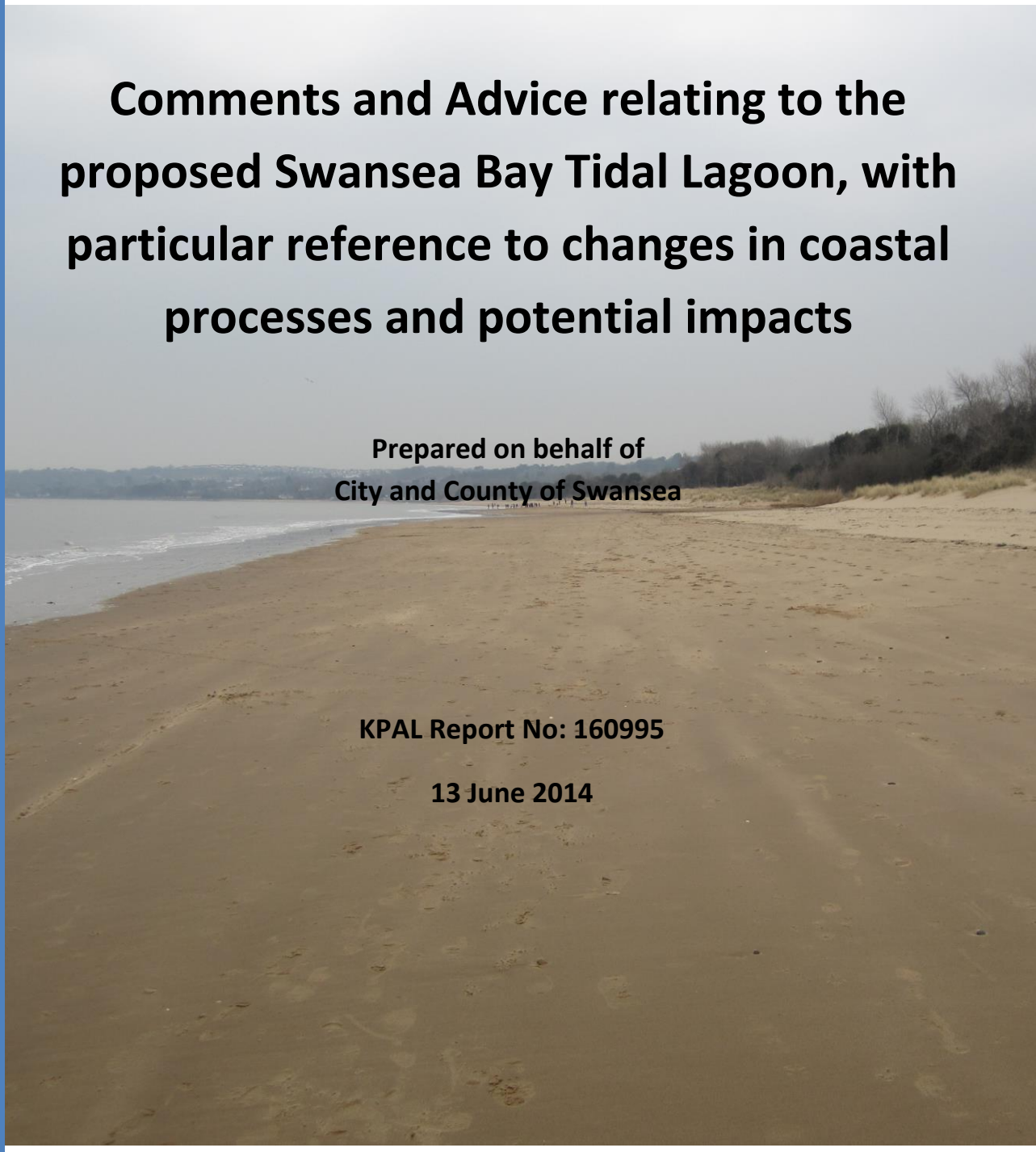

Comments and Advice relating to the proposed Swansea Bay Tidal Lagoon, with particular reference to changes in coastal processes and potential impacts

Prepared on behalf of
City and County of Swansea

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Kenneth Pye Associates Ltd.
Scientific Research, Consultancy and Investigations

Comments and Advice relating to the proposed Swansea Bay Tidal lagoon, with particular reference to changes in coastal processes and potential impacts

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13 June 2014

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SUMMARY

This report contains comments and advice to the City and County of Swansea (CCS) relating to the potential impacts of the proposed tidal lagoon development in northern Swansea Bay. Attention is given to the potential impacts of the Lagoon on coastal processes, sediment transport and rates of sediment accretion and erosion along the CCS frontage. A number of issues relating to coastal processes have been identified as being of concern to CCS, including: (a) the potential of the Lagoon to interrupt sediment supply to the recreational sandy beaches between Black Pill and West Pier; (b) the possible effect on the wind-blown sand problem which affects the promenade and Oystermouth Road; (c) possible greater mud accumulation in the shallow sub-tidal and intertidal areas of northwestern Swansea Bay which could encourage salt-marsh development, have negative impacts on the designated wildlife features of Blackpill SSSI, and adversely affect recreational use of the area; (d) possible increased dredging requirement upstream of the Tawe barrage and in the main Tawe navigation channel; (e) possible increased coastal flood risk in the Mumbles - Oystermouth area; (f) possible changes in wave conditions in the approach to Swansea Marina; (g) possible remobilization of contaminated sediments.

Confidence in the Coastal Processes, Sediment Transport and Contamination Baseline Assessment is limited by the following: (i) the background literature and data review is limited in scope, (ii) no quantitative analysis of historical maps, charts or aerial photographs has been undertaken, (iii) very limited analysis has been undertaken of existing environmental monitoring data, (iv) no geomorphological or sedimentological field studies have been reported; (v) only a limited number of intertidal and sub-tidal sediment samples has been collected and analysed for particle size and contaminants; (vi) water level, current, and suspended sediment data were collected from only two locations within the approximate lagoon footprint and only over a three month period. Confidence in the coastal processes modelling is also limited because (i) only a single suite of 2D modelling tools was used, (ii) no validation of the mud transport, sand transport or particle tracking modules has been demonstrated using observational data, (iii) the modelling has considered changes mainly at a regional scale and does not capture the details of processes and morphological changes on the beaches and in shallow intertidal areas; (iv) the wave modelling has concentrated almost exclusively on possible changes in wave height around the Bay, (v) the details of wave breaking, refraction and wave-generated sediment transport have not been modelled in detail, and (vi) only a very limited number of present and possible future scenarios have been modelled.

In order to minimise risks associated with uncertainties arising from the EIA it is recommended that a detailed monitoring, mitigation and remediation programme should be developed if a DCO is granted. This should include further detailed baseline studies as a precursor for further monitoring and the definition of ‘trigger’ thresholds for mitigation / remedial action.

1.0 REPORT SCOPE AND PURPOSE

1.1 This report contains comments and advice to the City and County of Swansea (CCS) relating to the potential impacts of the proposed tidal lagoon development in northern Swansea Bay (Figure 1). Particular attention is given to the potential impacts of the Lagoon on coastal processes, sediment transport and rates of sediment accretion and erosion along the CCS frontage.

1.2 The comments and advice presented below are based on an appraisal of chapters contained within the Tidal Lagoon Swansea Bay (TLSB) Environmental Statement (ES) which forms part of the Development Consent Order (DCO) application, information contained in a number of supplementary reports which have been made publically available by the Developer during the consultation process, and a review of previous scientific investigations, publications and environmental monitoring data relating to Swansea Bay.

1.3 Key components of the ES which are relevant to this appraisal are:

- TLSB ES Chapter 6. Coastal Processes, Sediment Transport and Contamination (prepared by ABPMer)
- Appendix 6.1: Swansea Bay Tidal Lagoon Coastal Processes: Model Setup, Calibration and Validation, ABPMer Report R.2108TN, December 2013
- Appendix 6.2 Model Bathymetry Review, ABPMer Report R2220TN, February 2014
- Appendix 6.3 Summary of results from contamination and PSA analyses (data supplied by Titan Environmental Surveys Ltd)
- Appendix 6.4 Summary of model run scenarios for Coastal Processes EIA (prepared by ABPmer)

1.4 Issues relating to coastal processes which have been identified as being of concern to CCS include:

- The potential of the tidal Lagoon to interrupt the supply of sediment to the sandy beaches to the west of the River Tawe; the compositional condition and visual appearance of these beaches are of vital recreational and amenity importance to the local population and contribute significantly to the overall attractiveness of Swansea as a destination for leisure and business visitors, longer stay tourists and University students. Many of the objectives and actions identified within the Swansea Bay Strategy (CCS, 2008) and the Environment Management Plan Pre-consultation draft

document depend on maintaining the quality of the existing beach features and overall seascape (Commons Vision 2012; Trawscoed Ltd & Commons Vision, 2012).

- The effect of a possible reduction in sand supply on long-term beach levels and the ability of the sand dune systems in northwest Swansea Bay to recover following storm events; this could have implications for coastal flood risk as well as net loss of sand dune habitat and recreational beach area.

- The likely effect of the Lagoon development on the wind-blown sand problem which currently affects the promenade and coastal road between the Civic Centre and Bryn Mill Lane (Figure 1).

- The potential impact of the Lagoon to cause greater mud deposition / accumulation in the shallow sub-tidal and intertidal areas, possibly leading to more extensive salt-marsh development in the medium term, which would have potentially negative implications for the existing habitats and biota, visual landscape and recreational use of the area.

- The possibility that construction of the Lagoon will lead to increased sediment dredging requirements upstream of the Tawe barrage, as well downstream in the main Tawe navigation channel (CCS has a Parliamentary obligation to dredge the impoundment).

- The magnitude of changes in flood risk arising from greater wave heights around some parts of the Bay (the ES suggests increases in wave heights, notably in the Mumbles - Oystermouth area, mainly from wave reflection off the Lagoon walls).

- The effect of possible changes in wave height / energy on recreational navigation in the approach to Swansea Marina, and on the potential for local sediment erosion adjacent to the western wall of the Lagoon.

- The potential risk of remobilization of contaminated sediments during, and following, Lagoon construction, and possible implications for sediment and water quality on the recreational beaches.

- The adequacy of the Coastal Processes Baseline Assessment undertaken for the EIA.

- The adequacy of the modelling undertaken as part of the EIA relevant to the above questions.

- Requirements for monitoring and mitigation measures which might be paid for by the Developer if the development is consented, including requirements for the specification of change thresholds for action.

2.0 SEDIMENT SUPPLY TO RECREATIONAL BEACHES

2.1 As stated in the Coastal Processes chapter (Chapter 6) of the ES, construction of the lagoon would effectively divide northern Swansea Bay into two separate hydrodynamic and sediment transport cells, one to east and one to the west of the lagoon structure. This is anticipated by ABPmer to have two main effects: (1) it would interfere with the anticlockwise residual current in northwest Swansea Bay which is capable of transporting suspended mud, and (2) it would prevent episodic storm-generated littoral transport of sand from north-eastern Swansea Bay towards the west, potentially cutting off the supply of sand to the recreationally important beaches between the West Pier and Singleton Park.

2.2 No results of sand transport modelling are presented in the ES to support this conclusion. Figure 6.15 of the ES shows postulated sand transport pathways in Swansea Bay based largely on previous work summarised in Collins *et al*. (1979). It shows (probably episodic) tidal current transport from the nearshore area off Crymlyn Burrows, across the proposed Lagoon footprint area, towards the anticlockwise tidal eddy in northwest Swansea Bay. However, there is very little empirical evidence to suggest that this pathway is significant for the transport of sand; as reported by Collins *et al*. (1979) and Collins & Banner (1980), tidal current velocities in northern Swansea Bay are too low to entrain sediment from the bed and can only transport fine grained sediment (mud and very fine sand) in suspension. Waves and wave-induced currents are more important for the entrainment and transport of sand across the Bay.

2.3 The main source of sand is provided by sources external to the Bay, and south-westerly storm waves, combined with the flood tide, play an important role in transporting sand south of Mumbles Head towards the northern and eastern parts of the Bay. The geomorphological evidence from shoreline features demonstrates that the dominant (net) direction of littoral sand transport along the entire shore of Swansea Bay between Oystermouth and the Neath estuary is easterly. No specific modelling of littoral sediment transport has been undertaken in the ES.

2.4 There is no reason to expect that the construction of the Lagoon will change the rate of sand supply from the southwest into Swansea Bay, although this has not been demonstrated in the ES by modelling using the Mike 21 Sand Transport module. However, retention (accumulation) of sand in northwestern Swansea Bay may be made more likely due to a predicted reduction in both significant wave height (and hence wave energy) (Figures 6.45, 6.46, 6.47, 6.48, 6.49) and tidal current speeds (e.g. Figure 6.34).

2.5 Sediment transport in the shallow sub-tidal and intertidal areas of northwestern Swansea Bay is complex. Aerial photographs taken since 1945 show indicate a

complex pattern of sand-waves which experiences significant change on annual to decadal timescales (Figure 2). No analysis of the importance of these features in onshore - offshore alongshore sand transport has been undertaken as part of the ES. No attempt has been made to construct a sediment budget for northwestern Swansea Bay, or to document net gains or losses of sediment using historical beach profile data or aerial photogrammetry. However, it is clear from a qualitative comparison of the aerial photographs and beach survey data that there have been periods when there has been a more or less continuous cover of mainly sandy sediment across the north-western part of the Bay, and others when the sand has been concentrated into discrete sand wave features separated by exposures of early to mid Holocene-age muds and peat. The width and elevation of the upper sandy beach between Black Pill and the Civic Centre has also varied in response to variations in wind and wave conditions. The period between 2000 and 2013 was one of relatively few storms and during this period there was a net movement of sand from the shallow sub-tidal areas and mid intertidal zone towards the higher intertidal zone. By 2005/6 a very large quantity of sand had accumulated on the upper beaches, giving rise to significant problems of windblown sand incursion onto the promenade and Oystermouth Road (see below). The problem has continued until the winter of 2013/14, when a series of severe storms caused significant upper beach and frontal dune erosion and transfer of sand back to the mid / lower intertidal zone (Pye & Blott, 2012, 2014a,b). However, since the 1970s there has been significant net accretion of littoral sand in northwestern Swansea Bay between the south side of Black Pill and West Pier with the exception of the Civic Centre frontage which lies seaward of the general shoreline alignment (see comparison of beach profiles in Figure 6).

2.6 On the basis of the available evidence, it appears unlikely that the supply of sand to the recreational beaches would be significantly reduced as a result of construction of the Lagoon. The net effect is more likely to increase the retention of sand brought into this part of the Bay (mainly by wave processes) and to reduce the severity of upper beach erosion during storms between St. Helens and West Pier due to the shelter provided by the Lagoon (especially from southeasterly waves).

3.0 RESILIENCE OF SAND DUNES AND IMPLICATIONS FOR COAST PROTECTION AND FLOOD RISK MANAGEMENT

3.1 Events during the stormy winter of 2013-14 demonstrated the importance of dunes as a reservoir of sand which is available to release sand to the beaches during storms, and in preventing direct wave attack on the sea wall behind (Pye & Blott, 2014b). Any increase in the frequency / magnitude of dune erosion would potentially diminish this role and increase the risk of storm damage to the sea wall and infrastructure behind. However, as noted in section 2.0, a consideration of the evidence suggests

that the effect of Lagoon construction would be to reduce wave heights, encourage sandy sediment retention on the beach, and reduce the risk of serious dune erosion between St Helens and West Pier. The 'protective' effect of the Lagoon would decrease westward, especially for southeasterly waves, with probably no net change in the vicinity of Black Pill.

4.0 WIND-BLOWN SAND HAZARD

4.1 If, as anticipated, there is a medium to longer term increase in total sand volume in the intertidal and supra-tidal areas between St Helens and the Civic Centre, the existing problem of wind-blown sand incursion onto the promenade, Oystermouth Road and into the Civic Centre west car park (Pye & Blott, 2012, 2014a,b) is likely to become worse. This would potentially result in increased maintenance costs associated with removal and disposal of sand from the promenade, road and car park, and increase the safety risk to pedestrians, cyclists and motorists.

4.2 Near Swansea Point, adjacent to the West Pier, the existence of a fairly wide belt of sand dunes should prevent any additional sand blowing on to the promenade and into properties, provided that the recent improvements to sand fencing and visitor management are maintained (for more detailed information see Phillips, 2014).

5.0 INTERTIDAL MUD-DEPOSITION AND POSSIBLE SALTMARSH DEVELOPMENT

5.1 The coastal processes modelling with the Lagoon in place has suggested increased mud deposition in parts of northwestern Swansea Bay, predominantly within shallow sub-tidal area adjacent to Blackpill SSSI, and to a lesser extent across the adjoining intertidal zone including the mid foreshore seaward of the recreational beaches between St. Helens and West Pier (ES Figure 6.50 , 6.52). The predicted reductions in high tide levels (e.g. ES Figure 6.42), current speeds (e.g. 6.34) and wave heights (e.g. Figure 6.45) suggest that there is a significant risk of increased mud deposition and accumulation across a much wider area, especially within the sheltered areas leeward of the higher intertidal sand bars.

5.2 The effect of increased mud deposition would be to restrict the mobility of the sand bars if mud drapes are formed on the bars and/ or the movement of sand across the surfaces between the bars is reduced a exposures of 'hard' peat and consolidated mid Holocene muds become progressively buried by new mud deposits. Such changes could have implications for the in-fauna and birds as well as affecting the exchange of sand between the upper beach and the lower sub-tidal areas.

5.3 The increased deposition of both sand and mud, together with slight reduction in high tidal levels, indicated by the ES modelling, implies a progressive reduction in average water depths and reduction in wave and current energy which will increase sediment accretion by positive feedback. If upper foreshore levels rise sufficiently and wave action is reduced, saltmarsh vegetation will become established, leading to a further acceleration in mud accretion rates. This would change the visual appearance of the shore and potential affect recreational usage. The extent of the existing saltmarsh elevation 'window' is shown in Figure 3. This could increase significantly in the medium term following Lagoon construction.

5.4 Considerable time and effort has been spent in the past to prevent the development of *Spartina* marsh in the western part of the Bay, involving spraying, pulling and bull-dozing of pioneer vegetation, and such measures could be required again in the future. These historical problems have not been considered in the Coastal Processes Baseline Assessment and the possibility that similar action in the future may be required following construction of the Lagoon have not been recognized.

6.0 DREDGING REQUIREMENT IN THE TAWE IMPOUNDMENT

6.1 The ES modelling with the Lagoon in place has indicated higher rates of mud deposition within the approach channel to Swansea Docks during 10 in 1 year and 1 in 20 year storm events, and it is estimated that there will be a mean increase in dredging requirement of 52 x 10^3 m^3, or 27%, annually). Mud accretion along parts of the eastern wall of the Lagoon wall where tidal energy would be reduced is also indicated by the modelling.

6.2 Figures 6.50 - 6.52 of the ES show no increase in mud deposition in the innermost part of the Tawe channel immediately downstream of the Tawe Barrage. However, the ES model domain does not extend upstream to include the areas on both sides of the barrage, and contains no specific assessment of potential changes in sedimentation within the impoundment.

6.3 The barrage structure, completed in 1992, includes a boat lock, spillway, fish pass and generator turbine, is designed to allow overflow at the approximate level of mean high water in Swansea Bay (c. 3.4 m OD). Tidal overtopping of the barrage therefore occurs on spring tides, allowing ingress of marine sediment carried in suspension. The majority of sediment transported into the impoundment is likely to settle out and require periodic removal by dredging. The magnitude of the sediment carried into the impoundment, and of any likely change in dredging requirement following Lagoon construction, has not be quantified in the ES coastal process modelling. However,

there is a significant possibility that some of the fine sand and mud released into the water column during the construction phase could be transported over the Tawe barrage on spring tides and become trapped within the impoundment. Longer-term increases in sediment accumulation are also possible and should be monitored.

7.0 WAVE HEIGHTS, TIDE - RIVER FLOW INTERACTION AND FLOOD RISK

7.1 The analysis of the potential impact of the Lagoon on wave heights undertaken by ABPMer indicated a potential increase in water levels with the Lagoon present of 0.1 to 0.23 m on the western side of Swansea Bay, with the largest increases between Mumbles and Oystermouth (Hydrology and Flood Risk, Chapter 17, p36 of the ES; also ABPmer, 2013d). This will lead to an increased risk of overtopping and flooding in this area, which is backed by areas of low-lying land (Figures 4 & 5).

7.2 It was concluded from the analysis that, since the biggest waves on the Swansea Bay waterfront originate from a southeasterly direction, construction of the Lagoon will provide a measure of shelter and lead to no increased flood risk along this frontage. However, Figure 17.7 of the ES shows that the Lagoon structure only provides shelter from waves from an easterly direction; there is effectively unbroken fetch from southeasterly to south-southwesterly directions. No modelling of waves from the SSW to SSE has been undertaken.

7.3 Paragraph 6.5.2.32 reports that consideration has been given to extreme waves under conditions of a 1.5 m surge on top of a MHWS tide. It is reported that for Point 8 on the Mumbles frontage there is an increase in significant wave height of 0.19 m compared with an increase of 0.17 m for the without-surge case. A consideration of the effects of sea level rise based on the UKCP09 medium emissions scenario 95th % model output value indicated an increase of 0.18 m compared with 0.17 m for the without sea-level rise case. The additional water depth associated with surges and sea level rise is therefore predicted by the modelling to have a relatively minor effect.

7.4 The overall conclusion to be drawn from this assessment is that there is likely to be an increase in tidal flooding risk as a result of the Lagoon construction, albeit relatively small.

7.5 Any increase in wave heights along parts of the shore of northwestern Swansea Bay where there is no high tide beach or dunes is also likely to increase the risk of wave reflection from the sea defences and to create increased risk of beach lowering by toe scour.

7.6 No specific assessment is provided in the ES of potential interactions between high tides, surges, waves and high flows from the River Tawe. The Tawe barrage is overtopped by tides which reach above mean high water level (c. 3.4 m OD). Potential increases in the still water levels or wave heights in the Tawe Channel, adjacent to the western arm of the lagoon, could potentially increase the frequency and/ or duration of overtopping of the barrage, or could impede the discharge of Tawe floodwater to the sea. Potential implications for the Lower Swansea Valley Flood Risk Management Scheme have not been explored by the ES hydrodynamic and wave modelling.

7.7 The ES Baseline Assessment contains no detailed analysis of severe historical floods of the Tawe, or modelling of the likely behaviour of water levels arising from interaction of tides, waves and river floods of magnitudes similar to those in 1929 and 1979 (e.g. Walsh, 1982).

8.0 RECREATIONAL NAVIGATION

8.1 ES Tables 6.15 and 6.16 summarise the changes in significant wave height and wave period for 10 in 1 year, 1 in 1 year, 1 in 10 year and 1 in 20 year waves approaching from the southwest at ten locations in Swansea Bay. Point location 2 relates to the seaward end of the Tawe navigation channel close to the southwestern corner of the Lagoon (position shown on ES Figure 6.44). These tables show an increase in significant wave height at Point 2 of between 8 and 12 cm. The predicted increases in wave period range from 0.11 to 0.15 seconds.

8.2 ES Table 6.17 presents values for changes in significant wave height and period at the same locations for 10 in 1 year and 1 in 10 year waves approaching from the southeast. A reduction in significant wave height of between 3 and 7 cm, and an associated increase in wave period of 0.07 to 0.16 seconds, is predicted at Point 2 due to the sheltering effect of the Lagoon.

8.3 No modelling results are presented for locations further up the navigation channel, and no modelling of waves approaching from a south-southwesterly direction, parallel to the axis of the navigation channel, has been undertaken. The possibility of complex wave interaction, arising from reflection, deflection and refraction of waves off the western wall of the Lagoon and/or the West Pier, has not been considered. However, from the results presented it is likely that small recreational vessels will encounter larger head-waves when navigating the Tawe entrance channel towards the open sea.

9.0 REMOBILIZATION OF CONTAMINATED SEDIMENTS

9.1 The ES concludes that there will be no significant risk of contaminant remobilization associated with dredging of sediment for construction of the Lagoon since none of the samples analyzed exceeds Cefas action level 2 for any specific contaminant (paragraph 6.4.4.5 of Chapter 6). However, this conclusion is based on the collection and analysis of a very limited number of sediment samples, most from the surface or shallow depth and largely excluding the intertidal areas of the Bay (see Figure 6.16 of the Coastal Processes Chapter, Figure 4.7b of the Marine Ecology chapter, and Figure 7 of this report). As noted in paragraph 6.4.4.1 of the ES Chapter 6, "Across the wider Swansea Bay region, and specifically within the footprint of the proposed Lagoon, there is a general paucity of historic sediment quality data".

9.2 ES Appendix 6.3 provides a summary of the particle size analysis and contaminant analysis performed on sediment samples collected during the sub-tidal benthic survey and the geotechnical investigation (Atkins, 2013; Titan 2012b, 2013a,b; EGS, 2013). The total number of samples analysed for particle size and composition is very small for a project of this scale and does not give a comprehensive picture of the surface or sub-surface sediment character in the northern part of Swansea Bay. No sampling or analysis has been undertaken in the intertidal and supra-tidal areas of northwestern Swansea Bay and only very limited sampling in the northern part of the Bay which will be directly impacted by the Lagoon construction.

9.3 No investigation has been carried out of the thickness of superficial sediment in these areas, or the sedimentary characteristics and chemical composition of older sediments which underlie them. A comprehensive baseline survey of sedimentary facies and contaminant levels in the surface and sub-surface sediments across northern Swansea Bay has not been undertaken, and uncertainty therefore remains regarding the potential for release and redistribution of contaminants outside the sampled areas.

10.0 ADEQUACY OF THE BASELINE ASSESSMENT

10.1 The Coastal Processes, Sediment Transport and Contamination Baseline Assessment displays the following limitations:

- Limited scope of literature review – no detailed consideration given to previous research projects such as those carried out by the Institute of Oceanographic Sciences Sker Project (e.g. Heathershaw *et al.*, 1980, 1981) and Swansea University (e.g. Collins, *et al*., 1979, 1980; Collins & Banner 1980) and more recently by SEACAMS).

- No detailed quantitative analysis undertaken of historical maps, charts or aerial photographs; no attempt made to quantify historical sediment volume or sea bed level changes in different parts of the Bay.

- Very limited analysis and use made of existing environmental monitoring data - e.g:
  - Tidal and mean sea level data for Mumbles held by the National Tidal and Sea Level Facility (NTSLF) and the Permanent Service for Mean Sea Level (PSMSL)
  - wind data for Mumbles available from Met Office
  - LiDAR data available from the Environment Agency (EA) Geomatics Group
  - Recent dredging data relating to Port of Swansea, Port Talbot, Port of Neath
  - Swansea Bay and Carmarthen Bay Coastal Engineering Groups (SBCBEG) intertidal profile monitoring data for the period 1998-2013.

- No detailed field studies have been undertaken from a geomorphological or sedimentological perspective.

- No intertidal sediment samples have been collected or analysed for particle size or levels of contaminants

- No measurements made of sediment thickness / lithostratigraphy (e.g. from shallow geophysics or boreholes).

- Only a limited number of sub-tidal sediment samples has been collected and analysed; the number and spatial distribution are inadequate to allow Sediment Trend Analysis (STA) or detailed mapping of sedimentary facies.

- Metocean data (water levels, currents, limited suspended sediment concentrations) were collected by Titan Environmental Surveys (2012a) from only two locations (both within the approximate lagoon footprint) and for a short time period (3 months between 16 February and 16 May, 2012); while the data are adequate for model calibration and validation purposes (as reported by ABPMer 2013a), they do not give a full picture of the range of conditions experienced in Swansea Bay. The measurement period included a significant period of time when conditions were dominated by high pressure and northeasterly winds. No long-term wave buoy deployment was used to provide data about wave conditions within the northwestern, northern and northeastern parts of the Bay.

11.0 ADEQUACY OF THE COASTAL PROCESSES MODELLING

11.1 The coastal processes, sediment transport and contamination modelling also has a number of limitations:

- Modelling has been restricted to use of a single suite of 2D modelling tools, mainly DHI Mike 21-FM-HD (Flexible Mesh Hydrodynamic model) and Mike 21 FM-SW (Flexible Mesh Spectral Waves model; these are widely used and highly respected models but are applicable only to modelling of change over relatively short time periods; they do not include process - sediment transport - bedform feedbacks and the Mike 21 FM-HD model only provides depth-averaged current velocities and suspended sediment concentrations.

- The discussions of the hydrodynamic and wave models provided in Appendix 6.1 are brief and lack detail. Some further information relating to the hydrodynamic and wave modelling is provided in a report by ABPmer (2013a), but there is no discussion of the DHI Mike 21 mud module, sand module or particle tracking module in any of the presented documents.

- No validation of mud transport, sand transport or particle tracking modules has been undertaken using observational data.

- No results for sand transport modelling are presented in the ES, even though much of Swansea Bay is sand-dominated.

- The modelling has considered changes mainly at a regional scale; the models do not capture the details of processes, sediment transport and morphological changes in shallow sub-tidal and intertidal areas.

- Although the short-term hydrodynamic, wave and sediment modelling, undertaken is adequate for the assessment of regional scale changes in water levels, depth-averaged currents and broad scale patterns of likely sediment erosion and accretion, it cannot resolve the detailed patterns of wave - current interaction and sediment movement in the intertidal and shallow sub-tidal areas which are critical for the understanding of likely impacts on the morphology and sedimentary character of receptors

- The ES contains no specific consideration of surface zone processes and littoral sediment transport.

- Appendix 6.4 provides a convenient summary, in tabular form, of all the model runs undertaken as part of the Coastal Processes assessment. Nine model runs were performed using the Mike 21 FM-HD (hydrodynamic) model (including three sensitivity test runs using modified intertidal bathymetry), six runs using the Mike 21 SW (Spectral Waves) model, three using the Mike 21 PT (Particle Tracking) module, two using the Mike 21 MT (Mud Transport) module, and two using the Mike 21 ST (Sand Transport) Module).

- The data used to construct the bathymetric grid used in the short-term modelling originate from several different sources and are of varying age and resolution (this is described in Appendix 6.2 of the ES (Model Bathymetry Review) and in reports by ABPmer 2013b,c). It would have led to increased confidence in the results if the baseline assessment for the project had included collection a comprehensive new bathymetric data set using specially commissioned, synoptic, multi-beam swath bathymetry and airborne LIDAR surveys.

- Most of the hydrodynamic and particle tracking model runs undertaken relate to the construction phase of the proposed development, specifically in relation to the effect of dredging of sediment within the lagoon area and the filling of Geotubes to construct the framework of the lagoon, and to a lesser extent the disposal of surplus dredged material at the Swansea Bay Outer disposal site. By their very nature, the modelling tools are unsuited to assessment of medium to long term (>30 days) effects on sediment erosion and deposition patterns / rates during the lagoon operation and decommissioning phases.

- It is evident from ES Chapters 1 and 4 that considerable uncertainty remains regarding the methods which might actually be used to construct the Lagoon. It is presently unclear whether Geotubes or more conventional construction methods using imported rock / concrete / fill will be used for parts or all of the construction. No modelling of possible alternatives to Geotubes has been undertaken in ES Chapter 6.

- It is also mentioned in ES Chapter 4 that the western training wall of the River Neath may be re-built; this has not been included in the modelling. The possible requirement to extend the existing treated sewage / storm-water discharge outfall beyond the limits of the Lagoon walls also has not been modelled.

- The wave modelling undertaken using Mike 21 FM-SW considered two wave approach directions, the prevailing southwesterly approach direction, and a southeasterly direction. The analysis focused mainly on changes in average wave height around the Bay. Patterns of wave refraction with changing pre- and post-construction bathymetries have not specifically been considered even though this aspect is likely to be important for nearshore and intertidal sediment transport.

- Waves from a south-south-west to southerly approach direction have not been considered although these could be important in terms of wave penetration into the mouth of the River Tawe (with implications for small craft navigation), wave interaction along the western walls of the proposed lagoon and the West Pier, and the transfer of sediment over the Tawe barrier.

- Longer-term changes have been considered only using Expert Geomorphological Assessment (EGA), based on the outputs of the short-term numerical modelling and the baseline conceptual understanding; no quantitative numerical modelling has been

undertaken for alternative future scenarios, using modified bathymetries; the fact that only a limited number of scenarios have been assessed by the short-term modelling, and the baseline assessment is of limited scope, results confidence in the EGA.

- No detailed modelling of the Decommissioning phase has been undertaken and only a very brief qualitative assessment based on EGA provided. The option of total removal of the lagoon structure on decommissioning has not been considered. The consequences of allowing the Lagoon structure to degrade through lack of maintenance in the long term also have not been considered.

12.0 REQUIREMENTS FOR MONITORING, MITIGATION AND POSSIBLE REMEDIATION

12.1 Two potential methods of monitoring are identified is the ES as potential contributors to an Operational Environmental Management Plan (OEMP):

- Beach profile monitoring to the west of the lagoon extending into the Blackpill SSSI and to the east in front of Crymlyn Burrows

- Monitoring of sedimentation within the navigation channel to Swansea Docks

12.2 In view of potential concerns about the potential impacts of the development on the beaches, intertidal flats and adjacent sub-tidal areas of northwestern Swansea Bay, including possible impacts on windblown sand hazard, mud accretion / saltmarsh development and dredging requirements in the Tawe barrage impoundment, it is suggested that a more extensive programme of pre-construction baseline data acquisition and subsequent monitoring should be agreed with the Developer, and other bodies including Natural Resources Wales (NRW), if a DCO is granted. Specific thresholds of change should be agreed which trigger further action in terms of mitigation / compensation / remediation.

12.3 From the viewpoint of physical processes and sediments, it is recommended that the following should be undertaken as part of a broader environmental monitoring package:

- A baseline LiDAR and comprehensive swath bathymetric survey of the whole of Swansea Bay before any construction activities commence.

- Repeat LiDAR / swath bathymetry surveys at 5 yearly intervals to allow quantitative assessment of changes in beach sediment volume.

- RTK GPS surveys of additional beach profiles to be established between the existing Swansea Bay and Carmarthen Bay profiles lines.

- Bathymetric surveys to monitor sediment accumulation in the impoundment above the Tawe barrage.

- Aerial photography surveys at 5 yearly intervals to monitor changes in morphological features and vegetation extent (e.g. saltmarsh).

- A comprehensive sediment characterization study of Swansea Bay, involving a minimum of 200 sampling points across the whole of the sub-tidal and intertidal area; samples should be taken from the surface and from specified depth intervals below the sea bed.

- Repeat sediment sampling at 5 yearly intervals in a reduced number of targeted locations.

- Continuous water level, wave and tidal current monitoring in at least two locations within northern Swansea Bay (e.g. using smart buoys).

- Installation of a weather station (including anemometer) at the control centre on the lagoon wall.

Agreement should be reached between TLSB and all interested parties regarding responsibility for any actions which may be required to tackle potentially adverse impacts such as increased windblown sand hazard, increased dredging requirement, improved coast protection / flood defence, and control of invasive saltmarsh vegetation. Additional agreements should be made in relation to habitat and species monitoring / mitigation.

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FIGURES

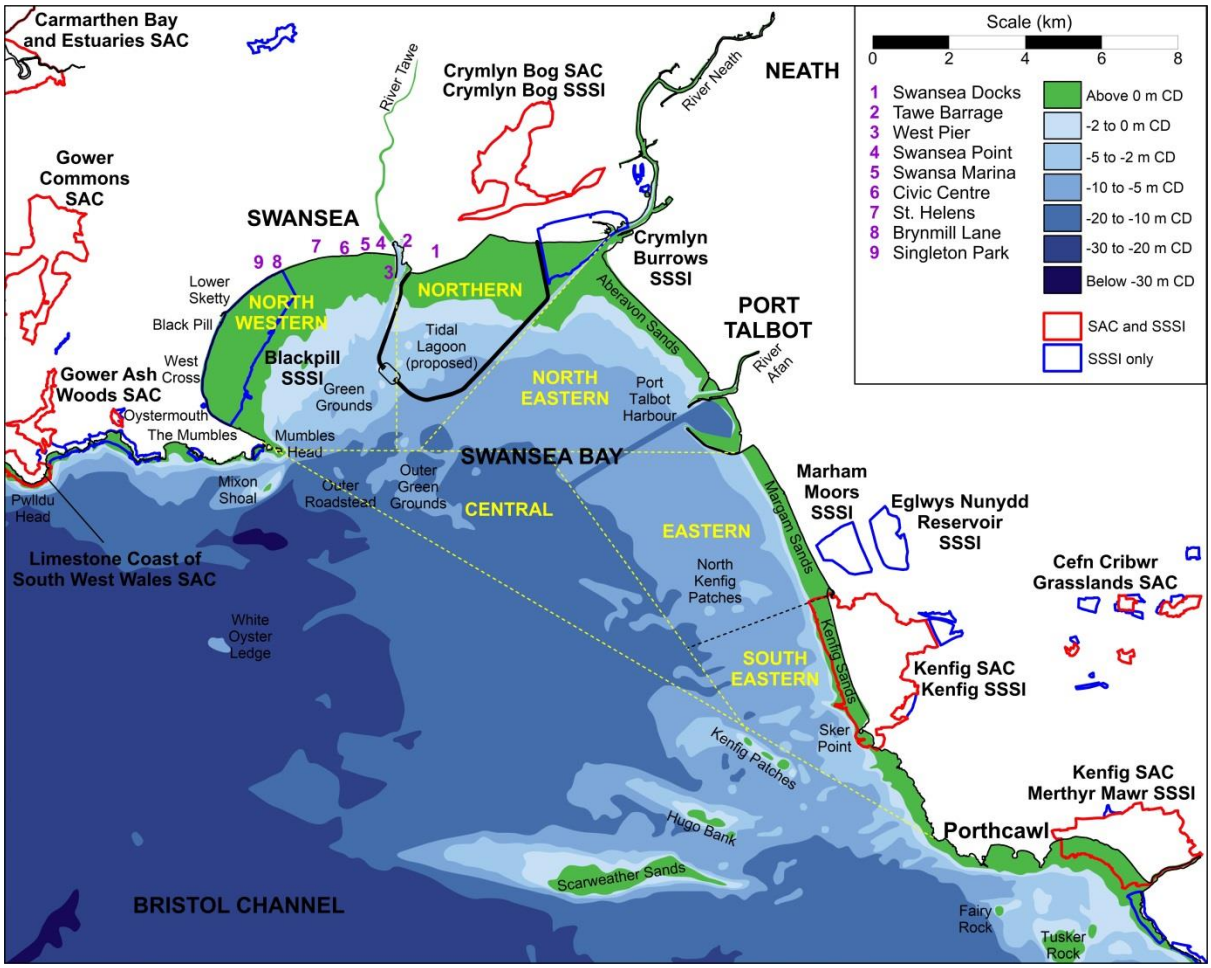

Figure 1. Map showing locations mentioned in the text, with bathymetry taken from the most recent Admiralty Charts (1161 and 1165), surveyed in large part 1980-1993 with minor recent corrections. Yellow lettering shows the main divisions of the Bay.


(a)
BLACK PILL


(b)


(c)

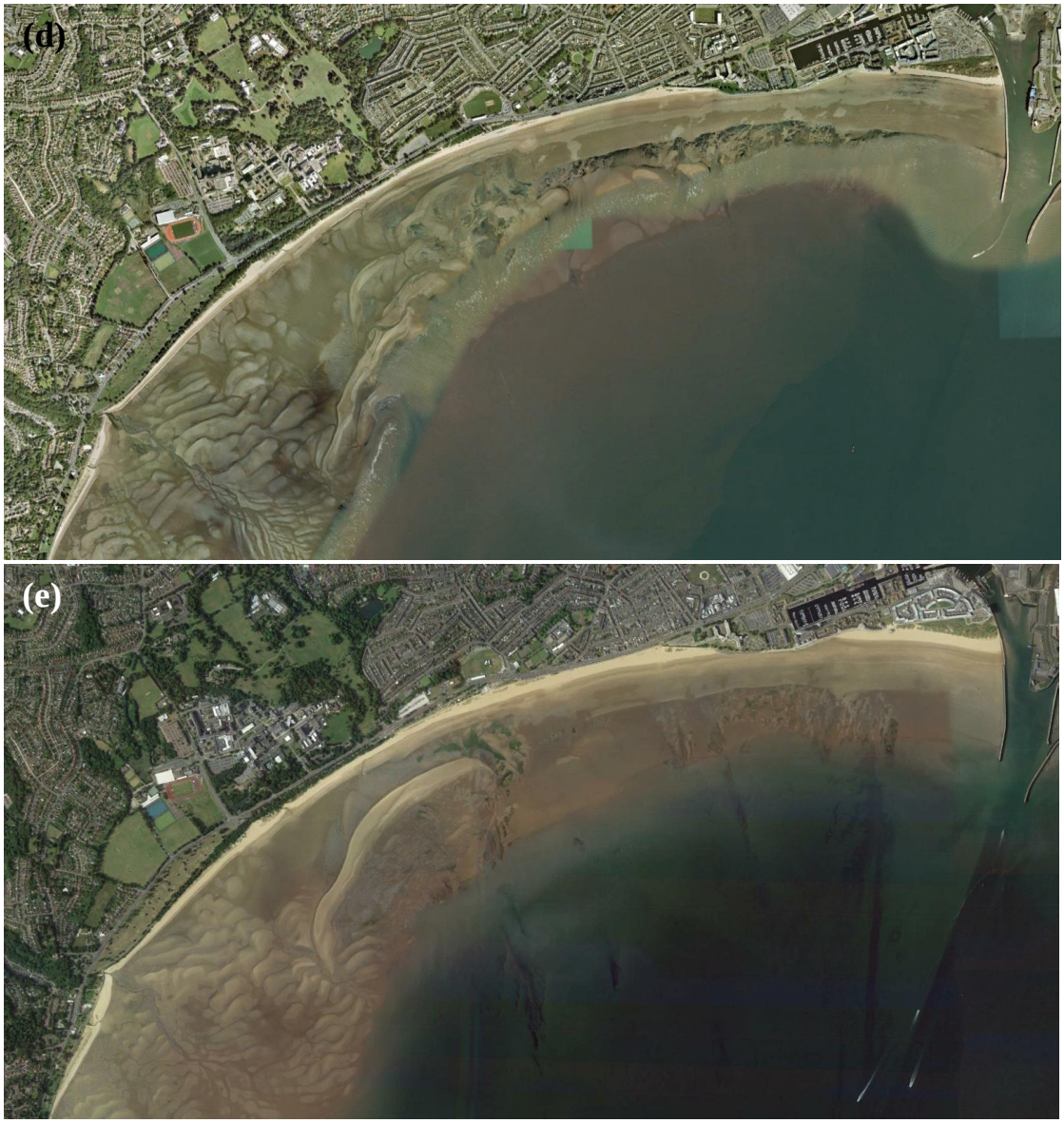

Figure 2. Aerial photographs of the northwestern part of Swansea Bay between Black Pill and West Pier: (a) 1945; (b) 1999: (c) 06/04/2002; (d) 05/09/2006; (e) 12/07/2013. Note variable size and position of intertidal sand bars, exposures of mid Holocene silt / peat platform, and upper dry sand beach / dunes. Data source: Google Earth

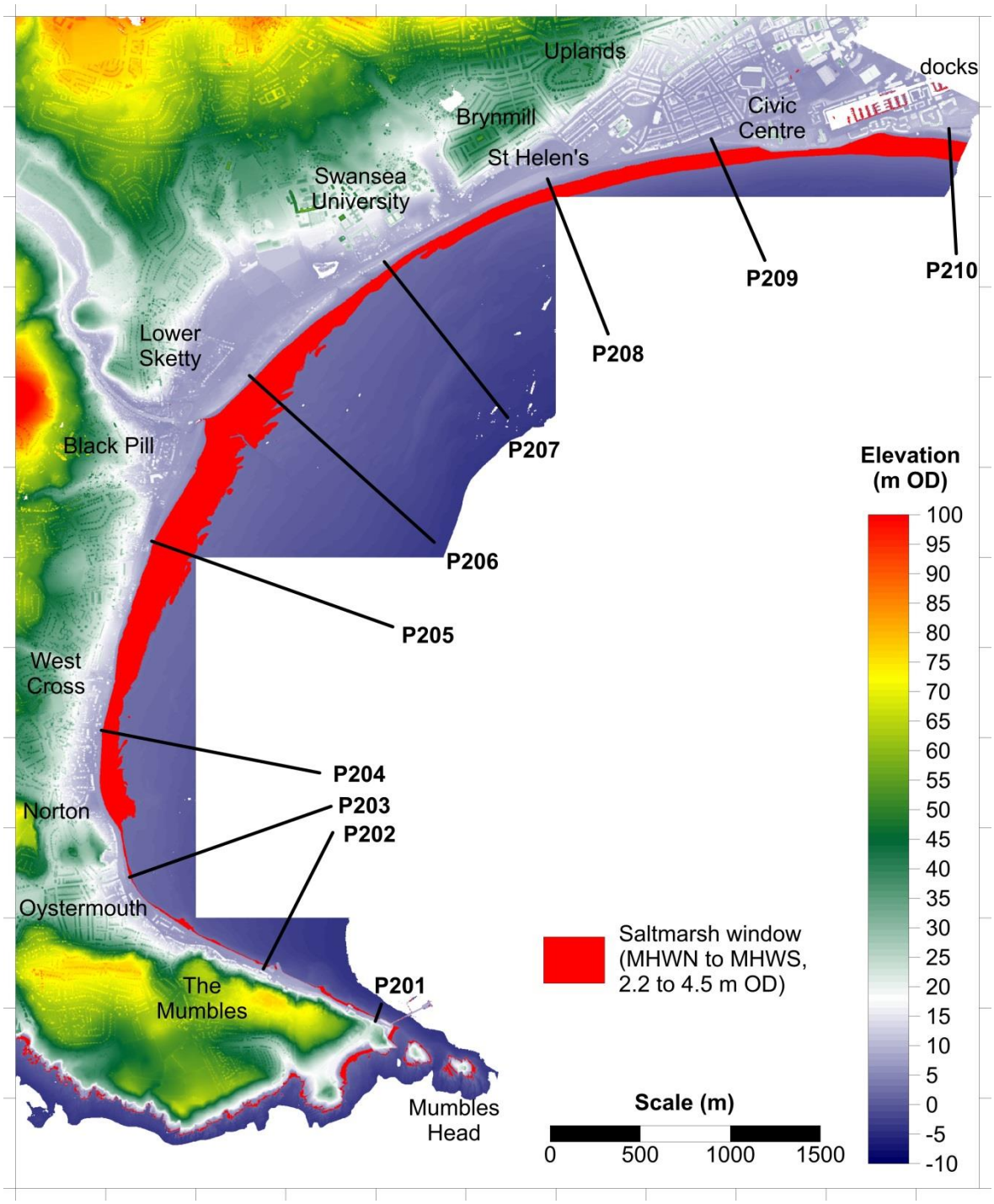

Figure 3. Lateral extent of the potential saltmarsh elevation 'window' (MHWN to MHWS) in western Swansea Bay, determined from LiDAR survey flown 26-27 February 2006. Positions of Swansea Bay and Carmarthen Bay Coastal Engineering Group beach topographic monitoring profiles are also shown

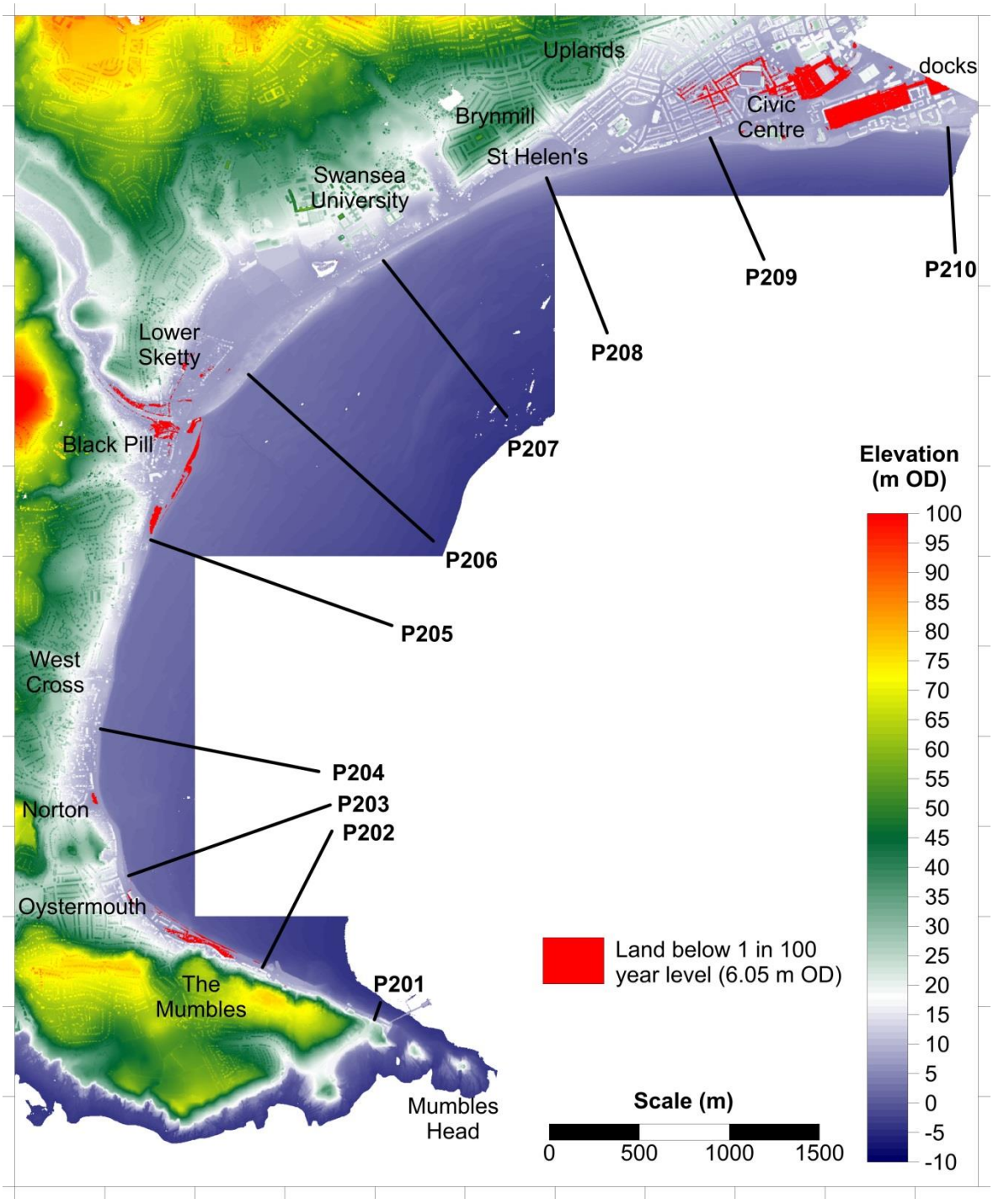

Figure 4. Land below the present 1 in 100 year return high water level (approx..6.05 m OD) in western Swansea Bay, determined from LiDAR survey flown 26-27 February 2006. Positions of Swansea Bay and Carmarthen Bay Coastal Engineering Group beach topographic monitoring profiles are also shown

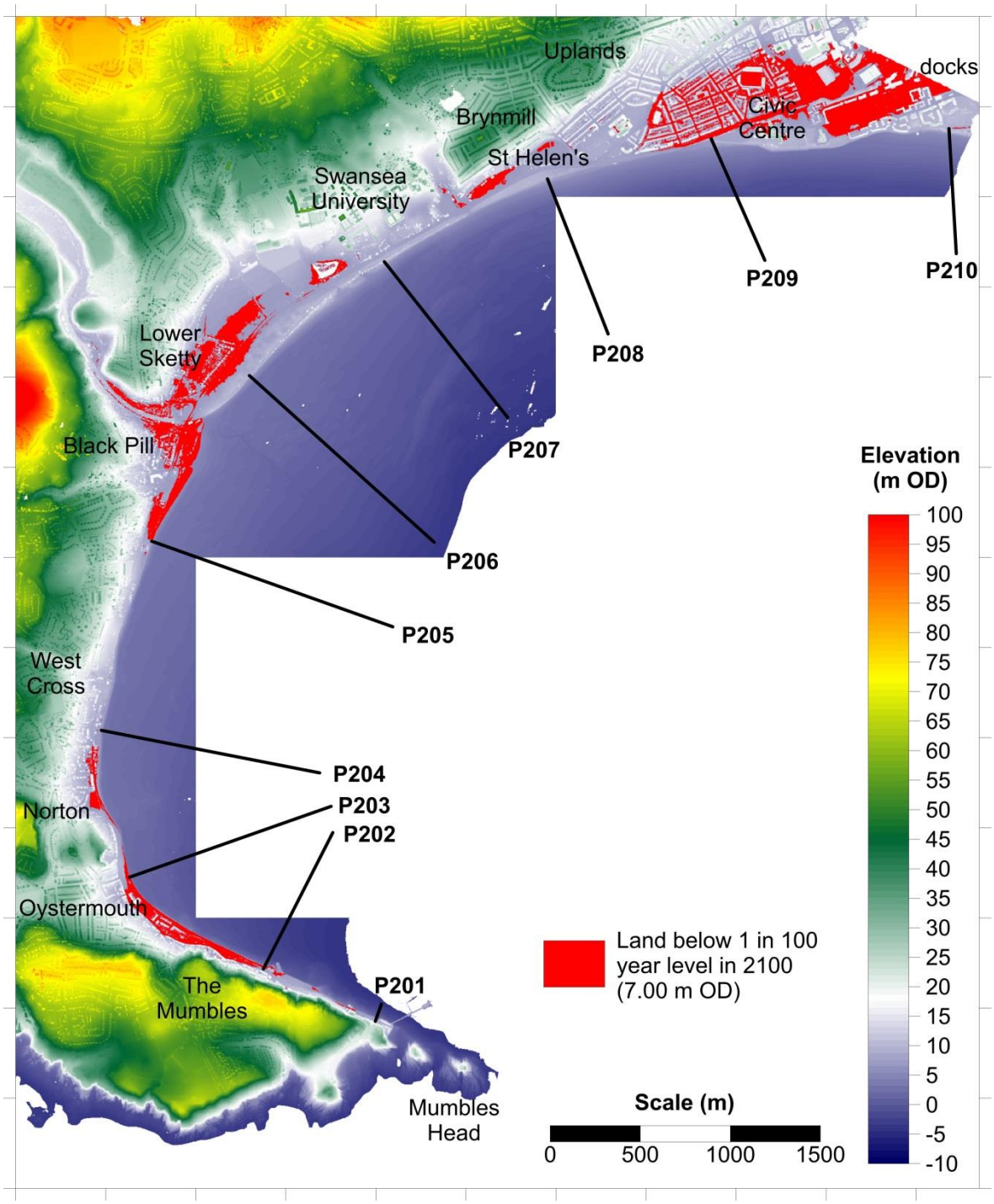

Figure 5. Land below the estimated 1 in 100 year return level in 2100 (approx.7.00 m OD) in western Swansea Bay, determined from LiDAR survey flown 26-27 February 2006. Positions of Swansea Bay and Carmarthen Bay Coastal Engineering Group beach topographic monitoring profiles are also shown

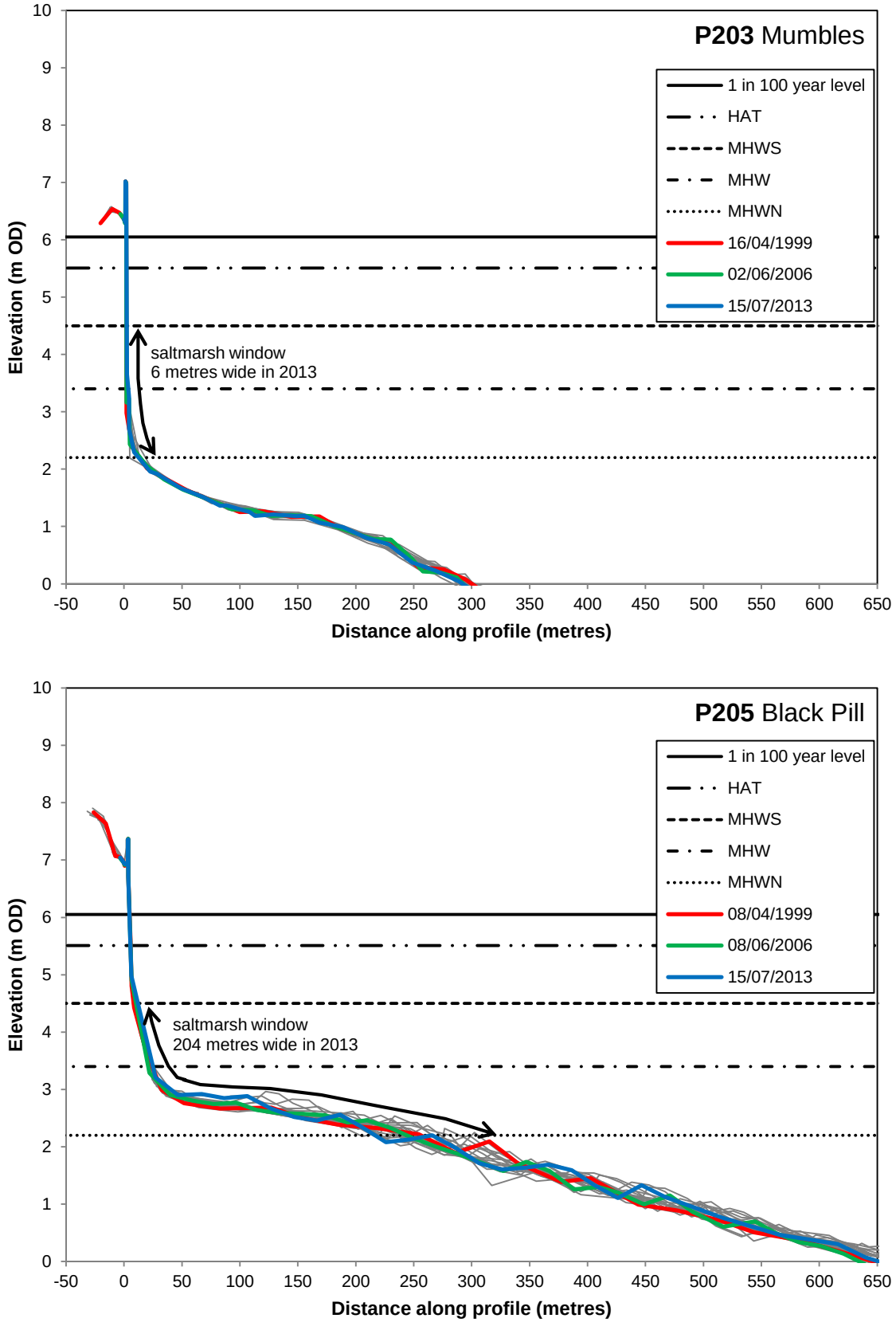

Figure 6. Beach cross-sections P203, P205 and P208 monitored by Swansea Bay Coastal Group between 1999 and 2013. Tidal levels and the extent of the saltmarsh window (MHWN to MHWS) are indicated

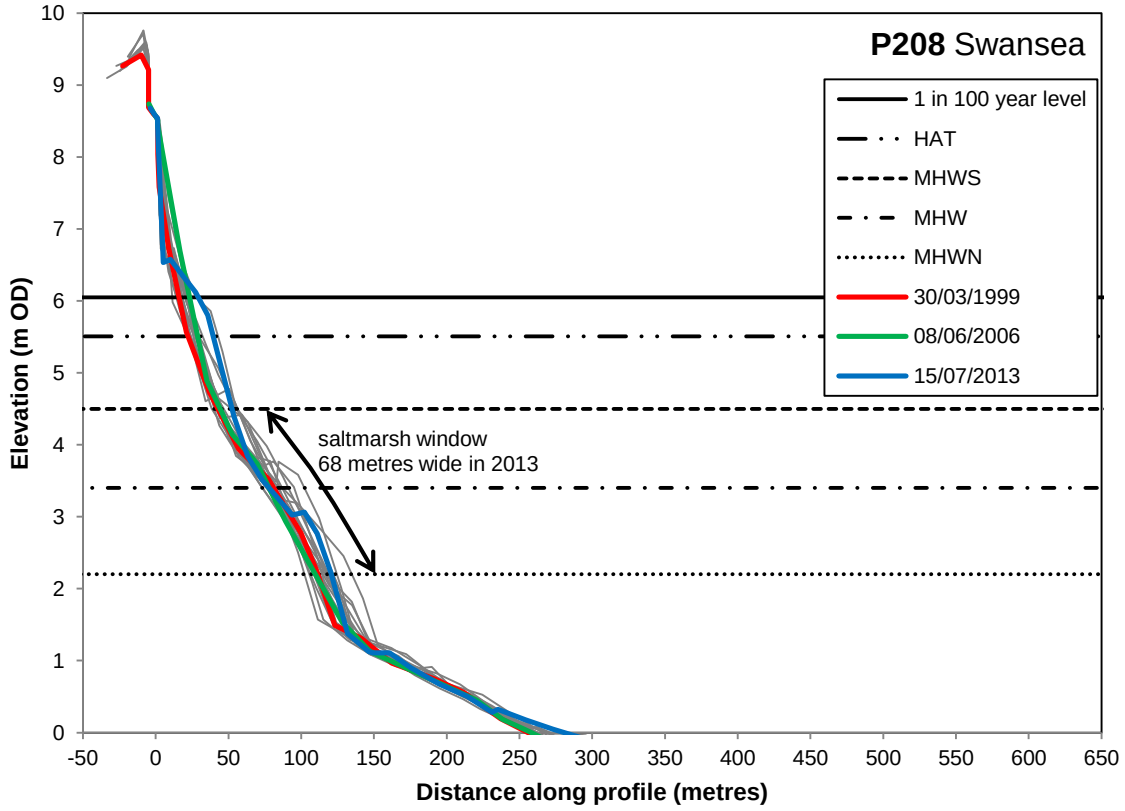

Figure 6. continued

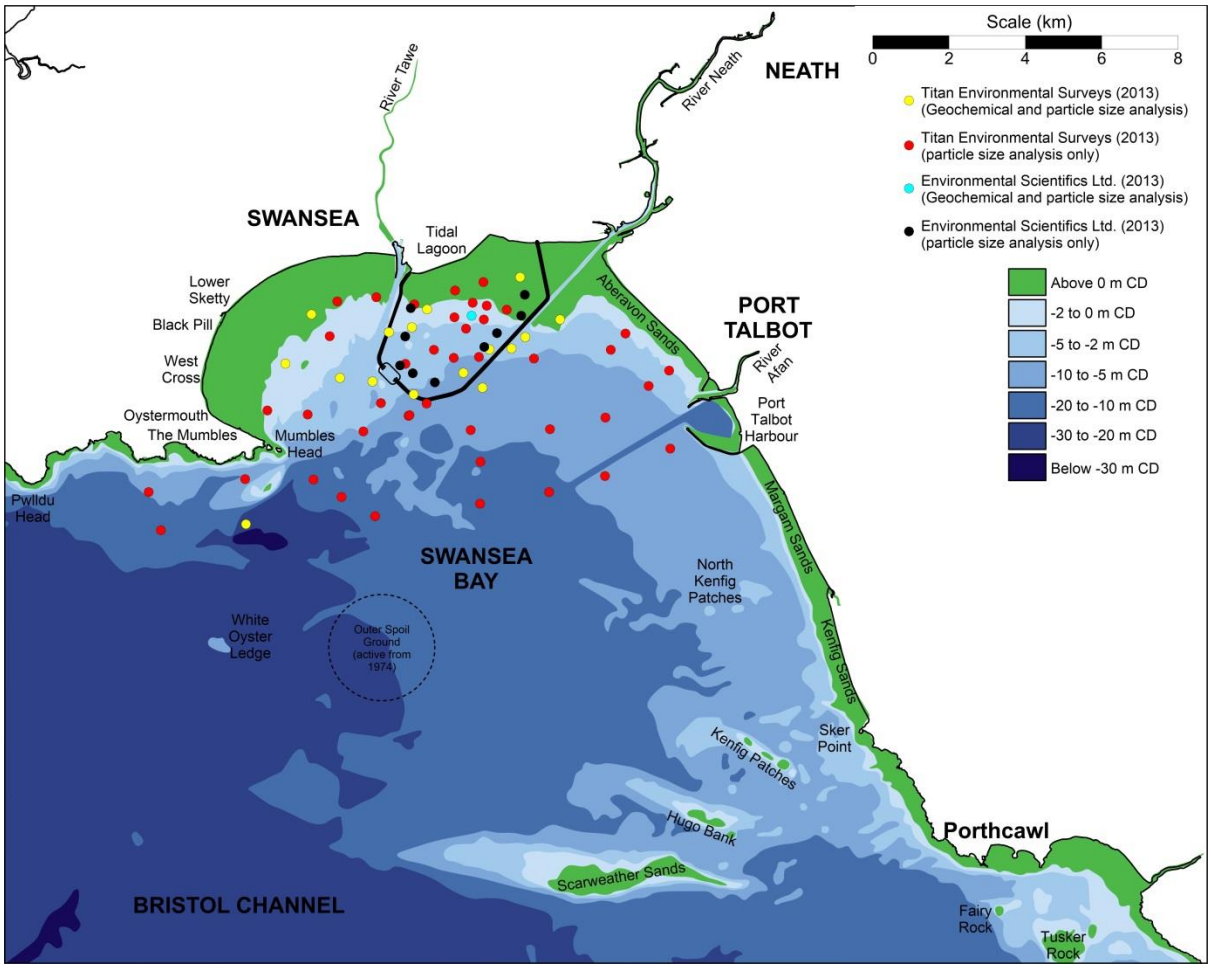

Figure 7. Locations where sediment samples were collected as part of the TLSB EIA for particle size analysis, determination of contaminant levels, and geotechnical testing. Note the absence of samples from the intertidal areas and supra-tidal areas

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