DECC

SEVERN TIDAL POWER - SEA TOPIC PAPER

Navigation

March 2010

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

In association with
Black and Veatch Limited

Prepared for
DECC
3 Whitehall Place
London
SW1A 2HD

ABBREVIATIONS

ABBREVIATIONS

The following abbreviations are used in this Topic Report:

AOD	Above Ordnance Datum
BERR	Department for Business, Enterprise and Regulatory Reform
BGS	British Geological Survey
BODC	British Oceanographic Data Centre
CCW	Countryside Council for Wales
CD	Chart Datum
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DSCT	Deep Sea Container Terminal
dwt	Dead Weight Tonnage
EIA	Environmental Impact Assessment
EC	European Commission
EU	European Union
GIS	Geographical Information System
H&G	Hydraulics and Morphology
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MW	Megawatt
NPS	National Policy Statement
OD	Ordnance Datum (Newlyn)
ODPM	Office of the Deputy Prime Minister
PPG	Planning Policy Guidance
PPS	Planning Policy Statements
ppt	Parts per thousand
PSU	Practical Salinity Units
SDC	Sustainable Development Commission
SEA	Strategic Environmental Assessment
SLR	Sea Level Rise
STP	Severn Tidal Power
STPG	Severn Tidal Power Group
TWh	Terrawatt hours
UKCIP	United Kingdom Climate Impacts Programme
UN	United Nations

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 Navigation 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 June 2009 and December 2009
- Consultation with the main Port and Harbour Authorities between March and October 2009 to discuss current port operations and navigation requirements
- Teleconferences in September 2009 and November 2009 with other key stakeholders such as Natural England, CCW, DEFRA and DECC to update key stakeholders on progress and answer any queries presented by the key stakeholders

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:

- Objective 1: To avoid adverse effects on Severn Estuary navigation arising from sedimentation, geomorphology, water density, and tidal water levels
- Objective 2: To avoid adverse effects on the integrity of existing and proposed port operations

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.

The key receptors to be included within the navigation topic paper comprise the main Port and Harbour Authorities which would be impounded by one or more of the STP alternative options and hence which could be significantly affected by changes to the environmental conditions in the estuary. These have been identified to be:

- Bristol Port Company, comprising Portbury and Avonmouth Docks at the Port of Bristol
- Associated British Ports, incorporating the commercial ports of Cardiff and Newport
- Gloucester Harbour Trustees, comprising Sharpness Dock and the Gloucester Sharpness Canal which links Sharpness Dock with Gloucester Docks and the rest of the inland waterway system
- Port of Bridgwater, comprising Dunball Wharf and Combwich Wharf accessed from the River Parrett.

Baseline environment up to 2009

Access to the ports listed above is tidally restricted, with water levels within the ports (apart from Bridgwater) being contained by lock gates and controlled by impounding pumps. Navigation to the

ports is often reliant on the incoming high tides and the lock gates to the ports are usually only operated for a few hours on either side of the high tide.

Ship movement data gathered from the ports indicates that they receive approximately 4,200 commercial vessels each year, with daily averages ranging between 7 and 15 vessels per day. Pilotage to the main commercial ports within the estuary is compulsory for the majority of large vessels. The pilot station for the ports is located at Barry. A summary of the number of vessels typically received by each port each year, the maximum size of vessel which can be received and the transit time required to navigate the largest vessels from the pilot station into the impounded docks is provided below

Port	Annual vessels received	Maximum size of vessel				Transit time
		Length	Beam	Draught	dwt	
Bristol (Portbury)	800	300	41.0	14.5	130,000	2 – 2½ hrs
Bristol (Avonmouth)	900	210	30.0	11.0	35,000	2 – 2½ hrs
Cardiff	1100	198	27.0	10.37	35,000	1 – 2 hrs
Newport	1120	244	30.1	10.5	40,000	1½ - 2 hrs
Sharpness	160	140	16.5	6.5	10,000	3 – 3½ hrs
Bridgwater	35	-	-	3.0-5.5	-	-

Future baseline during construction: 2014-2020

Discussion with the main Port and Harbour Authorities confirmed that there are no known plans for development of existing infrastructure at each of the ports which would enable larger vessels to enter the impounded docks. Potential expansion of Bristol Port will be considered as a cumulative effect but is assumed to not affect vessel movements to the existing impounded docks during the construction phase. For the purpose of this assessment it is assumed that commercial navigation during the construction phase of any selected STP option will be maintained as per the current baseline situation. Any predicted increase in commercial navigation will be considered during the operational phase.

Future baseline during operation 2020-2140, decommissioning and longer term trends

Current limitations to the maximum size of vessel which can enter the impounded docks of each port will remain unchanged and that there are no known plans for development of existing infrastructure at each of the ports which would enable larger vessels to enter the ports. It is also assumed that current restrictions to the size of vessel which can navigate through The Shoots, as defined by the New Severn Bridge (Restriction of Navigation) Regulations 1993, will not change.

However, it is considered likely that UK shipping will grow during the operational phase of any STP option as an economic, low carbon method of national and international trade. Through discussion with the main Port and Harbour Authorities it was confirmed that there would be capacity for growth within the ports within the vessel size limits which can currently be received. It is therefore predicted that shipping activity to the ports will increase during the operational period of the proposed STP option. This increase is likely to include an increase in the number of ship movements as well as an increase in the percentage of larger vessels entering the ports.

The Bristol Port Company lodged a Harbour Revision Order with the DfT for the construction of a Deep Sea Container Terminal (DSCT) in July 2008 which would increase the size and number of vessels received by the Port of Bristol. However, at the time of writing the approval of the DSCT has not been made and the assessment has therefore been based on the limitations set by current port facilities. The potential implications of the DSCT are considered within the Cumulative Effects section of this topic paper.

Key Environmental Issues and Problems

The ability to navigate safely to and from the main commercial ports is significantly dependant on the environmental conditions experienced within the estuary. Tidal water levels, water density and sediment accretion have the potential to reduce the available depth of water for navigation, particularly for passage over the lock sills. Tidal velocities could adversely affect navigational safety and the required transit time to manoeuvre a vessel into dock.

The maximum size of vessel which can be received by the ports is primarily restricted by the lock dimensions, particularly the outer sill level which limits the maximum draught of vessel which can be received. For the Port of Bridgwater, the maximum size of vessel is limited by the navigable depth of water up the River Parrett.

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.

This topic has also used the following specific assessment methods.

The scope of the Navigation topic comprises consideration of direct and indirect changes that alternative options for tidal power generation may bring about to navigational conditions in the Severn Estuary, with particular regard to:

- Tidal water levels
- Water velocity
- Mud and sand transport
- Morphological evolution
- Water density
- Transport and transit times
- Construction related navigation issues

The potential effects of the alternative STP options on current environmental conditions experienced within the Severn Estuary is assessed based on the results of the complex modelling undertaken by Black and Veatch, HR Wallingford and ABPmer. Data regarding current port operations has been sourced through direct consultation with the main Port and Harbour Authorities.

The potential effects of changes to the current tidal regime, salinity and changes to bed level on navigation have been determined by analysing the total available depth of water against vessel draught and additional clearance requirements. The data illustrates the number of tides within a typical year which reach selected tidal levels for different durations at the entrance to each of the main ports. The analysis indicates the percentage of vessels which would be affected by a change in tidal levels, increase in draught, or change in available depth of water. However, the overall magnitude of effect has been derived from considering the minimum depth of water required by the vessel of largest draught which can currently navigate into the impounded docks of each port. This methodology not only provides a worst case scenario, but it also accommodates for the future baseline scenario whereby the percentage of larger vessels may increase whilst remaining within the current size limitations presented by the impounded docks.

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, including the proposed number of locks available to commercial vessels, 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

During the construction and decommissioning phases of all of the STP options, the most significant risks are associated with navigational safety from construction activities and construction traffic. Deep water navigation channels and lock systems will enable vessels to navigate to the main commercial ports, but poor construction phasing and poor coordination of construction traffic could have a significant negative effect on the safety of vessels.

<u>Alternative Option B3: Brean Down to Lavernock Point Barrage (also known as Cardiff to Weston)</u>

A new navigation channel will link the Lavernock Point shipping lock with existing deep water navigation channels. The proposed route of the new navigation channel traverses areas where the sea bed reaches levels of less than 13m below Ordnance Datum (approximately 7m below Chart Datum). During the construction phase, there will be insufficient depth of water within the new navigation channel to allow navigation of some vessels of deep draught to the ports of Bristol, Newport and Cardiff at low and mid tides. The shallower draught of vessel which accesses Sharpness Dock is unlikely to be affected. During the operational phase, low tide levels upstream of the Barrage are not predicted to drop below approximately 0m Ordnance Datum (approximately 6m above Chart Datum) and the risk to navigation will be significantly reduced. There is still potential for significant effect during operation to the Port of Bristol as there will still be risk to the largest vessels of draught greater than 11m accessing this port.

During the operational phase, vessels transiting to the ports of Bristol, Cardiff, Newport and Sharpness will need to pass through the Barrage lock gates which could result in an increase in transit time to navigate vessels into the locks and balance upstream and downstream water levels. This increase could be significant to larger vessels that require high tides to access the ports upstream of the Barrage and hence have a potentially narrower window of opportunity. The increase in transit time will be dependent on the size of vessel, the number of vessels approaching the Barrage at a similar time, the ability of the vessel to time its approach to the port and Barrage, and the state of the tide.

Hydraulic modelling results indicate that the operation of the B3 Barrage will cause an overall reduction in the level of mean high water spring tide by approximately 1m. Whilst access to each of the ports is still possible, there will be a reduction in the number of available tides which enable access. There is potential for significant negative effect to the ports of Bristol, Newport and Sharpness.

The B3 Barrage has the potential to cause deposition of fine sediment immediately post construction and has the potential to cause long term morphological change beyond that currently experienced or predicted. Change in navigable depth in shallow navigation channels and port approach channels as a result of increased short term sediment deposition and/or long term morphological change could pose significant risk to the ports of Bristol, Cardiff, Newport and Sharpness.

Alternative Option B4: Shoots Barrage

During the operational phase, vessels transiting to Sharpness Dock will need to pass through the Barrage lock gates which could result in an increase in transit time to accommodate reduced speed at the lock and the balancing of upstream and downstream water levels. This increase could be significant for deep vessels that are limited by the high tide window to access the Dock and hence have a potentially narrower window of opportunity.

Hydraulic modelling results highlight a localised significant increase in peak flow speeds upstream of the turbine and sluice blocks of the B4 Barrage. For the most part, increased water velocities are to be expected on falling tides and will only be significant for isolated durations. However, the natural profile of this area of the estuary will also contribute to increased water velocities. The proposed lock structure is located immediately west of the turbine blocks hence if transit through the Barrage and in close proximity to the Barrage were to occur when water velocities are at their peak this could cause significant negative effect to vessels navigating to and from Sharpness.

Long term morphological change is predicted to raise bed levels by approximately 7m in the Inner Severn and approximately 1.8m in the Tidal River Severn by 2140. Potentially significant short term sediment deposition immediately post construction is also predicted in close proximity to the approach channel to Bristol Port. Change in navigable depth in shallow navigation channels and port approach channels as a result of increased short term sediment deposition and/or long term morphological change could pose significant risk to the ports of Bristol and Sharpness.

No significant effects are predicted as a result of changes to the tidal regime.

Alternative Option B5: Beachley Barrage

During the operational phase, vessels transiting to Sharpness Dock will need to pass through the Barrage lock gates which could result in an increase in transit time to accommodate reduced speed at the lock and the balancing of upstream and downstream water levels. This increase could be significant to deep vessels that are limited by the high tide window to access the Dock and hence have a potentially narrower window of opportunity.

Hydraulic modelling results indicate that the operation of the B5 Barrage will cause an overall reduction in the level of mean high water spring tide by approximately 0.5m upstream of the Barrage. Whilst access to Sharpness Dock is still possible, there will be a significant reduction in the number of available tides which enable access.

Hydraulic modelling results indicate a significant increase in peak water velocity of greater than 40% through the turbine blocks and sluice gates located within the existing deep water navigation channel at Beachley, where current peak water velocities exceed 2.8m/s. The proposed lock structure requires that vessels transiting from Sharpness must bear east from the Slime Road navigation channel and travel in front of the turbines to access the proposed lock located to the east of the Barrage. This is considered to pose significant risk to vessels navigating through this section of the channel when transiting to or from Sharpness.

Modelling predicts that long term morphological change could raise bed levels upstream and downstream of the B5 Barrage by up to approximately 2.5m in the Inner Severn and 3m in the Tidal River Severn by 2140. This has the potential to cause significant negative effect to the ability of vessels to navigate to Sharpness Dock.

Alternative Option L2: Welsh Grounds Lagoon

Little negative effect is predicted to commercial navigation during operation of the L2 Lagoon. The most significant effect is as a result of long term morphological change in the Mid Severn which has the potential to reduce navigable depth to the Port of Bristol.

Alternative Option L3d: Bridgwater Bay Lagoon

The hydraulic modelling results indicate that the operation of the L3 Lagoon will cause a reduction in the level of mean high water spring tide by approximately 1.2m within the Lagoon and approximately 0.5m throughout the estuary. This effect, combined with predicted sedimentation, could prevent access to the Port of Bridgwater. Access to the other main commercial ports within the estuary will still be possible but there will be a reduction in the number of available tides which enable access. There is potential for significant negative effect to the ports of Bristol, Cardiff, Newport and Sharpness.

Localised increases in water velocities of up to approximately 60% immediately upstream of the proposed L3 Lagoon lock gate could cause negative effect to vessels transiting to and from the Port of Bridgwater.

The impoundment of Bridgwater Bay will cause short term and long term sedimentation which could significantly affect the ability of vessels to navigate to and from the Port of Bridgwater.

Assumptions, Limitations and Uncertainty

The Navigation topic considers the potential effects of the STP options on the ability of commercial vessels to navigate to the key ports. The economic consequence of any potential effect on commercial navigation is addressed within the Phase 2 REIS (STP Regional Workstream, 2010).

Many of the potential effects to commercial navigation are based on the predicted effects to the estuarine environment which have been modelled by Black and Veatch, HR Wallingford and ABPmer and are discussed in detail in the H&G topic paper. The same uncertainties and limitations associated with the modelling will therefore be relevant to this assessment and are discussed in detail in the H&G topic paper. At this stage, the sensitivity of the H&G modelling is not sufficient to provide accurate results at specific locations within the estuary, such as in close proximity to turbine blocks or within immediate approach channels to the ports where the magnitude of potential effects will be most critical.

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

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

STP Option	Potential effect	Proposed measures to avoid or reduce effect
All options	Risks to navigational safety during construction and decommissioning	Good coordination and phasing of construction/decommissioning activities and traffic
	Increased transit time through lock structures	Improved logistics to incorporate approach to locks and accommodate increase in transit time
	Increased peak water velocities at structure	Raise awareness. Demarcation of high risk areas.
B3 Barrage	Ability of large vessels to navigate through the new deep water navigation channel from Lavernock Point	Dredge new channel to minimum depth of 16m below OD (approximately 10m below CD)
	Reduced high tide levels reducing navigable depth to ports	Reduce sill level by 0.75m at Bristol Port and Sharpness Dock and reduce sill level by 0.5m at Newport Port Dredge sections of shallow navigation channel up to 0.5m to Sharpness Dock and dredge approach channel by further 0.75m to Bridgwater Port
	Short term sediment deposition immediately post construction in shallow navigation channels	Dredge up to 0.4m in approach channel to Bristol Port and dredge up to 0.5m in approach channel to Cardiff and Newport ports
	Long term sediment accretion in shallow navigation channels up to 2140	Dredge up to 0.5m in shallow navigation channels to Bristol Port, Sharpness Dock and Bridgwater, and dredge up to 1.5m in approach channel to Cardiff and Newport ports
B4 Barrage	High water velocities near to sluice and turbine blocks and lock structure	Relocation of lock to west of Barrage and use of temporary navigation channel
	Short term sediment deposition immediately post construction in shallow navigation channels	Dredge up to 0.4m in approach channel to Bristol Port
	Long term sediment accretion in shallow navigation channels up to 2140	Dredge up to 1.8m in navigation channels to Sharpness Dock and dredge up to 7m in the Inner Severn navigation channels
B5 Barrage	Potentially high water velocities near to sluice and turbine blocks and lock structure	Relocation of lock to west of Barrage and use of temporary navigation channel.
	Reduced high tide levels reducing navigable depth to ports	Reduce sill level by 0.5m at Sharpness Dock and dredge sections of shallow navigation channel up to 0.5m to Sharpness Dock
	Long term sediment accretion in shallow navigation channels up to 2140	Dredge up to 3m in navigation channel to Sharpness Dock

STP Option	Potential effect	Proposed measures to avoid or reduce effect
L2 Lagoon	Long term sediment accretion in shallow navigation channels	Dredge up to 0.6m in approach channel to Bristol Port
L3 Lagoon	Reduced high tide levels reducing navigable depth to ports	Reduce sill level by 0.25 at ports of Bristol, Cardiff, Newport and Sharpness Dredge sections of shallow navigation channel up to 0.5m to Sharpness Dock and dredge navigation channel by further 0.75m to Bridgwater Port
	Short term sediment deposition immediately post construction in shallow navigation channels	Dredge up to 2m in navigation channel to Bridgwater Port
	Long term sediment accretion in shallow navigation channels up to 2140	Dredge up to 0.4m in navigation channel to Bridgwater Port

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.

The feasibility study has identified potentially significant issues which may affect vessel movements within the estuary, which could consequently affect commercial port operations. Potential effects could be a result of the inability to transit to the ports, increased transit times, navigational safety risks, and inability to access the ports due to insufficient water depths caused by a reduced tidal range, reduced salinity and sedimentation. Measures to prevent or reduce the identified potential significant effects have been identified. For the most part, it is considered that these will be successful in reducing the magnitude of effect to within acceptable limits to prevent significant effect to commercial navigation and enable the SEA objectives to be met. However, residual effects are still possible resulting from localised increases in peak water velocity, increases to transit time through lock structures, short term sediment deposition in shallow navigation channels and safety risks during construction and decommissioning.

A summary of residual risks with regards to the SEA objectives is provided below.

Nav1: To avoid adverse effects on Severn Estuary navigation arising from sedimentation, geomorphology, water density, and tidal water levels

The uncertainties within the H&G modelling pose residual risk to commercial navigation, particularly from short term sediment deposition as the rate and nature of deposition is highly dependent on construction phasing and methodology. However, the residual risk can be managed through further analysis and ongoing monitoring during construction and post-construction phases to identify and address potential issues.

Nav2: To avoid adverse effects on the integrity of existing and proposed port operations

Potentially significant residual risks have been identified to navigation through the B4 and B5 Barrages as a result of an increase to peak water velocities. For the most part, increased water velocities near to the turbine blocks are to be expected on falling tides and will only be significant for isolated durations. However, the natural profile of the estuary at these locations will contribute to increased water velocities. It is therefore recommended that further detailed analysis is undertaken during later phases of assessment to accurately determine potential changes to water velocities at different states of the tide immediately upstream of the Barrages.

An increase in total transit time is expected for vessels navigating through the lock structures of the B3, B4, B5 Barrages and L3 Lagoon. Whilst it is not possible to prevent this effect completely, improved logistics, coordination of transiting vessels and increased duration of high tide levels (assuming implementation of measures to reduce effect of reduced high tide levels) should enable this risk to be managed to within acceptable levels. This must be assessed further should Government's decisions be that development of tidal power generation within the estuary could be supported and must include close consultation with the main Port and Harbour Authorities.

Plan Implementation

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.

Monitoring during construction and post-construction of changes to tidal water levels, peak water velocities and short term sediment deposition will be required to support the predictions made in the H&G model and hence the predictions which have informed this assessment. Monitoring will also enable accurate calculation of required dredging to maintain safe access to and from the ports.

Long term monitoring of sea bed levels will be required during the design life of the selected STP option to enable dredging to be undertaken to maintain safe access to and from the ports.

The potential effects to transit time required to navigate vessels through the Barrages are based on qualitative analysis only. Monitoring during construction and post-construction will be required to quantitatively assess the effects of the locks on transit time and the success of measures to reduce this effect.