



Severn Estuary Commission Comisiwn
Aber Afon Hafren



Severn Estuary Commission

APPENDIX B

GoldSET Multi-Criteria Analysis





Western Gateway
Porth y Gorllewin

Severn Estuary Commission
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Severn Estuary Commission

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GoldSET Multi-Criteria Analysis

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1 INTRODUCTION

1.1 THE GOLDSET TOOL

- 1.1.1. The following appendix document provides a brief overview of the GoldSET© analysis conducted for the Severn Estuary Commission Environmental Consultancy Services work package.
- 1.1.2. GoldSET is an innovative, web-based set of Geographic Information System (GIS) tools that integrates a rigorous, multi-criteria analysis approach and geospatial information management with the ability to forecast project performance. It offers a simple, systematic process to help clients evaluate alternatives or monitor ongoing projects. The tool is used across the WSP Global business and provides insight into complex environmental features at an early stage of development.

1.2 GOLDSET IN THE SEVERN ESTUARY

- 1.2.1. Building on the work that has already been undertaken in the Estuary to identify environmental features and the potential locations for tidal energy schemes, GoldSET has been used to workshop, present, and agree key environmental features of the Estuary. Identifying areas of significant environmental sensitivity and supporting analysis of spatial constraints to tidal energy in the Severn.
- 1.2.2. The tool has generated a suite of outputs to support an evidence-based site selection process, taking consideration of environmental features to support engagement and understanding of options in the stakeholder workshop held on the 16th January 2025. The outputs of GoldSET supported the presentation of results for potentially viable locations of tidal energy in a visual and quickly discernible fashion.
- 1.2.3. As part of the wider reporting for which this document sits as Appendix B, these outputs are presented more methodically, yet similarly plainly interpreted to allow communication to wider stakeholders as part of the long-term vision for tidal energy in the Estuary.

1.3 METHODOLOGY

DATA LAYERS

- 1.3.1. GoldSET relies upon sourcing of GIS data layers which spatially represent environmental features, including but not limited to, Listed Buildings, National Sites Network Sites, and Flood Zones. Authoritative and industry standard data layers which represent the environmental features or constraints were collected from all specialists involved in the work package. Quality assurance was provided by the Project Management and WSP GIS teams to ensure these datasets could be integrated into the GoldSET analysis discounting any that may not have fitted the assumptions made in **Section 1.5**.

WEIGHTING

- 1.3.2. GoldSET operates as a sophisticated multi-criteria analysis tool which ranks environmental features with weightings that can be dialled in to project specific criteria. A workshop was held with technical specialists in attendance to assign weightings to the data layers collated. On a scale from 0-100 weightings for each data layer were determined based on four key criteria scored 0-25:
- Sensitivity to tidal development.
 - Challenge of compensation.



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- Consenting challenge.
- Data quality.

- 1.3.3. Each criterion was permitted a score from 0 to 25, the greater the score, the greater the challenge presented by the criterion. Two weightings were generated for each data layer, one in the context of a tidal barrage, one in the context of a tidal lagoon¹.
- 1.3.4. These weightings were applied to the GIS data and the GoldSET tool run, generating a suitability surface for both barrage and lagoon developments in the Estuary. The tool combines the environmental data layers, the weightings assigned to each feature, and the relative spatial location (overlaps/proximity/exclusion zones) to determine a suitability surface across the Estuary. These suitability surfaces (barrage and lagoon) were further analysed to provide statistics for each of the six case study projects in the context of the Estuary, alongside topic specific visualisations of suitability.

1.4 GOLDSET OUTPUTS

VISUAL REPRESENTATION OF THE ESTUARY ENVIRONMENT

- 1.4.1. Utilising the same study area as the main reporting documentation two summary suitability surfaces were generated for the Severn Estuary environment.
- 1.4.2. Figure 1-1 represents the locational suitability for a barrage development, with areas of unsuitability shown in darker blue. These areas are predominantly located nearer the coastline, where features such as archaeological heritage sites, ecologically important habitats, and key flood defence infrastructure is located.
- 1.4.3. It is therefore unsurprising the coastal environment is deemed less suitable for a tidal development in the context of a barrage development, with suitability increasing further from coastal environmentally sensitive receptors.

¹ Frequently, in consultation with technical specialists, tidal lagoon weightings scored lower than tidal barrage, reinforcing conclusions made throughout the reporting to date around lagoon developments being less impactful than barrages

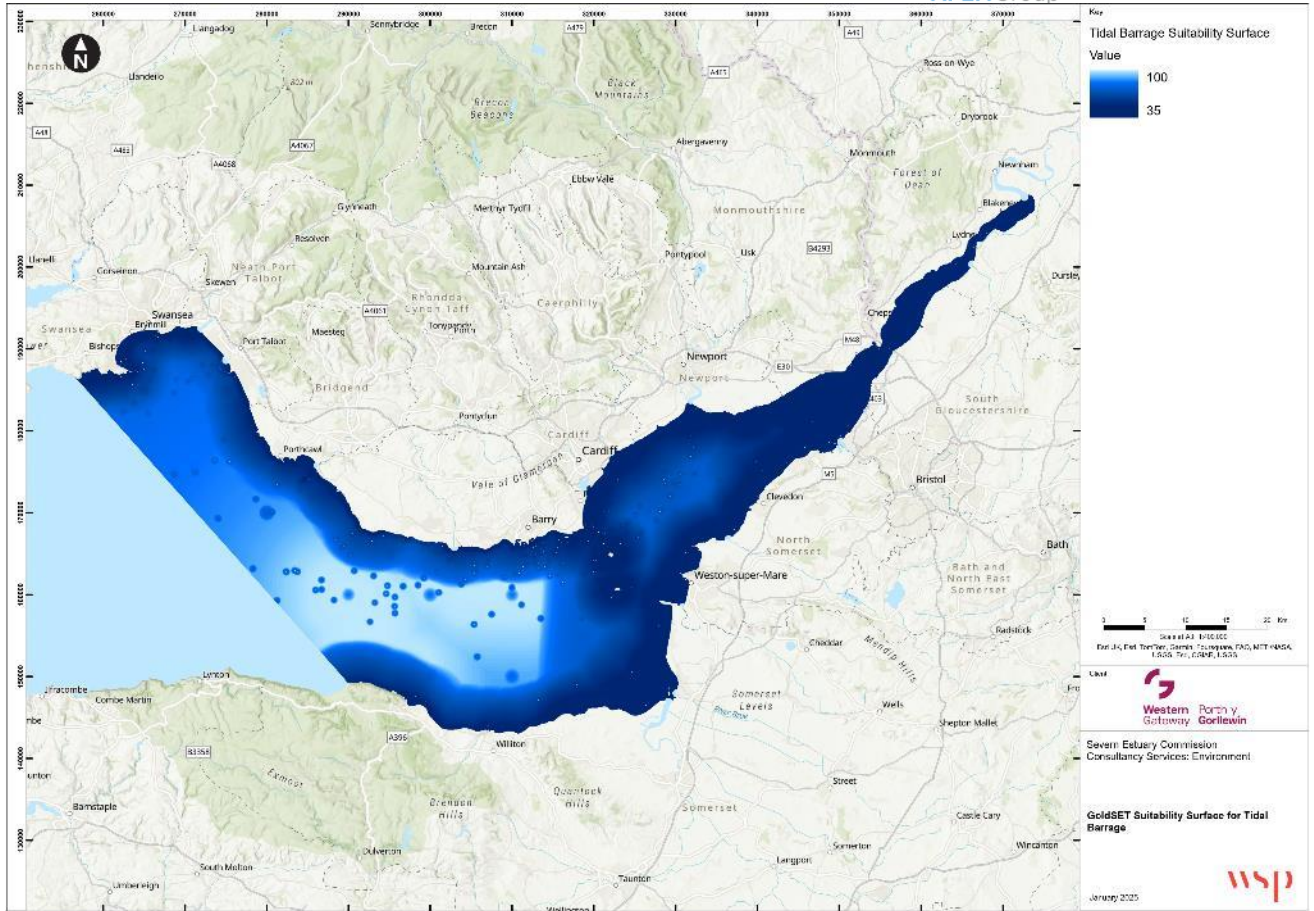


Figure 1-1 - Suitability Surface for a Tidal Barrage Project in the Severn Estuary

1.4.4. **Figure 1-2** represents the suitability surface as analysed for a lagoon type development. The similarities between both Figure 1 and Figure 2 are in part due to the direct impacts from tidal infrastructure, such as visual intrusion, noise and vibration disturbance, and direct land/sea take being broadly similar across development types. The coastal environment remains a challenging area for development of a tidal scheme in the context of environmental features due to the high relative unsuitability when considered in the context of two of the weighting criteria; sensitivity to tidal development, and challenge of compensation.

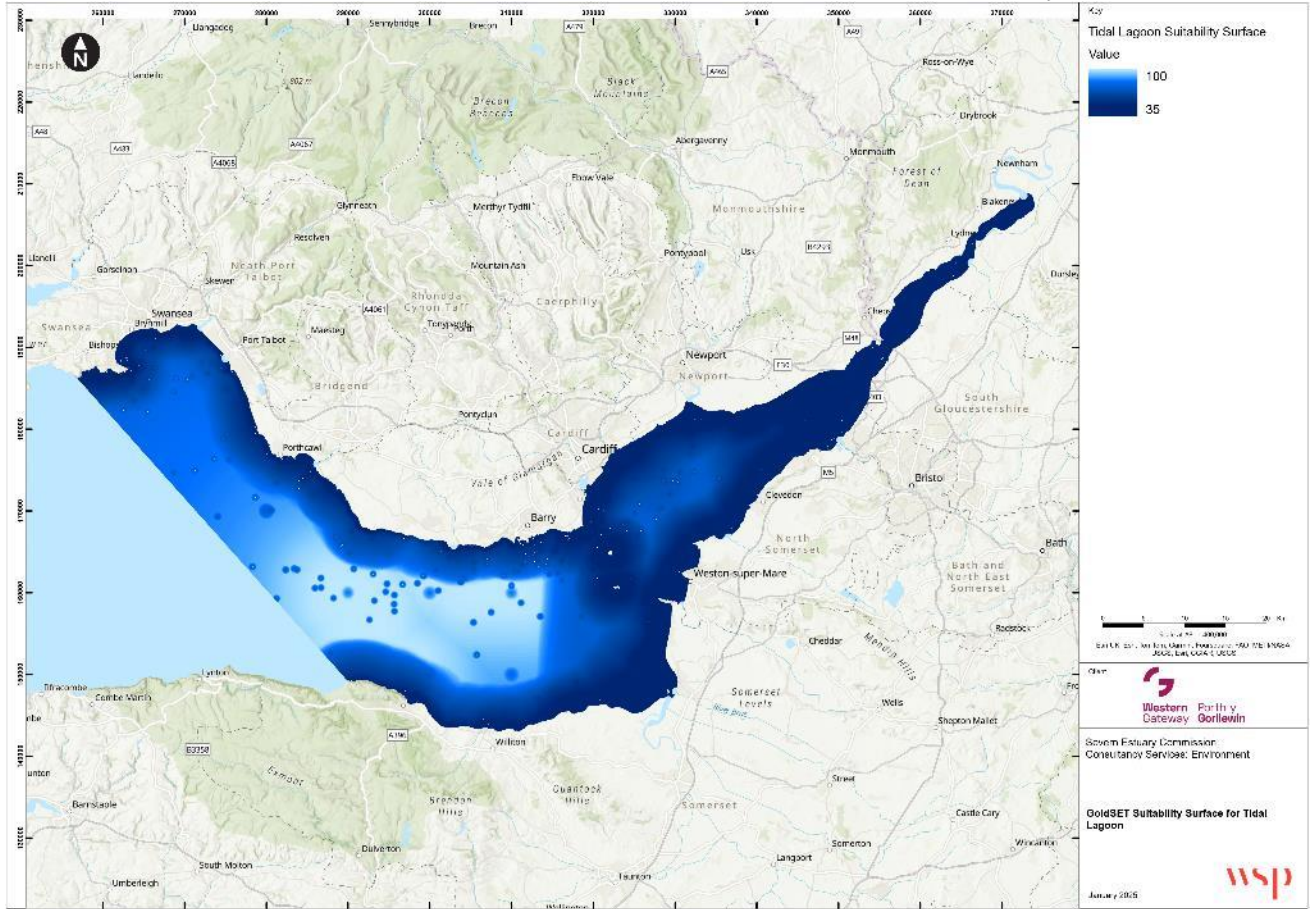


Figure 1-2 - Suitability Surface for a Tidal Lagoon Project in the Severn Estuary

- 1.4.5. Across both Figure 1 and Figure 2 the influence of intertidal habitats and the challenge of consenting is exemplified with the coastal unsuitability, however even at sporadic locations in the deep Estuary, the presence of features such as marine archaeology and potential compensation sites are identified as areas of unsuitability.
- 1.4.6. The percentage change between the two suitability surfaces was also generated to help support visual comparison between barrage and lagoon projects, and to aid with understanding the degree of change between the two.

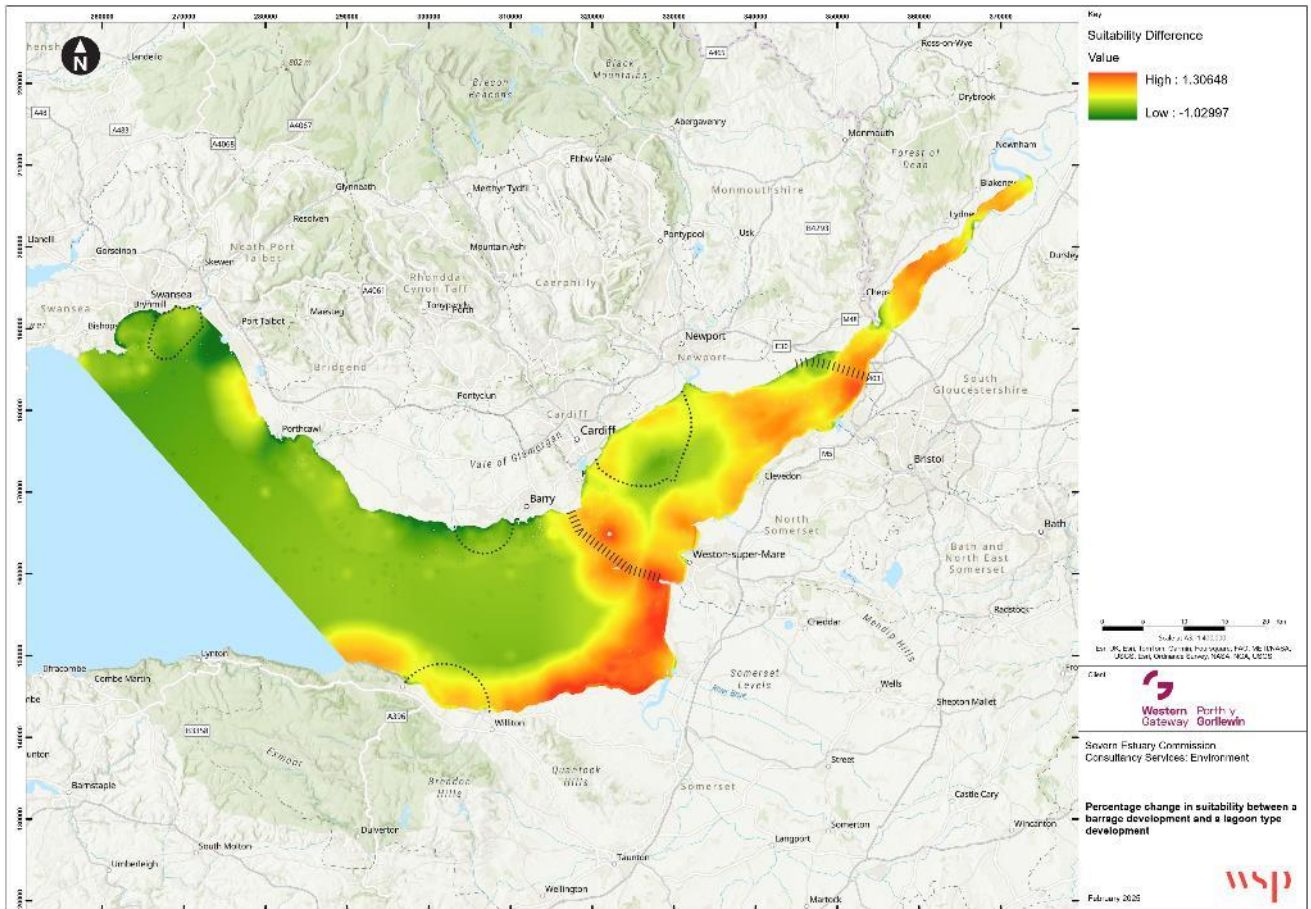


Figure 1-3 - Percentage change in suitability between a barrage development and a lagoon type development

1.4.7. **Figure 1-3** should be analysed with attention to the fact that percentage change in the suitability of less than $\pm 2\%$ is of such a small value, that changes in the underlying data are more likely to have an influence over the degree of variation between the suitability of a barrage and a lagoon project, more so than the weightings applied to each layer of data in the workshop.

INTERIM VISUALISATIONS

1.4.8. To support the interpretation of the final GoldSET suitability surfaces, four interim visualisations were produced. These figures aim to show the relative spatial influence of each topic area upon the final output suitability surfaces in Figure 1-1 and Figure 1-2.

1.4.9. Figure 1-4 illustrates the relative influence of ornithological constraints on the final suitability surfaces for the Estuary. There is a clear degree of unsuitability around the upper estuary and coastlines, which is likely contingent on the presence of intertidal habitats suitable for ornithology. The designated features of the Estuary are not represented here but are reflected in Figure 1-6.

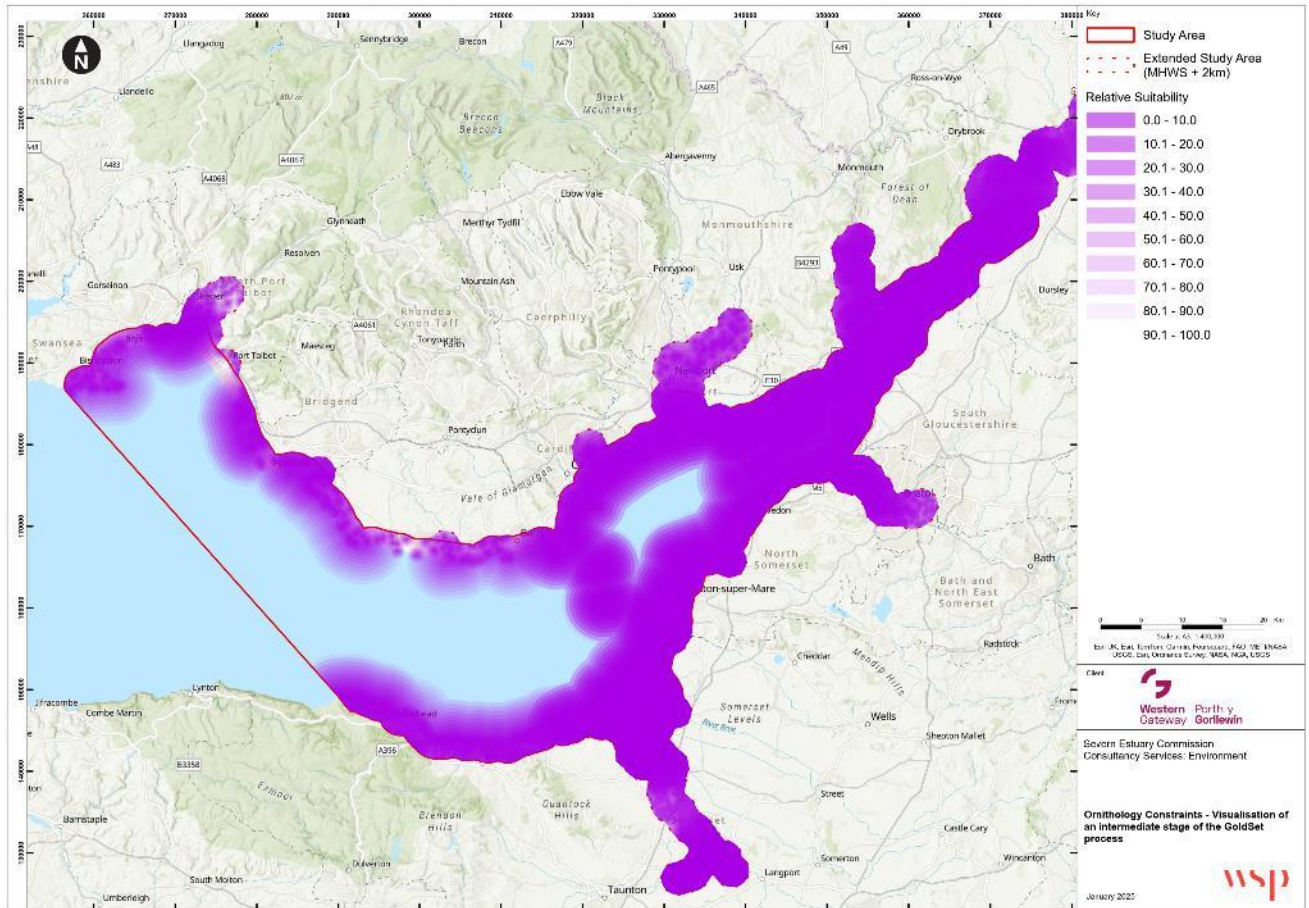


Figure 1-4 – Interim visualisation of ornithological features employed in the GoldSET process

1.4.10. Figure 1-5 illustrates the relative influence of flood risk constraints on the final suitability surfaces for the Estuary. There is a clear risk of flooding across the entirety of the Estuary, likely due to historic development of tidal floodplains. A reduced suitability is evident around urban centres, reflecting areas where impacts are likely to be more significantly experienced, should an increase in flood risk occur.

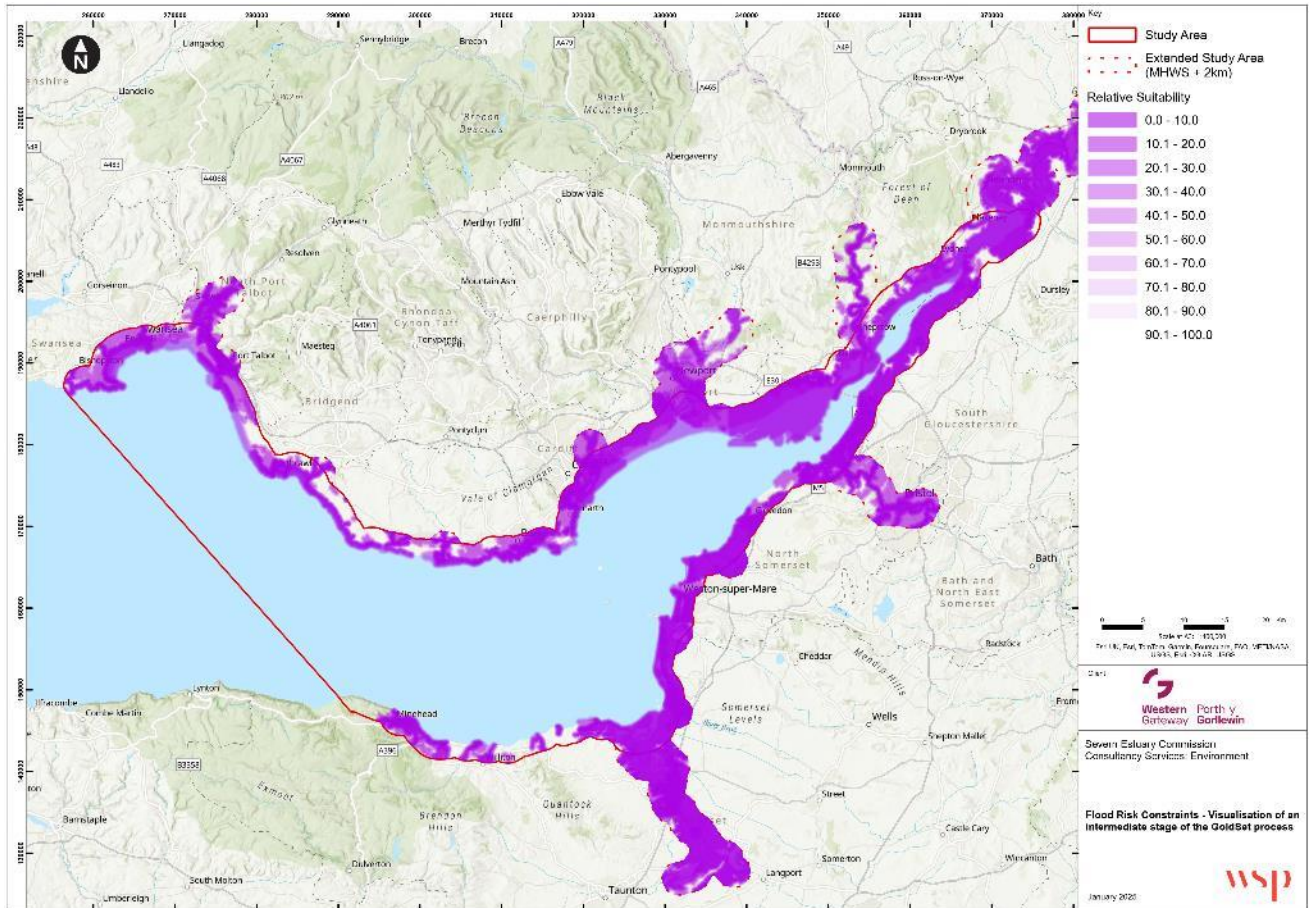


Figure 1-5 - Interim visualisation of representative flood risk features employed in the GoldSET process

1.4.11. Figure 1-6 illustrates the relative influence of fish features on the final suitability surfaces for the Estuary. Here, the influence of the Estuary’s designations is represented, marking vast swathes of the Estuary as less suitable by virtue of legal protections of internationally important and designated species and/or habitats

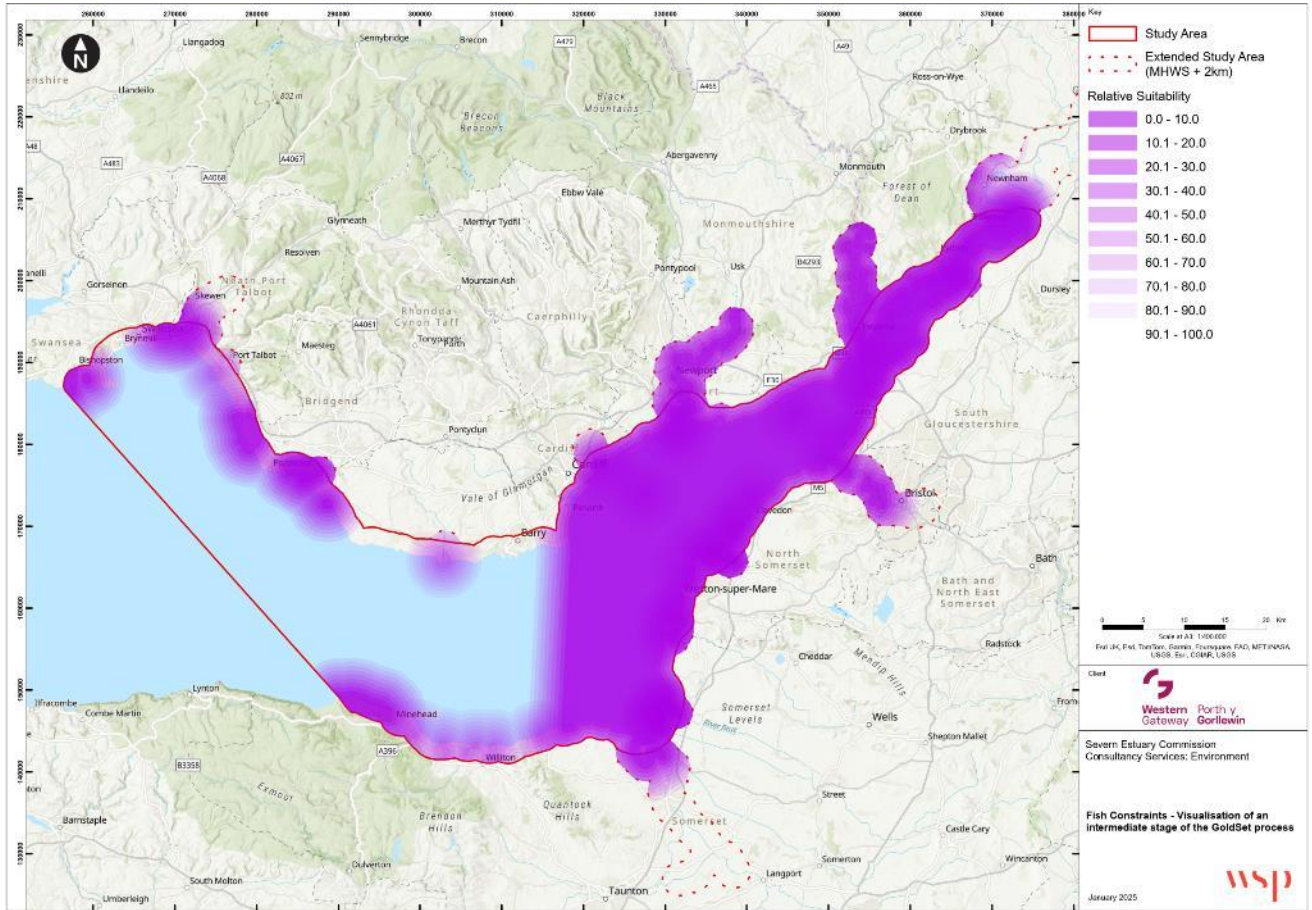


Figure 1-6 - Interim visualisation of representative fish features employed in the GoldSET process

1.4.12. Figure 1-87 illustrates the relative influence of estuarine habitat features on the final suitability surfaces for the Estuary. The presence of sensitive intertidal habitats and sites for potential compensation measures are represented here as unsuitable. These features are commonly present in the upper estuary, whilst areas of potential oyster restoration are dotted throughout the middle and lower estuary.

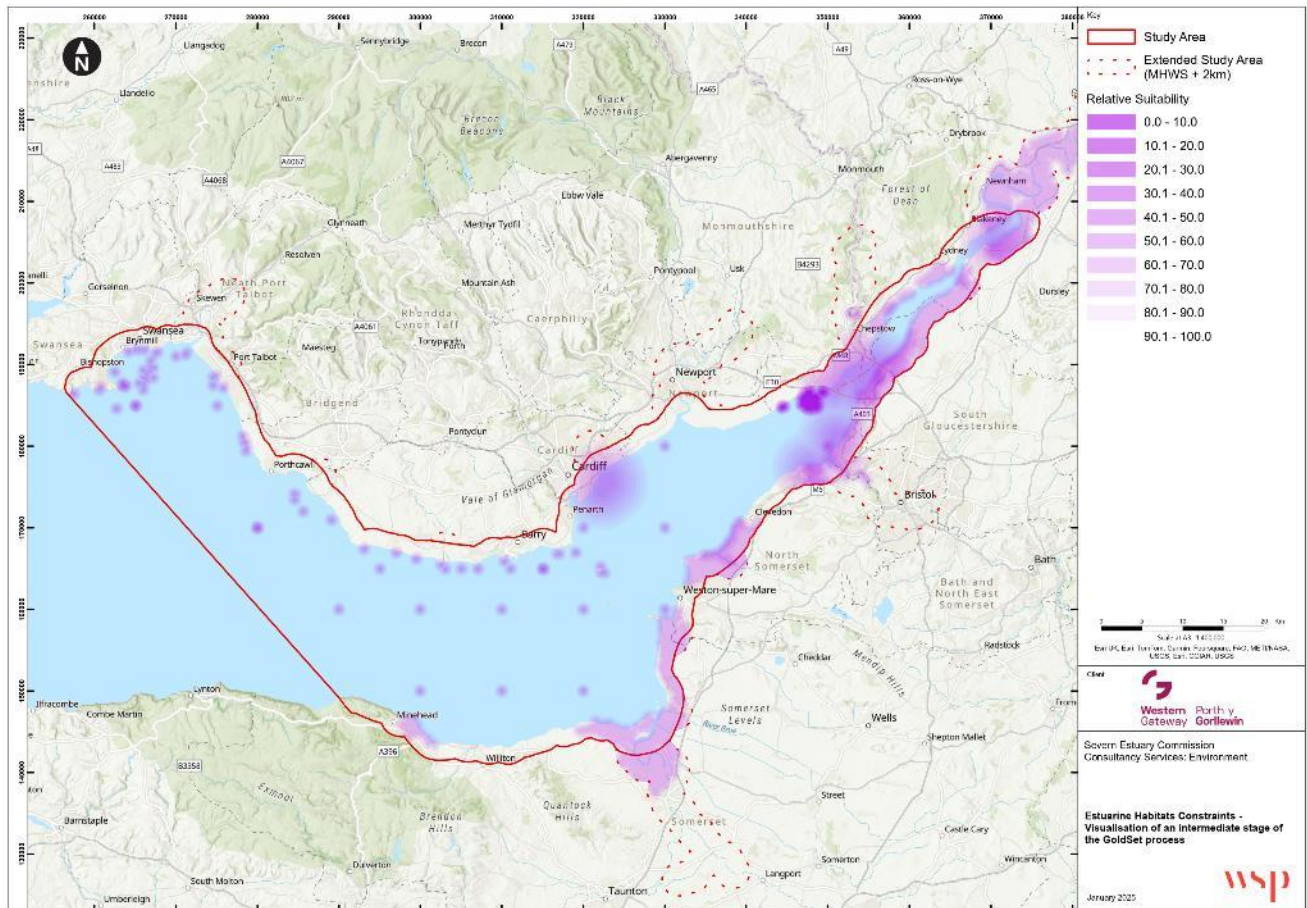


Figure 1-7 - Interim visualisation of estuarine habitat features employed in the GoldSET process

1.4.13. Figure 1-8 illustrates the relative influence of archaeology features on the final suitability surfaces for the Estuary. The coastal environment is deemed more unsuitable due to the concentration of terrestrial heritage assets in this location. Meanwhile the discrete areas of unsuitability throughout the estuary are representative of wreck sites or similar marine heritage assets.

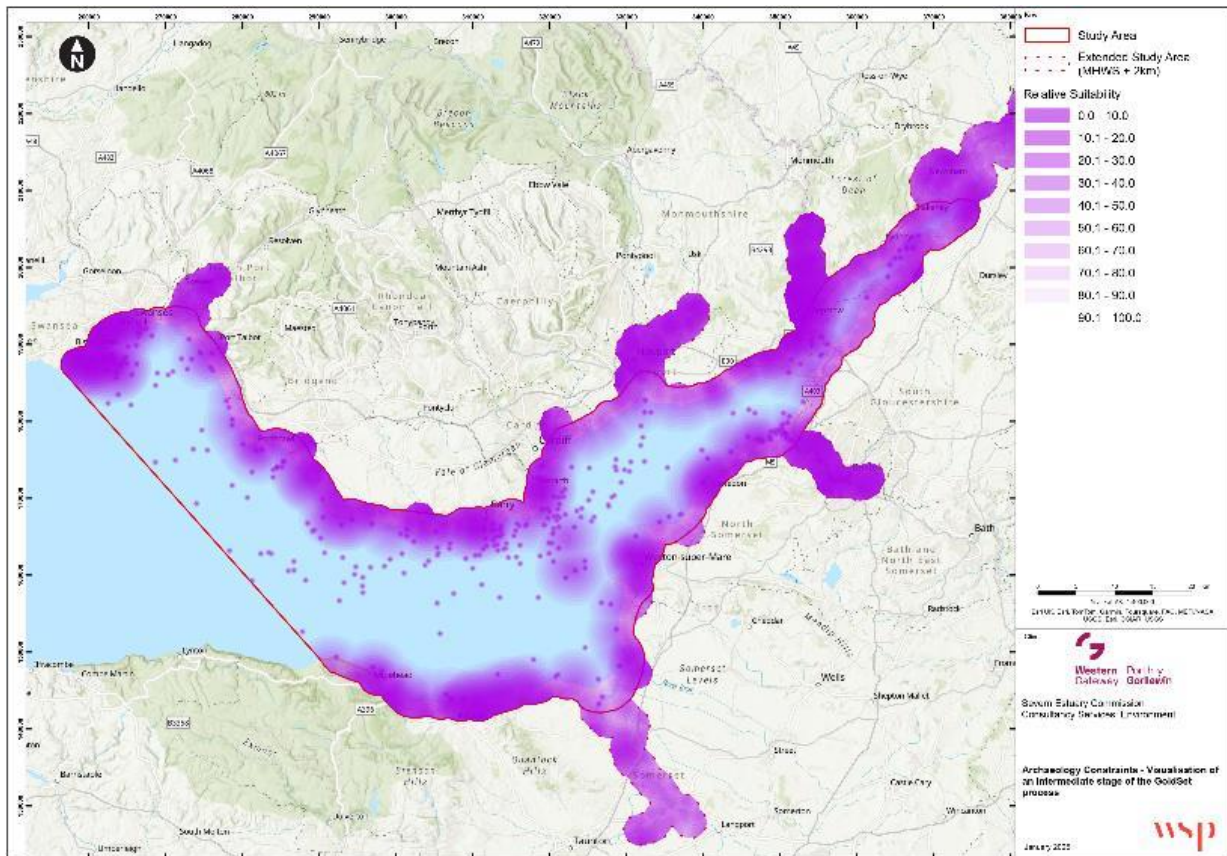


Figure 1-8 - Interim visualisation of Archaeology features employed in the GoldSET process
STATISTICAL ANALYSIS OF THE ESTUARY ENVIRONMENT

1.4.14. The statistics which underpin the GoldSET analysis were analysed for the following outputs:

- Most unsuitable development in light of environmental features of the Estuary collated in the GoldSET tool.
- Key environmental features leading to the greatest degree of unsuitability per project as determined by GoldSET.
- Proportion of project area within a direct exclusion (e.g. protected wreck site).

1.4.15. Comparison of the six case study projects against the backdrop of the barrage and lagoon suitability surfaces, analysed with respect to their development type, nominated for lagoon type developments in the Estuary, west of the internationally designated sites in the upper Estuary. The relative suitability of each is illustrated in **Figure 1-9** whereby the suitability index is presented atop each bar, the greater the score, the higher the suitability of the development.

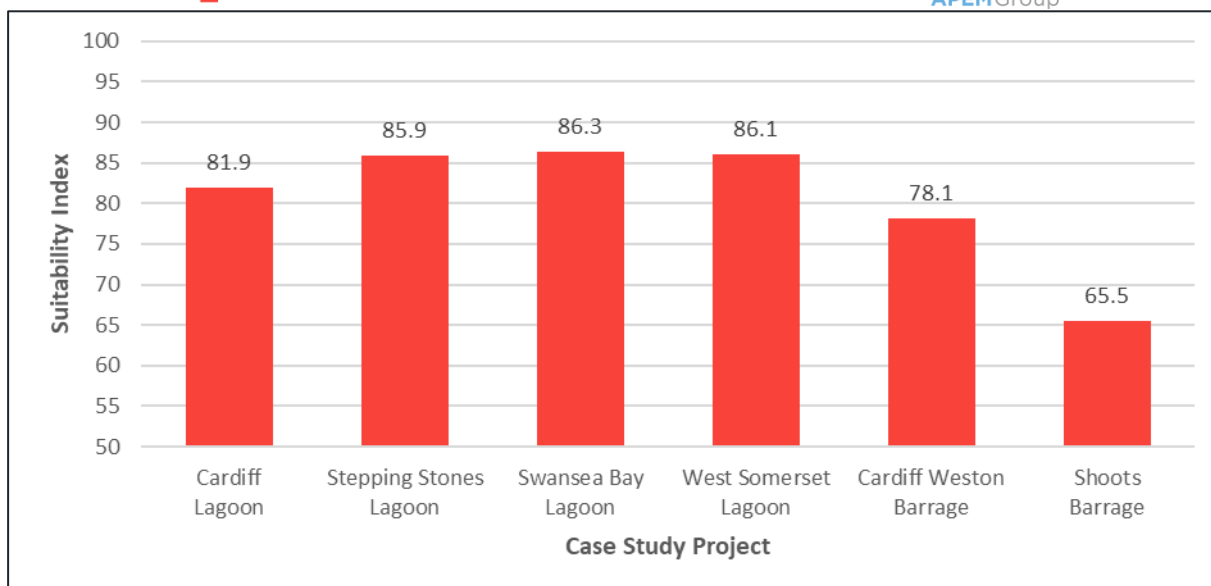


Figure 1-9 - Suitability of Case Study Projects in the Severn Estuary Environment as Analysed by GoldSET

- 1.4.16. The proposed location for Shoots Barrage in the upper estuary has been analysed to be least suitable from an environment perspective due to many factors. Principally, the presence of overlapping international and national designations in this area. The proposed location is host to the Severn Estuary Ramsar/Special Area of Conservation (SAC)/Special Protection Area (SPA) and multiple Sites of Special Scientific Interest (SSSI) amongst other local designations. Compounded with this, the proximity of the development to both north and south coastlines of the Estuary expose the development to the assumption of visual intrusion on cultural heritage assets at the coast, and terrestrial flood zones in the coastal areas of the upper estuary.
- 1.4.17. The Cardiff to Weston Barrage is subject to similar limitations due to the influence of both coastal environments, compounded with the presence of intertidal, and particularly cultural heritage assets located on and surrounding the Steep Holm and Flat Holm islands for which the barrage intersects.
- 1.4.18. In contrast the Swansea Bay Lagoon, located much further west of these international designations and subject only to one coastline's terrestrial features (due to its distance from the southern shore) scored more highly in terms of suitability. It is therefore unsurprising this location is the most progressed of all case study projects in terms of realisation of tidal energy potential in the Severn.
- 1.4.19. Analysing the limiting component of each development, that is the environmental feature which has led to the greatest degree of unsuitability, progressed the understanding of protected areas leading to the greatest challenge for a tidal development in the Severn Estuary. Table 1-1 illustrates the degree of unsuitability, on a scale of 0-100 for the most influential environmental feature on the development's suitability score. The lower the score, the greater the degree of unsuitability due to the limiting component.

Table 1-1 – Relative Suitability of Each Case Study Development and the Environmental Feature Leading to the Greatest Degree of Unsuitability (i.e. the ‘Fatal Flaw’)

Development	Limiting component	Degree of suitability (0-100)
Cardiff Lagoon	SACs	0
Stepping Stones Lagoon	Listed Buildings	38
Swansea Bay Lagoon	Annual Tidal Potential	29
West Somerset Lagoon	Sensitive Intertidal Habitats	27
Cardiff Weston Barrage	SACs	11
Shoots Barrage	SACs	0

RETROSPECTIVE ANALYSIS OF THE GOLDSET PROCESS

1.4.20. Through the GoldSET process and in consultation with specialist teams, conclusions and recommendations were able to be drawn from the data available for the Severn Estuary and limitations on analysis which were encountered. These are reflected in detail within the master reporting document with the root of the conclusion being developed through GoldSET.

- Data collated for the Severn Estuary is often siloed between nations. Therefore, an exercise of consolidating datasets to represent the entire Estuary was required. This meant combining datasets from mirror regulators such as Natural England and Natural Resources Wales, which although shared similar data, purpose and ease of access, there appeared to oftentimes be stark differences in their coverage of the intertidal environment.
- Project level data collection makes strategic assessment challenging. The granularity of data across the estuary varies, and where this data is extant in the Estuary, such as that for Wetland Bird Surveys (WeBS), significant work is required to analyse the features of each approximately 10km survey grid to construct a widespread picture of the Estuary’s features, for just one receptor.
- The workshop with subject matter experts identified the need to assess environmental features not only in isolation, but in the interrelationships between receptors. For example, a change in tidal prism affecting foraging behaviours or migratory bird species through changes in inundation of intertidal habitats. These impacts are not accurately reflected in GoldSET and a meta-analysis of the interrelationships between the datasets in the estuary to determine indirect effects not captured in the GoldSET analysis.

1.5 ASSUMPTIONS AND LIMITATIONS

1.5.1. Distilling the approximately 556km² of complex estuarine environment into one analytical process required the introduction of a range of assumptions and the outputs from the GoldSET tool should be viewed with the following in mind:

Open-Source Data

1.5.2. This iteration of GoldSET has been limited to open-source data to allow distribution of results to a wider audience. The limitation excludes the granular data frequently used at a project level for Environmental Impact Assessments, for example British Trust for Ornithology Wetland Bird Survey

data. Proxies have been included where possible, however it is suggested further iterations of the GoldSET tool and analysis for the Severn Estuary Environment look to gather, process, and filter these granular datasets, commonly used at a project level, to help support strategic level analysis of the Estuary.

Environment

- 1.5.3. The data layers included in the analysis are exclusively environmental variables, data covering variables such as economic considerations like shipping routes have not been included as they sit outside this package of work.

Expert opinion

- 1.5.4. The weightings assigned to each data layer were informed from an expert panel of industry professionals. Many of which hold Chartership status in their field. There is however an unavoidable element of human contribution to the analysis and therefore, despite best efforts to garner consensus at workshops with multiple expert contributors, the model inherently contains expert opinion.

Constraints

- 1.5.5. The data layers included in the analysis are exclusively environmental constraints and areas of unsuitability (nature designations, flood zones, listed buildings, etc.) it is suggested that further analysis be conducted to assess the influence of supporting factors such as proximity to existing infrastructure.

Snapshot

- 1.5.6. Due to limitations of the GoldSET tool, a snapshot in time has been produced for two scenarios based on currently available data up to December 2024. Any updates to data will require reanalysis.
- 1.5.7. Climate change influences on the environment of the Estuary have been discussed in the context of GoldSET but are not intentionally represented within the outputs. The influence of climate change on the Estuary has been discussed in the Master report, using GoldSET in an illustrative manner and reference point for further discussions.

Direct/Indirect Effects

- 1.5.8. The distillation of the functional linkages in the Estuary to a singular analytical technique is inherently challenging, and therefore only direct effects have been considered in detail. In the context of ecology this means direct habitat loss, direct mortality and severance/fragmentation have been considered, whilst impacts such as disturbance from noise, light, pollution and displacement have been considered as indirect effects.