

MERSEY TIDAL POWER

FEASIBILITY STUDY: STAGE 3

Feasibility Study Report

Date June 2011

Report prepared by:



Project Sponsors:



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Project Background

In the face of current and anticipated issues of security of supply and climate change, the need to find local sources of renewable energy has never been more urgent.

The Mersey Estuary has one of the largest tidal ranges in the UK, making it one of the best locations for a tidal power generation scheme. It has the potential to make a significant contribution to the Government's target to secure 15% of UK energy from renewable sources by 2020.

A large scheme could deliver enough renewable electricity to meet the needs of a significant proportion of the homes within the Liverpool City Region, as well as beyond. Any scheme put forward will need to take into account the ecological diversity of the Estuary, which supports internationally important bird habitats.

Phase 1 Pre-Feasibility Study - 'Power from the Mersey'

Peel, in partnership with the NWDA set out to explore the potential, the impacts and the implications of utilising the Mersey Estuary's renewable energy potential for the benefit of the Northwest region.

The Mersey Basin Campaign gave its full backing to the work and a consortium of consultants led by Buro Happold was commissioned in July 2006 to undertake a 'pre-feasibility' Phase 1 Study.

The primary objective of the Phase 1 Study was to undertake a full and open assessment of the options available for the generation of renewable energy and to undertake a preliminary assessment of viability.

A number of potentially viable schemes were identified. The continued development of marine power technology means that others may also need to be considered as the project moves into the next phase.

Meeting 2020 Renewable Energy Targets

An overall timetable was defined to ensure the project supports the policy objective of contributing to 2020 renewable energy targets. The key milestones of the project include submission of applications for planning or other statutory consents by 2012 and commissioning of the scheme by 2020.



Phase 2 Feasibility Study

Peel Energy and the Northwest Development Agency are progressing the project in line with the principles for sustainable development. A feasibility study has been commissioned to assess the options and identify a preferred scheme to take forward for submission of a planning application.

The feasibility study has been led by URS Scott Wilson, EDF and Drivers Jonas Deloitte, and supported by RSK, APEM, HR Wallingford, Regeneris, Turner and Townsend, University of Liverpool, Proudman and Global Maritime.

The feasibility study has been undertaken in three stages as follows:

- Stage 1: Definition of project strategies, data gathering and gap analysis, and selection of long list of suitable technologies
- Stage 2: Appraisal of the long list of technologies and formulation and appraisal of scheme options to identify a shortlist
- Stage 3: Further refinement and appraisal of the short list of scheme options and selection of the preferred scheme.

The project has been pursued in an open and transparent manner, building on the consultation and stakeholder engagement started in the Phase 1 study. An extensive programme of stakeholder engagement has taken place through project advisory groups, consultation with statutory and non-statutory consultees and public consultation targeted during appropriate stages of the project.

Mersey Tidal Power Scheme Objectives

The objectives of the Mersey Tidal Power scheme are:

- (a) To deliver the maximum amount of affordable energy (and maximum contribution to Carbon reduction targets) from the tidal resource in the Mersey Estuary with acceptable impacts on environment, shipping, business and the community either by limiting direct impact in the Mersey Estuary or providing acceptable mitigation and/or compensation;

and in doing so,

- (b) To maximise social, economic and environmental benefits from the development and operation of a renewable energy scheme, including where appropriate:
 - (i) the development of internationally significant facilities and skills to support the advancement of renewable energy technologies and their supply chains,
 - (ii) improvements to local utility and transport infrastructure,
 - (iii) improvements to green infrastructure and environmental assets,
 - (iv) the development of a leisure opportunity and tourist attraction.

Glossary and Abbreviations

0D	0-dimensional, used to describe the type of model used to predict the energy yields of sample schemes.
2D	2-dimensional, used with reference to the hydrodynamic modelling undertaken to inform the feasibility study. Such models are able to predict spatial and temporal changes to water flows.
Acceptability	Term used to refer to the project team's view on the likelihood of a particular scheme or variant passing the relevant tests required to enable the development to proceed, e.g. 'consenting acceptability' refers to the likelihood of a scheme/variant obtaining the necessary planning consents and passing the tests of the Habitats Regulations and Water Framework Directive.
ARPR	Average Real Price Required.
ASST	Annual Sea Surface Temperature.
Avoidance	Measures that are an integral part of a scheme's design or operating regime which avoid impacts.
BAP	Biodiversity Action Plan
Benthic	Living at the soil-water interface at the bottom of a sea or lake.
BIS	Department of Business Innovation and Skills.
CD	Chart Datum. A chart datum is the level of water that charted depths displayed on a nautical chart are measured from. A chart datum is generally a tidal datum; that is, a datum derived from some phase of the tide. The default datum within the study is Admiralty Chart Datum at Alfred Dock (CD). Chart Datum is 4.93 m below Ordnance Datum (OD) at Newlyn.
Cetacean	Whales, dolphins and porpoises.
CLG	Department of Communities and Local Government.
Coherence	Referred to within the definition of Natura 2000 site integrity. The term has not been formally defined within relevant legislation, however, coherence will be used in the context of the working definition adopted by OSPAR MASH (2006) in relation to Marine Protected Areas. This definition states that an ecologically coherent network: i. interacts with and supports the wider environment; ii. maintains the processes, functions and structures of the intended protected features across their natural range; and iii. functions synergistically as a whole, such that the individual protected sites benefit from each other in order to achieve objectives (i) and (ii).
Compensation	A term used in the ecological assessment to refer to measures to indirectly reduce overall adverse effects on ecological receptors, for example measures that would be implemented outside the SPA/Ramsar site boundary to reduce impacts on the site's integrity.
CO ₂	Carbon dioxide.
DECC	Department of Energy and Climate Change.
DEFRA	Department for Environment Food and Rural Affairs.
Ebb tide	The falling/ outgoing tide.
EIA	Environmental Impact Assessment.
Embodied carbon	Refers to the carbon dioxide emitted at all stages of a product's manufacturing process, from the resource extraction, transportation, fabrication and distribution of the product and/or material.
Enhancement	A term used to describe an improvement to the baseline conditions.
Exit losses	Loss of energy experienced by the water flow as it moves from a constricted location into an open location. Exit losses may occur at the downstream side of turbines, sluice gate channels, fish passage routes and locks.
Feasible	Capable of being brought about or accomplished.
Flood tide	The rising/ incoming tide.
FTE	Full Time Equivalent.

GW	GigaWatt, equivalent to 1,000 MW.
GVA	Gross Value Added, a measure of economic value.
IBv1	The first variant of an impounding barrage scheme developed for assessment, which was located at Band A.
IBv2a	The second design variant of an impounding (unrestricted head) barrage developed for assessment, which was located at Band A. 'a' indicates the operating regime.
IBv2b	The second design variant of an impounding (unrestricted head) barrage developed for assessment, which was located at Band A. 'b' indicates the operating regime.
Impounding barrage	A tidal barrage which creates a level difference between an impounded basin and the open sea as the tide rises or falls. Electricity can be generated by conventional horizontal axis bulb or Straflo turbines. Various operating strategies are possible leading to flexibility in operation. Within the context of the Mersey, an impounding barrage would be selected to operate with a differential head of about 4 m. It should be noted that an impounding barrage could be designed to operate at a range of head differences, including restricted head differences similar to those used by a 'very low head barrage', but for the purposes of this feasibility report, the term 'impounding barrage' is used to refer to a barrage that operates at a higher head difference than a very low head barrage as defined below (see 'Very low head barrage').
Integrity	Used in the context of the Habitats Directive to refer to the coherence of the site's ecological structure and function, across its whole area, or the habitats, complex of habitats and/or populations of species for which the site is or will be classified.
Invertebrate	Any animal that lacks a vertebral column, or backbone.
IPC	Infrastructure Planning Commission.
IROPI	Imperative Reasons of Overriding Public Interest.
IRR	Internal Rate of Return.
LEP	Local Enterprise Partnerships.
Location option	Refer to 'Option'.
MEAP	Marine Energy Action Plan.
MIPU	Major Infrastructure Planning Unit.
Mitigation	A term used to refer to measures to reduce adverse effects. In the ecological assessment, the term is used specifically to describe measures that are not part of the tidal power scheme design (see 'prevent harm' below) but that would be implemented within the SPA/ Ramsar site boundary or functionally linked habitat.
MMO	Marine Management Organisation.
MW	MegaWatt, equivalent to 1,000 kW or 1,000,000 W.
Natura 2000	A European collective term for SPAs and SACs. Ramsar sites are also generally included within the definition for ease of reference in the UK.
NIP	National Infrastructure Plan.
NPPF	National Planning Policy Framework
NPS	National Policy Statement.
NPV	Net Present Value.
NREAP	National Renewable Energy Action Plan.
NTSLF	National Tidal and Sea Level Facility.
NSIPs	Nationally Significant Infrastructure Projects, as defined by the Planning Act 2008.
NWDA	Northwest Regional Development Agency.
Option	'Option' is used to describe the technology type ('technology option', e.g. impounding barrage) or broad location ('location option').
pRamsar	A proposed Ramsar site, not fully designated but assumed for the purposes of assessment to be afforded the same level of protection as a designated Ramsar site.

Prevent harm	A term used to refer to measures included within the design of a tidal power scheme to avoid impacts on ecological receptors. These may comprise adaptations or additions to the scheme design, construction or operating regime to avoid impacts.
pSPA	A potential SPA, not fully designated but assumed for the purposes of assessment to be afforded the same level of protection as a designated SPA site.
Ramsar site	A wetland of international importance in terms of ecology, botany, zoology, limnology or hydrology, designated under the Ramsar Convention (the Convention on Wetlands of International Importance).
ROCs	Renewables Obligation Certificates.
RSS	Regional Spatial Strategy.
Runner	The rotating part of a turbine that converts the energy from flowing water into mechanical energy for driving a generator.
SAC	Special Area of Conservation, a protected site designated under the EC Habitats Directive to conserve habitats and species listed under Annexes I and II of the Directive (as amended).
Scheme	'Scheme' is used to refer to a combination of both technology and location options.
SEA	Strategic Environmental Assessment.
SIA	Strategic Investment Area.
SMEC	Spectral Marine Energy Converter. The SMEC is an innovative device being developed by VerdErg that concentrates the energy contained in a large body of slow moving water into a smaller body of fast flowing water using the Venturi effect. SMEC devices would be housed in a structure extending across the estuary. The system would be bi-directional and suitable for low velocity conditions.
SMECv1	The first variant of a SMEC scheme developed for assessment, which was located at Band A.
SMP	Shoreline Management Plan.
SoCC	Statement of Community Consultation.
SPA	Special Protection Area, a protected site designated under the EC Birds Directive to conserve birds listed on Annex I of the Directive and migratory species.
Spectral Marine Energy Converter	See SMEC.
SSSI	Site of Special Scientific Interest, a statutory designated nature conservation site.
SIA	Strategic Investment Areas.
Technology option	Refer to 'Option'.
TFv1	The first variant of a tidal fence scheme developed for assessment, which was located at Band A.
TFv2	The second variant of a tidal fence scheme developed for assessment, which was located at Band B.
Tidal fence	A tidal fence comprises a bank of energy conversion devices housed in a structure. The structure may be run across the full width of an estuary or only partial width. Flows are constricted to increase the velocity of the water passing through the generating devices. Turbines could be horizontal or vertical axis.
Tidal power gate	A tidal power gate comprises a series of small diameter turbines fixed within moveable gates which can be raised and lowered within a series of sluices or channels to allow generation. The power gates would be situated within a structure across the estuary and would operate under a low head.

Tide locking	A term used to describe the backing up of water in a watercourse that discharges into the Estuary, with potential impacts on flood risk. Tide locking occurs when the Estuary water level prevents free discharge from the watercourse.
UDP	Unitary Development Plan.
Upper Estuary	The Upper Estuary extends for a distance of about 42 km from approximately Dingle to Howley Weir.
UXO	Unexploded ordnance.
Variant	'Variant' is used to describe a particular version of a scheme in terms of its civil, structural and mechanical design and operating regime (e.g. 'operational variant'). Throughout this report, scheme variants are referred to using a shorthand reference (e.g. IBv1) to indicate the particular choice of design, configuration and operating regime assumed for the assessment.
Venturi effect	The reduction in fluid pressure that results when a fluid flows through a constricted section of pipe causing velocities to increase through the constriction.
Very low head barrage	A tidal barrage which creates a level difference between an impounded basin and the open sea as the tide rises or falls. Electricity can be generated by operating in the range typically below that of a conventional impounding barrage. Various technologies can operate in a very low head situation and various operating strategies are possible leading to flexibility in operation. Within the context of the Mersey, a very low head barrage would be designed to operate with a differential head of around 3 m.
Viable	Capable of being profitable.
VLCC	Very Large Crude Carrier.
VLHBv1	The first variant of a very low head barrage scheme developed for assessment, which was located at Band B.
VLHBv2a	The second design variant of a barrage designed for low head operation developed for assessment, which was located at Band A. 'a' indicates the operating regime.
VLHBv3a	The third design variant of a barrage designed for low head operation developed for assessment, which was located at Band A. 'a' indicates the operating regime.
WeBS	Wetland Bird Survey undertaken by the British Trust for Ornithology.
Wetted perimeter	The edge of an intertidal habitat, where the exposed area meets the water. Birds tend to feed near the water's edge, and follow this 'wetted perimeter' as the tide ebbs and floods.

Executive Summary

Introduction

A three-stage feasibility study has been undertaken to consider options and identify a preferred scheme to take forward for consent applications. Stage 3 represents the final stage of the feasibility study, and results in conclusions being drawn for all stages of the study and the identification of a preferred tidal power scheme for the Mersey Estuary.

The Mersey Estuary's large tidal range makes it highly suitable for a tidal power scheme but the Estuary is also an important ecological habitat recognised by its national and international nature conservation designations, and important for shipping.

Stage 1 Conclusions: Long List

Stage 1 started with consideration of the site characteristics of the Mersey Estuary and critically reviewed an extensive range of potential technologies to determine a long list of suitable tidal power generation technologies.

The output from Stage 1 identified four technology options all of which were considered to be technically feasible and suitable for the Mersey Estuary and (based on the information available at Stage 1) were anticipated to have timeframes for development compatible with the project programme. The four technology options were:

- horizontal axis turbines in an impounding barrage
- tidal gate comprising Hydromatrix™ turbines or Straflo™ matrix creating a very low head barrage;
- vertical axis cross flow machines or horizontal axis ducted stream flow machines in a tidal fence; and
- Spectral Marine Energy Converter (SMEC) forming a tidal fence.

Stage 2 Conclusions: Short List

In Stage 2 five sample schemes (IBv1, VLHBv1, TFv1, TFv2 and SMECv1) were developed using the selected technologies and indicative bands (A-C) that were identified to inform the assessment and enable the technologies to be tested. The indicative bands represented the two main types of location within the Estuary – narrow, deep locations towards the Estuary mouth and wide, shallow locations further upstream.

The sample schemes were assessed through studies of technical issues, energy yields, environmental and socio-economic impacts, sustainability appraisal and commercial viability. The findings were summarised in a decision making framework. The environmental assessments included two-dimensional hydrodynamic modelling, a Shadow Habitats Regulations Assessment considering potential effects on the structure and function of the Mersey Estuary Sites of Special Scientific Interest (SSSIs)/ Special Protection Area (SPA)/ Ramsar site (as a proxy for other international nature conservation sites further from the scheme) and flushing calculations to inform an initial assessment of water quality.

The Stage 2 studies concluded that the tidal fence technology could not provide a viable scheme due to the low energy yield and high capital costs, and the SMEC technology could not be considered further in the study until such time as the design and performance of the technology is better understood from the results of a prototype.

The assessment of location options concluded that locations near the mouth of the Estuary should be deselected at Stage 2, due to the significant constraints associated with development in this area including navigation.

The short list of schemes identified at the end of Stage 2 was:

- impounding barrage in the vicinity of Band A (i.e. a deep water location around New Ferry and Dingle, which has commercial shipping constraints);
- very low head barrage in the vicinity of Band A (defined as above); and
- very low head barrage in the vicinity of Band B (i.e. a shallow water location which has no commercial shipping constraints).

Key issues identified for further consideration included measures to avoid/ prevent harm and mitigate impacts on estuarine habitats, fish, flood risk, water quality, navigation and commercial viability. Potential measures identified to reduce environmental impacts included ebb and flood generation, low tide sluicing and high tide pumping.

Stage 3 Option Appraisal

At Stage 3, further consideration was given to potential locations for the short list technologies. An approximately 5.5 km stretch of the Estuary between New Ferry and Dingle at the downstream extent and Eastham and Garston at the upstream extent was considered.

The alignment for development of schemes at Band A was refined to minimise impacts on the Liverpool Garden Festival Site, which is currently being redeveloped for mixed uses including residential.

The Band A alignment is favoured as it provides a greater potential energy yield, lower construction costs due to the narrower Estuary width and avoids construction within the boundaries of the national and international nature conservation designations, however impacts on navigation would need to be mitigated.

The Band B alignment upstream was also reviewed and, following further engineering and commercial study, it was concluded that a scheme in this location could not be significantly improved from Stage 2 in terms of energy yield and capital cost due to the wide and shallow nature of the location. The Stage 2 assessment also indicated no significant reduction in ecological impacts could be achieved by adopting this location.

A single alignment between New Ferry and Dingle was therefore used for the sample schemes developed at Stage 3.

All Stage 3 scheme designs adopted conventional bulb turbines, including the schemes designed for operation at lower head differences, as no special low head turbines are sufficiently developed at the current time. If such turbines are developed within the project timescales, they could be substituted into the preferred scheme.

The sample schemes developed are as followed:

- IBv2a – a 28 turbine, 18 sluice gate design, operated using an unrestricted head on ebb tides only – developed to explore the maximum potential energy yield;
- IBv2b – a 28 turbine, 18 sluice gate design, operated using an unrestricted head on ebb tides only, but incorporating low tide sluicing and a low water hold period to increase intertidal habitat exposure – developed to explore the maximum potential energy yield with minimal environmental impact avoidance;
- VLHBv2a – a 44 turbine, 18 sluice gate design, operated using a restricted head on ebb tides only – developed to explore this operating mode as a means of reducing environmental impacts and associated impacts on energy yield; and
- VLHBv3a – a 44 turbine, 18 sluice gate design, operated using a restricted head on both ebb and flood tides – developed to explore this operating mode as a means of reducing environmental impacts and associated impacts on energy yield.

Additional variants were explored as the Stage 3 studies progressed to consider the potential benefits of fewer turbines, more sluice gates and high tide pumping.

The ecological studies have assessed potential effects on the Mersey Estuary SPA as a proxy for effects on all potentially affected designated sites. As part of the ecological assessment, packages of measures have been developed to prevent harm and mitigate impacts on important estuarine ecology features, particularly birds and fish. This strategy seeks to minimise the impact and reduce the residual effects of each scheme, and remaining residual effects would be addressed by compensation measures.

The range of design and operational variants testing through the Stage 3 assessment resulted in the following key conclusions:

- an alignment between New Ferry and Dingle presents the best opportunity for a viable tidal power scheme in the Mersey Estuary;
- ebb only unrestricted head generation would provide the greatest energy yield and therefore most likely to provide a commercially viable scheme, but this operating mode would also have potentially the greatest environmental impacts;
- ebb only restricted (low) head generation would have a significantly lower energy yield and therefore poorer commercial performance than unrestricted head generation but it provides some avoidance of environmental impacts;
- ebb and flood generation would also have a lower energy yield and greater risk for fish, but overall this operational mode would be likely to have less environmental impact and there may be more potential in some instances to match generation with peak demand;
- low tide sluicing and a low tide hold period have the potential to reduce impacts on intertidal habitats, birds and water quality but a greater number of sluices would be required to achieve significant benefits and sluicing would need to commence earlier on the ebb tide (possibly during generation);
- high tide pumping also has potential to reduce impacts on intertidal habitats and birds and could improve the net energy yield (although increasing the number of sluices may make it unnecessary for the purpose of maintaining high water levels and thereby reducing ecological impacts);

- a flexible operating regime would enable the benefits of each of the above operating regimes to be realised and the most effective management of potential adverse environmental impacts;
- the commercial performance of all schemes studied at Stage 3 is such that further optimisation and capital and/or price support would be required to achieve viability;
- all Stage 3 scheme variants assessed would have a positive carbon balance due to the generation of renewable energy and a carbon payback period of less than five years (in the context of a project life of up to 120 years);
- any scheme would bring significant socio-economic benefits to the city and region;
- consultation has indicated significant support for the project (74% positive responses).

Feasibility Study Conclusions: Preferred Scheme

The preferred scheme has been identified on the basis of the conclusions listed above. It would comprise a design using 28 or less turbines (to minimise capital costs whilst still enabled restricted head operation to be achieved) and 18 or more sluice gates (to enable natural low and high water levels to be better maintained, at minimal additional capital cost). The operating regime would be flexible and managed – a mix of unrestricted head, ebb only generation on spring tides and larger intermediate tides to maximise energy yield and improve the commercial performance of the scheme, and restricted head, ebb or ebb and flood generation at other times to manage environmental impacts. This flexible regime would enable ecological, sediment, water quality, groundwater, flood risk and sea level rise issues to be managed, and seasonal variation could be used to mitigate the impacts of extreme/emergency events (such as extreme cold weather with regards to bird survival, and flood or pollution events).

Fish passages have been introduced at a number of locations across the structure and other mitigation measures can be incorporated to enhance fish survival rates.

The preferred scheme as defined above is estimated to have an annual energy yield of around 920 GWh (although this could be improved through optimisation) and would require further refinement (optimisation and value engineering) and capital/ price support to be commercially viable.

The scheme would have an expected life of around 120 years, and have a carbon payback period of less than two and a half years.

Table of Contents

Project Background	ii
Glossary and Abbreviations.....	iii
Executive Summary	vii
Feasibility Study Conclusions: Preferred Scheme	x
1 Introduction	1
1.1 Purpose of Report.....	1
1.2 Definitions.....	2
1.3 Approach to Consultation.....	2
2 The Mersey Estuary	3
2.1 Geography.....	3
2.2 Coastal and Estuarine Processes	4
2.3 Flood Risk and Coastal Protection	8
2.4 Geo-environmental Conditions.....	9
2.5 Commercial and Recreational Navigation	10
2.6 Nature Conservation Importance	10
2.7 Water Quality	15
2.8 Access and Other Environmental Considerations	16
2.9 Local Social and Economic Considerations	16
3 Policy Context	18
3.1 Introduction.....	18
3.2 European Legislation	18
3.3 UK Legislation	19
3.4 National Policy	22
3.5 Regional Policy and Guidance	28
3.6 Sub-Regional Policy	30
3.7 Local Policy	31
4 Options Appraisal Methodology	37
4.1 Decision Making Framework.....	37
4.2 Approach to Stage 1 Options Appraisal	37

4.3	Approach to Stage 2 Options Appraisal	39
4.4	Approach to Stage 3 Options Appraisal	42
4.5	Habitat Regulations Assessment	43
4.6	Water Framework Directive Assessment	45
5	Summary of Stage 1.....	46
5.1	Identification of the Pre-Long List.....	46
5.2	Assessment of the Pre-Long List	47
5.3	Conclusions of Stage 1: Long List.....	49
6	Summary of Stage 2.....	50
6.1	Schemes Assessed at Stage 2	50
6.2	Appraisal of Location Options	53
6.3	Assessment of Technical Acceptability	54
6.4	Assessment of Consenting Risk	55
6.5	Assessment of Commercial/ Financial Risk	56
6.6	Conclusions of Stage 2: Short List	57
7	Stage 3 Option Appraisal.....	59
7.1	Schemes Assessed at Stage 3	59
7.2	Technical Acceptability	69
7.3	Consenting Acceptability.....	73
7.4	Financial Acceptability	108
7.5	Contribution to Targets	111
7.6	Conclusions of Stage 3: Sample Scheme Assessment.....	113
8	Stakeholder Consultation	115
8.1	Background	115
8.2	Consultation Process and Methodology.....	115
8.3	Consultation Feedback and Response	123
8.4	Conclusion.....	125
9	The Preferred Scheme	127
9.1	Lessons Learnt From Feasibility Study	127
9.2	Design and Operation.....	127
9.3	Technical Acceptability of Preferred Scheme.....	131
9.4	Consenting Acceptability of Preferred Scheme	131
9.5	Financial Acceptability of Preferred Scheme.....	134

9.6	Contribution to Targets from Preferred Scheme.....	135
9.7	Consenting Process.....	135
9.8	Risks.....	136
9.9	Scope of Further Studies	137
9.10	Programme.....	139
10	Overall Conclusions of Feasibility Study	140
10.1	Preferred Scheme.....	140
10.2	The Way Forward	141
11	Call for Information, Comments and Feedback	142
12	References.....	144

Figures

Figure 2.1: The Mersey Estuary (red line indicates Manchester Ship Canal)	4
Figure 2.2: Internationally and nationally designated nature conservation sites.....	11
Figure 2.3: Counts of SPA bird species within Mersey Estuary SPA (November 2008-September 2010 surveys), relative to internationally and nationally important thresholds for wintering birds	12
Figure 4.1: Decision making framework	37
Figure 4.2: Representative bands identified at Stage 2	40
Figure 4.3: Potential development area considered at Stage 3	42
Figure 6.1: Stage 2 Decision Making Framework Assessment.....	57
Figure 7.1: Indicative alignment for Stage 3 schemes (shown as red line).....	61
Figure 7.2: Indicative design of impounding barrage designed for unrestricted head, ebb only generation (IBv2a and IBv2b).....	66
Figure 7.3: Indicative design of impounding barrage designed for restricted head, ebb only generation (VLHBv2a) and ebb and flood generation (VLHBv3a)	67
Figure 7.4: Comparison with energy yields predicted by Mersey Barrage Company in 1992	68
Figure 7.5: 2D tidal curves for IBv1, IBv2b, VLHBv2a and VLHBv3a and an additional variant to explore the effect of using more sluice gates	72
Figure 7.6: Extent of 2D hydrodynamic model	76
Figure 7.7: Water levels at neap tide at different locations in the Estuary from Gladstone Dock to Widnes.....	78
Figure 7.8: Water levels at intermediate tide at different locations in the Estuary from Gladstone Dock to Widnes.....	79
Figure 7.9: Water levels at spring tide at different locations in the Estuary from Gladstone Dock to Widnes.....	80
Figure 7.10: Graphs showing comparison of spring tide water levels at various locations within and outside the Estuary	82
Figure 7.11: Predicted overall changes to current (2002) surface area of SPA habitats using water level data from 2D hydrodynamic model with no allowance for sedimentation changes	86
Figure 7.12: Total intertidal mud, muddy sand and sandy mud area exposed for bird foraging over spring 2060 tidal cycle with no allowance for sedimentation changes	90
Figure 7.13: Total intertidal mud, muddy sand and sandy mud area exposed for bird foraging over intermediate 2060 tidal cycle with no allowance for sedimentation changes	90
Figure 7.14: Total intertidal mud, muddy sand and sandy mud area exposed for bird foraging over neap 2060 tidal cycle with no allowance for sedimentation changes.....	91
Figure 7.15: Stage 3 decision making framework assessment.....	113
Figure 8.1: Feasibility study stakeholder groups	117
Figure 9.1: Initial proposed operating regime for preferred scheme	129
Figure 9.2: Completed decision making framework for the preferred scheme using an initial proposed operating regime.....	130

1 Introduction

1.1 Purpose of Report

1.1.1 This report sets out the findings of the Mersey Tidal Power feasibility study and should be read in conjunction with the Stage 1 and Stage 2 Options Reports (Scott Wilson, 2010a and 2010b) together with the series of technical reports published with this Feasibility Study Report.

1.1.2 The objectives of this overall Feasibility Report are to:

- summarise the findings from Stages 1 and 2 of the feasibility study;
- record the Stage 3 optional appraisal process and its conclusions;
- identify the preferred scheme;
- identify key issues to be resolved to progress the project and prepare applications for the necessary consents, licences and approvals; and
- provide a means for consulting with stakeholders and the public on the feasibility study, and inviting feedback.

1.1.3 The report is structured as follows:

- **Sections 1 to 3** provide contextual information on the Mersey Estuary and relevant legislation, policy and guidance;
- **Section 4** defines the methodologies used to undertake the options appraisal ;
- **Sections 5 and 6** summarise the findings of Stages 1 and 2;
- **Section 7** presents the findings of Stage 3;
- **Section 8** summarises the findings of stakeholder consultation;
- **Section 9** presents the preferred scheme;
- **Section 10** provides the overall conclusions of the feasibility study; and
- **Section 11** invites comments and feedback and provides contact details.

1.1.4 The report is accompanied by a number of technical assessment and appraisal reports produced at Stage 3 of the feasibility study as follows:

- Stage 3 Study of Tidal Barrage Scheme Options
- Stage 3 Civil Engineering Report
- Stage 3 Landside Facilities Report
- Stage 3 Grid Connection Report
- Stage 3 Navigation Options Report
- Stage 3 Marine Ecology Report
- Stage 3 Socio-economic Impacts Report
- Stage 3 Sustainability Report
- Stage 3 Cost Report
- Stage 3 Financial Modelling Report

1.2 Definitions

- 1.2.1 In the same way as the Stage 1 and 2 Options Reports, this report is written using as non-technical language as possible, however in order to describe the work that has been undertaken during the feasibility study there are a number of terms specific to tidal power generation and planning legislation that cannot be avoided. A glossary and list of abbreviations is provided at the front of this report to aid understanding. The technical reports that accompany this Feasibility Report necessarily use technical terminology.
- 1.2.2 Throughout this report, a distinction is made between the terms 'option', 'scheme' and 'variant'. 'Option' is used to describe the technology type ('technology option', e.g. impounding barrage) or broad location ('location option'), whereas 'scheme' or 'scheme option' is used to refer to a combination of both technology and location. To inform the feasibility study a number of sample schemes have been developed for assessment at Stages 2 and 3.
- 1.2.3 A further tier of classification described as the 'variant' is used to describe civil, structural and mechanical design and configuration details as well as the operating regime. As it is possible for a scheme with the same design to be operated flexibly using different operating regimes, design and configuration are examined and discussed separately to operational regime where appropriate.
- 1.2.4 To enable design and operational variants to be described separately, each Stage 3 scheme variant has been given a number to denote design and a lower case letter to denote operating regime (e.g. IB v2a). Scheme variants with the same number but different letters have the same design but would be operated differently.

1.3 Approach to Consultation

- 1.3.1 Engagement with stakeholders is critical to the success of the project. Through consultation, the project team has sought to ensure relevant issues were identified in a timely manner and considered at an appropriate stage of the feasibility study.
- 1.3.2 A range of stakeholder advisory groups, including environmental, design and navigation technical groups, have been established for the project and these have met throughout the feasibility study to help identify current interests in the Estuary, and provide comment and input to the assessment criteria and option appraisal process. Public consultation was also undertaken during Stage 3. Further details are provided in Section 8.

2 The Mersey Estuary

2.1 Geography

- 2.1.1 The Mersey Estuary is located in the north-west of England. It is one of the largest estuaries in the UK (approximately 45 km long) and has a catchment of approximately 4,600 km².
- 2.1.2 The River Mersey originates in the town centre of Stockport where it is formed at the confluence of the River Goyt and River Tame. From Stockport the Mersey flows south and into the Manchester Ship Canal at Irlam. The original course of the Mersey was completely changed between Irlam and Rixton during the construction of the Ship Canal. At Rixton, the River leaves the Ship Canal and flows through Warrington, before widening into the Mersey Estuary around Runcorn. The Ship Canal runs alongside the widening Estuary to Eastham Locks where the Canal enters the Estuary, which flows into Liverpool Bay and the Irish Sea. Tidal conditions extend as far upstream as Howley Weir in Warrington.
- 2.1.3 As described in Section 3.1 of the Stage 2 Options Report (Scott Wilson, 2010b), there are two distinct bathymetric and geographic areas in the Estuary (see Figure 2.1): the narrower, deeper area downstream of Dingle towards the Estuary mouth; and a wider, shallower area upstream of Dingle where extensive areas of intertidal habitat are exposed at low tide. The width of the Estuary ranges from 1 to 2 km near the Estuary mouth to a maximum of 4.8 km upstream.
- 2.1.4 The basic geography of the Estuary is important in the context of tidal power development – the closer to the mouth of the Estuary, the greater the volume of water passes through, and therefore the greater the quantity of energy is available. Due to the geography of the Mersey Estuary, the length of a structure required to span the Estuary would also be shorter towards the mouth of the Estuary. Therefore the further seaward the alignment the greater the energy yield and the lower the cost of construction. This encourages consideration of alignments towards the downstream, narrow section of the Estuary.
- 2.1.5 The River Gowy and River Weaver flow into the Mersey Estuary, together with a number of other tributaries: Sankey Brook, Ditton Brook, Rams Brook, Rivacre Brook, Dibbinsdale Brook and the River Birket (Environment Agency, 2009).

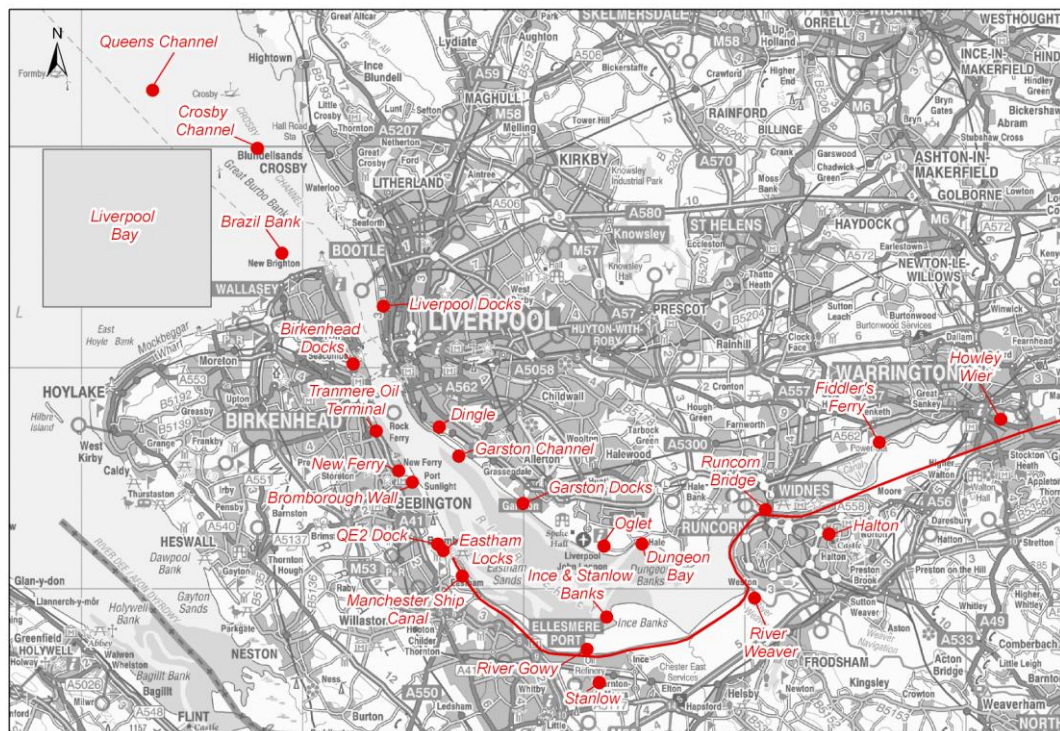


Figure 2.1: The Mersey Estuary (red line indicates Manchester Ship Canal)

2.2 Coastal and Estuarine Processes

- 2.2.1 During the feasibility study, information on a range of inter-related topics that influence the dynamics of the Estuary, including the tidal regime, water depths and levels, currents, waves, estuarine morphology and sediment transport, has been gathered. These issues are relevant to the feasibility study because a tidal power scheme may have an influence on these factors, and vice versa. In addition to the Estuary itself, consideration has been given to freshwater flows into the Estuary from upstream, and Liverpool Bay and the Irish Sea downstream.
- 2.2.2 Over the past 30 years there have been many numerical hydrodynamic models of the Irish Sea and Liverpool Bay; however the scale of the models is such that the Mersey Estuary is often not included in great detail. Modelling of Liverpool Bay has included structured and unstructured grid models and both two and three dimensional models. Model studies of the Mersey Estuary have focussed mainly on sediment transport and bathymetric evolution as well as tidal power applications. Key modelling studies of the Mersey Estuary have been carried out by Thomas et al. (2002). Two dimensional hydrodynamic modelling has been undertaken to inform the feasibility study.

Tidal Regime, Water Depths and Levels

- 2.2.3 The Irish Sea is a semi-enclosed sea area, lying between England, Scotland, Wales and Ireland and connected to the North Atlantic by narrow channels to the north and south. Water depths are less than 200 m. Liverpool Bay is deeper than the mouth of the Estuary, with an average depth of around 40 m compared to an average of 15 m depth in the narrow, deep areas around the Estuary mouth.
- 2.2.4 The tidal regime of the Irish Sea is such that the Mersey Estuary experiences two high tides and two low tides daily. The tidal levels in Liverpool Bay and the Mersey Estuary are able to be predicted with a high level of confidence due to the long historical record for some sites in the area. The tidal range in the Estuary is between 8.4 m and 9.0 m at spring tide and 4.4 m to 4.7 m at neap tide (Admiralty tide tables). The tidal range in Liverpool Bay increases from west to east, reaching around 10 m at Liverpool. For comparison the spring tidal range on the Severn at Bristol is around 12 m and the Thames at London Bridge is around 6-7 m. Table 2.1 summarises the published tidal levels for Liverpool.

Table 2.1: Published tidal levels for Liverpool

Tide Level	National Tidal and Sea Level Facility (NTSLF) website (mCD)	Admiralty tide tables (mCD)
Highest Astronomical Tide	10.37	10.5
Mean High Water Springs	9.39	9.3
Mean High Water Neaps	7.45	7.4
Mean Water Level	-	5.1
Mean Low Water Neaps	3.16	2.9
Mean Low Water Springs	1.12	0.9
Lowest Astronomical Tide	0.02	-0.2

- 2.2.5 The water level within Liverpool Bay and the Estuary is a function of two components. The first is the predictable tidal component and the second is surge due to atmospheric pressure variation and wind forcing. The maximum surge at Liverpool does not fall on high water due to interaction of these two components within the Irish Sea, Liverpool Bay and the Estuary (Woodworth and Blackman, 2002). Extreme water levels at Liverpool were investigated by Dixon and Tawn (1995) and the 1 in 100 year extreme level for Liverpool is estimated to be +10.83 mCD (5.9 mOD).
- 2.2.6 Sea level rise due to climate change within the area is expected to be close to the average predicted UK sea level rise, based on the medium emissions scenario. For the purposes

of this project the UK absolute sea level rise value of +36.9 cm by 2100 has been used, which equates to approximately 3.4 mm/year (added to the published 2010 levels).

Tidal Currents

- 2.2.7 The maximum tidal currents in the narrow sections of the Estuary are up to approximately 2-3 m/s. Further upstream, the broader width reduces the maximum tidal velocities (Blott *et al.* 2006).

Waves

- 2.2.8 The wave climate within Liverpool Bay is made up of locally generated wind-waves and waves moving into the area having been generated outside of the Bay. Liverpool Bay is open to the longest fetches from the west, north-west and north, with the dominant wave direction generated from westerly directions. The incidence of long-period waves from the Atlantic (swell) within the Bay are considered to be sufficiently rare that they can be ignored.
- 2.2.9 Within the Estuary the waves are generated by local winds. The configuration of the narrow section of the Estuary limits the amount of wave energy travelling upstream and it is considered reasonable to assume that the wave energy within the Estuary upstream of Fiddler's Ferry is dominated by internally generated wind waves. Downstream of Fiddler's Ferry it is possible that some wave energy from outside the Estuary does penetrate into the Estuary.

Estuarine Morphology and Sediment Transport

- 2.2.10 Liverpool Bay consists of approximately 180 km² of intertidal sandbanks and shallow water channels (McDowell and O'Connor, 1977). Over the last few centuries significant coastal developments have taken place within Liverpool Bay, including channel training works and coastal defence structures. The historical charts reveal that prior to the completion of the training works in 1910 the morphology of Liverpool Bay was dynamic, and over the last 30 years the general form of the Bay has remained relatively unaltered, which would suggest that currently Liverpool Bay has found a new stable regime position.
- 2.2.11 The purpose of the training wall was to reduce the need for dredging, stabilise the position of Queens Channel and stop its northern migration. The training wall has led to a redistribution of sediment within the Bay, resulting in the accretion of sediment on the banks and channels situated away from the main trained section of the channel. This has reduced the overall need for dredging although dredging is still required to maintain the channel depth. The channels around Brazil Bank are still changeable and depths seaward of the end of Queen's Channel and in the Crosby Channel are changeable.
- 2.2.12 Sewage sludge dumping was carried out in the outer part of Liverpool Bay for around 100 years, but these operations were phased out in 1998. Around 1.5 to 2 million tonnes of sludge waste was deposited annually and provided a source of fine sediments into the Bay. These fines may still remain, in part, within the local sediment.

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- 2.2.13 There is predominately northward drift of surface water through Liverpool Bay towards the Solway Firth and a predominately eastward drift at the near-bed towards the North Wales and Lancashire coasts. These flows are dependant on various factors including the strength of the inflow from the Atlantic, the density distribution across the Bay and variability of the wind. The predominately westerly waves ensure that the drift is greater along the northern coast than on the eastern coast of Liverpool Bay. This leads to sand accumulation within the inner part of the Bay in areas such as Burbo Banks. These processes combine to produce a net eastward transport of silt and sand in the Irish Sea and in Liverpool Bay as a result of the combined action of wave stirring and tidal currents.
- 2.2.14 The Mersey Estuary is classified as a flood dominated system, i.e. there is a net movement of material into the Estuary on the flood tide. Sedimentation within the Estuary is considered to be seasonal due to changes in freshwater inputs and water temperature affecting the movement of sediment particles and the amount of time that sediment has to consolidate on the Estuary bed.
- 2.2.15 The Mersey Estuary has always been thought of as an accretion Estuary and up until very recently there has been significant accretion taking place within most sections. However, HR Wallingford (1999) and Thomas (2002) suggest that the Estuary may be entering a new state of morphological equilibrium with little overall change in tidal capacity of the Estuary. HR Wallingford (1999) also noted that although tidal capacity has stabilised, there is a substantial amount of sediment redistribution particularly around Ince and Stanlow Banks and Dungeon Bay. In these areas, post 1956 surveys indicate periods of significant erosion and accretion.
- 2.2.16 The two principal sources of sediment in the Mersey Estuary are marine sources from the glacial and fluvial glacial deposits covering large parts of the eastern Irish Sea seafloor (which are considered to be most significant) and fluvial sources from the freshwater rivers (approximately 1%).
- 2.2.17 The distribution of material within the Mersey Estuary can be divided generally into sands, silts and rock. Within the narrow part of the Estuary, the bed consists of a large area of rock, with a small amount of sand at the Estuary mouth. Further upstream much of the bed is made up of sand material with small patches of mud mainly dispersed along the shoreline intertidal region. The upper intertidal areas contain more mud than sand providing a gradual change in sediment through the intertidal profile.
- 2.2.18 The sub-tidal channels through the Estuary have meandered and altered location several times over the past 100 years. The construction of the training walls outside the Estuary mouth, the River Weaver diversion and the Runcorn Bridge piers early in the 20th century have fixed the channels in these areas. The channel through the main Estuary has not stabilised to the same extent and there is still a variation in the path, although the variation appears to have decreased in the past 30 years.
- 2.2.19 The low water channel movements are influenced by a combination of dredging activity in the Estuary and the magnitude and duration of river flows into the Estuary. The arisings from these dredging activities are now deposited within the Estuary whilst previously they

were deposited at sea or on land. The sediment is therefore available for redistribution within the Estuary, possibly settling back in the channels from which it was dredged.

2.3 Flood Risk and Coastal Protection

Flood Risk

- 2.3.1 A number of urban areas in the Mersey Estuary catchment are at risk of flooding. The predominant source of flooding in the lower River Mersey (upstream of the tidal extent of the Estuary) and the Mersey Estuary are from extreme tidal conditions and a combination of tidal and river (fluvial) flooding events. There is also the potential risk of flooding from high groundwater levels, which fluctuate with the tide, and groundwater flooding has been recorded in some locations around the Estuary.
- 2.3.2 A number of major watercourses discharge into the lower sections of the River Mersey and the Estuary either directly or via controlled hydraulic structures. High water levels induced by tidal conditions in the Mersey can cause direct flooding to these watercourses or indirect flooding due to the prevention of free drainage due to tide locking.
- 2.3.3 The areas that are currently at highest risk of flooding are parts of Warrington and the Wirral, although the risk at Wirral is a residual risk of overtopping due to defence failure. Parts of Stanlow, Frodsham and Runcorn are also at risk of flooding due to tide locking. Other identified sources of historic flooding include surface water flooding and flooding from fluvial sources in Warrington, wave and tidal overtopping along the coastal frontage (in Wirral), sewer flooding and isolated cases of reported groundwater flooding (reported in Strategic Flood Risk Assessments).
- 2.3.4 Groundwater levels in the Mersey Estuary area are rising following reduced levels of abstraction, so the risk of flooding from groundwater sources may be increasing. In particular groundwater is known to be rising in Liverpool city centre, under the tunnels below the Mersey and in the Halton area (reported in the Strategic Flood Risk Assessments for each area).
- 2.3.5 Climate change could affect future flood risk in the lower River Mersey and the Mersey Estuary in two ways. Sea level rise is likely to cause an increase in mean and peak tidal levels, and an increase in rainfall and its intensity is likely to increase the risk of flooding from rivers, surface water and groundwater.

Coastal Protection

- 2.3.6 The Environment Agency operates a flood warning system in the Mersey Estuary. There are a number of flood defence structures, including tidal gates and pumping stations in the Estuary. Man-made raised defences are mainly present on the River Mersey within Warrington. Coastal defences are present along the coastal frontage and the mouth of the Estuary.

- 2.3.7 The Flood Risk Management Strategy for Warrington has recommended new flood defences and structures in some locations along the River Mersey and tributaries. Elsewhere in the lower River Mersey and the Estuary the approach is mainly to maintain the existing flood defences and continue current flood risk management practices.
- 2.3.8 The North West England and North Wales Shoreline Management Plan (SMP2) was published by the Environment Agency in July 2010, and provides the proposed policies for the management of the shoreline. Most of the Estuary shoreline is fixed by defences and has a policy of 'Hold the Line', although some small sections are naturally eroding cliffs where a policy of 'No active intervention' is proposed. Managed realignment is proposed for some sections of the north and south banks of the Upper Estuary over the next 20 to 100 years.

2.4 Geo-environmental Conditions

Geology

- 2.4.1 The Mersey Estuary and surrounding areas are underlain by rocks belonging to the Sherwood Sandstone group. The depth of the bedrock surface varies greatly across the Estuary and surrounding area from 0 m (i.e. exposed at ground surface) to 60 to 70 m below ground level where deep glacial valleys exist. There is a deep valley running beneath a significant part of the Mersey Estuary.
- 2.4.2 The sandstone is overlain by glacial till (comprising clays, silts, sands and gravels) and estuarine deposits. The thickness of the glacial deposits varies and is more than 10 m thick in places. The deep and variable bedrock profile has been identified as a significant geotechnical factor that will influence the design of foundations.
- 2.4.3 Information on the geotechnical conditions throughout the Estuary has been gathered from available sources including the British Geological Society and previous studies of the Estuary.

Sediment Quality

- 2.4.4 The Estuary has historically been polluted from industrial activities, but water quality has improved in recent years following the implementation of legislation to control discharges. Mobile sediments are expected to have relatively low levels of contaminants as they will have been flushed out of the Estuary over time, but some of the deeper, more stable sediments laid down in the last 100 years are likely to contain some contamination.

2.5 Commercial and Recreational Navigation

- 2.5.1 The Mersey Estuary is a busy commercial waterway with around 8,500 commercial vessel calls each year. Of these approximately 1,800 continue up the Estuary as far as Eastham Locks (for the QE2 Dock or Manchester Ship Canal) or Garston. The remaining 6,700 vessels berth at other locations along the Estuary including Liverpool Docks, Birkenhead, the Liverpool Landing Stages including the River Cruise Terminal, Tranmere Oil Terminal and various river berths including Bromborough Wall (also known as Mersey Wharf) and Twelve Quays Roll-on-Roll-off Terminal.
- 2.5.2 A wide variety of vessel types and size enter the Estuary. The largest, VLCC (Very Large Crude Carrier) type oil tankers, and cruise ships, serve the Tranmere oil terminal and the Cruise Terminal respectively. Another important vessel flow is container vessels serving the Seaforth Container Terminal within Port of Liverpool, which is the premier container terminal serving the North of England.
- 2.5.3 The Port of Liverpool proposes to develop a second container terminal, with river berths adjacent to the Seaforth Dock. There are also plans to develop further cargo handing capacity on the Manchester Ship Canal.
- 2.5.4 A number of recreational sailing/yachting and angling clubs use the Mersey Estuary. Freedom of recreational navigation is currently enjoyed along the whole of the navigable Mersey with the exception of the immediate vicinity of dock entrances where exclusion zones apply. Small craft, ranging in size from dinghies to yachts, regularly use the full length of the Estuary and there are organised sailing events held in the area.

2.6 Nature Conservation Importance

- 2.6.1 The Conservation of Habitats and Species Regulations 2010 (commonly known as 'The Habitats Regulations') enact the requirements of the European Habitats and Birds Directives in England, Wales and Scotland. Parts of the Mersey Estuary and other nearby areas are protected under this legislation for their European nature conservation importance (see Figure 2.2).
- 2.6.2 Descriptions of the three closest designated European sites (Mersey Estuary SPA, Mersey Narrows and North Wirral Foreshore pSPA and Liverpool Bay SPA) are provided below. These sites are also Sites of Special Scientific Interest (SSSIs) and Ramsar (or proposed Ramsar) sites but for simplicity, they are referred to using the SPA reference throughout this report.

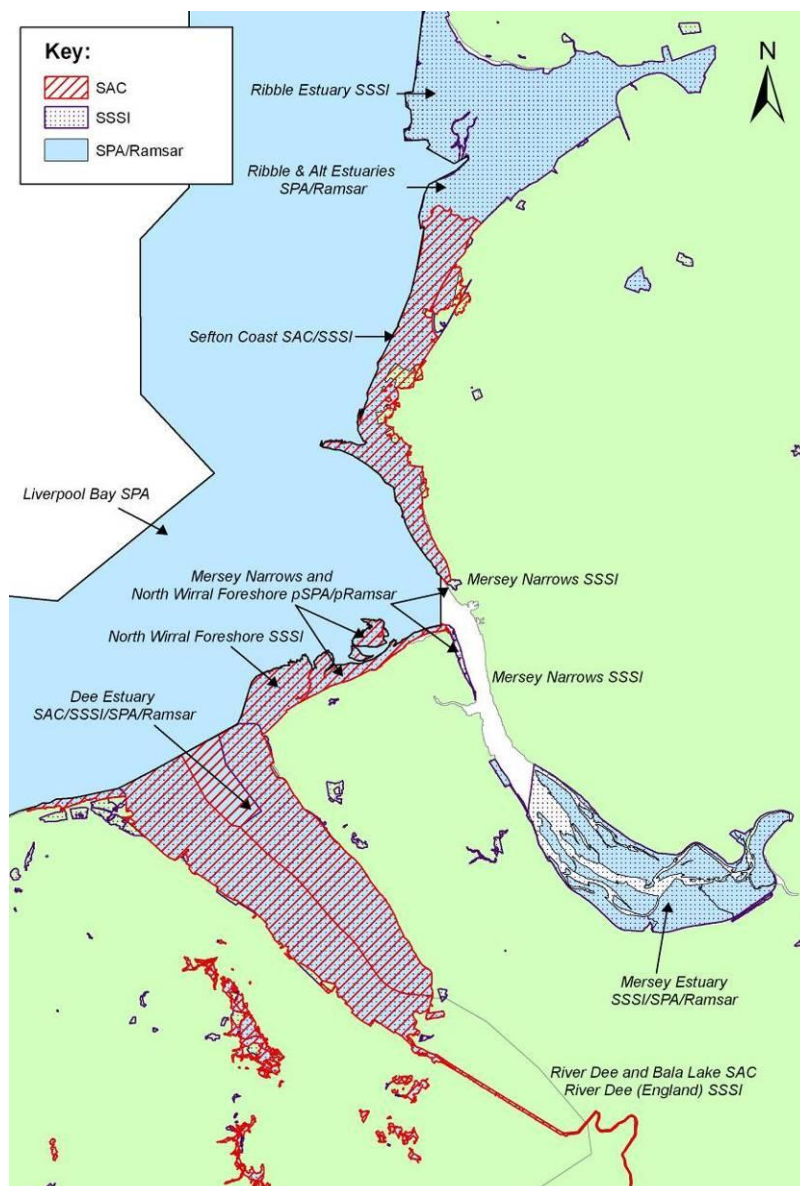


Figure 2.2: Internationally and nationally designated nature conservation sites
(Note Mersey Estuary SSSI/ SPA/ Ramsar includes New Ferry SSSI)

Mersey Estuary Special Protection Area

- 2.6.3 The Mersey Estuary Special Protection Area (SPA) encompasses the Mersey Estuary SSSI and New Ferry SSSI with an area of 5,033 ha. The SPA was originally designated in 1995, and extended to include New Ferry SSSI in 2004, for its internationally important over-wintering waterfowl assemblage (>20,000). The bird species listed on the SPA citation are passage and wintering populations of redshank and wintering populations of golden plover, shelduck, teal, pintail, dunlin and black-tailed godwit.
- 2.6.4 Bird populations have declined since the designation from a mean peak count of 105,000 individual waterfowl between 1993/94 and 1997/98 to 53,500 between 2004/05 and 2008/9

(Wetland Bird Survey (WeBS) data). Natural England has recently undertaken a condition assessment and found that some species are in unfavourable condition, based on significant declines in numbers. The reasons for these declines are unclear, but improving water quality in the Mersey Estuary and a national trend for wintering birds to stop at locations further north and east (closer to the Arctic) are likely contributors.

2.6.5 The intertidal sediments and salt marshes provide sources of food for birds, which roost in the saltmarsh and freshwater areas (English Nature, 2001). Intertidal sediments, saltmarsh and rocky shore habitats are identified as important 'sub-features' in the SPA citation.

2.6.6 Surveys of birds and intertidal habitats have been undertaken to inform the feasibility study to supplement data available from other sources such as the WeBS. Mean and peak counts for each SPA (passage and overwintering) bird species from November 2008 to September 2010 surveys within the Mersey Estuary SPA are shown in Figure 2.3 below. Wigeon numbers are not illustrated as the numbers counted were so low. It can be seen from Figure 2.3 that the recent survey data supports the conclusion that populations of some SPA bird species do not currently meet the SPA thresholds for designation.

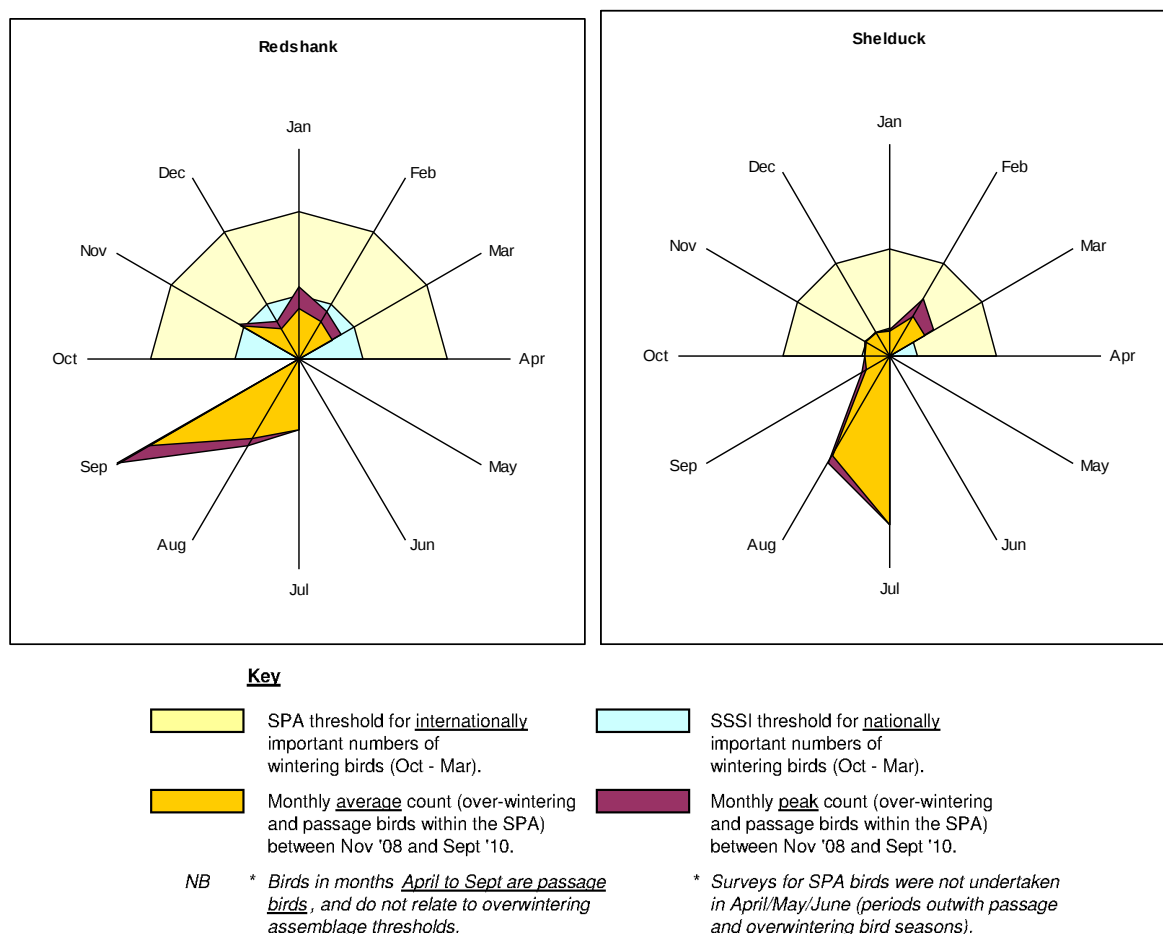


Figure 2.3: Counts of SPA bird species within Mersey Estuary SPA (November 2008-September 2010 surveys), relative to internationally and nationally important thresholds for wintering birds

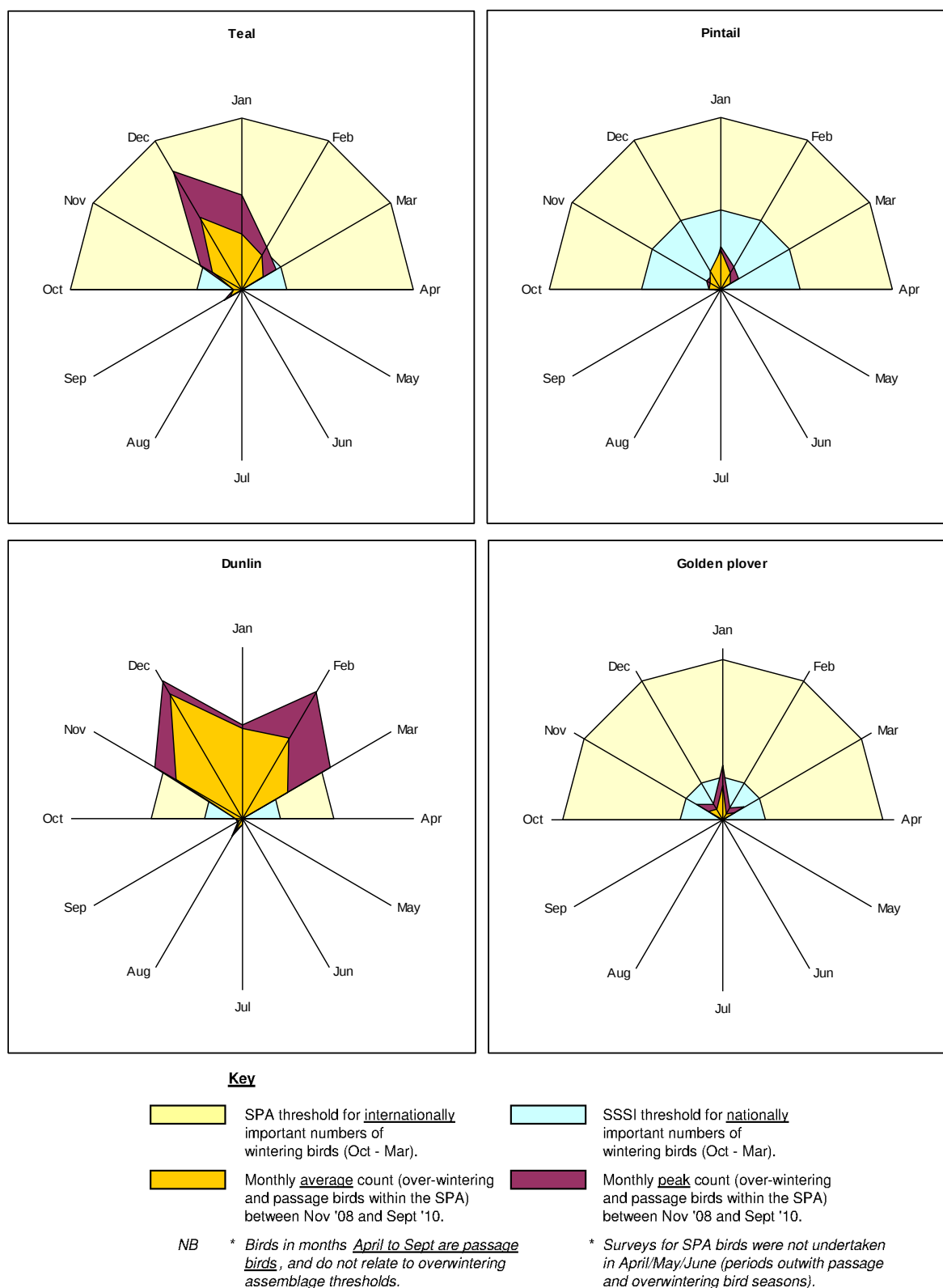


Figure 2.3 (cont.): Counts of SPA bird species within Mersey Estuary SPA (November 2008-September 2010 surveys), relative to internationally and nationally important thresholds for wintering birds

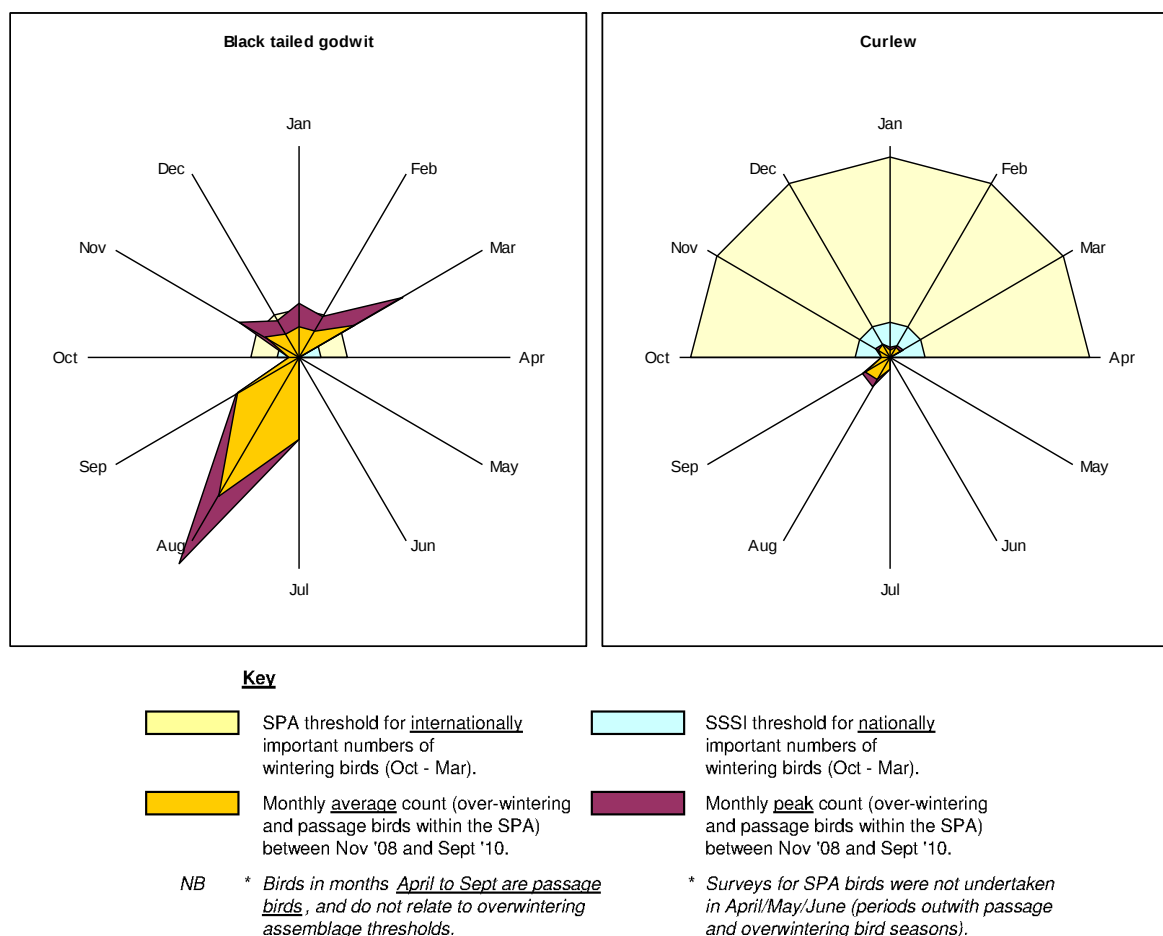


Figure 2.3 (cont.): Counts of SPA bird species within Mersey Estuary SPA (November 2008-September 2010 surveys), relative to internationally and nationally important thresholds for wintering birds

Mersey Narrows and North Wirral Foreshore proposed SPA

- 2.6.7 In addition to the Mersey Estuary SPA another SPA located partly within the Estuary has been proposed for designation. This incorporates the two SSSIs close to the mouth of the Mersey, the Mersey Narrows and North Wirral Foreshore. The total area of this pSPA is approximately 2,089 ha. This site qualifies under Article 4.2 of the Directive (79/409/EEC) by supporting populations of European importance of the migratory species common redshank and ruddy turnstone.

Liverpool Bay SPA

- 2.6.8 Liverpool Bay is a SPA, principally for its usage by water birds. Two water bird species have been identified in particular as their usage of the Bay represents more than 1% of the total Great Britain populations for these species (1% being the trigger level to qualify for SPA status under Annex 1 of the EC Birds Directive) – common scoter and red-throated diver. The Bay regularly supports more than 20,000 wildfowl during the non-breeding

season. The total area of the Liverpool Bay SPA is 197,504 ha. The SPA extends to the mean low water mark, with exceptions where it is adjacent to other estuarine SPAs.

Fish

- 2.6.9 Estuaries are important for juvenile fish as they provide relatively sheltered waters which are used as nursery areas. The mosaic of saltmarsh and mudflat habitats within the intertidal zone of the Mersey Estuary provide nursery and foraging areas for a diverse range of fish species including several species that are of commercial importance, a number of which are UK BAP species of national conservation importance (cod, herring, whiting, sole and plaice).
- 2.6.10 The Mersey Estuary also acts as a migratory corridor for a number of species, including salmon and river lamprey which are protected under Annex II of the EC Habitats Directive and European eel which are protected under a European eel management plan. European eel and sea trout, are designated UK Biodiversity Action Plan (BAP) species. Conservation organisations have aspirations for more salmon to return to the Mersey Estuary. Other legislation to protect migratory fish includes the Salmon and Freshwater Fisheries Act 1975 and the European Water Framework Directive. The main conservation requirement with regards to migratory fish is the maintenance of safe fish passage.

Marine Conservation Zones

- 2.6.11 The Marine and Coastal Access Act 2009 enables the designation of Marine Conservation Zones (MCZs), a network of protected marine areas. Natural England and the Joint Nature Conservancy Council (JNCC) have set up four regional projects covering the South West, Irish Sea, North Sea and Eastern Channel, to identify potential MCZ sites.
- 2.6.12 The Mersey Estuary is located within the Irish Sea project area. Two potential MCZ sites have been identified within Liverpool Bay (pMCZ 13 and 14) but none are proposed within the Estuary. The Government intends to designate MCZs by the end of 2012.

2.7 Water Quality

- 2.7.1 The industrial history of the Mersey Estuary area resulted in it becoming one of the most polluted rivers in Europe (Environment Agency, 2009), but improvements in land and water quality in the last 25 years mean the water quality of the Estuary is now greatly improved.
- 2.7.2 The Water Framework Directive came into force in 2000 and was enacted into UK legislation at the end of 2003. In accordance with this legislation, in December 2009 the Environment Agency published River Basin Management Plans for each river basin district setting out plans for protecting and improving the water environment. The Mersey catchment is included in the North West River Basin Management Plan (Environment Agency, 2009).

- 2.7.3 The Environment Agency monitors the water quality of relevant water bodies in accordance with the requirements of the Water Framework Directive. The status of water bodies is judged by a number of measures, including chemical water quality, biological water quality and geomorphology of the waterbody. The Mersey Estuary is currently classified as a heavily modified waterbody with moderate ecological status/potential under the Directive (Environment Agency, 2009). The Water Framework Directive requires all waterbodies to reach good status (or good potential in the case of heavily modified waterbodies) by 2015.

2.8 Access and Other Environmental Considerations

- 2.8.1 Information on other environmental aspects of the Mersey Estuary and surrounding areas has been gathered to inform the feasibility study including consideration of landscape character, visual receptors, terrestrial and estuarine heritage features, transport and accessibility, noise, vibration and air quality sensitive receptors and existing land uses. Key considerations identified relevant to a tidal power scheme include:

- the Liverpool Maritime Mercantile City World Heritage Site and its buffer zone;
- existing and proposed land uses either side of the Estuary, including residential areas and public spaces;
- access to the structure of any scheme and associated landside facilities, including emergency access;
- listed buildings, conservation areas and scheduled monuments;
- landscape character;
- road and rail transport links to the development site; and
- Liverpool Air Quality Management Area;

2.9 Local Social and Economic Considerations

- 2.9.1 Between 2000 and 2006, the European Union awarded structural funding to Merseyside which, at that time, was deemed to be one of the most deprived areas in Europe. Priority 3 of this "Objective One Programme" looked for ways to help businesses to grow, and the money was to be spent to help create new jobs. From 2000 to 2006, the £2.5 billion investment programme aimed at restructuring the local economy and restoring prosperity with the help of over £922 million of European Structural Funds alongside UK Government and private sector resources. The money was targeted at eight Strategic Investment Areas (SIAs) across Merseyside, five within or partly within Liverpool, as well as Wirral Waterfront, St Helens Regeneration Corridor and Huyton.
- 2.9.2 These areas have all seen large sums spent on infrastructure works and new buildings for offices, warehousing and industry. New jobs have been created, for example over 5,000 more people are working in the International Gateway SIA at the southern side of Liverpool. Development activity is continuing, with new offices and warehousing space completed in recent years, however there are still high levels of deprivation and pockets of high unemployment in the Merseyside area.

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- 2.9.3 Liverpool City Centre remains the hub of the Merseyside economy. High quality retail, leisure, office, residential and public realm schemes are dramatically transforming the city centre.
- 2.9.4 Despite a prolonged period of economic and employment growth nationally, employment in Wirral has actually fallen in recent years. Between 1998 and 2005 the total number of employee jobs in Wirral fell by some 6,600 which contrasts sharply with strong economic growth across Greater Merseyside in the same period.
- 2.9.5 The tourism sector in the North West has grown in recent years and has prospered from hosting the European Capital of Culture in 2008. According to trend data captured by North West Tourism, the visitor volume and value has demonstrated an upward trend between 2003 and 2007, when tourism spend equated to some £14.3 billion, although the recession has resulted in recent data showing a reduction in visitor volume since 2008. A study of the economic impact of tourism in the North West (NWDA, 2008) concluded that the revenue generated by tourism activity in the North West supported 6.0% (172,110) of the total full time equivalent (FTE) workforce across the region. The Mersey Estuary is itself used as a leisure facility, for activities such as sailing, yachting and angling although its full potential as a tourism asset is yet to be realised.

3 Policy Context

3.1 Introduction

- 3.1.1 This chapter sets out the relevant policy, guidance and legislation against which options have been considered, including European and UK legislation, and national, regional¹, sub-regional and local policy and guidance.

3.2 European Legislation

Renewable Energy Directive 2009

- 3.2.1 The EU Governments have agreed the following legally binding targets by signing up to the Renewable Energy Directive 2009 (2009/28/EC):
- a 20% cut in emissions of greenhouse gases by 2020, compared with 1990 levels;
 - a 20% increase in the use of renewable energy by 2020; and
 - a 20% cut in energy consumption through improved energy efficiency by 2020.
- 3.2.2 The renewable energy targets differ between member states in some cases. The UK's target is 15% by 2020, which is equivalent to a seven-fold increase in UK renewable energy consumption from 2008 levels.
- 3.2.3 The EU strategy is captured in '*Leading global action to 2020 and beyond.*' (2007) This document recognises the benefits to the EU of early action in order to achieve an energy efficient and low carbon economy. Under the Directive, each Member State was required to submit a National Renewable Energy Action Plan. The UK plan was updated in 2010 when the Coalition Government came into power (refer to paragraph 3.4.3 below).

Habitats Directive 1992

- 3.2.4 The Habitats Directive 1992 (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) is one of two EU Directives relating to wildlife and nature conservation, the other being the Birds Directive.
- 3.2.5 Its aim is to protect a range of listed species and habitats considered to be of European interest and, by that means, to contribute towards ensuring biodiversity. It requires Member States to take measures to maintain or restore at a favourable conservation status, natural habitats and species of European Community interest. In undertaking these measures Member States are advised to take account of economic, social and cultural requirements and regional and local characteristics.

¹ Until such time as they are formally revoked via the Localism Bill, Regional Spatial Strategies remain part of the Statutory Development Plan; however, a High Court ruling on 7 February 2011 confirms that the intended revocation is a 'material consideration' which can be taken into account by Local Planning Authorities and Planning Inspectors in decision making.

- 3.2.6 The Directive establishes a network of Special Areas of Conservation (SACs) composed of those sites those natural habitats and species of European Community interest. Together with Special Protection Areas (SPAs) which have equivalent protection, the SACs form a network of protected sites across the European Union, collectively known as Natura 2000.
- 3.2.7 Paragraph 3.3.14 below explains how the UK law has transposed this EC Directive via the Conservation of Habitats and Species Regulations 2010.

European Water Framework Directive 2000

- 3.2.8 The European Water Framework Directive 2000 established a Community-wide framework for water protection and management. It requires Member States to identify and analyse European waters on the basis of individual river basins and districts and to adopt management plans and a programme of measures for the protection and management of each body of water.
- 3.2.9 This Directive has a number of objectives aimed at preventing and reducing pollution, promoting sustainable water usage, environmental protection, improving aquatic ecosystems and mitigating the effects of floods and droughts. Its ultimate objective is to achieve good ecological and chemical status, as defined by the Directive, for all relevant Community waters, including estuaries, coastal waters and groundwater, by 2015.

3.3 UK Legislation

- 3.3.1 Legislation that is in force is summarised below, followed by proposed legislation (the Energy Bill and the Localism Bill).

Planning Act 2008

- 3.3.2 Part of the Planning Act 2008 is concerned with new procedures for handling applications for Nationally Significant Infrastructure Projects (NSIPs) for energy, transport, water and waste.
- 3.3.3 Broadly, there are three tasks identified in the Act which have been undertaken to set up the new regime:
- establishing an independent body, the Infrastructure Planning Commission (IPC), to take decisions on planning applications for NSIPs;
 - setting out the detailed procedures and processes of the new regime in Statutory Instruments and guidance; and
 - the preparation of National Policy Statements (NPSs), which set out the national need for particular types of infrastructure and provide the principal basis for the IPC's decision making.

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- 3.3.4 The Planning Act imposes a requirement on promoters of NSIPs to consult key stakeholders, affected parties and local communities prior to submitting an application, and sets out a new process for examining applications for NSIPs.
- 3.3.5 The Planning Act was introduced under the previous Government and the Coalition Government elected in 2010 has confirmed that, whilst the NPSs will be retained, the IPC will be abolished and its decision-making powers replaced by a democratically-accountable system. That change is to be made by the Localism Bill (see paragraph 3.3.18 below).
- 3.3.6 It remains possible to promote projects via a Private Bill in certain circumstances. Such Bills can be promoted by organisations seeking powers beyond or in conflict with the general law. Private Bills only change the law as it applies to specific individuals or organisations, rather than the general public. They have a track record of being used for authorising major construction projects. Private Bills can start in either House and are progressed largely via the same procedures as a Public Bill. The intended Bill must be publicised and affected parties have the right to petition Parliament against the proposed bill and present their objections to the Commons or Lords Committees. Private Bills are particularly applicable in the case of projects requiring statutory powers that the Planning Act 2008 cannot provide.

Climate Change Act 2008

- 3.3.7 The Climate Change Act 2008 establishes powers necessary to introduce measures that will achieve a range of greenhouse gas reduction targets and enable the UK to make the transition to a Low Carbon Economy.
- 3.3.8 The Climate Change Act made Britain the first country in the world to set legally binding 'carbon budgets', aiming to cut UK carbon emissions by 34% on 1990 levels by 2020 and at least 80% by 2050 (compared to 1990 levels). This is to be achieved through investment in energy efficiency and clean energy technologies such as renewables, nuclear and carbon capture and storage.

Energy Act 2008

- 3.3.9 The Energy Act 2008 implements the legislative aspects of the Energy White Paper 2007: '*Meeting the energy challenge*' and aims to ensure that both businesses and consumers can play a part in helping to achieve a low carbon energy mix. The Act supports the development of emerging renewable technologies and the seven-fold increase in renewables required to meet the ambitious but legally binding targets for 2020.

Energy Act 2010

- 3.3.10 The Energy Act 2010 implements some of the measures required to deliver Department of Energy and Climate Change's (DECC) low carbon agenda. It includes provisions on delivering a new financial incentive for carbon capture and storage, implementing mandatory social price support, and introducing a package of measures aimed at ensuring

that the energy markets are working fairly for consumers and delivering secure and sustainable energy supplies.

Marine and Coastal Access Act 2009

- 3.3.11 The Marine and Coastal Access Act 2009 aims to ensure clean, healthy, safe, productive and biologically diverse oceans and seas, by putting in place better systems for delivering sustainable development of the marine and coastal environment. The Act provides for the creation of the Marine Management Organisation (MMO) which is responsible for implementing new marine planning and licensing systems, which aim to provide a simpler, more efficient consenting regime for a range of marine projects, including wave and tidal schemes. The MMO will be a statutory consultee for NSIPs affecting the marine environment.
- 3.3.12 A new right of access to the English coast is also established. This will enable the creation of a continuous signed and managed route around the coast. Landowners will be consulted as part of the process of determining the best route.
- 3.3.13 The Act will also introduce a number of Marine Conservation Zones to assist with protection of marine biodiversity, putting in place a network of well-managed marine protected areas. Varying levels of protection will be given to sites, from restricting certain activities, to allowing no damaging activities at all. Stakeholders will be consulted as to how much of the network requires the highest level of protection and regional projects have been established to identify initial recommendations for sites, which are due in June 2011.

Conservation of Habitats and Species Regulations 2010

- 3.3.14 The Conservation of Habitats and Species Regulations 2010 transpose European Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (EC Habitats Directive) into UK national law. The 2010 Regulations consolidate all amendments made to the previous Conservation (Natural Habitats, &c.) Regulations 1994. The Regulations provide for the designation and protection of 'European sites', the protection of 'European protected species', and the adaptation of planning and other controls for the protection of European sites.

Proposed UK Legislation

Energy Bill 2010-2011

- 3.3.15 Part of the Energy Bill 2010-2011 is designed to make improvements to the UK's framework for securing and enabling low carbon energy supplies and fair competition in the energy markets.
- 3.3.16 The Bill is currently being considered in Parliament, and its Second Reading is expected to be held after the Easter recess 2011.

- 3.3.17 The Energy Bill is intended to enact legislation that will deliver the commitments of the Coalition Government in relation to energy and climate change, as set out in their Programme for Government. It is the first step in the legislative programme. Further legislation will be sought in order to implement the findings of the Electricity Market Reform Programme (see paragraph 3.3.21 below) and other initiatives.

Localism Bill 2010-2011

- 3.3.18 The Localism Bill was presented to Parliament on 13 December 2010. The Bill had its Second Reading debate on 17 January 2011 and was committed to a Public Bill Committee. The Committee last considered the Bill on 10 March 2011. The next stage is a Report to the House of Commons; at the time of writing this date has not been announced.
- 3.3.19 The Bill will devolve greater powers to Local Authorities in England and Wales and neighbourhoods and provide local communities with greater control over housing and planning decisions. The Bill will abolish the IPC and replace it with a Major Infrastructure Planning Unit (MIPU) which will form part of the Planning Inspectorate. It will return decision making on applications for NSIPs to the Secretary of State. The Bill also requires the Parliamentary scrutiny of NPSs.

Electricity Market Reform Programme 2011

- 3.3.20 DECC recently carried out consultation on the Government's preferred electricity market framework. The new framework is intended to reform the electricity market to allow equal access for a wider range of technologies, such as low carbon technologies (including tidal) and technology to reduce or manage demand, thereby enabling the cost effective delivery of secure supplies of low carbon energy.
- 3.3.21 The Electricity Market Reform Consultation responses will feed into the evidence base for a White Paper, which is due to be published in late Spring 2011, and will set out the legislative proposals to implement the new electricity market arrangements.

3.4 National Policy

- 3.4.1 At the national level, there is an existing wide evidence base and body of policy support for renewable energy projects.

National Infrastructure Plan (2010)

- 3.4.2 The Government published the UK's first National Infrastructure Plan (NIP) in October 2010. This document sets out a broad vision of the transformation of the UK's energy and transport systems to deliver a low-carbon economy. As part of the foundations of establishing a low-carbon economy, the NIP outlines the opportunity for the UK to achieve a supply of secure, affordable, low-carbon energy with a long-term reduction in the UK's dependence on imported hydrocarbons.

National Renewable Energy Action Plan (2010)

3.4.3 In accordance with the requirements of European Renewable Energy Directive, the Government submitted the National Renewable Energy Action Plan (NREAP) (DECC, 2010a, which sets out a 'lead scenario' for achieving 15% of energy consumption in 2020 to be derived from renewable sources. The 'lead scenario' demonstrates that it is possible to achieve the 15% requirement, however, it does not provide a target for any particular sector and nor is it an upper limit to the UK's ambition for renewable energy production.

3.4.4 The NREAP confirms that marine energy is a priority for development in the UK, noting that the UK is a natural place from which to develop marine energy due to our uniquely rich wave and tidal resource. It establishes that development and commercialisation of the wave and tidal power industry will be encouraged over the next decade, with the aim of developing a new world-leading UK-based energy sector. The estimation set out in the NREAP indicates that wave and tidal power will begin to contribute towards the 2020 renewable energy target in 2016.

The UK Renewable Energy Strategy (2009)

3.4.5 This document (DECC, 2009a) sets out the Government's strategy towards achieving the binding EU requirement of 15% of energy from renewables by 2020. It establishes a number of measurable targets:

- more than 30% of the UK's electricity could be generated from renewables;
- 12% of the UK's heat could be generated from renewable sources; and
- reduction of the UK's carbon dioxide emissions by over 750 million tonnes between 2009 and 2030.

3.4.6 The strategy recognises that tidal power can make a valuable contribution to achieving these targets.

The UK Low Carbon Transition Plan (2009)

3.4.7 This White Paper (DECC, 2009b) sets out the plan to 2020 for transforming the power sector, homes and workplaces, transport, farming and the way land and waste is managed.

Draft National Policy Statements – Energy

3.4.8 National Policy Statements (NPSs) are intended to be a primary consideration in decision-making on major infrastructure projects, whether that be via the IPC, the MIPU/ ministers or any other alternative mechanism.

3.4.9 The Coalition Government published and consulted on minor revisions to the draft energy NPSs between October 2010 and January 2011. The minor changes were mostly in relation to removal of repetition, an update to the section on the need for new energy

infrastructure and changes to Appraisals of Sustainability, including the reappraisal of the effects of the policies and the reconsideration of policy alternatives for each NPS.

- 3.4.10 The Government had previously committed to present the energy NPSs to Parliament for approval in spring 2011 and to designate them by summer 2011. The BIS report, 'Plan for Growth' states that: "Given recent events in Japan, Government considers it prudent to consider energy statements in light of these events, but will make an announcement about its timetable as soon as the situation has been clarified."

NPS EN-1 – Overarching Energy

- 3.4.11 The overarching draft *National Policy Statement EN-1*, recognises the important contribution that tidal power can play in meeting UK's carbon reduction mandate and addressing climate change.
- 3.4.12 Paragraph 3.3.10 of EN-1 states that as part of the UK's need to diversify and decarbonise electricity generation, the Government is committed to dramatically increasing the amount of renewable generation (see Section 3.4 of EN-1). It also sets out that: in the short to medium term, much of this new capacity is likely to be onshore and offshore wind, but increasingly it may include the generation of electricity from wave and tidal power.²
- 3.4.13 Paragraph 3.4.3 of EN-1 states that the UK has significant potential for wave and tidal energy. It also comments that, whilst many technologies for making use of the wave resource and tidal current are still at the prototype or demonstration stage, proven technology exists for tidal range generation.

NPS EN-3 – Renewables

- 3.4.14 Draft NPS EN-3 should be read in conjunction with EN-1 and relates to Renewable Energy Infrastructure. Paragraph 1.4.1 states that together these NPSs form the primary decision-making policy document for the IPC on nationally significant onshore and offshore renewable energy infrastructure projects in England and Wales.
- 3.4.15 However, EN-3 does not currently cover wave or tidal technology. It does state, at paragraph 1.7.2 that it is expected that tidal range schemes may be the subject of applications to the IPC within the near future. As a result, Government is "*considering the need for either a revision to this NPS or a separate NPS to provide the primary basis for decision-making*". At the time of writing, there are no further details available as to a timetable for this process.
- 3.4.16 The Planning Act 2008 states that, where no relevant NPS has been designated, the IPC must make a recommendation to the Secretary of State, who will determine the application (see sections 74 and 83 of the Planning Act). In developing its recommendation, the Council or Panel will have regard to relevant national policy, including any relevant draft NPS, and will make a judgment as to how that policy should be weighted. The Secretary of State should also take into account any matters which are important or relevant to the

² DECC, Draft National Policy Statement EN-1, paragraph 3.3.10, p.19

decision³; this could include the current regional and local policy. In any event, the provisions of the Localism Bill suggest that the Secretary of State would be the decision maker on any NSIP.

Offshore Energy Strategic Environmental Assessment

- 3.4.17 Further to the 2007 Energy White Paper, DECC is conducting a Strategic Environmental Assessment (SEA) of their 'draft plan/programme', the aim of which is to enable future renewable leasing for offshore wind, wave and tidal devices and licensing/leasing for seaward oil and gas rounds, hydrocarbon and carbon dioxide gas storage.
- 3.4.18 Offshore Energy SEA 2 (OESEA2) updates the scope of the previous OESEA (issued in January 2009), to consider the environmental implications of licensing/leasing within the UK Renewable Energy Zone and the territorial waters of England and Wales for wave, tidal stream and tidal range energy. A draft of the resulting Environmental Report has been published and DECC is currently conducting consultation as part of OESEA2.
- 3.4.19 The draft Environmental Report sets out the main activities associated with the development of facilities for wave, tidal stream and tidal range energy production and assesses the likely impact of these activities on a range of receptors. It recommends that site specific assessments should be undertaken before decisions can be taken on potential leasing, and the desirability and acceptability of individual tidal range projects.
- 3.4.20 Whilst the draft plan/programme recognises the majority of energy related activities in the UK marine environment, it does not set target generation capacities for wave, tidal stream or tidal range energy.

Marine Energy Action Plan 2010

- 3.4.21 The Marine Energy Action Plan (MEAP) stresses the important role that tidal power can play in carbon reduction, energy security and job creation / economic growth. The foreword by Lord Hunt states that: *"Our seas present a fantastic and as yet, largely untapped asset that can generate clean energy that will boost our transition to a low carbon economy. Wave and tidal energy technologies will not only make a valuable contribution to meeting our long term carbon reduction targets but increase the security of our energy supply and create jobs and export opportunities."* (DECC, 2010b).
- 3.4.22 The document makes a series of recommendations for delivering the opportunities – for example, supporting the development of technology, providing an appropriate consenting regime, targeted funding and capitalising on opportunities for marine energy by learning from, and building on, synergies related to the skills and supply chain for offshore wind.

³ Section 105 Planning Act 2008

Marine Policy Statement

- 3.4.23 Led by the Department for Food, Environment and Rural Affairs (DEFRA) and the MMO, the first stage of the new system of marine planning is the development of the Marine Policy Statement (MPS), which was adopted on 21 March 2011.
- 3.4.24 The MPS recognises the contribution that tidal power can make to meeting energy security, affordable energy and low carbon energy supplies in the medium to long-term. It recognises the fact that the potential sites identified for offshore renewables show the huge exploitable renewable energy resource in UK waters, which would keep the UK as a global leader in renewable energy production from these technologies. The potential impact of inward investment in wave and tidal energy related manufacturing and deployment activity, as well as the impact of associated employment opportunities on the regeneration of national and local economies, is identified as an important issue for consideration in the determination of applications and the development of Marine Plans.

Turning the Tide – Tidal Power in the UK (2007)

- 3.4.25 The Sustainable Development Commission's study: 'Turning the Tide – Tidal Power in the UK' (2007) identifies that the top UK tidal range sites, in terms of generation of tidal power, are concentrated in the estuaries off the west coast of Britain, including the Severn, the Mersey, the Duddon, the Wyre and the Conwy. The report states that the UK has the potential to generate large amounts of clean and secure electricity from both types of tidal resource – tidal stream and tidal range – at least 10% of the UK's electricity, if fully exploited.

National Planning Policy

- 3.4.26 A summary of national planning policy is provided in Table 3.1.

Table 3.1: Summary of national planning policy

PPS1 Delivering Sustainable Development (2005)
The guiding principles for achieving integrated, sustainable development in the country are set out in PPS1. <i>“Regional planning bodies and local planning authorities should ensure that development plans contribute to global sustainability by addressing the causes and potential impacts of climate change – through policies which reduce energy use, reduce emissions, promote the development of renewable energy resources, and take climate change impacts into account in the location and design of development.”</i>
PPS1 Supplement – Planning and Climate Change (2007)
Sets out how spatial planning should contribute to reducing emissions and stabilising climate change through new development. It places clear responsibility on Local Planning Authorities to plan positively for renewable energy.

PPS9 – Biodiversity and Geological Conservation (2005)
Expresses the broad aim that planning, construction, development and regeneration should have minimal impacts on biodiversity and enhance it wherever possible. It sets out to maintain and enhance, and restore or add to, biodiversity and geological conservation interest. Detrimental impacts should be avoided, but where harm is inevitable appropriate mitigation measures should be implemented. Development should avoid having an adverse effect on important ecological designations such as SSSIs, and should be prevented unless the benefits associated with the proposed development clearly outweigh the harm.
PPS25 – Development and Flood Risk (March 2010)
Aims to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas of highest risk.
PPS25 Supplement – Development and Coastal Change (March 2010)
Sets out a planning framework for the continuing economic and social viability of coastal communities. The policy aims to strike the right balance between economic prosperity and reducing the consequences of coastal change on communities.
PPS22 – Renewable Energy (2004)
Recognises that the increased development of renewable energy resources is vital to facilitating the delivery of the Government's commitments on climate change and renewable energy. It encourages the appropriate development of further renewable energy schemes throughout England and establishes a positive policy framework against which to appraise proposals for renewable energy projects. The PPS states that the wider environmental and economic benefits of all proposals for renewable energy projects, whatever their scale, are material considerations that should be given significant weight in determining whether proposals should be granted planning permission. The Companion Guide to PPS22 elaborates in stating that the benefits of renewable energy projects can extend beyond contributing to a reduction in carbon emissions.

National Planning Policy Framework

- 3.4.27 The Coalition Government intends to publish a NPPF which will integrate – into one document – the principal features of all national planning policies. Consultation inviting suggestions for the general policy areas which should be included in the NPPF recently closed; no details relating to further consultation have been confirmed. It is anticipated that the NPPF will be published in April 2012.
- 3.4.28 Recent CLG guidance confirms that, although the NPSs are part of the overall framework of planning policy, the planning system for major infrastructure is separate from the Government's localism reforms and the NPSs will be the decision-making framework by which nationally significant infrastructure projects will be determined⁴.

⁴ Major Infrastructure Planning Reform – Work Plan (CLG, 2010)

Plan for Growth 2011

- 3.4.29 On 23 March 2011, Greg Clark (Minister for Decentralisation) made a Written Parliamentary Statement setting out proposed reforms to the Planning System to support sustainable economic growth and jobs. The Statement was in response to the Chancellor of the Exchequer's call for action on growth and is capable of becoming a material consideration in local planning decisions with immediate effect.
- 3.4.30 In tandem with the Ministerial Statement, the Department for Business Innovation and Skills (BIS) published a document setting out the Government's intended 'Plan for Growth.' The document states that one of the current constraints to sustainable economic growth and job creation is the current planning system, described as "*overly bureaucratic, costly for business, and unresponsive to demand.*" The document goes on to outline a series of actions that make up the Government's collective approach to driving sustainable economic growth through national planning policy in particular.
- 3.4.31 The key actions, set out in the ministerial statement and BIS document can be summarised as set out below:
- The introduction of a powerful presumption in favour of sustainable development, so that the default answer to development is 'yes'.
 - Preparation of a more focused and inherently pro-growth National Planning Policy Framework (NPPF) to deliver more development in suitable and viable locations. The intention is for this document to combine all national planning policies into one concise, easy to use document which embodies the pro-growth principles set out in the Ministerial Statement.
 - The Government is committed to fast-tracking the planning process for major infrastructure applications through the Major Infrastructure Planning System and has pledged to determine major infrastructure applications within 12 months from the start of inquiry to decision. That performance will be overseen by a group of Ministers. This is in recognition that securing new investment in infrastructure will be an essential element in delivering sustainable economic growth over the coming decades.

3.5 Regional Policy and Guidance

- 3.5.1 Adopted Regional Policy for the North West complements and supports UK Legislation and national policy.
- 3.5.2 The Coalition has abolished the regional tier of governance and will soon revoke regional policy, in order to devolve policy making and control to the lowest level under the Localism agenda. The evidence base gathered during the preparation of Regional Spatial Strategies (RSS) will still be available and is still considered valid.
- 3.5.3 Until their formal abolition, Regional Strategies remain part of the statutory development plan. However, a High Court ruling on 7 February 2011 confirms that the intended

abolition of Regional Strategies is to be a 'material consideration' in decision making by local planning authorities and planning inspectors. It follows that it applies equally to other decision makers.

North West Regional Spatial Strategy (2008)

- 3.5.4 The North West RSS was published by the Secretary of State for Communities and Local Government in September 2008. It sets out the vision and policies for the North West region for the plan period of 2008 to 2021 and currently forms part of the statutory Development Plan for Local Authorities in the North West region.
- 3.5.5 The North West RSS (2008) is a strong supporter of renewable energy. It recognises that the production, security of supply and efficient use of energy is essential to the 21st Century society. As a policy document it supports the strategic objectives of national policy and the Northwest Sustainable Energy Strategy (2006a).
- 3.5.6 Policy EM 17 Renewable Energy states that at least 20% of the Region's electricity supply will be provided by renewable energy by 2020. Key messages from this policy are:

"Plans and strategies should seek to promote and encourage, rather than restrict, the use of renewable energy resources. Local planning authorities should give significant weight to the wider environmental, community and economic benefits of proposals for renewable energy schemes..."

"Opportunities should be sought to identify proposals and schemes for renewable energy."

"Local authorities should work with stakeholders in the preparation of the sub regional studies of renewable energy resources so as to gain a thorough understanding of the supplies available and network improvements, and how they can best be used to meet national, regional and local targets."

North West Regional Strategy 2010 (RS2010)

- 3.5.7 RS2010 was intended to replace the North West RSS and the Regional Economic Strategy with the intention to become the statutory document setting out the blueprint for sustainable economic growth, development and the use of land within the North West of England. In light of the Coalition Government's changes a decision was taken to use the evidence base assembled for the RS2010 to produce a succinct and streamlined non-statutory, high level framework/plan for the North West.
- 3.5.8 The resulting document, *Future North West: Our Shared Priorities*, was published in August 2010. *Future North West* specifically identifies the Power from the Mersey initiative as an opportunity to exploit low carbon economic opportunities, which will enable the realisation of Liverpool's potential as a world-class cultural city and a major driver of economic growth (NWDA, 2010a).

North West Regional Economic Strategy (2006)

- 3.5.9 The vision of the NW RES (NWDA, 2006b) is *“A dynamic, sustainable international economy which competes on the basis of knowledge, advanced technology and an excellent quality of life for all...”*
- 3.5.10 The NW RES recognises the positive contribution that renewable energy production can make in reducing climate change and energy use.

North West Sustainable Energy Strategy (2006)

- 3.5.11 The North West Sustainable Energy Strategy (NWDA, 2006) sets out a strategy for addressing the energy challenge that faces the Region.
- 3.5.12 The strategy prioritises and encourages sustainable energy practices that can be driven forward by intervention at regional and local levels, including *“deploying renewable energy”* sufficient to generate capacity to provide 20% of the region’s final demand by 2020.
- 3.5.13 The strategy recognises that the North West is seen as having significant potential both in terms of *“accessing the massive wave and tidal energy resource, and in developing a significant industry.”*

North West Climate Change Action Plan 2010 – 2012 (2010)

- 3.5.14 ‘Rising to the Challenge – A Climate Change Action Plan for England’s North West’ was first published by NWDA in 2006 and updated in 2010 (NWDA, 2010b). It will be regularly monitored to assess progress on the actions; it is also intended that the Action Plan will be reviewed every three years, for example to take into account changes in policy at national and other levels. The Plan identifies the need for innovation and acceleration of activity within all sectors of the economy in order to meet the challenge of meeting a carbon reduction of 80% in the region by 2050, and in particular supports renewable energy proposals, including tidal energy.
- 3.5.15 The Plan acknowledges that Liverpool City Region is *“seeking to become the first to deploy tidal energy.”*

3.6 Sub-Regional Policy

Atlantic Gateway Framework (2010)

- 3.6.1 The Atlantic Gateway is a non-statutory framework for collaboration between Manchester and Liverpool City Regions, including the wider shared hinterland across Warrington, Halton, Chester and northern Cheshire, which has been driven by public sector leaders. The primary objective is to support and accelerate their growth strategies and unlock the full sustainable economic growth potential by focusing on improving global transport, supporting the growth of key sectors, developing infrastructure and creating environments

to attract talent. The Framework seeks to complement and support the delivery of the individual growth plans of the two City Regions, which for Liverpool is the Multi-Area Agreement explained immediately below.

- 3.6.2 The Framework identifies a number of immediate priorities for action where there is Gateway-wide support and an opportunity to show the potential of the region. The Mersey Tidal Power Scheme is identified as one of these priorities. One of the Framework's key themes is Sustainable Infrastructure which identifies the need to provide appropriate levels of investment in renewable and low carbon energy generation facilities in order to meet the increased demand for energy as a result of the economic growth proposed.

Liverpool City Region Multi-Area Agreement

- 3.6.3 At the sub-regional level, Liverpool City Region Multi-Area Agreement states that the Liverpool City Region aims to become energy self-sufficient and a net energy exporter by the year 2030, through a combination of greater energy efficiency and renewable energy supply.
- 3.6.4 It is also targeted that the Liverpool City Region will become the biggest low carbon goods and services city-region economy in UK, increasing the number of people directly employed in the environmental technologies sector from 9,000 to 15,000 by 2015.
- 3.6.5 The potential contribution of the Mersey Estuary is specifically recognised as follows:

"Mersey Estuary has one of the largest tidal ranges in the UK and is considered one of the best locations for tidal energy. It has a critical role to play in enabling LCR [Liverpool City Region] to meet this target."

3.7 Local Policy

- 3.7.1 The Mersey Estuary is bordered by a number of local authorities. Each Local Authority has an emerging Local Development Framework and is progressing preparation of a Core Strategy. Those documents are at different stages of production as identified in Table 3.2.

Table 3.2: Status of Mersey Estuary Local Authorities' Local Development Framework documents

Local authority	Issues and Options	Spatial Options ⁵	Preferred Options	Refining Options	Final Core Strategy
Liverpool	Complete		Complete		Mid 2012
Wirral	Complete	Complete	Not yet known		Early 2012
Halton	Complete		Complete		Early 2012
Sefton			Autumn 2010		Not yet known
Cheshire West & Chester	Complete		Not yet known		December 2013
Knowsley	Complete		Not yet known		Late 2012
Warrington	Complete	Objectives & Options stage runs till 13 August 2010.	Not yet known		Early 2012

3.7.2 Prior to adoption of the Core Strategies, the adopted Development Plan for each Local Authority is currently made up of the Regional Spatial Strategy (as above) and saved Unitary Development Plan policies. Substantially progressed Core Strategies, even prior to adoption, can be treated as a material consideration in decision making by Local Planning Authorities.

3.7.3 The remainder of this sub-section focuses on the Liverpool and Wirral UDPs and provides the relevant emerging Core Strategy policies for each Local Authority.

Existing Unitary Development Plan (UDP) (Saved Policies)

3.7.4 In each of the Merseyside Authorities' adopted local plans, there is support for the development of standalone renewable energy projects subject to impacts on – typically – neighbouring uses, the local environment and residential amenity.

Liverpool UDP

3.7.5 The Liverpool UDP supports renewable projects provided no detrimental impact on neighbouring uses, environmentally sensitive areas and accordance with other policies. The relevant policies are listed in Table 3.3.

Table 3.3: Relevant Liverpool UDP policies

EP16 Renewable Energy - states that the City Council will support the development of renewable energy projects provided that there will be no detrimental impact on neighbouring uses, environmentally-sensitive areas, and that the proposal is in accordance with other policies of the UDP.
OE3 Green Wedges - new development should not reduce the open character of the area or physical separation with existing built up areas.
OE4 The Mersey Coastal Zone – the Council will only grant Planning Permission for proposals within the Undeveloped Coastal Zone if they require a coastal location, unless the proposals are clearly related to the recreational use of the zone and will not adversely affect the coast or the development cannot realistically be located elsewhere in the City by its nature.
OE5 Protection of Nature Conservation Sites and Features - development will not be permitted that would destroy, fragment or adversely affect – directly or indirectly – a designated or proposed SPA, Ramsar site, or (SSSI), unless the City Council is satisfied that there is no alternative solution and there is a case for IROPI.
OE7 Habitat Creation and Enhancement – sets out an objective to enhance the nature conservation interest of open land and watercourses through measures such as habitat creation and enhancement, as well as encouraging and supporting community groups, schools and other organisations to get involved in such initiatives and undertaking landscaping in an ecologically-sensitive manner.
OE8 New Countryside Areas - supports proposals which secure environmental improvement, enhance tree coverage, creation of open spaces, recreational facilities and activities, improved public access and enhanced nature conservation interest.
OE11 Protection of Greenspace – states that Planning Permission will not be granted for built development in locations where there would be material harm to the recreational function of the green space unless that development is either ancillary to a recreational use, does not fall within or would not result in open space deficiency.
The Speke/Garston economic regeneration area as defined in Policy GEN1 Economic Regeneration and is recognised by the City Council as an area that provides job opportunities close to areas of high unemployment, in locations generally well served by existing transport links.

Wirral UDP

- 3.7.6 The Wirral UDP recognises the need to develop renewable energy technologies. The relevant Wirral policies are listed in Table 3.4.

Table 3.4: Relevant Wirral UDP Policies

REN1 Principles for Renewable Energy - supports renewable energy proposals subject to assessment in relation to their siting and design, environmental impact, and impact on the amenity of neighbouring uses, subject to other policies of the UDP.
COA1 Principles for the Coastal Zone – to ensure that the character of the coast, in particular its national and international importance for nature conservation and the quality of the coastal landscape, is preserved and enhanced.
CO1 Development Within the Developed Coastal Zone - sets out criteria for consideration of development in Coastal Zones, including the need to demonstrate that the development requires a coastal location.
CO5 Development Requiring Additional Coastal Defence Works - development will only be permitted within areas considered to be at risk from coastal flooding or erosion where construction of additional sea defence or coastal protection works will not be necessary.
CO6 Development within Areas at Risk of Coastal Erosion and PO7 Development on Unstable Land - should there be a risk of coastal erosion, the proposal will need to ensure land instability can be overcome such that the development proposed can be shown to be suitable.
PO8 Development in the Coastal Zone Requiring Environmental Assessment - any revived proposal for a barrage across the River Mersey would require an EIA and would have to consider impacts on the hydrodynamics and nature conservation value of the Mersey Estuary.
NCO1 Principles for Nature Conservation - proposals will only be permitted where they do not adversely affect – either directly or indirectly – the integrity of the international, national and locally designated sites for nature conservation.
TLR1 The Protection of Urban Tourist Resources - supports proposals for tourist attractions and visitor facilities along the Wirral Waterfront and other coastal locations.
Policies NC3, NC4, NC5 and NC6 - relate to the protection of sites for nature conservation and biological importance. Development will only be permitted where the continued ecological viability of the habitat or wildlife interest of the site can be adequately safeguarded, with regard to the nature, layout, and density of development proposed, the impact on the long-term ecological viability of the habitat affected, the appropriateness of measures taken to minimise damage to the habitat and disturbance to wildlife and the appropriateness of provision for the future maintenance of the site.

Emerging Policy – Core Strategies

Liverpool Core Strategy

- 3.7.7 The Liverpool Core Strategy does not explicitly support power from the Mersey but Proposed Policy Approach 30 (Renewable Energy), in respect of the ‘Preferred Option’ delivery strategy states:

“In order to make efficient use of the City’s natural resources and to contribute further to the tackling of climate change, proposals for standalone schemes for the generation of renewable energy will be supported provided that they would have no unacceptable adverse impacts (including contributing to cumulative impacts) on the built or natural environment of the City.”

- 3.7.8 The supporting text to this policy goes on to state that: *“The City Council has expressed support for the current River Mersey Tidal Power study,”* whilst acknowledging that work is at an earlier stage.

Wirral Core Strategy

- 3.7.9 The Wirral Core Strategy does not explicitly support power from the Mersey but Preferred Option 14 (Decentralised Energy) states:

“The Core Strategy will include a general policy to encourage energy efficiency and the use and development of renewable, decentralised and low carbon energy...Opportunities to use tidal power in the River Mersey will be encouraged subject to appropriate environmental controls including a project level Habitats Regulations Assessment to select the most suitable design and location and assess the impact of construction and operation.” (Wirral Council, 2010)

Halton

- 3.7.10 The Halton Core Strategy provides support for proposals for decentralised renewable and low carbon energy schemes, provided that they do not result in unacceptable harm to the local environment, which cannot be successfully mitigated (Policy CS19 Sustainable Development and Climate Change). The accompanying paragraph 22.9 to Policy CS19 identifies specific support for the Mersey Tidal Power Project:

“Sub-regional developments which contribute to the production of renewable energy will also be supported by the Council including the Power from the Mersey project subject to the management and mitigation of any identified environmental impacts.” (Halton Borough Council, 2010)

Sefton

- 3.7.11 The Sefton Core Strategy is at an early stage of development and a draft of the Issues and Options Paper was published in February 2011, with the aim of conducting public consultation in Summer 2011. The draft Vision for Sefton envisages that the area will have:

“...helped to reduce the causes of climate change through limiting the amount of carbon from its own activities ... and by accommodating new forms of renewable energy.” (Sefton Council, 2011)

- 3.7.12 It also recognises that new job opportunities in connection with developing renewable energy will be provided in the private sector.

Cheshire West & Chester

- 3.7.13 The Cheshire West and Chester Core Strategy is at an early stage of production. The Issues and Options Paper published in 2009, introduces a draft Vision for Cheshire West and Chester, which identifies that by 202n Cheshire West and Chester “...*energy will be sustainable and renewable*”. One of the Strategic Objectives is to:

“Encourage sustainable development and prudent use of resources, including the ... increased use of renewable and low carbon energy sources”. (Cheshire West and Chester Council, 2009).

- 3.7.14 A number of options to enable this objective to meet are under consideration, including support for smaller local energy schemes or support for certain types of renewable energy in specified locations (Options 27A-D).

Knowsley

- 3.7.15 The Knowsley Core Strategy is at an early stage of production. The Issues and Options Paper published in November 2009, sets out a number of strategic objectives for the Borough, one of which is to:

“manage the use of resources prudently, to tackle the causes and to respond to the impacts of climate change, and to reduce the Borough’s overall carbon emissions”. (Knowsley Borough Council, 2009).

- 3.7.16 Issue TH13 sets out two potential options for new renewable energy locations within the Core Strategy. The first is to not specify locations, but rely on broad criteria policies and the second is to specify the preferred broad areas for renewable and low carbon energy production.

Warrington

- 3.7.17 The Warrington Core Strategy (Objectives and Options stage) contains a Vision, in connection with Sustainability and Climate Change, for the Borough’s carbon footprint to reduce. Objective S1 promotes the generation of more energy from renewable and low carbon sources as one strategy to achieve this. Objective S2 is to “*secure a proportion of the energy supply of new developments from decentralised and renewable or low carbon sources*” (Warrington Council, 2010).

4 Options Appraisal Methodology

4.1 Decision Making Framework

4.1.1 The methodology for appraising options and identifying the preferred scheme were defined at the outset of the feasibility study. A decision making framework was developed for the project, considering a comprehensive range of criteria that could affect the success of a scheme.

4.1.2 The decision making framework is presented in Figure 4.1.

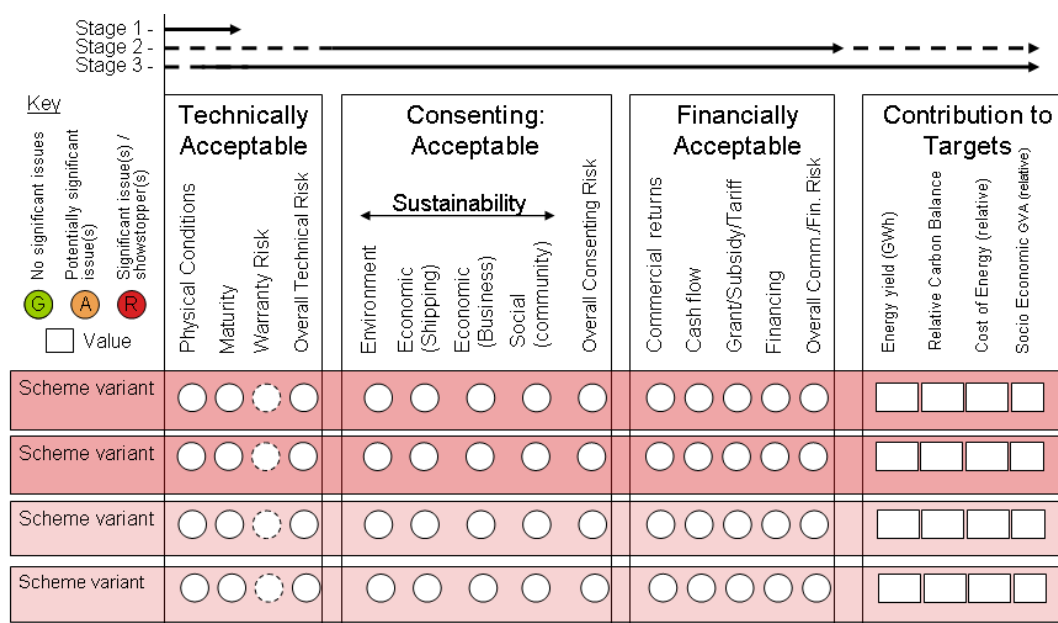


Figure 4.1: Decision making framework

4.1.3 A range of detailed studies feed into the rating of options and schemes on the decision making framework. Red, Amber and Green ratings are assigned to each option/ scheme considered based on the findings of these detailed studies. Red ratings have not necessarily resulted in an option or scheme fundamentally failing and being deselected from the feasibility study if it is reasonably expected (based on available information) that future variants could received Amber or Green ratings.

4.2 Approach to Stage 1 Options Appraisal

4.2.1 As signified by the arrows at the top of Figure 4.1, at Stage 1 only technical acceptability was considered in order to identify the long list of technology options that may be suitable for a tidal power scheme in the Mersey Estuary. This is because there would be no merit to this feasibility study trying to develop scheme options and assessing the wider range of

issues relating to consenting and financial acceptability of technologies that could not be technically implemented to generate power in the Mersey Estuary. The Stage 1 Options Report provides further details.

- 4.2.2 The primary objective of Stage 1 was to create a long list of technology options for assessment at Stage 2 that were considered to have some prospect of meeting the scheme objectives. This involved the evaluation of each technology option's physical and technical features against the basic characteristics of the Mersey Estuary.
- 4.2.3 Stage 1 commenced with an industry-wide search of available technologies to enable a pre-long list of power generation technologies to be compiled from a range of sources. Previous studies were reviewed and their findings were incorporated as appropriate.
- 4.2.4 A lagoon scheme in Liverpool Bay was considered but such schemes would be unlikely to preclude a development within the Estuary. If appropriate, such a scheme could be considered as a potential addition rather than as an alternative.
- 4.2.5 The Stage 1 technical assessment was based on five screening criteria, as set out in Table 4.1.

Table 4.1: Stage 1 technical assessment criteria

No.	Criterion	Details
1	Estuary water depth and width	Can the technology be implemented given the width of the Mersey Estuary and the water depth whilst achieving acceptable impacts, if necessary by adjusting the size of the scheme or modifying the operating conditions?
2	Water velocity	Will the technology be capable of generating a commercial quantity of energy from the natural tidal current velocities in the Estuary?
3	Performance parameters	Has the performance of the technology been sufficiently studied to enable its energy output to be assessed?
4	Technology maturity	Will a prototype of the technology have been sufficiently tested (or will there be the technical and financial capacity to undertake such tests) in representative conditions including adequate flow magnitude, physical scale and marine conditions, in time for the technology to be adopted as the basis of a commercial scheme in a planning application in late 2011?
5	Delivery	Will the technology have the support of a company with sufficient technical capability and financial security to enable it to be adopted as the basis of a commercial scheme in a planning application in late 2011?

- 4.2.6 Options that failed any one of the above criteria were de-selected. Those options remaining formed the long list at the end of Stage 1.

4.3 Approach to Stage 2 Options Appraisal

- 4.3.1 Consideration of technical, consenting (including environmental and socio-economic topics) and financial acceptability criteria, as well as potential contribution to renewable energy, carbon reduction, energy cost and socio-economic targets was undertaken at Stage 2 for the long list of technology options.
- 4.3.2 At the commencement of Stage 2 it was not necessary to reach decisions on location since the process of design refinement would continue through subsequent stages of the project. It was however necessary for initial alignments to be selected so that a sufficient degree of information could be obtained to undertake the necessary studies and appraisal of technologies.
- 4.3.3 Potential bands to locate a scheme were identified following consideration of geographic and bathymetric characteristics relevant to a tidal power development, including channel characteristics (width and depth), potential navigation impact and energy potential. Consideration of other opportunities and constraints was undertaken during Stage 2 to inform further location studies.
- 4.3.4 As noted in Section 2.1, the Mersey Estuary comprises two distinct geographic and bathymetric zones – a narrower, deeper section extending from the mouth of the Estuary about 10 km upstream and a wider, shallower section further inland where extensive areas of intertidal habitat are exposed at low water. The Estuary also supports a significant shipping industry, with vessels entering into and berthing at various points. The Manchester Ship Canal joins the Estuary at Eastham Locks and around a fifth of vessels entering the Estuary are bound for the Ship Canal.
- 4.3.5 The basic Estuary characteristics were considered to be represented by three broad location bands. Their extent and key characteristics are described in Table 4.2 and illustrated in Figure 4.2. Notional lines within these bands were used as the basis of the Stage 2 studies.

Table 4.2: Key characteristics of location bands

Band	Location	Channel type	Navigation interest	Energy potential
A	Upstream end of the narrows section, upstream of Tranmere, broadly in the Bromborough and Dingle area	Relatively narrow and deep, with limited intertidal exposure.	A little over 20% of commercial shipping passes this band	Approximately 80% of tidal flow passes this band
B	Upper Estuary, within the wide section, upstream of both Garston and the entrance to the Manchester Ship Canal at Eastham	Wide and shallow, with large intertidal exposure	No commercial shipping passes this band	Approximately 50% of tidal flow passes this band
C	Downstream end of the Estuary, between the entrance and Sandon Half Tide Lock	Relatively narrow and deep, with limited intertidal exposure	All Estuary shipping passes this band	Almost all of Estuary tidal flow passes this band



Figure 4.2: Representative bands identified at Stage 2

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- 4.3.6 Using the representative bands and the Stage 1 long list of technologies, five sample schemes were selected for initial assessment so that the range of technical, consenting and financial issues could be understood, and judgements made from the knowledge gained about the relative performance of the technologies and the locations. The initial scheme selection was targeted at where technologies were most suitable. Descriptions of the five schemes selected for assessment at Stage 2 are given in Section 6, and in the Stage 2 Options Report.
- 4.3.7 Initial alignments for sample schemes were selected as being typical of the bands within which they are located and did not represent selection of a final location.
- 4.3.8 Assessments of the five sample schemes was undertaken as follows:
- technical acceptability – evaluation of each scheme option against the criteria used in Stage 1;
 - consenting acceptability – assessment of each scheme option using a range of specialist assessments including
 - sustainability appraisal using 21 indicators,
 - Shadow Habitats Regulations Assessment informed by two dimensional (2D) hydrodynamic modelling,
 - water quality assessment using flushing calculations,
 - socio-economic, tourism and leisure assessment,
 - carbon accounting assessment,
 - identification of planning policy and land use constraints; and
 - financial acceptability – using costing and financial modelling.
- 4.3.9 Details of the sample scheme development process and specialist assessment methodologies are provided in the Stage 2 Options Report.
- 4.3.10 Using the findings of these assessments, each scheme variant was assigned Red, Amber or Green for every criterion on the decision making framework (with the exception of Warranty Risk which was not evaluated at Stage 2). These ratings represent a simplified summary of the wide range of issues that have been considered through specialist studies.
- 4.3.11 At Stage 1, Red ratings resulted in technology options not reaching the long list to be taken forward into Stage 2 as they represented an assessment of the technology and its suitability for the Mersey Estuary. However as Stage 2 considered particular variants of schemes (combinations of technology and location, with specific assumptions on the civil, structural and mechanical design and operating regime), Red ratings did not necessarily result in technology options and schemes fundamentally failing and being de-selected from the short list to be taken forward into Stage 3, if it was reasonably expected that future schemes or variants could receive Amber or Green ratings.
- 4.3.12 The Contribution to Targets section of the decision making framework was completed with relative figures at Stage 2 to inform the option appraisal.

4.4 Approach to Stage 3 Options Appraisal

- 4.4.1 As described in the Stage 2 Options Report, Stage 2 concluded that the focus of future work should be on an approximately 5.5 km stretch of the Estuary between New Ferry and Dingle at the downstream extent and Eastham and Garston upstream. This area is shown on Figure 4.3.

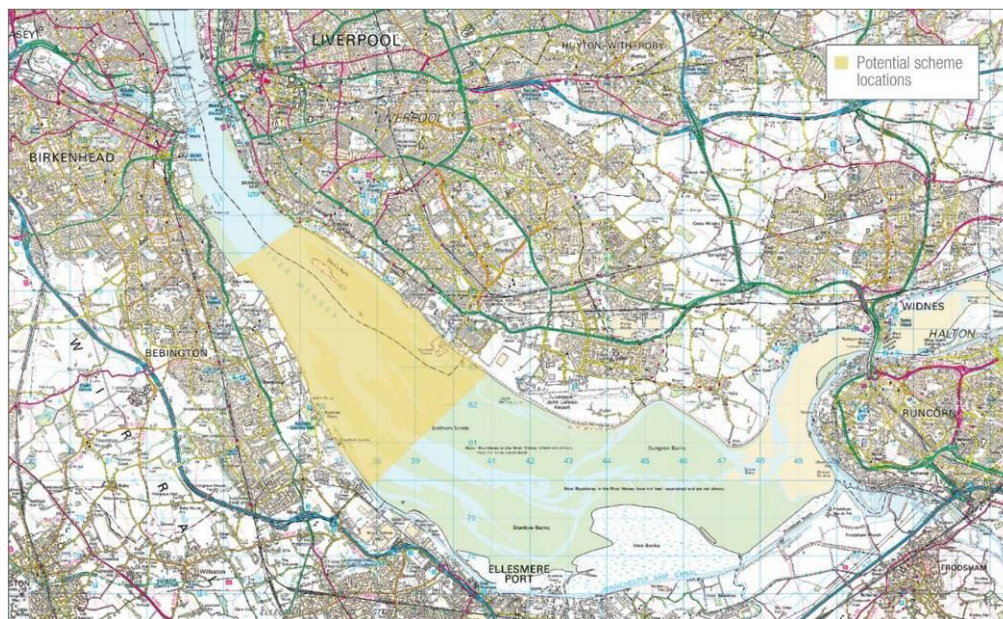


Figure 4.3: Potential development area considered at Stage 3

- 4.4.2 The initial alignments selected for the purposes of assessment at Stage 2 have been refined at Stage 3. Further information is provided in Section 7.
- 4.4.3 At the end of Stage 2 three schemes were selected for further study at Stage 3. These schemes have been refined based on the Stage 2 assessment findings, and a number of scheme variants have been studied to inform the option appraisal. Measures to avoid and reduce environmental impacts have been introduced at Stage 3, as well as measures to increase energy output and improve financial performance, including the evaluation of a range of operational variants.
- 4.4.4 Detailed descriptions of the schemes developed and assessed at Stage 3 are provided in Section 7.
- 4.4.5 At Stage 3, all criteria on the decision making framework have been assessed for the sample schemes developed at this stage using the same methodologies as for Stage 2, and the estimated contribution of each sample scheme to renewable energy, carbon reduction, energy cost and socio-economic targets has been presented using absolute figures.

- 4.4.6 The conclusion of Stage 3 has been the identification and recommendation of a preferred scheme to be taken forward for further design and consent applications, subject to commercial decisions.

4.5 Habitat Regulations Assessment

- 4.5.1 The Habitats Regulations define a procedure for the assessment of developments that may have a significant effect on a European designated nature conservation site. This procedure is summarised below.
- 4.5.2 Regulation 48 of the Habitats Regulations restricts the granting of consents for development that is not directly connected with or necessary to the management of a designated European nature conservation site where there is a probability or risk of a significant effect on the site. These are known as Natura 2000 sites in reference to the Europe-wide network of such sites having that name.
- 4.5.3 The competent authority (which is the consenting body for a project) will consider whether the effect of the development on the site, either individually or in combination with other projects, is likely to be significant in terms of the conservation objectives for which the site was classified. The assessment is made in respect of each conservation objective for which the site is classified and for each designation where a site is classified under more than one international obligation. In doing this, the competent authority will consult Natural England.
- 4.5.4 In considering the combined effects with other proposals it will normally be necessary to take account of outstanding consents for projects that are not fully implemented, ongoing activities or operations that are subject to continuing regulation (such as discharge consents or abstraction licences) and other proposals that are subject to a current application for any kind of authorisation, permission, licence or other consent.
- 4.5.5 If significant effects are considered likely, the competent authority will make an appropriate assessment of the implications in view of the site's conservation objectives. The scope and content of an appropriate assessment will depend on the nature, location, duration and scale of the proposed development and the interest features of the relevant site.
- 4.5.6 Following this assessment, the competent authority will determine whether it can ascertain that the development will not adversely affect the integrity of the site(s) before the consent decision is made. The integrity of a site is the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or the levels of populations of the species for which it was classified. As part of the judgement on integrity, the competent authority will consider the way in which it is proposed to carry out the development and whether conditions or other restrictions would help to ensure that site integrity was not adversely affected.
- 4.5.7 If the competent authority is unable to conclude that the proposed development will not adversely affect the integrity of the site, and this effect, or possible effect, will not be

-
- removed by mitigation secured by conditions or other restrictions, it will not grant consent except in certain circumstances.
- 4.5.8 First, the competent authority must be satisfied that there are no alternative solutions. If an alternative exists then consent cannot be granted because it would be precluded by the Habitats Regulations. Consideration of alternatives would include alternative sites and practicable approaches that would have a lesser impact than the proposals in question.
- 4.5.9 Second (if there is no alternative solution), the competent authority must consider whether there are imperative reasons of overriding public interest (IROPI) why the consent should be granted, despite a potentially negative effect on site integrity. Different tests apply depending on whether the site hosts a priority natural habitat type or species.
- 4.5.10 If the site does not host a priority natural habitat type or species, consent can be granted if the proposed development has to be carried out for IROPI reasons, including those of a social or economic nature. Such reasons would need to be sufficient to outweigh the harm to the ecological importance of the designation.
- 4.5.11 If the site hosts a priority habitat or species, the considerations that can justify the grant of consent are those which relate to human health or public safety, beneficial consequences of primary importance to the environment, or other imperative reasons of overriding public interest agreed by the European Commission. In other words, the potential for the grant of consent is more restricted.
- 4.5.12 Thus, consent may be granted where no alternative exists and the importance of the development is judged to outweigh the harm to a European site. In such circumstances, compensatory measures must be taken to ensure that the overall coherence of the Natura 2000 network is protected.
- 4.5.13 The requirements described above will often overlap with a duty to consult in respect of SSSI interests. However, the procedures relating to the Habitats Regulations relate to the integrity and conservation objectives of a European site (applying as a matter of policy to pSPAs and Ramsar sites) and may be narrower than the interest features of the SSSI (national designation). It will therefore be important for the competent authority to distinguish how the proposed development may affect the international interests and the interests of the SSSI in order to ensure that all the relevant legislative requirements are complied with.
- 4.5.14 The approach adopted for the Mersey Tidal Power project through the Shadow Habitats Regulations Assessment is to seek to prevent harm to the integrity of the designated sites. The appraisal of effects upon integrity is a key part of the optioneering process being followed to identify a preferred scheme. The preferred scheme will then be subject to a process of design iteration to develop the possible operational measures capable of preventing or reducing harm.
- 4.5.15 The scheme design process has also been informed by the identification and design of appropriate mitigation measures that seek to address potential impacts on the designated

sites that cannot be avoided by operational or other variations. These measures would form an integral part of the proposal as it proceeds to the consenting process, and would therefore be considered by the competent authority when it considers the scheme and mitigation measures.

- 4.5.16 If, following the appropriate assessment, a residual impact is identified and no alternative, the IROPI case will be supported by consideration of an appropriate level of compensatory measures.

4.6 Water Framework Directive Assessment

- 4.6.1 The potential impacts of a development must be assessed against the requirements of the Water Framework Directive and adverse impacts avoided and/or mitigated. There is currently no standard methodology for assessing the impacts of development in relation to the Water Framework Directive, so a scoping study has been undertaken in consultation with the Environment Agency. The Water Framework Directive requires consideration of a range of parameters including biological elements, chemical and physio-chemical water quality elements and hydromorphological elements. Any development that is likely to lead to a deterioration in the status or potential of a water body will not be granted consent unless over-riding public need for the development is demonstrated and there is no viable alternative with lower impact.

5 Summary of Stage 1

5.1 Identification of the Pre-Long List

- 5.1.1 Four broad categories of energy generation technologies have been considered for application in the Mersey Estuary: conventional impounding schemes, very low head barrages, open stream devices and tidal fences. These are described below.

Conventional Impounding Schemes

- 5.1.2 Conventional impounding technology is suitable for schemes where a water level difference is created as the tide rises or falls by a barrage between an impounded basin and the natural sea level. The turbines are generally horizontal axis bulb units and are designed to operate efficiently over a range of heads. This type of plant would be suitable for tidal barrage and lagoon developments. The minimum operating head depends on the size of the units but would typically be in the range of 3 – 4 m for larger diameter plant.

Very Low Head Barrages

- 5.1.3 The objective of very low head barrages is to command the tidal energy resource by imposing a much smaller water level change on the impounded basin to minimise environmental impacts. These devices can operate at head differences as low as 2 m. Concepts include the tidal power gate, tidal reef and very low head turbines.

Open Stream Devices

- 5.1.4 Open stream devices extract energy from the natural velocity of the tidal flow and do not need to impose a water level difference. There are a very large number of devices under development so an assessment was made of the development status of each device, from laboratory tank tests to commercial project.

Tidal Fences

- 5.1.5 The tidal fence comprises a line of energy conversion devices housed in a continuous structure. These devices typically operate on both the ebb and flood tides, constraining the tidal flow to a reduced cross-sectional area to induce higher local flow velocities to drive the devices. This effect will generate a water level difference across the fence which may be of the order of 0.5 to 1.5 m at the mid-point of the tidal cycle when flow rates are highest, reducing to a nominal value at high and low tide when there is no flow. Level differences depend on the constriction of flow and the type of device employed. Many of the technologies that might be suitable for a tidal fence are based on open stream devices.

Selection of the Pre-Long List

- 5.1.6 The primary objective of selecting technologies for inclusion on the pre-long list was to ensure that all generic types of energy conversion device were represented. It was also important to include plant suitable for both deeper and shallower parts of the Estuary so that a range of locations could be considered.
- 5.1.7 The resulting pre-long list is presented below (further details are contained in the Stage 1 Options Report):
- conventional impounding schemes –
 - tidal barrage (impounded reservoir created by barrage across the Estuary)
 - tidal lagoon (impounded reservoir created by perimeter embankment);
 - very low head barrages –
 - tidal power gate (moveable gates with matrix of small axial flow turbines)
 - tidal reef (new concept of low head barrage using a relatively low impounding structure)
 - very low head turbine (new turbines that would be enclosed in an impounding barrage);
 - open stream devices (arrays places where natural velocity is sufficient) –
 - ducted horizontal axis
 - unducted horizontal axis
 - vertical axis
 - oscillating; and
 - tidal fences –
 - tidal fence (line of tidal stream devices in a complete or partial barrier across the Estuary)
 - vortex turbine (new concept of ducted tidal stream device with no blades)
 - rotating blade vertical axis turbine (concept with new vertical axis turbines)
 - Spectral Marine Energy Converter (SMEC) (fence of tubes from which water is drawn by Venturi effect)
 - waterwheel (large diameter undershot water wheels within a structure across the Estuary).

5.2 Assessment of the Pre-Long List

- 5.2.1 Each of the pre-long list technology options were examined for compliance with the five selection criteria (see Table 4.1).
- 5.2.2 A summary of the key technical considerations for each technology and their evaluation against the five selection criteria is presented in Table 5.1.

Table 5.1: Summary of assessment of pre-long list technology options

Technology	Physical conditions		Maturity ⁶			Comments
	Estuary width and depth	Water velocity	Performance parameters	Technology maturity	Delivery	
Impounding tidal barrage	Pass	N/A	Pass	Pass	Pass	Mature and readily available from major suppliers. Previous studies confirmed suitable for Mersey Estuary.
Tidal lagoon	Fail	N/A	Pass	Pass	Pass	Mature and readily available from major suppliers but Mersey Estuary too constrained.
Tidal power gate	Pass	N/A	Pass	Pass	Pass	Mature and readily available from major suppliers. Previous studies confirmed suitable for Mersey Estuary.
Tidal reef	No data	N/A	Fail	Fail	Unclear	Early stage of development, insufficient information available.
Very low head turbine	No data	N/A	Fail	Fail	Pass	Early stage of development, insufficient information available.
Open stream devices	Pass	Fail	Pass	Pass	Pass	Some devices mature and generally available but velocities in Mersey Estuary do not exceed minimum required value.
	Unclear		Unclear	Unclear	Fail	
Tidal fence	Pass	N/A	Pass	Pass	Pass	Prototypes exist, some devices in/ approaching commercial operation. Suitable plant available from established suppliers.
Vortex or rotating blade vertical axis turbine	No data	No data	Fail	Fail	Unclear	Early stage of development, insufficient information available.
SMEC	Pass	Pass	Pass	Unclear	Unclear	Device appears suitable for Mersey Estuary and technology based on conventional units but no prototypes exist.
Waterwheels	Pass	N/A	Unclear	Fail	Fail	Early stage of development, insufficient information available.

⁶ The progress of new technologies have been monitored during the course of the feasibility study and any new information evaluated.

5.3 Conclusions of Stage 1: Long List

- 5.3.1 Details of the pre-long list technologies and their review with reference to the five selection criteria is presented in the Stage 1 Options Report.
- 5.3.2 In some cases technologies were at a relatively early stage of development and data for assessment was not available. It was not therefore possible to recommend those technologies for further study at Stage 2. In making this decision the timetable for development and the foreseen provision of information in the future was taken into account. In some cases an Amber classification was adopted where compliance with the criteria was marginal or unclear. If the option did not fail on other criteria then a recommendation for further study was made.
- 5.3.3 The Stage 1 review concluded that four basic technologies should be considered at Stage 2, as shown in Table 5.2.

Table 5.2: Long list of schemes identified at the end of Stage 1

Principle of operation	Power generation technology	Application
Impoundment of reservoir	Horizontal axis bulb or Straflo™ turbines	Conventional barrage impounding the tidal range of the Mersey Estuary to obtain energy from a head difference.
Very low head barrage (requiring impoundment of reservoir)	Tidal gate comprising Hydromatrix™ or Straflo™ matrix turbines (other technologies may be available in future and could be substituted)	Barrage operating at a low head difference, in a range typically below that of conventional plant (2-3 m for the purposes of the study). The tidal gate solution employs small diameter units and will therefore be suitable for a shallow water application.
Tidal fence	Vertical axis cross flow machines or horizontal axis ducted stream flow machines	Partial or continuous barrier across the Estuary constraining the tidal flow and increasing the velocity locally to drive stream flow generating plant.
	Spectral Marine Energy Converter	Innovative tidal fence solution developed by VerdErg Ltd based on the Venturi effect, suitable for low velocity conditions. Potentially requires deep water conditions, depending on final configuration of generating plant.

6 Summary of Stage 2

6.1 Schemes Assessed at Stage 2

- 6.1.1 Stage 2 commenced with the four technology options identified at Stage 1, all of which were considered to be technically feasible and suitable for use in the Mersey Estuary and, where appropriate, were anticipated to have suitable timeframes for development.
- 6.1.2 Using the representative location options identified in the Estuary (see Section 4.3), five sample schemes were selected for assessment at Stage 2 to inform the study. The rationale for the selection of these schemes, and details of the design and operational variants developed for assessment, are presented in Table 6.1.
- 6.1.3 General design considerations at Stage 2 were reported in the Stage 2 Options and are summarised below:
- all schemes would require a structure spanning the width of the Estuary, including the tidal fence which would require constriction of the Estuary width to generate the water velocities required by this technology;
 - structures could comprise concrete caissons, sheet piles and/or earth embankments;
 - sluices would be required for the barrage schemes to ensure sufficient water could pass through the structure for a sufficient head difference to be generated and to reduce impacts on low water levels;
 - VerdErg (who supplied all details of the SMEC scheme) did not include sluices although this would need to be reviewed in light of reservoir safety considerations
 - barrage turbines would need to be housed in a 50-80 m long pre-cast concrete caisson, and the SMEC would require similar concrete caissons;
 - sluices would also need to be housed in concrete caissons;
 - for lengths of the structure not associated with turbines or sluices, blank concrete caissons or earth embankment were considered;
 - foundation design would depend on local ground conditions within the final alignment – where sandstone bedrock is shallow, the caissons could be founded directly onto rock by removing the overlying glacial till, but where this is not possible a piled foundation would be required;
 - all schemes would require a navigation structure – schemes in Band B were designed to include a small lock for leisure and service craft and all schemes in Band A adopted the same commercial navigation solution for the purposes of assessment (a single ship lock adjacent to the Liverpool bank and a single ship lock on the Wirral bank with local dredging to maintain passage to existing navigation channels); and
 - all schemes would require landside facilities including grid connection, operation and maintenance facilities for the tidal power scheme, and assumptions were made on the areas required based on the predicted energy outputs of each scheme.

Table 6.1: Stage 2 sample schemes and design and operational variants selected to inform study

Scheme variant	Technology	Location	Rationale for sample scheme	Design				Operation
				Generating plant	Installed capacity	Sluice gates	Navigation	
IBv1	Impounding barrage	Band A	Water depths in Band B challenging Constraints at Band C challenging Start at Band A and apply knowledge to B or C as required at a later stage	28 bulb turbines with a runner diameter of 8 m housed in 75 m long caissons (four turbines per caisson)	700 MW	18 No 12 m long sluice gates with 4 waterways per caisson	Common Band A navigation option adopted	Starting head of 4 m; turbines to stop generating when head difference drops below 1.7 m
VLHBv1	Very low head barrage	Band B	Technology possible for all three bands although constraints at Band C challenging Start at Band B as technology does not require large water depths; apply knowledge to A or C as required at a later stage	640 ECOBulb™ turbines with a runner diameter of 1.45 m housed in 64 m long caissons (fourteen turbines per caisson) (Note: moving gate concept using Hydromatrix™ technology not selected due to operational issues; larger	256 MW	24 No 12 m long sluice gates with 4 waterways per caisson	Small lock for leisure and service craft	Starting head of around 3 m; turbines to stop when head level reaches 5 m CD

Scheme variant	Technology	Location	Rationale for sample scheme	Design				Operation
				Generating plant	Installed capacity	Sluice gates	Navigation	
				ECOBulb™ turbines in static barrage used in design instead)				
TFv1	Tidal fence	Band A	Suitable for all three bands although constraints at Band C challenging Consider schemes in Band A and Band B to inform on the differences arising from location	34 Open Hydro rim generator turbines with a diameter of 5 m	17 MW	None required	Common Band A navigation option adopted	N/A although channel restricted to increase velocities
TFv2	Tidal fence	Band B	See TFv1 above	24 Open Hydro rim generator turbines with a diameter of 5 m	14 MW	None required	Small lock for leisure and service craft	N/A although channel restricted to increase velocities
SMECv1	SMEC	Band A	Suitable for all three bands although constraints at Band C challenging Start at Band A; apply knowledge to B or C as required at a later stage	8 SMEC units, each 60 m long, housing a total of 16 Kaplan turbines	250 MW	None required although this assumption would need to be reviewed	Common Band A navigation option adopted	N/A

6.2 Appraisal of Location Options

- 6.2.1 The brief of the feasibility study was to consider the area from Queen's Channel to Runcorn Bridge. Further information regarding different locations in the Estuary was gathered at Stage 2. This included consideration of local planning policy, regeneration initiatives and objectives, and planning history to enable an appraisal of the constraints and opportunities.
- 6.2.2 Development at Band A (or any location between Bands A and B) would need to provide a solution for commercial shipping in the Estuary – just over 20% of commercial shipping passes Band A to Eastham, Garston and Bromborough Wall (or Mersey Wharf). Construction within the Mersey Estuary SPA boundary could be largely avoided by the footprint of the development but impacts due to tidal regime changes are still a significant consideration at this location. Impacts on the adjacent former Liverpool Garden Festival Site which is currently being redeveloped for mixed uses could be significantly reduced by locating landside facilities on the Wirral bank, and access on the Liverpool bank would be for emergencies only.
- 6.2.3 A development in Band B would avoid commercial navigation issues, support local regeneration initiatives and, as it is closer to the trunk road network, traffic to and from the land abutting Band B from main roads would be likely to affect fewer residential properties. However, a scheme in Band B would be constructed within the Mersey Estuary SPA boundary as well affecting designated habitats through changes to the tidal regime, and being upstream in the shallower, wider part of the Estuary there is less energy available combined with increased construction costs.
- 6.2.4 Development at Band C would impact on all established navigation interests along the Estuary, with resulting delays and financial impacts on operators and the local economy. It would also be located within the boundary the Mersey Narrows and North Wirral Foreshore pSPA as well as affecting designated habitats due to tidal regime changes. There would also be potential for impacts on the Liverpool Mercantile City World Heritage Site and its buffer zone, and construction and operation would be constrained due to the built-up landside areas and associated issues with access, availability of land for landside facilities, impacts on residential areas and less opportunity for site specific regeneration initiatives.
- 6.2.5 Development at any locations between Bands A and B would require the same navigation solution as Band A, but as the Estuary becomes increasingly wide and shallow upstream of Band A, there would generally be increasingly less energy available and greater construction costs.
- 6.2.6 Development between Bands A and C would impact upon a greater proportion of the navigation interests along the Estuary and would be closer to the World Heritage Site in Liverpool, but with little benefit in terms of ecological impacts, landside access and regeneration opportunities.

- 6.2.7 In the light of this assessment it was concluded that Band C (and other locations downstream of Band A) was the least favoured location option for tidal power schemes in the Mersey Estuary and no further consideration has been given to schemes in this location or any locations downstream of Band A.

6.3 Assessment of Technical Acceptability

Impounding Barrage

- 6.3.1 Technical risks associated with an impounding barrage were considered to remain low. The technology is proven and has been deployed in several locations around the world. The impounding barrage was therefore rated Green for all technical criteria, as at Stage 1.

Very Low Head Barrage

- 6.3.2 It was concluded that the power gate has a number of limitations that make it less suited to an estuarine environment, but different applications of very low head turbines could be used. The sample scheme in the shallower part of the Estuary was found to have some technical issues associated with localised bathymetry and sediment management, but this might be overcome by consideration of a different layout, configuration and choice of turbines. Overall the very low head barrage was rated Amber, with further consideration required to a number of practical issues to improve performance.
- 6.3.3 Further information on the development of very low head turbines was available during Stage 2 from the Severn Embryonic Technologies Scheme (SETS) studies, but this did not alter the overall Stage 1 conclusions on very low head turbines (see Table 5.1) due to the long development period.

Tidal Fence

- 6.3.4 The turbine used for the tidal fence sample schemes is approaching commercial availability and being tested in a high velocity marine current location, but is not mature. For use in the Mersey Estuary, the channel would need to be constrained to create the required water velocities, and relatively small energy yields would be achieved (see Figure 6.1). Multiple rows of turbines would improve the energy output (but not sufficiently to overcome the high capital and carbon cost of the schemes – see Sections 6.4 and 6.5). The technology is therefore not well suited to the Mersey and both tidal fence scheme variants were rated as Amber.

SMEC

- 6.3.5 Whilst the theory behind the SMEC device is well understood, there is currently a lack of available performance data for further study, and no prototype has been developed and deployed. In the absence of any further data, SMEC was rated Red for overall technical risk.

6.4 Assessment of Consenting Risk

Impounding Barrage IBv1

- 6.4.1 In general IBv1 was found to have the greatest potential for negative impacts on estuarine nature conservation interests and water quality, but it should be noted that no measures to prevent harm or mitigate impacts were included at Stage 2. However, it also had the potential to generate the largest amount of electricity and thus could be seen to be the option which makes best use of the available tidal power resource in the Mersey.
- 6.4.2 IBv1 was considered to have potential negative impacts on flood risk, but it has been recognised that beneficial flood risk impacts could also be achieved. This scheme variant performed best in socio-economic terms and would possibly create the most visitor interest, with the opportunity to create an iconic structure.
- 6.4.3 Given the above, IBv1 was rated Amber for overall consenting risk. Future work would need to concentrate on impact avoidance and mitigation measures as none was included at Stage 2.

Very Low Head Barrage VLHBv1

- 6.4.4 The location of VLHBv1 in Band B has local planning policy and regeneration, navigation and transportation advantages over Band A. Although VLHBv1 was assigned a 'likely negative' rating for flood risk in the sustainability appraisal, it also has potential flood alleviation benefits if designed and operated appropriately.
- 6.4.5 VLHBv1 was found to have some negative impacts on estuarine ecology, but the magnitude of the impact was predicted to be less than the impounding barrage scheme IBv1 because of the less significant impacts on the tidal regime caused by VLHBv1. This scheme option also performed slightly better than IBv1 in terms of potential water quality impacts. However the small, high speed turbines included in VLHBv1 were concluded to have unacceptable impacts on fish.
- 6.4.6 VLHBv1 was assigned an Amber rating overall. If the energy yield and financial performance could be improved and a larger, slower turbine could be used to reduce impacts on fish, the very low head barrage could become an attractive scheme in terms of consenting risk.

Tidal Fences TFv1 and TFv2

- 6.4.7 The tidal fence technology would not make best use of the opportunity to generate renewable energy from the Mersey and would make a small contribution to declared national targets for renewable energy. This is highlighted by the carbon balance for the fence schemes, which was found to be negative as the carbon cost of construction outweighed the carbon saving from renewable energy generation over 20 years (used as the basis for assessment). The Gross Value Added (GVA) and associated socio-economic

benefits that would be generated by the tidal fences was predicted to be relatively low compared to IBv1 and VLHBv1 as a result of the lower energy yield and capital and operating costs. Impacts on estuarine habitats were also predicted for the fence schemes.

- 6.4.8 The tidal fence schemes were therefore rated Red for overall consenting risk because of their poor use of the available tidal energy resource and negative carbon balance.

SMECv1

- 6.4.9 The SMEC technology is unlikely to be commercially available for a large scheme in time to contribute to the 2020 renewable energy targets. Although the SMEC seemed to perform better than the tidal fences in terms of its predicted energy yield and positive carbon balance, and better than either of the barrage schemes in terms of its predicted impacts on estuarine habitats, the technology option's lack of maturity (having not been proven with a prototype) represents a significant risk to the project objectives and reduces the certainty in any impact assessment and as such it was rated Red overall for consenting risk.

6.5 Assessment of Commercial/ Financial Risk

Impounding Barrage IBv1

- 6.5.1 IBv1 was predicted to be the best performing scheme variant of those considered but was rated Amber overall as the financial performance would need improvement in order to be a commercial prospect. Increased energy generation, reductions in both capital and operating costs as well as an increase in the number of Renewables Obligations Certificates (ROCs) for tidal energy would improve the scheme's financial performance.

Very Low Head Barrage VLHBv1

- 6.5.2 VLHBv1 performed financially better than the tidal fences, but not as well as IBv1 or SMECv1 (excluding the financing risks associated with the SMEC technology). The scheme variant assessed at Stage 2 was rated Red against all financial criteria and overall, but financial performance was expected to be significantly improved by increasing the energy generation and reviewing capital costs so the technology option was not de-selected for financial reasons.

Tidal Fences TFv1 and TFv2

- 6.5.3 The tidal fence schemes TFv1 and TFv2 were rated as Red against all financial criteria and Red overall. Both scheme variants were predicted to have negative return and no foreseeable measures could be identified to improve the financial performance of a tidal fence in the Mersey Estuary to provide an investment case due to the low energy yield and high capital cost to create the necessary conditions for tidal stream turbines to operate effectively.

SMECv1

- 6.5.4 Based on information provided by VerdErg, SMECv1 was found to be the second best performing option and with sufficient support was considered able to provide a positive return. Although this resulted in Amber ratings for many financial criteria, the technology was rated Red overall because it is as yet an undeveloped technology and would be too high a risk for financiers.

6.6 Conclusions of Stage 2: Short List

- 6.6.1 The completed decision making framework for Stage 2 is presented below in Figure 6.1.

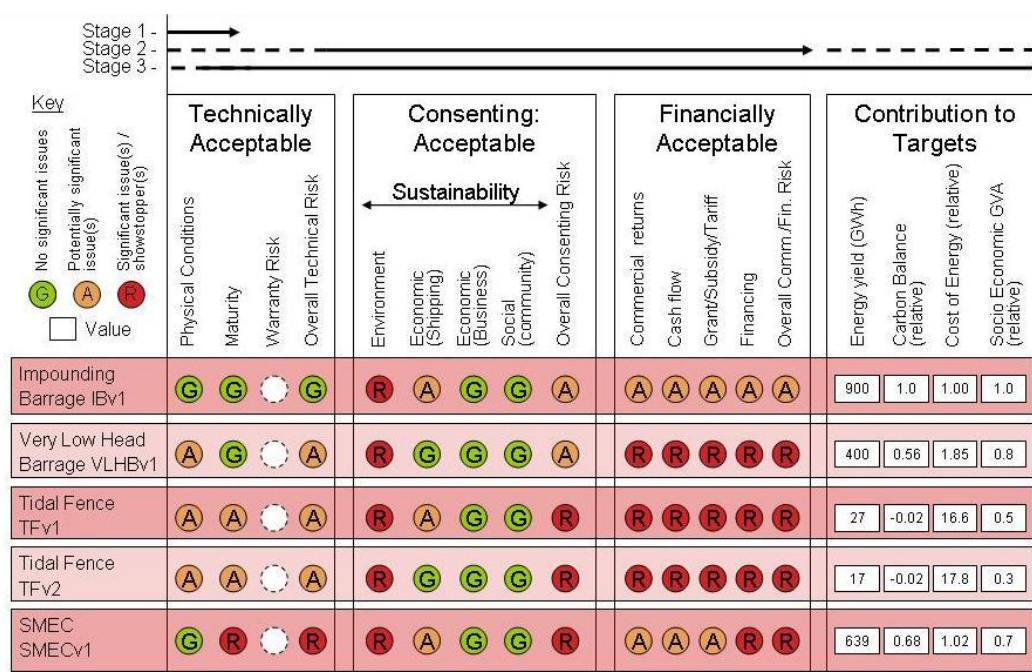


Figure 6.1: Stage 2 Decision Making Framework Assessment

- 6.6.2 The fence options were discounted at the end of Stage 2 on the basis of the technology's poor performance in the Mersey Estuary, making little use of the available tidal power resource in the Estuary to generate small amounts of renewable energy compounded by poor financial performance and negative environmental impacts.
- 6.6.3 Further consideration of the SMEC technology was put on hold until such time as further detailed information is available, based on trials of a prototype of the technology.
- 6.6.4 Band C was discounted from further study due to the range of constraints associated with the location that make tidal power development in this location considerably less favourable than other deep and narrow parts of the Estuary.

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- 6.6.5 The ongoing review of available technologies at Stage 2 did not identify any new technologies to be considered, or any changes to the conclusions of Stage 1 with regards the deselected pre-long list technologies.
- 6.6.6 The impounding barrage and very low head barrage technology options were recommended for further study at Stage 3 as the following three schemes:
- impounding barrage in the vicinity of Band A (i.e. a deep water location around New Ferry and Dingle, which has commercial shipping constraints);
 - very low head barrage in the vicinity of Band A (defined as above); and
 - very low head barrage in the vicinity of Band B (i.e. a shallow water location which has no commercial shipping constraints).
- 6.6.7 All of the schemes developed and assessed at Stage 2 had potentially significant issues that represent risks to the successful implementation of a tidal power scheme in the Mersey Estuary and would need to be overcome in order to meet the project objectives.
- 6.6.8 The key issues identified at Stage 2 to be addressed through the development of revised scheme variants at Stage 3 were: impacts on estuarine habitats; fish passage; flood risk; water quality; navigation; and commercial viability. The challenge of finding complementary measures to address these issues, in particular identifying measures to avoid and mitigate impacts on estuarine habitats without significantly reducing the potential for energy generation, was recognised.
- 6.6.9 A range of design and operational variations provide potential opportunities to avoid environmental impacts including restricted head generation (using larger turbines), ebb and flood generation, low tide sluicing and high tide pumping. The effectiveness of these measures at reducing impacts and their effects on energy yield were identified for further consideration at Stage 3, to be combined with a package of other measures to avoid and mitigate potential impacts.

7 Stage 3 Option Appraisal

7.1 Schemes Assessed at Stage 3

Development of Location Options

- 7.1.1 At the outset of Stage 3, a review of the location options was undertaken including consideration of improvements to the indicative alignments used at Stage 2. An approximately 5.5 km stretch of the Estuary was considered, from around New Ferry and Dingle upstream to Eastham and Garston, incorporating Band B at the upstream end and Band A at the downstream end (see Figure 4.3).
- 7.1.2 Consideration was given to locating a scheme between Bands A and B but no advantages to doing so were identified – the Estuary becomes increasingly shallow and wide upstream of Band A reducing the potential energy yield and increasing the length and capital cost of a scheme, and there are no perceived environmental, navigation or landside benefits.
- 7.1.3 The indicative downstream (Band A) alignment selected for assessment at Stage 2 was concluded to require little revision for Stage 3 scheme development following consideration of relevant key issues:
- energy yield – downstream locations are more favourable than upstream locations in terms of energy yield;
 - navigation – the alignment avoids conflict with Tranmere Oil Terminal but just over 20% of ship movements in the Estuary are to/from Garston and Eastham so a solution is required to enable ship passage through the structure;
 - construction costs – the adoption of a narrower location just upstream of New Ferry results in lower construction costs;
 - ground conditions and dredging – upstream locations within Band A would be subject to less favourable ground conditions (deeper bedrock and greater depths of glacial till) and require larger volumes of material to be dredged for construction, including part of Devil's Bank;
 - adjacent land uses – the Liverpool abutment was amended to minimise impacts on the Garden Festival Site, which is currently being redeveloped for mixed uses including residential; and
 - designated nature conservation sites – the alignment avoids SPA areas (any move upstream would be within the SPA area), although impacts on designated habitats would occur due to changes to the tidal regime.
- 7.1.4 A number of issues were identified with the upstream alignment (Band B) during the Stage 2 assessment, as follows:
- energy yield – upstream locations are less favourable than downstream locations in terms of energy yield so a Band B alignment would make less effective use of the natural energy resource of the Mersey Estuary;

- navigation – no commercial shipping upstream of Eastham and Garston;
 - construction costs – upstream locations such as Band B are wider so construction costs would be higher and this would affect the economic performance;
 - ground conditions and dredging – construction of a scheme in Band B would require considerable dredging to enable the construction of the structure and to create the required submergence depths for turbines, and there would be a risk of major sediment management issues during operation; and
 - designated nature conservation sites – Band B is located within the SPA so the scheme would be constructed within the designated site boundary as well as affecting habitats due to changes to the tidal regime.
- 7.1.5 A scheme at Band B would also bring potentially greater benefit to or from site specific local regeneration initiatives. The lack of commercial shipping upstream of Eastham and Garston is the main benefit of a Band B alignment.
- 7.1.6 A possible alignment in Band B has been revisited at the start of Stage 3, to determine measures that could improve the overall performance of a scheme at this location. Whilst improvements and alternative arrangements could be considered for a scheme in Band B (such as using larger turbines and more sluice gates to reduce the number of turbines required and thereby reduce the capital costs), consideration of the potential energy yield and commercial performance these revisions would bring concluded that they would not be sufficient to overcome the technical and financial disadvantages of this location when compared with Band A. Based on the conclusions of the Stage 2 assessments there was no apparent ecological advantage of Band B over Band A.
- 7.1.7 Band A offers a greater likelihood of accommodating a viable scheme in terms of energy generation and a flexible operating regime able to prevent harm and mitigate impacts on intertidal habitats. The ability to do this arises from the potential viability of a scheme in Band A which allows a degree of trade off between energy generation and habitat management. The converse relationship between these two parameters is discussed further throughout this section of the Feasibility Study Report.
- 7.1.8 From the initial work undertaken in Stage 3 it was concluded there was little benefit in considering Band B in further detail as a potential location for the tidal power scheme whilst opportunities have been identified to locate potentially viable schemes with an adequate navigation solution in Band A. No further detailed assessments of schemes in Band B were undertaken at Stage 3.
- 7.1.9 The revised indicative Band A alignment identified for the purposes of Stage 3 assessment is shown in Figure 7.1. The alignment would be informed by public consultation and may be subject to further refinement in future stages.



Figure 7.1: Indicative alignment for Stage 3 schemes (shown as red line)

Selection of Sample Schemes for Appraisal at Stage 3

- 7.1.10 The shortlist of schemes identified at the end of Stage 2 comprised an impounding barrage in the vicinity of Band A and very low head barrages in the vicinity of Bands A and B. Following the decision to focus on Band A as described above, further development of a very low head barrage at Band B was halted.

- 7.1.11 A review of the development of other tidal power technologies has not identified any other technology options that would pass the Stage 1 criteria and therefore would require further study at Stage 3.

- 7.1.12 Two of the key issues identified at Stage 2 to be assessed at Stage 3 were commercial viability and environmental impacts (in particular impacts on estuarine habitats, fish passage, flood risk and water quality). To improve commercial viability, reductions in the predicted capital costs would be required for any scheme and this would largely be achieved through refinement and detailed design of the preferred scheme in future stages. Commercial viability is also influenced by the energy yield and the Stage 2 studies identified an apparent relationship between energy yield and environmental impact. In order to better understand this relationship, it was decided that schemes that would test the extremes of energy yield and environmental impact should be developed at Stage 3. There were expected to be the impounding barrage schemes operated with unrestricted head and very low head barrage schemes operated with restricted head, although each would be able to adopt a range of operating strategies.

Scheme Operation Considerations

7.1.13 The range of available operating strategies for each scheme presents opportunities to avoid and mitigate environmental impacts, in particular to minimise impacts on intertidal habitats. They also have a potential effect on the cost and energy yield of the scheme. A range of operating strategies have been considered as follows:

- restricted head generation (this is the underlying design and operating philosophy of the very low head barrage concept although impounding barrages can also operate with restricted head when equipped with sufficient turbines and/or with sluicing capacity to manage water levels);
- ebb and flood generation (intended to best follow the existing tidal pattern by delaying the water level rise in the basin on the flood tide as well as delaying the water level fall on the ebb tide);
- low tide sluicing (to increase the discharge from the impounded basin at low water so as to increase intertidal habitat exposure);
- low tide hold period (to increase the time of exposure of habitats before allowing the flood tide to refill the basin); and
- high tide pumping (increasing the flow into the basin at the top of the flood tide).

7.1.14 The selection of schemes and operating strategies chosen for detailed assessment to inform the study comprised:

- IBv2a – a ‘best energy’ scheme comprising an unrestricted head, ebb only generation barrage scheme with no operational measures to avoid environmental impacts (a refined version of IBv1 as assessed at Stage 2);
- IBv2b – a ‘high energy with some environmental impact avoidance’ scheme comprising an unrestricted head, ebb only barrage scheme with low tide sluicing and a low tide hold period, which was considered likely to cause a small reduction in energy yield but with the benefit of reducing the low water level and increasing the time of intertidal habitat exposure;
- VLHBv2a – a scheme with the potential to be the ‘best environmental’ scheme comprising a very low head barrage, operated on the ebb tide only with a restricted head; and
- VLHBv3a – another scheme with the potential to be the ‘best environmental’ scheme comprising a very low head barrage, operated on both ebb and flood tides with restricted head.

Scheme Design Considerations

7.1.15 The use of new very low head turbines has been considered again at Stage 3. The ECObulb™ turbines included in the VLHBv1 scheme variant at Stage 2 were selected for the shallow water conditions that prevail in Band B and were concluded to have unacceptable impacts on fish due to their small size, fast rotating speed and the number of turbines required (spanning the entire Estuary width). Other very low head turbines such as the Rolls-Royce design, are still at an early stage of development, prototype

performance data is not available and there is a long anticipated duration for development of this technology. Whilst not their optimal application, it was determined that conventional bulb turbines could be used at a low restricted head. For this reason, all scheme variants, whether intended to be operated with an unrestricted head difference or using a restricted head difference of around 3 m, have been designed using the same conventional bulb turbines. This approach has enabled the project team to assess the likely effects of restricted head generation, and the findings could inform the potential to use new very low head technology if developed within suitable timescales.

- 7.1.16 One of the variables controlling the rate of discharge through turbines is the operating head and therefore, when operating under a restricted head, a larger number of turbines is required for discharging a larger volume of water in order to generate a larger amount of energy. Layout studies in Band A indicated that there is sufficient space to accommodate up to 56 turbines in conjunction with 18 sluice gates. 56 turbines were first considered for the restricted head schemes but OD modelling indicated that there were very few instances throughout the year when all 56 units would be required and the associated level of investment in generating plant would adversely affect the commercial viability of the schemes. A reduction in the number of turbines would reduce the capital costs and allow the number of sluice gates to be increased. Further modelling showed that the head difference across the barrage could be limited to generally less than 3 m for all but a few extreme spring tides each year with a smaller number of turbines. Consequently 44 turbines were adopted for the restricted head scheme variants (VLHBv2a and VLHBv3a).
- 7.1.17 Studies undertaken by the Mersey Barrage Company in the early 1990s determined that the optimum plant configuration for an ebb only impounding barrage scheme in Band A comprised 28 turbines units (25MW each). This study has indicated an Estuary basin volume that is lower than the 1993 study and future optimisation studies may therefore result in a lower number of units. It is also important to note that the 28 unit configuration is associated with high head operation on spring tides and a larger number of turbines would be required if lower head operation was to be undertaken on spring tides for ecological reasons.
- 7.1.18 The same broad principles developed at Stage 2 were adopted at Stage 3 for the design of the sample scheme structures, including the use of concrete caissons to house the turbines and sluice gates, and piled foundations where necessary.
- 7.1.19 All schemes, whether operated under a restricted or unrestricted head and ebb only or ebb and flood generation, require essentially the same infrastructure, i.e. a barrage across the Estuary with generating plant located in a power house together with a number of sluice gates. However the intended operating regime imposes requirements on the structure surrounding the generating plant. Operating under a restricted head permits generation at lower tide levels and necessitates the turbines to be set lower down, increasing excavation volumes and the depth of caissons. These heavier structures will therefore be more expensive. Operating on both the ebb and flood tides requires the geometry of the basin side of the turbine caisson structure to be modified (draft tubes would only be present on the seaward side for ebb only generation) to reduce exit losses.

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- 7.1.20 The configurations have been designed to accommodate a standard navigation solution (a double lock on the Wirral side of the Estuary, determined through further study of navigation options as described in Section 7.3) and a fixed number of sluices.
- 7.1.21 Fish passage routes have been included within each scheme design, and an allowance for 2% of flow to be directed through these routes has been made.
- 7.1.22 For the purposes of assessment, common landside facilities including those directly related to the power station and ship locks as well as visitor facilities have been included for each scheme variant. These are assumed to be located on a reclaimed area at the Wirral bank, adjacent to the ship locks. The area estimated to be required is around 4.2 ha.
- 7.1.23 The main access is assumed to be at the Wirral side of the structure, with emergency access only from the Liverpool bank. Maintenance access would be available across the structure, and there would be potential for a pedestrian and/or cycle route or light passenger transport to cross the structure.
- 7.1.24 All schemes would take around five years to construct and have a design life of around 120 years.

Scheme Variants: Design and Operation

- 7.1.25 The design and operation of each scheme variant developed at Stage 3 is summarised in Table 7.1 below. Indicative designs are illustrated in Figure 7.2 and Figure 7.3.

Table 7.1: Design and operation of Stage 3 scheme variants

Scheme variant	Technology	Location	Design				Operation
			Generating plant	Installed capacity	Sluice gates	Navigation	
IBv2a	Impounding barrage designed for unrestricted head operation	Band A	28 bulb turbines with a runner diameter of 8 m housed in 75 m long caissons (four turbines per caisson), at -5.7 mCD centreline setting	700 MW	18 sluice gates, each 12 m long, with 4 waterways per caisson	Common Band A navigation option adopted	Unrestricted head ebb tide generation, starting head optimised for maximum energy
IBv2b							Unrestricted head ebb tide generation with low tide sluicing and hold period
VLHBv2a	Impounding barrage designed for low (< 3 m) head operation		44 bulb turbines with a runner diameter of 8 m housed in 75 m long caissons (four turbines per caisson) at -8.5 mCD centreline setting	660 MW			Restricted head ebb tide generation (typically < 3 m)
VLHBv3a	Impounding barrage designed for low (< 3 m) head operation		44 reversible bulb turbines with a runner diameter of 8 m housed in 75 m long caissons (four turbines per caisson) at -8.5 mCD centreline setting	660 MW			Restricted head ebb and flood generation (typically < 3 m)

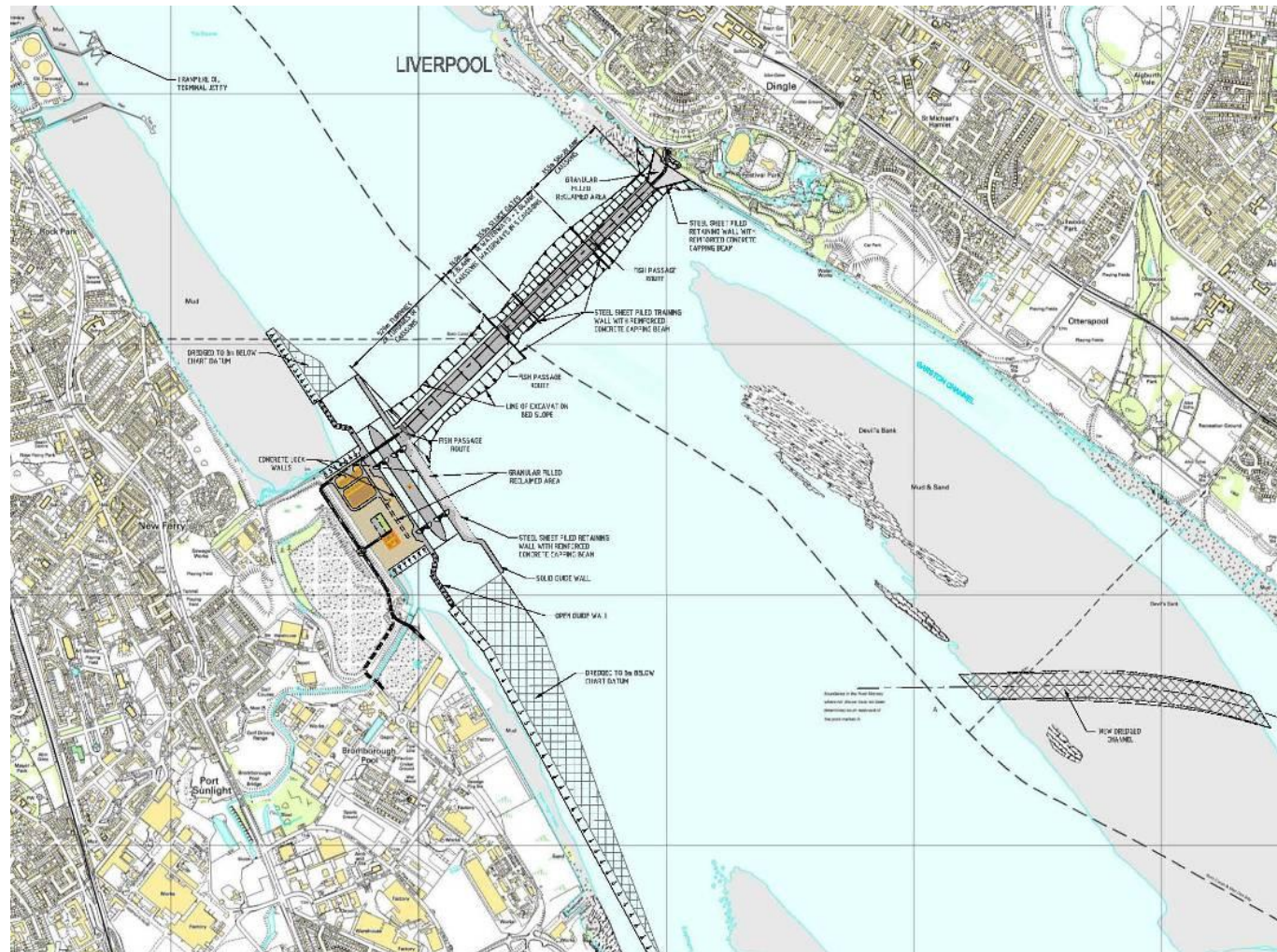


Figure 7.2: Indicative design of impounding barrage designed for unrestricted head, ebb only generation (IBv2a and IBv2b)

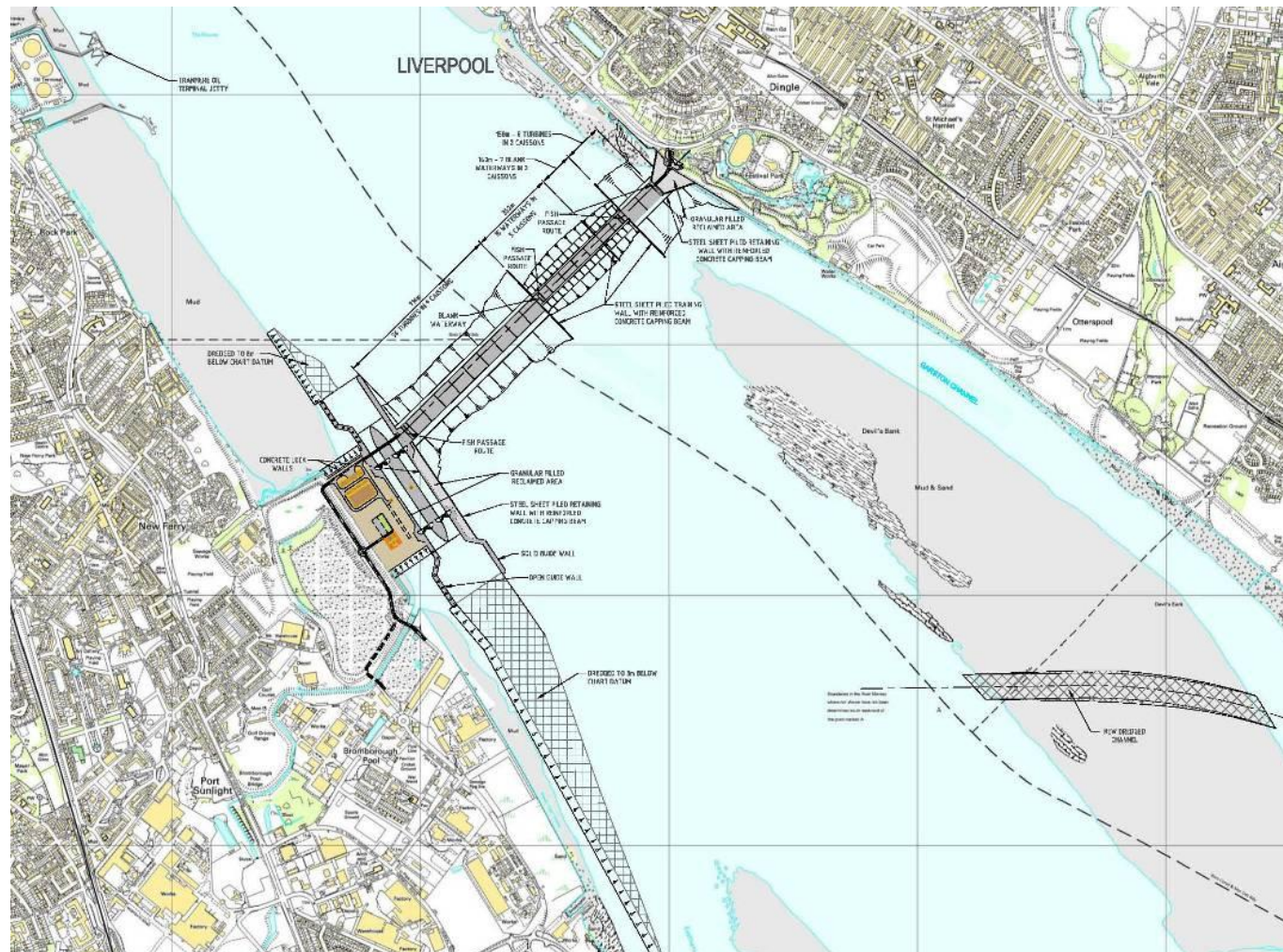


Figure 7.3: Indicative design of impounding barrage designed for restricted head, ebb only generation (VLHBv2a) and ebb and flood generation (VLHBv3a)

Scheme Variants Energy Yield

- 7.1.26 The annual energy yields predicted using OD modelling for each scheme variant are as follows:
- IBv2a 1,050 GWh
 - IBv2b 950 GWh
 - VLHBv2a 560 GWh
 - VLHBv3a 520 GWh
- 7.1.27 An IBv2 scheme design operating on a restricted head difference (achieved using sluice gates to manage water levels) has also been tested using OD modelling and was estimated to generate 530 GWh per year.
- 7.1.28 An IBv2 scheme design operating on both ebb and flood tides with an unrestricted head difference has also been tested using OD modelling and was estimated to yield 800 GWh per year.
- 7.1.29 Further details regarding energy yields are provided in the technical report.

The Mersey Barrage Company Stage III Report (1992) concludes in Table 4.9 that the energy yield of an ebb only barrage without flood tide pumping at our selected location would be:

- peak (1978) 1.21 TWh/yr
- mean (1974) 1.15 TWh/yr
- trough (1987) 1.08 TWh/yr

The range between 1.21 and 1.08 TWh/yr is due to the 18.6 year Nodal cycle that applies to the tidal amplitude in the Mersey.

The estimated energy yield for IBv2a of 1.05 TWh/yr applies to 2010. Year 2007 was the last trough and 2016 will be the next peak. Commissioning in 2020 would be on the way down towards the next trough again but roughly similar to 2010.

The reported estimate of 1.05 TWh/yr is within 10% of the Mersey Barrage Company mean figure. It is possible that further analysis and refinement of available bathymetry may result in an increase in the estimate produced from the OD modelling undertaken for this study but in view of the uncertainties associated with tidal energy modelling it is appropriate to adopt a prudently conservative approach at this stage.

Figure 7.4: Comparison with energy yields predicted by Mersey Barrage Company in 1992

- 7.1.30 IBv2a has not been assessed in detail by the 2D hydrodynamic modelling, Shadow Habitats Regulations Assessment, water quality assessment using flushing calculations, socio-economic, tourism and leisure assessment studies (see Section 7.3) given its similarity to IBv2b. The only difference between these schemes is the addition of low tide sluicing and a low tide hold period to the operational regime of IBv2b, to reduce low water levels in the impounded basin in order to increase the exposure of intertidal habitats. IBv2a has been studied as part of the technical and financial assessments (Sections 7.2 and 7.4) to establish the impacts of low tide sluicing on energy output and implications for financial performance. The impact on carbon balance of the higher energy yield of IBv2a compared to IBv2b has also been quantified.

7.2 Technical Acceptability

Physical Conditions

- 7.2.1 All schemes subject to detailed consideration at Stage 3 are located in Band A. The key details of the impounding barrage schemes appraised at Stage 3 are largely unchanged from Stage 2. The previously assigned Green rating for physical conditions (relating to water depth and estuary width) therefore remains valid for the impounding barrage with an unrestricted head.
- 7.2.2 Operating turbines under a restricted head permits operation at lower tide levels and therefore requires the turbines to be set lower down. However, the physical conditions in Band A permit this much more readily than upstream locations and so a Green rating for physical conditions is appropriate for the restricted (low) head schemes considered during Stage 3. If alternative turbines with a larger diameter or lower rated capacity were adopted for a low head scheme in future, the Estuary width in Band A may ultimately limit the number of turbines that could be installed but this should not influence the rating against physical conditions at this stage.

Maturity

- 7.2.3 At Stage 2 it was confirmed that bulb turbines are readily available within a commercial market and could be procured competitively. The technology was therefore rated Green. This rating remains valid and is applicable to all the schemes appraised at Stage 3 since all use conventional bulb technology.
- 7.2.4 A review of the low head turbine market concluded that only conventional bulb turbines and Ecobulb™ turbines operating over a low head could be technically suitable and commercially available at this time. Any other low head turbine would currently be rated as Amber or Red.
- 7.2.5 It should be noted that there is flexibility in the layout of the Stage 3 schemes so that if a low head turbine becomes sufficiently advanced within the project development timescales, it could be included within a revised barrage structure.

Warranty Risk

- 7.2.6 The performance of conventional bulb turbines is well understood and warranties would be available. As such the technology is rated Green for warranty risk.
- 7.2.7 For a warranty to be given by a manufacturer the performance would need to be well understood through an extended period of operation to demonstrate that units perform as expected from their prototype and demonstration trials. The adoption of any technology which has not had sufficient development time and initial commercial operation would mean that the supplier would be unlikely to be able to offer any substantive performance warranty and this would remain a risk to the project for any new turbine design.

Other Technical Issues

Grid Connection

- 7.2.8 The Stage 2 Options Report outlined the position in relation to the local distribution and transmission networks around Merseyside and grid connection. The transmission network in the Mersey area is characterised by a 275 kV ring network and National Grid have indicated that some or all of this may be upgraded to 400 kV in the next 10 years. Consequently there would potentially be benefits to the project by connecting at 400 kV as the infrastructure associated with a lower connection (275 kV or 132 kV) may require upgrading in the future if National Grid increase the ring to 400 kV.
- 7.2.9 A connection at the Capenhurst sub-station currently appears to be the most favourable location but further studies would need to be undertaken to understand upgrade requirements and connection thresholds. The assumption of a grid connection on the Wirral side remains valid for all options.

Flexible Operation

- 7.2.10 A range of operating strategies has been examined to explore the relationship between energy capture and environmental impact. Whilst this relationship is now better understood, no optimisation of operating rules has been carried out at this stage and further work would be required during the development of a preferred scheme to improve energy outputs and environmental performance.
- 7.2.11 Figure 7.5 shows the water levels at the structure through the tidal cycle for IBv2b, VLHBv2a and VLHBv3a compared to the natural tidal cycle (as predicted from the 2D hydrodynamic model). IBv1 (from Stage 2) is also included for comparison. IBv2b would create a much smaller tidal range in the upstream basin compared to the natural tidal cycle, with corresponding impacts on intertidal habitat exposure (see Section 7.3). VLHBv2a would have a smaller impact on low water levels and VLHBv3a an even smaller impact. However as the low water level would be better maintained by the restricted head operation schemes, there would be a greater impact on the high water level (with the greatest level of impact predicted for VLHBv3a).

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- 7.2.12 Increasing the number of sluice gates would offer benefits in terms of increasing high water levels (closer to natural high water levels) as more water can pass into the basin. If the sluice gates were to be opened sooner in the generating cycle, the low water levels would also be reduced although there would be some reduction in the energy yield. More sluices could be introduced in the development of the preferred scheme, at relatively little additional capital cost as the structure would require little modification. The effects of introducing additional sluice gates to IBv2b have been explored for the spring tide (when the impacts on natural low and high water levels would be greatest) (see Figure 7.5).
- 7.2.13 Introducing high tide pumping would also help to maintain natural high tide levels and could improve the energy yield by increasing the head and volume of water passing through the turbines on the ebb tide. There would be additional capital and operational costs associated and further study is necessary to explore the benefit:cost relationship, including consideration of the price of energy (the cost of buying and the price for selling) at different times of day.
- 7.2.14 The VLHBv2a and VLHBv3a scheme designs incorporate a larger number of turbines than the IBv2 schemes, and this would increase the capital cost. Although there is more flow through turbines during generation, the reduced head and operating efficiency associated with this mode of generation would result in the VLHBv2a and VLHBv3a schemes producing around half the energy yield of the IBv2 schemes. OD modelling has found that a smaller number of turbines operating in conjunction with sluice gates could be used to achieve restricted head generation but there would be a similar loss of energy output but a reduction in capital cost.
- 7.2.15 Flexibility in the mode of operation would enable generating patterns to be altered to better suit the peaks in demand for electricity. The greatest energy yield is available from the spring tide. The occurrence of spring tides is influenced by the sun and so follows a 24 hour cycle. In the Mersey Estuary spring ebb tides occur most often in windows around 6am and 6pm (see Figure 7.5) – so ebb generation on spring tides would be likely to occur around these morning and evening peak demand periods. At other times, ebb and flood generation could be used to create a better fit with demand.
- 7.2.16 The work undertaken has explored the inherent flexibility of a barrage scheme. It is possible to operate the barrage differently, at different periods in the tidal cycle, different times of year or indeed in response to specific issues such as flood risk or pollution.

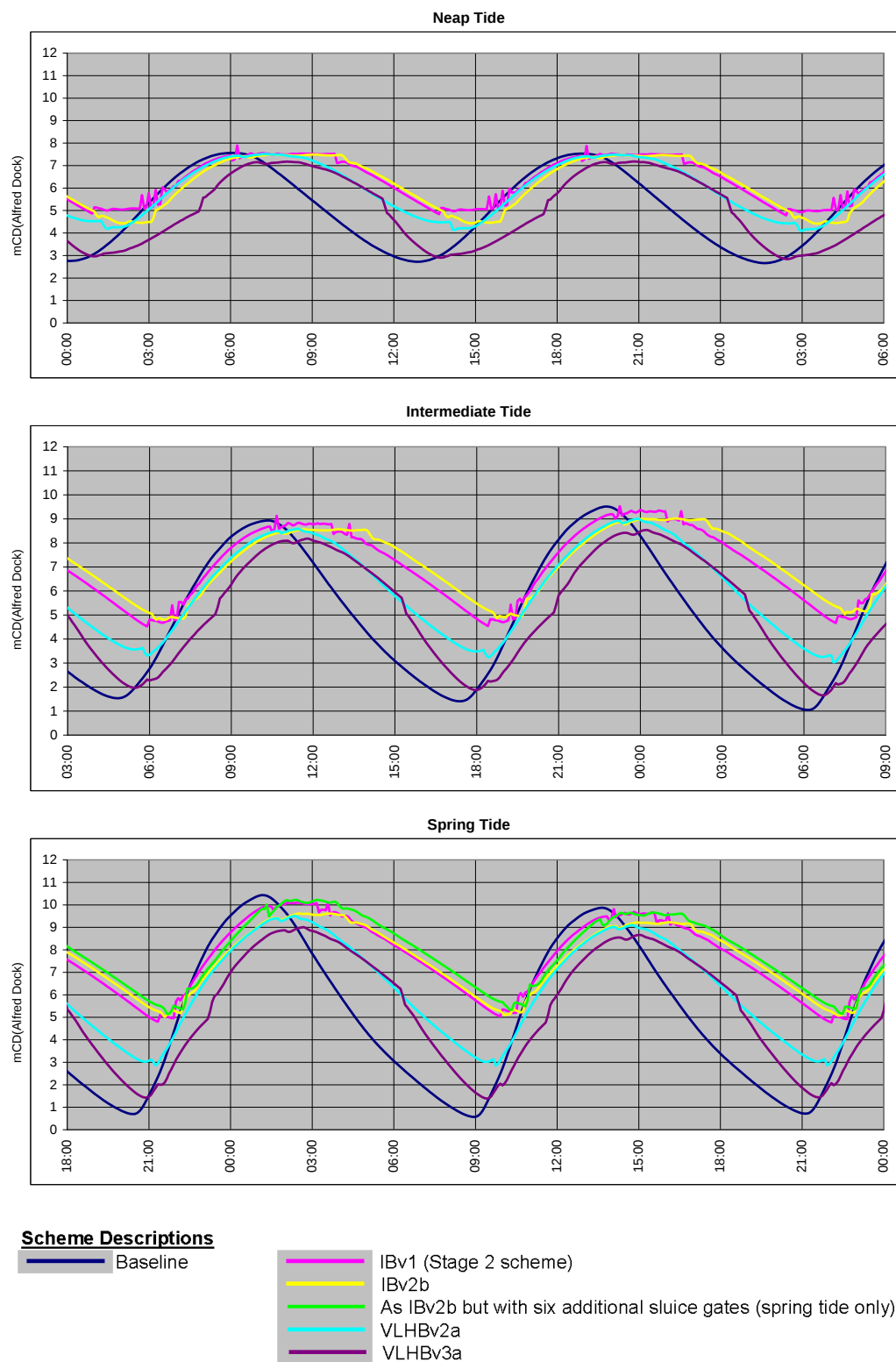


Figure 7.5: 2D tidal curves for IBv1, IBv2b, VLHBv2a and VLHBv3a and an additional variant to explore the effect of using more sluice gates

Overall Technical Acceptability

- 7.2.17 The technical risks associated with the schemes considered are discussed above, with all schemes under consideration rated Green technically.

7.3 Consenting Acceptability

- 7.3.1 Specialist assessments have fed into the sustainability appraisal, which has considered each of the scheme variants using the 21 indicators developed during a scoping study concluded during Stage 2. At Stage 2, a number of indicators were found not to be key differentiators between schemes because all scheme variants performed similarly. These indicators could have been scoped out for Stage 3, but the decision was taken to assess scheme variants against all 21 indicators for completeness.
- 7.3.2 The overall conclusions of the sustainability appraisal are illustrated in Table 7.2. A summary of the key conclusions of the specialist assessments (2D hydrodynamic modelling, Shadow Habitats Regulations Assessment, water quality assessment using flushing calculations, socio-economic, tourism and leisure assessment and carbon accounting assessment) is provided below. The technical reports that accompany this Feasibility Report provide further details.

Table 7.2: Sustainability appraisal summary matrix

Sustainability indicator		IBv2b	VLHBv2a	VLHBv3a
1	Internationally and nationally designated nature conservation sites	---	—	—
2	Species and habitats of conservation importance	---	—	—
3	Habitat creation or ecological enhancement	0	0	0
4	Levels of flood risk	—	—	0
5	Character and accessibility of places, landscapes and heritage assets	—	—	—
6	Lifecycle carbon balance of the development	++	++	++
7	Utilities infrastructure and resources	—	—	0
8	Waste production, reuse and recycling	—	—	—
9	Ecological status or potential of the Mersey Estuary and other water bodies (in relation to the Water Framework Directive)	—	—	—
10	Emission of air pollutants	—	—	—
11	Land quality	0	0	0
12	Transport infrastructure	0	0	0
13	Amenity for recreation, tourism and leisure	+	+	+
14	Human health and wellbeing	+	+	+
15	Education and skills training	++	++	++
16	Local business and jobs	++	++	++
17	Inward investment and image	++	++	++
18	Technological innovation	+	+	+
19	Commercial navigation	—	—	—
20	Generation of renewable energy from the Mersey Estuary	++	+	+
21	Commercial fish stocks	0	0	0

Key:

Rating colour and symbol	Rating description
++ (double plus sign)	Large benefit
+	Some benefit
0 (zero)	No change
— (single minus sign)	Some adverse effect
--- (double minus sign)	Large adverse effect

Environment

Coastal and Estuarine Processes

Potential Impacts

- 7.3.3 Regardless of the operating regime, any tidal power scheme will change the existing hydrodynamic and sediment transport regime, including changes to low and high water levels, changes to currents and flow velocities and changes to sedimentation patterns. Changes will occur over the short and longer term with a new hydrodynamic regime expected to take 50 to 100 years to be established. Significant changes due to climate change are likely to occur over a longer time period.
- 7.3.4 Impacts on the hydrodynamic and sediment transport regime will alter the morphology of the Estuary and therefore the extent, distribution and quality of estuarine habitats (see Ecology and Nature Conservation assessment below). Consideration of potential hydromorphological changes is also relevant to the Water Framework Directive. Water quality and flood risk changes could also occur (see Water Quality and Flood Risk assessments below). Without appropriate avoidance, mitigation and management measures, changes may be both adverse and beneficial – for example intertidal sediments may become sub-tidal in some areas, but new intertidal areas may be created elsewhere due to accretion.
- 7.3.5 2D hydrodynamic modelling has been used to provide an initial indication of changes to the hydrodynamic regime through the tidal cycle, particularly water levels. The extents of the model are shown in Figure 7.6. Sediment transport modelling has not been undertaken for option appraisal, but a qualitative assessment of the likely impacts of a tidal power scheme on these processes has informed the options appraisal. Sediment transport modelling would be undertaken to inform the development of the preferred scheme in later stages.

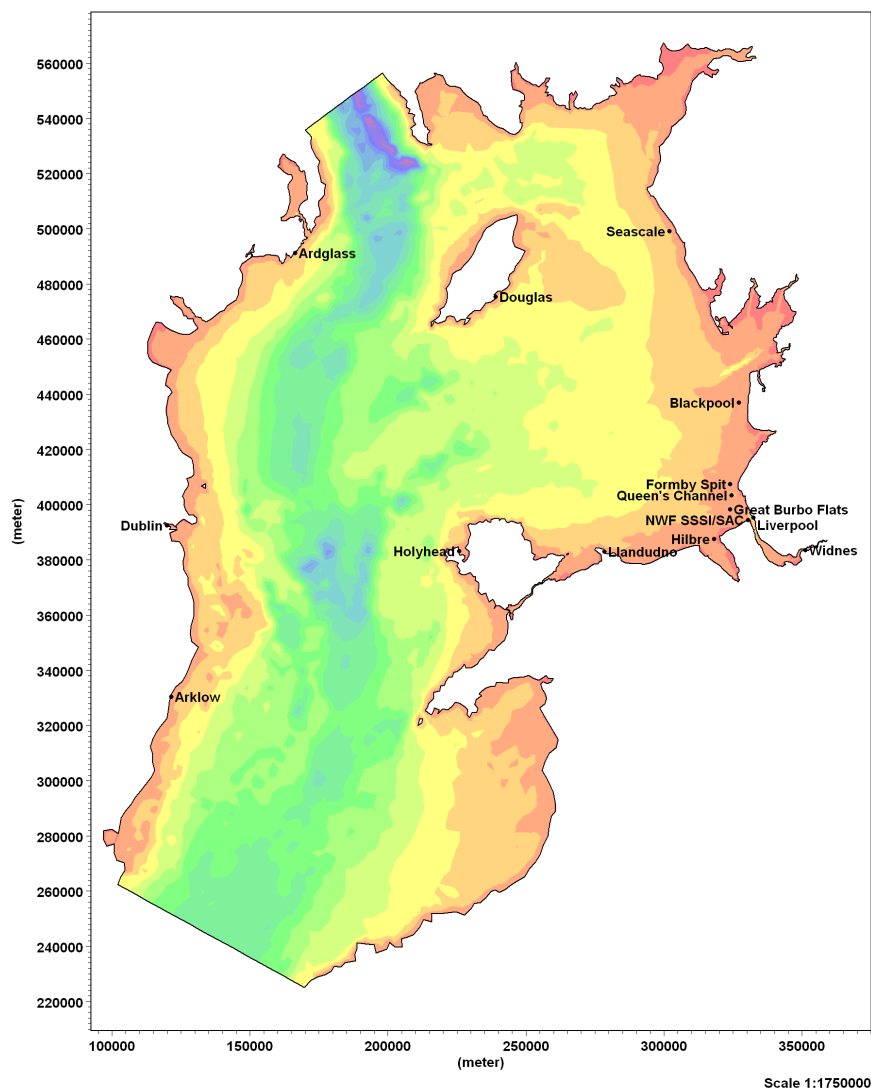


Figure 7.6: Extent of 2D hydrodynamic model

Colour indicates water depth, increasing from red to yellow to green to blue.

Impact Assessment

- 7.3.6 The water levels at five locations within and just outside of the Estuary have been evaluated for each of the schemes modelled compared to the baseline (without scheme) in 2060 (allowing for changes due to climate change). Water levels for the wider area (farfield effects) have also been considered.
- 7.3.7 Figure 7.7, Figure 7.8 and Figure 7.9 show the set of graphs used to complete the evaluation of impacts on water levels within the Estuary. These show (top to bottom) the water level at Gladstone Dock, The Narrows immediately downstream of the barrage, the basin (immediately upstream of the barrage), Eastham and Widnes for the three typical tidal conditions of neap, intermediate and spring tides.

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- 7.3.8 The curves show that at Gladstone Dock the high and low water levels for the neap tide would be more or less unaffected by the schemes; however the low tide level on spring tides would be affected. This is due to the release of water from the basin whilst the natural low water would be occurring; thereby raising the low water level. This is seen again at the Narrows, just downstream of the barrage.
- 7.3.9 Upstream of the barrage there would be more significant changes to the water levels throughout all tidal cycles and for all schemes. Notably the predicted high water level for neap tides was similar for all schemes with the neap tide being very close to the natural neap water level. The spring high water level was however predicted to be significantly reduced for all of the schemes. More sluice gates could be used to raise the high water level as discussed in Section 7.2 above.
- 7.3.10 The predicted low water levels were different for all schemes due to the differences in operating strategy. Notably the lowest low water level was achieved using VLHBv3a; however to achieve the low water level the sluice gates were assumed to be opened an hour prior to the predicted low water level (in fact the low water level was delayed so the sluice gates were opened around three hours before the actual low water level – as is evident on Figure 7.5). The low tide sluicing implemented on IBv2a was not effective at reducing the low water level because the water level outside of the basin would be rising shortly after the end of the generating period as the flood tide enters the Estuary, with insufficient time for sluicing to reduce the water level in the basin and expose more intertidal habitat.

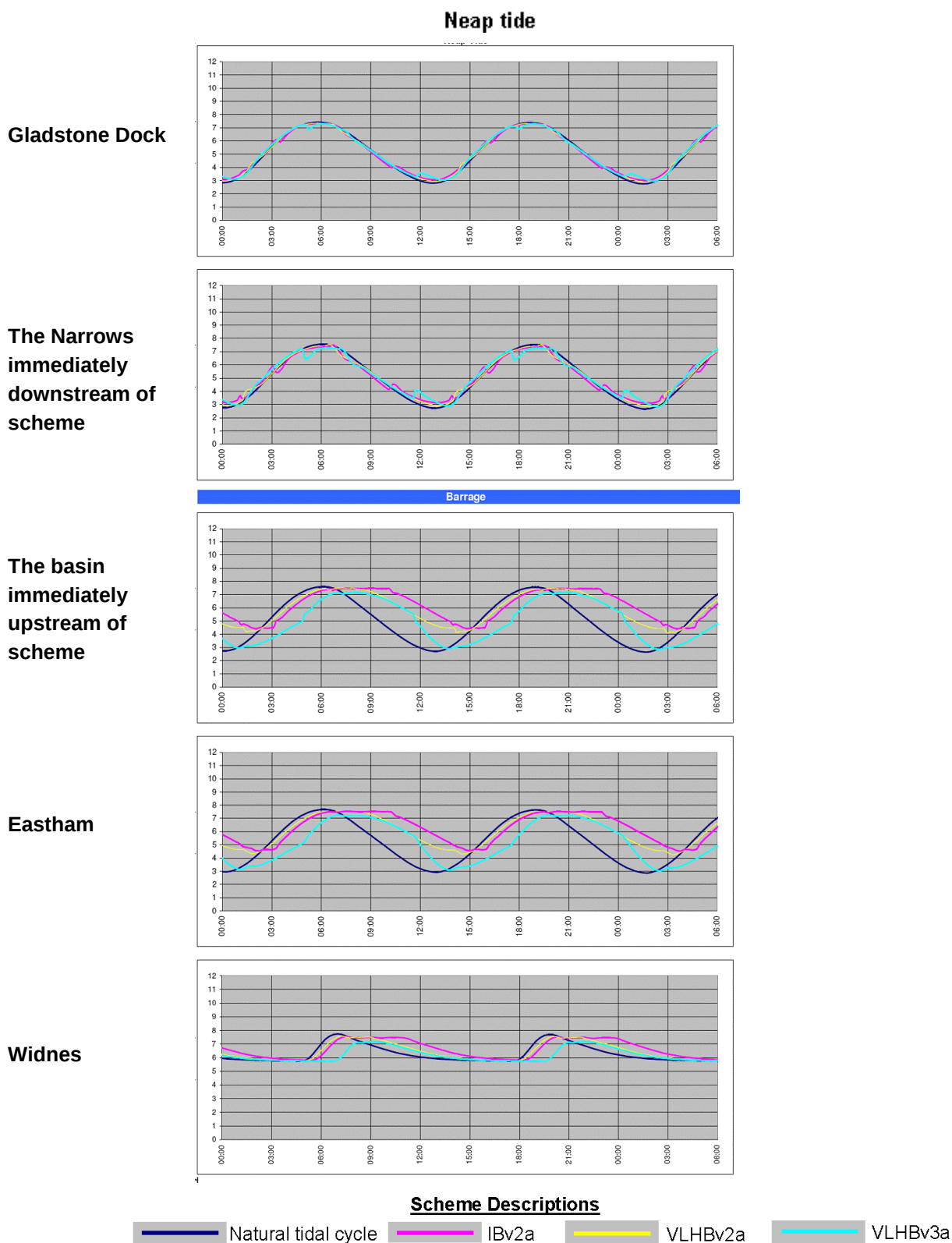


Figure 7.7: Water levels at neap tide at different locations in the Estuary from Gladstone Dock to Widnes

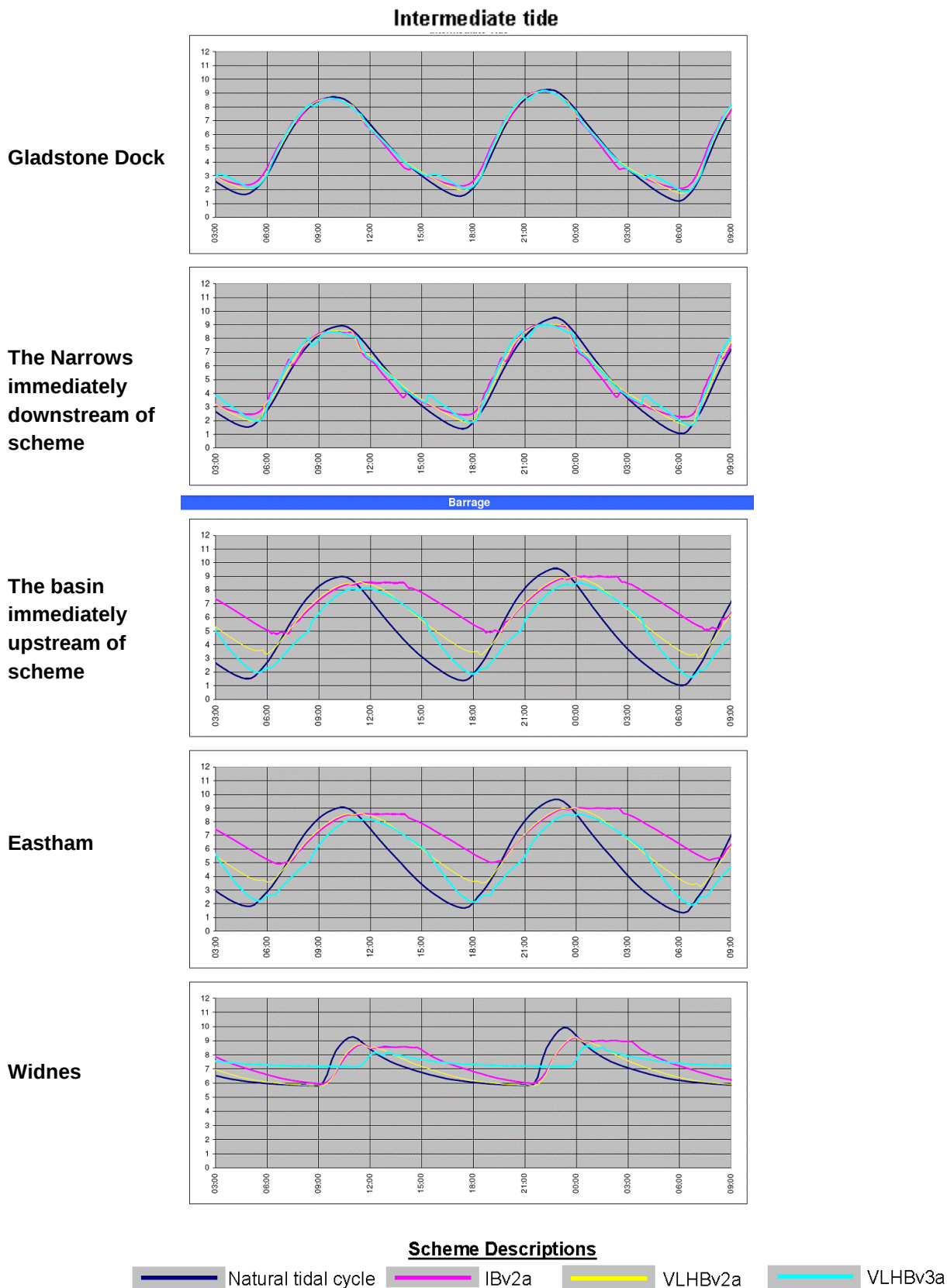


Figure 7.8: Water levels at intermediate tide at different locations in the Estuary from Gladstone Dock to Widnes

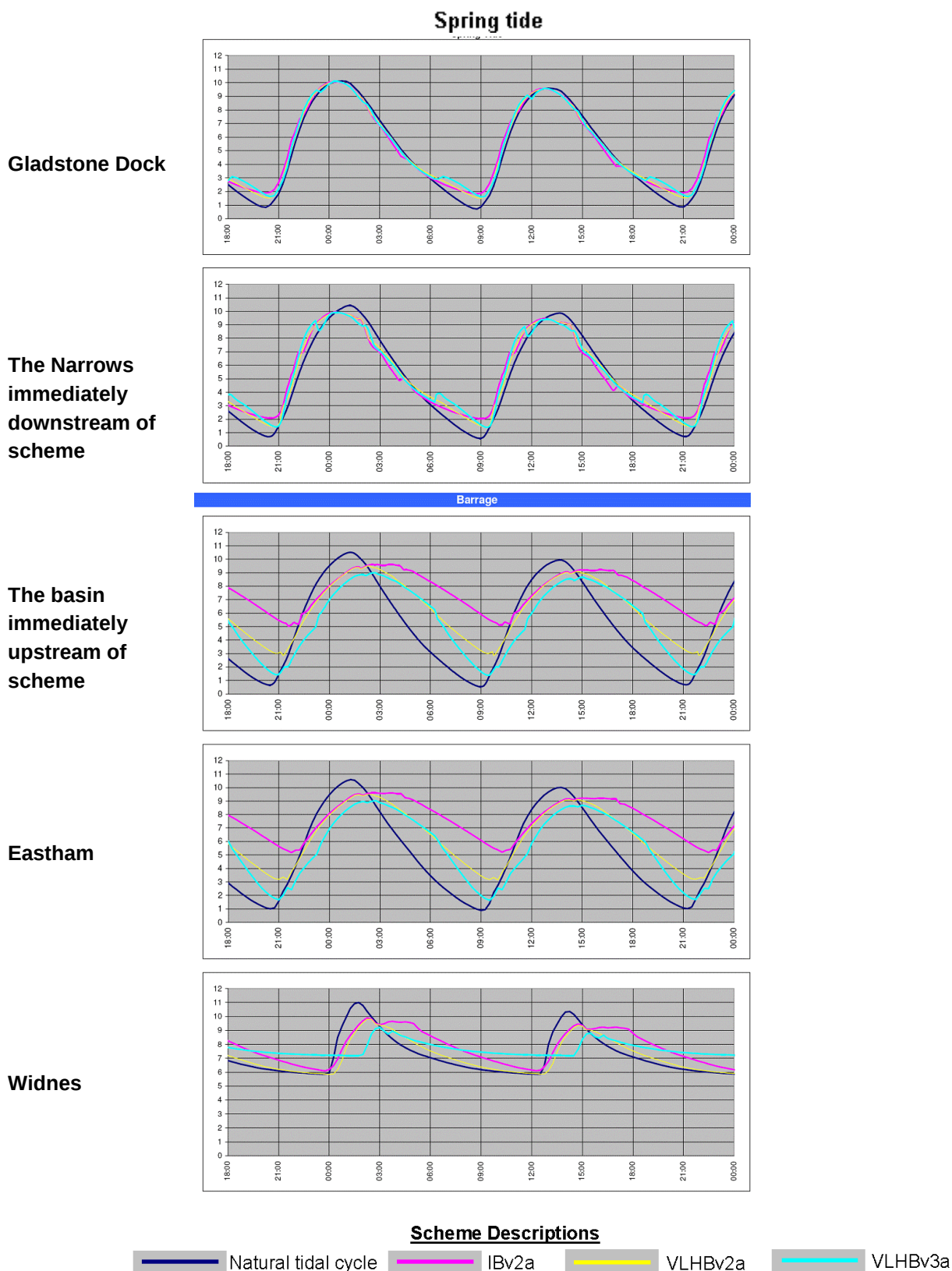


Figure 7.9: Water levels at spring tide at different locations in the Estuary from Gladstone Dock to Widnes

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- 7.3.11 Lower high water levels and raised low water levels upstream of the structure (see Figure 7.7 to Figure 7.9) would reduce the amount of water passing the barrage between high and low water and result in a general reduction in current speeds in the Estuary, with resulting effects on sediment transport and flushing of the Estuary (see Water Quality assessment below). Over the long term, it is estimated that there may be a reduction in siltation and loss of intertidal area without intervention, but sediment transport modelling is required to provide further detail.
- 7.3.12 Changes in high and low water levels would also result in a change in the mean water level in the Estuary with potential impacts on groundwater levels and saline intrusion (see Water Quality and Groundwater Level assessments below).
- 7.3.13 High or low water stand periods (when the low and high water levels are prolonged by the operation of the barrage) would allow fine sediments a longer period of time to settle out of the water column, which could result in lower turbidity at the end of the standing period. Conversely, shortening the period over which ebb and flood tidal currents run may result in increases in current speeds and increased suspended sediment concentrations during these periods. The distribution of sediments will alter as a result of changes to currents, but it is not possible to predict localised changes until sediment transport modelling is undertaken.
- 7.3.14 As waves upstream of Band A are locally generated, the presence of a barrage will not affect the amount of wave energy entering the Estuary from the sea. However a high water stand period could result in upper intertidal areas being exposed to waves for a longer period of time and this, combined with reductions in high water levels, could cause erosion of saltmarsh and increase sedimentation of sub-tidal areas.
- 7.3.15 Estuaries are dynamic environments, and the locations of channels are constantly changing. The configuration of turbines and sluices for each scheme variant has been selected based on the most suitable ground conditions for the turbines, but the flow patterns created by these arrangements may fix the locations of channels downstream of the structure. Channels may continue to change upstream, although sub-tidal channels may be infilled if the low water level is raised.
- 7.3.16 Farfield effects on water levels in the Irish Sea and Liverpool Bay have also been studied using the hydrodynamic model. Overall, farfield effects were predicted to be limited to areas within, and local to, the Estuary mouth (see Figure 7.10 and Table 7.3).
- 7.3.17 In the areas around the Estuary mouth where water level changes were predicted with scheme compared to baseline, low water levels were predicted to be higher than the baseline (ranging from a few centimetres difference at most sites to c.80-130 cm difference at Gladstone Dock (Liverpool), depending on the scheme) and high water levels were predicted to be lower than the baseline (generally <10 cm difference for each site with the exception of Gladstone Dock (Liverpool) where spring high water would be approximately 30 cm lower). Effects on the tidal range were predicted to be similar for spring and neap tides.

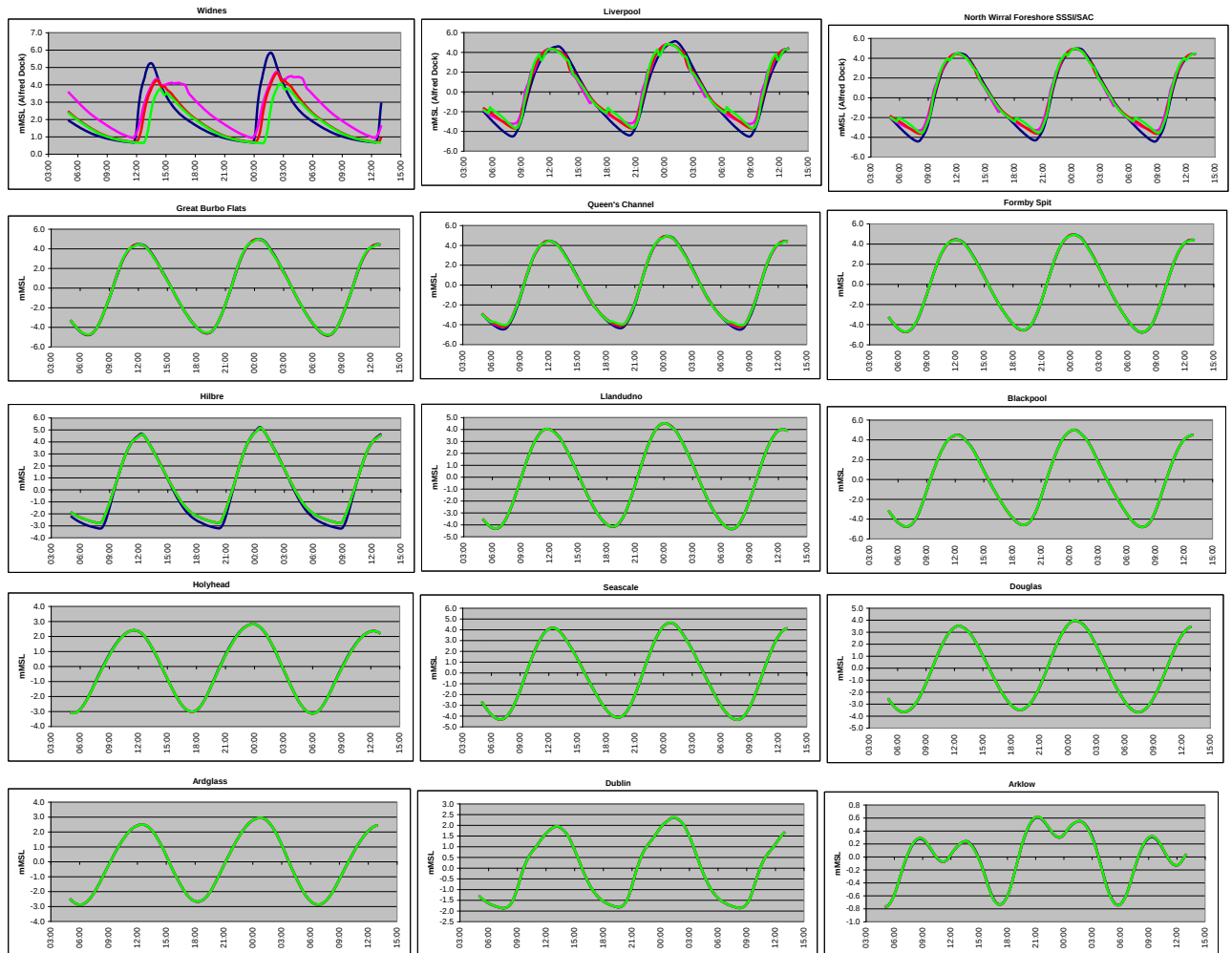


Figure 7.10: Graphs showing comparison of spring tide water levels at various locations within and outside the Estuary

Left to right and top to bottom: Widnes, Liverpool, North Wirral Foreshore, Great Burbo Banks, Queen's Channel, Formby Spit, Hilbre, Llandudno, Blackpool, Holyhead, Seascale, Douglas, Ardglass, Dublin and Arklow

Blue = baseline, pink = IBv2b, red = VLHBv2a, green = VLHBv3a

Note that where only one curve is visible, the values are all the same or similar

Table 7.3: Maximum absolute changes in water levels (m) at various locations

Location	Spring tide			Neap tide		
	IBv2b	VLHBv2a	VLHBv3a	IBv2b	VLHBv2a	VLHBv3a
Widnes	2.03	2.57	4.39	1.23	0.63	2.00
Liverpool	1.61	0.97	1.36	0.55	0.60	0.88
North Wirral Foreshore	1.11	0.89	1.26	0.41	0.43	0.63
Great Burbo Flats	0.21	0.11	0.15	0.11	0.10	0.15
Queen's Channel	0.30	0.30	0.48	0.13	0.13	0.21
Formby Spit	0.11	0.08	0.10	0.08	0.07	0.10
Hilbre	0.61	0.60	0.61	0.18	0.24	0.27
Llandudno	0.05	0.03	0.06	0.05	0.03	0.04
Blackpool	0.05	0.04	0.06	0.05	0.02	0.06
Holyhead	0.06	0.06	0.06	0.02	0.02	0.02
Seascale	0.04	0.03	0.04	0.03	0.02	0.03
Douglas	0.03	0.02	0.03	0.02	0.01	0.02
Ardglass	0.01	0.01	0.01	0.01	0.01	0.01
Dublin	0.02	0.02	0.02	0.02	0.02	0.02
Arklow	0.02	0.02	0.02	0.01	0.01	0.01

Potential Impact Avoidance and Mitigation Measures

- 7.3.18 Design and operational regime changes can be implemented to reduce impacts on high and low water levels. Low tide sluicing has been tested in IBv2b and the use of additional sluice gates could further reduce low water levels and help maintain closer to existing high water levels. High tide pumping could be used to increase high water levels.

Conclusions

- 7.3.19 The operating strategies tested have provided information on the effect of strategy components such as restricted head generation, optimised starting heads, low tide sluicing and two-way generation (ebb and flood). All of the schemes considered would have an impact on the hydrodynamics and therefore the sediment transport processes. The testing of these scheme variants provides information that has been used to develop an optimal scheme to meet the project objectives, that utilises a flexible operating regime to suit the tidal and seasonal cycles to provide the best overall scheme.

Ecology and Nature Conservation

Potential Impacts

- 7.3.20 Potential impacts on the Mersey Estuary SPA site have been considered as a 'proxy' for impacts on other nationally and internationally designated sites, on the basis that nearfield effects will be greater than farfield effects (see Coastal and Estuarine Processes section above). The hydrodynamic model has been used to examine the potential effects of the scheme on water levels at locations within the Irish Sea, Liverpool Bay and the Mersey Estuary for the baseline (without scheme) scenario and with each scheme.
- 7.3.21 Farfield effects on water levels have the potential to affect the exposure time and quality of intertidal habitats between Hilbre and Formby Spit. The potential effects of these impacts on birds would be considered for the preferred scheme in subsequent stages, but are anticipated to be relatively minor compared to nearfield effects and largely in proportion with those nearfield effects.
- 7.3.22 Impacts on the extent and quality of habitats that support the Mersey Estuary SPA bird populations, and the time available for feeding, have been assessed using the 2D hydrodynamic modelling outputs, which provide estimated water levels at 30 minute intervals through the tidal cycle for each scheme variant compared to the baseline (without allowing for changes to sediment levels and locations).
- 7.3.23 The assessment has followed a Shadow Habitat Regulations Assessment methodology, which has been developed in consultation with the Environment Technical Group. It has considered the likely impacts of each scheme variant on the features and sub-features of the SPA as follows:
- birds – change in numbers/ displacement (based on available bird foraging habitat area, exposure time and length of wetted perimeter), and change in obstructions to view lines;
 - intertidal sediment – change in extent and distribution of habitats, change in presence and abundance of prey species, and change in presence and abundance of mud-surface plants and green algae;
 - rocky shore habitat – change in extent and distribution, and change in presence and abundance of intertidal invertebrates; and
 - saltmarsh habitat – change in extent and distribution, change in presence and abundance of prey species, change in presence and abundance of soft-leaved and seed-bearing plants, and change in vegetation height in areas used for feeding and roosting.
- 7.3.24 The assessment of each sub-feature has enabled an overall assessment and comparison of likely impacts on the ecological structure and function of the SPA (and ultimately its integrity) as a result of each scheme variant, to inform the identification of a preferred scheme.

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- 7.3.25 In addition to assessment of impacts on the SPA, potential impacts on relevant biological elements in relation to the Water Framework Directive have been assessed. These comprise invertebrates, fish, phytoplankton, macroalgae and saltmarsh angiosperms.
- 7.3.26 The risk of increased predation of shorebirds and fish by birds of prey, obstruction to shorebirds sightlines and potential disturbance of birds by visitors to the area have been considered and would be similar for all schemes. Potential water quality impacts are discussed in the Water Quality section below.
- 7.3.27 Potential impacts on other ecological receptors that are not directly relevant to the Habitats Regulations or the Water Framework Directive, such as marine mammals and terrestrial ecology, have also been considered where relevant.

Impact Assessment

Mersey Estuary SPA

- 7.3.28 Changes in tidal levels associated with the presence and operation of a tidal power scheme in the Mersey Estuary would lead to short and likely long term changes to areas of intertidal habitat, their time of exposure and quality in terms of invertebrate communities for birds to feed on and wetted perimeter. Each of these parameters (extent, time and quality) has been considered in turn to inform consideration of likely overall impacts on bird fitness and therefore the ecological structure and function of the SPA.
- 7.3.29 The water level changes throughout the tidal cycle predicted by the 2D hydrodynamic model have been used to provide an initial indication of potential changes to intertidal habitat extent, exposure time and quality. It is important to note that the model does not take account of measures to prevent harm and mitigate impacts beyond the measures incorporated into the design and operation as described in Table 7.1. It also does not account for potential changes to sediment movement patterns, which may affect levels and locations of intertidal habitats (see Coastal and Estuarine Processes assessment above). The model uses a 2060 scenario that makes an allowance for sea level rise due to climate change (see paragraph 2.2.6).
- 7.3.30 The overall potential changes to the extent of intertidal habitat as a result of change to high and low water levels, based on the 2D modelling outputs (with no allowance for sediment movements), are shown in Figure 7.11 for each scheme variant, for spring, intermediate and neap tides. Changes in the extent of intertidal sediments habitat types (specifically, and in relative order of importance, mud, muddy sand and sandy mud) are most important for birds because they provide the most abundant food supply.

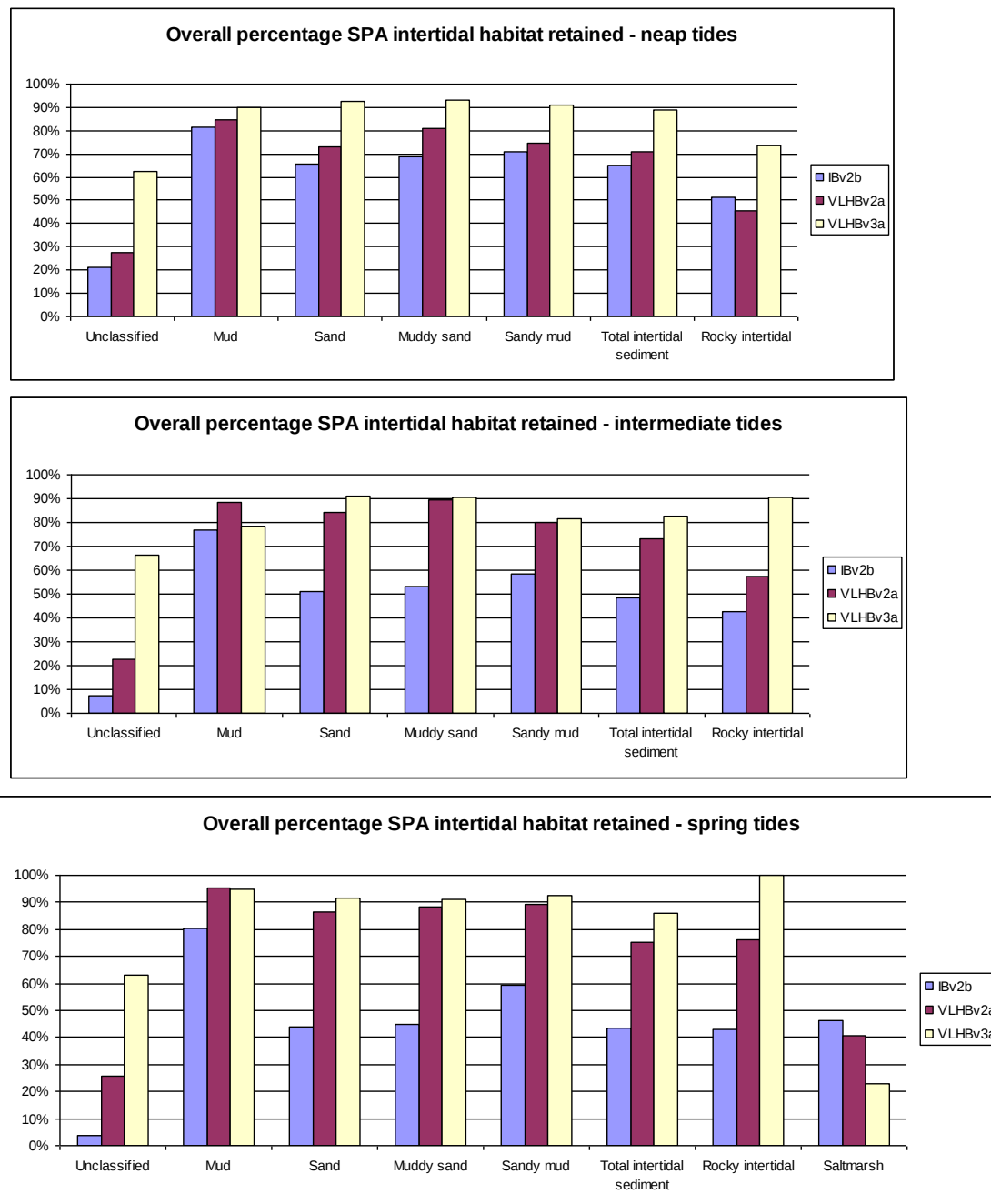


Figure 7.11: Predicted overall changes to current (2002) surface area of SPA habitats using water level data from 2D hydrodynamic model with no allowance for sedimentation changes

Note salt marsh is only shown on spring tide graph as this habitat would only be potentially lost (by encroachment of terrestrial vegetation) if not inundated on spring tides

- 7.3.31 Of the three scheme variants assessed at Stage 3, IBv2b was predicted to have the greatest impact on the extent of intertidal sediments at low water with over 50% of SPA intertidal sediments not exposed on spring tides and over 30% not exposed on neap tides. The benefits of introducing low water sluicing have been evaluated by comparison with the IBv1 scheme modelled and assessed at Stage 2. In terms of area exposed, low tide

- sluicing (using 18 sluice gates as included in IBv2b) provided a small increase in exposure but this is likely to be insignificant given both its small extent relative to the size of the intertidal habitats as a whole and its uncertain quality as a feeding area. The use of more sluice gates and changes to the operating regime to commence sluicing earlier on the ebb tide could provide a more significant benefit (but would reduce the energy yield).
- 7.3.32 The restricted head operation schemes VLHBv2a and VLHBv3a were predicted to have less impact on the low water level compared to IBv2b, with around twice the intertidal area predicted to be exposed at low water with VLHBv2a compared to IBv2b, and around twice the intertidal area predicted to be exposed at low water with VLHBv3a compared to VLHBv2a.
- 7.3.33 Lower high water levels would result in some loss of intertidal habitats. Reduced inundation would increase the risk of encroachment of intertidal sediments and succession to terrestrial vegetation communities, with corresponding changes to invertebrate populations. The predicted changes to saltmarsh areas at spring tide shown on Figure 7.11 are calculated based on areas of saltmarsh that are no longer inundated at spring high water due to reduced high water levels. Saltmarsh is not shown on the graphs for intermediate and neap tides, as saltmarsh no longer inundated on intermediate and neap tides could be maintained if inundated on spring tide only. In the long term the area of saltmarsh may occupy a similar area but be located slightly lower on the shore. The use of more sluice gates could increase high water levels to some degree and so reduce impacts on upper intertidal areas, as would the introduction of high tide pumping.
- 7.3.34 The extent of habitat available at any one point in the tidal cycle does not provide a complete picture of the area available for bird feeding. Reductions in intertidal habitat exposure time have been found to be more likely to reduce bird fitness than reductions in exposure area (Goss-Custard et al, 2006a), and habitat quality in terms of available prey items and their size is equally important (Goss-Custard et al, 2006b). For each scheme variant, hydrodynamic model data at 30 minute intervals during a full tidal cycle have therefore been used to estimate:
- the length of wetted perimeter (shorebirds tend to feed at the water's edge);
 - the total amount of time that intertidal sediments would be exposed and available for birds to feed at threshold densities of 100 birds/ha or less, and 200 birds/ha or less (above which significant competition may come into effect (Stillman and Goss-Custard, 2010)); and
 - the change in invertebrate prey biomass in intertidal habitats.
- 7.3.35 To calculate the areas required to allow feeding to occur at densities of less than 200 or 100 birds/ha the number of birds typically feeding on the intertidal sediments was considered. At designation the average peak population over the non-breeding season was 104,599 (based on counts from 1993/94 – 1997/8). These are peak counts (for the whole of the winter periods), and include species that do not feed at the very moment the flats are first exposed by the ebbing tide, tending rather to wait until the tide has fallen some distance, and other species that do not feed right up to high water on the flood tide. The peak count also includes species which do not feed on the intertidal sediments at all.

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- The number of birds selected for the density calculations to enable a comparison of the schemes, factoring in the above considerations was 40,000, – although for the purposes of comparison, the precise number of birds used would be very unlikely to affect the outcome.
- 7.3.36 Changes to invertebrate prey biomass could be caused by changes to their intertidal habitats, both in terms of exposure regime and sediment type. Invertebrate survey data from 2010 and predicted changes to habitat exposure from the 2D hydrodynamic model were used to estimate the likely change. Only low water changes were assessed as this is the most important feeding period for birds. The predicted changes to invertebrate prey biomass follow a similar pattern to the predicted changes to intertidal habitat areas at low water (see).
- 7.3.37 Changes to mud-surface plants and green algae, soft-leaved and seed-bearing plants on saltmarsh, and vegetation height on saltmarsh are relevant in terms of the SPA bird features but changes are likely to be of lesser importance to birds than changes to exposure of intertidal sediments and prey biomass. A qualitative assessment of effects was made for these sub-features as part of the overall assessment.
- 7.3.38 The findings of each aspect of the bird impact assessment before mitigation are presented in Table 7.4 with graphical representations of the tidal cycle for each scheme variant shown in Figure 7.12, Figure 7.13 and Figure 7.14.
- 7.3.39 The overall effect on SPA bird populations was predicted to be greatest for the IBv2b scheme and smallest for VLHBv3a. VLHBv3a (before mitigation) was predicted to increase the length of the foraging period such that risks to bird survival and potential for reduction in numbers would be lowest for this scheme variant.

Table 7.4: Comparison of Stage 3 scheme variants for impacts relevant to SPA bird populations before mitigation, compared to baseline (2060, i.e. with allowance for climate change)

Ecological parameter	IBv2b	VLHBv2a	VLHBv3a
Area of soft sediments at low tide within SPA (mud, muddy sand and sandy mud combined)	Decreased by 22-36%	Decreased by 9-17%	Decreased by 4-5%
Area of soft sediments at high tide within SPA (mud, muddy sand and sandy mud combined)	Over a relatively short timescale, sediment deposition and saltmarsh colonisation at the upper shoreline would be likely to result in no significant change in areas at high tide.		
Area of saltmarsh within SPA			
Area of intertidal rock at low tide within SPA	Decreased by 50-65%	Decreased by 30-50%	Decreased by 0-5%
Length of wetted perimeter over soft sediments at low tide within SPA (mud, muddy sand and sandy mud combined)	No change	No change	No change
Length of wetted perimeter over soft sediments at high tide within SPA (mud, muddy sand and sandy mud combined)	Increased by 7-226%	Increased by 3-257%	Increased by 33-428%
Invertebrate biomass in SPA	Decreased by 20-30%	Decreased by 9-15%	Decreased by 6-9%
Duration of intertidal feeding time with bird densities <200/ha and <100/ha in SPA on spring tides	Decreased by 2.33-3.45 hrs	Decreased by 0.33- 1.22hrs	0.43hrs increase- 0.33hrs decreased
Duration of intertidal feeding time with bird densities <200/ha and <100/ha in SPA on intermediate tides	Decreased by 1.88- 2.78hrs	Decreased by 0.22- 0.88hrs	Increased by 2.33- 0.33hrs
Duration of intertidal feeding time with bird densities <200/ha and <100/ha in SPA on neap tides	No decrease	No decrease	No decrease

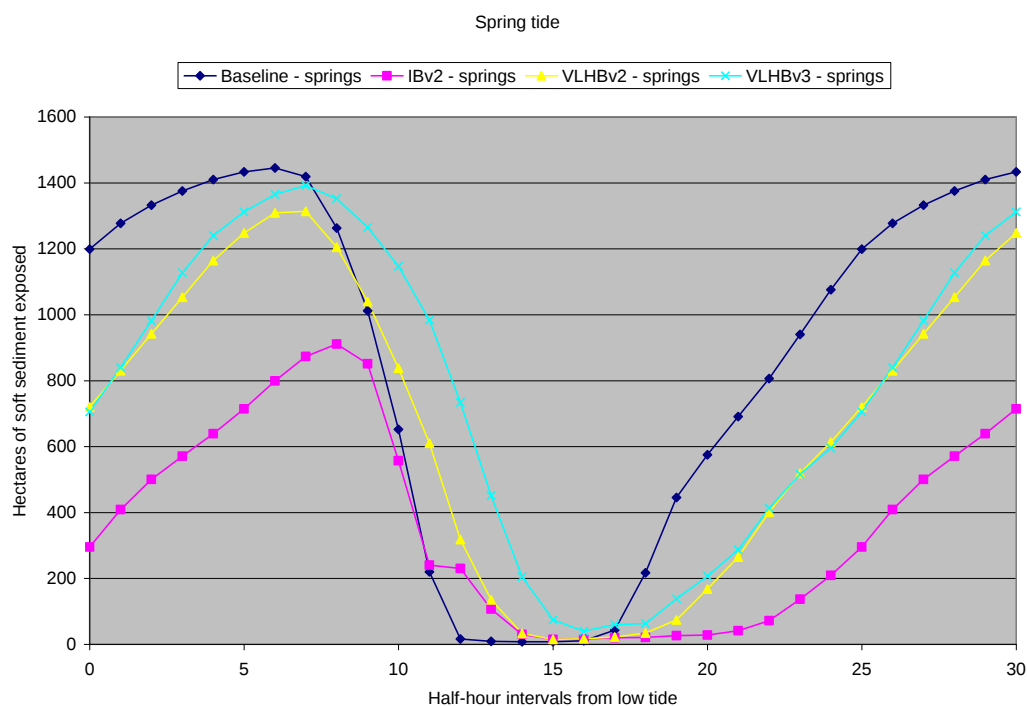


Figure 7.12: Total intertidal mud, muddy sand and sandy mud area exposed for bird foraging over spring 2060 tidal cycle with no allowance for sedimentation changes

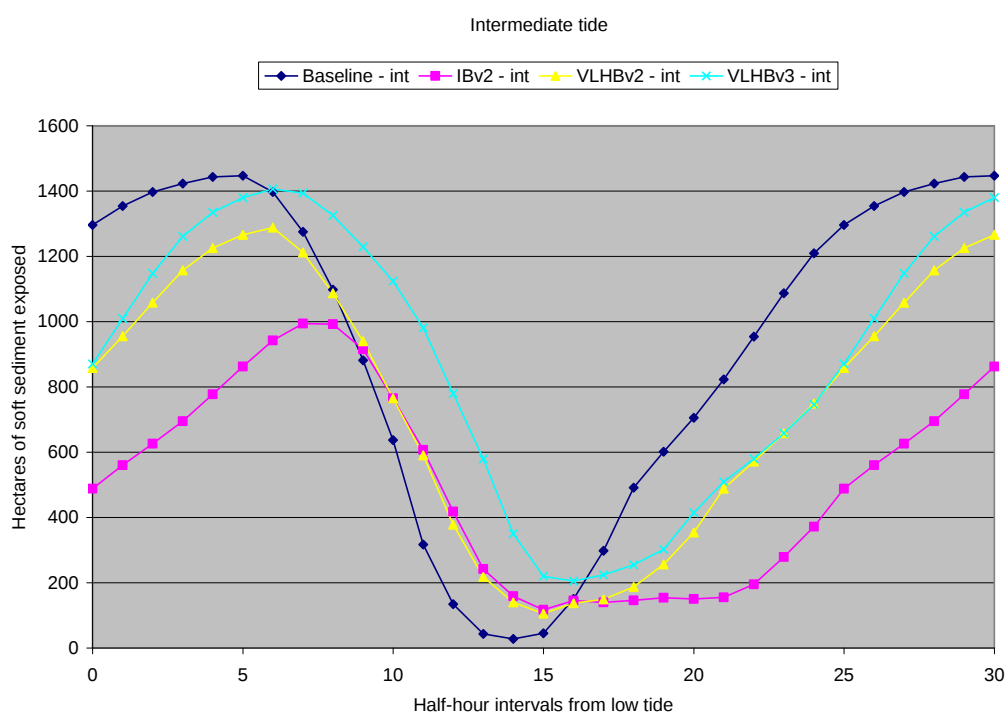


Figure 7.13: Total intertidal mud, muddy sand and sandy mud area exposed for bird foraging over intermediate 2060 tidal cycle with no allowance for sedimentation changes

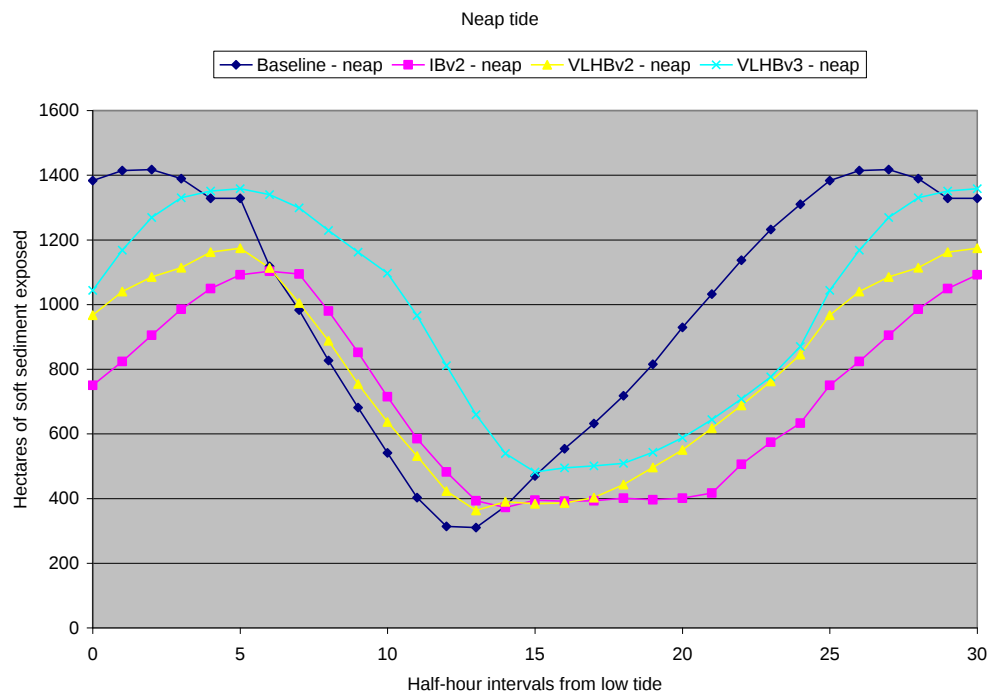


Figure 7.14: Total intertidal mud, muddy sand and sandy mud area exposed for bird foraging over neap 2060 tidal cycle with no allowance for sedimentation changes

7.3.40 Figure 2.3 indicate that there are currently very few teal, pintail, wigeon and golden plover feeding within the SPA such that the likely impacts of any scheme on the SPA areas used by these species will have limited adverse effects. Of the other species upon which the SPA is designated, relatively high numbers of redshank, shelduck, godwits and curlew have been recorded in July to September. Numbers are also high during November to March. The graphs illustrate how the SPA bird species use the Estuary at different times of year, with bird populations on the Estuary being largest in autumn and winter. Seasonal usage of the Estuary has been taken into account in the impact assessment and recommendations for the preferred scheme.

Water Framework Directive Biological Parameters

- 7.3.41 Adverse effects on invertebrate, phytoplankton and macroalgae biological Water Framework Directive parameters were predicted to be lower with VLHBv3a compared to IBv2b and VLHBv2a.
- 7.3.42 As described above, no significant overall change in the extent of saltmarsh is predicted for any of the scheme variants in the long term, but the location of the saltmarsh may alter.
- 7.3.43 Fish may be injured or killed from turbine passage during generation due to mechanical, pressure, shear, turbulence and cavitation mechanisms. Susceptibility of fish to injury or mortality may vary for different species. For example fish species reaching larger body sizes may be more prone to strike by turbine blades than smaller fish species, however,

smaller fish may be more at risk from other effects such as shear stress. Mortality rates from turbine passage have been studied for some species, for example mortality rates from passage through bulb turbines was found to be 2-10% for salmon and up to 38% for eels (APEM, 2010). Effects on fish would also likely be greatest for the ebb and flood generation scheme (VLHBv3a) because generation on both tides would increase the chance of fish passing through generating turbines.

Other Ecological Receptors

- 7.3.44 Relatively low numbers of marine mammals including cetaceans (whales, dolphins and porpoises) have been observed within the Mersey Estuary and in general the coastal waters of Liverpool Bay are also rarely visited by cetaceans (data collated by the Mersey Estuary Conservation Group (MECG) indicated that between 1829 and 1980, there were 320 sightings and strandings within the Estuary and Liverpool Bay region and between 2002 and 2005 another 50 were recorded (MECG, 2006)). Of the individuals recorded, harbour porpoise and bottlenose dolphin are the most frequently observed but thirteen other species of cetaceans have been recorded in Liverpool Bay and adjacent areas since 1975, including dolphin (Risso's and short-beaked common dolphin), orca and minke whale (Evans 1996, Evans and Shepherd, 2001). There are no major seal breeding sites in the Liverpool Bay area, though grey seals regularly feed in the outer Dee Estuary area.
- 7.3.45 Potential impacts of a tidal power scheme on marine mammals include effects of underwater noise generated during construction, disruption and visual disturbance and restricted movement of individuals along the Estuary.
- 7.3.46 A number of non-statutory designated nature conservation sites are located in the vicinity of Band A, including Pond at International Garden Festival, Otterspool Gorge and Otterspool Park Sites of Nature Conservation Value, and Brotherton Park and Dibbinsdale Local Nature Reserve. Ecological surveys of landside areas will be undertaken in future stages, to inform design.

Potential Impact Avoidance and Mitigation Measures

- 7.3.47 A number of operational measures to prevent impacts on estuarine habitats and bird populations have been tested at Stage 3 (see paragraph 7.1.13).
- 7.3.48 Restricted head generation is an operating regime that has been explored specifically for its perceived ecological advantages over unrestricted head generation. Comparison of IBv2b and VLHBv2a indicates that head restriction would significantly reduce impacts on intertidal habitats and SPA bird populations compared to unrestricted head generation.
- 7.3.49 Ebb and flood generation seems to create a more natural tidal cycle than ebb only generation. Intertidal habitat exposure at low water (the most important time for bird feeding) was greater for VLHBv3a than for the ebb only schemes, although high water levels would be lower than for the ebb only schemes.

- 7.3.50 The relatively small effect of low tide sluicing and the low tide hold period can be seen by comparison of 2D hydrodynamic model findings for IBv1 (assessed at Stage 2, not including either measure) and IBv2b (including both low tide sluicing and hold period). As indicated above it was found that in terms of area exposed there was little difference between the two scheme variants assessed, but improvements could be made by increasing the number of sluice gates and opening them sooner on the ebb tide (although this would reduce the energy yield).
- 7.3.51 High tide pumping or high tide sluicing could be used to increase high water levels, particularly for ebb and flood generation (VLHBv3a), which would cause the lowest high water levels. The risk of encroachment of intertidal sediments and saltmarsh may be reduced by the occasional use of pumping, rather than on every tidal cycle.
- 7.3.52 Fish passage routes have been included in the scheme designs as a measure to prevent harm to fish. Additional measures to prevent harm and mitigate effects on fish include:
- measures to prevent harm –
 - fish-friendly turbines
 - reduced number of turbines to reduce the proportion of the Estuary width where fish may pass through turbines
 - channel fixing to direct fish towards fish passage routes
 - fish screening to direct fish towards fish passage routes
 - noise effect reduction
 - predator control
 - timing of construction works; and
 - mitigation measures –
 - fish habitat enhancement
 - fish trapping, herding and stocking.
- 7.3.53 Any tidal power scheme will cause a change in the tidal regime of the Estuary and resulting effects on intertidal habitats of varying degrees. A package of additional measures (beyond the operational regime changes included in the scheme variants) to prevent harm and mitigate impacts on birds and estuarine habitats has been identified for each scheme. The implementation of a combination of these measures would seek to maintain the structure and function (and therefore integrity) of the SPA. These would be developed further for a preferred scheme. This approach considers the ability of the SPA to support the bird populations, and as such does not focus on habitat extent alone, but the overall structure and functioning of the site (habitat extent, exposure time and quality). This is in accordance with recent MMO publication 'Marine Licensing Guidance No.9 Habitat Regulations Appraisal and Appropriate Assessment Guidance' (MMO, 2011) which states that when considering the significance of likely effects as part of an Appropriate Assessment *"The competent authority should not be swayed by the notion that the likely significance of any effect of any plan or project on a site is necessarily related to the proportion or size of area affected. It is the potential effect on the ecological functioning of the site that is relevant...."*

7.3.54 The measures identified include:

- measures to prevent harm –
 - predator control
 - design of the structure to enhance sediment deposition and avoid erosion in certain areas (caisson placement and accretion guide walls), creating new intertidal habitat; and
- mitigation measures –
 - creation of new tidal lagoons within the SPA
 - measures to promote recovery of unfavourable SSSI/ SPA units
 - elevation of sub-tidal habitat (that is currently intertidal but would become sub-tidal as a result of tidal regime changes) to reinstate intertidal habitat
 - placement of ancillary structures to enhance sediment deposition within the SPA to reinstate intertidal habitat.

7.3.55 The prevention/ mitigation packages identified for each scheme are considered to significantly reduce the impacts identified in the assessment above, although some residual impacts would be expected. If residual impacts are identified following an appropriate assessment of the preferred scheme, taking account of the measures to prevent and mitigate impacts, then appropriate compensation measures would need to be developed to support the IROPI case.

7.3.56 Compensation measures may include managed realignment in the Mersey Estuary and enhancement or provision of new functionally linked habitats adjacent to the SPA (and currently used by SPA birds). As the SPA birds in the Mersey Estuary migrate across a large geographic area, compensation may also include measures that are not local to the Mersey but that would increase the survival rate of these bird species elsewhere, such that the meta-population across the network of Natura 2000 sites would be maintained or increased.

7.3.57 Potential mitigation measures to reduce potential impacts on marine mammals may include methods of working during construction such as safety zones, noise management and acoustic deterrents, and during operation acoustic deterrents could be used to manage passage during operation.

Conclusions

7.3.58 Measures to prevent harm and mitigate impacts have been developed to significantly reduce the impacts identified for each scheme variant. Bird populations in the Mersey Estuary have declined since the SPA designation, and the assessment has considered the full extent of the SPA habitats in the context of current bird populations.

7.3.59 From an estuarine habitats and birds perspective, the preferred operating regime would be restricted head, ebb and flood generation (VLHBv3a). This scheme variant follows the natural tidal cycle most closely, resulting in the smallest effects on the SPA features and sub-features. The unrestricted head, ebb only generation scheme variant (IBv2b) was

predicted to have the most significant effects on the tidal regime, and consequently the greatest residual impacts on estuarine habitats and birds.

- 7.3.60 Any structure across the Estuary has the potential to impede fish passage and cause fish injury and mortality during turbine passage. Converse to the conclusions with regards estuarine habitats and birds, ebb and flood generation would be less favourable because there would be greater risk of turbine passage during generation on both tides. Measures to prevent harm and mitigate impacts on fish have been identified for inclusion in the preferred scheme.
- 7.3.61 IBv2b has been rated Red for Environment because the scale of likely impacts is predicted to be such that residual impacts on the SPA bird populations would be likely to occur even with the package of measures to prevent harm and mitigate effects. The scale of impacts on the SPA bird populations (and therefore its structure and function) predicted for either of the restricted head generation schemes, VLHBv2a and VLHBv3a, was much less than IBv2b, and these schemes have therefore been rated Amber (see paragraph 7.3.144 for discussion of overall Environment ratings).
- 7.3.62 A flexible operating regime may be a valuable contribution to mitigating potential impacts. Restricted head operation provides an effective way of reducing impacts on estuarine habitats, but it is noted that energy yield is significantly reduced by this mode of operation. Even if it is not possible to achieve a viable scheme using only restricted head operation, use of restricted head operation on some parts of the generating cycle would help to prevent harm to the SPA. Ebb only generation could be used on some tides, and ebb and flood used on others (most likely intermediate tides). This would increase the area of exposed intertidal sediment in the mid and upper sections of the shore (the most important for bird feeding) and increase the feeding time available for birds whilst maintaining periodic high tide submersion of upper intertidal areas to reduce the risk of encroachment. The operational flexibility available from any scheme design could also be used to vary the operating regime as appropriate, including for extreme cold weather events during winter, to increase bird survival rates.

Water Quality

Potential Impacts

- 7.3.63 A tidal power development could lead to changes in the water quality of the Mersey Estuary and other water bodies, which could affect the ability of those water bodies to achieve good ecological status/ potential under the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003.
- 7.3.64 To inform consideration of water quality parameters relevant to the Water Framework Directive as part of the feasibility study, numerical modelling has been used to indicate the effect of a scheme on the ability of the Estuary to 'flush' (that is, allow pollutants within the Estuary to discharge to sea). This is used as a first indication of the potential changes to water quality parameters. Reduced flushing rates could lead to build up of dangerous

substances, eutrophication (due to increased nutrients) and subsequent changes to biological quality.

- 7.3.65 Other changes to the Estuary's hydrodynamics could lead to adverse or beneficial water quality changes, for example oxygenation may improve in areas of increased water velocity, and ponding upstream of the structure during hold periods may result in reduced turbidity. All schemes would lead to some redistribution of sediments, and sediment transport modelling would need to be undertaken.
- 7.3.66 Holding high water levels for ebb tide generation could increase saline intrusion into groundwater, and qualitative assessment of this risk has been made.

Impact Assessment

- 7.3.67 The modelling indicated that IBv2b would be likely to lead to the lowest flushing rate and VLHBv3a would be likely to lead to the highest flushing rate. VLHBv2a was slightly better than IBv2b as a result of the restricted head operation which results an earlier start to the generation cycle and more water flowing through the structure; increasing the amount of water exchanged each tide.
- 7.3.68 The model outputs suggest that IBv2b and VLHBv2a might lead to a greater build up of pollutants than VLHBv3a. However considering the range of other hydrodynamic changes that would be predicted to occur, including increased water velocities across the structure, decreased water velocities and ponding in areas upstream of the structure, and resulting changes to sedimentation in different parts of the Estuary, as well as the potential release of contaminants from disturbed sediments the overall water quality effects are difficult to predict without further water quality modelling, and could be adverse or beneficial for any of the schemes.
- 7.3.69 Potential risks of saline intrusion into groundwater could be expected to be proportional to the duration of the high water hold period – the longest period would occur with the operating regime of IBv2b and shortest for the ebb and flood generation scheme (VLHBv3a).

Potential Impact Avoidance and Mitigation Measures

- 7.3.70 Mitigation measures such as the use of more sluice gates to increase water mixing could be implemented, particularly for ebb only generation. The operating regime could also be used to effectively manage and mitigate impacts.
- 7.3.71 Sediment quality surveys and further modelling undertaken at future stages would be used to inform the detailed design of the preferred scheme, and minimise disturbance of contaminated sediments. Potential release of contaminants from sediments would need to be managed through appropriate working methods to avoid significant effects.

Conclusions

- 7.3.72 Numerical modelling suggests that unrestricted head, ebb only generation would reduce the flushing rate of the Estuary slightly more than restricted head, ebb only generation, and that ebb and flood generation would cause the least reduction of the flushing rate. The risk of saline intrusion would also be greatest with unrestricted head, ebb only generation and least with ebb and flood generation. Impacts on other water quality parameters, such as turbidity and oxygenation, may be adverse or beneficial, and would be expected to vary spatially within the Estuary.
- 7.3.73 A variable operating regime could be used to manage impacts on water quality and mitigate effects, including management of emergency pollution events.
- 7.3.74 Further hydrodynamic, sediment transport and water quality modelling would be required to gain a greater understanding of likely effects and develop appropriate impact avoidance and mitigation measures.

Flood Risk and Groundwater Levels

Potential Impacts

- 7.3.75 Each scheme under consideration would affect the tidal regime of the Estuary, including the level and duration of high tides and mean water levels, with potential effects on flood risk (for example as a result of tide locking) and groundwater levels. A barrage could also be used to provide flood defence.
- 7.3.76 The change to flood risk as a result of the preferred scheme would need to be evaluated using the statutory process in consultation with the Environment Agency.

Impact Assessment

- 7.3.77 The change in flood risk has been evaluated based on the changes to the mean and high water levels within the Estuary predicted by the 2D hydrodynamic model (see Coastal and Estuarine Processes section above) and not through detailed flood modelling. The assessment has also taken account of how each scheme would fit with existing strategies and surface water management plans.
- 7.3.78 All of the schemes considered in Stage 3 are predicted to result in an increase in the mean water level which would have impacts on tributary watercourses (tide locking) unless mitigated.
- 7.3.79 All of the schemes are predicted to have a similar (lower) high water level (see Coastal and Estuarine Processes section above), with IBv2b causing the least reduction in the high water level and VLHBv3a causing the greatest reduction. VLHBv3a is considered least likely to increase flood risk without further mitigation.

7.3.80 Changes to the high water hold periods may affect groundwater levels in areas adjacent to the Estuary.

7.3.81 Initial consultation with the Environment Agency on flood risk matters has been undertaken at Stage 3. Flood risk modelling would be required to assess the risk in more detail, including consideration of high flow fluvial events occurring at the same time as the high water stand period. The importance of tide locking during the high water stand periods would also need to be evaluated.

Potential Impact Avoidance and Mitigation Measures

7.3.82 The operation of any scheme could be modified to manage flood risk and groundwater impacts and provide some flood protection in extreme events. This would be considered further in future stages using flood risk modelling.

7.3.83 Flood risk impacts due to tide locking on tributaries and drainage systems would be evaluated as part of this future work, and appropriate mitigation developed. Possible mitigation measures include provision of additional storage, modification of existing hydraulic structures and pumping stations or additional flood protection measures.

Conclusions

7.3.84 The unrestricted head, ebb only scheme without mitigation could have adverse effects on flood risk and groundwater levels, as it would have the longest high water hold period. The ebb and flood scheme would most closely follow the natural tidal cycle and have the least effect on flood risk and groundwater levels. However a flexible operating regime could be used for any scheme to manage and mitigate impacts, with operation modified during extreme flood events to provide some flood protection.

Carbon Balance

Potential Impacts

7.3.85 Each of the scheme variants under consideration would generate renewable energy and reduce national emissions of carbon dioxide by reducing the need for thermal power production, helping to achieve the Government targets for cutting carbon emissions (see Section 3). However, the construction of any scheme would require significant quantities of materials, such as steel and concrete, which have a significant embodied carbon cost. Consequently, even though the project aims to reduce CO₂ emissions by providing renewable energy, it is important for the overall carbon balance to be positive.

7.3.86 The assessment considers the carbon balance of each scheme variant over 20 years of operation. Savings beyond this period cannot be predicted with accuracy due to future changes in the mix of power generation plant, but the scheme would provide a low carbon energy source for up to 120 years. Information has been obtained from published data sources regarding the embedded carbon cost of construction materials, emissions from

fuel use and carbon emissions from power production in the UK that would be offset (Defra, 2008).

- 7.3.87 Any carbon impacts due to changes to estuarine habitats and resulting impacts on carbon sequestration have not been assessed at this stage, but would be considered at future stages for the preferred scheme.

Impact Assessment

- 7.3.88 To measure the CO₂ emissions and savings associated with the project, a quantitative approach has been used. Energy yields are presented in Section 7.1. The results of the carbon study are shown in Figure 7.5.

Table 7.5: Net emissions savings associated with each scheme variant over 20 years

Scheme variant	Predicted energy generated from tidal power operation over 20 years (GWh)	Predicted avoided emissions (tCO₂)⁷ over 20 years	Predicted emissions associated with project construction (tCO₂)	Predicted net emissions saving (tCO₂) over 20 years	Payback period (years)
IBv2a	21,000	9.03 m	0.73 m	8.30 m	1.6
IBv2b	19,000	8.17 m	0.73 m	7.44 m	1.8
VLHBv2a	11,200	4.82 m	0.94 m	3.88 m	3.9
VLHBv3a	10,400	4.47 m	0.94 m	3.53 m	4.2

- 7.3.89 All schemes would generate a net carbon saving. Of the four scheme variants assessed, the emissions saving would be greatest from the IBv2a scheme variant because its construction would generate the least carbon emissions and its operation would generate the greatest amount of renewable energy. IBv2b also provides a high emissions saving, but slightly less than IBv2a as the carbon costs of construction would be the same but the energy yield (and so carbon savings) would be lower.
- 7.3.90 The scheme variants designed to operate at restricted (lower) heads would require more concrete (which has a high embodied carbon rating) and more turbines in their construction and generate less renewable energy, resulting in a less positive carbon balance.

⁷ A factor of 0.43 has been applied to the energy yield to estimate CO₂ emissions avoided (DEFRA, 2008)

Potential Impact Avoidance and Mitigation Measures

- 7.3.91 Further reductions could be made to the carbon emissions associated with construction through refinements to scheme design:
- reductions in the volumes of materials required through refinement of the design;
 - selection of materials with the lowest embodied energy, including re-used or recycled instead of primary materials;
 - use of locally sourced material and sustainable modes of transport whenever possible; and
 - use of energy efficient construction equipment, low carbon fuel and renewable sources of energy to feed the power requirements for the construction phase of the project.

Conclusions

- 7.3.92 IBv2a or b would provide the greatest positive net emissions saving, producing around double the amount of renewable energy of VLHBv2a and VLHBv3a but with over 20% lower embodied carbon. Concrete-based materials would be the main contributor to the total emissions generated during construction for all scheme variants.

Overall Conclusions for Environmental Criteria

- 7.3.93 Potential impacts on estuarine ecology, water quality and flood risk are key issues that have been considered further at Stage 3, including in the design of schemes and their operation and the development of packages of measures intended to prevent harm and mitigate impacts on intertidal habitats, birds and fish and identification of operational measures to manage water quality and flood risk impacts.
- 7.3.94 Although the package of ecological measures has reduced the significance of potential impacts on estuarine ecology, residual impacts on the Mersey Estuary SPA would be likely to remain particularly for the ebb only generation scheme variants.
- 7.3.95 The unrestricted head operation scheme variants (represented by IBv2b in the assessment above) has been rated Red for Environment on the decision making framework as it is expected that predicted impacts on the SPA could not be fully mitigated and would rely on a favourable IROPI conclusion and compensation measures.
- 7.3.96 The restricted head ebb only variant (VLHBv2a) was predicted to have around half the impact on intertidal habitats and birds compared to the unrestricted head variant (represented by IBv2b) before mitigation, and with the identified package of measures to prevent harm and mitigate impacts the residual effects on the structure and function of the SPA would be much less. As such this scheme variant has been rated Amber.
- 7.3.97 Ebb and flood generation used in VLHBv3a was predicted have the least impact on intertidal habitats and birds, flushing rates, saline intrusion, flood risk and groundwater levels, and has been rated Amber for Environment overall. Ebb and flood generation

would be the less favoured operating mode for fish, one of the Water Framework Directive's biological elements.

- 7.3.98 A flexible scheme with a range of operating regimes would present the best opportunity to manage environmental impacts. Further hydrodynamic, sediment transport and water quality modelling would need to be undertaken in future stages to inform the further development of this scheme, to quantify the effects and enable appropriate mitigation to be developed.

Economic (Shipping)

Potential Impacts

- 7.3.99 Options to enable ships passage through a structure at Band A were identified at Stage 2 and consultation with relevant stakeholders on the project Navigation Advisory Group has continued during Stage 3.
- 7.3.100 In addition to enabling passage for current and forecast vessel traffic, the navigation options identified at Stage 2 have been appraised based on their performance against a range of other criteria including impacts on access to existing berths and locks, potential changes to current velocities, sediment transport regime, water levels and associated tidal windows, potential congestion and shipping delays, and increases in shipping costs including pilotage and tugs.
- 7.3.101 Impacts associated with the construction phase of the development would be assessed at future stages to inform the development of appropriate mitigation measures.

Impact Assessment

- 7.3.102 A double lock on the Wirral side of the structure was identified as the recommended navigation option based on its performance against the evaluation criteria, including capacity for existing and future traffic, operational flexibility being able to accommodate two-way traffic and continue operating during maintenance of one lock, attractiveness to navigation stakeholders, capital cost and impacts on transit times.
- 7.3.103 Alternative navigation solutions considered in the appraisal included the extension of the Manchester Ship Canal (either to replace the current Ship Canal entrance lock with a lock at the barrage or to provide an extended tidal channel to the existing Ship Canal entrance lock) with a lock on the Liverpool bank for traffic to Garston. This option would be significantly more costly to construct than the recommended navigation option.
- 7.3.104 A tidal power structure could have some beneficial impacts for navigation such as longer tidal windows (due to changes to water levels), which could ease congestion at locks due to longer access periods.
- 7.3.105 Potential adverse impacts due to disruption during construction would be assessed in future stages.

Potential Impact Avoidance and Mitigation Measures

- 7.3.106 The navigation solution has been developed in consultation with relevant stakeholders to avoid and mitigate impacts on navigation interests.
- 7.3.107 Additional dredging would be required to maintain navigation channels to appropriate depths, and to create a new access across Devil's Bank to Garston.
- 7.3.108 Mitigation to manage impacts on commercial navigation during the construction phase would be developed in future stages.

Conclusions

- 7.3.109 The recommended commercial navigation option identified through the appraisal process was the double lock on the Wirral side of the structure. This has been included in all the Stage 3 scheme variants developed for assessment.
- 7.3.110 Further assessment and detailed design would take place at future stages, informed by ongoing stakeholder consultation. This would include further hydrodynamic and sediment transport modelling, a shipping traffic study, navigation simulation studies, a passing ship study for Bromborough Wall, an assessment of the available tug and pilot resource, a navigation risk assessment and an economic impact assessment. Recreational and service vessel movements would also need to be considered at the same time.
- 7.3.111 All scheme variants have been assigned an Amber rating for Economic (Shipping) on the decision making framework.

Economic (Business)

Potential Impacts

- 7.3.112 A Mersey Tidal Power scheme would bring significant economic benefits to the local and regional economies through direct and indirect employment.
- 7.3.113 Liverpool, Wirral and Knowsley are some of the most deprived areas in the UK, with pockets of high unemployment, and these communities in particular would be likely to benefit from local employment opportunities.
- 7.3.114 In addition to direct employment and supply chain opportunities during the construction and operation of the scheme, the area would also benefit from an influx of visitors and associated investment.

Impact Assessment

- 7.3.115 Estimates have been made of the number of direct jobs that could be created during the construction and operation of IBv2b, VLHBv2a and VLHBv3a, building on the assessment undertaken at Stage 2 with additional information. As the power generating technology

used is the same for all three scheme variants, the main difference between them in terms of economic impacts is driven by the capital value of each scheme variant, and associated inputs of materials and services.

- 7.3.116 The likely source of materials, technology and services has been estimated based on experience of previous large-scale projects and availability of key inputs. To maximise local benefit there is a preference to source locally wherever possible, but the nature and scale of the project is such that the construction would be likely to draw on sources from across the world. Similar renewable energy projects have been used to inform the assessment, including the potential supply chain study undertaken by DECC for the Severn tidal power project (DECC, 2010c).
- 7.3.117 The quantities of key materials such as sand, aggregates and cement would make this one of the largest civil engineering projects in the UK. It is assumed that these key materials would be sourced from within the UK, but the quantities required could not be supplied from the Liverpool City Region and North West alone. Some steel components may need to be sourced from overseas as there are limited facilities in the UK, and the turbines and power generation equipment would most likely be sourced from elsewhere in Europe or Asia, where existing suppliers are located.
- 7.3.118 There is scope to use local labour for many aspects of the construction, although some of the more specialised skills may need to be sourced from outside the region or overseas. Studies undertaken for the Severn tidal power project provide a breakdown of low, intermediate and high skills for each stage of the construction process (DECC, 2010c).
- 7.3.119 Employment estimates for the construction period are set out in Table 7.6 below. Supply and induced employment effects have also been estimated as a factor of the direct employment estimates to give an estimate of the total number of jobs. Low and high estimates are shown as a range, reflecting the level of uncertainty in the estimates. At this stage the margins of error are typically larger for the assumptions of the spatial pattern of purchases for smaller areas.

Table 7.6: Estimated construction employment impacts per year of construction

Scheme variant	Estimated annual employment (full time equivalent jobs)					
	Liverpool City Region		North West		UK	
	Direct	Total	Direct	Total	Direct	Total
IBv2b	1,700-2,300	2,200-3,000	2,300 – 2,700	3,500 – 4,100	3,200 – 3,600	5,400 – 6,100
VLHBv2a	2,300-3,100	3,000-4,000	3,000 - 3,600	4,500 - 5,400	4,200 - 4,700	7,100 – 8,000
VLHBv3a	2,300-3,100	3,000-4,000	3,000 - 3,500	4,500 – 5,300	4,100 – 4,600	7,000 – 7,800

- 7.3.120 The estimates relate to the economic activity associated with the design, manufacture, assembly and construction that will occur in the Liverpool City Region. This is not necessarily the same as the economic benefits which will be secured for Merseyside firms and workforce. For example, contractors from the Liverpool City Region may undertake activity within the Liverpool City Region using a workforce from beyond the city region. In this instance the manner in which the economic benefit from this activity is retained in or leaks out of the City Region is both complex and beyond the scope of the study at this stage.
- 7.3.121 Of the direct jobs during construction, around 750 – 950 are estimated to be low skilled positions and around 1,900 – 2,400 could require intermediate skills. This represents a significant opportunity for employment for local deprived areas.
- 7.3.122 The potential impact on GVA has been estimated based on the employment figures in Table 7.6. VLHBv2a could contribute between £0.84bn and £1.14bn in GVA to the Liverpool City Region over the construction period and £2.02bn-£2.49bn to the UK economy as a whole (see Table 7.7).

Table 7.7: Estimated GVA impacts over construction period

Scheme variant	Estimated GVA (£bn)					
	Liverpool City Region		North West		UK	
	Direct	Total	Direct	Total	Direct	Total
IBv2b	0.63	0.85	0.96	1.14	1.54	1.72
VLHBv2a	0.84	1.14	1.28	1.52	2.02	2.25
VLHBv3a	0.83	1.12	1.26	1.49	1.99	2.21

- 7.3.123 Estimates of the likely structure of the workforce required to operate and maintain the tidal power plant are assumed to be the same for all three scheme variants considered, totalling around 120 staff. Together with assumptions on average salary costs, overheads, insurance, business rates and maintenance contracts, the annual operating and maintenance costs typically represent around 1% of the capital costs (see Financial Acceptability for capital cost estimates). A summary of the annual gross employment and GVA likely to be supported by each scheme variant over the first 25 years of operation is provided in Table 7.8.

Table 7.8: Estimated employment and GVA impacts in North West during first 25 years of operation

Scheme variant	Estimated employment (full time equivalents)				Estimated GVA (£m)			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
IBv2b	120	220	60	380	4.8*	8	2	14.8
VLHBv2a	120	270	80	470	4.8*	12	3	19.8
VLHBv3a	120	260	80	460	4.8*	12	3	19.8

* Includes direct GVA generated by people working at the facility but excludes direct GVA from production and sale of electricity due to lack of information at this stage

- 7.3.124 It is not possible to robustly estimate the proportion of regional impacts which might arise in the Liverpool City Region at this stage, but it is anticipated that between half and two thirds of North West employment and GVA impacts would occur in the Liverpool City Region.
- 7.3.125 A visitor centre could be provided for any scheme, and would be expected to receive 60,000 – 100,000 visitors per year. Such a visitor facility could support around 30 – 40 jobs and £1m – £2m in GVA in the North West. It is anticipated that between half and two thirds of North West employment and GVA impacts in relation to a visitor centre would occur in the Liverpool City Region.
- 7.3.126 The incorporation of a testing and research facility within a scheme could act as a major catalyst for additional economic benefits for the region but this is unquantified at this stage.
- 7.3.127 There could be some adverse impacts on local businesses during construction as a result of disruption, but this will be minimised using best practice construction methods. Further assessment of these impacts would be undertaken in future stages.

Potential Impact Avoidance and Mitigation Measures

- 7.3.128 Benefits to the local and regional economy could be maximised through the procurement strategy, by sourcing materials and labour locally where possible.
- 7.3.129 Potential adverse impacts due to disruption during construction would be mitigated by appropriate management of the construction phase.

Conclusions

- 7.3.130 All schemes represent a significant potential benefit to the local, regional and national economy, generating around 1,900 – 3,200 direct full time equivalent jobs per year of construction for the Liverpool City Region, 2,300 – 3,600 for the North West, and 3,200 – 4,700 for the UK as a whole.

-
- 7.3.131 The resulting direct GVA impact during the five year construction period could contribute up to £0.93bn for the Liverpool City Region, up to £1.28bn for the North West and up to £2.02bn for the UK economy as a whole (for VLHBv2a).
- 7.3.132 A visitor centre could be provided for any scheme, and would be expected to receive 60,000 – 100,000 visitors per year. Such a visitor facility could support around 30 – 40 jobs and £1m – £2m in GVA in the North West.
- 7.3.133 During operation, the estimated GVA impact for the North West from the first 25 years of operation would be up to £19.8m (for VLHBv2a).
- 7.3.134 All schemes have been assigned a Green rating on the decision making framework.

Social (Community)

Potential Impacts

- 7.3.135 Many of the social impacts of a tidal power scheme would be directly related to the economic benefits described above – employment and training opportunities for deprived communities, inward investment and regeneration. New recreational, tourism and leisure facilities could also be incorporated into any of the schemes. There could also be potential adverse impacts on local residents, particularly during construction, and on some river users, such as yachting and sailing interests. Recreational navigation groups have been consulted during Stage 3 (see Section 8).

Impact Assessment

- 7.3.136 There are strong synergies between the proposed tidal power scheme and strategic planning and regeneration objectives, such as increasing the number of residents who are in work, increasing the scale of economic activity and the pursuit of a low carbon economy across the Liverpool City Region.
- 7.3.137 Employment and training opportunities for areas with current high levels of unemployment and low average income would also have associated health and wellbeing benefits.
- 7.3.138 All scheme variants would be visible above the water line and could include a visitor centre and viewing areas, providing an attraction for visitors as well as educational opportunities. Water-based tourism and leisure facilities, such as a new marina, could also be provided for any of the schemes, further contributing to the health and wellbeing of local people. A small boat lock would be included to enable recreational vessels to pass the structure.
- 7.3.139 Adverse impacts such as noise, dust and visual impacts, mainly during the construction period, would be mitigated using best practice techniques.
- 7.3.140 Impacts on recreational navigation due to changes in water levels may be positive or negative, depending on the operating regime. Predictable tides are required for safe

navigation. Passage through the Estuary for small vessels would be maintained with a suitable lock that would be provided as part of any scheme.

Potential Impact Avoidance and Mitigation Measures

- 7.3.141 The inclusion of a visitor centre and other tourism and leisure facilities would maximise benefits to local communities as well as attracted inward investment and regeneration. Further benefits could be realised by the provision of a pedestrian/cycle access across the structure, linking the Liverpool Garden Festival site (which is being redeveloped for mixed uses) and the proposed parkland at Bromborough. Adverse impacts on local residents from construction traffic and activities would be mitigated by adopting best practice.
- 7.3.142 A small boat lock to enable leisure and small service vessels to pass the structure has been included within the cost model for all Stage 3 schemes and would be provided as part of the preferred scheme.

Conclusions

- 7.3.143 All schemes are predicted to have positive social impacts, and have been rated Green on the decision making framework. Some adverse impacts would need to be mitigated, such as potential adverse impacts on sailing and yachting in the Estuary.

Overall Consenting Risk

- 7.3.144 The scheme variants assessed at Stage 3 have illustrated the converse relationship between impacts on the intertidal habitats and energy yield: IBv2b has the greatest potential for impacts on nature conservation interests but would also generate the most electricity; VLHBv2a is predicted to have less impact on estuarine habitats than IBv2b, but a corresponding reduction in energy yield; and VLHBv3a is predicted to have the least impact on estuarine habitats but the lowest energy output. (Note that IBv2a would have a greater impact and greater energy yield than IBv2b, but this scheme was not assessed in detail in this section.)
- 7.3.145 All schemes would have similarly positive socio-economic impacts overall, although the restricted head schemes (VLHBv2a and VLHBv3a) have slightly higher predicted GVA impacts due to their large number of turbines and consequently higher capital costs.
- 7.3.146 All scheme variants assessed at Stage 3 have been rated Amber for overall consenting risk as each has benefits and disbenefits.
- 7.3.147 A flexible scheme combining elements of all three operational regimes with a lower cost structure is recommended as the preferred scheme.

7.4 Financial Acceptability

- 7.4.1 The Stage 3 scheme variants shown in Table 7.1 have been appraised for their financial acceptability using the criteria in the decision making framework. As described at Stage 2, the financial assessment has concluded in a rating applicable to each scheme variant.

Capital Costs for Construction and Commissioning

- 7.4.2 For each scheme variant, the capital costs (in real terms, i.e. taking account of inflation) during construction and commissioning have been built up by examining the estimated costs of individual elements and then applying an additional factor to account for ancillary costs. The individual elements for which cost estimates were prepared include all civil and mechanical engineering, generation equipment, utility connection and a package of ecological measures, the total of which is defined as the 'upfront' capital cost. Each element of ancillary expenditure (including preliminary works, design, supervision and contingencies) was assumed to cost a set percentage of the upfront capital cost, totalling 33%. The breakdown of estimated capital costs for construction and commissioning of each scheme variant is shown in Table 7.9.

Table 7.9: Capital expenditure (£bn real) for construction and commissioning

£bn (real)	Scheme variant		
	IBv2a&b	VLHBv2a	VLHBv3a
Upfront capital cost	2.15	2.84	2.79
Preliminaries & site overheads/profits	0.25	0.34	0.33
Design and supervision fees, legal fees, enquiry costs	0.29	0.38	0.37
Capital expenditure contingency	0.53	0.71	0.70
Total ancillary cost	1.07	1.43	1.41
Total capital expenditure for construction and commissioning	3.22	4.27	4.20

- 7.4.3 The IBv2 scheme variants would have the same capital cost as they differ only in the way they are operated.
- 7.4.4 The cost of caissons for VLHBv2a and VLHBv3a would be respectively 69% and 64% greater than for the IBv2 scheme variants, likewise the cost of the turbines would be 47% greater because there would be a larger number of turbines.
- 7.4.5 VLHBv2a and VLHBv3a would have lower capital ecology costs because smaller packages of ecological measures would be required as ecological impacts are predicted to

be less (see Ecology and Nature Conservation assessment above), but these differences are too small to have any significant off-set against the higher caisson and turbine costs.

Capital Costs for Operation

- 7.4.6 Capital costs during operation are assumed to be limited to renewal of navigation structures and power generation equipment.

Operating Costs

- 7.4.7 The real annual routine operating and maintenance costs were assumed to be the sum of:

- 1% of the upfront capital expenditure; and
- allowances for overhead costs, rents, dredging costs, ongoing ecological management and transmission use of system charges.

- 7.4.8 The total annual operating expenditure for each scheme is estimated to be:

- IBv2a: £35.52m
- IBv2b: £35.40m
- VLHBv2a: £45.01m
- VLHBv3a: £44.43m

- 7.4.9 The operating costs of the IBv2 variants were assumed to differ only in the (transmission) use of system charges, which are proportional to the electricity generating capacity of each scheme variant.

- 7.4.10 The higher estimated operating costs of the VLHB schemes (compared with the IBv2 schemes) are a consequence of the higher upfront capital costs for these schemes, which are used to derive the estimated operational overhead costs.

Financial Performance

- 7.4.11 A financial model was constructed to assess the commercial viability of the Stage 3 scheme variants. Details are provided in the accompanying technical report.

- 7.4.12 Since Stage 2, the Government has proposed reforming the electricity market. All renewable energy projects commencing operation after 31st March 2017 will not qualify for support from Renewable Obligation Certificates (ROCs). Instead, they will be supported by a Feed-in Tariff. The project financial model has been altered to allow the Feed-in Tariff to be included.

- 7.4.13 The estimated levelised cost of generation (£ per MWh) has been calculated for each scheme variant. This is the key measure used by DECC to compare different types of new-build power generation plant. It can be used to compare the Mersey Tidal Power project with other potential tidal schemes, such as those proposed in the Severn Tidal

Power commercial assessment (DECC, 2010d) as well as other technologies such as offshore wind.

- 7.4.14 The levelised cost of generation used by DECC is calculated by taking the sum of the discounted whole life real capital and operational costs and dividing this by the sum of the discounted whole life forecast electricity output. The calculation has been made twice for each scheme variant using discount rates of 10% and 8%.
- 7.4.15 The average real unit prices of electricity (£ per MWh) required to produce an internal rate of return (IRR) of 8% and 10% have also been calculated for each scheme variant. This average real price required (ARPR) is useful in that the costs of finance, tenor of debt and the effects of taxation are taken into account in its calculation.
- 7.4.16 The results for the base case for all scheme variants are shown in Table 7.10. Base case assumptions are explained in the accompanying technical report.

Table 7.10: Base case results for levelised cost of generation and average real price required (ARPR)

Base Case	Scheme variant			
	IBv2a	IBv2b	VLHBv2a	VLHBv3a
Levelised cost of generation at 10% discount rate (per MWh)	£456	£504	£1,176	£1,197
Levelised cost of generation at 8% discount rate (per MWh)	£355	£392	£906	£932
ARPR to achieve 10% project IRR (per MWh)	£491	£543	£1,270	£1,295
ARPR to achieve 8% project IRR (per MWh)	£373	£412	£956	£986
ARPR to achieve 6% project IRR (per MWh)	£258	£285	£662	£688

- 7.4.17 The scheme variant with the best financial performance, having the lowest levelised cost at a 10% discount rate of £456/MWh, was IBv2a. This was anticipated, as this scheme variant has the highest electricity output (see Section 7.5) combined with the lowest capital and operational expenditure of the variants assessed at Stage 3. To achieve a project IRR of 10%, the ARPR would need to be £491/MWh. These results indicate that this does not present a financially viable scheme under the current assumptions that it is wholly funded by the private sector.
- 7.4.18 The results of sensitivity analysis indicate that the levelised cost of the project is most responsive to reduction in the capital expenditure. For example, reducing capital expenditure by 30% would reduce the estimated levelised cost of IBv2a from £456/MWh to £321/MWh (a reduction of around 30%). Reducing operational expenditure by 30% would only reduce the estimated levelised cost to £446/MWh (a reduction of around 2%).

- 7.4.19 Increasing energy yield through optimisation would have a positive impact on financial performance: for each 1% increase in energy yield, the levelised cost of IBv2a would reduce by around 0.9%, in other words a 10% increase in output would reduce the levelised cost to £415/MWh.
- 7.4.20 If a viable scheme is to be achieved, the IBv2 scheme design should form the basis of future studies with and measures being taken to reduce capital and operating expenditure, and energy output being increased through optimisation. Value engineering would be expected to offer some significant capital cost savings. The level of financial support from the Government for future renewable projects is not yet known, but will significantly affect the viability of any scheme.

Overall Commercial/Financial Risk

- 7.4.21 IBv2a and b have been rated Amber for all financial criteria as there may be potential for them to be developed to viable schemes with sufficient Government support.
- 7.4.22 The restricted head scheme variants (VLHBv2a and VLHBv3a) assessed at Stage 3 have been rated as Red as their financial performance appears to be very poor due to higher (c. 130%) capital costs combined with around 50% lower energy yield.
- 7.4.23 To improve the financial performance of any of the scheme variants, reductions in capital and operating expenditure would need to be identified and adequate capital and/or price support would be required through the Government's proposed electricity market reforms.

7.5 Contribution to Targets

Energy Yield

- 7.5.1 The annual energy yield for each scheme has been calculated using 0D modelling as follows (relative values in brackets):
- IBv2a 1,050 GWh (1.00)
 - IBv2b 950 GWh (0.90)
 - VLHBv2a 560 GWh (0.53)
 - VLHBv3a 520 GWh (0.50)
- 7.5.2 An IBv2 scheme design operating on a restricted head difference was estimated to generate 530 GWh per year (0.50) and an IBv2 scheme design operating on both ebb and flood tides with an unrestricted head difference was estimated to yield 800 GWh per year (0.64).

Carbon Balance

7.5.3 The carbon accounting study is described in Section 7.3 above. Comparing the estimated carbon emissions associated with construction and the predicted emissions avoided by renewable energy generation, the net emissions savings from each scheme variant are estimated to be (relative values in brackets):

- IBv2a 8.30m tCO₂ (1.00) payback period 1.6 years
- IBv2b 7.44m tCO₂ (0.90) payback period 1.8 years
- VLHBv2a 3.88m tCO₂ (0.47) payback period 3.9 years
- VLHBv3a 3.53m tCO₂ (0.43) payback period 4.2 years

Cost of Energy

7.5.4 The financial assessment is described in Section 7.4 above. The levelised costs of energy for each scheme variant are estimated to be (relative values as shown on the decision making framework (Figure 7.15) in brackets):

- | | 10% discount | 8% discount |
|-----------|-------------------|-------------|
| • IBv2a | £456/MWh (1.00) | £355/MWh |
| • IBv2b | £504/MWh (1.11) | £392/MWh |
| • VLHBv2a | £1,176/MWh (2.58) | £906/MWh |
| • VLHBv3a | £1,197/MWh (2.63) | £932/MWh |

Socio-Economics

7.5.5 The contribution of each scheme to North West GVA from the first 25 years of operation has been estimated. IBv2a is assumed to have the same impact as IBv2b, as follows (relative values as shown on the decision making framework (Figure 7.15) in brackets):

- | | Construction
GVA/yr (total
North West) | Operation GVA
(total
North West) | Construction jobs
(total full time equiv
Liverpool City Region) |
|---------------|--|--|---|
| • IBv2a and b | £1.14bn (0.75) | £14.8m | 2,200-3,000 |
| • VLHBv2a | £1.52bn (1.00) | £19.8m | 3,000-4,000 |
| • VLHBv3a | £1.49bn (0.98) | £19.8m | 3,000-4,000 |

7.5.6 All schemes are estimated to generate around 120 direct jobs during operation.

7.6 Conclusions of Stage 3: Sample Scheme Assessment

Application of Decision Making Framework

7.6.1 Based on the findings reported in Sections 7.2-7.5 above, the decision making framework has been completed for the particular scheme variants assessed at Stage 3 (see Figure 7.15 below).

	Stage 1 -														Stage 2 -														Stage 3 -																										
Key																																																							
No significant issues														Potentially significant issue(s)														Significant issue(s) / showstopper(s)																											
Value																																																							
														Technically Acceptable								Consenting: Acceptable								Financially Acceptable								Contribution to Targets																	
														Physical Conditions								Sustainability								Commercial returns								Energy yield (GWh)																	
														Maturity								Environment								Cash flow								Relative Carbon Balance																	
														Warranty Risk								Economic (Shipping)								Grant/Subsidy/Tariff								Cost of Energy (relative)																	
														Overall Technical Risk								Economic (Business)								Financing								Socio Economic GVA (relative)																	
																						Social (community)								Overall Comm./Fin. Risk																									
																						Overall Consenting Risk																																	
IBv2a																																						1,050 1.00 1.00 0.75																	
IBv2b																																						950 0.90 1.11 0.75																	
VLHBv2a																																						560 0.47 2.58 1.00																	
VLHBv3a																																						520 0.43 2.63 1.00																	

Figure 7.15: Stage 3 decision making framework assessment

Summary of Key Issues Identified at Stage 3

7.6.2 Potential locations for a tidal power scheme were revisited at the start of Stage 3, and it was concluded that attention should be focussed on Band A as the location with the most opportunity for a viable scheme to be developed.

7.6.3 The scheme variants developed and assessed at Stage 3 have given important consideration to the benefits and disbenefits of a range of operating regimes. Key conclusions are as follows:

- ebb only unrestricted head generation would provide the greatest energy yield but potentially the greatest environmental impacts;
- ebb only restricted head generation would have a lower energy yield than unrestricted head generation but provide some mitigation of environmental impacts;
- ebb and flood generation would result in a further reduced energy yield and greater risk for fish, but overall this operational mode could have less environmental impact and there may be more potential in some instances to match generation with peak demand;
- low tide sluicing and a low tide hold period have the potential to reduce impacts on intertidal habitats, birds and water quality but a greater number of sluices would be

required to achieve significant benefits and sluicing would need to commence earlier on the ebb tide (possibly during operation);

- high tide pumping also has potential to reduce impacts on intertidal habitats and birds and could improve the energy yield, although increasing the number of sluices may achieve a similar reduction in ecological impact;
- a flexible operating regime would enable the benefits of each of the above operating regimes to be realised and the most effective management of adverse and beneficial impacts;
- all Stage 3 scheme variants would have a positive carbon balance due to the generation of renewable energy and a carbon payback period of less than five years;
- the commercial performance of all schemes studied at Stage 3 is such that further optimisation and financial support would be required to achieve viability; and
- any scheme would bring significant socio-economic benefits to the city, North West region and UK.

8 Stakeholder Consultation

8.1 Background

- 8.1.1 This section of the report provides an overview of the consultation process which has been undertaken to date. It summarises both stakeholder and public consultation undertaken during Phase 1 and Phase 2 of the project (see Project Background).
- 8.1.2 At this stage of the project the consenting route for a scheme has not yet been determined. The future of the IPC and the Government's promotion of the Localism Bill are key reasons for this. However, the consenting regime introduced through the Planning Act 2008 for NSIPs, via the IPC or the MIPU which is to replace it, contains robust provisions for consultation procedures.

8.2 Consultation Process and Methodology

Purpose of Consultation

- 8.2.1 The guidance from the CLG on Pre-Application Consultation (September 2009) has been followed as best practice. The guidance sets out that early engagement with stakeholders is a vital aspect of the IPC regime. Accordingly, the key principles promulgated by the IPC and CLG formed the foundation of the project's consultation process.
- 8.2.2 The key consultation objectives adopted for the project were therefore:
- to build awareness of and educate on the need for renewable energy and the part that tidal energy, and specifically the project, can play in meeting that need;
 - to carry out effective consultation to enable the community and stakeholders to understand the aims and objectives of the project, the methodology for assessment and the reasons why decisions are made;
 - to obtain input from the local community at each stage of the project, where viable, which may be useful in assessing the options;
 - to secure 'buy-in' from the community and stakeholders to the project's aims and objectives;
 - to enable communities and stakeholders to comment on the proposals and make their views known;
 - to secure buy-in to the preferred option where possible; and
 - to meet the requirements of the Planning Act 2008 and Infrastructure Planning (EIA) Regulations 2009.

Phase 1 Pre-Feasibility Study

- 8.2.3 An open transparent approach was taken by the study team during Phase 1 of the project. Formal community consultation was not undertaken at this initial phase, however the progress of the study was reported to the Mersey Basin Campaign open meetings and the Mersey Estuary Forum during 2005 and 2007.
- 8.2.4 Consultation was undertaken with key consultees with relevance to environmental assessment, to agree the major environmental issues for each of the options and to request data. Contact was also made with a range of manufacturers and developers of tidal power generation technologies.
- 8.2.5 Initial consultations were also commenced with statutory and non-statutory authorities to offer a basic introduction to the study and to reassure those concerned that the project team were starting with a completely open mind and that serious consideration was being given at all stages to environmental considerations. In addition, initial consultations were undertaken with a range of regeneration organisations within the North West. The Government Office North West was also briefed on the project.
- 8.2.6 All local Members of Parliament were informed on Phase 1 of the project and a number of meetings were undertaken. Informal meetings were also held with all Local Authorities in Merseyside. These consultations focused upon identification of regeneration priorities that the project could contribute towards.
- 8.2.7 Three working groups were established as detailed below:
- Marine Power Generation and Technology Group;
 - Environmental and Marine Group; and
 - Regeneration Group.
- 8.2.8 The purpose of these working groups was to make initial contact with relevant organisations, introduce the project and obtain feedback where necessary.
- 8.2.9 In July 2007 a leaflet summarising the results of Phase 1 was issued to relevant MPs and Council Leaders in Merseyside. The full, completed Pre-Feasibility Study Report was published in September 2007. An executive summary of the Study was uploaded at that time onto the project website.
- 8.2.10 A number of presentations were made to groups at forums such as the Mersey Estuary Forum.

Phase 2 Feasibility Study

- 8.2.11 A Stakeholder Engagement Strategy was formulated at the inception of the feasibility study building on the Phase 1 work. Early engagement was undertaken to allow consultees an opportunity to fully understand the background to the project in accordance with national guidance on consultation and guide the work and methodologies adopted.

8.2.12 A phased consultation approach was adopted inviting formal consultation responses at key stages of the project as detailed below:

- Stages 1 and 2 (September 2009 –September 2010) – Consultation on Stage 1 Options Report and Consultation on Stage 2 Options Report; and
- Stage 3 (October 2010 – March 2011) – Round One Community Consultation.

8.2.13 Ongoing consultation with experts and key influencers has been undertaken throughout the project at the stakeholder group meetings (see below). A wide range of methods of consultation were adopted which are set out below.

Stakeholder Groups

8.2.14 A number of stakeholder groups were established during the feasibility study phase of the project to provide a structured forum for engagement and facilitate proactive and reactive engagement with interested parties, including statutory consultees and government bodies.

8.2.15 The structure for engagement of stakeholder groups is illustrated in Figure 8.1.



Structure for Stakeholder Engagement Groups

Figure 8.1: Feasibility study stakeholder groups

8.2.16 The purpose of setting up the above groups was to provide a range of forums for establishing early input from stakeholders and experts and act as a precursor to the formal engagement of consultees. The stakeholder meetings were the primary mechanism for ensuring efficient and effective engagement between the project team and key stakeholders. Stakeholder representatives and experts were recruited to the Key Stakeholder Advisory Group and Technical Groups who could provide specialist advice and link to the wider engagement of interested parties and communities.

8.2.17 A number of initial briefing meetings were also undertaken during the early stages of the feasibility study which did not form part of the formal stakeholder group meetings. The organisations met were:

- National Grid;
- Merseyside Policy Officers;
- The Mersey Partnership;
- Liverpool Vision;
- Environment Agency; and
- Infrastructure Planning Commission.

8.2.18 Presentations were also made to:

- Mersey Estuary Forum;
- Mersey Basin Campaign Environment 09 conference;
- Northwest Tidal Energy Group;
- Low Carbon Liverpool Seminar;
- Cheshire Region Biodiversity Partnership;
- Institution of Civil Engineers Northwest; and
- Joint Institute of Civil Engineers Cheshire Branch and Chartered Institution of Water and Environmental Management.

8.2.19 The aim of these meetings and presentations was to provide an overview of the project and to make initial contact with organisations with a vested interest in the surrounding area and the project, either to obtain or provide information relevant to the project assessment.

8.2.20 In addition to project specific consultation, the Mersey Tidal Power project team played an active role in the DECC lead Marine Energy Action Plan working groups.

Stage 1 Options Report

8.2.21 The Stage 1 Options Report was consulted on between February and April 2010. This report covered the work carried out during the first stage of the feasibility study.

8.2.22 The long list of options was set out along with the decision making framework. The Report was issued for stakeholder and public comment and made available on the project website. The objectives during consultation on both the Stage 1 and Stage 2 Options Reports were to ensure that anyone interested in or potentially impacted by a tidal power project on the Mersey Estuary:

- had access to information;
- could put forward their own ideas and feel confident that there was a process for considering ideas;
- could play an active role in developing proposals and options to ensure local knowledge and perspectives were taken into account;
- could comment on and influence formal proposals; and

- get feedback and be informed about progress and outcomes.

Stage 2 Options Report

- 8.2.23 The Stage 2 Options Report was consulted on between November 2010 and January 2011. Stage 2 represented a position midway through the feasibility study, which resulted in the identification of a short list of options. As such, the Stage 2 Options Report set out and explained the appraisal of the shortlisted options in terms of technical, consenting and financial acceptability. The decision making framework was also detailed and explained.

Community Consultation

- 8.2.24 Formal community consultation was not undertaken during Phase 1 or Stages 1 and 2 of the feasibility study phase as insufficient clarity of potential schemes was available on which to base public consultation. However, a project website was established during Phase 1 which was accessible to members of the general public and which provided information on the progress of the scheme and contact details if further information was required. The website was enhanced during Stage 2 to provide access to project reports.

- 8.2.25 During Stage 3 of the feasibility study, the community consultation strategy was formulated and specific timeframes were identified when community consultation would take place (assuming a preferred scheme was to be taken forward in the consenting process) as follows:

- **Round One: Feasibility Study, December 2010 – February 2011**
This first tranche of consultation concentrated upon raising awareness of the plans and making sure that the feasibility study took into account relevant aspects of local communities that may be affected by a tidal power scheme.
- **Round Two: Preferred Option – Late 2011 (TBC)**
Further consultation would be undertaken on aspects of the preferred scheme design including options for associated development, such as connections to the National Grid, and construction access and facilities.
- **Round Three: Application for Consent, 2012 (TBC)**
Once further work was completed on the design of the proposed scheme, an EIA would be carried out to evaluate the likely impacts of the scheme. Consultation would aim to address any remaining aspects of the scheme to be put forward in the consents applications.

- 8.2.26 It was also identified that there would be an opportunity to comment on an application once it has been submitted to the consenting authority.

- 8.2.27 The key aims of community consultation were agreed as follows:

- to explain and gain feedback on the aims and objectives of the project, the methodology for assessment of options and the reasons behind decisions made to date;

- to build awareness and understanding of the part that tidal energy can play in meeting the need for renewable energy;
- to enable communities and local stakeholders to comment on proposals developed by the project team and ensure local considerations are taken into account;
- to enable communities and local stakeholders to contribute ideas to the project to enhance the proposals and ensure maximum benefit is obtained from the development; and in doing so:
- to meet the requirements of the Planning Act 2008 and of requirements for EIA.

Round One Community Consultation Methodology

- 8.2.28 The purpose of this first round of Community Consultation was to make sure that local people were aware of and understood the project. It also presented an opportunity for the local community to provide ideas and comments about the project and respond to any concerns they had, as well as help to influence the ultimate location of a preferred option. The specific topics for consultation are provided at paragraph 8.2.35.

The Statement of Community Consultation

- 8.2.29 In accordance with the Section 47 of the Planning Act 2008 ("The Act") a Statement of Community Consultation (SoCC) was prepared for this round which set out how the project team proposed to consult about the proposed scheme with people living in the vicinity of the land.
- 8.2.30 Due to the nature and location of the proposed scheme it was deemed necessary to consult the following Local Authorities to agree the consultation process: Liverpool City Council; Wirral Metropolitan Borough Council; Cheshire West and Chester Council; Halton Borough Council; Sefton Council; Warrington Borough Council and Knowsley Council.
- 8.2.31 The draft SoCC document was circulated to the relevant contacts at the above Local Authorities, many of whom were already engaged in the Key Stakeholder Advisory Group, in October 2010 and discussed at meetings. All comments received were taken into consideration. A revised document reflecting the feedback and suggestions received, where appropriate, was issued in November 2010. Each authority was notified where suggestions were not taken on board and the reasons why explained. All the Local Authority representatives confirmed that they were happy with the final SoCC.
- 8.2.32 In accordance with section 4 of the Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 the SoCC was published in newspapers which circulate in the vicinity of the land on which the scheme would be built. These included: Liverpool Echo; Liverpool Daily Post; Wirral News Group; Chester Chronicle; Chester Xtra; Runcorn and Widnes Weekly News; Ellesmere Port Pioneer; Formby Times; Crosby Herald; and The Southport Visitor.

Who Was Consulted

- 8.2.33 Given the nature of the potential tidal power scheme, it was recognised that a scheme could ultimately have impacts upon communities located further afield which might be able to see any scheme or be affected by the indirect impacts associated with it or with (for example) the grid connection. However, during this first round, consultation was focussed on those aspects which differentiated between options or presented material consideration for the feasibility study.
- 8.2.34 As such, the consultation audience was identified to enable us to capture the views of those who live in, work in and use the areas which had been identified as the potential location for development as follows:
- local communities and businesses who may potentially be directly affected by development of a tidal power scheme, plus surrounding communities who may have strong views or fears about development of a tidal power scheme;
 - Interest Groups, including clubs and associations, whose activities are based on the estuary; and
 - the wider public in the Liverpool City Region, West Cheshire and Warrington.

Topics for Consultation

- 8.2.35 At this point a shortlist of technology options that could support a power scheme within the Mersey had been identified and the project team had a broad understanding of what a scheme would comprise. The topics for consultation are summarised below.
- **Location:** Two main options for where a scheme should be located within an approximately 5.5 km stretch of the Estuary were considered. Feedback in relation to any relevant local issues that may help determine the choice of location or layout of facilities within the broad area was requested.
 - **Physical characteristics:** The core elements of the scheme and the potential change to access and the tidal regime had been identified. Views on how these might affect local communities and their use of the Estuary were sought.
 - **Potential impacts:** Some potential environmental and socio-economic impacts had been identified as part of the feasibility study. Views were welcomed in relation to any aspects of the local area that may be affected by the project and hence required assessment.
 - **Relevant local issues:** Feedback about other relevant local issues that needed to be taken into consideration by the project was invited.
 - **Complementary opportunities:** Opportunities for complementary development such as a visitor centre, recreational facilities, enhanced green spaces and local ecological habitats have been identified. Existing and new ideas for complementary development that local communities might like to see alongside a tidal power scheme were sought.

Methods of Consultation

- 8.2.36 A variety of consultation methods were adopted for this first round of community consultation and were agreed to be acceptable by the relevant Local Authorities.

Public Exhibitions

- 8.2.37 A number of public exhibitions took place as shown in Table 8.1 below.

Table 8.1: Public exhibitions

Date	Time	Venue
Saturday 11 December 2010	10am – 2pm	Bebington Civic Centre
Monday 13 December 2010	12pm – 5pm	Birkenhead Market
Wednesday 15 December 2010	2pm – 7pm	Sefton Park Community Library
Thursday 16 December 2010	12pm – 6pm	The Bluecoat, Liverpool
Tuesday 11 January 2011	2pm – 7pm	Ellesmere Port Civic Hall, Civic Suite
Thursday 13 January 2011	12pm – 6pm	Bromborough Central Library
Saturday 15 January 2011	10am – 2pm	Britannia Inn, Riverside Drive, Dingle
Thursday 20 January 2011	12pm – 6pm	Stobart Stadium Halton, Widnes
Saturday 22 January 2011	10am – 2pm	Eastham Country Park Visitors Centre
Monday 24 January 2011	12pm – 5pm	Garston Community Library

- 8.2.38 The exhibitions consisted of eight information panels, a short introductory video and the opportunity to discuss the proposals with a member of the project team.
- 8.2.39 The exhibitions were located in accessible venues in a variety of locations around the Mersey Estuary. As this consultation timeframe included Christmas and New Year, exhibitions were held on either side of the holiday period.
- 8.2.40 The publication of the SoCC in the local media provided the main advertisement for the public exhibitions. The SoCC was published in local newspapers from the end of November 2010 to the start of January 2011. The exhibitions were open to all members of the public and provided detailed information about the project. Members of the team were also available to answer any questions and feedback forms were provided to allow members of the public to express their views and ideas.
- 8.2.41 The exhibitions were well attended with 494 attendees recorded at the exhibitions.

Community Briefings

- 8.2.42 Town and Parish Councils and local community forums identified by the relevant Local Authorities were written to and notified about the consultation, and also asked to raise awareness of the public exhibitions. Liverpool Community Voluntary Service posted the SoCC on their website. In order to notify the business community about the consultation the Mersey Partnership notified all their members (500+) about the exhibitions. Furthermore, a number of Local Community Groups were written to and offered individual briefings about the project. The only group that took up the offer was South Liverpool District Committee, and a presentation was made on the 15th March after the original meeting on 8th February had to be cancelled due to a power failure in the local area.

Consultation Document

- 8.2.43 A short consultation document was prepared which set out the background and context to the project, an outline of the proposals being considered, the purpose and timetable of the consultation and explained how the public could provide feedback on the project. The document was placed in 38 local libraries and on the project website.

Project Website

- 8.2.44 Detailed information about the project and all consultation material was made available on the project website (www.merseytidalpower.co.uk).

Interest Group Workshops

- 8.2.45 A number of interest groups and organisations were invited to attend workshops to discuss the project with similarly interested parties. The organisations were grouped as follows: community/ regeneration focus groups; youth groups; environmental groups; angling groups; and watersports/ sailing groups.
- 8.2.46 Two workshops took place in January 2010 for the environmental and watersports/ sailing groups. No responses were received from the youth groups. Only Faiths 4 Change replied from the community/ regeneration focus group and as such a representative from Peel Energy met with them individually to discuss the project on 4th February 2011. Similarly, the North West Association of Sea Angling Clubs were the only organisation that responded from the angling group and were also given an individual briefing on 7th February 2011.

8.3 Consultation Feedback and Response

Phase 1 Pre-Feasibility Study

- 8.3.1 The responses received during Phase 1 were both positive and constructive. However, some concerns were raised in relation to changes to the hydrodynamic regime caused by any structure, and the effects this would have on the key features of designated ecological sites. This was taken into account by the project team and the effect on ecological sites

was a key issue further investigated during the feasibility study in order to address the concerns raised.

Phase 2 Feasibility Study - Stages 1 and 2

8.3.2 The aim of consultation during Stages 1 and 2 of the project was principally to inform and educate on the project's aims and objectives, obtain input to the project methodologies, and obtain feedback of relevance to the assessment of a long list of options.

8.3.3 The feedback obtained has been instrumental in informing the further stages of the assessment (shortlist and preferred option). Stages 1 and 2 were not designed to consult on specific scheme or location options. Notwithstanding this, formal responses to the Stage 1 and 2 Options Reports were requested and the feedback obtained from this process is detailed below.

Stage 1 Options Report

8.3.4 The following organisations and groups provided responses to the Stage 1 Options Report:

- Environment Agency;
- Wildlife Trusts for Lancashire and Cheshire;
- Liverpool Friends of the Earth;
- Cheshire and Wirral Ornithological Society; and
- Mersey Estuary Conservation Group.

8.3.5 The comments mainly related to environmental issues such as flood risk, impact upon internationally protected sites and the effect upon wildlife and their habitats, highlighting areas for future or ongoing assessment as part of the project.

Stage 2 Options Report

8.3.6 The following organisations and groups provided responses to the Stage 2 Options Report:

- Environment Agency;
- Merseyside Environmental Advisory Service on behalf of the five Merseyside districts and Halton Council;
- Wildlife Trusts for Lancashire and Cheshire;
- Royal Society for the Protection of Birds; and
- Friends of the Earth.

8.3.7 Again, the comments mainly related to environmental issues highlighting areas for future or ongoing assessment as part of the project.

Round One Community Consultation

- 8.3.8 151 respondents provided feedback to this round of community consultation and overall, the results from the community consultation were positive with 74% of respondents supporting the Mersey Tidal Power proposals in principle, 45% of whom strongly support the proposals (based on 143 respondents that expressed a view). It can be concluded from the consultation responses that the majority of those who provided feedback support renewable energy and importantly support a tidal power scheme within the Mersey Estuary in principle.
- 8.3.9 A limited number of respondents were strongly opposed to the project; 5% of respondents strongly opposed and 5% opposed the proposals for the Mersey Tidal Power Project. Interestingly, out of the respondents that either opposed or strongly opposed the proposals 30% support tidal range or tidal stream as a form of electricity generation. 21 letters and emails were also received from groups and individuals.
- 8.3.10 The key issues identified during the consultation related to:
- concerns about the environment and wildlife, in particular bird and fish populations;
 - access to the river and promenade areas;
 - traffic both during construction and operation;
 - navigation – concerns about sailing and shipping restrictions / locks;
 - noise both during construction and operation;
 - visual impact of the proposed scheme;
 - flood risk concerns;
 - siltation concerns;
 - provision of local jobs; and
 - potential opportunities for a river crossing, visitors centre, recreational areas and enhanced watersports, angling and bird watching facilities.
- 8.3.11 All the issues and concerns outlined above have and will continue to be taken into consideration by the project team. A response to the issues raised will be provided in future rounds of community consultation.

8.4 Conclusion

- 8.4.1 The consultation undertaken during Phases 1 and 2 of the project has been thorough and effective. The consultation has enabled stakeholders and members of the community to provide feedback on, and influence, options to date. Furthermore, an open, transparent approach has been implemented from the inception of the project.
- 8.4.2 Extensive consultation has been undertaken with both local and national stakeholders. Through the stakeholder groups information on environmental, social and economic interests has been obtained in order to help refine options and scheme design. Members of these groups have been enthusiastic and constructive participants. The stakeholder groups have been effective forums for engaging with stakeholders including statutory consultees.

These regular meetings enabled all members to be kept up to date on the progress of the project and provided an opportunity to receive feedback.

- 8.4.3 The Key Stakeholder Advisory Group has been effective in engaging with representatives of external organisations and feedback has been received at all stages. Furthermore, the Environmental Technical Group has been instrumental in engaging with environmental stakeholders and demonstrating that serious consideration has been given to the environmental interests and regulations. The meetings and subsequent correspondence have provided an effective forum to allow technical issues to be discussed and resolved, including the scope of environmental and sustainability assessments.
- 8.4.4 The first round of community consultation was extremely successful. It raised awareness of and educated the community about the need for renewable energy and the part that tidal energy, and specifically the project, can play in meeting that need. Furthermore, it provided an opportunity for members of the community to comment on the proposals and express their views.
- 8.4.5 The public exhibitions were well attended which is extremely encouraging as specific details of the scheme design had not yet been decided nor had a specific location for a scheme. The results have illustrated that there is strong, in-principle support for a tidal power project in the Estuary although many issues, predominantly concerned with the environment and sediment movement, need to be addressed as the project evolves.
- 8.4.6 Other opportunities have been provided for all stakeholders to comment on the progress of the Study through the consultation undertaken on the Stage One and Stage Two Options Reports. Initial briefing meetings have also been undertaken and presentations given at seminars and conferences to raise awareness of the project throughout all stages.

9 The Preferred Scheme

9.1 Lessons Learnt From Feasibility Study

- 9.1.1 The sample schemes developed and assessed during the feasibility study have tested the performance of a range of scheme parameters (technology, location, engineering design and operating regime) against the broad spectrum of technical, consenting and financial criteria summarised on the decision making framework.
- 9.1.2 The sample schemes assessed at Stage 3 represent the extremes of performance – IBv2a represents the best energy scheme and VLHBv3a represents the best scheme in terms of limiting environmental impacts. By identifying the issues arising from these two extremes it is now possible to identify a preferred scheme that is considered to best meet the project objectives and be taken forward for further development.
- 9.1.3 As reported in the Stage 2 Options Report and reiterated by the Stage 3 appraisal findings, there is generally a relationship between energy output and tidal regime change – generally the greater the energy output, the greater the change to the tidal regime. Any tidal power scheme will alter the tidal regime, but given the large capital costs of any tidal power structure in the Estuary and the resulting need for a high energy output in order to achieve commercial viability, the preferred scheme will inevitably cause a relatively large change to the natural tidal regime. However, given the importance of the Estuary for nature conservation and navigation, and the need to avoid increases to flood risk and adverse impacts on water quality, the preferred scheme will need to be designed to operate flexibly such that the effects of tidal regime changes can be managed across the tidal cycle and potentially seasonally.
- 9.1.4 None of the schemes assessed are currently viable without support in the form of revenue enhancement or capital grants. Reductions in the high capital costs associated with generating plant would improve financial performance, and testing of schemes with fewer turbines using OD modelling has demonstrated that restricted head generation could still be achieved with fewer turbines but more sluice gates to manage the head difference.

9.2 Design and Operation

- 9.2.1 The preferred scheme design most closely resembles the IBv2 layout developed at Stage 3, with 28 turbines or less and 18 or more sluice gates, but with ebb and flood generating plant and the turbine caissons replaced with the design developed for VLHBv3a.
- 9.2.2 An operating regime that varies throughout the tidal cycle (and possibly seasonally) to provide a combination of periods of high energy output for commercial viability and constrained output to reduce effects on intertidal habitats is proposed. Flexibility of operation could also potentially improve the timing of energy generation in relation to peak demand to achieve higher prices. Depending on the precise combination of operating

strategies adopted, an energy output in the region of 920 GWh per year might be achieved. This annual energy yield could be improved with optimisation studies and the introduction of an element of high tide pumping, although this form of operation would introduce new issues that require further study and assessment (for example flood risk). Additional energy from high tide pumping could however provide an increased level of flexibility in the way in which the scheme is operated to address the two requirements of commercial viability and limiting impacts on protected habitats. Depending on the acceptability and application of high tide pumping such flexibility might result in energy outputs of around 1,000 GWh per year.

- 9.2.3 A number of variables can be applied to the operating regime to address the balance between energy output and impacts on habitats. It may be considered appropriate to use a different operating regime at certain times of year, for example such that maximum intertidal habitat exposure is achieved when overwintering bird populations are present in the Estuary. A level of exposure would also need to be maintained throughout the year for these intertidal habitats to maintain invertebrate populations to provide suitable feeding habitat for birds. A significant shift in operation between summer and winter has therefore not been recommended, but smaller seasonal shifts (or changes to operation in extreme weather conditions) may be beneficial.
- 9.2.4 An initial proposed operating regime for the preferred scheme design has been identified based on the conclusions of the studies undertaken to date (see Figure 9.1). On the spring tide, when the volume of water passing the structure is greatest and the greatest amounts of renewable energy can be yielded, generation could use an unrestricted head and take place on the ebb tide only. This mode of operation could also be used on the neap tides when ebb and flood generation would be operationally more difficult (based on experience at La Rance, which has found the number of gate and turbine operations required for ebb and flood generation on restricted amplitude tides to be impractical). However, on smaller tides, when the potential energy yield is less, generation could take place on both ebb and flood tides and/ or using a more restricted head, to enable the upper and mid intertidal habitats that are most important for birds' feeding to be exposed for more time and to a greater extent. In some instances ebb and flood generation may also offer a better chance of this energy supply matching the timing of peak demand.
- 9.2.5 Flexible operation could also enable other issues such as flood risk, water quality and sediment movements, as well as longer term changes such as climate change and associated sea level rise, to be managed.
- 9.2.6 A number of potential variables within the operating regime would be explored in more detail in future stages. Optimisation of the initial representative operating regime described above would include:
- assessment of the beneficial and potential adverse impacts of high tide pumping on some generating cycles;
 - the identification of appropriate seasonal changes operation;
 - further modelling of potential impacts on bird populations (such as Individual Bird Modelling) to identify operational measures that prevent harm to be balanced with

other measures to mitigate impacts (with consideration of impacts on the renewable energy output);

- modelling of sediment transport, water quality, water resources, wave and flood risk impacts associated with different operating regimes.

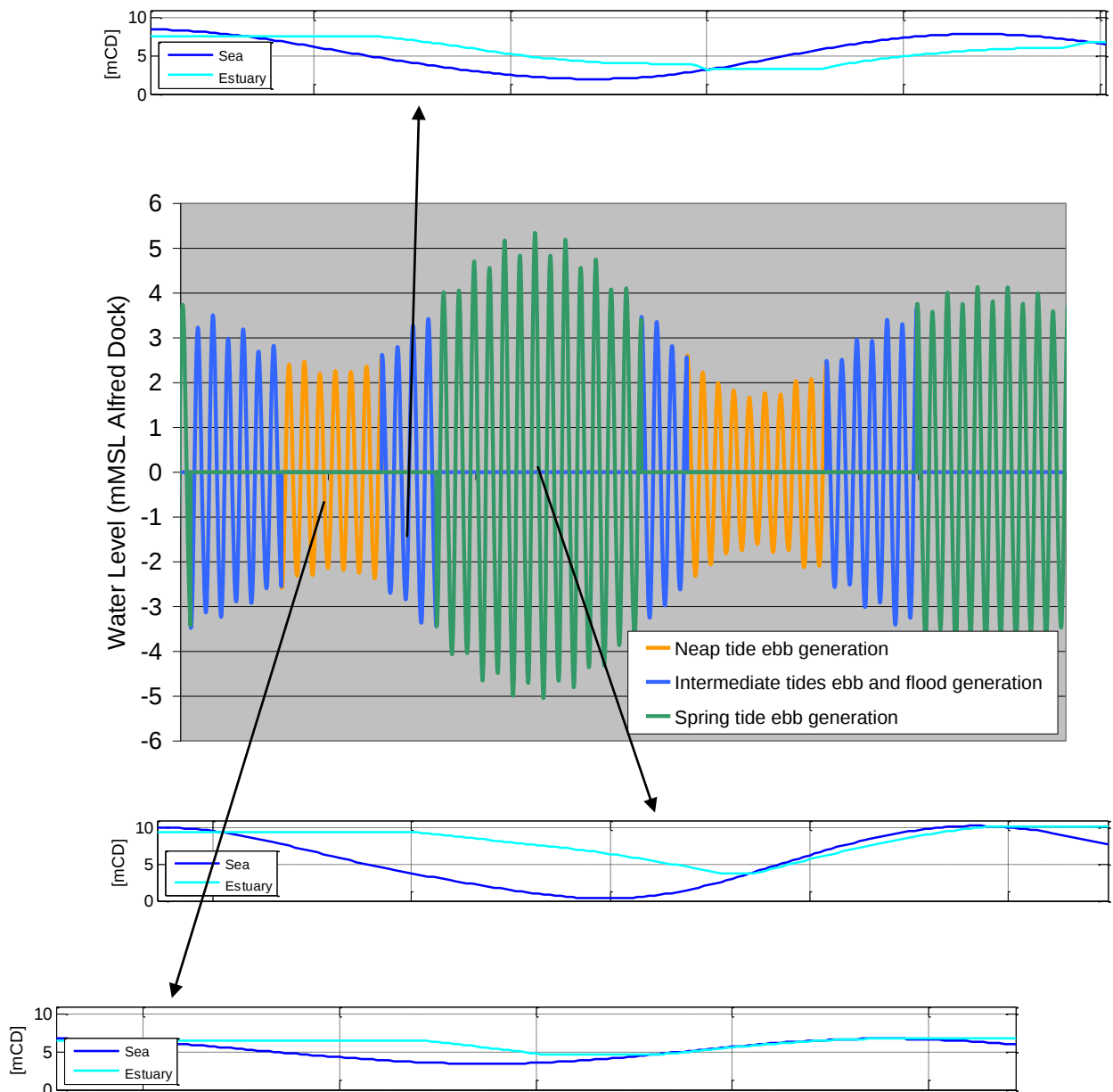


Figure 9.1: Initial proposed operating regime for preferred scheme

- 9.2.7 The number and size of turbines and sluice gates would be refined at future stages. Initial studies suggest that similar performance could be achieved with a smaller number of turbines (between 20 and 28) and thereby a lower capital cost. Increasing the number of sluice gates would incur almost no additional capital cost but would help manage the head difference during restricted head generation, increase high tide water levels in the impounded basin by allowing the flood tide to enter the basin more quickly, and assist in achieving lower sluice gate flow velocities with corresponding reductions in sediment mobilisation and transient wave formation.
- 9.2.8 The preferred scheme would also include a range of harm prevention and mitigation measures identified and designed to reduce impacts on the structure and function of sites with national and European nature conservation designations and other environmental interests including fish. Residual impacts would be likely and compensation measures may be required.
- 9.2.9 The preferred scheme has been assessed for its technical, consenting and financial acceptability, based on the initial proposed operating regime and using the conclusions of the Stage 3 scheme variant assessments and some additional analysis of energy yield and financial performance. This assessment is summarised in Sections 9.3-9.6 below and in the decision making framework (Figure 9.2). Where relative figures are quoted, these are relative to the Stage 3 sample schemes.

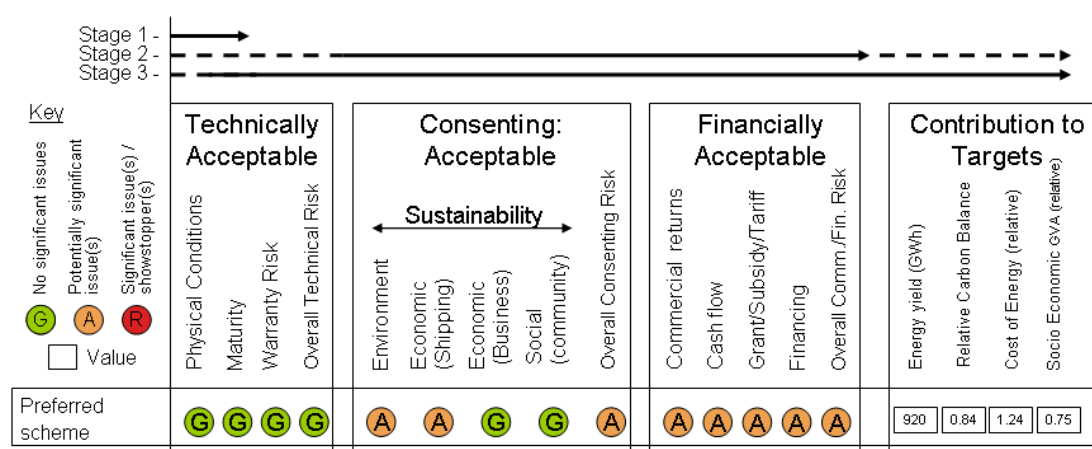


Figure 9.2: Completed decision making framework for the preferred scheme using an initial proposed operating regime

9.3 Technical Acceptability of Preferred Scheme

- 9.3.1 The preferred scheme would include conventional turbines that are suitable for use in the Mersey Estuary and would be readily available through competitive procurement with appropriate warranties. As such all technical criteria are rated as Green.
- 9.3.2 If new turbines were to become available within the project timescales, these would be considered and could be substituted into the scheme if appropriate.

9.4 Consenting Acceptability of Preferred Scheme

- 9.4.1 Measures identified at Stage 3 to manage changes to the tidal regime and thereby avoid/prevent harm and mitigate environmental impacts included different operating regimes (see Section 7.3). A flexible operating regime could enable many of the impacts to be managed:
- restricted head generation would maintain larger areas of lower intertidal habitat;
 - ebb and flood generation on some tidal cycles may also help to maintain larger areas of lower intertidal habitat, improve water mixing and therefore flushing of the Estuary, and reduce potential impacts on groundwater quality and levels;
 - ebb only generation on some tidal cycles would reduce potential impacts on fish from turbine passage during generation;
 - additional sluice gates could be used to reduce low basin water levels and increase high basin water levels, particularly on ebb and flood generation;
 - high tide pumping could be used to help maintain high water levels and has potential to increase the energy yield; and
 - flood risk (and future sea level rise) could be managed by operational changes during extreme events, including the potential use of the structure as a barrier to limit high water levels within the impounded basin.
- 9.4.2 The preferred scheme would affect the existing hydrodynamic and sediment transport regime, including changes to low and potentially high water levels, changes to currents and flow velocities and changes to sedimentation patterns. Changes would occur over the short and longer term with a new hydrodynamic regime expected to take 50 to 100 years to reach dynamic stability. However, the scheme and its operating regime could be developed to minimise the impact on the hydrodynamic regime and therefore the sediment processes within the Estuary. The use of more sluice gates would increase the chance that natural high water levels could be achieved for all tidal conditions and the use of the gates during the generating cycle would allow lower water levels to be achieved when compared to a scheme without this sluicing operation. For the ebb and flood generation periods it is possible that both high and low natural water levels could largely be achieved depending on the timing of the end of the generating cycle.
- 9.4.3 Although the changes have been minimised there would still be changes to the sediment transport regime and the morphology of the Estuary. This would affect the distribution of

sediment within the Estuary and potentially affect the quality of estuarine habitats. Specifically the location, depth and width of channels and height of intertidal areas would continue to change.

- 9.4.4 As a result of changes to the tidal regime, there could be impacts on the extent, exposure time and quality of intertidal habitats (and the SPA bird populations they support), hydrodynamic and sediment movements, water quality, groundwater levels and flood risk. During spring tides, there would be a reduction in the extent and levels of exposure of intertidal soft sediment habitats similar to that predicted for the operation of IBv2b on spring tides, however during intermediate tides the operational mode would have less impact. The lowest sections of intertidal sediment habitat would be lost throughout the tidal cycle, but these are the least important areas for birds in terms of abundance of prey items, and overall a large proportion of the intertidal sediment habitat area (the mid and upper sections of the shore which are most important for bird feeding) would remain as intertidal. Unrestricted head operation during spring tides, although having a greater impact on intertidal sediment habitats, would allow a higher high water level upstream of the structure and thereby reduce impacts on saltmarsh, which is also a sub-feature of the SPA designation. Based on the 2D modelling undertaken at Stage 3, the preferred scheme would be expected to result in a scale of impact on intertidal habitats and birds somewhere between that predicted for the IBv2b and VLHBv3a scheme variants assessed at Stage 3.
- 9.4.5 The Stage 3 assessment found there was no predicted decrease in the soft sediment wetted perimeter (where birds tend to feed) for any of the scheme variants assessed (see Table 7.4), and the same would be expected for the preferred scheme. This is important as birds tend to feed at the water's edge. Based on the 2D modelling outputs for IBv2b and VLHBv3a, the impacts on the available duration of bird feeding time (at appropriate bird densities to avoid excessive competition) can be estimated for the initial proposed operating regime presented in Section 9.2 assuming that similar tidal regimes can be created through optimisation of the preferred scheme operating regime. At low water on spring tides, the preferred scheme could be expected to decrease the time available for birds to feed at appropriate densities by around 2.33-3.45 hours (based on the IBv2b model outputs, which could be improved by the use of additional sluice gates). However at low water on some intermediate tides (when the operating regime could be switched to restricted head ebb ebb and flood operation) the preferred scheme could be expected to increase the time available for birds to feed at appropriate densities by 0.33-3.3 hours (based on VLHBv3a model outputs, which could also be improved by the use of additional sluice gates). On neap tides, the Stage 3 assessment concluded there would be no reduction in feeding time at appropriate densities compared to baseline (see Table 7.4).
- 9.4.6 A package of measures to prevent harm and mitigate impacts on estuarine ecology features, including creation and enhancement of areas for SPA birds to feed, would reduce the overall impacts on the structure and function of the SPA. There may be residual effects, and these would be considered in formulating a package of compensation measures.

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- 9.4.7 Considering the effects on the different sub-features of the SPA designation, the preferred scheme is considered to be broadly acceptable, notwithstanding some compensation measures may be required.
- 9.4.8 Impacts on fish would be less than for a scheme that operated using ebb and flood generation at all times, as turbines would only be operated on the flood as well as ebb tide for some tidal cycles. Mitigation for fish would be required but there may still be a consenting 'risk' in relation to the ecological status of the Estuary under the Water Framework Directive due to potential impacts on fish passage, which need to be considered further.
- 9.4.9 The changes in the hydrodynamics and sediment processes could also affect the water quality of the Estuary. It is possible that the changes to different water quality parameters could be either positive or negative. For example although the increased duration of low currents during the high water stand period could lower the dissolved oxygen, the high velocities of water entering the Estuary could be more turbulent and increase the levels of dissolved oxygen prior to every high water stand. The net change could be positive, neutral or negative and would need to be considered in more detail in future stages, but measures could be developed to manage the effects, including operational changes.
- 9.4.10 Changes in high and low water levels would also result in a raising of the mean water level in the Estuary with potential impacts on groundwater levels. Detailed impact assessment would be undertaken as part of future studies to inform the development of appropriate mitigation measures.
- 9.4.11 The carbon balance for the preferred scheme would be similar to that predicted for IBv2b assuming a similar layout (but with ebb and flood generating plant) and similar (slightly lower) average energy yield. The estimated net emissions saving from the first 20 years of operation would be around 7m tCO₂, with a payback period of less than two and a half years. Refinement of the scheme at future stages would seek to increase the net emissions savings by reducing the volumes of materials used in construction (including the number of turbines) and increasing the energy yield.
- 9.4.12 The preferred scheme has been rated Amber for Environment, with particular regard to the estimated level of impacts on the structure and function of the SPA as described above.
- 9.4.13 The navigation solution identified in consultation with relevant stakeholders at Stage 3 would mitigate impacts on navigation interests in the Estuary, and the preferred scheme has been rated Amber for Economic (Shipping) as for the other scheme variants assessed at Stage 3.
- 9.4.14 The socio-economic benefits arising from such a significant investment in the Mersey Estuary, both in the short term during the construction period and in the longer term during operation, would provide an important source of employment and contribution to GVA in the Liverpool City Region as well as the North West and UK. Such benefits will need to be considered alongside any residual environmental impacts. Assuming a similar level of investment as scheme IBv2b (although further studies would seek to reduce the capital

cost), the construction phase could be estimated to generate 2,200-3,000 jobs (total full time equivalent) per year for the Liverpool City Region and up to £0.85bn total GVA. The total North West GVA impact during construction is estimated to be around £1.14bn. During operation there could be around 380 full time equivalent jobs created for the area and £14.8m-£19.8m GVA in the first 25 years.

- 9.4.15 A visitor centre would be included as part of the development to provide wider benefits to the areas, and it may be possible to provide a pedestrian and/or cycle route across the structure, linking in to local regeneration initiatives, such as the proposed parkland at Bromborough.
- 9.4.16 The scheme could provide opportunities for the testing of new tidal power technologies, attracting further interest and investment to the area.
- 9.4.17 Mitigation for potential adverse social impacts, such as impacts on yachting and sailing interests and construction impacts on nearby residents, would be developed in future stages, as the nature of such impacts is studied further.
- 9.4.18 Economic (business) and Social (community) have both been rated Green.
- 9.4.19 Considering the above, the preferred scheme has been rated Amber for overall consenting risk.

9.5 Financial Acceptability of Preferred Scheme

- 9.5.1 The preferred scheme identified would be subject to further refinement and optimisation in future stages, and this would be expected to improve the financial performance of the scheme. Based on the scheme designs developed at Stage 3, and the predicted energy yield from the flexible operating regime presented in Section 9.2, the financial performance of the preferred scheme is estimated to be as shown in Table 9.1 below.

Table 9.1: Financial performance of preferred scheme based on Stage 3 design

Base Case	£/MWh
Levelised cost of generation at 10% discount rate (per MWh)	£564
Levelised cost of generation at 8% discount rate (per MWh)	£439
ARPR to achieve 10% project IRR (per MWh)	£608
ARPR to achieve 8% project IRR (per MWh)	£460
ARPR to achieve 6% project IRR (per MWh)	£315

- 9.5.2 If the capital expenditure could be reduced by 30% by scheme refinement and value engineering, the levelised cost of energy at 10% and 8% discount rates would be reduced to £397/MWh and £309/MWh respectively. Reductions to operational costs would result in less significant improvements, as concluded in Section 7.4 above. With optimisation of

energy output by 10%, the levelised cost of energy at 10% discount rate could be reduced to around £513, or with a 30% reduction in capital expenditure, 10% increase in energy yield and 8% discount rate, the levelised cost of energy at 10% discount rate could be reduced to around £281.

- 9.5.3 The preferred scheme has been rated Amber for all Financial criteria in the decision making framework, the same rating given to the IBv2a and IBv2b scheme variants at Stage 3 which are estimated to have similar financial performance. The scheme would rely on capital and/or pricing support to attract private sector investment.

9.6 Contribution to Targets from Preferred Scheme

Energy Yield

- 9.6.1 The energy yield of the preferred scheme based on a initial proposed operating regime has been estimated to be around 920 GWh. The introduction of high tide pumping and further refinements to operational strategy could increase the energy yield to around 1,000 GWh.

Carbon Balance

- 9.6.2 Based on the VLHBv3a design carbon costs and using the estimated energy yield above, the net emissions savings would be estimated to be around 7m tCO₂., with an estimated payback period of less than two and a half years.

Cost of Energy

- 9.6.3 The levelised cost of energy assuming a 10% discount rate is currently estimated to be around £564/MWh. This would be improved through refinement of the scheme in future stages, including a potential reduction in the capital costs and improvements in energy yield.

Socio-Economics

- 9.6.4 Assuming a similar level of investment to that estimated for IBv2, on which the layout of the preferred scheme is based, the total contribution of the preferred scheme to North West GVA during construction would be around £1.1bn and around £14m from the first 25 years of operation. This figure might be expected to fall slightly in future as the capital costs are reduced through refinement of the design.

9.7 Consenting Process

- 9.7.1 The consenting route that would be followed for the preferred scheme has not yet been determined, but two potential routes have been identified. One option would be through the Planning Act 2008 which provides the means for consenting of Nationally Significant Infrastructure Projects. The alternative option would be a Private Bill.

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- 9.7.2 In any event, the information required to support the consenting process will be similar, including a range of environmental and other assessments (including Environmental Impact Assessment and assessments to inform the competent authorities' Habitats Regulations Assessment and Water Framework Directive assessment).
- 9.7.3 Further work is required with Government and regulators to determine the nature of the consent and operational management. Flexibility will be required to allow a competitive procurement process in order to deliver savings and value for money for any public support.
- 9.7.4 Consultation undertaken at Stage 3 has followed the additional specific requirements of the Planning Act, including preparation and consultation on a Statement of Community Consultation, to ensure the process is aligned with that procedure (see Section 8).

9.8 Risks

- 9.8.1 Throughout the feasibility study, risks to the success of the project have been identified, recorded, managed and mitigated where possible. Risks may have potentially adverse or beneficial consequences on the project. The key risks that have been considered throughout the study are summarised below.

Technical Risks

- 9.8.2 Many of technical risks associated with the choice of technology for the preferred scheme were identified at Stages 1 and 2 and have been managed through the options appraisal process. Technologies that would represent a risk to the project because they would not be suitable for use in the Mersey Estuary or they lack maturity have been deselected. The preferred scheme would have to utilise commercially proven and warranted technology that is suitable for use in the Mersey in order to raise the necessary financial support.
- 9.8.3 Assumptions have been made regarding ground conditions at the proposed scheme location based on available data. Ground investigations will be required to provide further information to inform the design, and there is potential for unexpected ground conditions to be identified. This may have an adverse or beneficial financial impact, but would inform the precise alignment of the preferred scheme.
- 9.8.4 The timing of a grid connection for the scheme could present a technical risk, but this would be managed in consultation with National Grid.

Consenting Risks

- 9.8.5 The Habitats Regulations enact the European Habitats Directive which seeks to identify and protect the network of Natura 2000 sites, which include the Mersey Estuary SPA. The flexible operating regime proposed for the preferred scheme, together with the package of harm prevention and mitigation measures developed at Stage 3, are intended to manage the risk of effects on the structure and function of the Mersey Estuary SPA (and other nearby designated sites), and thereby maintain the integrity of the Natura 2000 network.

However there may be residual effects on the SPA, and these would have to be addressed by a package of compensation measures.

- 9.8.6 The Water Framework Directive considers a wide range of parameters in the overall consideration of ecological status/ potential of freshwater and transitional (estuarine) water bodies. The scheme could affect some of these parameters and therefore there is some risk to the project, but avoidance and mitigation measures would continue to be developed in future stages, informed by hydrodynamic, water quality and sediment transport modelling.
- 9.8.7 The consenting route for the scheme has not yet been decided, and the decision will take account of the final make-up of the scheme (and mitigation measures) and the powers of the Planning Act. There is potential for delay with any consenting route, in particular if objections are received. Consultation with stakeholders, which has been undertaken throughout the feasibility study and would continue through future stages, seeks to ensure issues are identified and addressed before the consent applications are submitted.
- 9.8.8 The feasibility study has been undertaken on the basis of available information on the current and historic baselines of the Estuary, supplemented by survey data where necessary. Whilst appropriate for the options appraisal, there is some risk that the assumptions made, whilst not affecting decisions between options, could affect the development of the scheme design and mitigation measures. As the detail of the preferred scheme progresses during future stages, more detailed information will be required to inform the design and environmental assessments, including modelling of changes to sediment movements and potential impacts on water quality, flood risk and groundwater levels.

Financial Risks

- 9.8.9 The financial performance of the preferred scheme and requirement for adequate capital/ price support from the Government currently represent a significant risk to the project. The design and capital and operational costs estimated at Stage 3 would require refinement in future stages (including the likely cost of grid connection), together with optimisation of the scheme to improve the energy yield. A cautious approach to the cost estimates has been taken throughout the feasibility study.

9.9 Scope of Further Studies

Further Studies

- 9.9.1 The following studies are likely to be undertaken in subsequent stages to inform the development of the preferred scheme and manage the risks identified above:
- detailed baseline data collection to inform design, modelling and assessment –
 - bathymetric and topographic surveys
 - further environmental surveys including ecology, water quality and resources, noise and air quality

- appropriate ground investigations and seismic risk assessment
- road traffic surveys
- identification of local regeneration opportunities, including creation of new recreational and leisure facilities
- identification of construction waste management requirements
- identification of utilities that may require diversion or protection
- identification of land ownership within and adjacent to the proposed development area and consultation with those parties as required;
- design and optimisation studies –
 - development of more detailed scheme design including caissons, training walls and transitions between sections of the structure (locks for commercial and service/ recreational vessels, turbines, sluices and blank caissons), scour protection, locks and landside facilities
 - development of preferred option for commercial and recreational vessel passage
 - development of plant design to determine materials, noise levels, construction and installation requirements, sequence and methods (including location for caisson casting), maintenance requirements and spatial requirements
 - optimisation of design to reduce capital costs
 - optimisation of design and operation to improve energy yield and commercial performance
 - operation of design and operation to achieve best environmental performance
 - development of masterplan for scheme including opportunities for associated landside development, e.g. visitor centre, pedestrian/cycle or light passenger transport
 - design of appropriate access routes and new access roads
 - development of a construction methodology;
- modelling of impacts against baseline and development of mitigation (to be undertaken iteratively with optimisation studies listed above) –
 - further hydrodynamic modelling together with sediment transport, wave, water quality and flood risk modelling and related impact assessments
 - modelling of likely impacts on birds and fish
 - further development of measures to prevent harm and mitigate ecological impacts including fish passage route structures and measures to direct fish towards them, and compensation measures to address any residual effects
 - development of flood mitigation measures
 - navigation traffic modelling, a navigation simulation study and passing ship study (with regards large ships passing closer to smaller ships berthed at Bromborough Wall) to inform design of locks and approach structures, assess risks and development appropriate safety measures
 - assessments of tug and pilot availability and economic (shipping) impact assessment
 - assessment of impacts on tributaries, outfalls and hydraulic structures to inform design
 - assessment of risks to river users (including yachting and sailing) and identification of appropriate health and safety measures; and
- development of financial solutions to support the scheme.

9.9.2 The above work would inform the formal planning, environmental and socio-economic assessments to support the applications for consent..

9.9.3 Consultation would continue to engage all stakeholders and inform the development of the preferred scheme and preparation of consents applications.

9.10 Programme

9.10.1 The programme of work going forward will depend on the level of support identified for the preferred scheme, both political and financial. At present, it is anticipated that the earliest date for consent applications to be submitted (if it was to follow the Planning Act route) would be late 2012, assuming continued investment in the project.

10 Overall Conclusions of Feasibility Study

10.1 Preferred Scheme

- 10.1.1 The Mersey Estuary provides one of the best opportunities in the UK for the generation of tidal power, a renewable energy source that could contribute to the Government's renewable energy targets for 2020.
- 10.1.2 The sample schemes studied during the feasibility study have provided a good understanding of the performance of a range of technologies, locations, designs/configurations and operating regimes, through consideration of technical, consenting and financial criteria.
- 10.1.3 Sample schemes have been tested using a variety of specialist assessment methodologies, including 0D and 2D hydrodynamic modelling, a shadow Habitats Regulations Assessment, water quality assessment using flushing calculations, socio-economic, tourism and leisure assessment, carbon accounting assessment, identification of planning policy and land use constraints, sustainability appraisal, capital costing and financial modelling.
- 10.1.4 These studies have informed the identification of a preferred scheme.
- 10.1.5 The preferred scheme would be located between New Ferry and Dingle, a deep and narrow location downstream of the majority of the Mersey Estuary SPA areas and avoiding direct impacts on the SPA from the scheme footprint. Around 20% of the shipping traffic entering and leaving the Estuary passes this location, and so appropriate provision would need to be made to enable ship passage – a double lock close to the Wirral bank is proposed.
- 10.1.6 The preferred scheme would comprise a structure spanning the width of the Estuary, with 28 (or less) bulb turbines and 18 (or more) sluice gates, housed in concrete caissons.
- 10.1.7 The scheme would have a flexible operating regime, designed to maximise energy whilst managing potential adverse impacts on the environment, in particular the structure and function of the SPA but also fish, water quality and other Water Framework Directive parameters, as well as flood risk and groundwater levels.
- 10.1.8 The feasibility study concludes that ebb only, unrestricted head generation would provide the greatest energy yield but potentially the greatest environmental impacts. Restricted head generation would have a lower energy yield but would limit impacts on the structure and function of the SPA, particularly when combined with the package of measures that has been developed to prevent harm and mitigate adverse impacts. However the study has shown that this operating mode is not viable.
- 10.1.9 Using a representative operating regime that includes unrestricted head, ebb only generation on spring tides and larger intermediate tides to maximise the energy yield, and restricted head ebb or ebb and flood generation on other smaller tides to manage

environmental impacts, the energy yield of the preferred scheme is estimated to be around 920 GWh.

- 10.1.10 The financial performance of such a scheme would need to be improved through refinement and value engineering of the scheme design at future stages, and would require adequate capital grant and/or price support through the Government's proposed electricity market reforms.

10.2 The Way Forward

- 10.2.1 The consenting route that would be followed for the preferred scheme has not yet been decided, but two potential routes have been identified – either the Planning Act 2008, which provides the means for consenting for NSIPs, or a Private Bill. The information required to support the consenting process would be similar for either route.
- 10.2.2 A wide range of further studies would be required to develop and optimise the design with input from modelling and impact assessments. These studies would help to manage the technical, consenting and financial risks that are outstanding from the feasibility study.
- 10.2.3 The programme of work going forward will depend on the level of support identified for the preferred scheme, both political and financial. At present, it is anticipated that the earliest date for consent applications to be submitted would be late 2012, assuming continued investment in the project.

11 Call for Information, Comments and Feedback

11.1.1 This Feasibility Study Report has been issued to stakeholders and for public information as part of a broad programme of consultation. The objective is to ensure that all those interested in or potentially impacted by a tidal power scheme on the Mersey Estuary:

- have access to information;
- can put forward their own ideas and feel confident that there is a process for considering ideas;
- can play an active role in developing proposals and options to ensure local knowledge and perspectives are taken into account;
- can comment on and influence formal proposals; and
- get feedback and be informed about progress and outcomes.

11.1.2 The purpose of this call for information and comment is to seek input from the public and from organisations and groups with a commercial, environmental, technological or other interest in the scheme.

11.1.3 If you would like to provide input or comment please respond under one or more of the following headings:

- 1) Are you aware of any tidal power technologies that have not been considered in the study?
- 2) Are you aware of anything that would invalidate or cast doubt on the conclusions of this report?
- 3) Are you aware of, or do you possess, any environmental, technological or other information that you think the project should be aware of?

If so, please provide details.

If you are proposing new or a different form of technology from that described in this report, please note that it can only be considered if a supporting case is provided under each of the following requirements:

- a) Suitability for the Mersey Estuary water depth and width
- b) Operability in the natural water velocity of the Mersey Estuary
- c) Survivability of the mechanical and electrical plant and other infrastructure
- d) Demonstrable maturity of the technology such that it can be adopted for a planning application by 2012 for a commercial energy generation scheme.

11.1.4 Your response, together with your full contact details, should be sent to:

Anthony Hatton
Peel Energy
Peel Dome
The Trafford Centre
Manchester M17 8PL
or emailed to energy@peel.co.uk

11.1.5 The closing date for the receipt of responses is 5th August 2011.

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