DECC

SEVERN TIDAL POWER - SEA TOPIC PAPER

Waterbirds

April 2010

Prepared by
Parsons Brinckerhoff Ltd
Queen Victoria House
Redland Hill
Bristol
BS6 6US

In association with
Black and Veatch Limited
and the British Trust for Ornithology

Prepared for
DECC
3 Whitehall Place
London
SW1A 2HD

ABBREVIATIONS

ABBREVIATIONS

The following abbreviations are used in this Topic Report:

AONB	Areas of Outstanding Natural Beauty
BAP	Biodiversity Action Plan
BTO	British Trust for Ornithology
CCW	Countryside Council for Wales
CHaMP	Coastal Habitat Management Plan
DECC	Department of Energy and Climate Change
EC	European Commission
EU	European Union
H&G	Hydrology and Geomorphology
HAM	Habitat-Association Model
HRA	Habitats Regulations Assessment
IBA	Important Bird Area
IBM	Individual-Based Model
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
LNR	Local Nature Reserve
MW	Megawatt
NE	Natural England
NNR	National Nature Reserve
ODPM	Office of the Deputy Prime Minister
RSPB	The Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SDC	Sustainable Development Commission
SEA	Strategic Environmental Assessment
SNH	Scottish Natural Heritage
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
STP	Severn Tidal Power
SWRDA	South West Regional Development Agency
TWh	Terrawatt hours
UKCIP	United Kingdom Climate Impacts Programme
WAG	Welsh Assembly Government
WeBS	Wetland Bird Survey
WWT	The Wildfowl and Wetlands Trust

NON TECHNICAL SUMMARY

NON TECHNICAL SUMMARY

Introduction

A strategic environmental assessment (SEA) is being conducted as part of the Severn Tidal Power (STP) feasibility study, in accordance with the requirements of the EU SEA Directive and UK Regulations. The SEA comprises two phases: Phase 1, the scoping stage, has already been undertaken. This Waterbirds topic paper forms part of the reporting arising from Phase 2, the main assessment of short-listed options.

Consultation
The following consultation activities have been undertaken:

- Scoping consultation in January 2009
- Technical Workshops held in July 2008, June 2009 and December 2009
- In addition to requests for data to inform the baseline, further consultation took place through two teleconferences during phase 2, specifically to discuss progress in implementing the work plan and preliminary results.

SEA Objectives
SEA Objectives have been developed to enable alternative options to be compared. Objectives may not necessarily be met in full by a given alternative option, but the degree to which they do will provide a way of identifying preferences when comparing effects of alternative options. The SEA Objectives for this topic are listed below:

- To avoid adverse effects on designated wildlife sites for birds and protected habitats of international and national importance
- To avoid adverse effects on other protected bird habitats and species
- To avoid adverse effects on national and local biodiversity target features that include bird habitats and species

Baseline Environment

Baseline information provides the basis for predicting and monitoring environmental effects, by describing the area that may be affected. Due to the long timescales associated with the construction and operation of alternative options, baseline information is considered over three time periods, to reflect the predicted changes in the area when considered without the development of a Severn Tidal Power project. The baseline therefore also describes the estuary in a 'do-nothing' scenario.

Baseline environment up to 2009
This paper evaluates the potential effects of the proposed options on waterbirds – i.e. waders, wildfowl, divers, grebes, cormorants, shags, herons and egrets – and also seabirds, notably gulls. The potential effects of the proposed options on terrestrial bird species are considered separately in the Terrestrial and Freshwater Ecology topic paper (STP 2010c).

Different levels of study area are considered reflecting the varying effects that the alternative tidal power options might potentially have on waterbirds. Reflecting this, the paper thus considers receptors a. within the area of the Severn Estuary; b. within the study area floodplain; and c. at sites outside of the Severn Estuary that might be affected by the alternative options by far-field effects. Baseline environments are described for a total of 50 receptors (comprising 45 waterbird or gull species and five assemblages).

The principal source of data used to inform the baseline environment up to 2009 was the Wetland Bird Survey (WeBS), a partnership scheme that monitors the UK's non-breeding waterbirds. A programme of survey work (described in Waterbirds Technical Annex 1) was undertaken through 2008/09 to enhance coverage on the Severn Estuary by the WeBS Core (high tide) Counts (which

provide information on waterbird populations) and the WeBS Low Tide Counts (which provide information on species distributions) and also provide information on differences in waterbird numbers through the tidal cycle and between the day and night.

Five-year mean peak values from WeBS Core Counts – i.e. means of annual peak numbers over a five-year period, as used to define the waterbird features of SPAs and Ramsar Sites in the UK – are used to describe baseline numbers of non-breeding waterbirds in this paper. For receptors using the area of the Severn Estuary, data come from the period 2004/05-2008/09. For receptors using other sites, five-year mean peak values are presented for the period 2003/04-2007/08. These figures represent the latest and most complete assessment of the waterbirds using these sites. They differ from the five-year means presented in SPA and Ramsar Site citations, as used in the Regulation 33 Conservation Objectives of the Severn Estuary SPA and Ramsar Site, which are based on data available at the time of designation. The latter represent the five year mean peak values for 1988/89-1992/93 and are thus not the most current data available. It should also be noted that in cold winters, the southwest coast of Britain, including the Severn Estuary, may act as a refuge for many waterbirds that in milder winters would occur on the east coast or on the Continent. The fact that the numbers of birds supported on the estuary in such conditions may be greater than the baseline figures used here, should thus be recognised. Further published information was also collected for this baseline on breeding waterbirds and gulls.

Using this approach, the overall waterbird assemblage using the Severn Estuary was calculated to be 72,909 birds. Numbers of each receptor within the areas of the proposed alternative options are also described.

Indices from WeBS data reported in Technical Annex 1 show that there have been considerable changes in the numbers of waterbirds using the Severn Estuary over the past 25 years, with some species showing declines and others increases. Such changes are often related to wider-scale trends. WeBS Alerts trends indicate that the decreases of several waders on the Severn reflect patterns across southwest Britain and research has linked these declines to climate change. Other existing environmental issues for waterbirds include the introduction of cord-grass *Spartina*, changes in organic input, sea-level rise that may result in erosion, flooding and habitat loss from coastal defence measures, development for industry, housing, infrastructure and recreation, and recreational disturbance (BirdLife International, 2003).

Future baseline during construction: 2014-2020 / Future baseline during operation 2020-2140, decommissioning and longer term trends

There are clearly uncertainties associated with predicting the numbers of birds that might occur on the Severn Estuary (or on other sites) during the construction and operation phases. Existing research indicates that the distributions of some waders have shifted in response to climate change and this can be used to broadly predict future trends. The Habitat Association (HA) models, described in Waterbirds Technical Annex 2, that have been developed to predict numbers of birds on the Severn Estuary following the development of each of the alternative options also incorporate temperature. They have thus also been used in this assessment to predict "baseline" numbers of birds in the absence of the options during the construction and operation phases. Likely trends in numbers can also be inferred by recent trends from WeBS. Species that use intertidal habitat would also be expected to be negatively affected by predicted rises in sea-level (UKCP09, 2009). The assumption with these predictions is that current trends will continue into the future, and it should be noted that this is not inevitable, even though current trajectories for some species suggest trends may continue for some time. It should thus not be assumed that numbers of any particular species will decline to below (SPA or Ramsar Site) qualifying levels.

Both the HA models and the previous research described are based on the national WeBS Core Count dataset. While this scheme has been running for a long time (with data available back to the late 1960s), there is clearly likely to be a large level of uncertainty in any predictions made for much greater periods into the future. Thus it is not thought appropriate in this assessment to give

quantitative predictions of the numbers of birds likely to be occurring on the Severn Estuary through to the predicted end of the operation phase. Instead, the likely direction of change is discussed, based on results of HA models, previous published research and present trends.

Key Environmental Issues and Problems
The Regulation 33 Conservation Objectives of the Severn Estuary SPA and Ramsar Site aim to maintain the populations of the features of the sites and their supporting habitats in favourable condition (NE & CCW, 2009). It should be noted that these conservation objectives (and the statutory requirements of EU member states) would require that the specific reference populations should be maintained during construction and operation of any of the alternative options whether or not they might also be adversely affected in the future by factors such as climate change.

Evaluation of Plan Alternatives

Assessment Methodology
The SEA Directive specifies the criteria that should be taken into account when determining the likely significant effects of the plan and thus these criteria have been adopted throughout the assessment process of this SEA. This topic paper therefore considers the characteristics of the effects and of the area likely to be affected.

Aside from describing the baseline environment, the main aim of this topic paper is to determine the most likely effects of the alternative options on waterbirds. This assessment is fundamentally linked to the accuracy of predictions from the Hydrology and Geomorphology and Marine Ecology topics and, consequently, uses results of the assessments of significant effects from these topics as a basis for predicting likely significant effects for waterbirds.

The methods used to assess the significance of effects on Waterbirds vary by effect – see Section 3.4 for a list of potentially significant issues for the Waterbirds topic and Appendix E for a fuller description.

The principal effect for waterbird receptors within the area of the Severn Estuary of changes to or loss of intertidal habitat has been evaluated using two separate modelling approaches: Habitat-Association Models (HA Models) and Individual-Based Models (IBMs) (see Waterbirds Technical Annexes 2 & 3 respectively). Both approaches aim to estimate the number of birds that might be expected to be supported on the Severn Estuary as a result of the immediate changes following implementation of each of the options and thus the percentage change relative to baseline figures. Both approaches use predictions from the Hydrology and Geomorphology and Marine Ecology topics on the short-term changes in the extent of intertidal habitats under each alternative option. It was not possible to produce quantitative predictions of long-term changes in waterbird numbers from HA models, as it was not possible for the Hydrology and Geomorphology to produce accurate long-term predictions of the high and low water marks required by these models. However, it was possible to quantitatively evaluate the effects of the further long-term changes predicted in the extent of intertidal habitats using IBMs.

Both approaches make a number of assumptions, which are outlined in the Technical Annexes. The purpose of using these two, complementary modelling approaches was to provide a better understanding of the range of uncertainty in model predictions. A conservative approach is used in determining which prediction should be followed in assessing the magnitude of effect, tempered by further qualifications as outlined in Appendix E. However, reasons for differences between results from the two approaches, and any consequential differences in the resulting assessment of likely significant effects are discussed.

A qualitative approach is generally used in the assessment of the potential significance of other effects; specific details relating to each effect evaluated are also outlined in Appendix E.

Alternative Options

There are five shortlisted alternative options that are being assessed within Phase 2 of the SEA for their likely significant effects. These alternative options and key parameters associated with the alternative options are:

Alternative	Location	Length (approx)	Operating mode	Turbine type	No. turbines	Annual energy output	Caissons	Locks
B3: Brean Down to Lavernock Point Barrage	Lavernock Point to Brean Down	16km	Ebb only	Bulb-Kapeller	216 (40MW)	15.1 to 17.0 TWh/year	129	2
B4: Shoots Barrage	West Pill to Severn Beach	7km	Ebb only	Bulb-Kapeller	30 (35MW)	2.7 to 2.9 TWh/year	46	1
B5: Beachley Barrage	Beachley to land directly to the east on the English side	2km	Ebb only	Straflo	50 (12.5MW)	1.4 to 1.6 TWh/year	31	1
L2: Welsh Grounds Lagoon	River Usk to Second Severn Crossing	28km	Ebb only	Bulb	40 (25MW)	2.6 to 2.8 TWh/year	32	1
L3d: Bridgwater Bay Lagoon	Brean Down to Hinckley Point	16km	Ebb & Flood	Bulb-Kaplan	144 (25MW)	5.6 to 6.6 TWh/year	42	1

Assessment of Likely Significant Effects on the Environment

Quantitative predictions of changes in waterbird numbers on the Severn Estuary resulting from short-term changes in estuary morphology from Habitat-Association Models (HAMs: Waterbird Technical Annex 2) and Individual-Based Models (IBMs: Waterbird Technical Annex 3) and the resultant likely significance of the effect of changes to or loss of intertidal habitat are summarised in the table below.

The predictions from the models are a starting point to the assessment of this effect. They should not be taken as the magnitude of effect as this is tempered by further qualification. The final assessment of magnitude is indicated in this table by shading.

An overall assessment of all likely significant effects on waterbirds for each of the options follows.

Summary of predictions of changes in waterbird numbers on the Severn Estuary resulting from short-term changes in estuary morphology from Habitat-Association Models (HAMs: Waterbird Technical Annex 2) and Individual-Based Models (IBMs: Waterbird Technical Annex 3) and the resultant likely significance of the effect of changes to or loss of intertidal habitat.

Receptor	B3			B4			B5			L2			L3		
	HAM	IBM	Sig[1]	HAM	IBM	Sig[1]	HAM	IBM	Sig[1]	HAM	IBM	Sig[1]	HAM	IBM	Sig[1]
Mute Swan	-42[2]	-		-7	-		-13	-		-26	-		-7	-	
Shelduck	-22	-	Y	-15	-	Y	-11	-	Y	-31	-	Y	-2	-	
Wigeon	-49[2]	-	Y	-20	-	Y	-20	-	Y	-35	-	Y	-3	-	
Gadwall	-20[2]	-		-2	-		-17	-		-10	-		-17	-	
Teal	-44[2]	-	Y	-23	-	Y	-24	-	Y	-31	-		-8	-	
Mallard	-41[2]	-	Y	-27	-	Y	-27	-	Y	-30	-	Y	-11	-	
Shoveler	-49[2]	-	Y	11	-	Y	6	-		-29	-		3	-	
Pochard	-25[2]	-	Y	-21	-	Y	-29	-	Y	-17	-		-18	-	
Tufted Duck	-33[2]	-	Y	-11	-	Y	-19	-	Y	-21	-		-13	-	
Cormorant	-49[2]	-		-19	-		-19	-		-34	-		-3	-	
Little Egret	-49[2]	-	Y	13	-	Y	8	-		-29	-	Y	4	-	
Ringed Plover	-49[2]	-6	Y	-21	-5	Y	-21	-4	Y	-35	-4	Y	-4	-6	
Golden Plover	-49[2]	-19	Y	-18	-15	Y	-19	-15	Y	-34	-1		-3	-16	Y
Grey Plover	-76[2]	-17	Y	-40	-12		-37	-12		-44	-1	Y	-14	-17	Y
Lapwing	-48[2]	-20	Y	-23	-14	Y	-22	-14	Y	-35	-4		-5	-18	Y
Knot	-47[2]	-30	Y	-2	-9		7	-8		-39	-8		-4	-8	
Dunlin	-45	-5	Y	-25	-3	Y	-20	-3		-34	-3	Y	-10	-5	Y
Snipe	-49[2]	-21	Y	-18	-4		-18	-3		-34	-9		-2	-14	
Black-tailed Godwit	59	-1	Y	40	-11		39	-4		-23	0	Y	37	-5	Y
Curlew	-48[2]	-	Y	-24	-	Y	-22	-	Y	-35	-	Y	-5	-	
Greenshank	-49[2]	-	Y	-22	-	Y	-21	-	Y	-35	-	Y	-4	-	
Redshank	-48[2]	-21	Y	-24	-8	Y	-23	-4		-35	-11	Y	-5	-12	Y
Turnstone	-48[2]	-21	Y	-23	-9		-22	-4		-35	-12		-5	-14	

[1] The likely significance of effects reflects receptor value and vulnerability, the probability of the effect (in this case high) and the magnitude of the effect – the latter was determined using the results of modelling but on a conservative basis, and was tempered by further qualification (see below). Red = High Magnitude Negative Effect (50% or greater decline); Orange = Medium Magnitude Negative Effect (25-49% decline); Yellow = Low Magnitude Negative Effect (10-24% decline); Light Green = Low Magnitude Positive Effect (11-32% increase).

[2] Predictions are thought likely to have overestimated the scale of probable declines (as, for the B3 option, the change in the 'fetch' value measured for this study greatly underestimated the change in turbidity predicted by the Hydrology and Geomorphology topic – see Appendix E).

No model predictions were possible or appropriate for Bewick's Swan, European White-fronted Goose, Pintail, Water Rail, Oystercatcher, Avocet, Ruff, Bar-tailed Godwit, Whimbrel, Spotted Redshank, Black-headed Gull, Common Gull, Lesser Black-backed Gull or Herring Gull.

Note, the predictions from the models are a starting point to the assessment of the effect of changes to or loss of intertidal habitat. They should not be taken as the magnitude of effect as this is tempered by further other qualification. The final assessment of magnitude and whether an effect is assessed to be significant is indicated in this table by shading.

Alternative Option B3: Brean Down to Lavernock Point Barrage
Six effects were assessed as of being of likely significance for waterbirds under this option.

The effect of disturbance was identified as a likely significant negative effect, principally during the construction and decommissioning periods, under the B3 option for two waterbird receptors within the Severn Estuary (Lesser Black-backed Gull and Herring Gull), as this option may affect a high proportion of the populations of these receptors on the estuary.

The loss of (and associated changes to) intertidal habitat resulting from this option represents the principal effect for waterbird receptors. The main, initial effect would follow construction and implementation of the option, when an estimated 51% of the intertidal would be lost (based on area exposed at lowest astronomical tide and not including intertidal areas of sub-estuaries); an additional 7.4% decrease in the extent of the intertidal is predicted over the operational phase. The predicted level of 2.0 Mm^3 of maintenance dredging per year may also affect intertidal habitat quality (by exposing mudflats to erosion and affecting the maintenance or development of invertebrate communities).

This effect was identified as a likely significant negative effect under the B3 option for 30 waterbird receptors, including the overall waterbird assemblage, as the scale of (both immediate and long-term) habitat loss and the changes to the intertidal exposure period are predicted to outweigh any positive changes in the quality of intertidal habitat. While HA models predicted larger declines than IBMs as a result of the immediate changes following implementation of this option, both indicated significant negative effects (either in the short- or long-term) for the 10 waterbird receptors that were looked at using both methods.

In addition to declines predicted because of the initial loss of and changes to intertidal habitat under this option, there are expected to be increased losses of several waterbird receptors over the long-term because of the further erosion that is predicted. Consequently, for these receptors, the magnitude of this effect is assessed to be greater than it would have been if based solely on the declines predicted because of the immediate loss of intertidal habitat. An important analogue for this effect of long-term erosion is provided by the case of the Eastern Scheldt (Oosterschelde) storm-surge barrier in the Netherlands, where continuing erosion of the intertidal has been associated with a halving of the Oystercatcher population on the estuary (though it should be noted that there are differences in the tidal regime there). While Oystercatcher numbers on the Severn might not be expected to show such a decline under this option, as their limited shellfish prey stocks might increase in a less turbid environment, numbers of many other waterbird species are predicted to show considerable declines over the long-term in association with the further erosion.

The effect of changes to saltmarsh was identified as a likely significant negative effect under the B3 option for four waterbird receptors (Bewick's Swan, European White-fronted Goose, Shelduck and Redshank), due to the short-term loss of saltmarsh and potential for further long-term losses.

Effects on breeding seabirds were also identified as a likely significant negative effect under the B3 option for three waterbird receptors (Cormorant, Lesser Black-backed Gull and Herring Gull).

Effects of changes to fish populations were not identified as a likely significant negative effect under the B3 option.

The effect of changes to freshwater wetlands was not identified as a likely significant effect under the B3 option for any waterbird receptor, as the probability and magnitude of effect are both considered low because it is assumed that water levels would be managed to avoid increase in flood risk.

The effect of displacement to far-field sites was identified as a likely significant negative effect under the B3 option for 15 waterbird receptors on a minimum of three adjacent sites (the Somerset Levels & Moors, Chew Valley Lake and Burry Inlet).

The effect of changes to water-levels at far-field sites is also identified as a likely significant effect under the B3 option for two waterbird receptors (Greenland White-fronted Goose and Greenshank), which are features of the Dyfi Estuary SPA / Cors Fochno & Dyfi Ramsar Site where (far-field) water-level changes are predicted to be greatest.

Note, if effects on receptors within the area of the Severn Estuary resulting from this or other options cannot be prevented or reduced, or compensated for, then other sites in the Natura 2000 network might also be affected. There is a high degree of uncertainty as to which sites could be affected, though Appendix B provides a review of those in the UK most likely to be affected, those which could potentially be affected and those unlikely to be affected, as well as broad regions of Europe where Natura 2000 sites could additionally be affected.

Alternative Option B4: Shoots Barrage
Two effects were assessed as of being of likely significance for waterbirds under this option.

The effect of disturbance was not identified as a likely significant negative effect under the B4 option.

The loss of (and associated changes to) intertidal habitat resulting from this option represents the principal effect for waterbird receptors. The main, initial effect would follow construction and implementation of the option, when an estimated 11% of the intertidal would be lost (based on area exposed at lowest astronomical tide and not including intertidal areas of sub-estuaries); an additional 1.7% decrease in the extent of the intertidal is predicted over the operational phase. The predicted level of 1.75 Mm^3 of maintenance dredging per year may also affect intertidal habitat quality (by exposing mudflats to erosion and affecting the maintenance or development of invertebrate communities).

This effect was identified as a likely significant negative effect under the B4 option for 17 waterbird receptors as the scale of (immediate) habitat loss and the changes to the intertidal exposure period are predicted to outweigh any positive changes in the quality of intertidal habitat. Positive effects were predicted for two waterbird receptors (Shoveler and Little Egret). While both modelling approaches predicted declines in numbers of waterbirds as a result of the immediate changes following implementation of this option, HA models tended to predict larger declines than IBMs. Following qualification, HA models and IBMs respectively indicated significant negative effects (either in the short- or long-term) for five and three of the 10 waterbird receptors that were looked at using both methods.

The effect of changes in saltmarsh was not identified as a likely significant effect under the B4 option for any waterbird receptor as, although saltmarsh was predicted to increase in extent in the short-term, this gain would potentially be counteracted by erosion in the long-term.

Effects of changes to fish populations were not identified as a likely significant negative effect under the B4 option.

The effect of changes to freshwater wetlands is also not identified as a likely significant effect under the B4 option for any waterbird receptor, as the probability and magnitude of effect are both considered low because it is assumed that water levels would be managed to avoid increase in flood risk.

The effect of displacement to far-field sites was identified as a likely significant negative effect under the B4 option for one waterbird receptor (Pintail) which is an interest feature of two adjacent designated sites (the Burry Inlet and Somerset Levels & Moors SPA / Ramsar Sites).

See note above regarding the possibility of effects on other sites in the Natura 2000 network.

Alternative Option B5: Beachley Barrage
Two effects were assessed as of being of likely significance for waterbirds under this option.

The effect of disturbance was identified as a likely significant negative effect, principally during the construction and decommissioning periods, under the B5 option for one waterbird receptor within the Severn Estuary (Wigeon).

The loss of (and associated changes to) intertidal habitat resulting from this option represents the principal effect for waterbird receptors. The main, initial effect would follow construction and implementation of the option, when an estimated 9% of the intertidal would be lost (based on area exposed at lowest astronomical tide and not including intertidal areas of sub-estuaries); it is estimated that there would then be a small 0.1% increase in the extent of the intertidal over the operational phase. The predicted level of 1.0 Mm^3 of maintenance dredging per year may also affect intertidal habitat quality (by exposing mudflats to erosion and affecting the maintenance or development of invertebrate communities).

This effect was identified as a likely significant negative effect under the B5 option for 15 waterbird receptors as the scale of (immediate) habitat loss and the changes to the intertidal exposure period are predicted to outweigh any positive changes in the quality of intertidal habitat. While both modelling approaches predicted declines in numbers of waterbirds as a result of the immediate changes following implementation of this option, HA models tended to predict larger declines than IBMs. Following qualification, HA models and IBMs respectively indicated significant negative effects (either in the short- or long-term) for three and two of the 10 waterbird receptors that were looked at using both methods.

The effect of changes in saltmarsh was not identified as a likely significant effect under the B5 option for any waterbird receptor as, although saltmarsh was predicted to increase in extent in the short-term, this gain would potentially be counteracted by erosion in the long-term.

Effects of changes to fish populations were not identified as a likely significant negative effect under the B5 option.

The effect of changes to freshwater wetlands was not identified as a likely significant effect under the B5 option for any waterbird receptor, as the probability and magnitude of effect are both considered low because it is assumed that water levels would be managed to avoid increase in flood risk.

The effect of displacement to far-field sites was also not identified as a likely significant effect for any waterbird receptor under the B5 option.

See note above regarding the possibility of effects on other sites in the Natura 2000 network.

Alternative Option L2: Welsh Grounds Lagoon
Two effects were assessed as of being of likely significance for waterbirds under this option.

The effect of disturbance was identified as a likely significant negative effect, principally during the construction and decommissioning periods, under the L2 option for 11 waterbird receptors within the Severn Estuary, as this lagoon option crosses extensive areas of intertidal habitat used by waterbirds.

The loss of (and associated changes to) intertidal habitat resulting from this option represents the principal effect for waterbird receptors. The main, initial effect would follow construction and implementation of the option, when an estimated 23% of the intertidal would be lost (based on area exposed at lowest astronomical tide and not including intertidal areas of sub-estuaries); it is estimated

that there would then be a small 0.7% increase in the extent of the intertidal over the operational phase. (There is not predicted to be a significant need for maintenance dredging within the area of this option.)

This effect was identified as a likely significant negative effect under the L2 option for 13 waterbird receptors, including the overall waterbird assemblage, as the scale of (immediate) habitat loss and the changes to the intertidal exposure period are predicted to outweigh any positive changes in the quality of intertidal habitat. While both modelling approaches predicted declines in numbers of waterbirds as a result of the immediate changes following implementation of this option, HA models tended to predict larger declines than IBMs. Following qualification, HA models and IBMs respectively indicated significant negative effects (either in the short- or long-term) for five and one of the 10 waterbird receptors that were looked at using both methods.

The effect of changes in saltmarsh was not identified as a likely significant effect under the L2 option for any waterbird receptor as, although saltmarsh was predicted to increase in extent in the short-term, this gain would potentially be counteracted by erosion in the long-term.

Effects of changes to fish populations were not identified as a likely significant negative effect under the L2 option.

The effect of changes to freshwater wetlands was not identified as a likely significant effect under the L2 option for any waterbird receptor. This is because the probability and magnitude of effect are both considered low, because it is assumed that water levels would be managed to avoid increase in flood risk, and as direct habitat loss at the landfalls is considered likely to counteract any positive effects from the possibility of increased water tables.

The effect of displacement to far-field sites was not identified as a likely significant effect for any waterbird receptor under the L2 option.

See note above regarding the possibility of effects on other sites in the Natura 2000 network.

Alternative Option L3d: Bridgwater Bay Lagoon
Three effects were assessed as of being of likely significance for waterbirds under this option.

The effect of disturbance was identified as a likely significant negative effect under the L3d option for three waterbird receptors (Wigeon, Ringed Plover and Grey Plover) within the Severn Estuary, as this option may affect a high proportion of the populations of these receptors on the estuary.

The loss of (and associated changes to) intertidal habitat resulting from this option represents the principal effect for waterbird receptors. The main, initial effect would follow construction and implementation of the option, when an estimated 8% of the intertidal would be lost (based on area exposed at lowest astronomical tide and not including intertidal areas of sub-estuaries); an additional 1.1% decrease in the extent of the intertidal is predicted over the operational phase. The predicted level of 0.06 Mm^3 of maintenance dredging per year may also affect intertidal habitat quality (by exposing mudflats to erosion and affecting the maintenance or development of invertebrate communities).

This effect was identified as a likely significant negative effect under the L3d option for nine waterbird receptors (Pintail, Golden Plover, Grey Plover, Lapwing, Dunlin, Black-tailed Godwit, Bar-tailed Godwit, Spotted Redshank and Redshank), as the scale of (immediate) habitat loss and the changes to the intertidal exposure period are predicted to outweigh any positive changes in the quality of intertidal habitat. While both modelling approaches predicted declines in numbers of waterbirds as a result of the immediate changes following implementation of this option, HA models tended to predict smaller declines than IBMs. Following qualification, HA models and IBMs respectively indicated

significant negative effects (either in the short- or long-term) for two and five of the 10 waterbird receptors that were looked at using both methods.

The effect of changes in saltmarsh was not identified as a likely significant effect under the L3d option for any waterbird receptor as, although saltmarsh was predicted to increase in extent in the short-term, this gain would potentially be counteracted by erosion in the long-term.

Effects on breeding seabirds were also identified as a likely significant negative effect under the L3d option for two waterbird receptors (Lesser Black-backed Gull and Herring Gull).

Effects of changes to fish populations were not identified as a likely significant negative effect under the L3d option.

The effect of changes to freshwater wetlands was not identified as a likely significant effect under the L3d option for any waterbird receptor, as the probability and magnitude of effect are both considered low because it is assumed that water levels would be managed to avoid increase in flood risk.

The effect of displacement to far-field sites was not identified as a likely significant effect for any waterbird receptor under the L3d option.

See note above regarding the possibility of effects on other sites in the Natura 2000 network.

Assumptions, Limitations and Uncertainty

Assumptions, limitations and sources of uncertainty exist in relation to the assessment of each of the potential significant effects.

In relation to the principal effect of changes to or loss of intertidal habitat, it should first be noted that the models used to assess this effect, and thus the assessment itself, are fundamentally dependent on the accuracy of Hydrology and Geomorphology and Marine Ecology predictions. Two, complementary modelling approaches – HA models and IBMs – have been used to provide a better understanding of the range of uncertainty in model predictions.

Both modelling approaches aim to provide the best possible assessment of the likely effects of changes to or loss of intertidal habitat. The key Hydrology and Geomorphology and Marine Ecology predictions for these models and this assessment are i. the change in the extent of the intertidal area in the short-term ii. changes in sediments in the short-term iii. changes in productivity and iv. changes in the extent and quality of intertidal sediments in the long-term. Given the predicted level of intertidal habitat loss, the levels of uncertainty associated with these predictions are unlikely to affect the overall conclusion that the effect of changes to and loss of intertidal habitat under the B3 option would be of likely negative significance for most waterbird receptors, though could affect the assessed magnitude of effect. For the other options, where the loss of intertidal habitat is predicted to be less, the uncertainty associated with these predictions is also unlikely to affect the overall conclusion that the loss of habitat would likely have significant negative effects. However, these uncertainties may be important in determining how many and which waterbird receptors might be affected.

The results presented for IBMs use predictions from the Marine Ecology topic of the extent of intertidal sediments within the respective option areas following implementation. For the B3 option, the Marine Ecology topic also predicts significant increases in benthic invertebrates due to both decreased disturbance of sediments and an increase in primary productivity. Thus the IBM predictions presented in this topic paper for this option are taken from a scenario in which the benthic invertebrate community becomes similar to that found in other southwest estuaries (i.e. increases in biomass). For the other options, there is predicted to be no significant increase in primary productivity. Thus IBM predictions for these options are taken from a scenario in which the invertebrate species community remains as it presently is on the Severn Estuary. For each option, the scenario used is thus based on

the most likely outcome predicted by the Marine Ecology topic. Predictions from both scenarios for each option are presented in Waterbirds Technical Annex 3.

Uncertainty exists in the fit and accuracy of the model predictions; results are also qualified according to how well they take into account the predicted geomorphological and hydrological changes and whether they reflect the proportion of the population that uses the area of the option in question. Data on intertidal invertebrates on the Severn Estuary and other south-west English estuaries used to parameterise the IBMs also came from the 1980s and, though this was the best dataset available, it should be noted that invertebrate communities may have changed since then. It should also be noted that both approaches initially aim to estimate the number of birds that might be expected to be supported on the Severn Estuary as a result of the immediate changes following implementation of each of the options. Predictions of longer-term changes are available from IBMs, and results from HA models can be qualified by the further predicted changes in the extent and quality of intertidal habitat (as provided by the Hydrology and Geomorphology and Marine Ecology topic) over the operational lifetime of each option.

The assessment of the effect of changes to saltmarsh for waterbirds is primarily dependent on the accuracy of predictions of changes in the extent of saltmarsh. In particular, there is uncertainty as to whether saltmarsh might become more vulnerable to erosion in the long-term. There is also uncertainty as to the quality of saltmarsh habitat in the long-term given the changes to tidal flooding.

In relation to the effect of changes to freshwater wetlands, there is uncertainty as to the extent of effects on water tables and thus to the potential benefits for waterbirds, in part because it is probable that water levels would be managed through measures to prevent or reduce adverse effects to avoid an increase in flood risk.

It is assumed that displacement effects would only occur on far-field sites if there are significant negative effects on waterbirds within the area of the Severn Estuary itself. It is also assumed that displacement is most likely to affect features of adjacent sites; however, effects on sites further afield cannot be discounted.

The assessment of the effect of far-field changes in water-levels for waterbirds is dependent on the predictions of change in water levels, which carry a high degree of uncertainty.

There is also a high degree of uncertainty as to whether and which other sites in the Natura 2000 network might also be affected if effects on receptors within the area of the Severn Estuary cannot be prevented or reduced, or compensated for. Appendix B reviews those UK sites most likely to be affected, those which could potentially be affected and those unlikely to be affected, as well as broad regions of Europe where Natura 2000 sites could additionally be affected.

In summary, there is a degree of uncertainty in relation to the assessment of each of the potential significant effects. The assessment of the principal effect of changes to or loss of intertidal habitat is primarily limited by the accuracy of Hydrology and Geomorphology and Marine Ecology predictions and secondarily by the limitations of the modelling approaches used. Both the HA models and IBMs nevertheless aim to predict the most likely outcome based on the predictions of changes from the Hydrology and Geomorphology and Marine Ecology topics.

Measures to prevent, reduce and as fully as possible offset any significant adverse effects

Six measures identified to prevent or reduce likely significant adverse effects identified within this topic are described below.

i. Measure M8 – One operational measure has been identified aiming to reduce the principal effect for waterbirds of the loss of intertidal habitat. Management of sluices, e.g. sluicing after the generation period on a spring tide for those options (B3, B4, B5 and L2) where ebb only

options are presently proposed, would reduce predicted spring low tide levels and thus increase the intertidal exposed on these tides. The effectiveness of this would vary depending on the arrangement of sluices, but would also potentially decrease losses in numbers of waterbirds because of a reduced loss in the intertidal and also help maintain a more natural tidal regime. For option B3 this has the potential to lower low water levels on spring tides by around 0.5m. Such a measure would reduce intertidal habitat loss by approximately 500ha. It is assumed that this measure would be implemented for all ebb only options, though as the measure would reduce the loss of intertidal habitat by less than 5%, its effectiveness for waterbirds would be correspondingly small.

ii. Measure M9 – Topographic modification (i.e. intertidal habitat creation) both within and outwith the impounded areas of the alternative options has been proposed as a measure that could lessen the effect of loss of intertidal area. For the B3, B4, B5, L2 and L3d options respectively, following modelling work assessing how much intertidal habitat it might be viable to attempt to create and assuming that at least twice as much habitat would need to be created to effectively replace lost habitat, it is suggested that the compensation requirement could be reduced by 1,000-2,250 ha, 250-562 ha, 250-562 ha, 530-1,192 ha and 390-877 ha respectively – approximately 10.0-22.5% of that which might be required. The proposals mostly aim to 'recreate' intertidal habitat lost due to increased low water levels within the areas of the tidal power options. New intertidal habitat might also be formed by raising existing sub-tidal habitat. The proposed habitat creation would thus not completely prevent or reduce the loss of intertidal habitat and is untried at this scale. Its efficacy at compensating for the effect of intertidal habitat loss on waterbirds is highly uncertain and would depend on the sustainability of the habitat created, its quality and its exposure.

iii. Measure M12 – While complete avoidance of disturbance during construction (and decommissioning phases) is unrealistic as many receptors are present on the Severn Estuary for much of the year, restricting the level of during the midwinter period and stopping work completely close to intertidal areas in periods of severe weather would be of benefit to non-breeding waterbirds. Restricting the timing of construction (and decommissioning) or methods used in terrestrial areas and, for the B3 option, close to Flat Holm and Steep Holm, would also be particularly effective in limiting the effects of disturbance on breeding birds.

iv. Measure M13 – The introduction of purpose built roost sites would help to reduce the effect of losses of safe roosting areas, associated with the loss of saltmarsh (resulting from alternative option B3 only). Such measures have been used with some success elsewhere where developments have resulted in the loss of traditional waterbird roosts.

v. Measure M11 – Minor option alignment adjustments would be effective at avoiding particular rich waterbird feeding habitats, e.g. eelgrass beds found in the vicinity of the L2, B3 and B4 options.

vi. Measure M10 – Alignment adjustments could also ensure that the B3 barrage is sufficiently far from Flat Holm and Steep Holm to limit disturbance to breeding birds and prevent sediment connecting the islands. If the B3 option became connected to or was too close to these islands, this could potentially lead to colonisation by rats (which, through predation of eggs and young, can lead to large decline in numbers of breeding seabirds). A rat control programme should also be considered to negate this risk.

Other measures identified aiming to prevent or reduce the predicted effects of the alternative options on receptors considered by the Migratory and Estuarine Fish (STP 2010b), Terrestrial and Freshwater Ecology (STP 2010c), Marine Water Quality (STP 2010f), Navigation (STP 2010d) and Resources and Waste (STP 2010e) topic papers that might also potentially affect waterbirds are discussed.

Offsetting measures within this SEA are measures to as fully as possible offset any significant adverse effects on the environment. These measures therefore make good for loss or damage to an environmental receptor, without directly reducing that loss/damage. In this SEA 'compensation', a subset of offsetting, is only used in relation to those measures needed under the Habitats or Birds Directives. Offsetting measures required for waterbirds are considered to be compensation measures under the Birds Directive and are thus being considered by the Compensation Workstream. Compensation measures for waterbirds are likely to entail, for example, managed re-alignment to create saltmarsh adjoining the Severn Estuary, managed re-alignment to create saltmarsh and mudflat at a distance from the Severn Estuary and the creation of freshwater wetland habitat close to Severn Estuary.

In this topic paper, it is assumed that all the measures outlined above aiming to reduce or prevent effects for waterbirds would be implemented. Of these, measure 'M10' which aims to reduce effects on breeding seabirds has the potential to prevent this effect entirely. Other measures will mostly have only relatively small effects, with the exception of measure 'M9', topographic modification.

Topographic modification would aim to reduce the compensation requirement for intertidal habitat by 1,000-2,250 ha, 250-562 ha, 250-562 ha, 530-1,192 ha and 390-877 ha for the B3, B4, B5, L2 and L3d options respectively – i.e. approximately 10.0-22.5% of that which might be required. Even if this is successful, there would thus still be a large outstanding residual effect from the loss of intertidal habitat under each option, and thus compensation would be required.

It is also very important to note that, while this measure would undoubtedly be of benefit, the efficacy of intertidal habitat creation through topographic modification is highly uncertain on the scale proposed. Further work would be needed to reduce the uncertainty of the effectiveness of intertidal habitat creation on the large scale required. Until this further work is carried out the estimates of its effectiveness have a high degree of uncertainty and so their value in determining the scale of the reduction in the compensation requirement is limited at the present time.

It should also be noted that even if sufficient habitat could be created within the Severn Estuary or elsewhere to support, in the long-term, the same numbers of waterbirds as at present, effects may still be felt because of the time that it might take for such habitat to become fully functional. Ideally such habitat creation measures would be put in place at least five years before the closure of the barrage / lagoon, or longer, depending on predictions of the length of time it would take for such habitat could become fully functional. However, in the case of ebb only generation, intertidal areas within the impoundment would change their inundation patterns during construction and thereafter upon closure. Even if there are parts of the estuary where replacement habitat could be created, the effects of the initial changes to and loss of intertidal habitat would still have an effect as waterbirds would be displaced and need to redistribute within the estuary to the new habitat to survive.

Assessment against SEA Objectives

This topic paper includes a full assessment of how each alternative option performs against each SEA Objective over the course of its entire life-cycle.

In summary:

SEA Objective 1 – to avoid adverse effects on designated wildlife sites for birds and protected habitats of international and national importance. This objective relates to 43 of the receptors considered in this topic paper.

Likely significant negative effects are predicted for 27 of these receptors under option B3, 16 under option B4, 14 under option B5, 14 under option L2 and 12 under option L3d (Tables 3.1 to 3.5; Table 4.1). Positive effects are predicted for two receptors for option B4.

Changes to or loss of intertidal habitat within the Severn Estuary represents the principal effect for all options. Disturbance (mainly) during construction and decommissioning is predicted to be of particular significance for the lagoon option L2, as this option crosses a considerable length of existing intertidal areas. Negative effects of changes to saltmarsh are largely restricted to the B3 option and negative effects on breeding seabirds to the B3 and L3d options.

Changes in water-levels and displacement have the potential to also affect waterbirds at far-field sites under all options (the former more so for the B3, L2 and L3d options). Likely significant effects are assessed to be largely restricted to the B3 option, though a displacement effect is predicted for one receptor under the B4 option. It should be re-iterated that while the displacement of birds from the Severn is most likely to affect features of adjacent sites, though effects on sites further afield cannot be discounted, particularly for species that are dependent on a limited number of sites. Likewise, there is a potential risk of effects from far-field changes in water levels from the B3 option beyond the area modelled and sites considered here, but these effects cannot be quantified until more detailed studies are undertaken.

Assuming the success of measures to prevent effects on breeding seabirds and that topographic modification might reduce losses of waterbirds by up to 22.5% (see section 3.6), likely significant negative residual effects would be predicted for 27, 15, 13, 13 and 11 of the 43 receptors relevant to this objective under options B3, B4, B5, L2 and L3d respectively.

SEA Objective 2 – to avoid adverse effects on other protected bird habitats and species, i.e. at statutory or non-statutory wildlife sites other than SPAs, Ramsar Sites and SSSIs.

As such sites (e.g. NNRs, IBAs) overlap with SPAs, Ramsar Sites and SSSIs, the two objectives have many receptors in common and thus there is overlap in the effects as discussed above.

Likely significant negative effects are predicted under all of the tidal power options for many of the 45 receptors relevant to this objective – in total, 31, 16, 14, 14 and 13 under options B3, B4, B5, L2 and L3d respectively (Tables 3.1 to 3.5; Table 4.1). Positive effects are predicted for two receptors for option B4.

Assuming the success of measures to prevent effects on breeding seabirds and that topographic modification might reduce losses of waterbirds by up to 22.5% (see section 3.6), likely significant negative residual effects would be predicted for 30, 15, 13, 13 and 12 of the 45 receptors relevant to this objective under options B3, B4, B5, L2 and L3d respectively.

SEA Objective 3 – to avoid adverse effects on national and local biodiversity target features that include bird habitats and species.

Again, this objective has many receptors in common with the first and thus there is overlap in the effects as discussed above.

Likely significant negative are predicted under all of the tidal power options for many of the 40 receptors relevant to this objective – in total, 28, 13, 11, 12 and 13 under options B3, B4, B5, L2 and L3d respectively (Tables 3.1 to 3.5; Table 4.1). Positive effects are predicted for two receptors for option B4.

Assuming the success of measures to prevent effects on breeding seabirds and that topographic modification might reduce losses of waterbirds by up to 22.5% (see section 3.6), likely significant negative residual effects would be predicted for 27, 13, 10, 12 and 12 of the 40 receptors relevant to this objective under options B3, B4, B5, L2 and L3d respectively.

Plan Implementation

Legislation and policy compliance

This paper contains a review of legislation and policy that is specifically relevant to this topic. An assessment has been made as to whether each alternative option would be compliant with existing relevant legislation and policy.

It will be essential for any tidal power option to demonstrate compliance with the requirements of the European Community (EC) Habitats and Birds Directives. These establish a network of areas designated to conserve natural habitats and species that are rare, endangered, vulnerable or endemic within the European Union, i.e. the 'Natura 2000' network. The requirements of the EC Habitats and Birds Directives are transcribed into UK law by the Habitats Regulations[1] and have led to the establishment of SACs and SPAs.

An appraisal of whether an STP scheme could comply with the Habitats Regulations needs to be undertaken and integrated into the selection of the preferred option or options to enable an informed decision and to ensure that the chosen option or options can comply with the law. Thus a report to inform a consideration of the screening of likely significant effects under the Habitats Regulations has been prepared (DECC, 2010). The report identifies the potential hazards associated with each short-listed option and assesses whether Natura 2000 sites would be exposed to these hazards and be subject to likely significant effects. A report that collates, analyses and presents the information that would be required for an Appropriate Assessment (Stage 2 of the HRA process), i.e. to evaluate likely effects on features of SPAs and Ramsar Sites under each option in more detail, is also being prepared. These reports will build on the assessment presented here for waterbirds.

The principal legislation of relevance at a national level for waterbirds is the Wildlife & Countryside Act (amended 2000) which deals with the establishment and management of sites including SSSIs and National Nature Reserves. Also of relevance at a UK level are species listings as UKBAP species and Birds of Conservation Concern (BoCC), together with the Natural Environment and Rural Communities Act (2006) (in particular, Sections 41 and 42 which list BAP Species of Principal Importance in England and Wales).

Future research and monitoring of significant environmental effects

The SEA Directive requires that monitoring measures are described within the environmental reporting. The monitoring proposals contained within this paper are applicable to all of the alternative options under consideration.

With respect to any further assessment of the options, and informing any future proposals for other tidal power schemes, further development of the Habitat Association modelling approach to allow predictions to be made at a within-estuary scale would be of benefit.

Development of approaches to better predict benthic invertebrate communities and biomass would also benefit the use of IBMs.

Further investigation into the effectiveness of topographic modification (i.e. intertidal habitat creation) as a measure to reduce the effects of changes to and loss of intertidal habitat will reduce the uncertainty presently associated with this. An investigation of 'natural experiments' when new intertidal areas have been formed, e.g. by natural breaking down of seawalls, or deliberately as measures to prevent or reduce adverse effects or compensation, would help to reduce the uncertainty of the likely success of this measure.

[1] The Conservation (Natural Habitats, &c.) Regulations 1994 (SI 1994/ 2716). From 1 April 2010, the regulations will be replaced by The Conservation Of Habitats And Species Regulations, 2010.

With respect to monitoring of significant environmental effects, comprehensive monitoring of the waterbirds of the Severn Estuary should be undertaken for a number of years prior to the proposed start of construction in 2014. A minimum of five years comprehensive monitoring would provide the five-year mean peak data required to establish a firm baseline, though it should be noted that this would not be achievable with the present suggested start date for construction.

This monitoring should continue through the proposed 2014-2020 construction period.

As the estuary is predicted to continue to evolve over the full period of operation (2020-2140) under all options, then waterbird populations are predicted to be continued to be affected and continued monitoring would be required for this whole period. Particular effort would be needed to provide comprehensive monitoring of the Severn Estuary in the immediate period following implementation of any of the alternative options.

By establishing a sound and long-term monitoring programme from the outset, a firm evaluation of the changes consequent of construction of any of the alternative options would be possible. This could also be important in informing any future proposals for other tidal power options.

The following elements of the monitoring programme are recommended:

- The main element of the monitoring programme should be to ensure that complete coverage by WeBS Core Counts of the Severn Estuary is achieved annually. It is recommended that counts should be undertaken twice (rather than once) a month during the key periods to provide greater power in being able to detect changes in numbers.

- WeBS Core Count data from other sites that might be affected by the options (e.g. as identified in this assessment, the Burry Inlet, Somerset Levels & Moors, Chew Valley Lake and Dyfi Estuary SPAs) should be assessed to determine whether gap-filling is also required to ensure complete coverage of these sites. Data should then be evaluated annually to determine whether there have been increases in bird numbers at those sites that might be concurrent with declines on the Severn Estuary.

- To monitor changes in distributions within the Severn Estuary, the monitoring programme should also ensure complete annual coverage by WeBS Low Tide Surveys for the five year baseline period, and that further comprehensive Low Tide Surveys are undertaken regularly through construction and operation.

- The WeBS Core and Low Tide Counts should also be supplemented by a regular programme of through-the-tide counts and nocturnal surveys, as described in Waterbirds Technical Annex 1 and used to inform the baseline to this topic paper.

- Any habitat created through topographic modification or as compensation should be more intensively monitored in order that its success could be properly assessed. Such areas should be included in those covered by the programme of WeBS Core and Low Tide Counts described above, though it should be noted that it would not be possible to monitor any offshore habitat created through the WeBS volunteer network.

- Annual surveys of breeding seabirds on Flat Holm and Steep Holm and breeding waders using saltmarsh areas are also recommended.

- In addition to monitoring changes in numbers, it is also important to be able to understand the mechanisms behind such changes. It is thus important to establish a marking programme for key species during the baseline phase to monitor changes in juvenile recruitment, movements, body condition and survival before, during and after the development.

- It is also recommended that annual benthic invertebrate surveys are undertaken in order that changes in waterbird numbers can be understood in relation to changes in their food supplies. This would be important both in remaining areas of existing habitat and in assessing the success of any habitat created through topographic modification or as compensation.