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## **SEVERN TIDAL POWER - SEA THEME PAPER**

### **Historic Environment and Landscape & Seascape Effects and Interrelationships**

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## **ABBREVIATIONS**



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## ABBREVIATIONS

The following abbreviations are used in this Environmental Report:

AAI	Area of Archaeological Importance
AONB	Areas of Outstanding Natural Beauty
BERR	Department for Business, Enterprise and Regulatory Reform
BP	Before Present
CCW	Countryside Council for Wales
CHaMP	Coastal Habitat Management Plan
COWRIE	Collaborative Offshore Wind Research Into The Environment
cSAC	Candidate Special Area of Conservation
DCMS	Department of Media and Sport
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
EIA	Environmental Impact Assessment
EC	European Commission
EH	English Heritage
ELC	European Landscape Convention
ES	Environmental Statement
EU	European Union
GGAT	Glamorgan Gwent Archaeological Trust
GIS	Geographical Information System
GW	Gigawatts
H&G	Hydraulics and Geomorphology topic
HC	Heritage Coast
HER	Historic Environment Record
HLCA	Historic Landscape Characterisation Area
HLOHIW	Historic Landscape of Outstanding Historic Interest in Wales
HRA	Habitats Regulations Assessment
ICZM	Integrated Coastal Zone Management
IFA	Institute of Field Archaeologists
JNAPC	Joint Nautical Archaeology Policy Committee
LCA	Landscape Character Assessment
LDP	Local Development Plan
MW	Megawatt
NMR	National Monuments Record
NP	National Park
NPS	National Policy Statement
ODPM	Office of the Deputy Prime Minister
PMRA	Protection of Military Remains Act
PPG	Planning Policy Guidance
PPS	Planning Policy Statements
PWA	Protection of Wrecks Act
RCAHMW	Royal Commission for Ancient and Historical Monuments Wales
RCZA	Rapid Coastal Zone Assessment
ROV	Remotely Operated Vehicle
SAC	Special Area of Conservation
SDC	Sustainable Development Commission
SEA	Strategic Environmental Assessment
SLR	Sea Level Rise
SNCI	Sites of Nature Conservation Importance
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
STP	Severn Tidal Power

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TAN	Technical Advice Note
TWh	Terrawatt hours
UKCIP	United Kingdom Climate Impacts Programme
UKHO	United Kingdom Hydrographic Office
WA	Wessex Archaeology
WHS	World Heritage Site
WSI	Written Scheme of Investigation
ZTV	Zone of Theoretical Visibility

## **NON TECHNICAL SUMMARY**



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## NON TECHNICAL SUMMARY

### Feasibility Study and Purpose of the SEA

The Government announced a two-year feasibility study on harnessing the renewable energy from the tidal range in the Severn Estuary in January 2008. This work is being carried out by a cross-Government team led from the Department for Energy and Climate Change (DECC). The aim of the Severn Tidal Power (STP) Feasibility Study is to investigate whether Government could support a tidal power scheme in the Severn and, if so, on what terms.

The Feasibility Study has been split into two phases: Phase One examined the scope of work and analysis required to make an evidence-based decision on whether to support a tidal power project in the Severn and what potentially feasible schemes exist for converting this energy. Phase One ended with the publication of the consultation document in January 2009. Phase Two (the current stage) has involved work on environmental, regional, economic, commercial, technical and regulatory issues to inform the study conclusions including whether any of the potential schemes are feasible.

A Strategic Environmental Assessment (SEA) is being carried out in support of the Feasibility Study, in accordance with EU Directive 2001/42/EC (the SEA Directive), implemented in England and Wales through the Environmental Assessment of Plans and Programmes Regulations (SI 2004/1633 and Welsh SI 2004/1656), to predict and analyse the environmental effects of alternative short-listed Severn tidal power options over their entire lifetime, in order to inform decision making at the end of the Feasibility Study.

### Purpose of the Theme Papers

The SEA Directive requires that 'the likely significant effects on the environment... and the interrelationship' are described (SEA Directive Annex 1 (f)). The theme papers therefore summarise the interrelationships between related topics and thereby ensure that the many complex issues that are not self-contained within a given topic are recognised and their implications understood. Each theme paper also examines the interrelationships between this theme and other themes within the STP SEA. This is the Historic Environment, Landscape & Seascapes theme paper. This paper covers the Historic Environment and Landscape & Seascapes topics.

Furthermore, the theme papers also assist the Environmental Report to meet the requirements of the SEA Directive by collating the difficulties (such as technical deficiencies or lack of know-how) encountered in compiling the required information (SEA Directive Annex 1 (h)).

Each theme paper therefore provides an integrated summary across the theme, drawing on information presented in its topic papers. Each theme paper also considers the likely significant effects on the environment of the variations of alternative options referred to as combination and multiple basin options.

This theme paper covers the Historic Environment and Landscape & Seascapes Topics. The historic environment or historic environment resource is a collective term applied to a diverse resource which encompasses archaeological sites and monuments, evidence for past environments (palaeoenvironmental), historic buildings and structures, historic landscapes and artefacts and structures relating to seafaring. Some of these features have already been identified, but many exist within the environment but are unknown to us. Landscape is an area whose visual features and character are the result of the action of natural and/or cultural (that is, human) factors, within which seascapes applies to an area of sea, coastline and land. All landscapes and seascapes are essentially historic, their defining features and characteristics are the product of human interaction with the environment over thousands of years. However, some have more historic value than others. Visual effects and effects on viewers is an important element of changes to landscape and seascapes from STP options.

## Historic Environment, Landscape and Seascape Baseline Environment and Significant Effects

### Baseline Environment 2009 -2140

This is a strategic level study and the information collected for the historic environment, seascape and landscape must be for a large area, when much of the detail for these topics would really be relevant at a local level for different options. Nonetheless a coherent a picture as possible is presented for these topics across the estuary. The Severn Estuary has many landscape and seascape characters, many of which are designated for their importance. In places it is wild and rugged with a sense of remoteness whilst at other locations, such as coastal resorts, it is more developed in character. It has rich historical connections but is also the scene for modern industry and commerce. These characteristics relate back to the evolution of the Severn Estuary.



*The Severn Estuary Crossings from the air.*

Archaeological investigations, surveys and research programmes have recorded evidence demonstrating the interaction and interplay of humans and the dynamic environment of the estuary from the earliest prehistoric periods through to the present. Within the estuary specific sites, monuments and landscapes of national importance have been designated or registered. Potential remains, which are preserved exceptionally well within the waterlogged deposits of the Severn Levels and intertidal mudflats flanking the estuary, are key to providing further insight into activities such as settlement, industry, defence and seafaring within the estuary. The historic landscapes of the reclaimed levels offer an additional layer of importance and it is possible to identify the potential for buried archaeological remains within these landscapes.

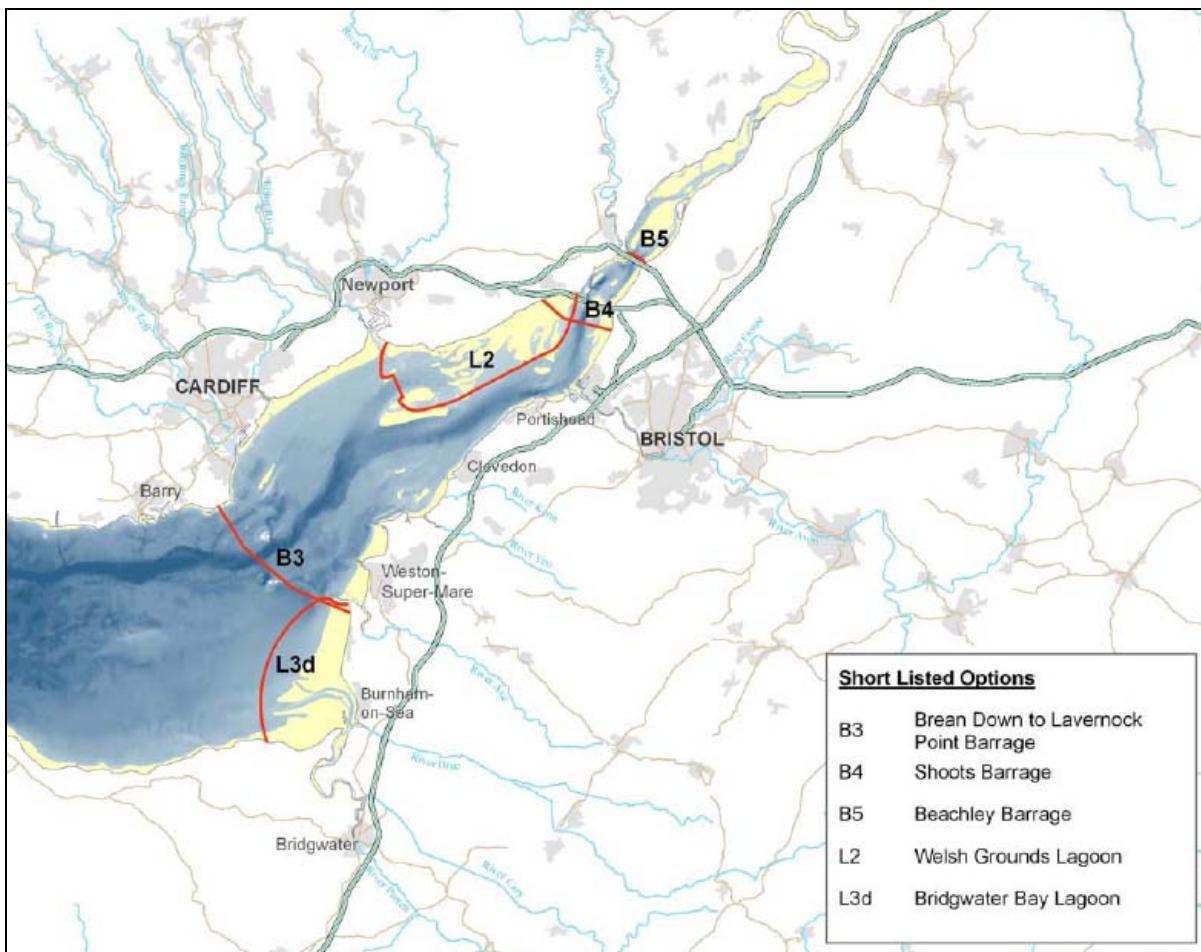
Assumptions have been made about the future of the Estuary without Severn Tidal Power, and there is some uncertainty associated with these, particularly for longer time periods (e.g. 100 years). The main issues and forces for change for historic environment, landscape and seascape of the Severn Estuary include:

- Sea level rise, predicted at approximately 0.5m by 2100 (UKCP09), which would damage the historic environment and change seascape characteristics. Coastal erosion would directly affect known and unknown sites but also lead to flood defences, with further effects. In some areas flood defences would be set back, opening up areas to tidal inundation and changed erosion and accretion.

- Preservation of the historic environment and changes to the landscape and seascape characteristics and quality in relation to new development. This may be in the form of power related industries, such as redevelopment of existing power stations or future wind development; flood risk management measures as described above; the growth of coastal towns and resorts; increased tourism and leisure industry; and transport and communication infrastructure.

### Significant Effects

There are five short listed alternative options that are being assessed within Phase 2 of the SEA for their likely significant effects. These alternative options are shown below.



Significant effects identified for the historic environment, landscape and seascape include:

- Damage the known and unknown historic environmental resource during construction, and to a lesser extent during operation and decommissioning from earthworks, dredging and other activities.
- Negative changes to the setting of the historic environment, seascape and landscape during all phases of development (construction, operation and decommissioning) from new lighting, structures and ancillary development (e.g. grid connections).

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These effects are potentially greatest for larger options such as the B3 Barrage (also known as Cardiff to Weston), L3d Bridgwater Bay Lagoon and L2 Welsh Lagoons Lagoon due to the scale of the structures and areas of unknown archaeology. However, the sensitivity of the environment should also be taken into account. For instance, the Cardiff to Weston Barrage and Bridgwater Bay Lagoon affect Brean Down, a prominent landmark, viewpoint and Scheduled Monument which represents over 4000 years of history. The Shoots Barrage and Welsh Grounds Lagoon affect the Gwent Levels Landscape of Outstanding Historic Interest in Wales, which contain estuarine alluvial silt deposits from the last 8,000 years as well historic landscapes related to drainage and water level management since Roman times.

- Changes to the tidal regime with a reduced high tide and higher water levels for the low tide. This could affect the preservation of historic features, reduce current access to intertidal sites. There would be reduced daily variety in the estuary's seascape and beaches would appear smaller at low tide.
- Changes to patterns of erosion and deposition would change the local landscape and seascape. Erosion could damage the historic environmental resource whereas deposition of sediment would help preserve sites *in situ*.

The areas affected by these changes mainly comprise the impounded area of each option, but also extend downstream of the barrage options. The extent of intertidal differences are greatest for the Cardiff to Weston Barrage and Welsh Grounds Lagoon.

- Cumulative effects from other projects in the estuary and consequential development such as energy intensive industries and tourism could cause further damage to both the known and unknown historic environment, in addition to loss of remoteness and relative sense of tranquillity associated with landscape/ seascape.

## Interrelationships

The historic environment forms the basis of present day landscapes and seascapes. Effects on the historic environment, landscape and seascape are therefore interrelated as these components cannot be separated. Loss or damage to individual features within the historic environment would also degrade the local landscape or seascape. Changes to the landscape or seascape characteristics and quality also affect the setting of the historic environment.

Interrelationships between this theme and other SEA themes can be summarised as follows:

- The requirement for aggregate abstraction including dredging and quarrying for construction is covered in the Air & Climatic Factors and Resources and Waste Theme and Society and Economy Themes (Other Sea Uses Topic). Additional aggregate abstraction would affect the historic environmental resource through damage from dredging and quarrying, and new quarries would also negatively affect landscapes.
- Changes to the extent of saltmarsh and other intertidal features play a key role in the characteristics of seascapes. Changes to the tidal regime similarly affect preservation and access to the historic environment. Intertidal changes are covered in relation to changes in the tidal range in the Physicochemical Theme (Hydraulics and Geomorphology) and habitats (e.g. mudflat, saltmarsh etc) within the Biodiversity Theme (in particular Marine Ecology Topic).
- A number of effects, such as preservation of currently waterlogged heritage remains, could arise from altered water levels due to pumping or drainage. These changes are covered in the

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Physicochemical Theme (Flood Risk and Land Drainage, Freshwater Environment and Associated Interfaces Topic) and the Biodiversity Theme (Terrestrial and Freshwater Ecology Topic).

- There is an interrelationship between leisure and tourism and landscape & seascape. Increased demand for leisure pursuits and growth of seaside resorts within the Severn Estuary would have effects on landscape. Tourism and leisure is covered by the Society & Economy Theme (Communities Topic).
- There is an interrelationship between the historic environment and fishing. A STP option would have effects on heritage fishing and other cultural issues, such as place names with cultural associations or traditional skills dependent on the estuary. These are assessed by the Estuarine and Migratory Fish topic within the Biodiversity Theme.
- A need for compensatory habitat under Directive 92/43/EEC (the Habitats Directive) has been identified by the Biodiversity Theme (primarily the Marine Ecology and Waterbirds Topics) and this is also covered in the Habitats Regulations Assessment for the Feasibility Study. Provision of compensatory habitat is likely to affect survival of the historic environment resource in these areas as well as changing characteristics of landscapes and seascapes.

### **Measures to Prevent, Reduce and as Fully as Possible Offset any Significant Adverse Effects**

It is very difficult to prevent effects on the historic environment, landscape and seascape due to the nature of the receptors and proposed options. Although preservation of the historic environment in situ is preferable, in many cases some loss or damage of this finite resource would be unavoidable. Measures to reduce effects to the historic environmental resource comprise preservation by record to ensure better understanding of, and compile and disseminate a record. Measures can take many practical forms depending on the scale, location and nature of the resource and include archaeological excavation, building recording, landscape survey, environmental sampling etc.

There are several measures to reduce effects on the setting of the historic environmental resource, landscape and seascape. However, these may only be effective at a local level due to the scale of the STP options. They include:

- Measures to reduce effects on setting – e.g. careful selection of location of structures, ancillary development, temporary construction works, lighting etc in relation to the features of the historic environment, landscape and seascape.
- Measures to minimise sizing – including land-take and size of structures.
- Measures to address styling of the option – visually attractive rather than utilitarian project and product design.

No measures to offset effects have been proposed for this theme as once the resource is lost, it cannot be created elsewhere.

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## SEA Objective Compliance

The SEA Objectives were drafted and consulted upon as part of the Phase 1 SEA scoping stage. This theme paper identifies any interactions or inconsistencies between topics within this theme with regards to the assessment against SEA Objectives. The SEA Objectives for topics within theme are set out as follows:

- To avoid adverse effects on designated sites in the historic environment.
- To avoid adverse effects on the non-registered internationally, nationally, regionally and locally important sites within the historic environment.
- To avoid adverse effects on the potential historic environment, the as yet unidentified sites and finds, within the Severn Estuary.
- To avoid adverse effects on the character and quality of the historic landscape.
- To conserve the character and qualities of the landscape/seascape, recognising its diverse features and distinctiveness at different scales – including designated and non-designated areas.
- To conserve the character and qualities of the physical and visual resource associated with land and sea.
- To accord with the Aims and Articles of the European Landscape Convention (ELC)<sup>1</sup>

Overall, the STP options did not meet SEA objectives for this theme. The majority of options (with the exception of the Beachley Barrage) would affect designated historic sites and the characteristics and quality of the historic landscape. All options would have negative effects on non-designated features within the historic environment, ranging from international to local importance. Although there is some uncertainty as to unknown sites within the historic environment, it is likely that of the options would affect potential sites. The majority of options have negative effects on receiving landscapes, seascapes and viewers, as well as those that would view the options at a distance. The exceptions are the Beachley Barrage and Shoots Barrage, where the visibility is limited and landscape/seascape effects over distance were not assessed as significant (although there would still be negative effects on individual viewers).

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<sup>1</sup> the European Landscape Convention (ELC) was signed by the UK government on 24 February 2006 and became binding on 1 March 2007. Its aims are considerable as it promotes the protection, management and planning of European landscapes.

## Implementation

Monitoring proposals for the implementation of a STP option include

- Programme of archaeological monitoring, where appropriate, during construction phase. Monitoring of application and effectiveness of protective measures.
- Planned programme of foreshore and subtidal surveys including walkovers, prospection, sampling, excavation etc to reduce the long-term loss through the recording of the resource.
- Completion of landscape character assessments post-scheme.
- Interviews of samples of people within landscapes and seascapes areas with inter-visibility immediately after the works completed and thereafter at regular intervals say after 1 year, 5 years and 10 years.
- Monitor implementation and effectiveness of measures to reduce effects on landscapes and seascapes as described above – use of materials, design, lighting, siting, size of structures etc,

Further studies suggested to support further consideration of tidal power in the Severn Estuary include:

- Combining the results of desk-based archaeological assessment with the results of specific field surveys at a later stage of a STP option development in order to ground-truth the known and potential resource identified by desk-based assessment.
- Formulation of a landscape strategy in addition to local landscape and visual assessment would need to be undertaken in order to get a more detailed view of the receiving environment, plan landscape change and be able to specify specific measures to reduce the effects of a STP option on landscape and seascapes.



## **SECTION 1**

### **INTRODUCTION**



**1****INTRODUCTION****1.1 Background**

1.1.1 The Government announced a two-year feasibility study on harnessing the renewable energy from the tidal range in the Severn Estuary in January 2008. This work is being carried out by a cross-Government team led from the Department for Energy and Climate Change (DECC), including representatives of the Welsh Assembly Government (WAG) and the South West Regional Development Agency (SWRDA), taking external advice as necessary and engaging stakeholders and the wider public. The aim of the Severn Tidal Power (STP) Feasibility Study is to investigate whether Government could support a tidal power scheme in the Severn and, if so, on what terms.

1.1.2 Any project to generate power from the tidal range of the Severn Estuary will need to meet the following objectives:

- To generate electricity from the renewable tidal range resource of the Severn Estuary in ways that will have an acceptable overall impact on our environment and economy both locally and nationally, will meet our statutory obligations and provide benefit to the UK; and
- To deliver a strategically significant supply of renewable electricity, which is affordable and represents value for money compared to other sources of supply in the context of the UK's commitments under the forthcoming EU Renewable Energy Directive and Climate Change Act and our goal to deliver a secure supply of low-carbon electricity.

1.1.3 The Feasibility Study has been split into two phases:

- Phase One: Examining the scope of work and analysis required to make an evidence-based decision on whether to support a tidal power project in the Severn and what potentially feasible schemes exist for converting this energy. Phase one ended with the publication of the consultation document in January 2009.
- Phase Two: Work on environmental, regional, economic, commercial, technical and regulatory issues to inform the study conclusions including whether any of the potential schemes are feasible. This is the current stage.

**1.2 Purpose of the SEA**

1.2.1 A Strategic Environmental Assessment (SEA) is being carried out in support of the Feasibility Study, in accordance with EU Directive 2001/42/EC (the SEA Directive), implemented in England and Wales through the Environmental Assessment of Plans and Programmes Regulations (SI 2004/1633 and Welsh SI 2004/1656), to predict and analyse the environmental effects of alternative short-listed Severn tidal power options over their entire lifetime, in order to inform decision making at the end of the Feasibility Study.

### 1.3 Purpose of the Theme Papers

- 1.3.1 The SEA Directive requires that ‘the likely significant effects on the environment, including on issues such as biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between the above factors’ are described (SEA Directive Annex 1 (f)).
- 1.3.2 The theme papers therefore summarise the interrelationships between related topics – see Table 1.1 below – and thereby ensure that the many complex issues that are not self-contained within a given topic are recognised and their implications understood. This approach emerged from the SEA scoping phase to allow related topics to interact and interface more effectively. Each theme paper also examines the interrelationships between this theme and other themes within the STP SEA.

**Table 1.1 SEA themes and topics**

SEA Theme	SEA Topics
Physicochemical	Hydraulics & Geomorphology Marine Water Quality Freshwater Environment & Associated Interfaces Flood Risk & Land Drainage
Biodiversity	Marine Ecology Waterbirds Migratory & Estuarine Fish Terrestrial & Freshwater Ecology
Landscape & Seascapes and Historic Environment	Landscape & Seascapes Historic Environment
Air & Climatic Factors and Resources & Waste	Air & Climatic Factors (including Carbon Footprint) Resources & Waste
Society & Economy	Communities Navigation Other Sea Uses Noise & Vibration

- 1.3.3 Furthermore, the theme papers will also assist the Environmental Report to meet the requirements of the SEA Directive by collating the difficulties (such as technical deficiencies or lack of know-how) encountered in compiling the required information (SEA Directive Annex 1 (h)).
- 1.3.4 Each theme paper therefore provides an integrated summary across the theme, drawing on information presented in its topic papers. Each theme paper presents a review of the environmental baseline and considers the environmental effects for the topics within this theme, taking into account the interrelationships between them and identifying difficulties in compiling the information and uncertainties in the assessment. However, no substantive analysis is undertaken within each theme papers that is not already contained within its topics.
- 1.3.5 Each theme paper also considers the likely significant effects on the environment of the variations of alternative options referred to as combination and multiple basin options.

## SECTION 1



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- 1.3.6 This theme paper covers the Historic Environment and Landscape & Seascape Topics. The historic environment or historic environment resource is a collective term applied to a diverse resource which encompasses archaeological sites and monuments, evidence for past environments (palaeoenvironmental), historic buildings and structures, historic landscapes and artefacts and structures relating to seafaring. Some of these features have already been identified, but many exist within the environment but are unknown to us. Historic environment receptors are identified as existing within broad physical environments comprising the terrestrial, intertidal and subtidal areas.
- 1.3.7 This theme also covers the broad issues of landscape, seascape and visual effects associated with each of the alternative options. Landscape is an area as perceived by local people or visitors whose visual features and character are the result of the action of natural and/or cultural (that is, human) factors. Seascape is a subset of landscape and applies to an area of sea, coastline and land. Receptors comprise receiving landscape and seascape, landscapes or seascapes with intervisibility or interrelationships and viewers from the land or sea.



## SECTION 2

### **APPROACH**



## 2 APPROACH

### 2.1 Overall approach adopted in the SEA

2.1.1 The assessment process involved the collection of information and the development of SEA objectives, definition of alternatives and identification of significant environmental effects. Measures to prevent, reduce and as fully as possible offset significant adverse effects on the environment were developed, and proposals reviewed in the light of identified significant environmental effects. A more detailed description of the purpose of each SEA task and the STP SEA approach is given in the Environmental Report (PB. 2010).

### 2.2 SEA Objectives

- 2.2.1 SEA Objectives are a recognised tool for comparing alternative options. SEA Objectives, and associated assessment criteria and indicators were drafted and consulted upon as part of the Phase 1 SEA scoping stage. The Government response to the consultation for the most part confirmed the SEA Objectives and in some cases made some minor modifications (DECC, 2009b).
- 2.2.2 The SEA Objectives for this theme, as amended in response to the Scoping consultation, are set out in Table 2.1.

**Table 2.1 SEA Objectives for Historic Environment and Landscape & Seascape Theme**

SEA Topic	SEA Objective
Historic Environment	To avoid adverse effects on designated sites in the historic environment.
Historic Environment	To avoid adverse effects on the non-registered internationally, nationally, regionally and locally important sites within the historic environment.
Historic Environment	To avoid adverse effects on the potential historic environment, the as yet unidentified sites and finds, within the Severn Estuary.
Historic Environment	To avoid adverse effects on the character and quality of the historic landscape.
Landscape & Seascape	To conserve the character and qualities of the landscape/seascape, recognising its diverse features and distinctiveness at different scales – including designated and non- designated areas.
Landscape & Seascape	To conserve the character and qualities of the physical and visual resource associated with land and sea.
Landscape & Seascape	To accord with the Aims and Articles of the European Landscape Convention (ELC).

### 2.3 Alternative Options for Tidal Power

- 2.3.1 At the beginning of Phase 2, five alternatives for the development of tidal power using the tidal range of the Severn Estuary were identified as the preferred candidates for more detailed study. The five options comprise three tidal barrages and two tidal

lagoons (PB, 2010). These alternative options and key parameters associated with alternative options are shown in Figure 2.1 and set out in Table 2.2.

**Table 2.2 Alternative options**

Alternative	Location	Length (approx)	Operating mode	Turbine type	No. turbines	Annual energy output	Caissons	Locks
B3: Brean Down to Lavernock Point Barrage (commonly known as Cardiff to Weston)	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 Hinkley Point	16km	Ebb & Flood	Bulb-Kaplan	144 (25MW)	5.6 to 6.6 TWh/year	42	1

- 2.3.2 Variations in the alternative options have also been considered. Whilst at this stage none of these constitute alternative options under the feasibility study, initial consideration has nonetheless been given to their potential effects. The variations considered included multiple basins and combinations of the five short-listed alternative options. Multiple basin variants are configured with the aim of providing continuous power to better align energy yield with peak demand.
- 2.3.3 Following an evaluation process (considering energy yield, costs, programme and opportunities for optimisation) one multiple basin and two combinations of options were identified for further high level review. This does not constitute the same level of detail as assessment of the short listed alternative options, but if any of the variations are found to have advantages over the alternatives, then further work would be required. The assessment of combination of options at this high level uses professional judgement to determine whether effects are likely to be equal to or greater than the combination of the assessment of the individual options.
- 2.3.4 The multiple basin option variant identified for high-level consideration of environmental effects is a double basin version of the L3d Bridgwater Bay lagoon (with pumping). The double basin concept splits the L3d lagoon into a high basin and a low basin using a rockfill dividing wall with its landfall at Berrow. The variant is then

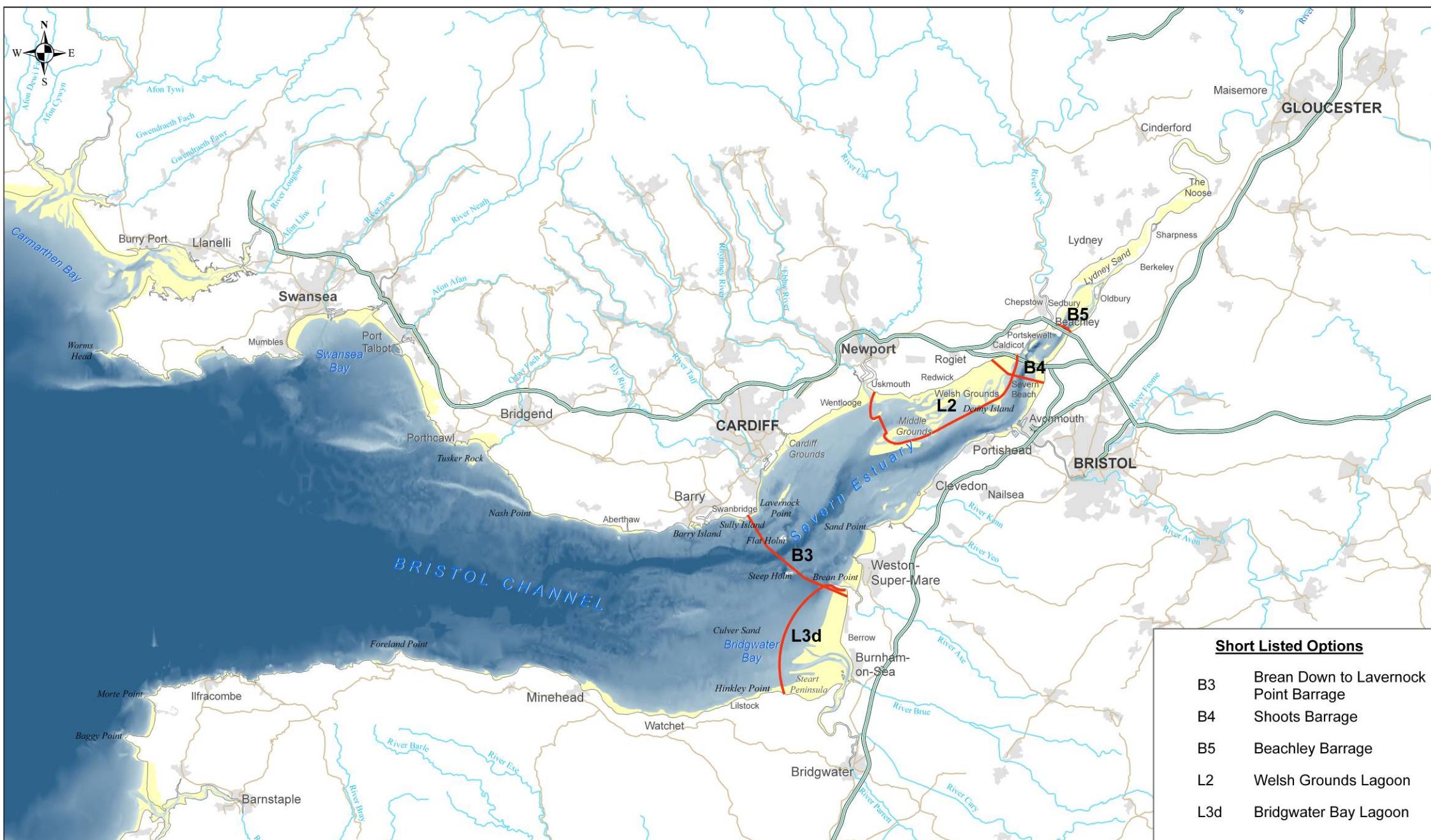
configured to provide a continuous cycle of water from the sea to the high basin, from the high basin to the low basin and then from the low basin to the sea. This variant employs two powerhouses, one between the high and low basins and a second between the low basin and the sea. Each basin would experience a tidal range, but the high basin water levels would always be kept above the low basin. Pumping is used to raise water levels in the high basin and lower them in the low basin to increase power output. The option variant would utilise single direction turbines (in contrast to the ebb/flood generation of the standard L3d alternative option).

- 2.3.5 Both of the potential combinations of options include the standard single basin L3d option, with the assumption that it would generating with an ebb/flood configuration. A combination of L3d (ebb/flood) with B3 Brean Down to Lavernock Point barrage (ebb only) has been shown to be worthy of further consideration; as has a combination of L3d (ebb/flood) with B4 Shoots barrage (ebb only).
- 2.3.6 L3d and B3 would be constructed sequentially due to the large amount of resources required to build either of these alternative options. Either option could be constructed first. L3d and B4 could be constructed either sequentially or concurrently. The operating rules and forms of construction for the combined options are assumed for the purpose of this high-level review to be the same as those for the individual alternative option.

SECTION 2



Figure 2.1 Severn Tidal Power Options



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Rev	Date	Description	LEGEND	Parsons Brinckerhoff in association with Black & Veatch	DEPARTMENT OF ENERGY & CLIMATE CHANGE	DATE 26/10/09 SCALE 1:1,000,000 @ A3 GIS REF 1213201100108MXD
NOTES				Parsons Brinckerhoff 100 YEARS	SEVERN TIDAL POWER STP-LHE-0001	DRAWING NUMBER STP-LHE-0001
THIS DRAWING WAS PRODUCED USING ARCGIS AND SHOULD ON NO ACCOUNT BE AMENDED BY HAND			Legend	Parsons Brinckerhoff Queen Victoria House, Redland Hill, Bristol, United Kingdom, BS6 6US Tel: 44-(0)117 9339300 Fax: 44-(0)117 9339253	TITLE Short-list Options	©Copyright Parsons Brinckerhoff

## 2.4 Technical studies within the theme

- 2.4.1 A number of studies have contributed to this Theme Paper. Topics in this theme undertook baseline data collection at different levels of detail, more general sources of information to cover the entire estuary and more targeted data searches for the alternative options and landfall sites. Sources of information are summarised below.
- 2.4.2 To provide a general estuary scale overview, records of the known historic environment sites (terrestrial and maritime) were collected from sources such as National Monuments Record (NMR) for England and Wales, the Register of Landscapes of Outstanding Historic Interest in Wales, National Landscape Character Database, Seazone Data. More detailed information on known historic environment sites was collected in the vicinity of the alternative options from county historic environment/ sites and monuments records.
- 2.4.3 Additional contextual information obtained from relevant strategic heritage documents and publications including Severn Maritime Assessment (ALSF 2008); The Severn Estuary Rapid Coastal Zone Assessment (RCZA); publications of the Severn Estuary Levels Research Committee; academic research; county journals; other palaeoecological and archaeological literature.
- 2.4.4 A general literature review of relevant published information relating to landscape and seascape was undertaken and included: national and regional landscape character and seascape assessments; LANDMAP; National Park and Area of Outstanding Natural Beauty (AONB) management plans; national and regional landscape planning policies.
- 2.4.5 For the ten landfall points associated with the five alternative options the local seascape and landscape characteristics for each has been assessed in more detail using the sources listed above, specifically: Regional Landscape Character Area (Natural England's National Character Areas and Draft Regional LANDMAP areas from the Countryside Council for Wales); Regional Seascapes Units prepared by the Countryside Council for Wales and the seascape units presented in Natural England's Advice on Potential Landscape/Seascape and Visual Impacts of a Severn Barrage (NE, 2007).
- 2.4.6 The assessment methodology follows a qualitative approach informed by professional judgement comparing the key changes to the existing environment resulting from the construction and operation of the alternative options to the baseline resource with reference to the results of other SEA topics, in particular: Hydraulics and Geomorphology; Flood Risk and Land Drainage; Terrestrial and Freshwater Ecology; Waterbirds; and Navigation.

### Difficulties encountered

- 2.4.7 One of the largest technical difficulties is the representation of this theme, and particularly the historic environment, as a coherent entity at the large scale required for SEA. There are often inconsistencies between data sets, level of research and terminology in different areas, for instance between Wales and England.
- 2.4.8 For example, In Wales, comprehensive assessments of the archaeology of the coast were carried out between 1993 and 1998. The survey involved field walking the entire

length of the coastline and adding sites to the existing record and recommending some sites for statutory protection. In England, it has been recognised that there is a critical need to achieve a comparable level of reconnaissance to the Welsh side (e.g. Turner et al 2000: 7-8). Similarly, The Severn Estuary RCZA Phase I report is a recent and large-scale heritage study within the estuary which provides a comprehensive synthesis of research and fieldwork conducted within the English part of the Estuary.

- 2.4.9 The large area of the Severn estuary doesn't necessarily split readily into landscape and seascape character areas, and there are transitional areas between larger scale character mapping. In particular, seascape units merge with each other as the Severn changes from a wide river, to an estuarine seascape to one of the open sea in the Bristol Channel. The estuary is a large entity with varying pockets of local interest, settlement and landscape features.
- 2.4.10 In relation to the historic environment, none of the sources of data record all of the surviving elements of the historic environment resource but instead contain information about the known and recorded resource. The information from these sources is not complete and does not preclude the subsequent discovery of further elements of the historic environment that are, at present, unknown. A precautionary principle has been applied, particularly in areas where there are data gaps, which may be important to the future study and knowledge base of the Severn Estuary.
- 2.4.11 Views of the landscape and seascape are highly subjective. For instance, if mudflats become permanently flooded as a result an STP option, this could be seen as a positive effect on visual amenity, for example within townscapes, but could also be seen as loss of local distinctiveness created by the Severn's exceptional tidal range.
- 2.4.12 In developing the future baseline projections, assumptions are made about environmental trends, and policy responses to these trends. It has been assumed that UK Climate Projections (UKCP09) central estimate projections for the medium emissions scenario apply for most topics (UKCP09, 2009). However, there is some uncertainty relating to how these predictions would influence changes within the estuary and subsequent flood management measures put in place which affect the historic environmental resource, seascape and landscape.
- 2.4.13 This study is undertaken at a strategic level, and in order to more fully assess the effects of Severn Tidal Power on historic environment, landscape and seascapes, clear more information would be needed. This comprises both information regarding the baseline environment, particularly at a local level, and project information on a Severn Tidal Power option - for instance alignment, construction methods, ancillary development etc. This information would be collected at a later stage of project development and suggestions for further work are given in Section 7.

## 2.5 Consultation

- 2.5.1 Both the Feasibility Study and the SEA within it have included a programme of formal and informal consultation activities. These include the public consultation exercise in early 2009, technical workshops during both Phase 1 and 2, and informal meetings and other communications. These are detailed in the topic papers and summarised in the Environmental Report (PB, 2010).

## **SECTION 3**

### **HISTORIC ENVIRONMENT AND LANDSCAPE & SEASCAPE**

### **BASELINE ENVIRONMENT AND SIGNIFICANT EFFECTS**



**3**

## **HISTORIC ENVIRONMENT AND LANDSCAPE & SEASCAPE BASELINE ENVIRONMENT AND SIGNIFICANT EFFECTS**

### **3.1 Introduction**

- 3.1.1 This section summarises the current state, characteristics and evolution of the environment for the topics within this theme.
- 3.1.2 This section also considers, within this theme, the likely significant effects on the environment for each alternative option and the interrelationships between these effects (SEA Directive Annex 1 (f)). These effects may arise from direct, indirect, far-field, cumulative and consequential development effects during construction, operation and decommissioning phases and may include secondary, cumulative, synergistic, short, medium and long-term permanent and temporary, positive and negative effects (SEA Directive Annex 1 (f)).
- 3.1.3 This section also considers the difficulties encountered in compiling the required information (SEA Directive Annex 1 (h)) and the level of certainty in the assessment of effects.

### **3.2 Current state, characteristics and evolution of environment**

- 3.2.1 Baseline information provides the basis for predicting and monitoring environmental effects. Alternative options considered within this Feasibility Study would only be developed several years into the future and would have a long life. It is therefore necessary to project a 'future baseline' against which to compare effects, rather than using the present day baseline.

#### *Baseline environment (up to 2009)*

- 3.2.2 The Severn Estuary has many landscape and seascape characters. In places it is wild and rugged with a sense of remoteness whilst at other locations, such as coastal resorts, it is more developed in character. It has rich historical connections but is also the scene for modern industry and commerce. These characteristics relate back to the evolution of the Severn Estuary. Known features of the historic environment are presented in Figure 3.1 and landscape designations are presented in Figure 3.2.
- 3.2.3 In terms of seascape character, the Severn Estuary ranges from the appearance of a wide river in the upper estuary, through the visual intricacies and textural variety of the estuary where the river flow itself seems to disappear at low-tide to the open sea bounded by cliffs, sandy beaches and muddy bays. Its waters are muddy, turbulent and wide when viewed from the shore. The Severn Bore is a naturally occurring phenomenon gives visual variety and adds to the sense of unique identity within the Severn Estuary.
- 3.2.4 The great scale of the estuary has been tamed with the spanning of two iconic bridges across its waters, albeit at a narrow point of the estuary. The bridges act as a visual reference in the upper estuary and are estuary wide, if not national landmarks.
- 3.2.5 The subtidal environment of the Severn Estuary and Bristol Channel is a high energy and dynamic system. The seabed sediments range from areas of deep mud and

sand, such as in Bridgwater Bay or the English Grounds, to areas where the seabed has been scoured to bedrock. The strong tidal currents influence highly mobile sediments, and during the spring tides, vast quantities of sediment are held in suspension. The areas of deep mud and sand, where the sediments are settled, offer areas of high potential for the preservation of shipwrecks, aircraft wrecks and other maritime archaeological materials, and although the areas of bedrock provide a more challenging environment for preservation, geophysical surveys have indicated the presence of wrecks and wreck debris throughout the estuary.

Photo 3.1 Ship wreck on beach at Burnham-on-Sea



### 3.2.6

The huge tidal range of the Severn Estuary means that at low tide a very wide intertidal area is exposed. The complex sedimentary sequence of clays and peat layers of the Wentlooge Formation are exposed by coastal erosion in the intertidal area on both sides of the estuary. The intertidal area functions as a temporary and intermittent window directly onto the extremely well preserved prehistoric land surfaces, which survive buried often at unreachable depths within the reclaimed claylands of the Severn Estuary Levels. The preservative qualities of the waterlogged intertidal environment extend beyond the remains of palaeo-landscapes to evidence relating to historic estuarine specific activities such as fish weirs and fish traps. The intertidal area also preserves the remains of sunken vessels, harbour installations and aircraft.

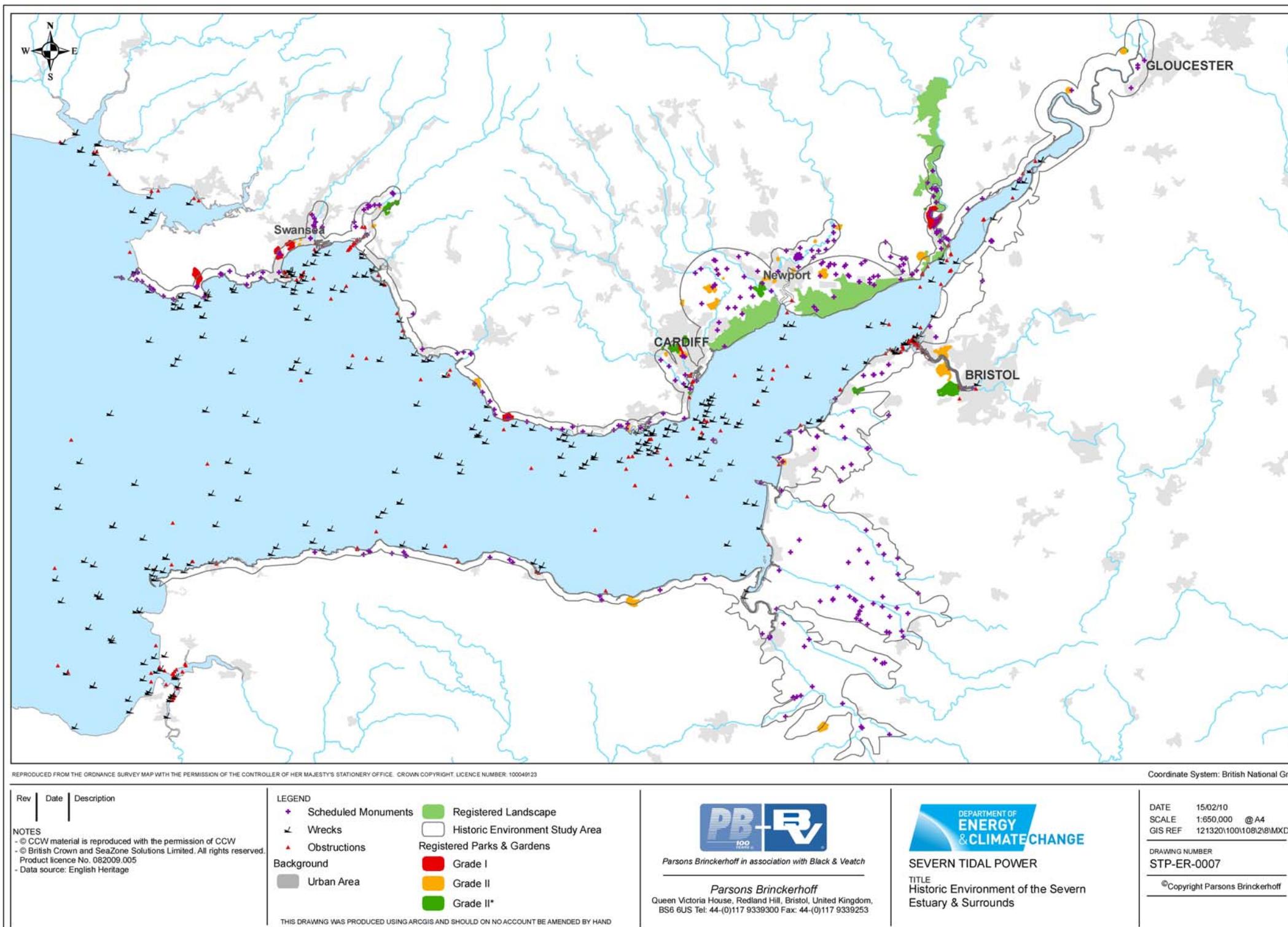
### 3.2.7

The landscape looking down onto the Severn Estuary is also varied. It includes high ground which affords expansive views out over the estuary such as the Quantocks, Brean Down and the South Wales Valleys ridges above Cardiff. In contrast there are considerable stretches of flat low lying ground butting up to the Severn such as the Gwent and Somerset Levels.

SECTION 3



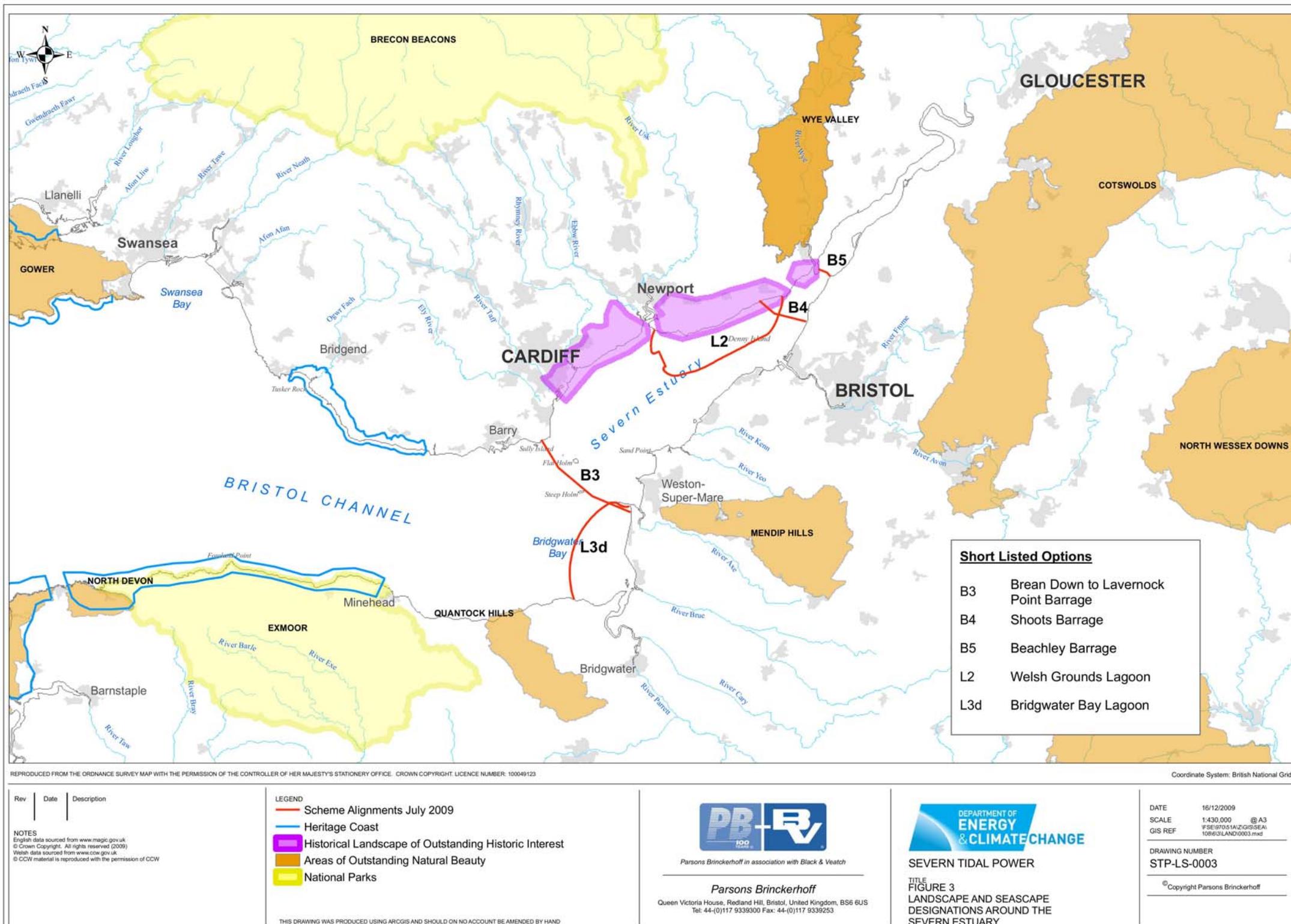
Figure 3.1 Historic Environment of the Severn Estuary



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Figure 3.2 Landscape Designations in the Severn Estuary



- 3.2.8 The topographical conditions combine with land-use to give the present landscape character around the estuary. At points it is highly industrial in nature such as Avonmouth and Cardiff Docks and in stark contrast agricultural in appearance on both sides of the estuary. Some towns have developed as resorts to prosper from holiday makers such as Barry Island and Weston Super Mare where others have their purpose in industry and commerce such as Newport and Lydney.
- 3.2.9 Power production in the form of Hinkley Point, Aberthaw, Oldbury and associated pylon lines have created modern landscape references within the scene, whilst natural ones include the massive finger of rock Brean Down pointing out into the estuary at the twin islands of Steep Holm and Flat Holm.
- 3.2.10 These landmarks are visible from around the estuary's shore, from the water itself and from parts of the surrounding landscape, particularly high ground in both England and Wales.
- 3.2.11 The nature, character, location and extent of the historic environment resource within the terrestrial environment of the Severn Estuary is governed by the morphological effects of sea-level on the landscape of the estuary throughout the Pleistocene and into the Holocene; the remarkable conditions for preservation provided by the waterlogged burial environment of the Wentlooge Formation<sup>2</sup> and by processes of land reclamation and drainage which have taken place over the last 2,000 years.
- 3.2.12 Two of the most important features of the historic environment in the Severn, which illustrate the evolution the landscape of the estuary are presented below.

<sup>2</sup> A sequence of soft estuarine sediments and peats and which contain an important record of climatic and sea level fluctuations which gave rise to different estuary environments at the beginning of the Holocene period.

### Brean Down



Brean Down is a narrow promontory of limestone projecting 1.6km into the Bristol Channel, with steep cliffs on all sides and a relatively flat top. It is a Scheduled Monument and on top of the down are at least 9 prehistoric burial mounds or clearance cairns, a small Iron Age hillfort near the eastern end, a 4th century Romano-Celtic temple near the eastern summit and extensive evidence of a field system which is undated but may have had its origin in the Bronze Age. More recent military activity is represented by a Palmerstonian fort at the west end as well as 20th century gun batteries and other fortifications. Of equal importance is the existence of a Pleistocene sandcliff sequence containing abundant archaeological material on the Bridgwater Bay side of the headland. Human bones have been weathering out since the early 20th century and Beaker period, Bronze Age and Iron Age artefacts have been collected from the foreshore. Brean Down is currently owned by the National Trust and this relict landscape is an important landmark and vantage point of the Estuary.

### Gwent Levels



The c.111km<sup>2</sup> (111,000 ha) area of low-lying estuarine alluvium which stretches from the west of Cardiff to the River Wye at Chepstow is a geographical area referred to as the Gwent Levels. As with the rest of the Severn Estuary Levels, the Gwent Levels consist of a series of alternating estuarine alluvial silt and peat deposits up to 15m in depth. These have accumulated over the last 8000 years as a result of an upward (but fluctuating) trend in sea level rise following the end of the last glaciation. The landscape of the Gwent Levels contains hundreds of extant historic landscape components which combine to help elucidate the process of draining and water management which has been undertaken here since at least the Roman period. In addition the alluvial deposits seal and preserve organic peat layers which contain incredibly well preserved artefactual and palaeoenvironmental evidence detailing human interaction with the landscape back to the Mesolithic period. For these combined reasons the Gwent Levels have been designated, by Cadw and the Countryside Council for Wales, as a Landscape of Outstanding Historic Interest in Wales.

3.2.13 Currently the key environmental issue in landscape terms is managing the change of varied and rich landscape character, through planning and other processes, whilst highlighting specific elements, features and processes at particular locations that do merit conserving in any scenario. The landscape is at risk from change caused by insensitive development around existing towns and cities. Likewise infrastructure projects could alter the key characteristics of parts of the Severn's surrounding landscape in terms of new road and power generation projects. Once consent to these projects has been given the rapidity of change at a location is relatively swift.

3.2.14 Coastal edge development pressures and new infrastructure are also likely to affect seascapes. In addition, a key environmental challenge relates to sea-level rise. This change is barely perceptible to observers with a gradual reduction in intertidal habitats or a narrowing of saltmarsh fringes around the estuary. However at times the change in seascapes and coastal characteristics is marked when there is the need to construct new sea defences such as those recently constructed at Weston Super Mare.

*Baseline during construction (2014 – 2020)*

3.2.15 Within the next 10 years the main environmental change for the historic environment and landscape and seascapes is new development and infrastructure such as power stations, particularly redevelopment at Hinkley and Oldbury and continued dredging in the Severn for aggregate abstraction. This development would introduce new features, but not change the general characteristics of the estuary.

3.2.16 There would also be some influence of natural processes such as sea level rise and coastal erosion, although over this time frame there would be a negligible change to historic environmental resource, landscape or seascapes. Of greater influence would be flood management works, in particular managed realignment at sites such as Steart.

3.2.17 These influences are part of longer term trends are discussed in further detail below.

*Baseline during operation (2020 – 2140), Decommissioning and Longer Term Trends*

3.2.18 Over time the effects of sea level rise will become more pronounced with lower intertidal areas, such as mudflats, becoming permanently submerged and features at the top of the tidal range, such as saltmarsh, becoming subject to greater erosion. In addition to changing the landscape, this means that some historic sites within the intertidal area (known and unknown) will become submerged and others will be subject to erosion. Intertidal and low lying areas, such as the Gwent Levels Historic Landscape, will be at increased risk of flooding. In response to these predicted changes, flood defences will be strengthened in some areas and in others, realigned so that low-lying areas are flooded. The need to create 'compensatory habitat' under the Habitats Regulations will also drive creation of intertidal habitat, to offset the effects of loss from coastal protection (and other coastal development) elsewhere. Many of these changes will be set out in the forthcoming Severn Estuary Flood Risk Management Strategy which is being prepared by the Environment Agency and is due summer 2010. Both coastal defence and realignment would change the local landscape, although maintain the wider estuary wide context. There is potential to damage the historic environmental resource either directly through construction works or indirectly through changes in water levels, erosion and accretion.

3.2.19 The future planning system will define development areas tightly, with a likely result of very distinct areas set for different purposes. For example industrial development will be separate from residential areas being distinct from recreational locations and

surrounding agricultural production land. In terms of land use, as pressure for low carbon food and increased self-sufficiency increases the importance of agricultural areas is likely to rise. There is a predicted increase in national afforestation, the Forestry Commission has announced initiatives to increase woodland cover from the existing 12% to 16% over the next 40 years. There is also pressure to protect natural habitats.

- 3.2.20 New development is a continuing influence. There is unlikely to be any major new settlement around the estuary due to flood risk. However, existing settlements are likely to experience increased development of residential properties due to population growth and trends in smaller living groups.
- 3.2.21 Associated infrastructure, including power, transport links and leisure pursuits would also be developed in and around the estuary. Power generation may take many forms but the drive for renewable energy is likely to lead to both onshore and offshore wind turbines around and in the estuary. Extensive areas of wind farms would lead to a significant effect and change to the existing landscape and seascape characteristics if built within the actual Severn Estuary, and would affect the sub-tidal historic environment. Power stations, including nuclear and coal, may be decommissioned or redeveloped. The existing landmarks are likely to remain but in different forms. Communication routes such as road, rail and shipping would remain, although some refurbishment, such as the original Severn Crossing, would be required. New routes may be also be developed. There is likely to be increased demand for the leisure use around the estuary which may involve new development, but there is also likely to be a demand for activity based holidays and eco-tourism which would rely on preserving the quality of the environment and uniqueness of place.
- 3.2.22 These types of piecemeal development would affect the terrestrial, intertidal and subtidal historic resource. The ethos of the current historic environment planning policy and legislation promotes the preservation and conservation of the historic environment record. Where the resource cannot be preserved, then it is recorded through gathering knowledge about its loss.

### **3.3 Significant environmental effects**

- 3.3.1 This section considers, within this theme, the likely significant effects on the environment and the certainty of this assessment for each alternative option and the interactions between these effects. The full methodology for identifying these significant environmental effects is set out in the Environmental Report.
- 3.3.2 Consideration has also been given to the potential effects of combination options and multiple basin options although this has not been subject to the same level of detailed assessment as the individual shortlisted options. Alternative options are summarised in Table 2.2 and shown in Figure 2.1.
- 3.3.3 There are a number of effects that are common to all options. These are summarised and then discussed with reference to each option below.
- 3.3.4 During construction there would be direct damage to historic environment features and disturbance of their wider surroundings from construction works. Damage can be caused by groundworks, excavations, large-scale earth movements and dredging (for both structures and aggregates). These effects are negative and significant.

- 3.3.5 There would be direct effects on the historic environment, landscape and seascape from presence of construction activity and change of setting. These effects may rise from lighting, construction yards, access roads, workers accommodation, storage of materials, equipment and machinery. These effects are negative and significant.
- 3.3.6 During operation there would also be direct visual effects on the historic environment, landscape and seascape. These arise from the physical structures of the options, night time lighting and ancillary works, including access and new grid connections. They could result in negative and significant changes to the context and setting of the designated and non-designated historic sites, seascape, present landscape and historic landscapes. Over the long term the structure would become part of the historic landscape. People would have different subjective responses to such a change to the existing view and characteristic of the area.
- 3.3.7 Beyond damage to the historic environment incurred during construction, there may be additional direct effects from maintenance dredging for most of the options. Although dredging would concentrate on newly deposited sediment in existing shipping channels, there may still be some additional damage to the seabed. These effects were assessed as negative and significant.
- 3.3.8 Indirect effects during operation occur due to physical changes to the estuarine environment. Effects are predicted to be significant and both negative and positive, they include:
- Changes to the tidal regime through changes in water levels which would affect historic features in the intertidal and subtidal zone through altering the preservation and survival of deposits and have visual effects on the intertidal area. There would be reduced daily variety in the estuary's seascape and beaches would appear smaller at low tide.
  - Changes to patterns of erosion or deposition which could change the landscape/seascape of coastal areas as well as damage or increase protection of the historic environmental resource. Significant negative effects would occur where erosion is exacerbated or new scour occurs along the coastal fringe, intertidal or subtidal areas and known or potential historic sites are damaged. Conversely, the accretion of sediments within the subtidal and intertidal areas as a result of the alternative options could result in the protection/preservation of the historic environment resource beneath estuarine deposits. Loss of saltmarsh in areas of erosion would affect the variety of seascapes within the estuary.
- 3.3.9 During operation there would be changes to access to the historic environment which are negative and significant. Changes to the sedimentation and erosion patterns within the subtidal zone could lead to the covering of sites on the seabed (e.g. shipwrecks/aircraft crash sites) or the reduction in access to certain estuarine environments such as the intertidal zone which would result in a loss/reduction in the opportunity to gain knowledge.
- 3.3.10 Consequential development such as energy intensive industries and tourism could cause further damage to both the known and unknown historic environment, in addition to loss of remoteness and relative sense of tranquillity associated with landscape/ seascape.
- 3.3.11 There would be cumulative effects on the survival of the historic environmental resource, landscape and seascape from other development, including the proposed

Bristol Deep Sea Container terminal, demolition of Hinkley Point Nuclear Reactors and habitat creation at Steart Peninsula.

- 3.3.12 Removal of the structure during decommissioning would result in a direct negative effect on the historic landscape and seascape due to the importance the feature would have by that time. However, views of the estuary would be opened up again. There may also be further damage to the known and potential historic environment resource from decommissioning activities. Other effects in relation to visual changes to setting of historic environment, landscape and seascape would similar to those described during construction. There would also be changes to estuary processes, these effects are unknown but likely to be significant.

**B3: Brean Down to Lavernock Point Barrage (known as Cardiff to Weston)**

- 3.3.13 B3 is the largest of the barrage short-listed options being an approximately 16km long structure impounding the Severn Estuary between Lavernock Point near Cardiff and Brean Down, adjacent to Weston-Super-Mare. A representation of what the Cardiff to Weston Barrage would look like is shown in Figure 3.3 below.

**Figure 3.3 Computer generated image of the B3 Cardiff to Weston Barrage**



- 3.3.14 It is predicted that in addition to the footprint of the structure, an area of approximately 10 ha for the accommodation of onshore temporary infrastructure and 2.5ha for permanent onshore facilities would be required in the vicinity of the landfall of the option at Lavernock and Brean Down. Table 3.1 below summarises the historic environmental resource, landscapes and seascapes directly affected by construction activities. There would also be indirect effects from quarrying and dredging the large quantities of aggregate required to build this structure and effects from ancillary development including power distribution (3.3.15 below).
- 3.3.15 The receptors in Table 3.1 would also be affected by the physical presence of the structure during the 120 year operation, but at a reduced level assuming remediation of construction areas. Illumination of the barrage for navigation or safety would reduce sense of space and wildness at night. There would also be effects from up to 200 km of new overhead lines and 12 new substations.

**Table 3.1 Summary of historic environment, landscape and seascape receptors directly affected by B3 Cardiff to Weston Barrage.**

<b>Terrestrial and intertidal historic environment resource, receiving landscape (including historic)</b>	
Total of 68 known historic environment receptors directly affected by option (does not include indirect estuarine changes) are characterised by known archaeological and palaeoenvironmental remains and deposits naturally eroding from prehistoric peat deposits within the intertidal and sand cliffs on the beach on the English side.	
Penarth Coastline – cliffs and cliff tops considered to have outstanding landscape quality.	
Lavernock Point & Scheduled Monument - prehistoric activity on the headland and historic landscape - undeveloped fieldscape with surviving buildings and landscape features indicative of a medieval origin.	
Lavernock Hinterland – considered to have moderate quality landscape character.	
Sully Island Fort (Iron Age fort on a small coastal promontory) and St Mary's Bay Well Scheduled Monuments	
Brean Down Scheduled Monument– evidence of human activity dating back 4000 years	
Brean Beach part of the Somerset Levels and Moors Countryside Character Type.	
Rural Somerset Levels a mix of flat agricultural land dominated by holiday caravans in and around Brean.	
Area of known archaeological significance and one areas of high archaeological potential at Bridgwater Bay.	
<b>Subtidal historic environment resource and receiving seascape</b>	
No known wrecks within the design footprint but several known wrecks in areas of proposed dredging.	
Structure and dredging within areas of medium to high maritime archaeological potential.	
Penarth Coastline – Intertidal seascape considered to be of outstanding quality.	
Steart/Berrow seascape unit – open sea dotted with the visually prominent Steep Holm and Flat Holm. Large inter-tidal mud and sand flats fringed with rock sea defences.	
<b>Visual receptors</b>	
Immediate views of B3 - Brean Beach, Brean Down SM, Lavernock Point, Penarth coast and cliff tops, Flat Holm and Steep Holm.	
Views in moderate proximity to B3 - Parts of Somerset Levels around Breen, Parts of the Mendip Hills AONB, Weston Bay, Steart Peninsula; Barry, Penarth and Cardiff Bay built up areas with clear sea views	
Views distant from B3 – Quantocks, Coastal parts of the Vale of Taunton and Quantock Fringes, Exmoor Heritage Coast, Valley ridges above Cardiff and Cwmbran	

3.3.16 Indirect effects on the historic environment and seascape are associated with changes to estuary processes:

- Changes to the tidal prism would result in approximately 50% loss of intertidal exposure within the estuary study area (immediately post-implementation). Within the large impounded area there would be a reduced high tide (up to 1m) and slightly lesser effect on the low tide. This would affect the known and potential archaeological and palaeoenvironmental resource along both coastlines between B3 and the Severn Road Bridge. There would also be changes to landscape and seascape such as reduced mudflats at Weston Super Mare and loss of some of the exposed rocky bays between Lavernock and Penarth. Outside the barrage there would be reduced high water levels and raised low water levels with reducing affect as far west as Ilfracombe and the Gower

peninsular, with further effects on the historic environment, landscape and seascape.

- A small increase (0.1-0.2m) to Spring High Tide levels along parts of the southern Irish and west Wales coast could result in changes to the existing erosion pattern in areas of intertidal mudflats have a negative effect on the survival of the historic environment resource where it exists and is sensitive to this type of change. There may also be visual effects on local residents, fishermen and other viewers to whom this change would be evident.
- There would be longer term erosion of the intertidal profile within the impounded basin of between -1 to -3m over the 110 year period, in addition to some erosion outside the intertidal area affecting the known and potential historic resource within the intertidal area, landscape and seascape in some areas.
- Sediment deposition immediately post-implementation in the new and existing subtidal areas (up to 0.3-0.5m) would cover and protect any vulnerable features. But it would also restrict access and trigger the requirement for increased navigational dredging (2.0 Mm<sup>3</sup>/yr) which increases the risk of additional damage to seabed features and deposits which would otherwise be left undisturbed.
- The option would lead to the loss of the Severn Bore during operation.

#### B4: Shoots Barrage

3.3.17

The B4 Shoots Barrage is an approximately 7km long structure impounding the Inner Bristol Channel between land adjacent to West Pill on the Welsh side and Severn Beach on the English side. A representation of the Shoots Barrage is shown in Figure 3.4 below.

**Figure 3.4 Computer generated image of the Shoots Barrage**



3.3.18

In addition to the footprint of the structure, it is predicted that an area of approximately 7.5ha would be required for temporary onshore facilities and 2.5ha for permanent onshore facilities at Caldicot on the Welsh coast and Severn Beach on the English coast as close as possible to the landfall point for the option. Table 3.2 below summarises the historic environmental resource, landscapes and seascapes directly affected by construction activities and operation. There would also be indirect effects from quarrying and dredging of aggregate, although this is one of the smallest structures so the extent of damage to the historic environmental resource is potentially less.

3.3.19

The receptors in Table 3.2 would also be affected by the physical presence of the structure during the 120 year operation. Night time illumination would be most evident

in the Gwent Levels Historic Landscape area making the area appear more developed and visually active into the night. There would be very limited grid transmission requirements, with a new connection at a planned substation at Aust and a short length of overhead line.

**Table 3.2 Summary of historic environment, landscape and seascape receptors directly affected by B4 Shoots Barrage**

<b>Terrestrial and intertidal historic environment resource, receiving landscape (including historic)</b>
Total of 10 known historic environment receptors directly affected by option (does not include indirect estuarine changes) submerged Mesolithic forest associated with peat deposits and numerous fish traps and fish weirs.
Area of high potential for the presence and survival of additional archaeological and palaeoenvironmental remains, especially buried prehistoric material.
Gwent Levels Landscape of Outstanding Historic Interest.
Gwent Levels Hinterland – home to industry, M4 and rails communication routes and farming areas.
Severn Beach area part of the Severn and Avon Vales National Character Area.
The immediate landscape scene of the proposed development is a mix of residential settlement set behind floodbanks adjacent to the estuary and extensive industrial land use stretching up from Avonmouth to the south.
<b>Subtidal historic environment resource and receiving seascape</b>
No known wrecks that would be affected by the design footprint and dredging areas, although known sites in proximity.
The structure and dredging are within areas of medium to high maritime archaeological potential.
Unit 50 of the Welsh Regional Seascape Character Assessment runs from Gold Cliff to Welsh – English border at Chepstow. A flat seascape scene with long, relatively straight and flat stretches of coast. Two iconic structures of the Severn Bridges clearly evident but otherwise little coastal development and extensive views out across the estuary.
Avonmouth seascape unit as defined by Natural England in their study on the potential effects of a Severn barrage. This area has dramatic changing tides that expose extensive inter tidal mud flats, rocky outcrops and a myriad of channels. Prime visual influences are the Second Severn Crossing and the industrial development in and around Avonmouth.
<b>Visual receptors</b>
Immediate views of B4 - Gwent Levels historic landscape; Severn Beach settlement; Avonmouth industrial hinterland; Gold Cliff to Chepstow seascape unit; Avonmouth seascape unit; People crossing the Second Severn Crossing.
Views in moderate proximity to B4 - Uskmouth area, ridges of high ground in South Wales valleys. Parts of Portishead and Avonmouth, potentially high ground above Chepstow, Bridgwater Bay, Glamorgan Heritage Coast.
Views in distant proximity to B4 – High ground from Penarth round to Newport; high ground in Weston Super Mare; Clevedon pier and high ground; potentially high ground in Cotswolds with a westerly aspect; Lavernock Point to Gold Cliff Seascape Unit; views from the Upper Severn Estuary under both Severn Bridges.

3.3.20 Indirect effects are associated with changes to estuary processes comprise:

- Immediately post-implementation, changes to the tidal prism would result in approximately 10% loss of intertidal exposure within the estuary study area. Within the impounded area there would be a reduced high tide (up to 0.3m) and slightly lesser effect on the low tide. Outside the barrage there would be a 0.2m increase in high water levels from Newport, extending, with reducing effect, as far west as Swansea. Effects on historic environment, landscape and seascape are therefore greatest within the Shoots and Inner Severn Estuary. Changes to

landscape and seascape include loss of views of extensive mudflats in the shallow bay at Severn Beach.

- Longer term erosion of steeper intertidal profile at new MHWM (up to -2m) is predicted and has implications for the seascape and survival of the known and potential archaeological and palaeoenvironmental resource along both coastlines between the Shoots Barrage and Lydney Harbour. This is of particular concern along stretches of intertidal exposure at Caldicott, and to the north of the outfall of the River Usk where there is a rich resource and the potential for further important discoveries.
- Subtidal sediment deposition (up to 7m) during operation would cover and protect any vulnerable features, but it would also restrict access and necessitate the increased navigational dredging (1.75 Mm<sup>3</sup>/yr) increasing the risk of additional damage to seabed features and deposits which would otherwise be left undisturbed.
- The option would lead to the loss of the Severn Bore during operation.

#### B5: Beachley Barrage

- 3.3.21 The B5 Beachley Barrage is the smallest of the short-listed barrage schemes. It is a 2km long structure running from Beachley on the Welsh side of the River Severn to land directly to the east on the English side.
- 3.3.22 It is predicted that the majority of the temporary and permanent onshore facilities associated with this option would be located at Aust with a 7.5ha area for temporary onshore facilities and a need for a 2.5 ha area identified for permanent facilities. Table 3.3 summarises the historic environmental resource, landscapes and seascapes directly affected by construction activities. There would also be indirect effects from quarrying and dredging of aggregate, although this is one of the smallest structures so the extent of damage to the historic environmental resource is potentially less, depending on the dredging site.
- 3.3.23 The receptors in Table 3.3 would also be affected by the physical presence of the structure during the 120 year operation. The effect of night time lighting would be limited as the considerably larger and taller Severn Crossing is the subject of considerable illumination. There may be effects from grid reinforcement which is unspecified at this stage but likely to be similar to that for B4 Shoots Barrage.

**Table 3.3 Summary of historic environment, landscape and seascape receptors directly affected by B5 Beachley Barrage**

<b>Terrestrial and intertidal historic environment resource, receiving landscape (including historic)</b>
Approximately 13 recorded components of the heritage resource within the potential design footprint - remains of prehistoric and Romano-British date.
Earthwork remains of Offa's Dyke SM ends at Sedbury Cliffs just to the north of the proposed landfall - an 8 <sup>th</sup> century land division which roughly follows the border between England and Wales
Behind the modern sea defences on the right bank of the estuary areas of medieval and postmedieval ridge and furrow survive as earthworks around Cote Farm.
Area is considered to be of medium potential for the presence and survival of as yet unrecorded remains.

<b>Terrestrial and intertidal historic environment resource, receiving landscape (including historic)</b>
Beachley Peninsula on the west shore is part of the Severn and Avon Vales National Character Area. The peninsula is a mix of extensive army training facilities, residential development and service facilities. Its most prominent landmark is original Severn Crossing overlying the area.
Severn View area on the east shore is also part of the Severn and Avon Vales National Character Area. The landscape character is one dominated by the original Severn Crossing and transport infrastructure of the M48.
<b>Subtidal historic environment resource and receiving seascape</b>
No known wrecks within the design footprint and proposed construction dredging areas
Within an area of medium maritime potential.
The Upper Severn Estuary narrows at the point of the proposed barrage before opening out both up and down stream to wider estuarine areas. The west shore is low lying with a relatively undeveloped hinterland and a visually diverse mix of sand, mud and rock exposed within the inter-tidal area. The east shore differs in the sense of its topographical height of 30m at the top of cliffs and the presence of development in the hinterland behind the shore.
<b>Visual receptors</b>
Immediate views of B5 – Beachley settlement, Severn View, Upper Severn estuary seascape unit, people crossing the original Severn Crossing
Views in moderate proximity to B5 - Sedbury on the Beachley Peninsula Area around Old Passage, New Passage and Redwick downstream of the original Severn Crossing, potentially high ground above Chepstow, Users of the sea and coast between the two Severn crossings, Portskewett and Caldicot area, the Oldbury Lake and other reaches in the Upper Severn Estuary.
Views distant from B5 – Lydney Harbour area, Oldbury on Severn area, Sharpness Docks and its surroundings, coastal footpaths, Lower Wye Valley and Forest of Dean.

3.3.24 Indirect significant effects on the historic environment and seascape are associated with changes to estuary processes:

- Immediately after impoundment, approximately 10% of the existing intertidal area within the estuary study area would be affected by the predicated changes to the tidal prism area. Within the impounded area there would be a reduced high tide (up to 0.3-0.4m) and slightly lesser effect on the low tide affecting the seascape of the Upper Severn Estuary and access to intertidal areas important to future research, such as the foreshore at Sedbury. Outside the barrage there would be a small increase in high water levels from Newport, extending, with reducing effect, as far west as Minehead.
- Up to 3m average subtidal accretion within the impoundment is predicted over 120 years, with a small amount of erosion (-0.4m) within the intertidal profile, which although a much smaller effect than other options, would nonetheless continue to affect access to and survival of the known and potential historic environmental resource.
- Immediately outside the impoundment 2.1m of subtidal accretion and 1.7m intertidal accretion is predicted, protecting deposits but also restricting access to this resource. This accretion would also require increased navigational dredging (1.0 Mm<sup>3</sup>/yr) increasing the risk of additional damage to seabed features and deposits which would otherwise be left undisturbed.
- The option would lead to the loss of the Severn Bore during operation.

### L2: Welsh Grounds Lagoon

- 3.3.25 The Welsh Grounds Lagoon is the largest of the lagoon short-listed options with an approximate length of 28km starting from land adjacent to the mouth of the River Usk, running in a general easterly direction across an area referred to as Welsh Grounds, continuing to the south of Denny Island and reaching land fall adjacent to the Second Severn Crossing. A representation of the Welsh Grounds Lagoon is shown in Figure Figure 3.5.

**Figure 3.5 A computer generated image of the Welsh Grounds Lagoon**



- 3.3.26 In addition to the footprint of the structure, at Uskmouth a 7.5ha area would be required for temporary onshore facilities with permanent facilities located within a 5ha site. At Sudbrook temporary onshore facilities would require an area of 2.5ha with permanent onshore works. Table 3.4 summarises the historic environmental resource, landscapes and seascapes directly affected by construction activities and operation. Of particular note is the Gwent Levels Historic Landscape. There would also be indirect effects from quarrying and dredging the large quantities of aggregate required to build this structure and effects from ancillary development including power distribution.
- 3.3.27 The receptors in Table 3.4 would also be affected by the physical presence of the structure during operation. Night time illumination would adversely affect the Gwent Levels shore which currently appears dark and undeveloped. There would also be effects from grid reinforcement which is unspecified at this stage but likely to be similar to that for B4 Shoots Barrage.

**Table 3.4 Summary of historic environment, landscape and seascape receptors directly affected by the L2 Welsh Grounds Lagoon**

<b>Terrestrial and intertidal historic environment resource, receiving landscape (including historic)</b>
Approximately 13 recorded components of the heritage resource within the potential design footprint
The impounded area of the option contains some of the most important components of the archaeological resource along the Welsh coast including the prehistoric activity and settlement site of Goldcliff; prehistoric peat exposures in the intertidal zone containing prehistoric artefacts and a number of archaeological sites associated with phases of Romano-British land reclamation in the area which is now defined as the Gwent Levels Historic Landscape.
Area of Welsh Grounds is considered to be of one of high potential for the presence and survival of archaeological deposits.
Northern landing point is in the Gwent Levels Landscape of Outstanding Historic Interest in Wales but the southern landing point is not as the Gwent Levels designation does not include the River Usk's mouth.
Northern landing point is part of the Caldicot fen-edge with its pattern of small regular fields.
The southern landing point is in close proximity to the RSPB managed Newport Wetlands Nature Reserve. This estuarine landscape includes the industrial characteristics of power stations, overhead transmission lines, steel works as well as small villages, hedged fields and a rural character.
<b>Subtidal historic environment resource and receiving seascape</b>
There is one known wreck within the lagoon impoundment. A number of known wrecks around the impoundment have been removed (Seazone data), however, there may still be potential to find remains from these wrecks.
Area of medium high to high maritime archaeological potential.
Welsh Grounds is part of Regional Seascape Unit 50 Gold Cliff to Chepstow. The southern end of the lagoon wall actually clips the outer part of Unit 49 Lavernock Point to Gold Cliff.
The intertidal features of the shallow sloping shore are mud banks and their colonisation to form saltmarsh. Shore defences are continuous through along this coastal stretch, block stone used to form sea banks to reduce the risk of flooding to the flat agricultural land behind the shore.
<b>Visual receptors</b>
Immediate views of L2 – Blackrock Picnic Area, Uskmouth, the coastal fringe of the Gwent Levels Historic Landscape, a 28km strip of activity through the Welsh Grounds; the confluence of the River Usk with the Severn Estuary.
Views in moderate proximity to L2 - Land areas between Newport and Cardiff; areas to the upstream or northern end of the lagoon around Portskewett; land areas on the English shore around Severn Beach facing across the narrow part of the estuary; Users of the sea and coast between the two Severn crossings Portskewett and Caldicot area; the Oldbury Lake and other lower reaches in the Upper Severn Estuary just upstream of the original Severn Bridge.
Views distant from L2 - Coastal and raised areas from Cardiff to Penarth; land around the Upper Severn estuary especially on the eastern shore; land areas on the English shore running down from Avonmouth, taking in Portishead and down to Clevedon; areas around Portishead and Clevedon as they look across to the L2 Lagoon; Seascape Unit 49 Lavernock to Gold Cliff and associated water users working or enjoying the estuary.

3.3.28 Indirect significant effects are associated with changes to estuary processes:

- Immediately after impoundment, approximately 25% of the existing intertidal area exposed at low tide within the estuary study area would be affected by the changes to the tidal prism. Low water levels would be raised above the baseline mean tide level, but there would be little change to high tide levels. These changes would render extensive areas of intertidal area along the foreshore of

the Gwent Levels Historic Landscape inaccessible at low tide. In the Severn estuary outside the lagoon there would be a small decrease in high water levels, though in the Bristol Channel between Barry and Swansea increases of around 0.1m in spring high level are predicted.

- Within the impoundment, subtidal deposition in the region of 3.4m over 120 years would occur. There is no requirement for maintenance dredging to alleviate sedimentation so the historic resource would remain protected, albeit with reduced accessibility.

#### L3d: Bridgwater Bay Lagoon

- 3.3.29 L3D Bridgwater Bay Lagoon is a land connected tidal lagoon comprising approximately 16km long embankment, proposed to run from land falls at Brean Down in the north to just east of Hinkley Point in the south.
- 3.3.30 In addition to the footprint of the structure, at Brean Down a 7ha area would be required for the temporary onshore facilities with the permanent facilities situated in a 2.5ha located as close as possible to the landfall. At Hinkley the temporary onshore works would be located in a 10ha area with the permanent works situated in a 2.5ha site. Table 3.5 below summarises the historic environmental resource, landscapes and seascapes directly affected by construction activities. There would also be indirect effects from quarrying and dredging the large quantities of aggregate required to build this structure and effects from ancillary development including power distribution.
- 3.3.31 The receptors in Table 3.5 would also be affected by the physical presence of the structure during the 120 year operation, but at a reduced level assuming remediation of construction areas. Illumination of the lagoon wall for safety and navigation purposes would be clearly evident from the immediate landscape and seascapes setting due to the low levels and sparseness of existing lighting offshore in Bridgwater Bay. There would be effects from grid reinforcement which is unspecified at this stage but likely to be similar to that for B3 Cardiff to Weston Barrage.

**Table 3.5 Summary of historic environment, landscape and seascape receptors directly affected by the L3d Welsh Grounds Lagoon**

<b>Terrestrial and intertidal historic environment resource, receiving landscape (including historic)</b>	
The 59 terrestrial and intertidal receptors within the design footprint, are characterised by known archaeological and palaeoenvironmental remains and deposits naturally eroding from prehistoric peat deposits within the intertidal and sand cliffs on the beach on the English side.	
Brean Down Scheduled Monument – evidence of human activity dating back 4000 years	
Area of known archaeological significance and one areas of high archaeological potential within the intertidal zone of Bridgwater Bay.	
The southern landing point is close in visual proximity terms to the current Hinkley Point nuclear power station. Any works in this area could add to the industrial nature of the local landscape and seascape characteristics.	
<b>Subtidal historic environment resource and receiving seascape</b>	
A number of known wrecks within the impounded area including a wooden vessel built in 1870. Little detail is available regarding the other wrecks.	
Area of high maritime archaeological potential	
In seascape terms the lagoon wall would run through two seascape areas titled Bridgwater Bay and Steart / Berrow in Natural England's report (REF)	
The intertidal features of the shallow sloping shore are mud banks and their colonisation in their upper parts to form saltmarsh.	
<b>Visual receptors</b>	
Immediate views of L3d - Brean Down SM at the north end of the lagoon; Stolford and Hinkley Point at the south end of the lagoon; a 16km strip of activity through the Bridgwater Bay and Steart / Berrow regional seascape units; the inter-tidal areas at Brean Down SM and between Hinkley Point and Stolford.	
Views in moderate proximity to L3d - Land areas of the coastal fringe running from Brean, past Berrow, Burnham on Sea running round to Steart and Stolford beyond. The western end of the Quantocks AONB such as Beacon Hill that have clear views over Bridgwater Bay; Steep Holm and to a lesser extent Flat Holm; Weston regional seascape unit	
Views in distant proximity to L3d – Exmoor National Park; the landscapes of Glamorgan facing across the Bristol Channel towards the L3d lagoon route; Exmoor Heritage Coast Glamorgan Heritage coast; the remainder of the Welsh coast between Lavernock Point and Llanwit Major that face across the Bristol Channel.	

3.3.32 Indirect significant effects are associated with changes to estuary processes:

- At the start of the operational phase approximately 7% of the existing intertidal area exposed at low tide within the estuary study area would be affected by the changes to the tidal prism. The tidal range will change within the lagoon by about 1m by raising low water levels and reducing high tide levels. In the Severn estuary outside the lagoon there would be a small decrease in tide range lowering high tides by about 0.3m and raising low tide levels by a similar amount. These changes should reduce to less than 0.05 west of Port Talbot. Changes are minimal and would not result in substantial changes to the accessibility of the subtidal historic environment resource, or the survival of the intertidal resource.
- The predicted small increase of (up to <0.1m) in Spring High Tide levels along parts of the southern Irish coast could result in changes to the existing erosion pattern in areas of intertidal mudflats which could result to changes in erosion and deposition. These changes could have a negative effect on the survival of

the historic environment resource where it exists and is sensitive to this type of change.

- In the short term an initial deposition of fine sediments is predicted with the impounded basin in the vicinity of the turbines in the region of 0.5 to 1m, and just outside the option in the region off Hinkley Point in the order of 2m. This would require dredging to maintain navigation channels (0.06 Mm<sup>3</sup>/yr), and this activity could have an adverse effect on the survival of seabed features and the resource within the impoundment is very sensitive and fragile. Erosion on the intertidal flats within the lagoon is predicted at a rate of 0.5m over 120 years.

#### Multiple Basins

3.3.33 The use of multiple basins has also been considered for this option to better align energy yield and peak demands and provide the possibility of continuous power (see paragraph 2.3.4 above).

3.3.34 The additional embankment required for a multiple basin would have increased effects on the historic environment, landscape and seascape. The embankment would introduce an additional engineered element to the seascape and receiving landscape. There are known wrecks in the bay and it is of high archaeological potential so the embankment is also likely to have an increased effect on the known and unknown historic environmental resource. The altered tidal range within the high and low basins may affect the intertidal resource through survival of deposits and access to the historic environment resource.

#### Combinations

3.3.35 There are two possible combinations of options identified (paragraphs 2.3.5- 2.3.6):

- B4 Shoots Barrage and L3d Bridgwater Bay Lagoon could be built together. These could either be constructed sequentially or concurrently.
- B3 Cardiff to Weston Barrage and L3d Bridgwater Bay Lagoon would need to be constructed sequentially due to the large resource requirements.

3.3.36 The effects of the combinations of options would largely be the sum of those described for each option above. However, for sequential construction, the longer construction period would mean greater duration of construction effects on the setting of historic sites, landscape and seascape. During operation, there is also predicted to be a marginal increase in the loss of intertidal area associated with two options working in combination. This would also marginally increase effects on seascape and the intertidal historic environmental resource described for each option. This includes the reduction of beaches at low tide, access to and preservation of the historic environment.

## **SECTION 4**

### **INTERRELATIONSHIPS**



## 4 INTERRELATIONSHIPS

**4.1.1** The SEA Directive requires that the interrelationships between likely significant effects are described (SEA Directive Annex 1 (f)). This theme paper therefore summarises the interactions between related topics and thereby ensures that the many complex issues that are not self-contained within a given topic are recognised and their implications understood. Each theme paper also examines the relationships between this theme and other themes within the STP SEA.

### **4.2 Interrelationships between topics within the Historic Environment, Landscape & Seascapes theme**

**4.2.1** The historic environment forms the basis of present day landscapes and seascapes. Section 3.2 describes how the Wentlooge formation records past changes in sea level and estuarine conditions. The existing and future seascapes of the estuary are part of this dynamic system but have also been shaped by the past.

**4.2.2** The present day landscape of the Severn Levels has been shaped by nearly two millennia of human intervention, which has served to stabilise and permanently claim large areas of saltmarsh and fen described above from marine inundation by means of a complex and protracted process of drainage and sea defence. Landscape features relating to water management forms a major component of this landscape with sea walls to prevent inundation and a network of ditches to carry ground water (rain and upland drainage) and prevent flooding across the low lying reaches. Much of the Gwent Levels Historic Landscape lie well below the level of the highest tides and are only kept from inundation by the modern sea defences.

**4.2.3** Similarly, features at Brean Down represent many periods of history including Bronze Age, Roman and more recently Second World War artefacts and associations. These features are part of the landscape and the site is also a landmark and viewpoint for the Estuary.

**4.2.4** Effects on the historic environment, landscape and seascapes are therefore interrelated as these components cannot be separated. Loss or damage to individual features within the historic environment would also degrade the local landscape or seascapes. Changes to the landscape or seascapes characteristics also affect the setting of the historic environment.

### **4.3 Interrelationships between Historic Environment, Landscape & Seascapes and other themes**

#### Construction

**4.3.1** Large amounts of aggregates would be required for the options. In particular existing aggregate production in the UK is unlikely to meet the requirements of the larger options of the B3 Cardiff to Weston Barrage, L2 Welsh Grounds Lagoon and L3d Bridgwater Bay Lagoon. These would require additional aggregate abstraction including dredging and quarrying. This is covered in the Air & Climatic Factors and Resources & Waste Theme and Society & Economy Theme (Other Sea Uses Topic). Additional aggregate abstraction would affect the historic environmental resource through damage from dredging and quarrying, in addition to having negative effects on landscape and seascapes.

### Operation

- 4.3.2 Perhaps the most significant relationship between this theme and other themes identified in Section 3 relates to changes to the intertidal environment. The extent of saltmarsh and other intertidal features obviously plays a key role in the characteristics of seascapes. Changes to the tidal regime similarly affect preservation and access to the historic environment. Intertidal changes are covered in relation to changes in the tidal range in the Physicochemical Theme (Hydraulics and Geomorphology) and habitats (e.g. mudflat, saltmarsh etc) within the Biodiversity Theme (in particular Marine Ecology Topic).
- 4.3.3 A number of effects, such as preservation of currently waterlogged heritage remains, could arise from altered water levels due to pumping or drainage. These changes are covered in the Physicochemical Theme (Flood Risk and Land Drainage, Freshwater Environment and Associated Interfaces Topic) and the Biodiversity Theme (Terrestrial and Freshwater Ecology Topic).
- 4.3.4 There is an interrelationship between leisure and tourism and landscape & seascapes. There is a demand for leisure pursuits within the Severn Estuary, which is predicted to increase due to more local holiday patterns from increased travel cost. The growth of seaside resorts would have effects on landscape. However, there is also increasing demand for activity based holidays and eco-tourism which depends on preservation of high quality landscapes. Tourism and leisure is covered by the Society & Economy Theme (Communities Topic).
- 4.3.5 In addition, many recreational beaches need to be sandy and this is dependent on particular tidal and wave processes, the effects of which are uncertain at this level study. However, this relationship would need to be explored further, depending on the outcome of the Feasibility Study. Coastal processes are covered by the Physicochemical Theme (Hydraulics & Geomorphology Topic Paper).
- 4.3.6 There is an interrelationship between the historic environment and fishing. A STP option would have effects on heritage fishing and other cultural issues, such as place names with cultural associations or traditional skills dependent on the estuary. These are assessed by the Estuarine and Migratory Fish topic within the Biodiversity Theme.
- 4.3.7 The potential reduction in the quantity of wading birds able to survive on the estuary would have an indirect effect on the landscape and seascapes characteristics of the estuary. The presence of large flocks of migratory birds adds to the perceived sense of wildness and quality of the natural environment. Changes to wading bird populations are covered by the Biodiversity Theme (Waterbirds Topic).

### Measures to prevent, reduce or offset effects

- 4.3.8 There are a couple of interrelationships arising between this theme and measures identified by other topics to prevent or reduce adverse effects of the options on the environment. These interrelationships are set out below.
- 4.3.9 The feasibility of undertaking topographic modification to reduce the effect of intertidal losses has been undertaken as part of this study (PB/BV, 2010). The technique for intertidal habitat creation would entail the construction of a water-permeable bund in parallel with a suitable section of coast. Then by process of natural sedimentation and/or the introduction of dredged materials from the estuary or further afield these areas would effectively silt up, raising relative ground level and creating a new man-made intertidal zone in areas deemed suitable. This would create new areas of

intertidal habitat, changing existing seascapes. Deposition of sediment is unlikely to affect the survival of the historic environmental resource, but would restrict access to it. However, mooring of machinery and disturbance of sediments during construction could damage the historic environment.

- 4.3.10 Additional dredging would be required during operation to keep navigational channels open. This is covered in the Navigation Topic in the Society and Communities Theme. Dredging could have additional effects on the survival of historic seabed features including wrecks. The magnitude of the effect on the historic environment depends on a number of factors including the amount of dredging required, the archaeological potential in the area of dredging and whether the area has been previously dredged.

#### Decommissioning

- 4.3.11 Material generated by the decommissioning works, most notably the quantity of concrete demolition arisings from the barrage itself has the potential to have visual and seascape effects depending on how and where it is temporarily and permanently stored.

### **4.4 Interrelationships with the Habitats Regulations Assessment**

- 4.4.1 The main interrelationship between this theme and the Habitats Regulations Assessment is the requirement for provision of compensation under Directive 92/43/EEC (the Habitats Directive). The need for such compensatory intertidal habitat has been identified by the Biodiversity Theme (primarily the Marine Ecology and Waterbirds Topics). Geographical locations and specifications for the quality, type and extent of habitat required outside the Severn Estuary European Site have not been defined at this stage, but an indication of the scale of habitat required can be deduced from the predicted areas of loss for each option as summarised in Table 4.1.

**Table 4.1 Summary of intertidal losses predicted.**

Option	% remaining (immediately post-implementation)	Amount lost (ha) (immediate post-implementation)	% lost from further long term change (from post-implementation)
B3	49	15,910	-7.4%
B4	89	3,260	-1.7%
B5	91	2,760	+0.1%
L2	77	7,200	+0.7%
L3	92	2,450	-1.1%

- 4.4.2 The environmental characteristics of the areas identified for compensatory habitat are likely to be similar to those described in relation to the historic environment, landscape and seascape within this theme paper. Significant adverse effects to the survival of the historic environment resource are likely to be similar in nature to those outlined in the assessment. In addition, creation of large areas of compensatory habitat is likely to have a significant effect on landscapes and seascapes, potentially

## SECTION 4



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introducing these elements where there was previously sea defences with little intertidal area.

## SECTION 5

### **MEASURES TO PREVENT, REDUCE AND AS FULLY AS POSSIBLE OFFSET ANY SIGNIFICANT ADVERSE EFFECTS**



**5**

## **MEASURES TO PREVENT, REDUCE AND AS FULLY AS POSSIBLE OFFSET ANY SIGNIFICANT ADVERSE EFFECTS**

## 5.1.1

The SEA Directive requires that information is provided on the measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the plan or programme (SEA Directive Annex I). These measures are considered within this theme paper in terms of the interrelationships between topics within this theme.

## 5.1.2

In this SEA, and in line with UK practice, these measures are split into those to prevent or reduce effects and measures to as fully as possible offset any significant adverse effects on the environment. Offsetting measures make good for loss or damage to the environment, without directly reducing that loss/damage.

**5.2**

### **Measures to prevent or reduce significant adverse effects**

## 5.2.1

It is very difficult to prevent effects on the historic environment, landscape and seascape due to the nature of the receptors and proposed options. In relation to the historic environment, it may be possible to preserve known heritage assets of national or international importance *in situ* through adjusting the layout or siting of structures during the detailed design process. However, due to the extensive nature of the historic environmental resource in the Severn estuary, in many cases some loss or damage would be unavoidable.

## 5.2.2

Measures to reduce significant adverse effects to the historic environmental resource comprise preservation by record to ensure better understanding of, and compile and disseminate a record of the threatened resource. Whilst this measure cannot completely ameliorate loss of the resource which is finite and non-renewable, it is accepted that obtaining knowledge, understanding and permanent record of the resource before it is lost/damaged is preferable to its loss without record. Measures can take many practical forms depending on the scale, location and nature of the resource and include archaeological excavation, building recording, landscape survey, environmental sampling etc.

## 5.2.3

There are several measures proposed to reduce effects on the setting of the historic environmental resource, landscape and seascape. However, these may only be effective at a local level due to the scale of the STP options. The measures comprise:

- Measures to reduce effects on setting - including selection of the best location in relation to the individual features of the landscape and seascape for landfalls, temporary construction works, transport and power infrastructure; consideration of using existing assets instead of building new ones; use of bunding and planting for onshore facilities where appropriate; minimising light pollution.
- Measures to minimise sizing – minimum land and sea areas to be taken for construction; keeping height of all structures (embankments, walls, locks, lighting, construction compounds) to a minimum.
- Measures to address styling of the option – visually attractive rather than utilitarian project and product design (e.g. existing Severn Bridges), particularly in landfall or visitor areas; consider including of visual variety where appropriate; complement structures such as the existing Severn Bridges.

- Measures to reduce secondary effects – sensitive route selection for power lines e.g. by utilising existing routes; consideration of underground cables in some circumstances; keep operational facilities to a minimum and reinstate construction areas to meet local landscape objectives and deter further development.

5.2.4 There are interactions between measures proposed by other themes to prevent or reduce effects and this theme and these are discussed in section 4 above.

### 5.3 Measures to as fully as possible offset significant adverse effects

5.3.1 It is difficult to offset effects on the historic environment, landscape and seascape as once the resource is lost, it cannot be created elsewhere. Therefore no measures to offset effects have been proposed for this theme.

## **SECTION 6**

### **SEA OBJECTIVE COMPLIANCE**



**6****SEA OBJECTIVE COMPLIANCE****6.1 Compliance with SEA objectives**

6.1.1 The SEA Objectives which were drafted and consulted upon as part of the Phase 1 SEA scoping stage are set out in Section 2.2. This theme paper identifies any interactions or inconsistencies between topics within this theme with regards to the assessment against SEA Objectives.

6.1.2 The performance of the alternative options against SEA objectives for the Historic Environment and Landscape & Seascapes Topics are summarised in Table 6.1 below.

**B3: Brean Down to Lavernock Point Barrage**

6.1.3 Table 6.1 shows that the Cardiff to Weston Barrage does not meet the SEA objectives for this theme. Performance is assessed as 'major negative' for the majority of objectives. This is mainly due to the scale of the option. It is a large structure and has wide ranging effects on the historic environment resource, landscapes and seascapes within the Severn Estuary, including important sites such as Brean Down. It also would require large areas of compensatory habitat to be created, which would have effects on landscape, seascapes and the historic environment, the details of which are not yet known. Although measures to reduce the effects of the barrage have been specified, these would not be sufficient to avoid significant negative effects.

**B4: Shoots Barrage**

6.1.4 The Shoots Barrage does not meet the majority of SEA objectives for this theme (Table 6.1). Performance is generally assessed as either 'minor negative' or 'major negative' for the majority of objectives. The structure is somewhat smaller than some of the other STP options with less extensive effects on the historic environment, landscape & seascapes. Nonetheless, the structure is located within a sensitive area adjacent to the designated Gwent Levels Historic Landscape, with significant negative effects on historic landscapes and palaeo-environmental deposits. Effects arising from creation of compensatory habitat are not known.

**B5: Beachley Barrage**

6.1.5 The Beachley Barrage does not meet several of SEA objectives for this theme (Table 6.1). Performance is generally assessed as either 'minor negative' or 'major negative' for the majority of objectives, although there is no effect on some objectives including designated historic sites and landscapes with intervisibility with the option. The structure is the smallest of the options with less extensive effects on the historic environment, landscape & seascapes. Effects arising from creation of compensatory habitat are not known.

**L2: Welsh Grounds Lagoon**

6.1.6 Table 6.1 shows that the Welsh Grounds Lagoon does not meet the SEA objectives for this theme. Performance is generally assessed as either 'minor negative' or 'major negative' for the majority of objectives. This is a large structure and has wide ranging effects on the historic environment resource, landscapes and seascapes within the

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Severn Estuary and is located in proximity to the sensitive Gwent Levels Historic Landscape. Effects arising from creation of compensatory habitat are not known.

### L3d: Bridgwater Bay Lagoon

6.1.7

The Bridgwater Bay Lagoon does not meet the majority of the SEA objectives for this theme (Table 6.1) with the exception of compliance with the aims and articles of the European Landscape Convention by being able to retain the greater part of the tidal range and inter-tidal visual characteristics of the Bridgwater Bay seascape area. Performance is generally assessed as 'minor negative' for other objectives. This is a large structure and has wide ranging effects on the historic environment and views. Effects arising from creation of compensatory habitat are not known.

**Table 6.1 SEA Objective Assessment Summary Table****Key**

Performance is based on number or proportion of receptors linked to each SEA Objective for which significant effects have been predicted, and informed by consideration of SEA Assessment Criteria.			
Major negative performance against SEA Objective	--	Major positive performance against SEA Objective	++
Minor negative performance against SEA Objective	-	Minor positive performance against SEA Objective	+
No Effects	0		

SEA Objective	Relevant Receptors	Alternatives Performance against SEA Objectives over entire life-cycle				
		B3: Brean Down to Lavernock Point Barrage	B4: Shoots Barrage	B5: Beachley Barrage	L2: Welsh Grounds Lagoon	L3d: Bridgwater Bay Lagoon
To avoid adverse effects on designated sites in the historic environment.	Recorded designated sites, monuments and buildings and areas within the terrestrial and intertidal receptor areas	--  Construction and operation would result direct damage to the form and setting of the Scheduled Monument which incorporates a multi-period archaeological site on the sand-covered limestone headland of Brean Down would have an adverse effect on the setting of Sully Island and St Marys Well (Scheduled Monuments).	-  Construction and operation of the option would result in damage to part of the form and setting of the Gwent Levels Historic Landscape of Outstanding Historic Interest.	0  No effects to the designated historic environment resource have been identified.	--  Construction and operation of the option would result in damage to the form and setting of the Gwent Levels Historic Landscape of Outstanding Historic Interest.	--  Construction and operation of the option would result in damage to the form and setting of the Scheduled Monument which incorporates a multi-period archaeological site on the sand-covered limestone headland of Brean Down.
To avoid adverse effects on the non-registered internationally, nationally, regionally and locally important sites within the historic environment.	Recorded sites and monuments in terrestrial, intertidal and subtidal receptor areas.	--  Construction and operation would result in direct adverse effects to the known historic environment resource within the design footprint and onshore works. Indirect effects to survival of the resource within the intertidal and subtidal receptor areas as a result of changes to the tidal prism are also predicted.	--  Construction and operation would result in direct adverse effects to the known historic environment resource within the design footprint and onshore works. Indirect effects to survival of the resource within the intertidal and subtidal receptor areas as a result of changes to the tidal prism are also predicted.	--  Construction and operation would result in direct adverse effects to the known historic environment resource within the design footprint and onshore works. Indirect effects to survival of the resource within the intertidal and subtidal receptor areas as a result of changes to the tidal prism are also predicted.	--  Construction and operation would result in direct adverse effects to the known historic environment resource within the design footprint and onshore works. Indirect effects to survival of the resource within the intertidal and subtidal receptor areas as a result of changes to the tidal prism are also predicted.	--  Construction and operation would result in direct adverse effects to the known historic environment resource within the design footprint and onshore works. Indirect effects to survival of the resource within the intertidal and subtidal receptor areas as a result of changes to the tidal prism are also predicted.

SEA Objective	Relevant Receptors	Alternatives Performance against SEA Objectives over entire life-cycle				
		B3: Brean Down to Lavernock Point Barrage	B4: Shoots Barrage	B5: Beachley Barrage	L2: Welsh Grounds Lagoon	L3d: Bridgwater Bay Lagoon
To avoid adverse effects on the potential historic environment, the as yet unidentified sites and finds, within the Severn Estuary.	Identified areas of potential within the intertidal and subtidal receptor areas.	--  Combination of construction and operation would result in direct and indirect adverse effects to areas of medium and high potential within the design footprint and the intertidal and subtidal receptor areas. Likely to be greater effect due to provision of compensatory habitat (15,910ha of intertidal habitat lost)	--  Combination of construction and operation would result in direct and indirect adverse effects to areas of medium and high potential within the design footprint and the intertidal and subtidal receptor areas. Likely to be effect from provision of compensatory habitat (3,260ha of intertidal habitat lost)	-  Combination of construction and operation would result in direct and indirect adverse effects to areas of medium potential within the design footprint and the intertidal and subtidal receptor areas. Likely to be effect from provision of compensatory habitat (2,760ha of intertidal habitat lost)	--  Combination of construction and operation would result in direct and indirect adverse effects to areas of medium and high potential within the design footprint and the intertidal and subtidal receptor areas. Likely to be effect from provision of compensatory habitat (7,200ha of intertidal habitat lost)	--  Combination of construction and operation would result in direct and indirect adverse effects to areas of medium and high potential within the design footprint and the intertidal and subtidal receptor areas. Likely to be effect from provision of compensatory habitat (2,450ha of intertidal habitat lost)
To avoid adverse effects on the character and quality of the historic landscape.	Historic landscape within terrestrial receptor area.	-  Construction and operation of the option and that of the temporary, ancillary and permanent onshore works would have an adverse effect on the character and quality of the historic landscape	-  Construction and operation of the option and that of the temporary, ancillary and permanent onshore works would have an adverse effect on the character and quality of the historic landscape	0  No effects to the character or quality of the historic landscape have been identified.	--  Construction and operation of the option and that of the temporary, ancillary and permanent onshore works would have an adverse effect on the character and quality of the historic landscape	--  Construction and operation of the option and that of the temporary, ancillary and permanent onshore works would have an adverse effect on the character and quality of the historic landscape
To conserve the character and qualities of the landscape/seascape, recognising its diverse features and distinctiveness at different scales – including designated and non- designated areas	Receiving landscapes	--  Due to length and scale of development adversely affecting local landscapes at Welsh and English landfalls, particularly Brean Down SSSI.	-  Primarily due to adverse landscape effects in the Gwent Levels Historic Landscape.	-  Primarily due to the adverse local effects on the Beachley area.	--  Due to adverse landscape effects from two landfall points in the Gwent Levels Historic Landscape.	--  Due to length and scale of development adversely affecting local landscapes at both end points particularly Brean Down SSSI
	Receiving seascape	--  Due to the area of marine habitat constructed over and the large extents of inter-tidal habitat lost due to the raising of low water levels upstream of the barrage. Loss of Severn Bore.	--  Due to the area of marine habitat constructed over and the large extents of inter-tidal habitat lost due to the raising of low water levels upstream of the barrage. Loss of Severn Bore.	--  Due to the area of marine habitat constructed over and the large extents of inter-tidal habitat lost due to the raising of low water levels upstream of the barrage. Loss of Severn Bore.	--  Due to the area of marine habitat constructed over and the smaller amounts of inter-tidal areas lost with the ebb-flood turbines keeping a greater tidal range within the lagoon area.	--  Due to the area of marine habitat constructed over and the smaller amounts of inter-tidal areas lost with the ebb-flood turbines keeping a greater tidal range within the lagoon area.
	Landscapes with	-  0	-  0	-  0	-  -	-  -

SEA Objective	Relevant Receptors	Alternatives Performance against SEA Objectives over entire life-cycle				
		B3: Brean Down to Lavernock Point Barrage	B4: Shoots Barrage	B5: Beachley Barrage	L2: Welsh Grounds Lagoon	L3d: Bridgwater Bay Lagoon
	inter-visability to the option	Due to the length and scale of development the greatest number of Welsh and English character areas would have an interrelationship with this barrage, none of the landscapes suffer significant adverse effects.	This barrage has intervisibility with few other landscapes receptors than its receiving ones and where it does its effects are not considered to be significant.	This barrage has intervisibility with few other landscapes receptors than its receiving ones and where it does its effects are not considered to be significant.	Due to length and scale of development both Welsh and English character areas would have an interrelationship with this barrage, none of the landscapes suffer significant adverse effects.	Due to the length and scale of development both Welsh and English character areas would have an inter-relationship with this barrage, none of the landscapes suffer significant adverse effects.
	Seascapes with inter-visability or connectivity	--	--	--	--	-
To conserve the character and qualities of the physical and visual resource associated with land and sea.	Visual receptors on land	--	-	-	-	-
		Due to the length, scale and visual prominence of the barrage blocking views across the Inner Bristol Channel and the Severn Estuary and altering the setting of Steep Holm and Flat Holm. This effect is most notable at both landfalls where even though they are non-designated landscapes significant negative visual effects would occur.	Due to the length, scale and visual prominence of the barrage blocking views up and down the Severn Estuary. This effect is most notable at the Welsh landfall in the Gwent Levels Historic Landscape where open views would be foreshortened	Due to the positioning of this shortest barrage views up and down the Severn Estuary would be blocked at the original Severn Crossing. This effect would visually separate the Upper Severn Estuary from The Shoots part of the estuary.	Due to the length, scale and visual prominence of the lagoon wall blocking views across the Severn Estuary.	Due to the length, scale and visual prominence of the lagoon wall blocking views out from Bridgwater Bay into the Inner Bristol Channel. This effect is most notable at both landfalls but particularly at Brean Down SM, a designated historic site valued for its landscape setting and views it affords across the wider estuary.
	Visual receptors on the estuary	--	-	-	-	-
		Due to the length, scale and visual prominence of the barrage blocking views across the Inner Bristol Channel and the	Due to the length, scale and visual prominence of the barrage blocking views up and down the Shoots section of the	Due to the length, scale and visual prominence of the barrage blocking views between The Shoots and the Upper	Due to the length, scale and visual prominence of the lagoon wall blocking views into the lagoon basin for the	Due to the length, scale and visual prominence of the lagoon wall blocking views into the lagoon basin for the estuary and

SEA Objective	Relevant Receptors	Alternatives Performance against SEA Objectives over entire life-cycle				
		B3: Brean Down to Lavernock Point Barrage	B4: Shoots Barrage	B5: Beachley Barrage	L2: Welsh Grounds Lagoon	L3d: Bridgwater Bay Lagoon
		Severn Estuary and altering the setting of Steep Holm and Flat Holm.	estuary restricting sight to other parts.	Severn Estuary.	estuary and from the basin out to the estuary.	from the basin out to the estuary.
To accord with the Aims and Articles of the European Landscape Convention (ELC).	Compliance with European Landscape Convention	--	--	-	-	+
		Not in line with the aims and articles of the European Landscape Convention as large quantities of the Severn Estuary's intrinsic landscape quality namely the lower parts of the inter-tidal areas upstream of B3 are permanently lost from sight,	Not in line with the aims and articles of the European Landscape Convention as large quantities of the Severn Estuary's intrinsic landscape quality namely the lower parts of the inter-tidal areas upstream of B4 are permanently lost from sight,	Not in line with the aims and articles of the European Landscape Convention as large quantities of the Severn Estuary's intrinsic landscape quality namely the lower parts of the inter-tidal areas upstream of B5 are permanently lost from sight, As this is a smaller area it has been graded a single minus sign.	Not in line with the aims and articles of the European Landscape Convention as large quantities of the Severn Estuary's intrinsic landscape quality namely the Welsh Grounds inter-tidal are permanently lost from sight, Even though this is not a barrage and the rest of the estuary's inter-tidal areas remain visible the extent of inter-tidal habitat lost at the Welsh Grounds and loss of landscape quality along the Gwent Levels Historic Landscape means it cannot be considered to comply with the ELC	Not in line with the aims and articles of the European Landscape Convention by being able to retain the greater part of the tidal range and inter-tidal visual characteristics of the Bridgwater Bay seascape area through the use of flood and ebb turbines. In addition the fact it is a lagoon development means that it does not significantly affect the seascape characteristics upstream of its position. However the effect on landscape and seascape characteristics as defined in SEA Objective 1 and 2 above should be noted.

## **SECTION 7**

## **IMPLEMENTATION**



**7****IMPLEMENTATION****7.1 Proposals for monitoring**

- 7.1.1 The SEA Directive requires that measures to monitor the significant environmental effects are described within the environmental reporting. Monitoring allows the actual significant environmental effects of implementing a Severn Tidal Power alternative option to be tested against those predicted.
- 7.1.2 This section sets out suggestions for the framework for the monitoring of the plan against the predicted significant effects within this theme which can be applied to all of the Severn Tidal Power Schemes under consideration. Table 7.1 includes a brief summary of monitoring proposed for this theme and identifies any interactions or inconsistencies between the topics within this theme.

**Table 7.1: Potential Monitoring Summary for Theme Reporting**

<b>Monitoring proposal for significant environmental effects</b>	<b>Receptor</b>	<b>Topics covered</b>	<b>Comment</b>
Programme of archaeological monitoring, where appropriate, prior to and during construction phase.	Known and potential resource within all three receptor areas.	Historic Environment	To monitor the application and effectiveness of protective measures associated with the direct effects of an option (e.g. physical damage, loss, effects to setting etc).
Planned programme of foreshore and subtidal surveys including walkovers, prospection, sampling, excavation etc post option development.	Known and potential resource within all three receptor areas (particularly subtidal and intertidal).	Historic Environment	To reduce the long-term loss through the recording of the resource as it becomes threatened by the changes resulting from the indirect effects of an option (e.g. erosion, exposure etc).
Completion of landscape character assessments post-scheme.	Receiving landscapes and seascapes	Landscape and seascape	To see how the landscape character of the receiving and inter-related landscapes and seascapes have changed when compared to their pre-construction characteristics and to guide landscape change during and post development.
Interviews of samples of people within landscapes and seascapes areas with inter-visibility immediately after the works completed and thereafter at regular intervals say after 1 year, 5 years and 10 years.	Viewers	Landscape and seascape	To gauge the actual perceptual response to change in character in the inter-visibility areas.

<b>Monitoring proposal for significant environmental effects</b>	<b>Receptor</b>	<b>Topics covered</b>	<b>Comment</b>
Consideration of the effects of night-time illumination by taking a pre-construction survey and comparing it with illumination levels and effects when the scheme comes into operation.	Receiving landscapes and seascapes, viewers	Landscape and seascape	
Monitor implementation and effectiveness of measures to reduce effects on landscapes and seascapes.	Receiving landscapes and seascapes, viewers	Landscape and seascape	Includes height of structures, use of lighting, local materials, land-take etc.

## 7.2 Suggestions for further research

- 7.2.1 This section includes some suggestions for research to support further consideration of tidal power in the Severn Estuary. This study is undertaken at a strategic level, and in order to more fully assess the effects of Severn Tidal Power on historic environment, landscape and seascapes, clear more information would be needed. This comprises both information regarding the baseline environment, particularly at a local level, and project information on a Severn Tidal Power option - for instance alignment, construction methods, ancillary development etc.
- 7.2.2 The results of desk-based archaeological assessment would need to be combined with the results of specific field surveys at a later stage of a STP option development in order to ground-truth the known and potential resource identified by desk-based assessment. The techniques and methods of field survey would depend on the nature of the resource but scope and standards of such surveys are set out in planning policy and by the Institute for Archaeology, Cadw and English Heritage. The results of these surveys are essential in order to accurately design with timely application the correct measures to reduce and prevent negative effects on the historic environment resource. These surveys would be most effective at a stage in the STP option development where detailed and fixed option designs were available and are not appropriate at the level of SEA.
- 7.2.3 Local landscape and visual assessment would need to be undertaken in order to get a more detailed view of the receiving environment, plan landscape change and be able to specify specific measures to reduce the effects of a STP option on landscape and seascapes, particularly at landfall points. This would be undertaken to accepted standards including Guidelines for Landscape and Visual Assessment (Landscape Institute, 2002). This would be undertaken as part of a future Environmental Impact Assessment. In addition formulation of a landscape strategy linked to planning delivery mechanisms would help guide landscape change during and post development.
- 7.2.4 Further engineering and architectural work would need to be undertaken to better predict the appearance of the barrages/lagoon structures by producing physical or virtual models of what the walls would look like. Landfall points would particularly benefit from this.

## **SECTION 8**

## **GLOSSARY**



## 8

## GLOSSARY

Term	Definition
Appropriate Assessment	A process required by the Habitats Regulations (SI 1994/ 2716) to avoid adverse effects of plans, programmes and projects on Natura 2000 sites and thereby maintain the coherence of the Natura 2000 network and its features.
Ancillary development	Other works beyond a Severn Tidal Power scheme but are needed to build or operate the scheme, including measures to prevent, reduce or as fully as possible offset significant environment effects, e.g. dredging, bypasses etc.
Barrage	A manmade obstruction across a watercourse to retain a head of water on the rising tide, and then run the water through turbines when the tide level drops.
Bristol Channel	The area seaward of the headlands at Lavernock Point on the Welsh coast and Brean Down on the English coast (see Severn Estuary and also Inner Bristol Channel and Outer Bristol Channel)
Bulb Kapeller type turbines	The Kapeller Bulb turbine is a turbine regulated only by its adjustable runner blades (single regulation). It has fixed wicket gates. It is adaptable to pumping as well as generation but only suited to one way generation. Kapeller Bulb turbine technology has largely been superseded by Bulb Kaplan turbines.
Bulb Kaplan turbines	The Kaplan turbine is a propeller-type water turbine that has adjustable blades and adjustable wicket gates (double regulation). It is adaptable to pumping as well as generation. Kaplan turbines are now widely used throughout the world in high-flow, low-head power production. The Kaplan turbine is an inward flow reaction turbine, which means that the working fluid changes pressure as it moves through the turbine and gives up its energy. The Kaplan turbine is suited to one or two way generation.
Bulb turbines	The generator is mounted in a bulb on the main turbine axis upstream of the runner blades for one way generation. Bulb turbines can be used for one or two way generation depending on the type (see above).
Caissons	Prefabricated concrete units used to construct parts of a barrage, lagoon or other offshore structures. Caissons can be used to house turbines, sluices or to construct navigation locks, or they may just be plain units used for impoundment construction.
Coalfield river	A river draining a coalfield valley
Coastal Squeeze	Process whereby the coastal margin is squeezed between a fixed landward boundary and the rising sea level
Compensation	Measure which makes good for loss or damage to an SAC or SPA feature, without directly reducing that loss/damage. Only used in relation to the Habitats Directive (see offsetting, below).
Consequential development	It is conceivable that a major tidal power scheme will facilitate or attract other developments, which may themselves pose significant environmental effects. These developments are described as 'consequential developments'.

Term	Definition
Cumulative effects	Effects arise, for instance, where several developments each have insignificant effects but together have a significant effect, or where several individual effects of the plan have a combined effect.
Direct effects	The original effect as a result of an option (see indirect effects)
Ebb	When the sea or tide ebbs, it moves away from the coast and falls to a lower level.
Ebb mode	One way generation on ebb tides only i.e. during the period between high tide and the next low tide in which the sea is receding.
Ebb and flood mode	Two way generation during the ebb and flood tides
Effect	Used to describe changes to the environment as a result of an option (see also direct effects, indirect effects, far-field effects and cumulative effects)
Eutrophication	An increase in chemical nutrients (compounds containing nitrogen or phosphorus). This in turn can lead to 'eutrophication effects' – an increase in an ecosystem's primary productivity (excessive plant growth and decay), and further effects including lack of oxygen and severe reductions in water quality, fish, and other animal populations.
Flood	The inward flow of the tide - This is the opposite of ebb. This refers to a mode of operation for a STP alternative option.
Far-field effects	Effects that are felt outside the Severn Estuary study area.
Future baseline	Baseline during construction (2014-2020) and operation (2020-2140), decommissioning and longer term trends.
Geomorphology	The study of the changing form of the estuarine environment and its components in relation to physical forcing.
Hydrodynamics / hydraulics	The science of physical forces acting on the water.
Hypertidal	A tidal range in excess of 6m.
Impoundment	A body of water, such as a reservoir, made by impounding
Indicator	A measure of variables over time, often used to measure achievement of objectives.
Indirect effects	Those effects which occur away from the original effect or as a result of a complex pathway.
Inner Bristol Channel	The downstream limit extends from Nash Point in Wales to the west of Minehead along the English coast. The upper limit extends from Swanbridge on the Welsh coast to Brean Down along the English coast.
Irreversible	If the timescale for a receptor's return to baseline condition is greater than 50

Term	Definition
	years then it will be considered irreversible.
Lagoon(s)/ Land-connected lagoons	A man-made enclosed body of water that retains a head of water on the rising tide and then runs the water through turbines when the tide level drops. A land connected lagoon uses the shoreline to make the enclosure.
Landscape	An area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors. (Article 1, European Landscape Convention Council of Europe, 2002). The explanatory note expands on this definition as follows: "Landscape" is defined as a zone or area as perceived by local people or visitors, whose visual features and character are the result of the action of natural and/or cultural (that is, human) factors. This definition reflects the idea that landscapes evolve through time, as a result of being acted upon by natural forces and human beings. It also underlines that a landscape forms a whole, whose natural and cultural components are taken together, not separately."
Long-listed options	All options identified in the SDC report, Call for Proposals and other strategically selected proposals as well as the Interim Options Analysis Report.
Measures to prevent or reduce effects	Measures to prevent, or reduce any significant adverse effects on the environment.
Natura 2000	Natura 2000 is the European Union-wide network of protected areas, recognised as 'sites of Community importance' under the EC Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora). The Natura 2000 network includes two types of designated areas: Special Areas of Conservation (SAC) and Special Protection Areas (SPA).
Negative effects	Changes which are unfavourable for a receptor. Can sometimes be referred to as 'adverse'.
Offsetting	Measures to as fully as possible offset any significant adverse effects on the environment. Such measures will aim to make good for loss or damage to an environmental receptor, without directly reducing that loss/damage. Not used in relation to the Habitats Directive (see compensation, above).
One way generation	The operating mode whereby power is generated on only one phase of the tidal cycle. For Severn tidal power, one way generation is typically ebb mode.
Original scheme	The form of the scheme when it was shortlisted at the end of phase 1.
Outer Bristol Channel	The outer limit extends from St. Govans Head in Pembrokeshire to Hartland Point in Devon, which traditionally defines the lower limit of the Bristol Channel. The upper limit extends from Nash Point in Wales to the west of Minehead along the English coast.
Permanent effect	An effect which will last at least for 50 years.
Phase 1	The current stage of the STP Feasibility Study - i.e. the Decision Making Assessment Framework (to develop a short-list of options) and SEA Scoping.

Term	Definition
Phase 2	The second stage of the STP Feasibility Study - i.e. short-listed options appraisal and main assessment stage of the SEA.
Phreatic	Ground water below the static water table.
Positive effects	Changes which are favourable for a receptor. Can sometimes be referred to as 'beneficial'.
Pumping	Operating turbines in reverse to pump water from lower to higher levels. Pumping can be used during one way generation to raise impounded water levels so that more energy can be generated when the ebb tide is receding.
Ramsar site	Ramsar sites are designated under the International Convention on Wetlands of International Importance 1971 especially as Waterfowl Habitat (the Ramsar Convention).
Receptor	An entity that may be affected by direct or indirect changes to an environmental variable.
Reversible	If the timescale for a receptor's return to baseline condition is less than 50 years then it will be considered reversible.
Scoping	The process of deciding the scope and level of detail of an SEA, including the environmental effects and alternatives which need to be considered, the assessment methods to be used, and the structure and contents of the Environmental Report.
SEA objective	A statement of what is intended, specifying the desired direction of change in trends.
Seabed	The areas permanently covered by the sea, i.e. Lowest Astronomical Tide. Sometimes referred to as sub-tidal.
Seascape	The definition of seascape is taken from the Welsh Seascape Assessment – CCW 2010 – ‘An area of sea, coastline and land, as perceived by people, whose character results from the actions and interactions of land and sea, by natural and/or human factors.’
Severn Estuary	<p>This is the physical extent of the Estuary and does not reflect the Study Area (see below) or nature conservation designations.</p> <p>Downstream limit - headlands at Lavernock Point on the Welsh coast and Brean Down on the English coast passing through the small island features of Flat Holm and Steep Holm.</p> <p>Upstream limit – Haw Bridge, upstream of Gloucester on the River Severn (based on 1 in 100 year flood risk area and also used by Shoreline Management Plan (SMP) (Gifford, 1998) and Coastal Habitat Management Plan (CHaMP) (ABPmer 2006)).</p> <p>N.B. The tidal limit, which for the Severn is at Maisemore (West Parting) and Llanthony (East Parting) weirs, near Gloucester.</p>
Severn Tidal	The general study area used for the project broadly extends downstream on the

Term	Definition
Power Study Area	<p>Estuary as far as Worm's Head to Morte Point. It includes the landward fringe and tributaries such as the River Wye and the River Usk.</p> <p>Study areas for individual topics for Phase 2 may extend beyond this area and these are defined separately according to topic.</p>
Short-listed options	Options screened from long-listed options, to be taken forward for analysis in the SEA following the public consultation conducted in 2009.
Significant environmental effects	Effects on the environment which are significant in the context of a plan or programme. Criteria for assessing significance are set out in Annex II of the SEA Directive (2001/42/EC).
Site of Special Scientific Interest (SSSI)	Designated under the Wildlife and Countryside Act 1981, any land considered by Natural England to be of special interest because of any of its flora, fauna, or geological and physiographical features.
Sluice caissons	Prefabricated concrete structures placed into the water to house a sluice.
Special Area of Conservation (SAC)	Strictly protected site designated under the EC Habitats Directive 92/43/EEC. Article 3 of the Habitats Directive requires the establishment of a European network of important high-quality conservation sites that will make a significant contribution to conserving the 189 habitat types and 788 species identified in Annexes I and II of the Directive (as amended). The listed habitat types and species are those considered to be most in need of conservation at a European level (excluding birds).
Special Protection Area (SPA)	<p>Strictly protected site classified in accordance with Article 4 of the EC Directive on the Conservation of Wild Birds (79/409/EEC), also known as the Birds Directive.</p> <p>They are classified for rare and vulnerable birds, listed in Annex I to the Birds Directive, and for regularly occurring migratory species.</p>
Straflo type turbines	A more compact turbine compared to Bulb turbine technology. Instead of containing the generator in a bulb, it is located and designed for ebb only operation and not suited to pumping.
Strategic Environmental Assessment (SEA)	Term used to describe environmental assessment as applied to policies, plans and programmes. 'SEA' is used to refer to the type of environmental assessment required under the SEA Directive.
Sub tidal	Areas (particularly with reference to habitats) that lie below the level of the lowest astronomical tide.
Synergistic effects	Effects which interact to produce a total effect greater than the sum of the individual effects, so that the nature of the final impact is different to the nature of the individual effects. Included within cumulative effects (see above).
Temporary effects	An effects which only lasts part of the project lifetime, e.g. is confined to the construction period.

Term	Definition
The Shoots	The downstream boundary extends from Undy along the Welsh coast to Severn Beach along the English coast, just to the south of the M4 motorway crossing. The upstream limit extends just to the north of the M46 motorway crossing, between Beachley on the Welsh coast and Aust on the English coast.
Tidal bore	A tidal phenomenon in which the leading edge of the incoming tide forms a wave (or waves) of water that travel up a river or narrow bay against the direction of the current.
Tidal Prism	The difference between the mean high-water volume and the mean low-water volume of an estuary.
Transboundary Effects	An environmental effect upon another EU Member State
Turbine caissons	Prefabricated concrete structures placed into the water to house turbines.
TWh/year	A unit used to describe how much energy generated, sold, consumed, etc. A terawatt-hour refers to generating or using power at a capacity of 1 terawatt (1012 watts) for one hour. A terawatt-hour per year means the equivalent amount of power sometime within the period of a year.
Two way generation	The operating mode whereby power is generated on both phases of the tidal cycle (ebb and flood)
Upper Severn Estuary	Upstream from the M46 motorway crossing, between Beachley on the Welsh coast and Aust on the English coast, to the tidal limit along the River Severn at Maisemere, Gloucestershire.
Variant	A modified version of the original shortlisted scheme.

## **SECTION 9**

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