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SID 5 Research Project Final Report

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Project identification

1. Defra Project code: FD2609
2. Project title: WFD Expert Assessment of Flood Management Impacts
3. Contractor organisation(s): Royal Haskoning
4. Total Defra project costs (agreed fixed price): £ 57506
5. Project: start date .... 01 October 2007
   end date .... May 2009

6. It is Defra's intention to publish this form.
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(a) When preparing SID 5s contractors should bear in mind that Defra intends that they be made public. They should be written in a clear and concise manner and represent a full account of the research project which someone not closely associated with the project can follow.
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Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

The Water Framework Directive (WFD) (2000/60/EC) is a substantial piece of EC water legislation which was made law in England and Wales in 2003 (Water Environment (Water Framework Directive) (England and Wales) Regulations 2003). The main purpose of the WFD is to establish a framework for the protection and sustainable use of the water environment. The Directive sets Environmental Objectives for all surface waters (rivers, transitional, lakes and coastal waters at the water body scale, the effective unit of management and monitoring defined under the WFD. The Objectives, set out in Article 4 of the Directive, include the prevention of deterioration of Ecological Status within the water body.

The objective of this project is to design a Framework for the assessment of the impacts of flood and coastal risk management (FCRM) activities on ecological status applicable to all surface water body types excluding lakes, where flood risk management activities were deemed to be limited. The types of FCRM activities considered are those relating to physical modification of water bodies as documented in Environment Agency operational guidance.

The project concluded that there is currently insufficient data on the hydromorphological conditions within each water body to develop a quantitative scoring mechanism to evaluate whether hydromorphological change results in deterioration between ecological status classes. The majority of surface water bodies have been modified in terms of river continuity and morphological structure and/or the hydrological, tidal and sediment regime, thus it is not possible to assume morphological response for a given surface water type. In addition, due to the gap in the science base in understanding the relationship between hydromorphological change and consequent impact on biology, it is not possible to define generic pressure impact relationships.

An Expert Assessment Framework has therefore been developed to provide a consistent process for selecting the proportionate level of assessment to determine the likely changes resulting from FCRM activities and potential ecological impacts. The Framework consists of three tiers: Preliminary, Level 1 and Level 2 assessment each with clear guidance on when each level of assessment should be undertaken. The assessments are based on professional judgement supported by accepted methods of geomorphological and ecological investigation and analysis. The expected outputs from each level of assessment and decision making process for when further assessment should be undertaken are contained within this guidance.

The outputs from the assessment will be used to document whether there is a potential for a deterioration in ecological status and the nature and magnitude of the hydromorphological changes causing adverse impact. This can be used as a record if there is later found to be deterioration in status in a water body where FCRM activities have been ongoing. The assessment could also be used as a basis for identifying better environmental options and practicable mitigation measures as part of project appraisal.

Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
   - the scientific objectives as set out in the contract;
   - the extent to which the objectives set out in the contract have been met;
   - details of methods used and the results obtained, including statistical analysis (if appropriate);
   - a discussion of the results and their reliability;
   - the main implications of the findings;
   - possible future work; and
   - any action resulting from the research (e.g. IP, Knowledge Transfer).

Section A Introduction

This project had ten specific objectives. The extent to which the objectives have been met, methods used and the limitations including peer review by the expert group have been discussed in relation to these objectives. Further to this possible future work and actions arising from the research have been outlined.

Section B Review of objectives

1. Design a framework for the expert assessment of the impact of FCERM infrastructure and activity on ecological status

The framework was completed and reviewed through the Project Steering Group (PSG) including Environmental Policy from the Environment Agency; Flood Risk Management Environmental Management Policy team representative and Defra Flood Management. A project start up meeting was held to agree the project plan and approach. A final inception report was produced from the Project Start Up meeting and circulated to steering group members. Subsequent meetings were used to obtain Project Steering Group input.

2. Use case studies and analysis of existing FCERM activity and infrastructure types as an integral element to inform this work.

A number of different types of FCRM schemes representing different elements of infrastructure and management activities were presented to the PSG. Four case studies were selected to be used during the project as shown in the table 1.

Table 1 Elements of engineering within each FCRM project or scheme

Case Studies presented to PSG	Engineering elements	✓/✗	Reasons for selection
A) Rural Flood Defence			
Ashfordby Flood Alleviation Scheme (560m)	Flood embankment Drainage	✓	This small scale scheme was identified further to the Project Steering Groups request for a more representative scheme of protection from localised flooding in rural areas.

	channel Culverts		
B) Complex Rural Flood Defence			
Yorkshire Derwent, Upstream of Malton to Norton (1km – 2km)	Earth Embankment Flood walls Flood gates Access gates for maintenance	✓	This scheme was originally proposed as simple rural flood defence scheme (A). During discussion at the meeting, it was concluded that complex urban examples originally requested, by the PSG, involved consideration of Integrated Urban Drainage Solutions and pluvial flooding beyond the scope of this current study. This case study is large scale and comprises a number of different elements associated to a larger urban area and thus warrants consideration as the complex flood risk management example. Urban flood risk management will be considered as a later part of this or other System Asset Management Planning projects. Scottish examples included in the project proposal were discounted as the project related is only related to England and Wales.
C) Structural Coastal Protection			
Clacton-on Sea (3km)	Fishtail Groynes	✗	Discounted as, whilst a useful example, undertaken using best practise, it is only representative of a single FCERM activity.
Duver Coastal Protection Scheme (550m)	Stonefaced reinforced concrete Rock armourstone	✗	This scheme is not on the open coast and is less representative than the other case studies of defences required on the open coast for both flood and coastal erosion risk.
Maryport Coastal Defence Scheme (1km)	Flood walls and gates Rock revetments Sheet piling	✓	The scheme was agreed by the PSG to represent a number of core FCERM activities and is a typically sized scheme.
Seahouses Breakwater (500m)	Breakwater	✗	Discounted as the primary function of the structure harbour wall protection as opposed to flood risk management.
D) Soft Coastal Protection			
Medmerry, West Sussex (5-10km)	Shingle renourishment Reprofiling	✗	It was agreed that Horsey Island is a good example of a scheme working with natural processes for FRM, but these activities do not yet represent core (expressed as >80%, Defra) FCERM activity. Of the two remaining examples, although Medmerry was agreed to be a representative example of a larger scheme, the Hunstanton to Heacham scheme was selected as it comprises a greater number of different core FCERM elements.
Hunstanton-Heacham, Norfolk (1km)	Sea wall Sand renourishment Sand recycling Groynes	✓	
Horsey Island, Essex (1km)	Fine Sediment recharge Nearshore breakwaters Polders	✗	

The case studies were used as points of reference throughout the project but in particular were used to test the use of the look-up tables and preliminary assessment by project team members who had not been involved with the project. These case studies are contained as an addendum to this short report.

3. Identify the critical factors and elements of FCERM activity that are essential to the assessment, and consider these in different types of natural environment

Critical elements of engineering were defined using the Sea Defence Survey and emerging Asset System Management Guidance. Strong steer was provided from Defra and the PSG that terminology used to describe FCRM should be consistent with Flood Risk Management and Asset System Management Guidance. A review of the types of assets and their characteristics is provided in Appendix A of the final project report (look up table 1).

4. Identify how these factors could be combined to make an overall quantitative assessment of their impact on the ecological quality of a water body

A review of potential hydromorphological changes associated to each separate engineering elements was carried out including possible influence of climate change as a separate column. The word 'potential' was used here as the same engineering element will illicit different hydromorphological response in different environments, thus the changes identified may or may not occur to greater or lesser extents. The purpose of the table was to act as prompt to identify change.

It was identified during this process (and using case studies) that schemes are usually based on a number of components and viewed in the first instance separately and then as cumulatively. It was recognised during this stage of the project that a scheme or activity is designed to achieve an outcome to meet the requirements of flood risk management: This outcome is hydromorphological. However, there may be changes to hydromorphology which occur as a result of the design occurring over spatial and temporal scales which are not intended as part of design but may occur as a result of complex hydromorphological response (localised changes having a longer term or knock-on impact) or changes in the environmental controlling factors.

The consideration of hydromorphological functioning in the particular environment where the scheme is located. Environmental controlling factors such as hydrological regime, wave and tidal regime and vegetation (controlled by primary factors such as geology, topography and precipitation regime) will have an influence on functioning (how the morphology affects the hydromorphological processes and vice versa).

In addition, the degree to which the system has already been modified will alter the functioning of the system, for example, the pinning of an estuary mouth through use of piling to maintain a constant channel width will control the tidal prism within in an estuary, and thus the ecology it supports.

These two areas are split under environmental types and degree of modification to report on the discussion from the first Expert Group Meeting relating to hydromorphological response and assessment of ecological impact.

Generalised review of outcomes from Expert Group Meeting: Part 1 Hydromorphological Functioning

Environmental types

Whilst there are broad characterisations of different types of morphology related to environment across the UK, it was agreed that there are few hydromorphological 'types' which can be used specifically to deal with hydromorphological response. The Water Framework Directive already breaks down water bodies into the core types (rivers, lakes, transitional and coastal surface waters). There have been numerous exercises to classify morphological types in different surface water categories, which can be useful in quickly identifying attributes of hydromorphological form (for example, River Habitat Survey typologies which identify flow types or classifications of saltmarsh morphologies). However, when understanding the functioning of a system, the response is likely to be variable on a localised scale dependent upon the particular factors at the site.

Several possible sub-divisions that could be made were identified by the Expert Group; in rivers, baseflow dominated (chalk streams); and in coastal water bodies hard and soft rock coasts. However, even for these typologies the response will be dependent upon degree of modification, in addition to the proposed new FCERM activities which may still render the same response.

Degree of physical modification

In addition to the natural environmental controlling factors, the extent to which these have already been altered as a result of physical modification, either at the location of the scheme or elsewhere within the system, will be fundamental in assessing any future response.

This alteration will have changed hydromorphological functioning away from its unmodified behaviour (hydromorphological quality elements identified in the Directive). The level of modification is recognised at a high level through the designation of Heavily Modified or Artificial water bodies where physical alteration has been significant and physical functioning may be more significantly altered a result. However, the hydromorphological response will still need consideration even in these cases as replacing like for like where this may not be necessary to support the designated use may not be defended and the potential for improving the physical condition should be identified if morphological quality is improved.

Summary of approach

It was agreed that due to the complexity of factors controlling hydromorphological response when taking the degree of previous modification into account and combining with this with the variable combination of FCRM elements which comprise a scheme and the differing extent of application of those elements, hydromorphological response must be considered case by case. It is not possible to use a formulaic approach as a small physical modification in an extremely sensitive environment, that is a water body that cannot absorb the change but will alter functioning significantly due to its current state, will be different from the change that may occur in an already modified system or one in which the change is insignificant given the dynamic nature of the water body. The scale of the activity is not commensurate with the scale of the hydromorphological response, though it will have some bearing.

There was broad agreement that the potential hydromorphological responses can be listed to prompt the user into considering potential hydromorphological responses which may occur as a result of the engineering activity (see Appendix B of the Technical Report). In addition, a consideration of climate change will also be given to prompt the user to think of change over longer timescales (and possibly wider spatial scales). The assessment of likely extent of response (and any uncertainty to this) should be made. To conclude, possible hydromorphological responses can be provided for each activity. The extent to which these apply or not should be evaluated on a case by case basis.

5. Relate this assessment to the proposed Morphological Condition thresholds;

Final documentation on Morphological Condition Thresholds was only produced during this project (March 2008). Conclusions on the assessment process (under Objective 4) lead the development of the methodology to be associated to expert assessment which did not take account of condition thresholds, referring instead to assessing hydromorphological change and impact upon biological elements used to define Good Ecological Status or Potential.

6. Document the staged methodology

The methodology used a tiered approach to assessment hydromorphological change to biological impact at three levels. The approach was based on achieving a proportionate level of assessment at each level. Look up tables were used at the Preliminary Level to assist those determining the need for Level 1 assessment and when defining the problem at the early stages of FCRM appraisal. Level 1 should be undertaken unless reasons for not progressing with any further assessment could be demonstrated. Level 2 should only be undertaken if there is evidence that the process would reduce uncertainty. The process is fully documented in the Technical Report.

7. Test the methodology to demonstrate its capability and the outputs that would be delivered

The methodology was tested using the case studies and taking into account the Supplementary Guidance on Project Appraisal for Water Framework Directive where the levels of assessment could defined against project appraisal. This outcomes from the preliminary assessment are contained in an addendum to this report.

8. Identify the skills and expertise required to undertake the assessment

The skills and experience needed to undertake the assessment were provided after discussion with the Project Steering Group and the Expert Group.

Level	Description
Expert	Sufficient experience through applying methods, often in combination, across a wide range of environments and to a wide range of problems. Would review and direct work of experienced staff.

Level	Description
Experienced	Good working understanding and knowledge of particular method(s) and its application through experience of application in a range of environments.
Intermediate	Knowledge of the subject area and could use certain methods with training and/or under the direction of experienced or expert staff.

9. Identify tools, data, and techniques that are required to support the process, and identify and knowledge gaps

The linkage of the assessment of hydromorphological change and consequent impact on ecological status to the decision making process for FCRM needs to be made. This would include considering how the conditions might be met under Article 4.7 of the WFD in relation to selecting practicable measures to mitigate for deterioration in status. Linkage to other projects aimed at defining mitigation measures would be useful.

The Technical Report is provided as a hard copy document and would lend itself well to being accessed as an electronic tool. The Look-up tables would be easier to use as a web-based tool and this should be considered when developing the methodology.

10. Estimate the resources required to undertake an expert assessment of different types of infrastructure, specifically in terms of time

Level 1 methods: estimated time requirements

Method	Time required (assuming supporting information is readily available and collated)
Desk based review of existing reports/analyses	3 days for up to 10-100km
Historical Trend Analysis	3-5 hours per km
Field assessment	1 day for up to 8km
River Habitat Survey and geoRHS repeat survey comparison	3 hours per 500m
Stream Power Assessment	1 day per reach
Tidal Prism Analysis	2-3 days per estuary

Level 2 Methods: estimated time requirements

Method	Time required (assuming supporting information is readily available and collated)
Fluvial audit	3 days per km
Physical biotope mapping	2 days per km
Ecological surveys	Variable dependent upon survey type. Specific guidance provided with standard guidelines through Natural England.
Particle tracking	1 day to seed, 2 days to collect tracers
Erosion monitoring	1 day to install equipment; monitoring for period of interest; 1 day to undertake measurements or retrieve data loggers

Accretion monitoring	1 day to install equipment; monitoring for period of interest; 1 day to undertake measurements or retrieve data loggers
Repeat survey	3 days for up to 5km
Water level monitoring	1 day to install monitoring equipment; monitoring period dependant on nature of interest; frequency of measurement dependant on type of equipment used
Sediment survey	2 days per 5km for sample collection; 3 days for laboratory analysis of physical characteristics; 5 days for laboratory analysis of chemical characteristics
Sediment Budget Analysis	1 day per 10km to calculate a detailed sediment budget based on archive data, plus additional timing for field measurements if necessary
Regime analysis	5-10 days for TraC water body
Physical niche modelling	2-8 days for TraC water body
Geomorphic Dynamics Assessment	5 days for a 1km river reach
Physical modelling	Timing dependant on the complexity of simulations and the number required. Should allow at least 1 day for each simulation if reasonably complex
Numerical modelling: 1D, 2D, 3D	Dependent upon the objectives of the modelling and existence of input data and definition of boundary conditions.

Section C Gaps in the knowledge base and further research

It was considered that the link between hydromorphology and ecology has only just started being addressed. There is no significant progress on defining research needs and thus the project identified undertaking discrete elements of work which would link to this project (and enable update of this guidance in the future with a view to providing tools which will assess hydromorphological change and impacts on biology). These could also be linked together specific tools for system functioning. Examples would be:

- Linking benthos to volatility (degrees of variability in level and nature of sediments and substrate) to provide (semi) quantitative linkage to degree and rate of surface change level to relevant benthic species.

- (Semi) quantification of the link between carbon input from organic input into intertidal areas such as mudflats and sandflats to quantify the interrelationship of these and hence the relevance of quantification of saltmarsh area and its relationship to benthic communities.

- Quantification of relationship between creek density and nursery area requirements for different species of fish.

- Relationship of water depth to structure and condition of the riparian zone.

Addendum

Case Study A	Simple Rural Flood Defence Scheme
Name	Asfordby Flood Alleviation Scheme
Extent of works	Direct impact = 560m Impact footprint = < 1km
Function of works	Prevention of flooding of residential and commercial properties in the village of Asfordby, near Melton Mowbray.
FCRM activities **(look-up table 1)**	Watercourse alteration (soil) Embankments (soil) Culverts (concrete)
Potential hydromorphological	*Watercourse alteration:*

Case Study A	Simple Rural Flood Defence Scheme
responses **(look-up table 2)**	Reduced morphological diversity, natural headward migration, regrading, increased sediment supply downstream, destabilisation of downstream bed and banks, siltation downstream, loss of shading associated with riparian zone. *Embankments:* Loss of floodplain ecology associated with connectivity, reduction/prevention of sediment input, reduction/prevention of channel in/outflow, increase in channel bank-full capacity, loss of shading associated with riparian zone. *Culverts:* Removal of morphology, increased sediment supply downstream, destabilisation of downstream bed and banks, increased siltation downstream, upstream flow impoundment, increased upstream siltation, reduced sediment supply downstream.
Biological Quality Elements **(look-up table 3)**	No direct data available, but could potentially include: Phytoplankton Macrophytes and phytobenthos Benthic invertebrate fauna
Physical dependencies **(look-up table 4)**	*Phytoplankton:* Residence time, water depth, thermal regime, turbidity. *Macrophytes and phytobenthos:* Slope, longitudinal position, bankline complexity, light quality and quantity, episodicity of flows and inundation, turbidity, baseflow, riparian shade and structure, substrate conditions. *Benthic invertebrate fauna:* Rainfall patterns, light, groundwater connectivity, availability of leaf litter/organic debris, connectivity with riparian zone.
Potential links between hydromorphological responses and physical dependencies	Increased sediment supply ≈ potentially increased turbidity, altered light quality and quantity, altered substrate conditions. Loss of floodplain ecology associated with connectivity ≈ riparian shade and structure, availability of leaf litter/organic debris, connectivity with riparian zone. Loss of shading associated with riparian zone ≈ light quality and quantity, availability of leaf litter/organic debris. Removal of morphology ≈ reduced bankline complexity, riparian shade and structure, connectivity with riparian zone.
Level 1 assessment required?	✓
Reasons	• Biological quality elements could be affected by hydromorphological responses • Insufficient hydromorphological and biological data to make an informed assessment at this stage
Recommended techniques	Desk based review, field assessment

Case Study B	Complex Flood Defence Scheme
Name	Yorkshire Derwent, Upstream of Malton to Norton
Extent of works	Old Malton - 800m Malton to Norton 1km to 2km (works on both sides of the river)
Function of works	Flood alleviation schemes completed in 2006 to alleviate flooding for the urban areas mentioned above.
FCRM activities **(look-up table 1)**	Embankments (soil) Flood walls (concrete, masonry) – incorporating gates for maintenance access Bank protection (brick)
Potential hydromorphological responses **(look-up table 2)**	*Embankments:* Loss of floodplain ecology associated with connectivity, reduction/prevention of sediment input, reduction/prevention of channel in/outflow, increase in channel bank-full capacity, loss of shading associated with riparian zone. *Flood walls:* Loss of floodplain ecology associated with connectivity, reduction/prevention of sediment input, reduction/prevention of channel in/outflow, increase in channel bank-full capacity, loss of shading associated with riparian zone. *Bank protection:* Reduced morphological diversity, increased sediment supply downstream, destabilisation of downstream bed and banks, siltation downstream, loss of shading associated with riparian zone.
Biological Quality Elements **(look-up table 3)**	Macrophytes and phytobenthos Fish fauna Phytoplankton and benthic invertebrate fauna are also likely to be present, but insufficient data are available to make an assessment at this stage
Physical dependencies **(look-up table 4)**	*Macrophytes and phytobenthos:* Slope, longitudinal position, bankline complexity, light quality and quantity, episodicity of flows and inundation, turbidity, baseflow, riparian shade and structure, substrate conditions. *Fish fauna:* Heterogeneity of habitat (substrate, provision of shelter), continuity for migration routes, substrate conditions, presence of macrophytes, accessibility to nursery areas. *Phytoplankton:* Residence time, water depth, thermal regime, turbidity. *Benthic invertebrate fauna:* Rainfall patterns, light, groundwater connectivity, availability of leaf litter/organic debris, connectivity with riparian zone.
Potential links between hydromorphological responses and physical dependencies	Loss of floodplain ecology and shading associated with riparian zone ≈ altered light quality and quantity, altered riparian shade and structure, reduced availability of leaf litter/organic debris, reduced connectivity with riparian zone. Reduced sediment input ≈ altered light quality and quantity, reduced turbidity, altered substrate conditions. Increased sediment supply ≈ potentially increased turbidity, altered light quality and quantity, altered substrate conditions. Reduced morphological diversity ≈ reduced bankline complexity, riparian shade and structure, connectivity with riparian zone.
Level 1 assessment required?	✓
Reasons	• Biological quality elements could be affected by hydromorphological responses • Insufficient hydromorphological and biological data to make an informed assessment at this stage
Recommended techniques	Desk based review, field assessment, ecological change assessment

Case Study C	Structural Coastal Protection Scheme
Name	Maryport Flood and Coastal Flood Defence scheme
Extent of works	1km
Function of works	To alleviate flooding in the village of Maryport
FCRM activities **(look-up table 1)**	Flood barriers Re-pointing of rock revetments and flood walls Replacing elements of rock revetments and sheet piles
Potential hydromorphological responses **(look-up table 2)**	*Flood barriers:* Localised scour and change in flow patterns around structures, increase in water levels to seaward when operated leading to more frequent inundation of intertidal areas. *Re-pointing:* No consequence. *Replacing elements:* No consequence.
Biological Quality Elements **(look-up table 3)**	No direct data available, but likely to include: Phytoplankton Macroalgae and angiosperms Benthic invertebrate fauna
Physical dependencies **(look-up table 4)**	*Phytoplankton:* Residence time, water depth, thermal regime, turbidity. *Macroalgae:* Episodicity (at the low end of the velocity spectrum), salinity, abrasion (associated with velocity). *Angiosperms:* Inundations (tidal regime), sediment loading, land elevation, salinity, abrasion (associated with velocity). *Benthic invertebrate fauna:* Beach water table, rainfall patterns, light, groundwater connectivity, availability of organic debris.
Potential links between hydromorphological responses and physical dependencies	Localised scour and change in flow patterns ≈ altered turbidity, altered sediment loading, altered abrasion (associated with velocity). More frequent inundation of intertidal areas ≈ altered water depth, altered inundation patterns.
Level 1 assessment required?	✓
Reasons	• Biological quality elements could be affected by hydromorphological responses • There is currently insufficient biological data to make an informed assessment
Recommended techniques	• Desk based review to consider likely changes to scour and flow and tidal regime (would expect this to be mostly covered under the scheme design work and EIA but consideration of abrasion may require further work, estimated additional cost £1000-2000) • Ecological change assessment to identify the nature of organisms in the intertidal and sensitivity to change (would anticipate the need for a survey prior to works to identify existing and assessment of impact as part of an EIA, however, this may not cover the level of detail necessary (for example may be Phase 1 only), estimated additional cost £1000-3000).

Case Study D	Soft coastal management scheme
Name	Hunstanton-Heacham, Norfolk
Extent of works	1km
Function of works	To enhance the natural protection provided by the beach by replenishment of sediment volume, and hence increasing beach level and width.
FCRM activities **(look-up table 1)**	Seawall Recharge (sand) Recycling (sand) Repositioning groyne (modifications to existing structure)
Potential hydromorphological	*Seawalls:* When exposed, reflect wave energy leading to clapotis and scour, beach

Case Study D	Soft coastal management scheme
responses **(look-up table 2)**	lowering, movement of sediment offshore of alongshore. *Recharge:* Feed longshore drift and absorb wave energy. *Recycling:* Fix position of the beach, oversteepen upper profile, sediment source for natural sediment movement.
Biological Quality Elements **(look-up table 3)**	No direct data available, but likely to include: Phytoplankton Macroalgae and angiosperms Benthic invertebrate fauna
Physical dependencies **(look-up table 4)**	*Phytoplankton:* Residence time, water depth, thermal regime, turbidity. *Macroalgae:* Episodicity (at the low end of the velocity spectrum), salinity, abrasion (associated with velocity). *Angiosperms:* Inundations (tidal regime), sediment loading, land elevation, salinity, abrasion (associated with velocity). *Benthic invertebrate fauna:* Beach water table, rainfall patterns, light, groundwater connectivity, availability of organic debris.
Potential links between hydromorphological responses and physical dependencies	Reflected wave energy leading to clapotis and scour ≈ altered turbidity, altered abrasion (associated with velocity), altered sediment loading, altered light quality and quantity. Beach lowering ≈ altered water depth, altered land elevation, altered beach water table. Movement of sediment offshore/alongshore ≈ altered turbidity, altered sediment loading. Feed longshore drift ≈ altered turbidity, altered sediment loading. Fix position of the beach ≈ altered land elevation, altered beach water table.
Level 1 assessment required?	✓
Reasons	• Biological quality elements could be affected by hydromorphological responses • There is currently insufficient biological data to make an informed assessment
Recommended techniques	• Desk based review to consider likely volatility in the beach system and liklihood of exposure of the seawall once the beach is recharged (would expect this to be required under the scheme design work, no additional cost) • Field assessment to consider the existing sedimentary system and how beach recharge might affect this as well as potential impact from reflection beyond the footprint of the beach (this may require modification of the design work to address this specific issue, estimated additional £1500 - 3000) • Ecological change assessment to identify the nature of organisms in the beach and sensitivity to change in sediment thickness/water table position/and sediment size (would anticipate the need for a survey prior to recharge to identify existing organisms and assessment of sensitivity as part of an EIA, adjustments to these existing activities may be require, estimated additional cost £500.)

References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

UKTAG (April 2008) UK Environmental Standards and Conditions (Phase 1) Final Report

Water Framework Directive Supplementary Guidance on Project Appraisal, Environment Agency (2007)

Water Framework Directive Expert Assessment Framework FD2609, Defra (2009)

Water Framework Directive Mitigation Measures for Flood Risk Management and Land Drainage Activities, Environment Agency, Scottish Environmental Protection Agency and Environment Heritage Service (under development 2009)

The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003).

The Water Framework Directive (2000/60/EC)

The Restoration of Vegetation on Saltmarshes: R&D Technical Report W208 (Environment Agency, 1999).

Flow and Level Criteria for Coarse Fish and Conservation Species (Environment Agency, 2004).

The Life in UK Rivers series of reports provides detailed habitat information for freshwater species and habitats of conservation concern (www.natural-england.org.uk).