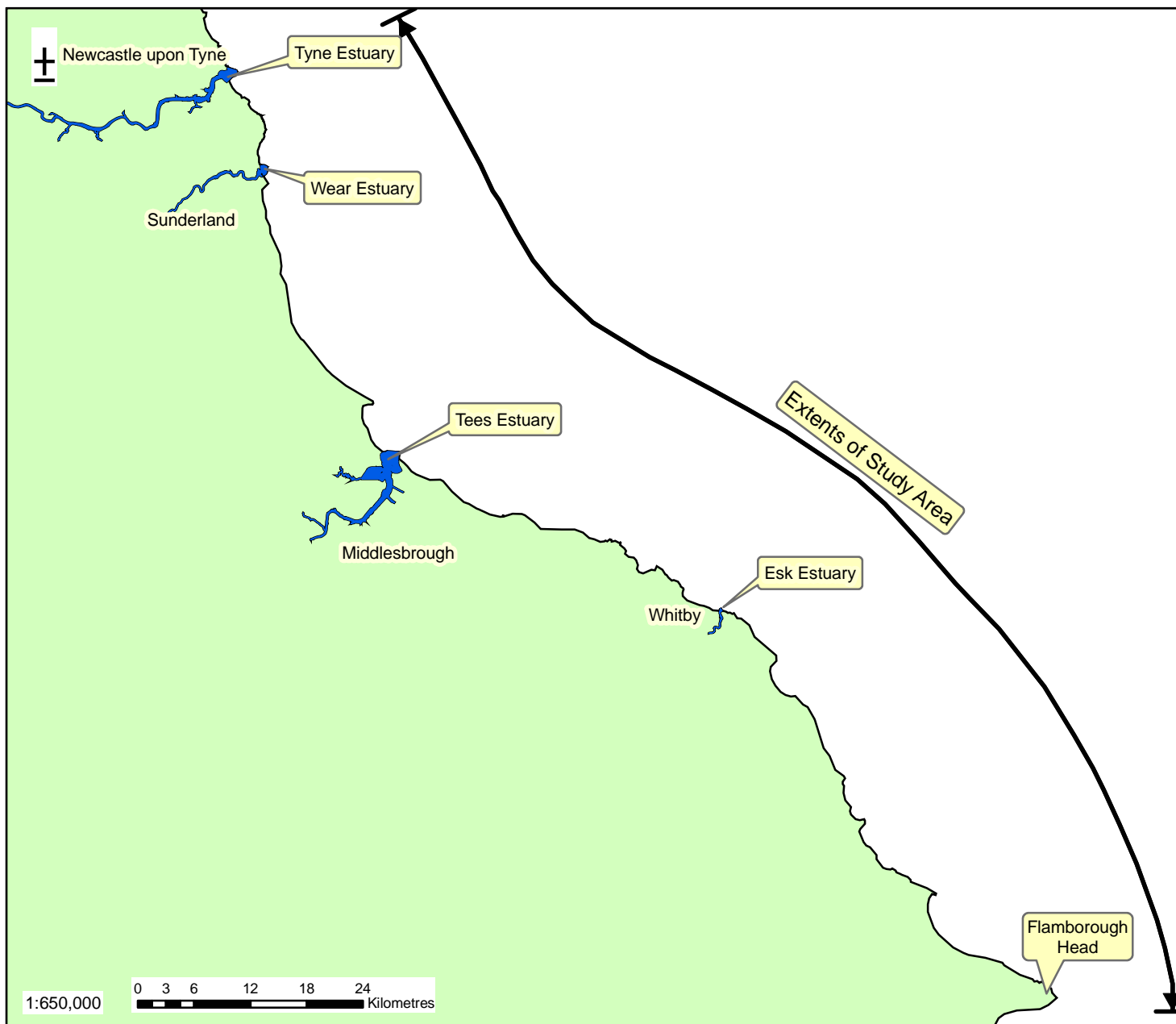
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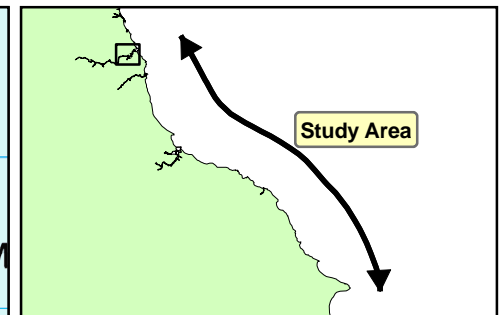
Figures



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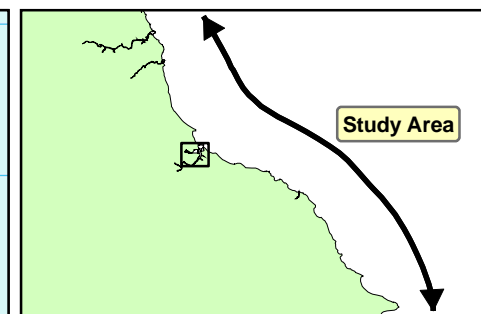
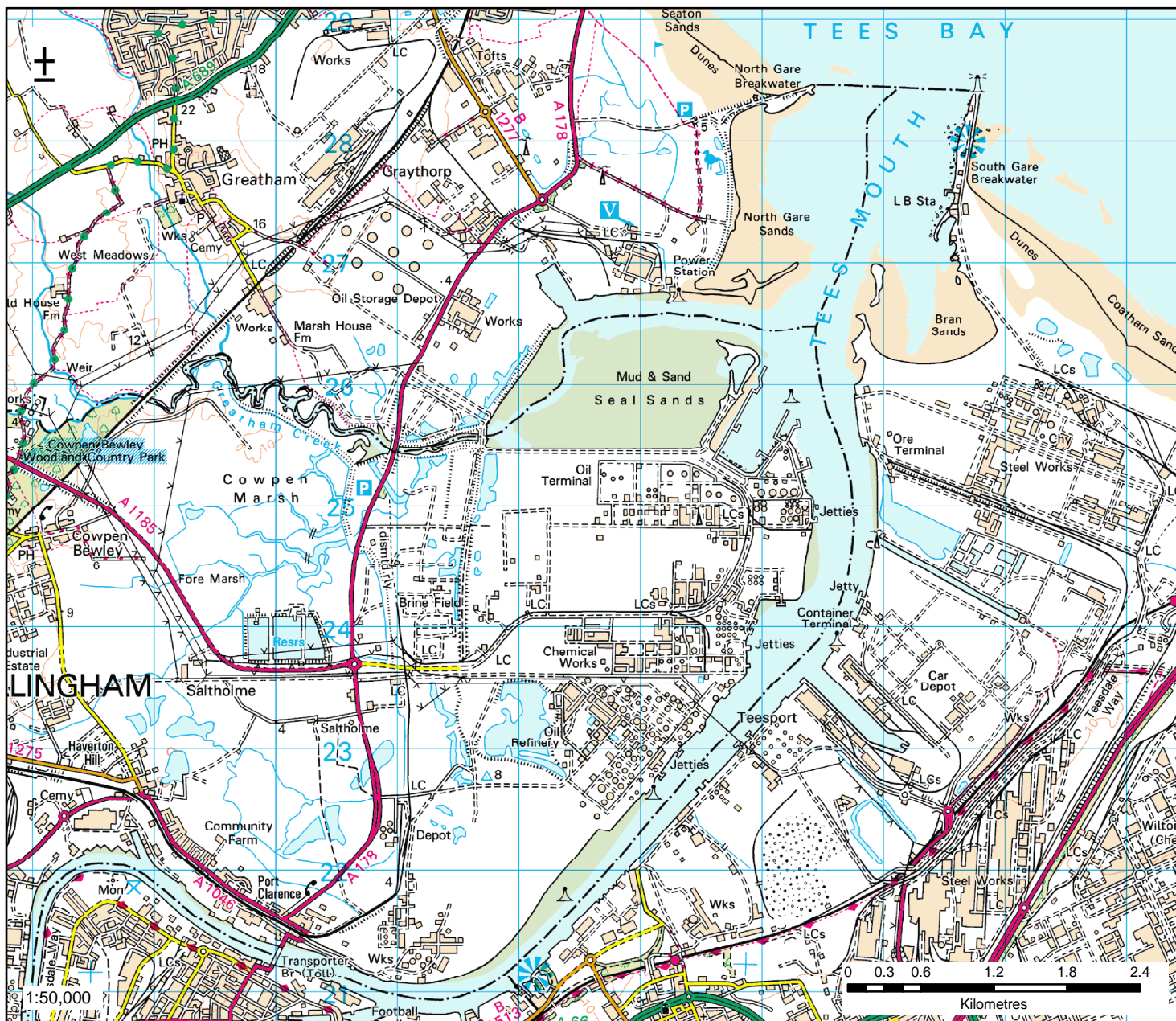
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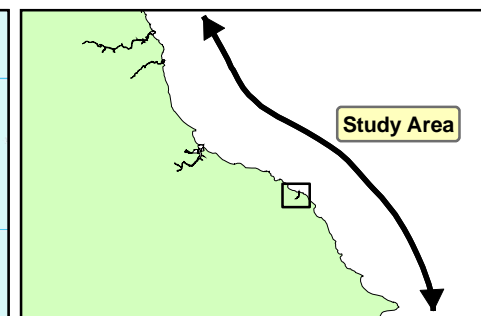
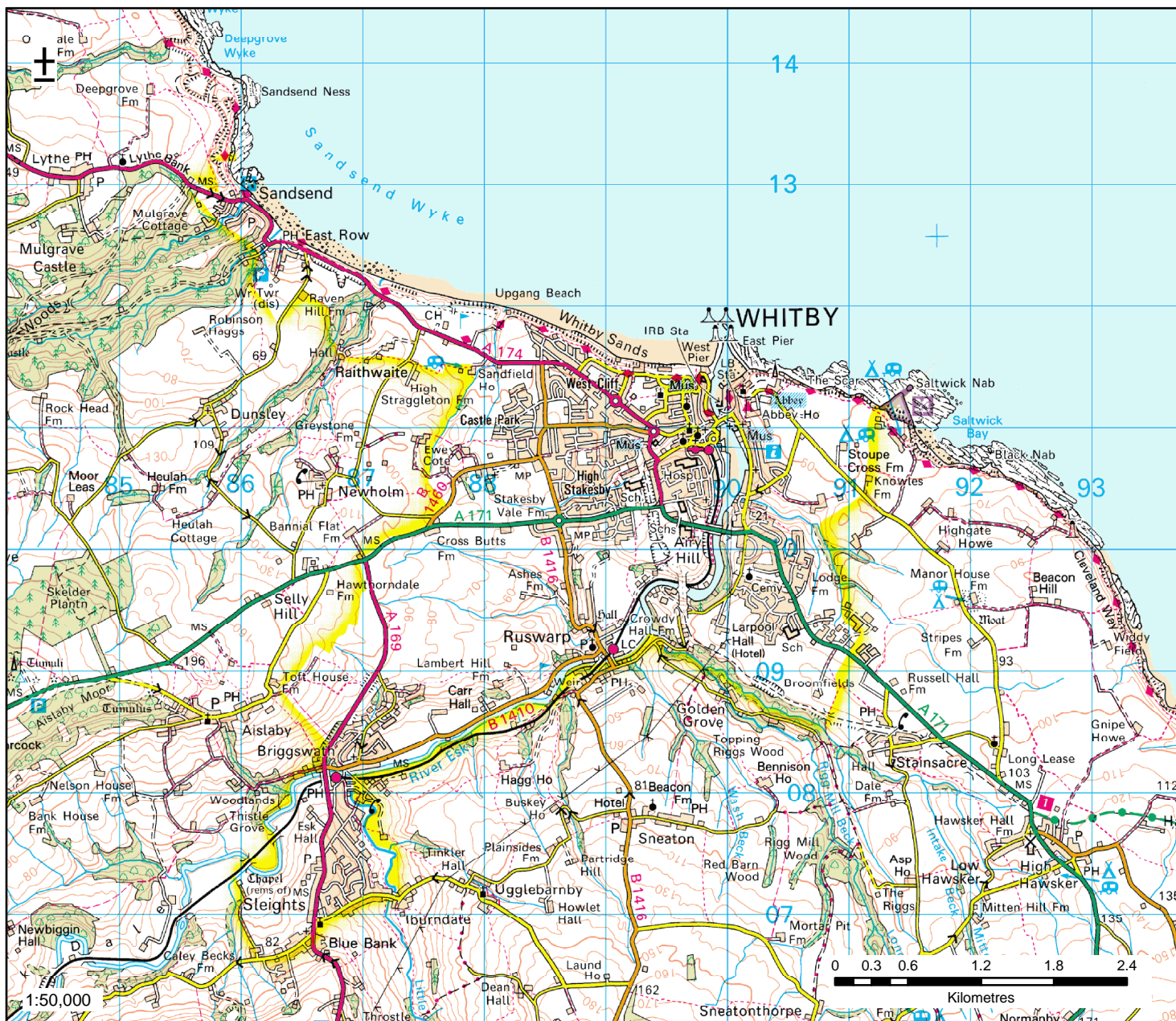
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Appendix A

Estuary Guidance Tables

(Extracts from Procedural Guidance for Production of Shoreline Management Plans, Appendix F: Integration of Estuaries)

Appendix A. Estuary Guidance Tables

(Extracts from Procedural Guidance for Production of Shoreline Management Plans, Appendix F: Integration of Estuaries)

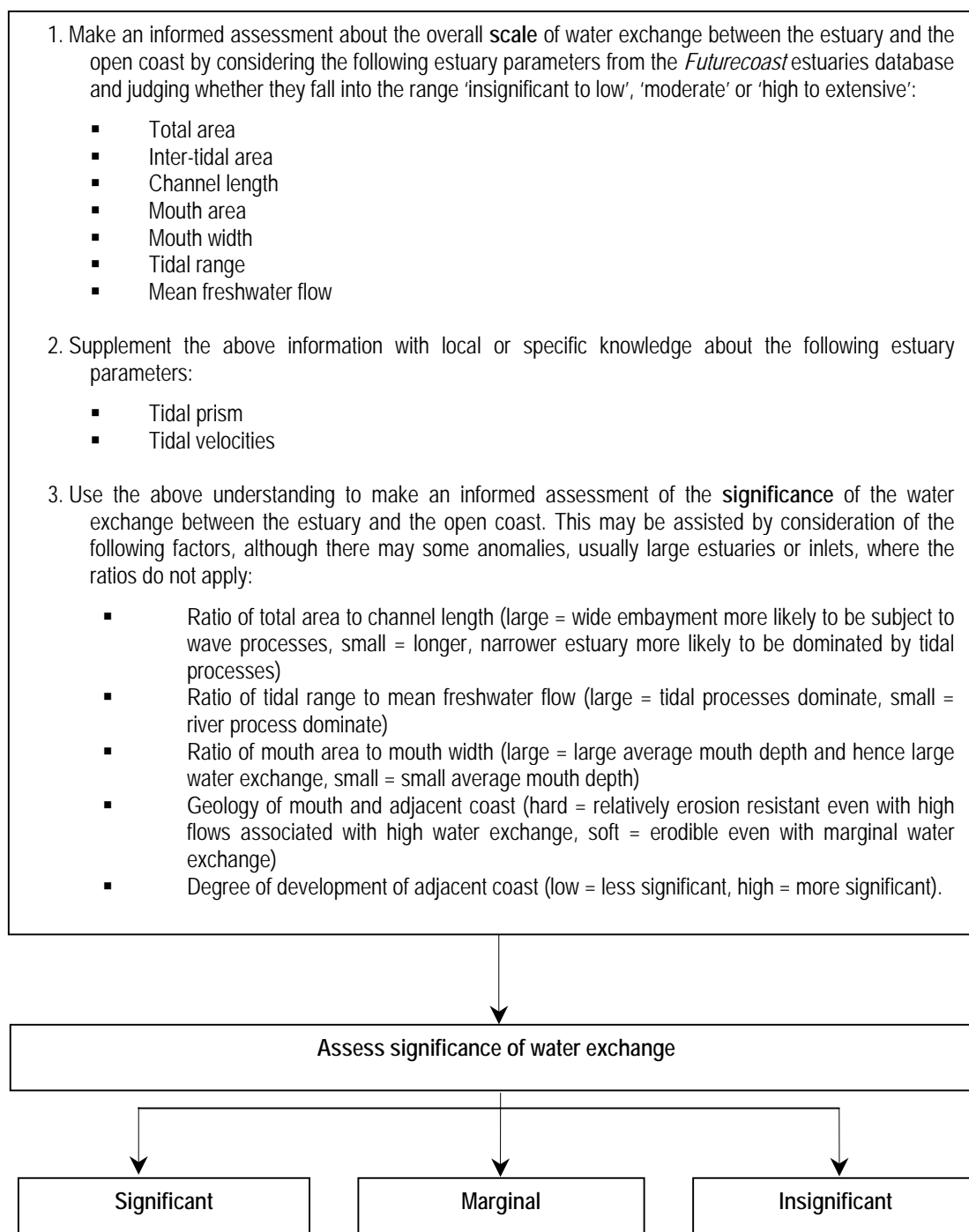
Estuary Guidance Table 1. General Decision-Support Framework

The purpose of this Table is to provide the overall context within which decisions will be made concerning the inclusion, or otherwise, of estuaries within the SMP process. EGT1 is supported by further tables EGT2-EGT7.

Key Question	Key Issues for Consideration	Indicators	Reference Tables
Should the estuary be included in the SMP process?	Type, scale and significance* of physical** interactions	<ul style="list-style-type: none">Physical size parameters of the estuaryPhysical process parameters of the estuary, and degree of sediment supply from river(s) and sediment exchange with the open coastPresence/absence of morphological features within estuary and/or at estuary mouthPhysical constraints within estuary and/or along adjacent coast (e.g. defences and/or geological controls)Potential for large-scale changes in alignment of defences within estuary and/or along open coast	EGT2-5
	Nature and complexity of management issues	<ul style="list-style-type: none">Presence/absence of control structures at the estuary mouth and/or within the estuary and/or along the open coastCommon sources of risk between the estuary and open coast (e.g. tidal flooding, wave erosion)Continuity, location and/or scale of receptors at risk close to the estuary /coast interface (e.g. life, development, nature conservation, natural heritage, existing land and water uses)Limits of other 'strategic' flood and coastal management initiatives (e.g. CFMPs and/or CHaMPs)	
How should the estuary be included?	SMP	<ul style="list-style-type: none">Physical size (logistics)Complexity of management issues	EGT6
	eSMP		
How far upstream should the estuary be included?	Consideration of estuarine processes	<ul style="list-style-type: none">Balance in fluvial, tidal and coastal processes throughout estuary and extent of interactions (physical and logistical)Presence of natural or man-made constraints and assessment of cross-sectional morphological form	EGT7
	Selection of shoreline management policy	<ul style="list-style-type: none">Presence/absence of morphological features and their interconnectivity between different environmentsLocation, extent and type of management issues	
* Significant* interaction need not necessarily only be confined to 'large', but could relate to other factors key to the development of either the coast or estuary (i.e. complexity of interactions). Assessment of 'significance', therefore, needs to take account of the scale of the interaction relative to other factors (e.g. resistance of geology, availability of sediment).			
** Physical interactions principally relate to water and sediment exchanges between the estuary and open coast. Chemical and biological interactions and water quality issues may be incorporated, if appropriate, in consideration of 'management issues'.			

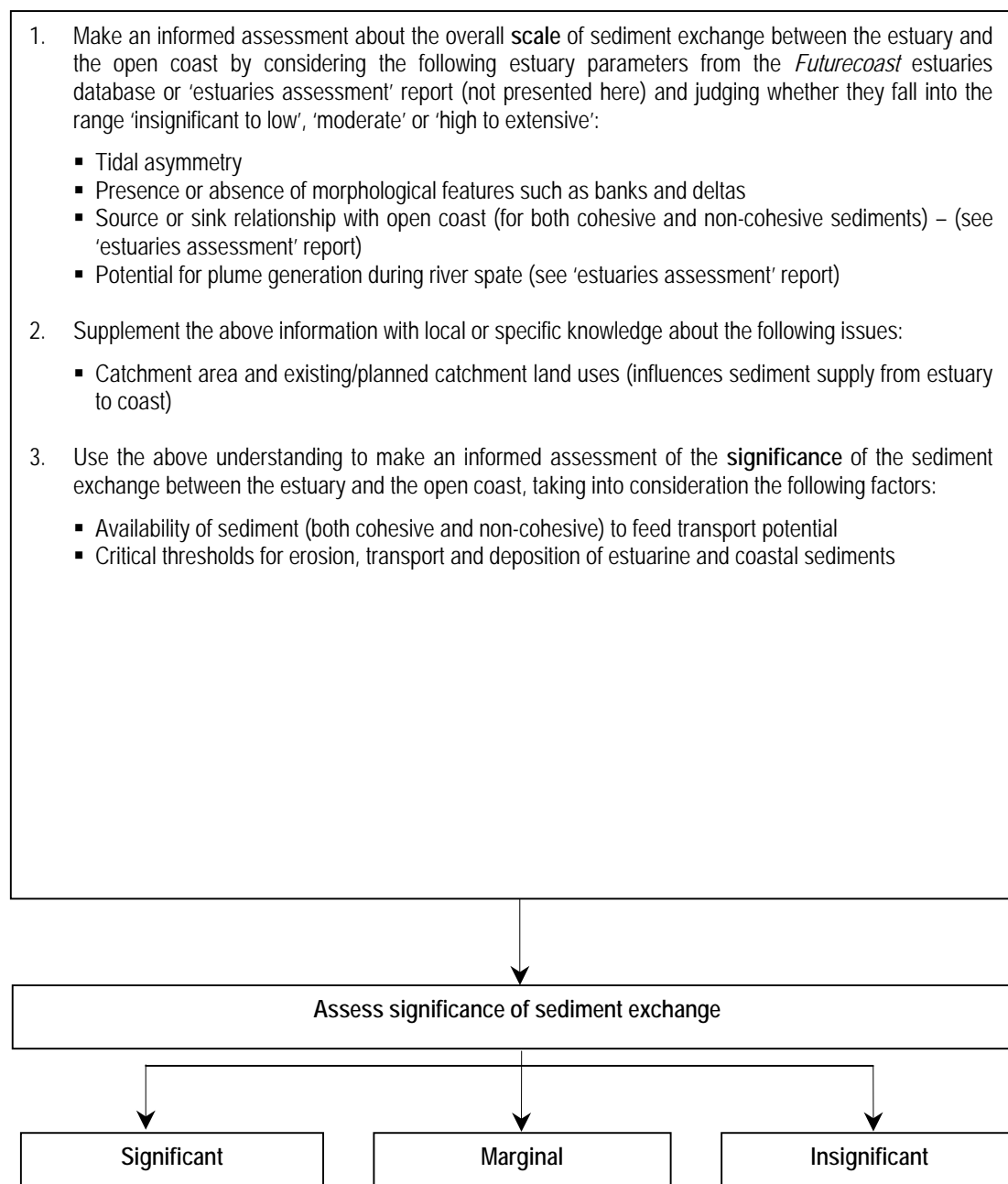
Estuary Guidance Table 2. Significance of Water Exchange

This table assists the user in determining the significance of water exchange between the estuary and the open coast in order to inform the decision about whether or not an estuary should be included in the SMP process.



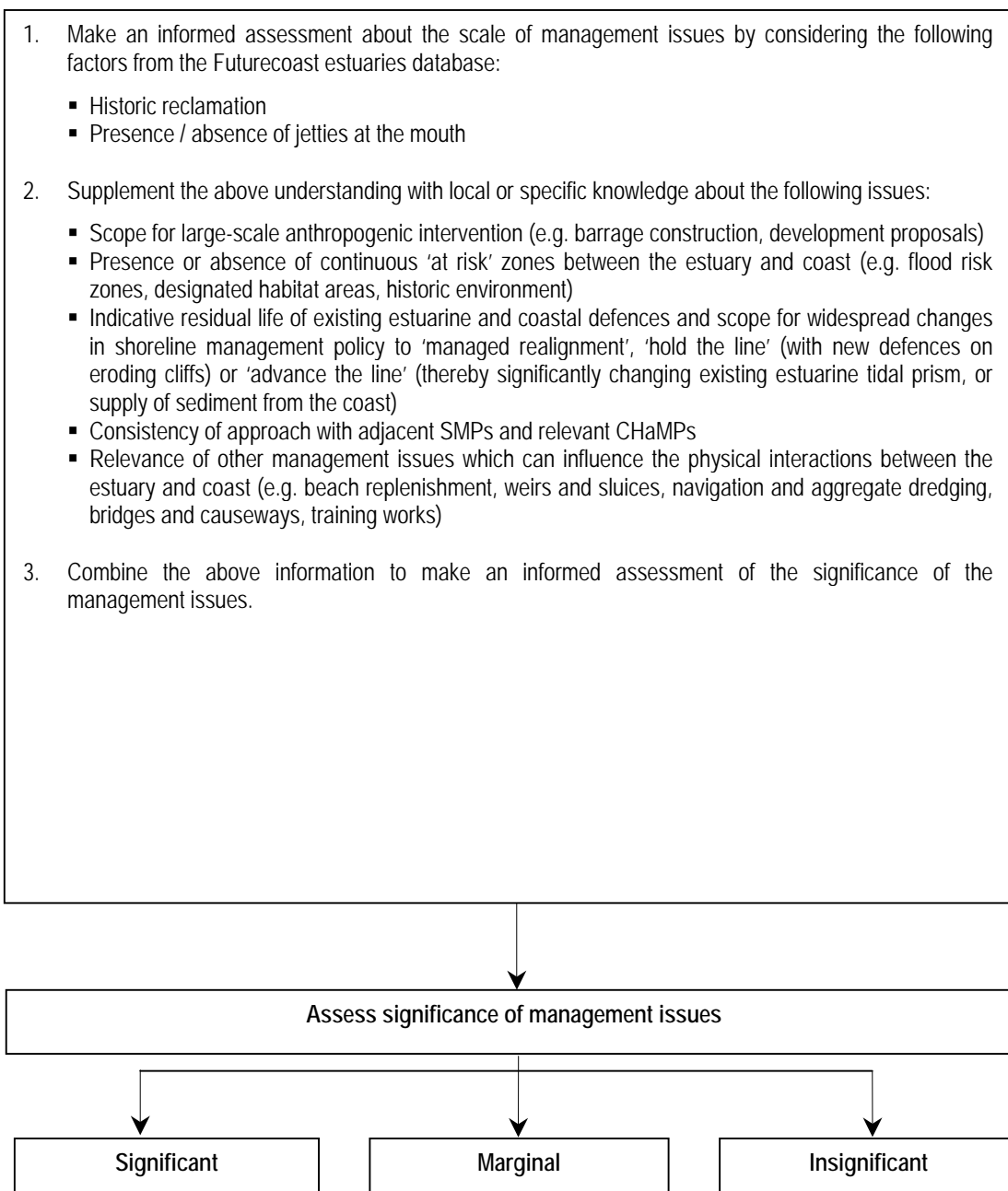
Estuary Guidance Table 3. Significance of Sediment Exchange

This table assists the user in determining the significance of sediment exchange between the estuary and the open coast in order to inform the decision about whether or not an estuary should be included in the SMP process.



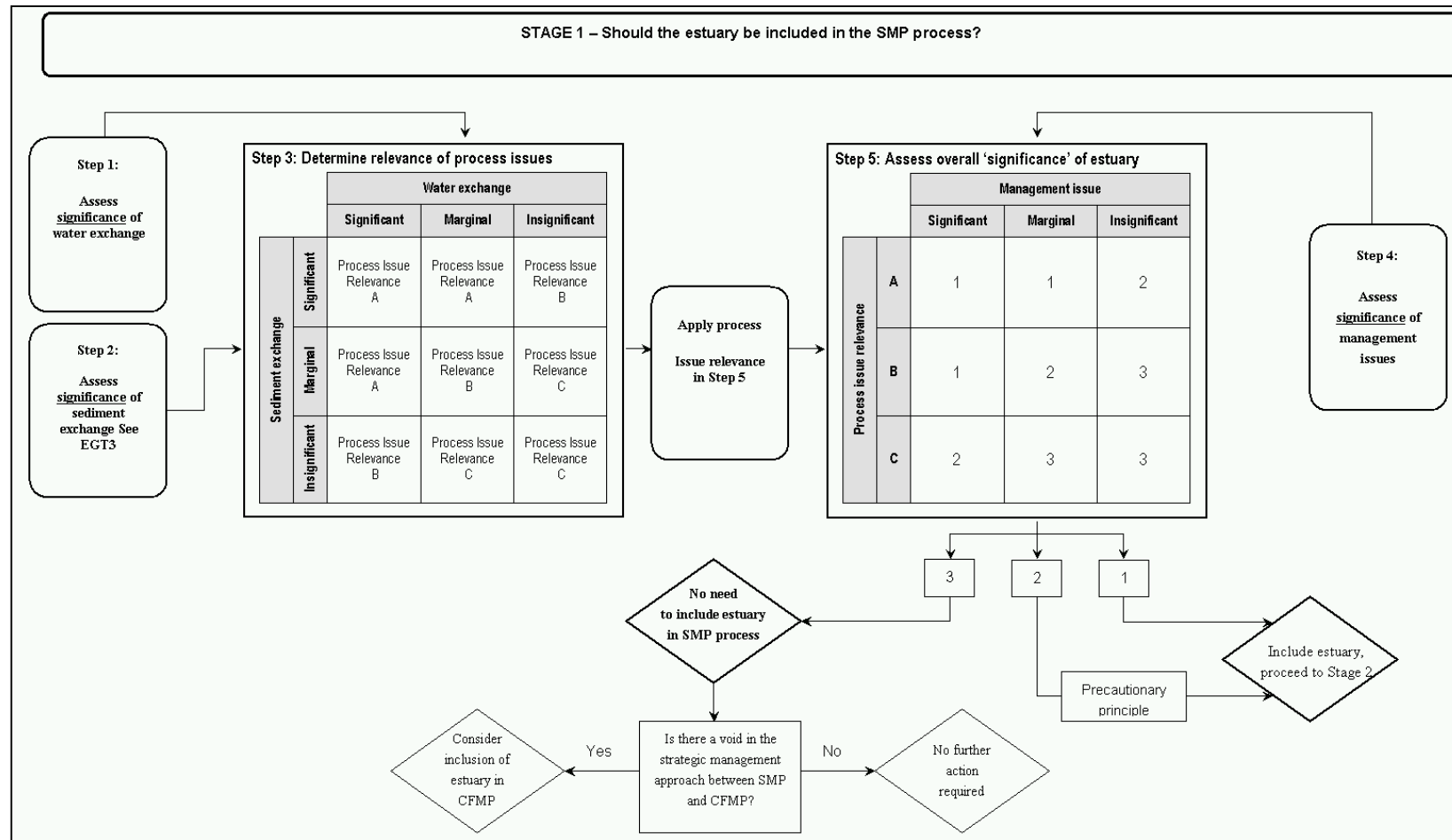
Estuary Guidance Table 4. Significance of Management Issues

This table assists the user in determining the scale of management issues between the estuary and the open coast in order to inform the decision about whether or not an estuary should be included in the SMP process.



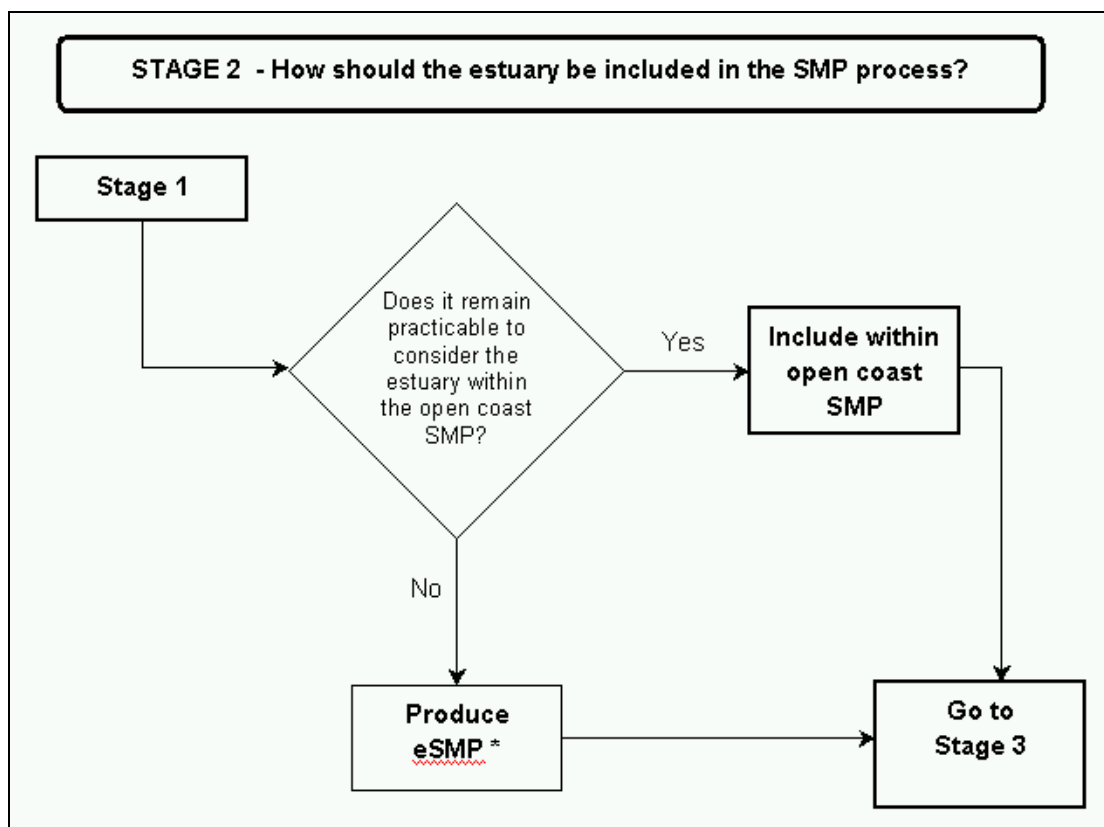
Estuary Guidance Table 5. Assessment of Estuarine Inclusion in SMP Process

The purpose of Estuary Guidance Table 5 is to assist the user in combining findings from EGT2-4 to determine whether or not an estuary should be included in the SMP process. The sensitivity of the decision from this table to changes in the outputs from Tables 2, 3 and 4.



Estuary Guidance Table 6. Assessment of Method for Inclusion of Estuaries in SMP Process

This table assists the user in determining how an estuary should be included in the SMP process. It is clearly a qualitative appraisal and should only be undertaken by those familiar with the estuary and its issues.



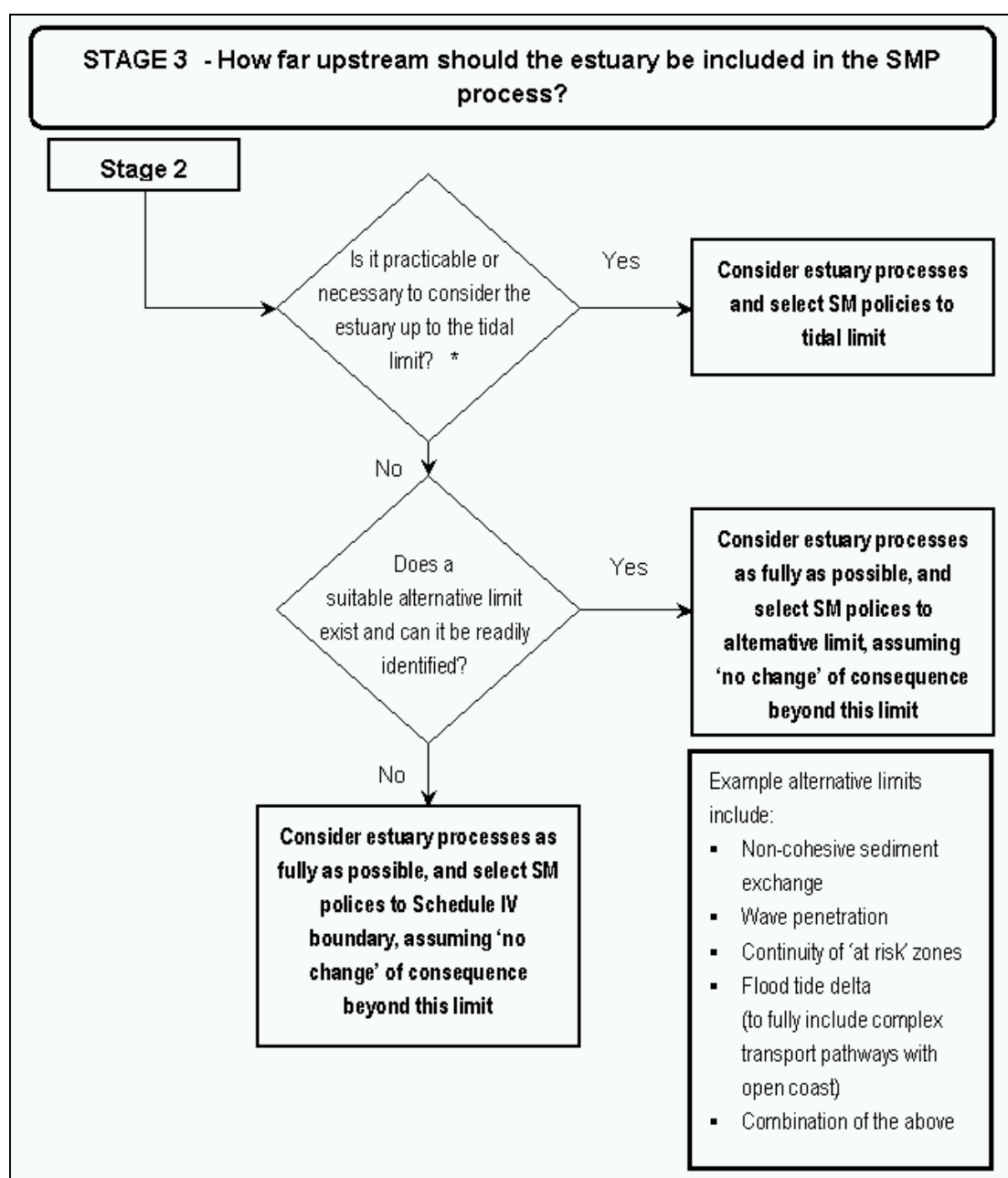
* eSMP must overlap with open coast SMP and those producing each plan must maintain information exchange throughout the plan preparation process

Examples of where it is not practicable to include estuary within open coast SMP are:

- Where the estuary is sufficiently large to necessitate consideration of its process and management policies outside of the open coast SMP.
- Where the estuarine management issues are too complex or diverse to consider within the open coast SMP.

Estuary Guidance Table 7. Assessment of Extent of Estuarine Inclusion in SMP Process

This table assists the user in determining how an estuary should be included in the SMP process.



* It may be necessary to consider an estuary to the tidal limit where there is potential for large-scale change in tidal prism or the estuary is morphologically dynamic (i.e. high natural variability).



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