

A high-level appraisal of areas of constraint and areas of opportunity for coastal habitat roll-back

Report No: 859

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Report number: 859

Publication date: 06/2025

Title: **A high-level appraisal of constraints and areas of opportunity for coastal habitat roll-back**

Author(s): Iain Fairley

Technical Editor: N. Rimington

Quality assurance: Tier 2

Peer Reviewer(s): H. Lewis, J. Creer, L. Pennington

Approved By: K. Ramsay

Restrictions: None

Recommended citation for this volume:

Fairley, I., 2025. A high-level appraisal of areas of constraint and areas of opportunity for coastal habitat roll-back. NRW Evidence Report No: 859, 72pp.

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Crynodeb Gweithredol

Proses yw 'ymgiliad cynefinoedd arfordirol' pan fo cynefinoedd yn symud tua'r tir fel ymateb i gynnydd yn lefel y môr. Mae deall ble gallai ymgiliad ddigwydd – neu ble na allai ddigwydd - yn bwysig er mwyn ein helpu i ddeall sut y bydd maint cynefinoedd arfordirol amrywiol yn newid dros amser ac er mwyn datblygu strategaethau rheoli. Mae gan Cyfoeth Naturiol Cymru (CNC), felly, ddau angen tystiolaeth blaenoriaeth uchel mewn perthynas ag ymgiliad cynefinoedd arfordirol: y naill i nodi ble mae cyfyngiadau ar ymgiliad cynefinoedd a'r llall i asesu ble mae ymgiliad wrthi'n digwydd. Mae'r adroddiad hwn yn mabwysiadu dull lefel uchel ar raddfa genedlaethol i ddechrau ateb y cwestiynau hyn. Nid yw asesu safleoedd lle mae ymgiliad yn digwydd yn bosibl ar y raddfa hon - yn lle hynny pennir darnau o'r arfordir lle gellid bod cyfle i gynefinoedd ymgilio. Bydd hyn yn helpu i fireinio meysydd chwilio ar gyfer astudiaeth fanylach.

Tri chynefin arfordirol sy'n cael eu hystyried, sef: morfa heli, blaendwyni tywod, a graean. Mae'r adroddiad hwn yn defnyddio data a gynhyrchwyd fel rhan o brosiect diweddar ar wasgfa arfordirol (Oaten J, Finch D, Frost N, 2024a, 2024b) i wneud asesiad o ymgiliad yn seiliedig ar system wybodaeth ddaearyddol (GIS). Bu'r asesiad yn ystyried safle cynefinoedd arfordirol, presenoldeb neu absenoldeb amddiffynfeydd arfordirol, a'r ardaloedd lle mae'r gefnwlod yn ddigon isel i ganiatáu ymgiliad.

Mae'r ardaloedd sy'n gyfyngedig a'r ardaloedd sydd â chyfleoedd yn gysylltiedig â lleoliad naturiol y cynefinoedd: mae twyni tywod a thrumiau graeanog yn fwy cyffredin ar arfordiroedd agored tra bo morfeydd heli yn fwy cyffredin mewn aberoedd.

Yn achos morfeydd heli, mae 55% o gynefin yr arfordir yn gyfyngedig, sy'n cyfateb i 255 cilomedr. Dim ond 14% o gynefin yr arfordir (65km) sy'n gynefin â chyfle i ymgilio. Mae hyn yn awgrymu bod maint morfeydd heli yng Nghymru yn debygol o leihau dros amser. Yn achos morfeydd heli, mae rhan helaeth (75%) o'r arfordir sy'n gyfyngedig i'w gweld mewn ardaloedd gwledig, sy'n awgrymu y gallai fod opsiynau rheoli a allai liniaru'r gostyngiad posibl hwn.

O ran graean hefyd mae llai o ddarnau â chyfleoedd i ymgilio (63km. 11% o gynefin yr arfordir) na darnau cyfyngedig (119km, 22%). Fodd bynnag, mae bron i hanner y darnau cyfyngedig i'w gweld mewn ardaloedd trefol lle mae'n annhebygol y gellid gwneud gwaith i ganiatáu ymgiliad.

Yn achos blaendwyni, ceir mwy o ddarnau â chyfle i ymgilio na darnau cyfyngedig. Gall 54% (147km) o dwyni tywod yr arfordir ymgilio o'i gymharu â 20% (54km) o'r cynefin arfordirol hwn sy'n gyfyngedig. Fodd bynnag, rhaid bod yn ofalus wrth ddehongli canlyniadau'r twyni tywod gan fod y cyfyngiadau a'r cyfleoedd wedi eu hasesu ar hyd yr arfordir yn unig - ac mae twyni tywod yn gynefin uwchlanwol a all ymestyn i mewn i'r tir. Yr hyn sy'n cael ei asesu yma, felly, yw'r potensial i'r blaendwyni symud tua'r tir - a allai, yn ei dro, arwain at golli cynefin pe bai'r maes twyni tua'r tir yn gyfyngedig, yn enwedig gan fod symudiad ymylon y twyni (hynny yw, tua'r môr a thua'r tir) yn cael ei reoli gan wahanol brosesau a thros wahanol gyfnodau o amser.

Executive summary

Coastal habitat roll-back is the process by which habitats move landward in response to sea level rise. Understanding where roll-back could or could not occur is important to help understand how the extent of various coastal habitats will change through time and develop management strategies. Accordingly, Natural Resources Wales (NRW) have two high priority evidence needs related to coastal habitat roll-back: one that identifies where there are constraints to habitat roll-back and another that assesses where roll-back is occurring. This report takes a high-level national-scale approach to start to answer these questions. Assessing sites where roll-back is occurring is not possible at this scale, but instead lengths of coast where there may be opportunities for habitats to roll-back are determined. This will help refine areas of search for more detailed study.

The three coastal habitats considered are: saltmarsh, frontal sand dunes, and shingle. This report makes use of data generated as part of a recent project on coastal squeeze (Oaten J, Finch D, Frost N, 2024a, 2024b) to conduct a geographical information system (GIS) based assessment of roll-back. The assessment considered the position of coastal habitats, the presence or absence of coastal defences and the areas where the hinterland is sufficiently low lying to enable roll-back.

The areas of both constraint and opportunity are linked to the natural position of the habitats: dunes and shingle ridges are more common on open coasts whereas saltmarsh is more common in estuaries.

There is 462km of saltmarsh along the Welsh (high tide) coastline, 55% of this coastline habitat length is constrained, which equates to 256km. Conversely the opportunity length is only 14% of the coastline habitat length (65km). The percentage of roll-back constraint and the percentage of roll-back opportunity does not equal 100% because there are areas of habitat backed by high ground where roll-back would not be possible. These figures suggest that over time the extent of saltmarsh in Wales is likely to decrease. Much (75%) of the constrained coastline length for saltmarsh is in rural areas which suggests there may be management options to mitigate for this potential decrease.

Shingle, of which there is 539km along the Welsh coastline, also shows less opportunity length (63km, 12% of coastline habitat length) compared to constraint length (119km, 22%). However, almost half of the constrained length is in urban areas where it is unlikely that work to allow roll-back could be conducted.

There are greater lengths of opportunity for roll-back than lengths of constraints to roll-back for frontal sand dunes. There is 270km of sand dunes along the Welsh coastline. 54% of this sand dune coastline length is able to roll-back (147km) compared to 20% of the coastal habitat length (54km) being constrained. It should however be noted that some caution is recommended in interpreting the sand dune results because constraints and opportunities were assessed along the coastline and sand dunes are a supratidal habitat which can extend some way inland. This means that what is assessed here is the potential for the frontal dune to move inland, which may still lead to a loss of habitat if the landward

dune field extent is constrained, especially since movement of the seaward and landward edges of dunes are governed by different processes over different timescales.

1. Introduction

The term 'roll-back' refers to the lateral translation inland of a coastal habitat or feature in response to rises in sea level. Coastal habitats generally occupy specific levels in the tidal frame caused by biophysical attributes of the habitat or associated sediment. Therefore, habitats will try to maintain this position as sea levels rise which can lead to an inland migration of the habitat. The concept is shown as a schematic for saltmarsh in Figure 1.

This report details a high-level geographical information system (GIS) assessment of areas where there might be anthropogenic constraints to, or opportunities for, the roll-back of coastal habitats. The habitats considered are saltmarsh, frontal sand dunes and shingle. These three habitats are examined because they are found in the upper intertidal or supratidal zones of the coastal profile and are therefore most likely to be the first habitats to meet hard constraints. The analysis is based on data from a recently completed coastal squeeze project (Oaten et al. 2024a, Oaten et al., 2024b), see Section 2.1.

The aim of this report is to provide initial information to feed into the delivery of two of NRW's marine and coastal high priority evidence needs:

- **Where are there constraints to habitat roll-back, including development and intensive agriculture?** The roll-back of coastal habitats in response to climate change and sea level rise is expected where conditions allow, however, where there are hard coastal defences, other structures and land management issues, this will not be possible. Spatial evidence in relation to the physical constraints to roll-back are required to provide a better understanding of where the coast is likely to be most vulnerable to habitat loss and to take action.
- **Where is habitat roll-back occurring and what gains are there in response to coastal change?** The roll-back of coastal habitats in response to climate change, sea level rise and cliff erosion is expected where conditions allow. Evidence is required to record and provide a register of where this is currently occurring, documenting habitat gains in terms of extent and condition. Evidence is also required concerning the actual change relating to climate and storm events. The requirement would be to create up to date maps (and a methodology to keep them updated) showing locations where change is occurring due to storms / sea level rise on unconstrained coasts.

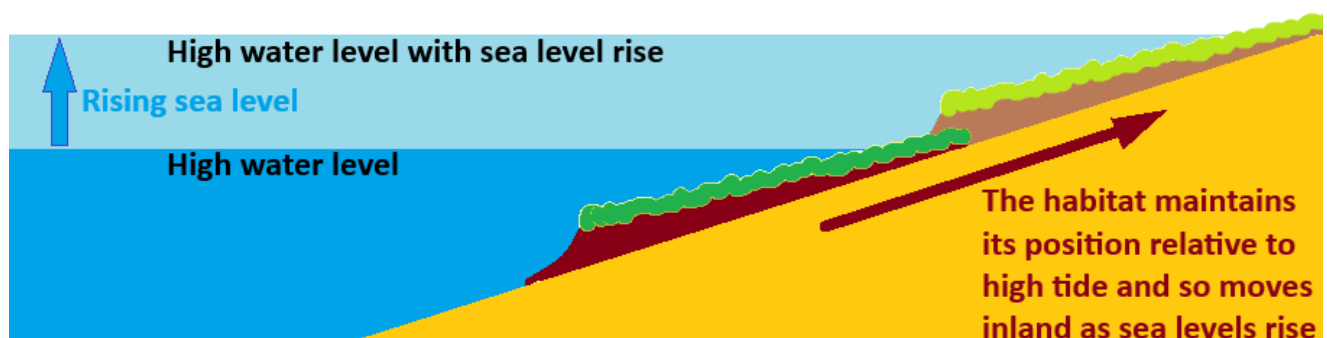


Figure 1: A schematic showing the concept of habitat roll-back for saltmarsh

The processes that lead to roll-back are different for the three habitats, but these mechanisms are too complex and site dependent to be actively considered in the report (see Section 4). It should be noted that sand dunes are different to the other two habitats because they are supratidal habitats: this means that rising sea levels will lead to erosion and landward transgression of the seaward edge, but will not explicitly influence landward transgression of the landward habitat extent. This work only considers the ability for the seaward edge of the dune (termed the frontal dune here) to migrate landward. The process of landward migration of the inland edge of a dune field depends on suitable supply of mobile sand and appropriate conditions for aeolian sand transport, therefore the timescales and forcing mechanisms are different between the seaward and landward edge of the habitat. Moreover, a range of habitats and transitions occur within one dune field.

2. Methodology

The approach in this study is to use the data generated from a recent NRW project on coastal squeeze (Section 2.1) to estimate areas where there might be constraints to roll-back (Section 2.2) and areas where roll-back might be occurring (Section 2.3). It should be noted that no quality control was applied to the data from the coastal squeeze project. Additionally, an agricultural land classification layer¹, SMP policy data² ([Natural Resources Wales / Shoreline Management Plans](#)) and an OS urban area layer³ were used to support the analysis: agricultural land classification and SMP policy data were only used to establish whether there were likely to be additional lengths of constrained coastline not captured in the analysis (see Section 2.2), while the urban areas layer was used to establish proportions of opportunities and constraints within urban areas (Sections 2.2).

2.1 Coastal Squeeze project data

Coastal squeeze is linked to coastal roll-back: it is the phenomenon where coastal habitat is lost or degraded by the presence of structures or management activities that prevent coastal roll-back. A recent project, run under contract by ABPMer for NRW, looked at the magnitude, timing and consequences of coastal squeeze for Welsh Marine Protected Areas (MPAs). The project is detailed in the following reports:

- [Understanding the likely scale of deterioration of Marine Protected Area features due to coastal squeeze: Volume 1- Methodology \(naturalresources.wales\)](#)
- [Understanding the likely scale of deterioration of Marine Protected Area features due to coastal squeeze: Volume 2- Results and Discussion \(naturalresources.wales\)](#)

¹ From NRW X: drive: "X:\Physical\Agricultural\Agricultural Land Classification.lyr"

² From NRW X: drive: "X:\Flood Risk\Coastal Erosion Risk\Shoreline Management Plan Policies.lyr"

³ From NRW X: drive: "X:\Basemapping\Ordnance Survey Mapping\OS Strategi Vector 200k\Urban Areas.lyr"

A large amount of data was created as part of the coastal squeeze project, and some of these datasets have been used in this study. The used data are summarised below:

Assessment units: The Welsh coastline was split up into a series of assessment units along a line around the Welsh coast that represents an anthropogenic structure or natural frontage. Each unit was defined as either high ground, cliff, defended or natural:

- High ground is areas of natural, undefended, high ground within estuaries that prevents flooding of the hinterland. High ground may prevent roll-back occurring (termed 'natural squeeze') but is not considered as a constraint here because the report focuses on anthropogenic constraints which could potentially be managed in future (see Section 2.2).
- Cliff refers to any cliffed area on the open coast that is not also protected by a structure, and has no accommodation space behind it. Like high ground, cliffs prevent roll-back occurring but were not considered a constraint due to the difficulty of managing such features to allow rollback.
- Defended refers to a frontage protected by an anthropogenic structure. Coastal structures can be a constraint to roll-back. Since these structures could be managed (breaching or removal) to allow roll-back to occur, these are considered as a constraint.
- Natural refers to low and undefended frontages, e.g. a shingle or sand dune frontage that could be breached and the hinterland flooded. Natural frontages can provide opportunities for habitat roll-back.

Accommodation space: The accommodation space was defined as the area in the hinterland between the assessment unit line and the ground level of Highest Astronomical Tide (HAT) +1m in 2155 (i.e. including a sea level rise allowance). It is the area that could be flooded if a structure / natural defence on the assessment unit line was breached or removed. Therefore, it can be considered to be the space that a coastal habitat could roll-back into. The accommodation space layer was developed using a Digital Terrain Model (DTM), tidal levels and the assessment unit line. The accommodation space calculation does not consider the use of land within the accommodation space and therefore real-world constraints such as built infrastructure are included as viable accommodation space, which may not actually be the case.

Habitat type: Polygons were produced for different coastal habitat types to be assessed in the coastal squeeze project. The saltmarsh and sand dune layers were based on NRW habitat mapping. The coastal squeeze data differentiated between vegetated shingle (produced from NRW mapping) and littoral coarse sediment (created from the JNCC EUNIS Level3 Habitat Map). For this project, the vegetated shingle and littoral coarse sediment layers were merged to produce one shingle layer.

2.2 Constraints to roll-back

Locations where there may be constraints to roll-back were defined as lengths of the assessment unit line (a proxy coastline) which were classified as 'Defended' and where there was coastal habitat abutting or overlapping the assessment unit line and accommodation space on the landward side. These lengths were calculated by manipulating the coastal squeeze datasets in ArcGIS:

1. The portions of the 'assessment unit' line that were marked as 'Defended' were split out from the other section of the assessment unit line.
2. The 'Defended' line was clipped using the accommodation space polygon to produce a 'Defence with accommodation space' line showing the areas of defended coast that had accommodation space on the inland side.
3. The portions of the three different habitats fronting this line were assessed. The habitat areas did not necessarily directly abut or overlap the line and so a buffer of 25m was applied around all habitat polygons before the 'Defence with accommodation space' line was clipped by the different habitat layers to give a line showing locations of roll-back constraint for each habitat.

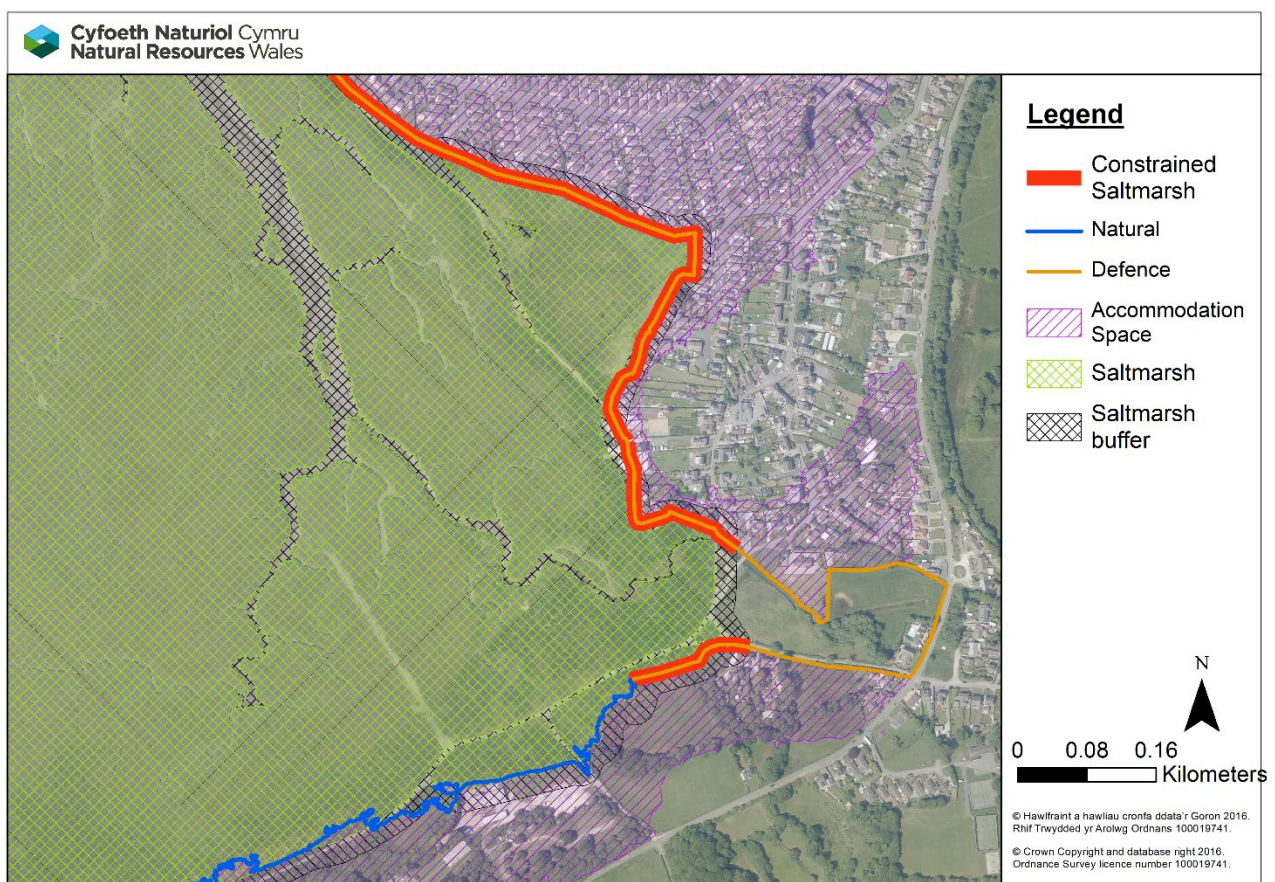


Figure 2: A map of a section of the Burry inlet showing how saltmarsh constraint is identified

This approach is demonstrated in Figure 2 with an example of constraints to saltmarsh roll-back. Much of the coastline in Figure 2 is defended, with accommodation space behind it (potential for roll-back if the defences weren't present) and saltmarsh close to or adjacent to the defence. Therefore, that section is considered a constraint to saltmarsh roll-back. To the south is a length of coast with saltmarsh in the intertidal and accommodation space inland but assessment unit classed as natural and so this is not a constraint (this would be a roll-back opportunity (Section 2.3)). In the east there is a small portion of defended assessment unit with accommodation space inland but there is no saltmarsh within 25m of the defence and so it is not considered as a constraint to roll-back.

Sections of cliff or high ground that front an area of accommodation space are not considered as a constraint to roll-back in this analysis because, while likely constraining the landward migration of habitat, they are a natural constraint which could not be managed to promote roll-back. There is only a small portion of the Welsh coast where this is the case (3.5km) and so this decision has little implications for the results.

The decision to apply a 25m buffer will have some implications for the results, since it means that the mapped constraint is not an immediate constraint (i.e., there is up to 25m space for roll-back before it becomes constrained).

There will be other constraints to roll-back which are not explicitly covered in this analysis:

- High grade agricultural land, which is specified in the evidence need, was not included in the analysis. However, using Agricultural Land Classification (MAFF, 1988) mapping⁴, the amount of Grade 1 and Grade 2 (highest two grades) land within the accommodation space is small (for definition of the different grades see Appendix 1 of [Agricultural land classification: frequently asked questions \(gov.wales\)](https://gov.wales)). There is only 2.2 Ha of Grade 1 land (excellent quality) agricultural land in two sections, one on the Llŷn Peninsula and one in the Gwent levels; in both cases they are set back from the coast and behind defended sections so would not provide an additional constraint. There are 2280Ha of Grade 2 (very good quality) agricultural land in the accommodation space, however this is predominantly also behind existing defences. Therefore high grade agricultural land is assumed not to cause an additional constraint (in terms of length of currently constrained coastline) over and above the defended length.
- Some coastal areas are actively managed for forestry, and in these cases the forest management may cause a constraint to roll-back. This is particularly the case for sand dunes, e.g. Newborough.
- There are some areas which are not defended but are subject to a 'hold the line' shoreline management policy and hence may cause a constraint to roll-back in future. However, using an SMP policy layer⁵, it was estimated that this occurs for

⁴ From NRW X: drive: "X:\Physical\Agricultural\Agricultural Land Classification.lyr"

⁵ From NRW X: drive: "X:\Flood Risk\Coastal Erosion Risk\Shoreline Management Plan Policies.lyr"

only 25km of Welsh coastline in the current epoch and much of this is for lengths of cliff or high ground which would not be considered a constraint to roll-back.

- There may be assets and infrastructure that need to be defended but which currently aren't and which do not fall under a 'hold the line' shoreline management policy. These can only properly be assessed at a local level and are likely to lead to some short coast sections which are defended in future hence causing additional roll-back constraint. An example of this can be seen in the southern portion of Figure 2, where industrial units are situated in undefended accommodation space. This is considered at a high level in the results by assessing the areas of constraint not in urban areas.

Once the line of constrained coast for each habitat was established, this line was clipped by the OS Strategi Vector 200k urban area layer in order to estimate the amount of constraint outside of urban areas. The motivation for this was that it was assumed it would be easier to manage constraints to allow for inundation of the hinterland and habitat roll-back outside of urban areas. Similar to the clipping by habitat type, a 25m buffer was applied around the urban area polygon.

2.3 Opportunities for roll-back

The approach for assessing areas where there is opportunity for roll-back is similar to the approach for the constraints to roll-back:

1. The portions of the 'assessment unit' line that were marked as 'natural' (undefended and not cliffed or high ground) were split out from the other sections of the assessment unit line.
2. The 'natural' line was clipped by the 'accommodation space' polygon to produce a 'natural with accommodation space' line showing the areas of undefended coast with accommodation space behind it, i.e. areas where there is the potential for habitat roll-back.
3. The portions of the three different habitats fronting this line were assessed. The habitat areas did not necessarily directly abut the line and so a buffer of 25m was applied around all habitat polygons before the 'Natural with accommodation space' line was clipped by the different habitat layers to give a line showing areas of roll-back opportunity.

An example of where roll-back opportunity would be identified for saltmarsh is the orange line in Figure 2, where the assessment unit line is marked natural and there is saltmarsh in the intertidal and accommodation space inland.

Similar to the discussion in Section 2.2, there are constraints not covered that may reduce the area where there is opportunity for coastal habitat roll-back; for example assets within an undefended portion of accommodation space. This can be seen in the southern portion of Figure 2, where there is an industrial unit in the undefended accommodation space that may prevent that section being a roll-back opportunity. Similar to the constraints analysis (Section 2.2), the OS urban areas layer (with a 25m buffer applied) was used to estimate the length of roll-back opportunity outside of urban areas. The assumption behind this step was that opportunities for roll-back inside urban areas may be less realistic than the opportunities outside of urban areas.

Some areas may be marked as high ground and so not considered as locations of roll-back opportunity, where habitats may be able to roll-back. This is particularly the case for sand dunes, where aeolian (wind blown) sand transport is the mechanism for roll-back. The converse is also true, particularly for saltmarsh, as there may be areas which are marked as natural but where the gradient of the natural land is too steep to make roll-back likely.

3. Results

3.1 Constraints to roll-back

The lengths of coastline where there are constraints to roll-back are given in Table 1, both as a kilometre value and as a percentage of the overall length of habitat (including 25m buffer) along the assessment unit line (a proxy coastline). This shows that a large portion of saltmarsh (55% of coastline habitat length) has a defence that is preventing it rolling back in response to sea level rise. Shingle and frontal sand dunes are less constrained

Figures 3 – 5 show the areas where there is constraint to roll-back for the three habitats. Apart from a few small areas on the open coasts of North Wales and Anglesey, constraints to saltmarsh roll-back (Figure 3) are inside estuaries, although the Severn Estuary may be considered more similar to an open coast environment. This is not surprising because saltmarsh is largely found in estuarine environments. The converse is true for frontal sand dunes (Figure 4) and shingle (Figure 5) where constraints are largely on open coasts. In many cases, the same section of defence is a constraint for both sand dunes and shingle. This is both due to the use of a 25m buffer around the habitats and because in Wales it is common to have a composite beach (sand in the lower intertidal and shingle in the upper intertidal) backed by sand dunes. Further maps of constrained coastlines are presented in Appendix A: all constrained areas are shown in higher resolution than the national level maps.

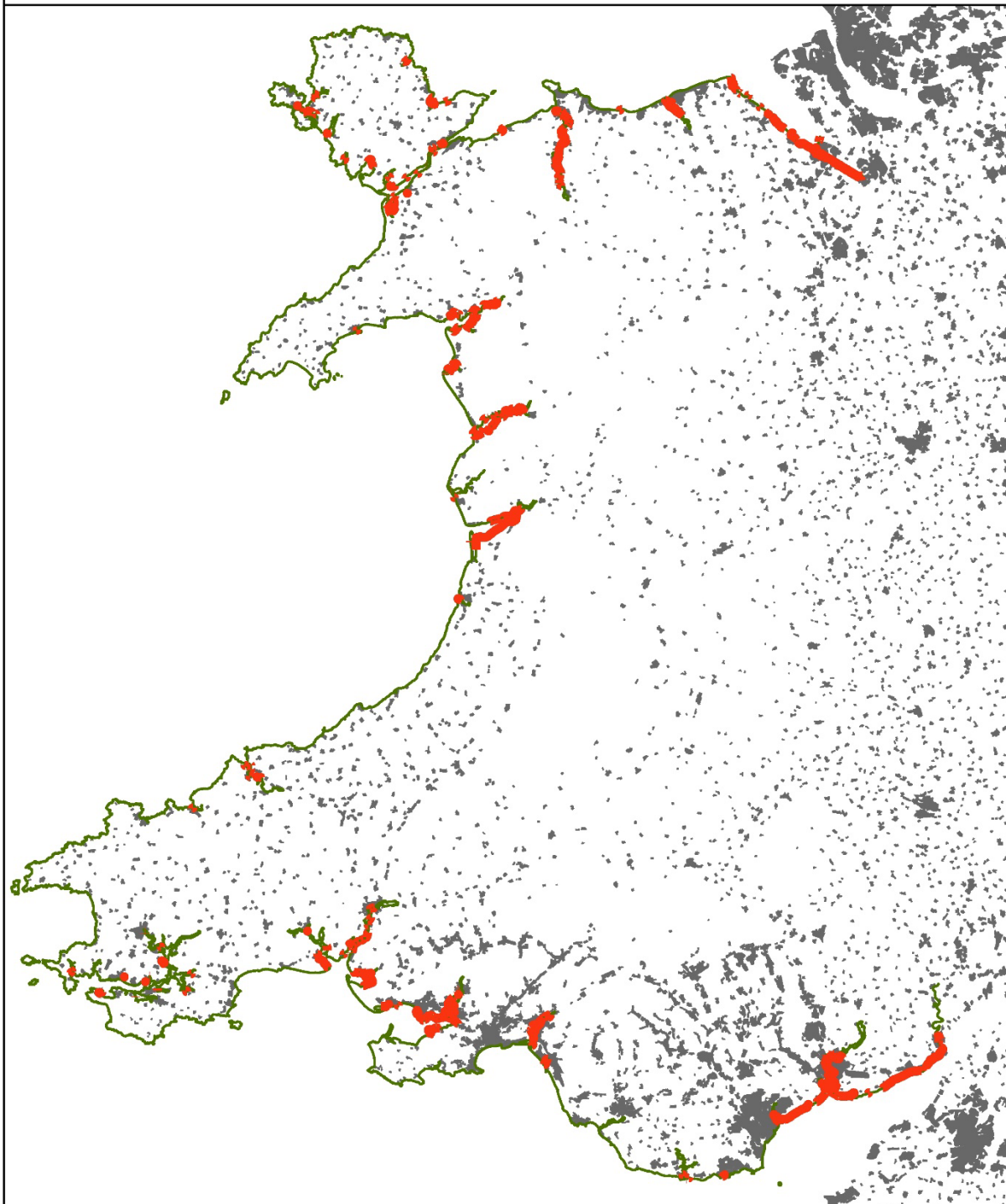
To consider the potential for management changes to reduce constraints, the amount of constrained coast not in urban areas was calculated (Table 2). While substantially more saltmarsh is constrained overall, 75% of the constrained coast is not adjacent to urban areas indicating a slightly greater potential for management to rectify this compared to sand dune (55% of constrained length not urban) and shingle (56% of constrained length not urban).

Table 1: Total length of roll-back constraint for the three coastal habitats, both as distance and percentage of total habitat

Length metric	Saltmarsh	Shingle	Sand dune
kilometre	256	119	54
% of habitat length	55%	22%	20%

Table 2: The amount of constrained coastline not adjacent to urban areas for the three habitat types.

Length metric	Saltmarsh	Shingle	Sand dune
kilometre	193	67	30
% of constrained length	75%	56%	55%



Legend

- Constrained Saltmarsh
- Assessment Unit
- Urban areas

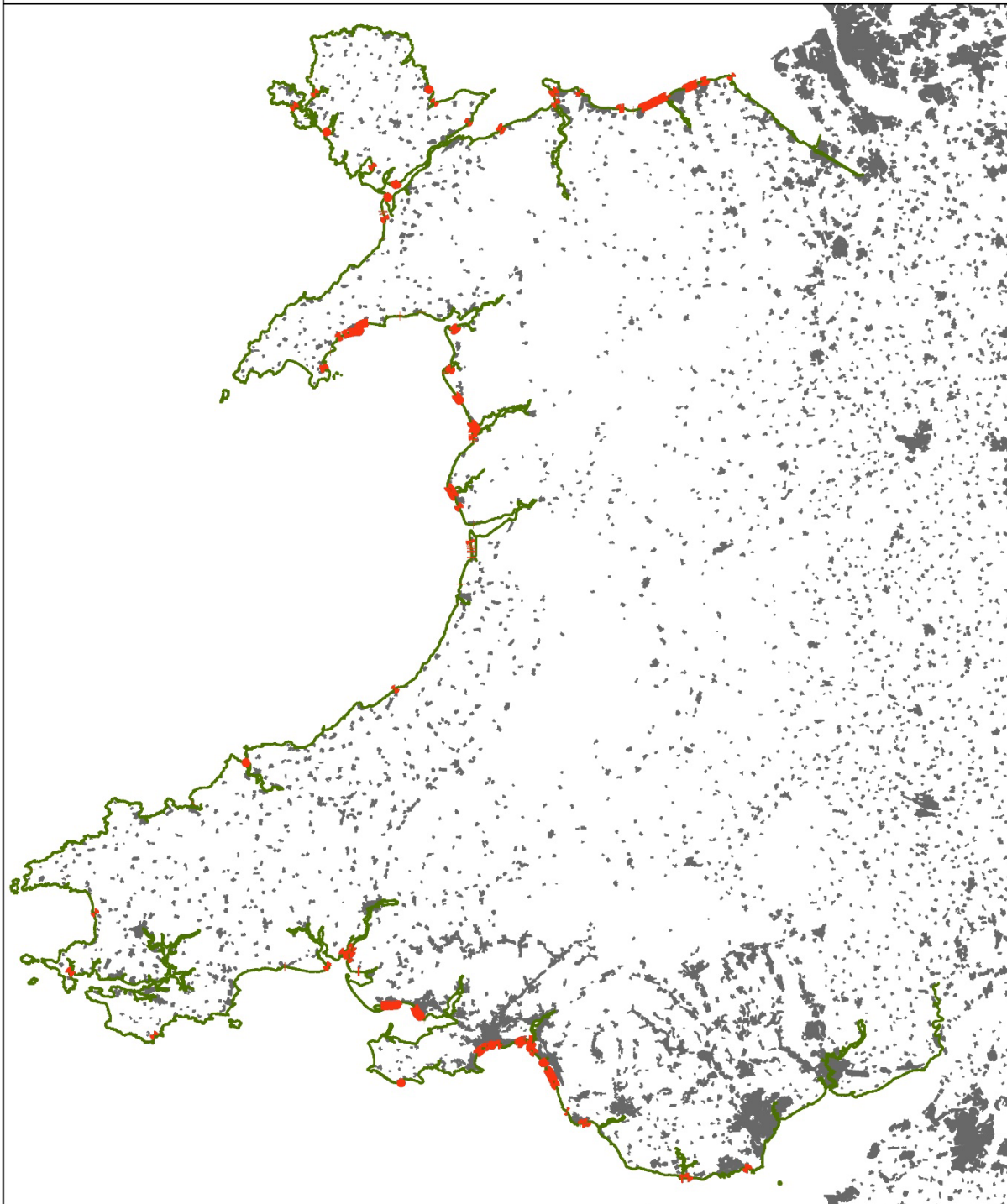
0 5 10 20 30
Kilometers

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Rhif Trwydded yr Arolwg Ordnans 100019741.

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Figure 3: Areas of constraint for saltmarsh roll-back around the Welsh Coast.



Legend

- Constrained Sand Dunes
- Assessment Unit
- Urban areas

0 5 10 20 30
Kilometers

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Figure 4: Areas of constraint for sand dune roll-back around the Welsh coast.

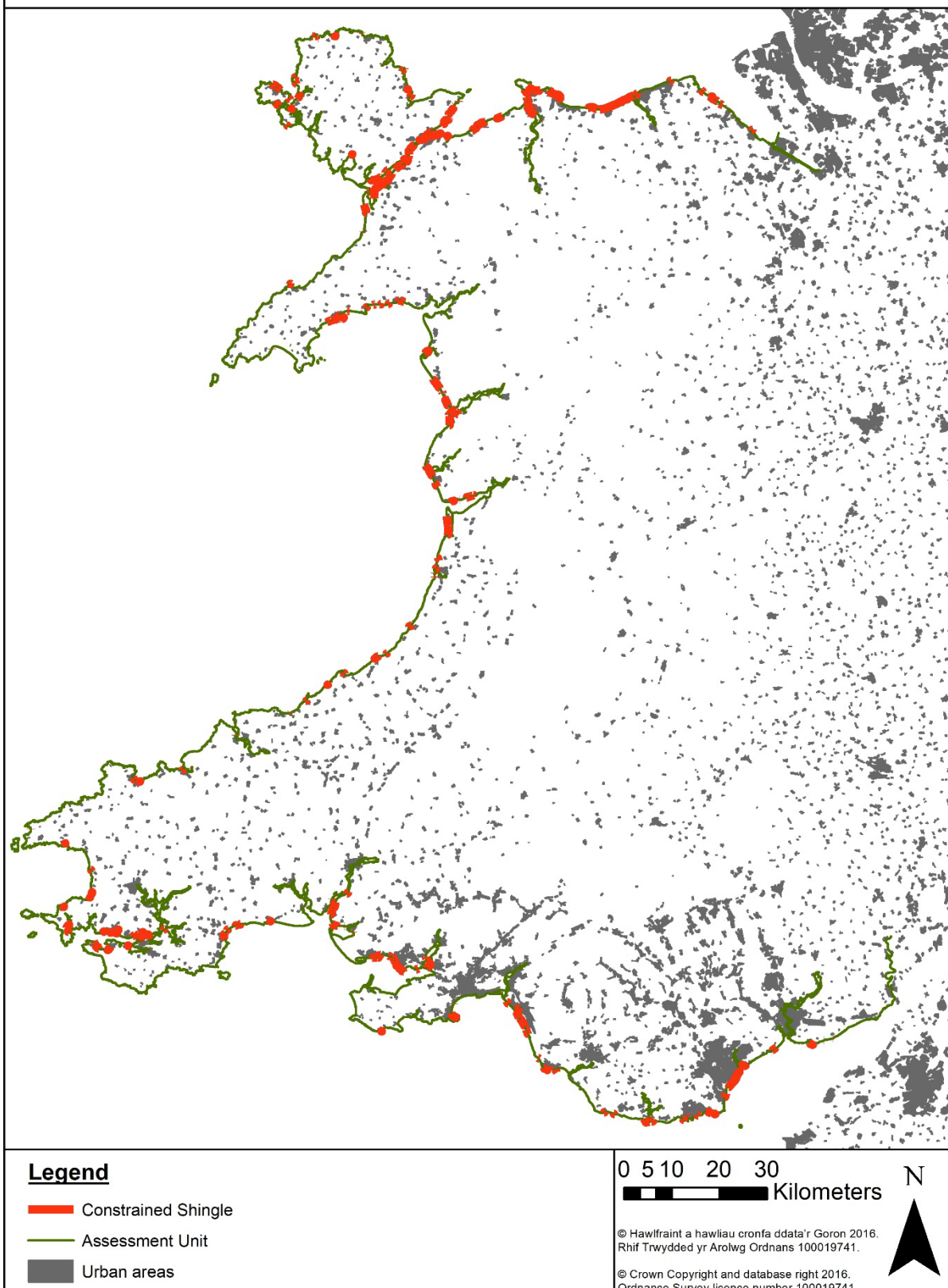


Figure 5: Areas of constraint for shingle roll-back around the Welsh coast.

3.2 Opportunities for roll-back

The length of roll-back opportunities for each habitat type are given in Table 3, similarly to the table of constraint length, the length is given as a distance (km) and as a percentage of the total habitat length along the assessment unit line (similar to the high tide line). It should be noted that the percentage of roll-back constraint and the percentage of roll-back opportunity does not equal 100% because there will be some lengths of habitat without accommodation space inland. There are less opportunities for roll-back than constraints (Table 1) for saltmarsh and shingle but more opportunities than constraints for sand dunes.

Figures 6-8 show the areas where there is opportunity for roll-back to occur. There are currently few areas available where this analysis suggests saltmarsh could roll-back (Figure 6). These are centred around the Burry Inlet and West Anglesey. It is interesting to note that there are very few points in the large estuaries of the Dyfi, Mawddach and Glaslyn/Dwyrhyd where this high level analysis suggests roll-back could occur.

The coastline sections where frontal sand dune roll-back could occur (Figure 7), occupy similar geographical spaces to the areas where there are constraints to frontal sand dune roll-back (Figure 4). One thing to note is that this analysis misses out areas such as Freshwater West, Pembrokeshire, and Llangennith, Gower, where there are large dune systems backed by farmland and hence could feasibly roll back. In both cases, the reason is that the hinterland is largely above the height threshold for accommodation space (HAT in 2155 + 1m), thus little accommodation space is mapped for these areas and they are not included in the analysis (Example shown in Figure 9). However, since dunes roll-back via aeolian processes and hence reach higher elevations, such areas could be included in any future local scale refinement of the work.

The sections of roll-back opportunities for shingle are largely on the open coast (Figure 8). Whereas constraints to shingle roll-back were reasonably evenly distributed around the Welsh coast, Figure 8 shows there are fewer opportunities for shingle to roll back in South Wales compared to North West Wales.

The amount of opportunity within urban areas was tested (Table 4), but it was found that for all three habitats very little of the predicted opportunity lengths were within urban areas and therefore this consideration does not really affect these high-level results.

Table 3: Total length of roll-back opportunities for the three habitats, as both distance and percentage of total habitat.

Length metric	Saltmarsh	Shingle	Sand dune
kilometre	65	63	147
% of habitat length	14%	12%	54%

Table 4: The amount of opportunity length in urban areas

Length metric	Saltmarsh	Shingle	Sand dune
kilometre	0.5	3.5	6.8
% of opportunity length	1%	6%	5%

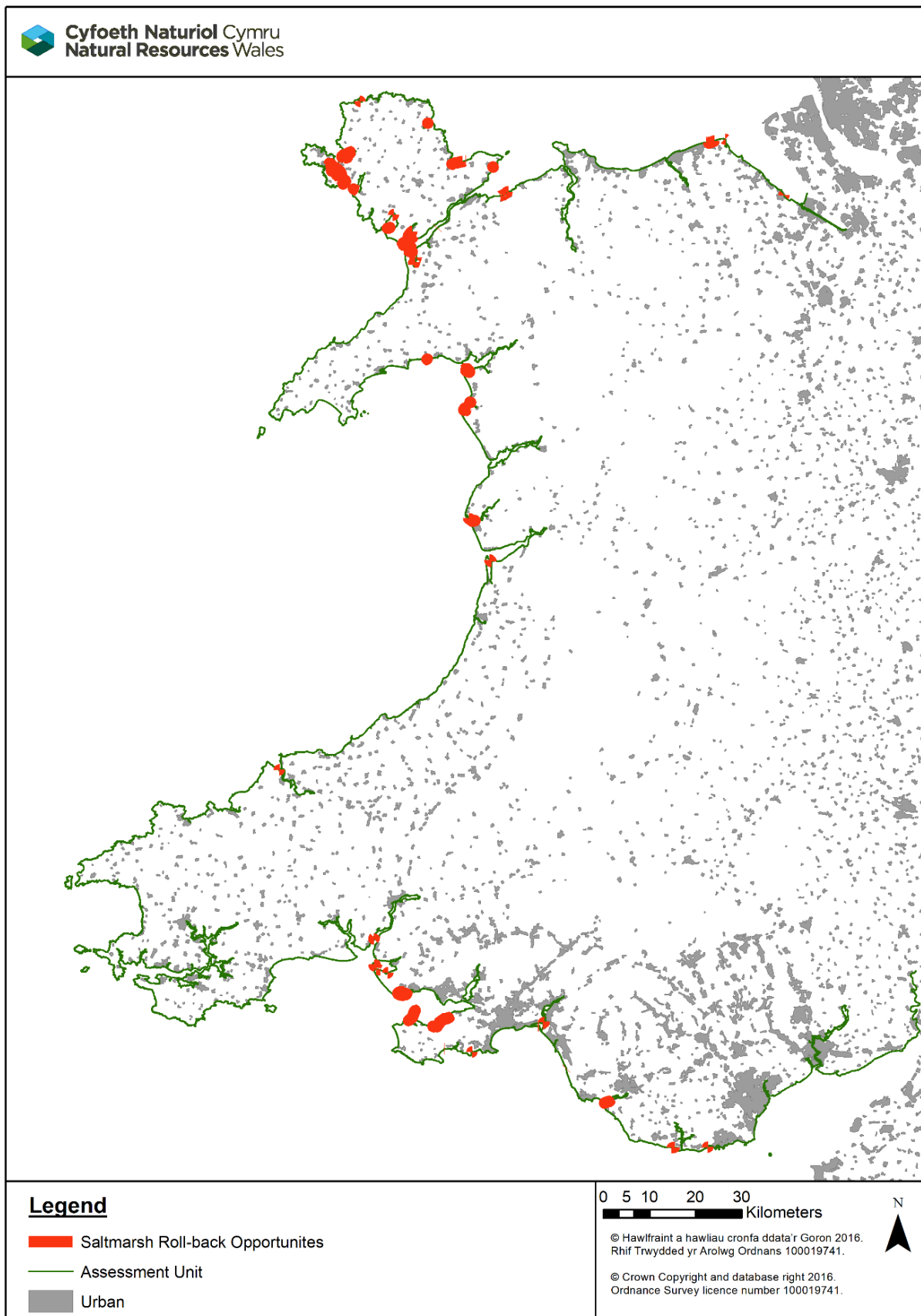


Figure 6: Areas of saltmarsh roll-back opportunity

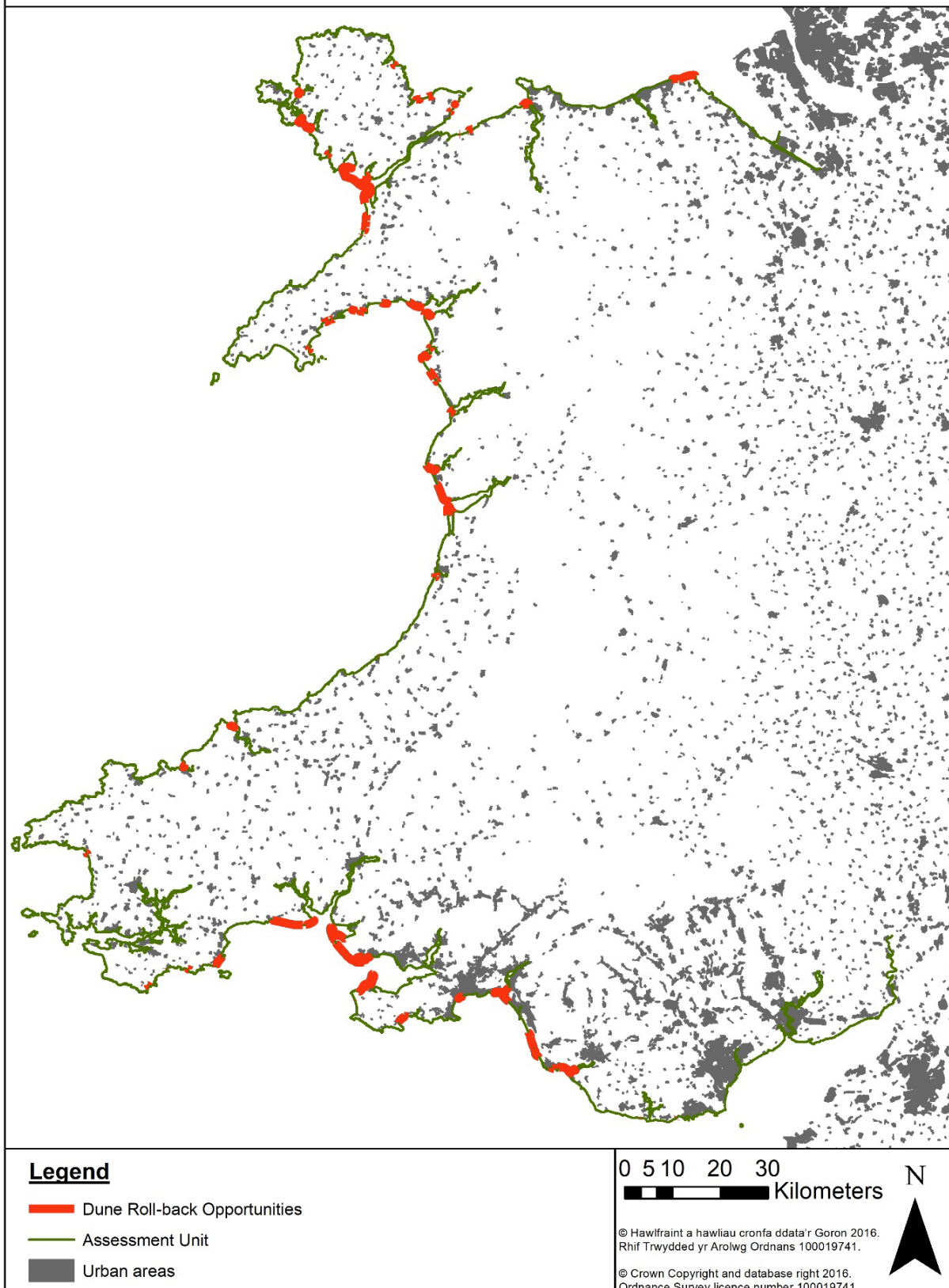
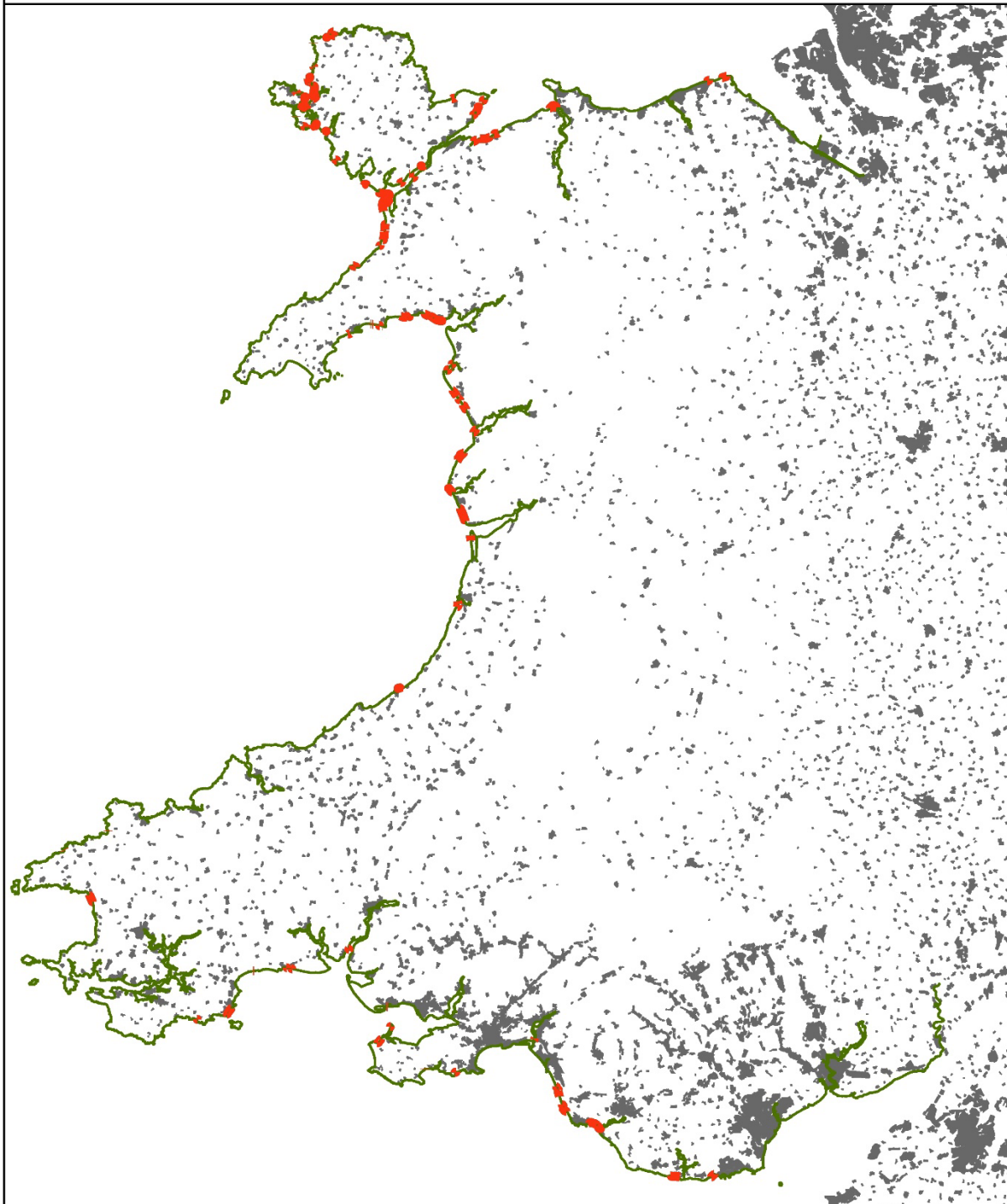


Figure 7: Areas of sand dune roll-back opportunity



Legend

- Shingle Roll-back Opportunities
- Assessment Unit
- Urban areas

0 5 10 20 30
Kilometers

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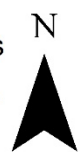


Figure 8: Areas of shingle roll-back opportunity

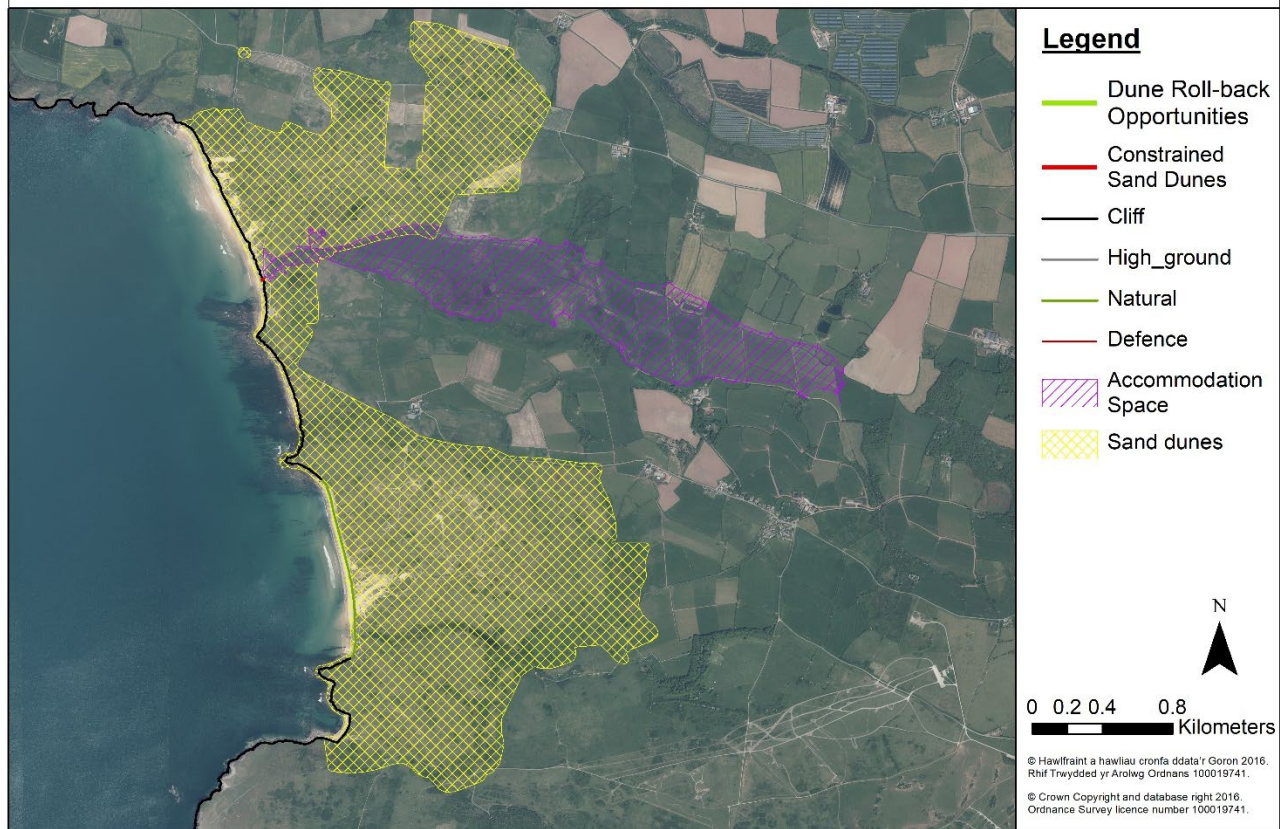


Figure 9: An aerial photo of Freshwater West, Pembrokeshire, showing how the minimal accommodation space leads to little roll-back opportunity being identified despite the large and relatively unconstrained areas of dune. The accommodation space is the area of floodable land connected to the assessment unit line, defined as being below a level of highest astronomical tide (HAT) in 2155 +1m. The sand dune field is above this elevation and so does not get included as accommodation space.

4. Discussion

This work has taken a high level approach to assessing areas where there are likely to be constraints or opportunities for coastal roll-back. Data from an existing project were used. Some errors will have been introduced based on this data: Oaten et al. (2024a) provide a comprehensive description of the development and limitations of the layers used in this project. Overall, the level of inaccuracy was deemed small given the national scale of the data products and the methods and assumptions regarded as suitable for large scale mapping.

One aspect of the method which will introduce some errors is that constraints and opportunities are estimated along the assessment unit line, which is similar to, or just inland of, the high tide line. This is appropriate for saltmarsh, which is a largely intertidal habitat, and shingle, which normally forms a barrier ridge around the high tide line. However sand dunes are a supratidal habitat and therefore the assessment unit line is nearer the seaward rather than landward edge of the habitat extent and so only movement of the frontal dunes can be considered. Accordingly, it is recommended that lower confidence is attributed to the sand dune results.

This report does not consider the biophysical mechanisms that enable roll-back and these differ between habitats:

- Shingle roll-back is a largely wave-driven process (Dornbusch and Ferguson, 2016) as wave overtopping at high water levels lead to overwash of shingle material which remains on the landward side of the shingle crest; as sea levels rise, there will be greater likelihood of shingle being washed over the crest and the barrier will move landward. Seaward and landward edge migration rates of shingle barriers are likely to be tied because of the narrow width of many shingle barriers, the conservation of shingle material and the same forcing (wave) being responsible for the movement of sediment at both sides.
- Roll-back of the landward saltmarsh boundary is related to increased tidal inundation of the hinterland and encroachment of halophyte vegetation, however, the detailed mechanisms of landward boundary translation are poorly understood (Fagherazzi et al., 2020). At the same time, rising sea levels will allow larger wave heights to reach the seaward marsh edge and greater erosion of the marsh edge. Timescales of migration of the seaward edge (erosion) compared to landward edge (habitat translation) may be very different, and erosion or accretion of the wider marsh area may influence changes in extent.
- Mapped sand dune extents comprise of a range of habitats, from (ephemeral) embryo dunes through shifting dunes along the shoreline (the frontal dune) to fixed (vegetated) dunes in-land. Onshore migration of the frontal dune can either be a purely aeolian process (wind-driven erosion on the seaward flank and deposition on the lee slope under onshore winds) or a combination of wave driven erosion of the seaward face and aeolian transport of sand from the beach over the crest, with deposition in the lee. In the second case, rates of wave-driven sediment transport is often greater than aeolian transport (Hird et al., 2021) and so the frontal dune may not maintain its shape or volume as it moves. Roll-back of the landward sand dune extent is driven by landward aeolian sand transport and vegetation dynamics. Since dunes near the landward extent may be highly vegetated (fixed), there may be minimal movement of this border and instead the fixed dune component becomes squeezed as the frontal dune is eroded and moves inland.

These complexities mean that local scale refinement will be needed to better understand the opportunities and constraints for roll-back.

Sediment availability will need to be considered, since insufficient sediment may in some cases lead to loss of habitat with rising sea levels rather than habitat roll-back. Aspects of the accommodation space, such as gradient and substrate type will also determine roll-back feasibility and extent. The gradient of the undefended accommodation space could be established using LiDAR data, but it would be more difficult to establish the limiting steepness above which roll-back would not occur which is likely to be site and sea level rise scenario dependent. Substrate type is likely to be most important for saltmarsh. For example, if an area of saltmarsh is fronting an area of bedrock, roll-back would not occur through the increased tidal inundation and saline intrusion changing the hinterland vegetation composition, but would require accumulation of sediment; while some research

suggests that saltmarsh accretion can keep pace with sea level rise (Weston et al., 2023), accretion rates are site dependent (e.g. Masselink and Jones, 2024). Conversely, shingle roll-back would likely cover any hard substrate behind.

As noted in the results, the ability of sand dunes to roll-back under aeolian transport may open up more areas of opportunity for roll-back than estimated here due to the potential to roll-back into higher areas not marked as accommodation space. Conversely, if dunes are highly vegetated to the extent they are no longer mobile, roll-back of the landward edge may not occur and instead extent would reduce as the frontal dunes are eroded. Many of the predicted areas of roll-back opportunity for sand dunes are in areas where the dune system is being used for forestry, for example Pembrey and Newborough. Therefore, careful management of forestry activities will be required to ensure sufficient space for roll-back (Pye and Blott, 2024).

Being a high-level study, this work has considered shingle in general, but specific work on vegetated shingle would also be important to conduct. Vegetated shingle is sensitive to disturbance and thus sea-level rise and increased storminess (the process by which shingle will roll-back) can be considered a threat to vegetated shingle (Doody and Randall, 2003). Therefore, the roll-back of vegetated shingle is likely to be more nuanced than the roll-back of unvegetated shingle.

It can be seen that a more detailed, habitat and location specific assessment will be required to fully answer the two evidence needs; nonetheless, this assessment is considered to provide a useful foundation for future work. This is particularly the case for the evidence need on constraints to roll-back, which is simpler to answer based on existing mapping. Constraints are largely caused by man-made structures and so this contribution will provide a good first pass at answering the question for present day constraints. However, in some areas SMP policy (<https://naturalresources.wales/flooding/managing-flood-risk/shoreline-management-plans/?lang=en>) changes between epochs, typically away from a 'hold the line approach': from 2025 (the start of epoch 2), 56 policy units will switch from 'hold the line' to 'managed realignment' or 'no active intervention,' and in epoch 3 (starting from 2055), a further 38 policy units will cease to be 'hold the line.' Therefore, if policies are implemented in future and defences removed or not maintained then constraints will reduce and opportunities increase.

Given the complexity of habitat roll-back, the areas of opportunity identified here just indicate a starting point for the evidence need on the occurrence of roll-back. The evidence need requires identification of locations where roll-back is actually occurring and this will require detailed site-level mapping, potentially including field work, rather than high-level analysis.

5. Conclusions

Some useful insights can be taken from the analysis presented here. The most constrained of the three habitats is saltmarsh, both in terms of length (256km) and percentage of coastline habitat length (55%); around 20% of coastline habitat lengths are constrained for frontal sand dunes (54km) and shingle (119km). Of these constrained lengths the majority (75%) of the saltmarsh constraint is not in urban areas, whereas ~45% of shingle and sand dune constraints are urban (and so it is unlikely that the constraints could be removed). There is less opportunity than constraint for saltmarsh (65km, 14% of coastline habitat length) and shingle (63km, 12% of coastline habitat length), whereas there is more opportunity than constraint for frontal sand dunes (147km, 54% of habitat length). Of these opportunity lengths, relatively little is in urban areas (1 – 6% of opportunity length) and so this factor being neglected is unlikely to change results on opportunity areas too much.

Given the large proportion of saltmarsh constraint length compared to opportunity length and the land use setting of the saltmarsh constraint (predominantly not in urban areas), it seems it would be most fruitful (out of the three habitats) to explore where changes in management could reduce constraints / increase opportunities for saltmarsh roll-back, for example by implementing SMP policies for areas of managed realignment. In terms of geographic spread, the locations of saltmarsh constraints and opportunities are largely estuarine, whereas shingle and sand dune are largely open coast. This just represents the geographic distribution of the habitats in general. It is worth noting that there is very little present day opportunity for roll-back in the Dyfi, Mawddach and Glaslyn/Dwryd estuaries due to the presence of defences, despite there being large areas of saltmarsh and large areas of accommodation space; in some areas following SMP policy would create roll-back opportunity.

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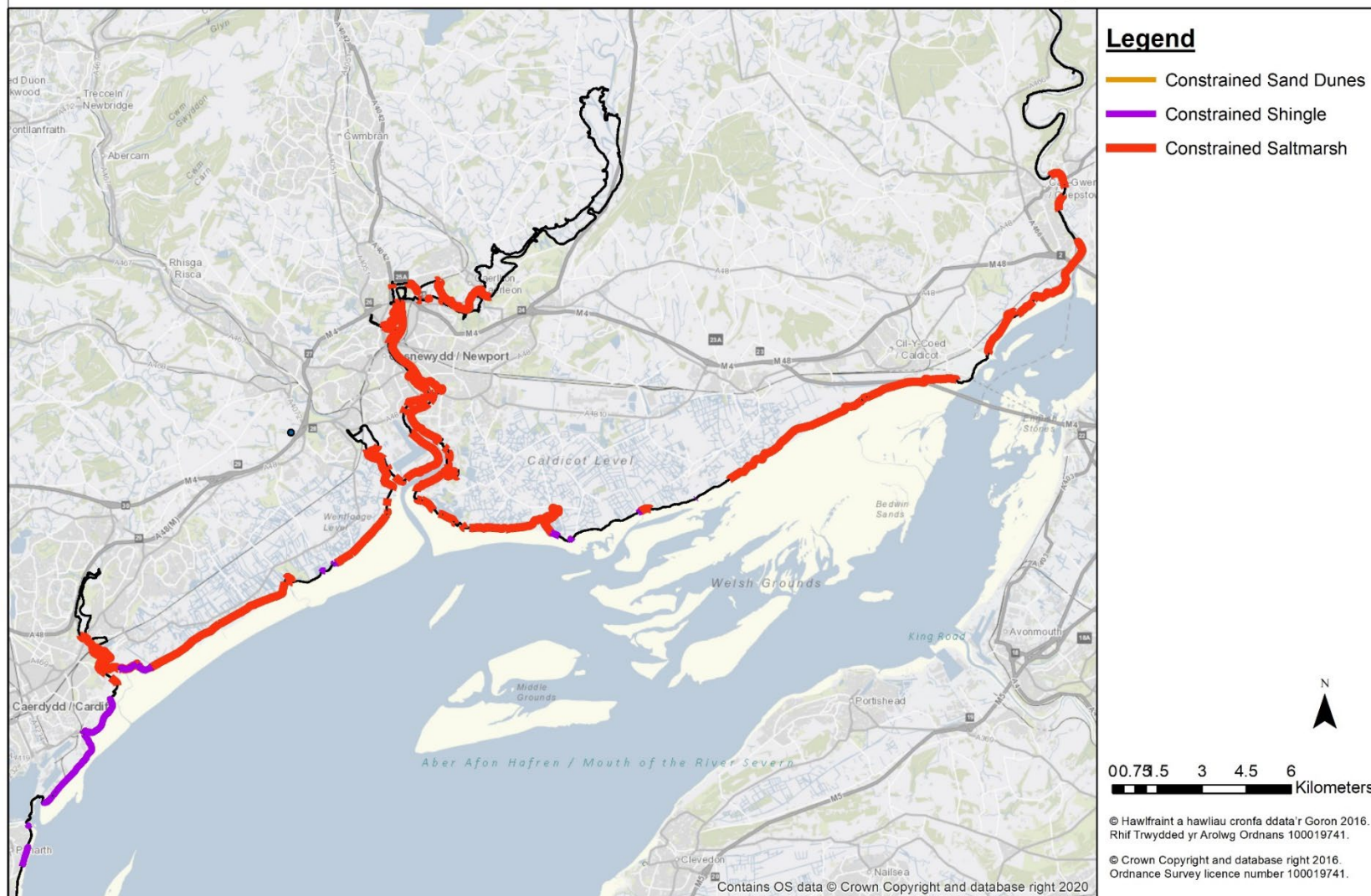
Appendices

Appendix A: Fine-scale maps of roll-back constraint areas.

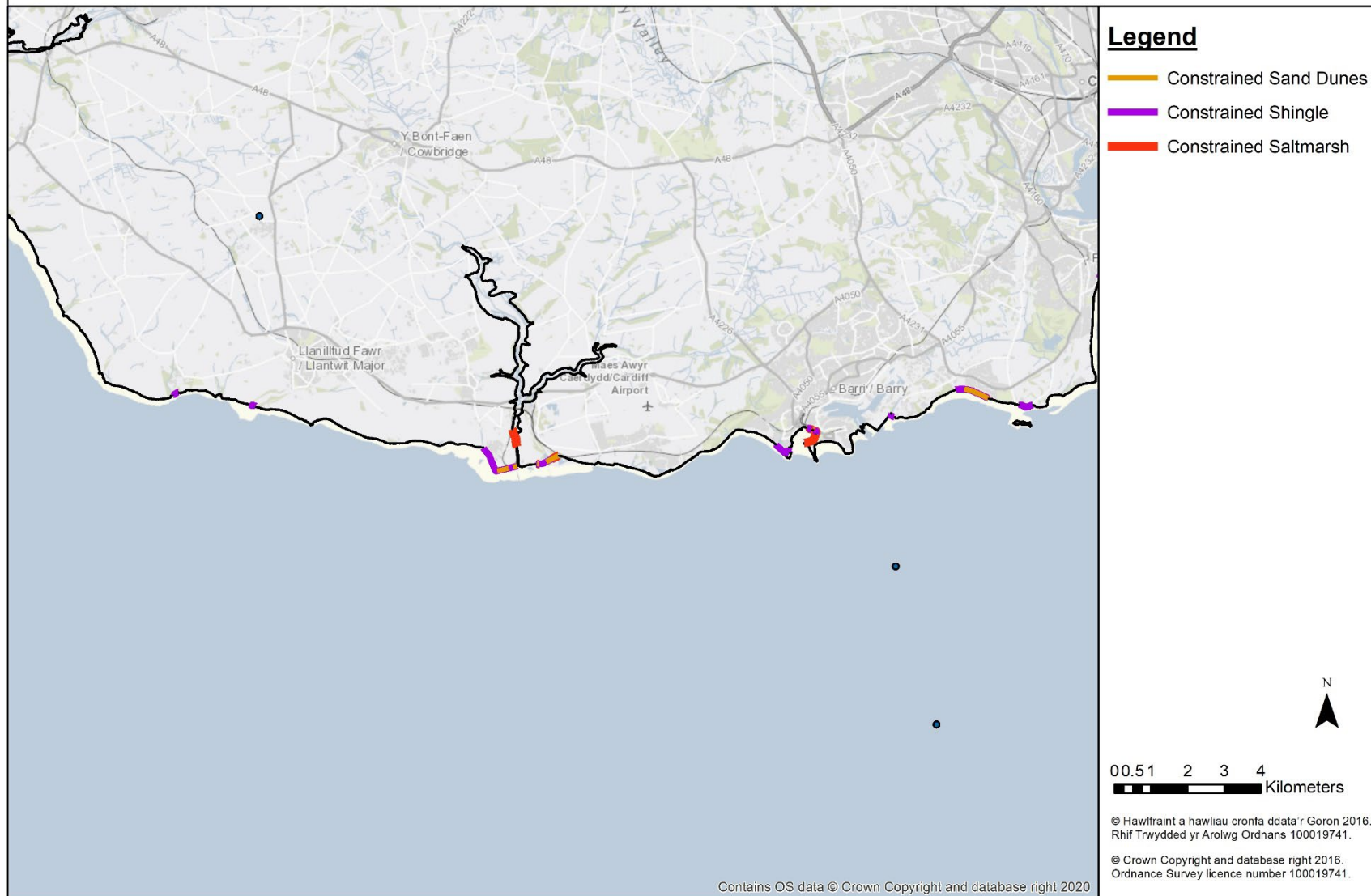
On the following pages, higher resolution maps of the Welsh coast are presented showing the areas of habitat constraint. All habitat constraints are displayed on the same maps, the lines denoting constraint are different widths so that areas where multiple habitats are constrained can be visualised. Since there are not constraints for the entire Welsh Coast, not all areas of coastline are covered. Note that the scale of these maps is not constant. The maps go from the southeast, in a clockwise direction around the Welsh coast, to the north-east. The maps are:

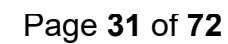
- A1: Roll-back constraints, English border to Cardiff
- A2: Roll-back constraints, Vale of Glamorgan coast
- A3: Roll-back constraints, Swansea Bay
- A4: Roll-back constraints, Burry Inlet
- A5: Roll-back constraints, Three Rivers complex
- A6: Roll-back constraints, Western Carmarthen Bay
- A7: Roll-back constraints, Milford Haven
- A8: Roll-back constraints, St Brides Bay and St Davids
- A9: Roll-back constraints, North Pembro. Coast
- A10: Roll-back constraints, Aberporth to Llanrhystud
- A11: Roll-back constraints, Aberystwyth and Borth
- A12: Roll-back constraints, Dyfi and Dysynni estuaries
- A13: Roll-back constraints, Mawddach estuary and surrounds
- A14: Roll-back constraints, Artro, Glaslyn/Dwyrhyd and Criccieth
- A15: Roll-back constraints, Llŷn Peninsula
- A16: Roll-back constraints, South-west Menai Strait and Anglesey
- A17: Roll-back constraints, Holy Island and northern Anglesey
- A18: Roll-back constraints, Red Wharf Bay and the eastern Menai Strait
- A19: Roll-back constraints, Conwy Estuary, Llandudno and Colwyn Bay
- A20: Roll-back constraints, Llanddulas to Prestatyn
- A21: Roll-back constraints, Outer Dee Estuary
- A22: Roll-back constraints, Inner Dee Estuary

A1: Roll-back constraints, English border to Cardiff



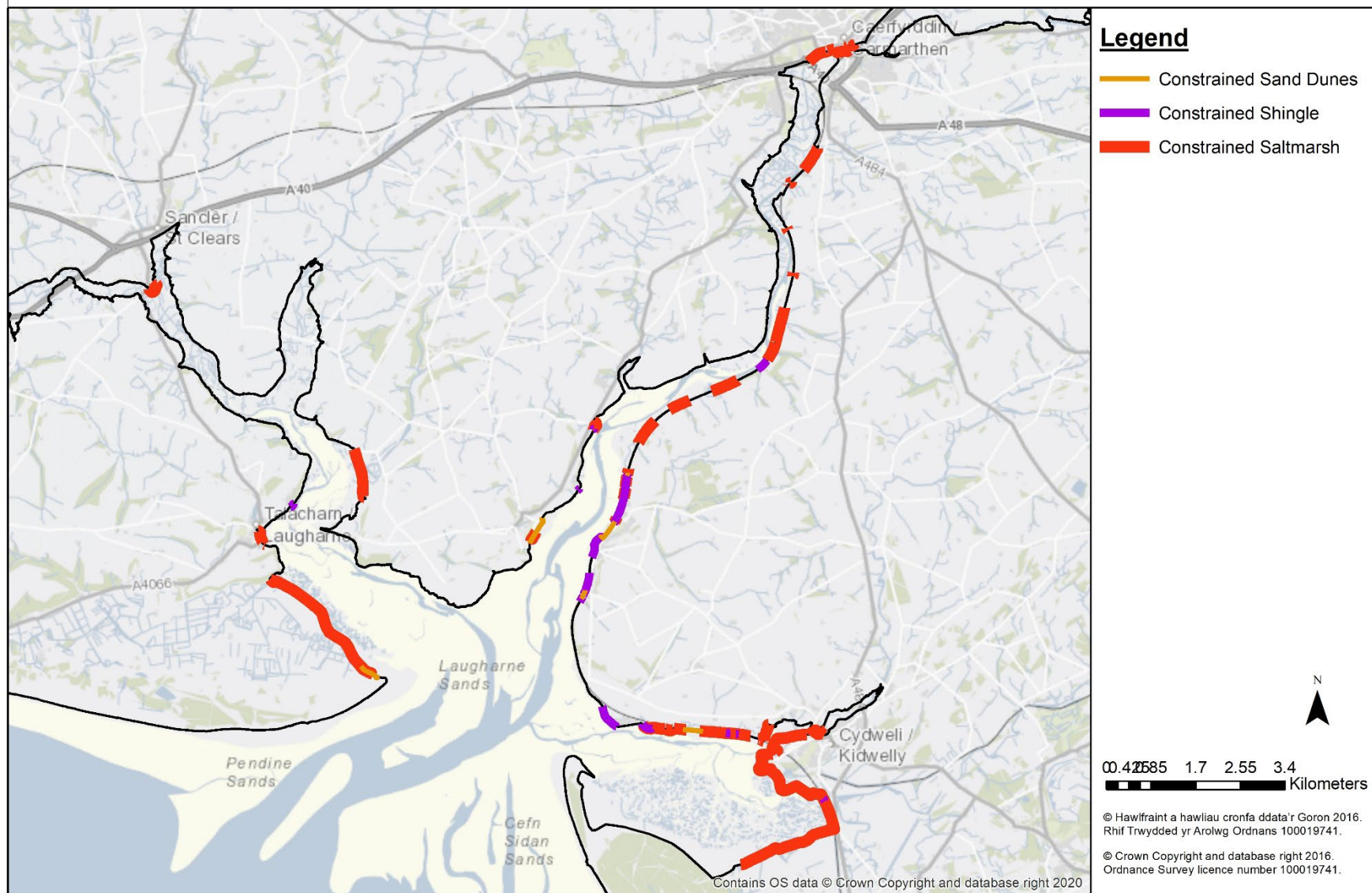
A2: Roll-back constraints, Vale of Glamorgan coast



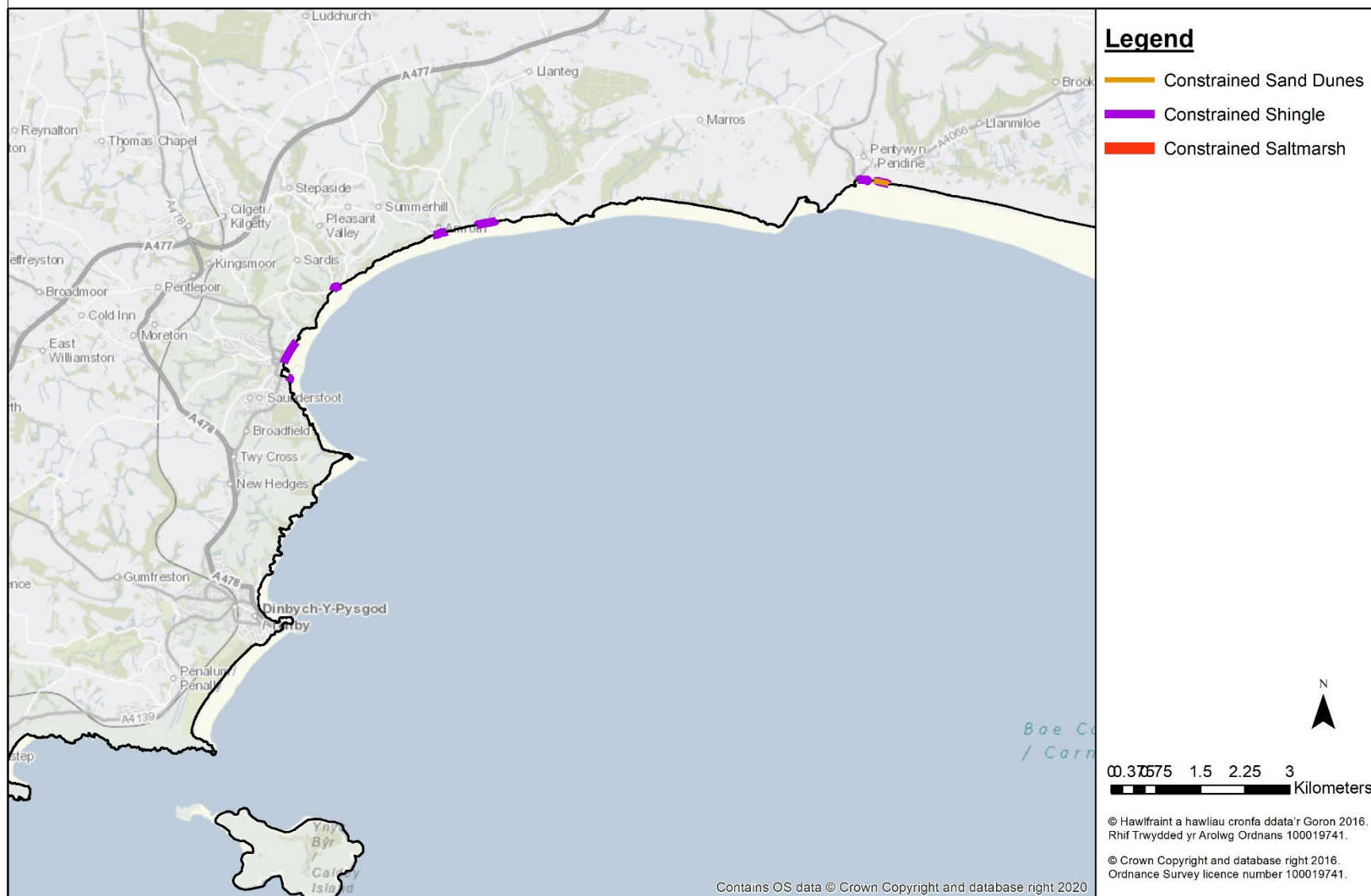




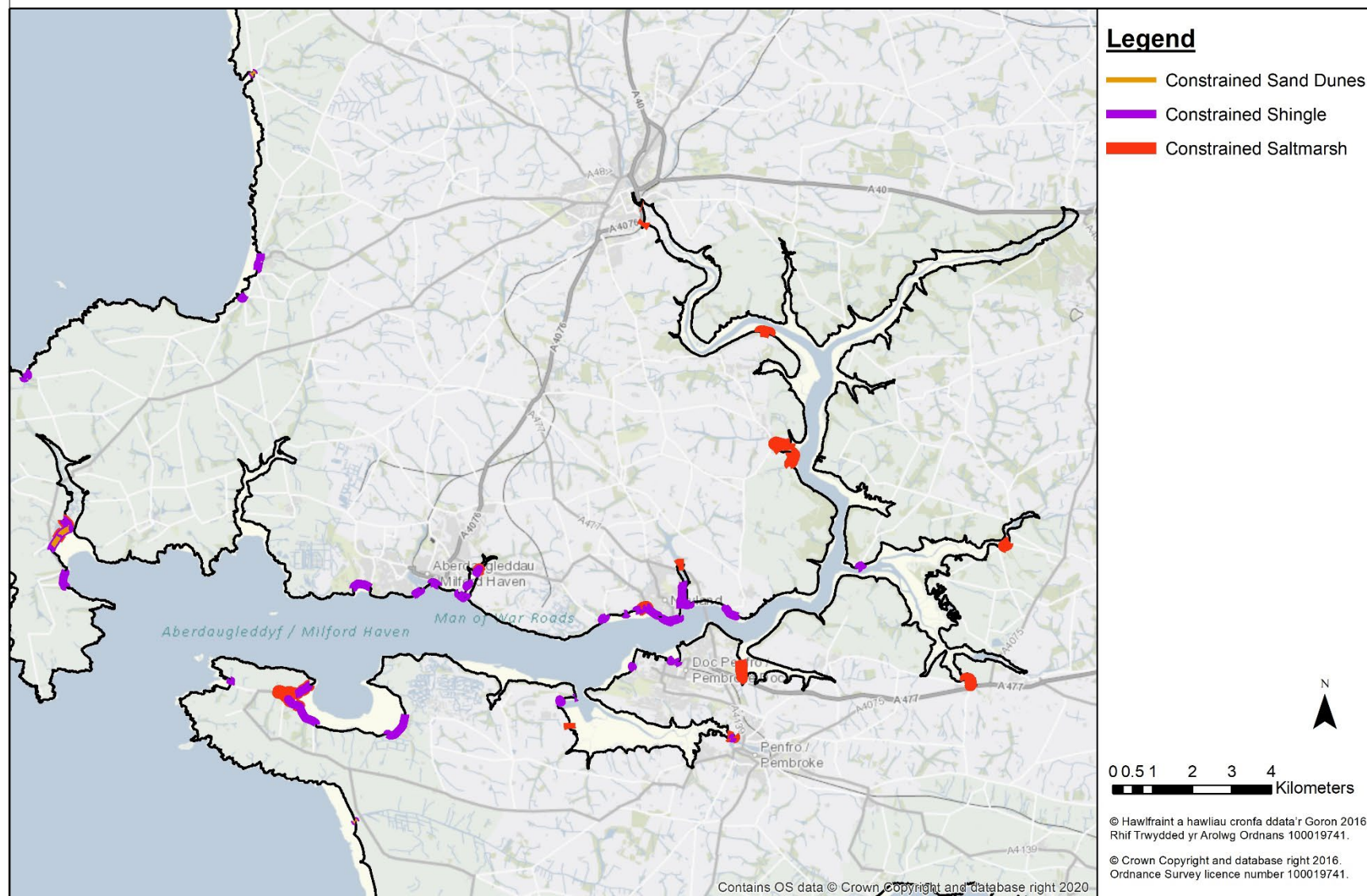
A5: Rollback constraints, Three rivers complex



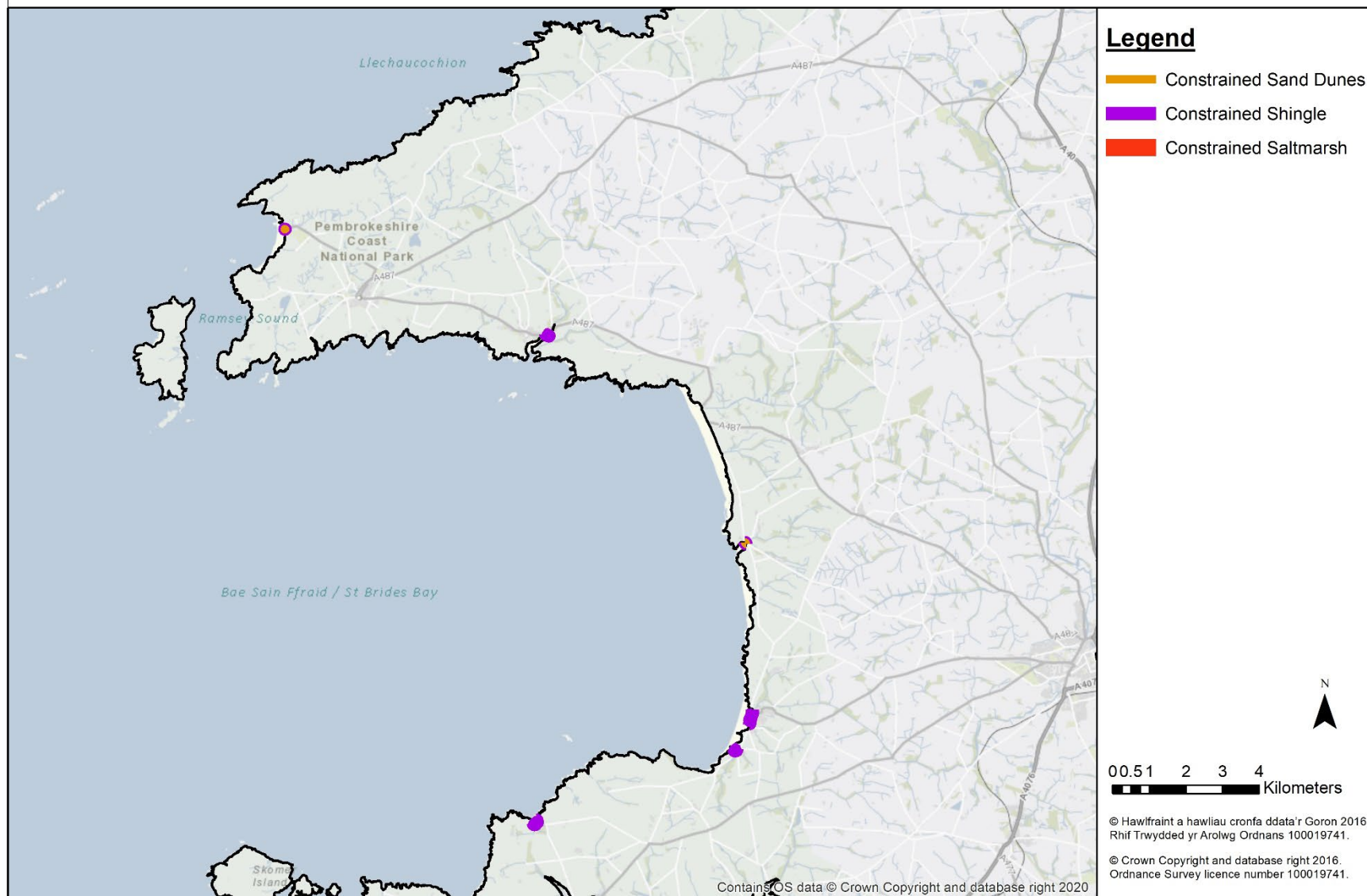
A6: Rollback constraints, Western Carmarthen Bay



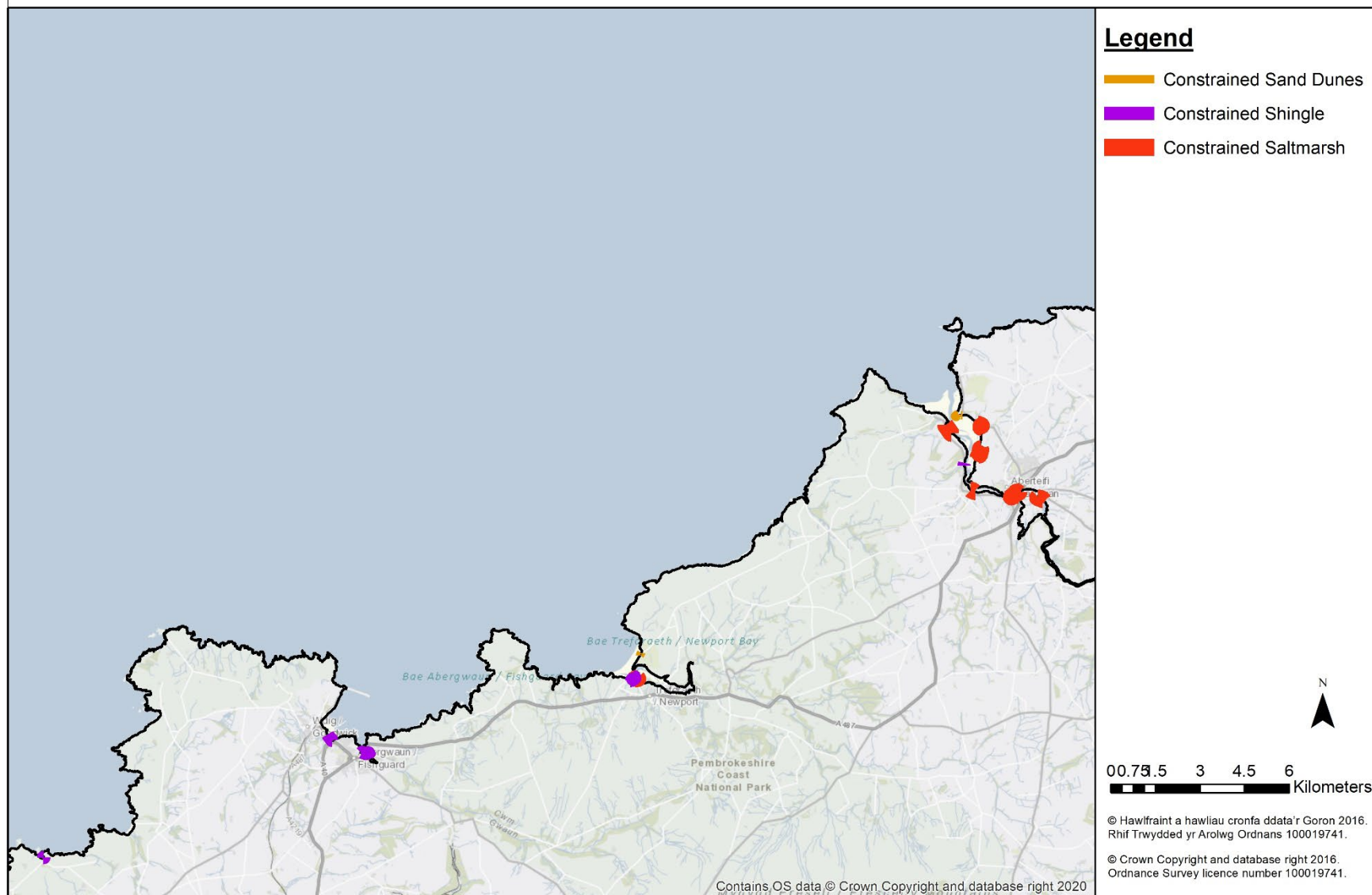
A7: Rollback constraints, Milford Haven



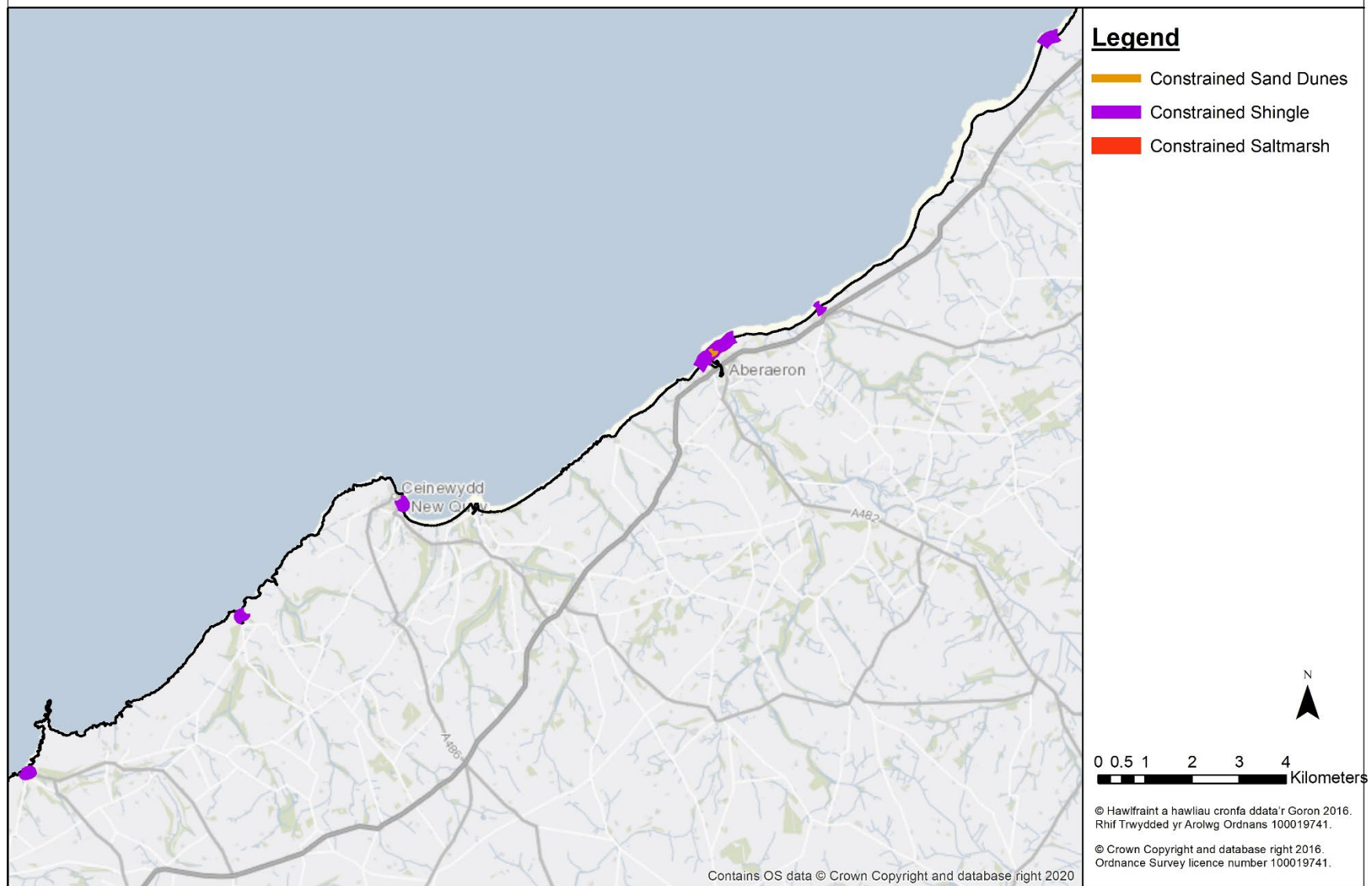
A8: Rollback constraints, St Brides Bay and St David's



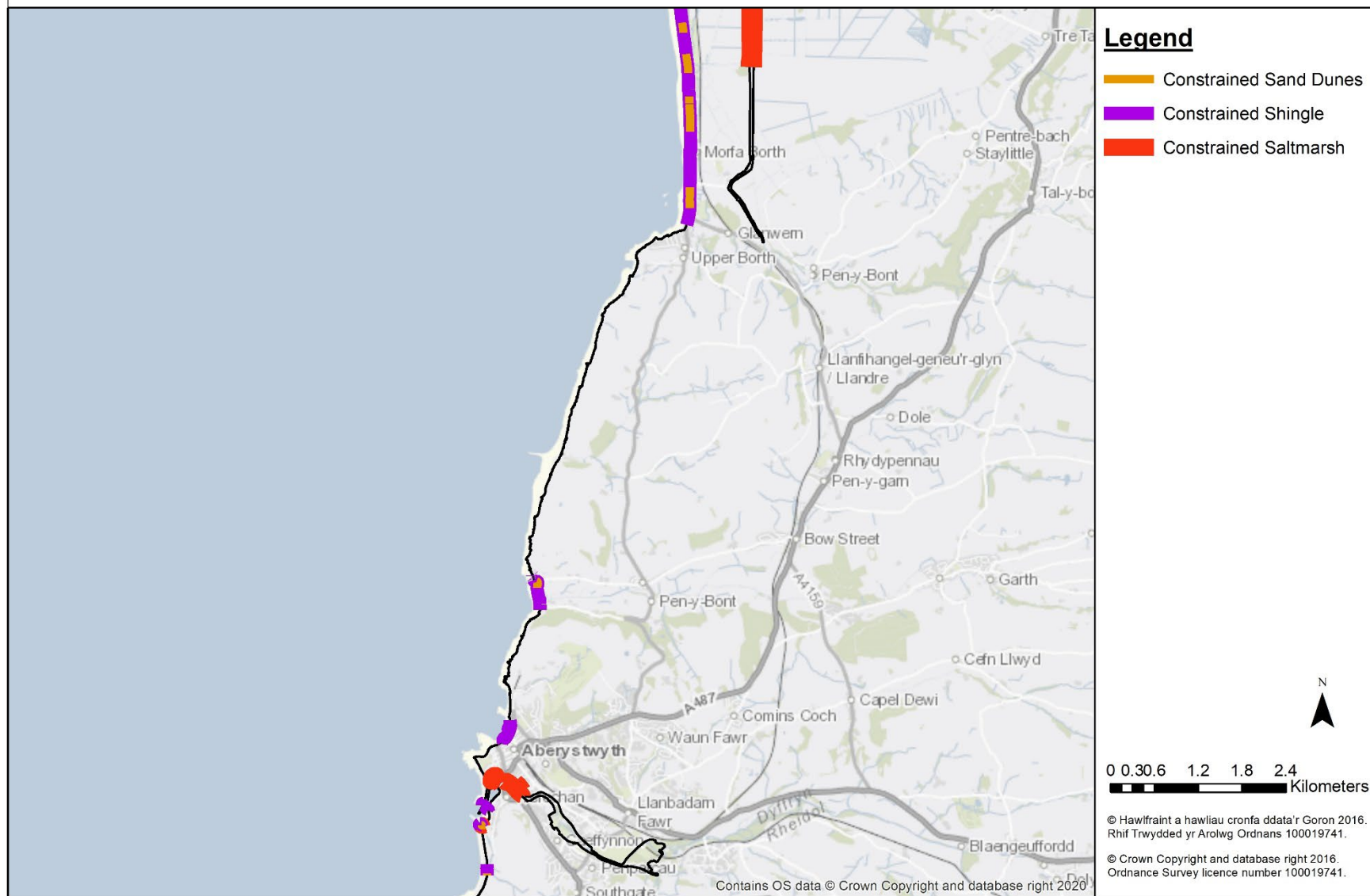
A9: Rollback constraints, North Pembro. Coast



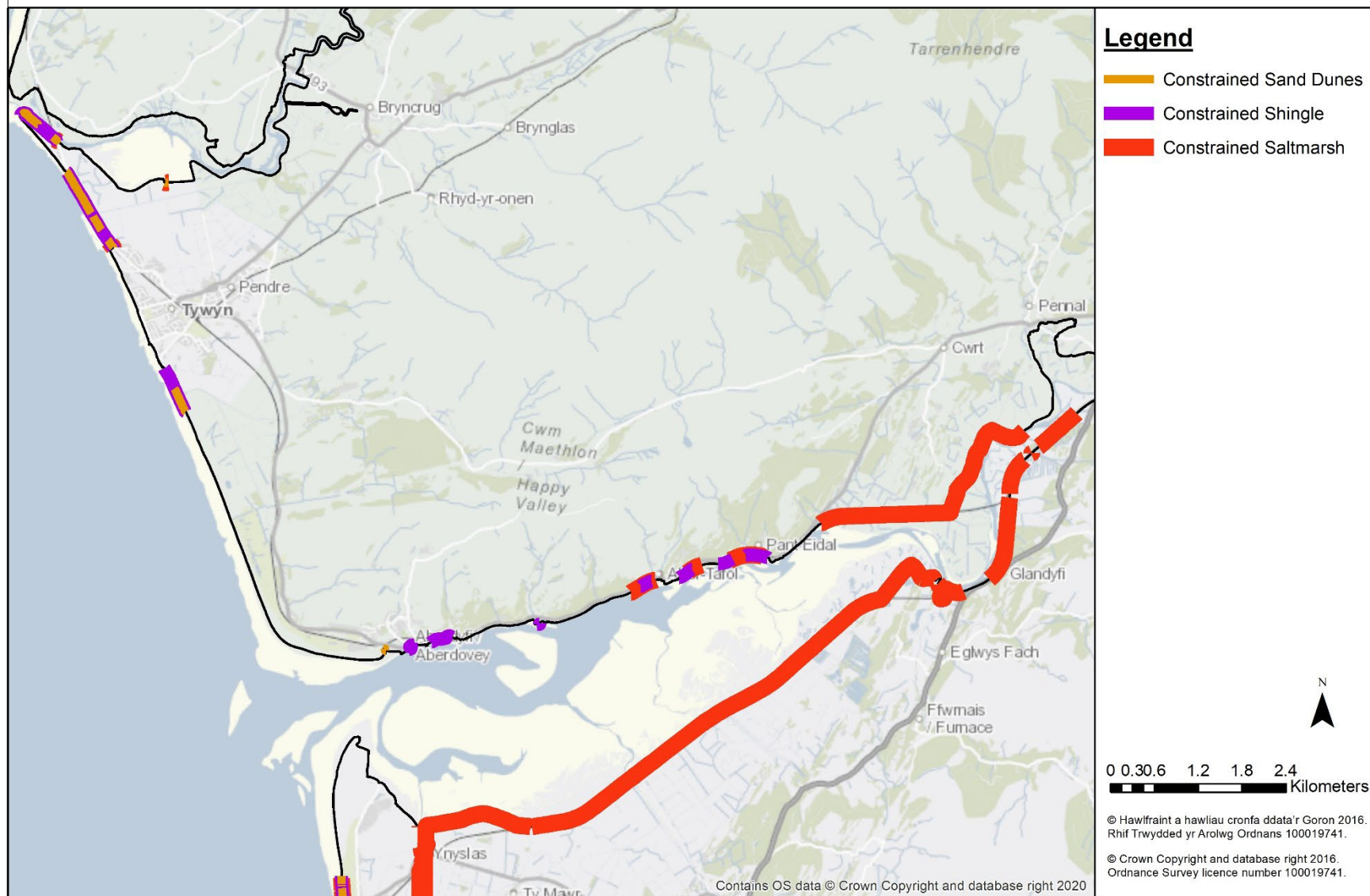
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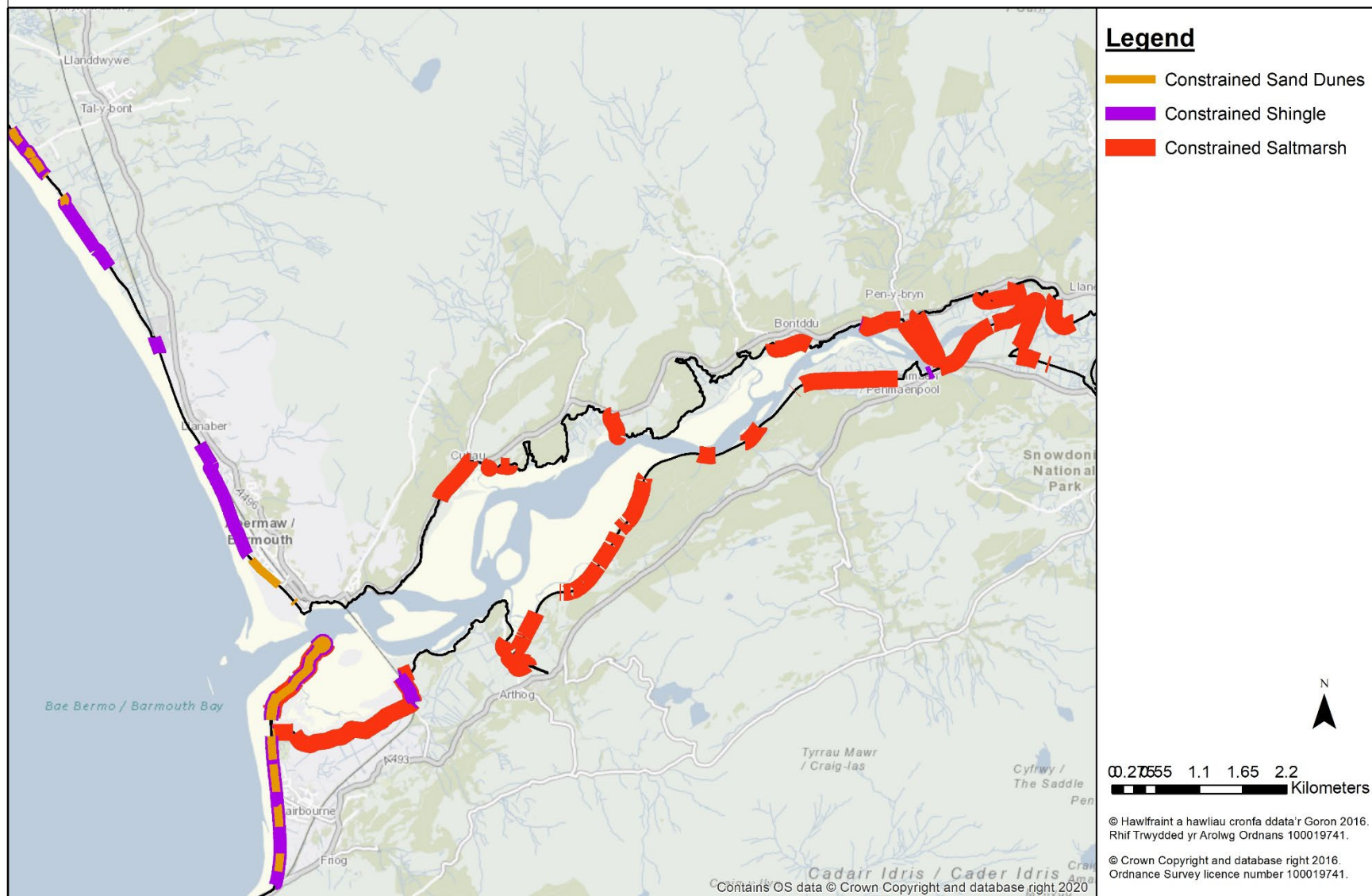
A11: Rollback constraints, Aberystwyth and Borth



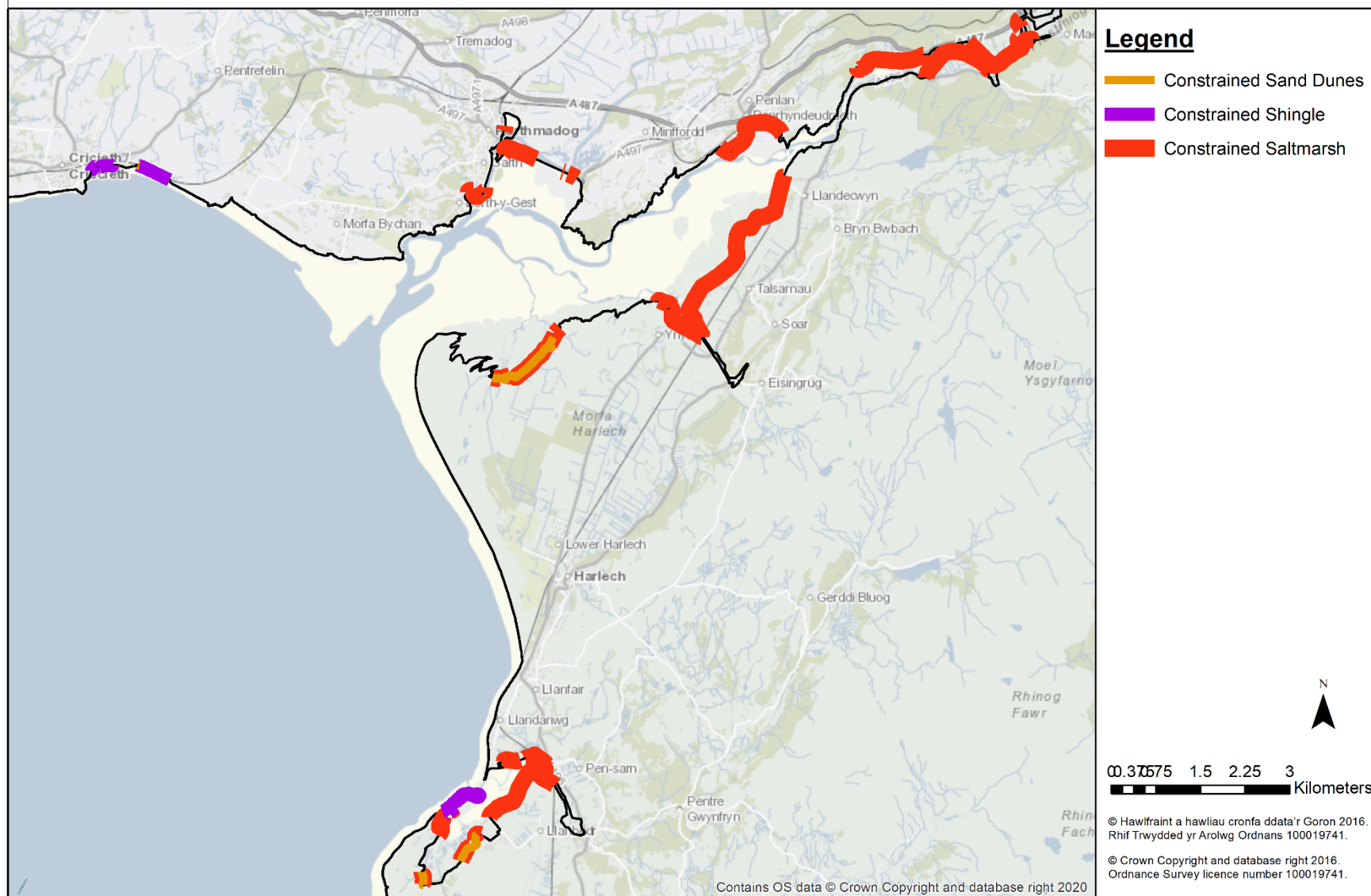
A12: Rollback constraints, Dyfi and Dysynni estuaries



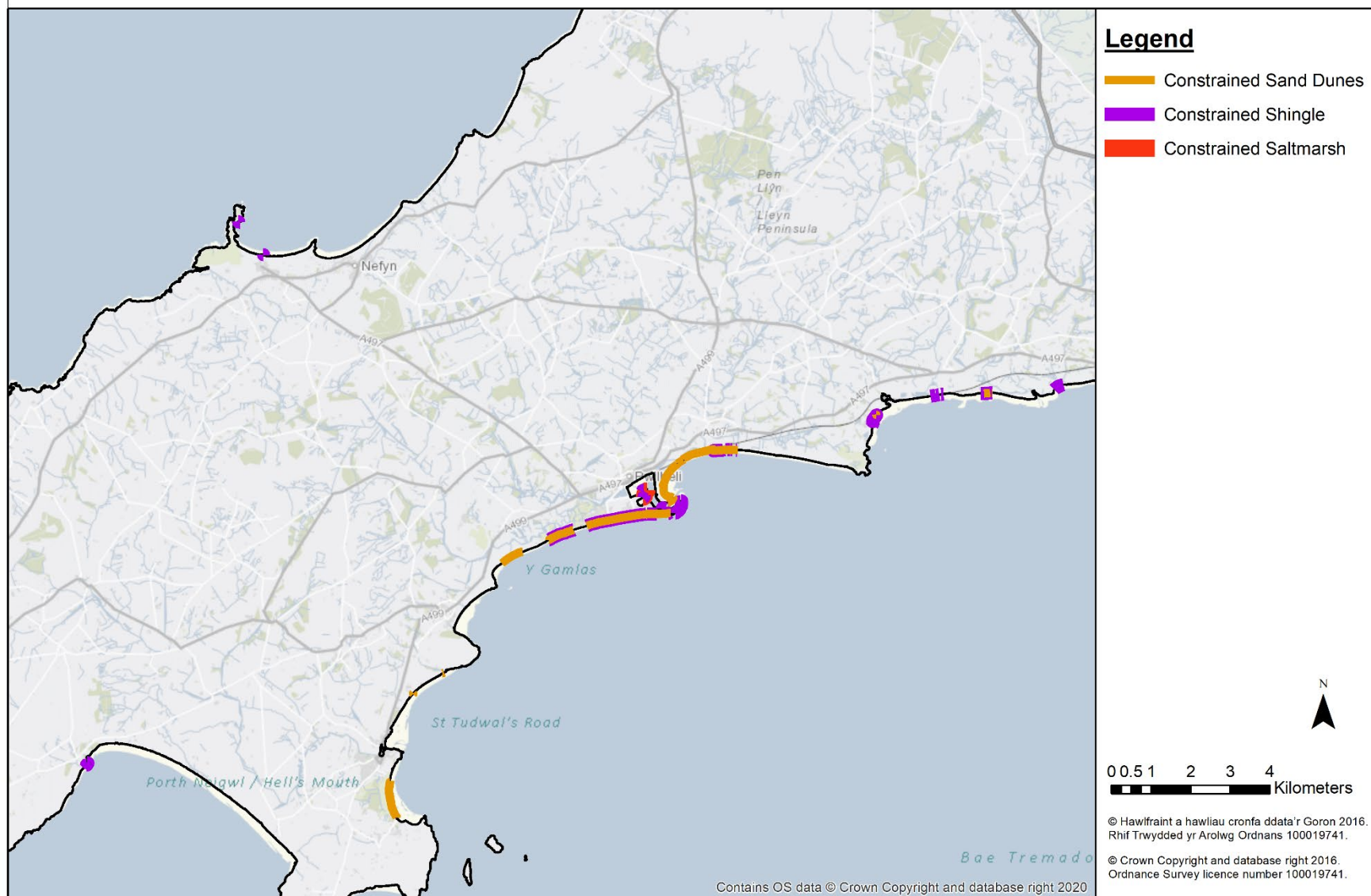
A13: Rollback constraints, Mawddach estuary and surrounds



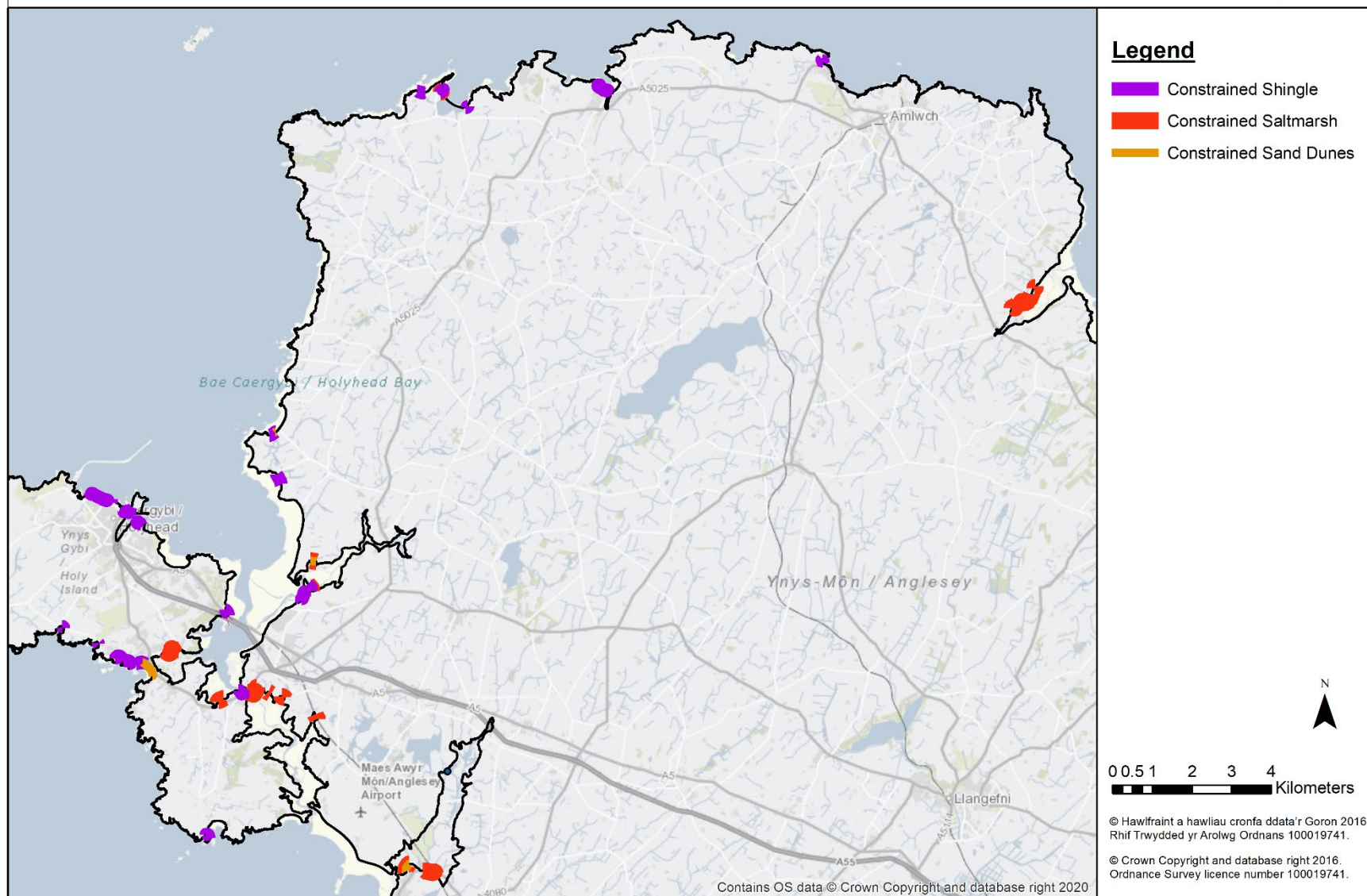
A14: Rollback constraints, Artro, Glaslyn/Dwryd and Criccieth



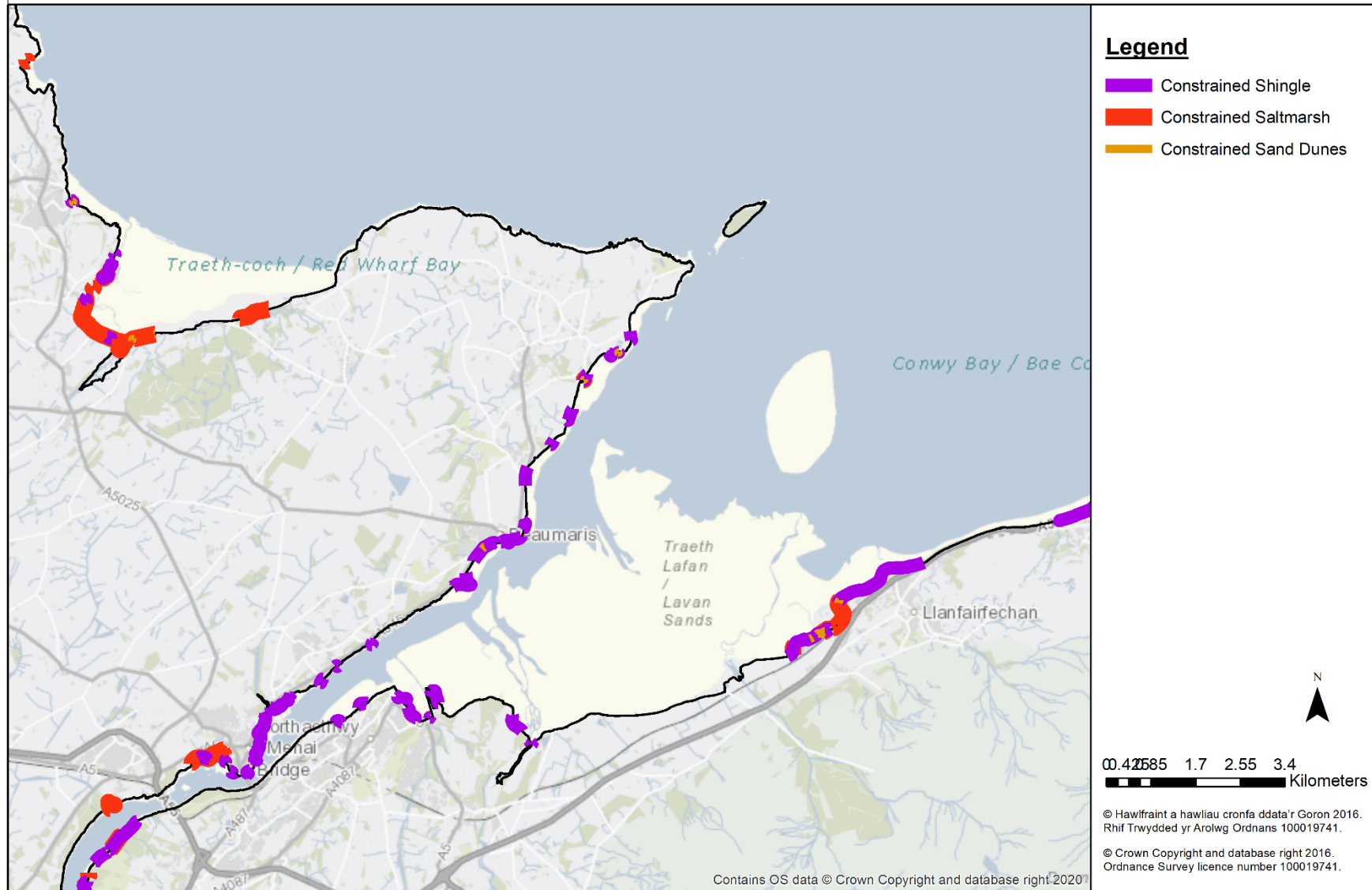
A15: Rollback constraints, Llyn Peninsula





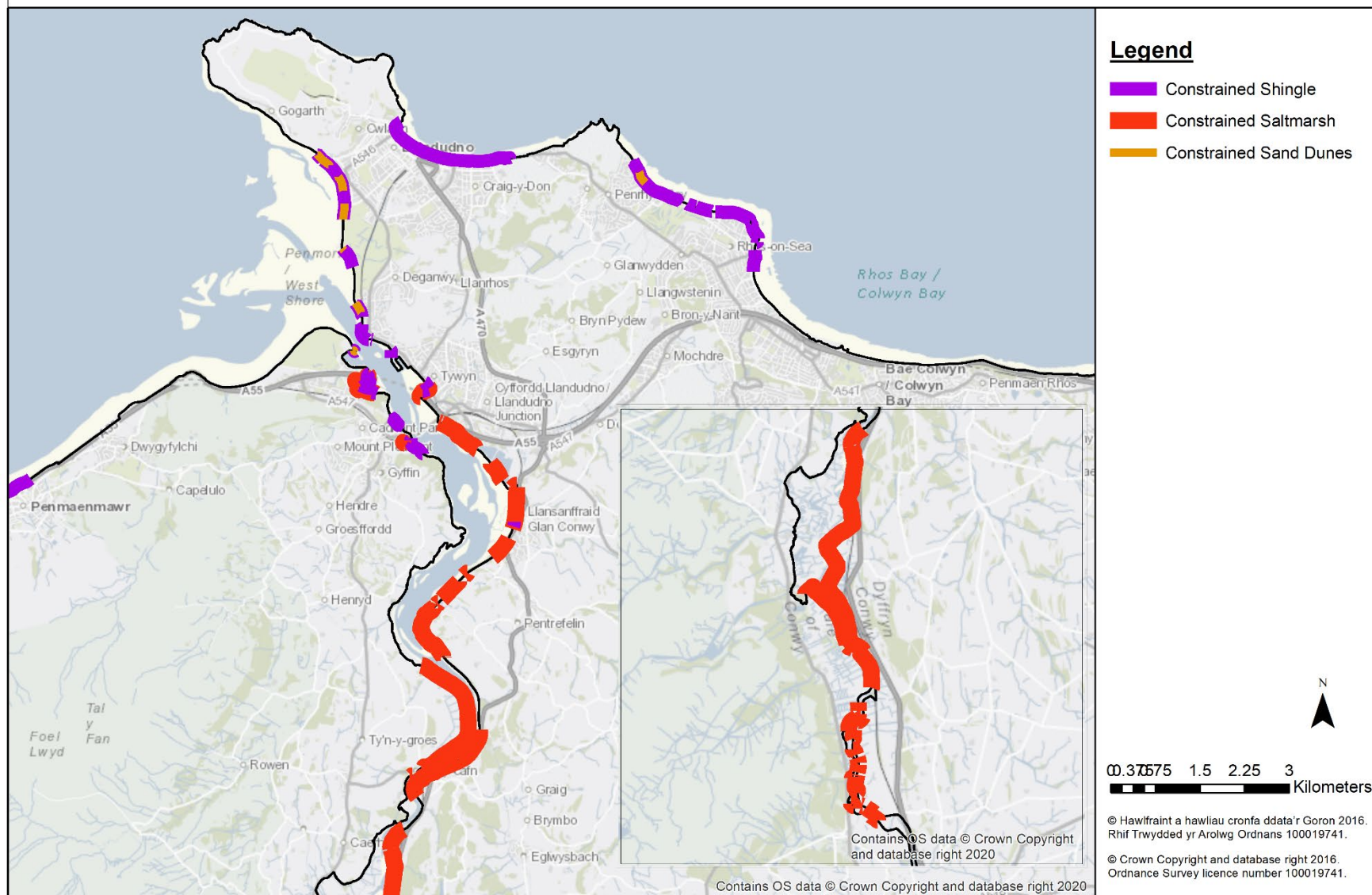


A18: Red Wharf Bay and the eastern Menai Strait

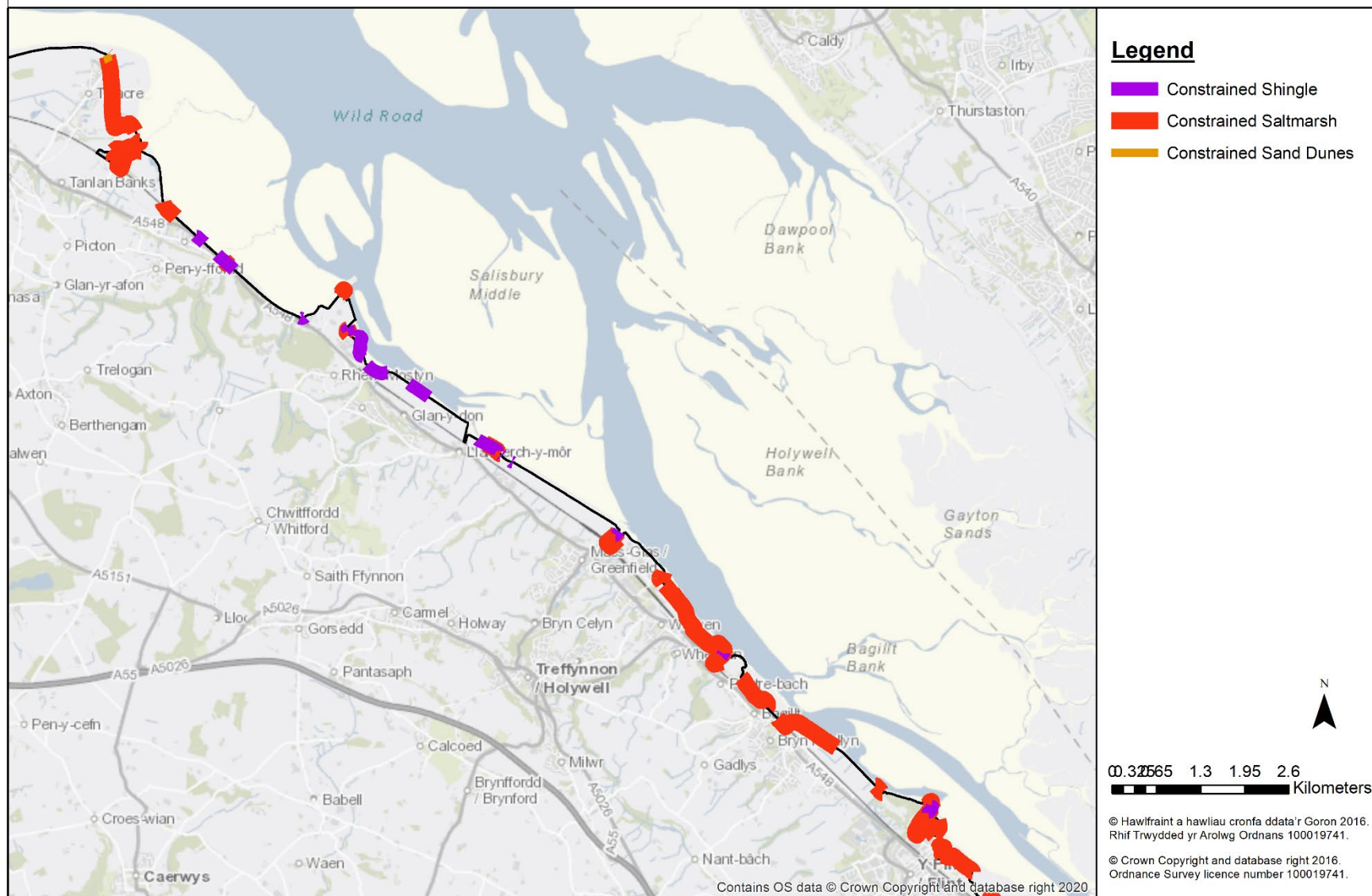


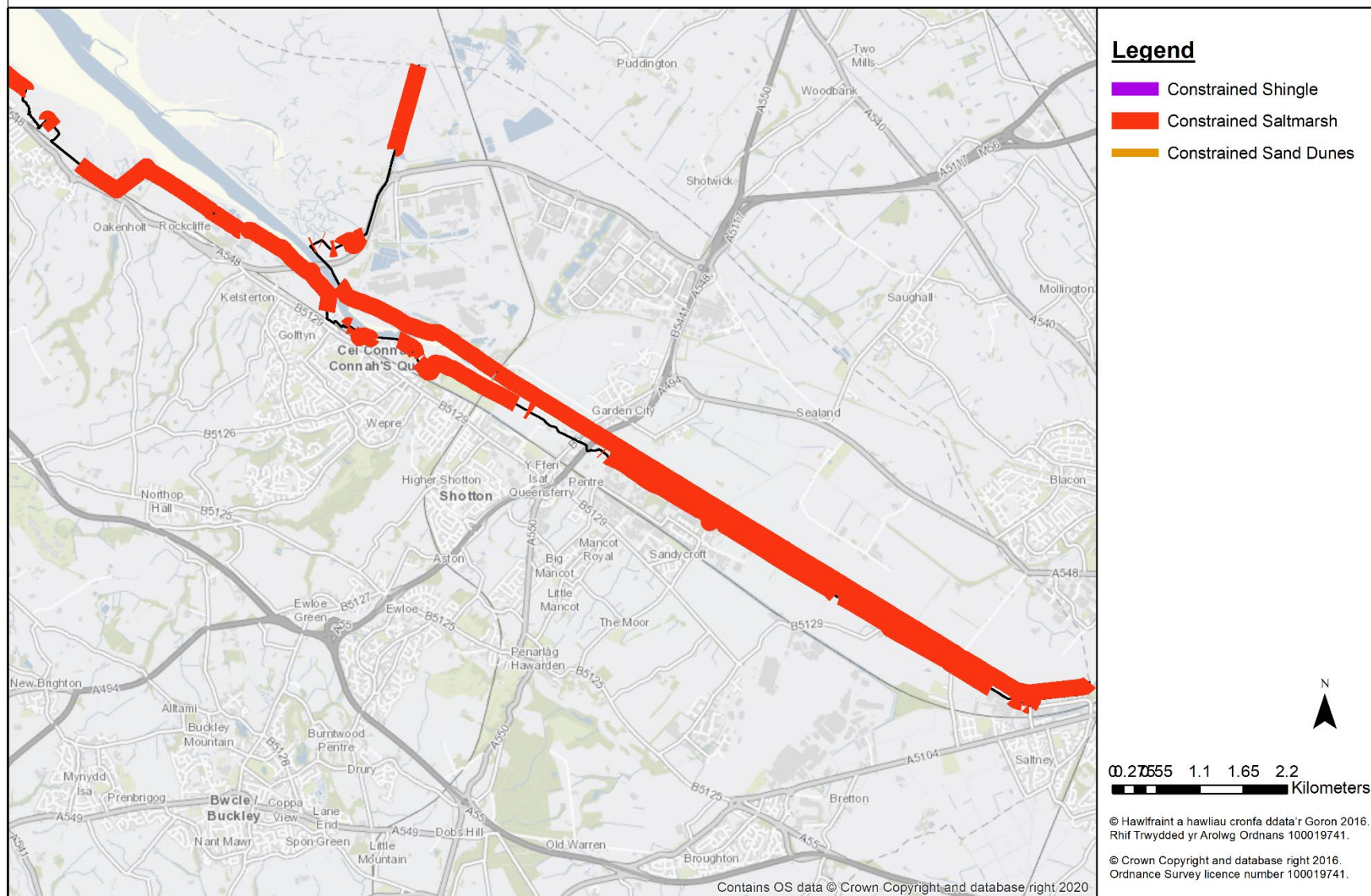


A19: Conwy Estuary, Llandudno and Colwyn Bay (inset shows upper estuary)







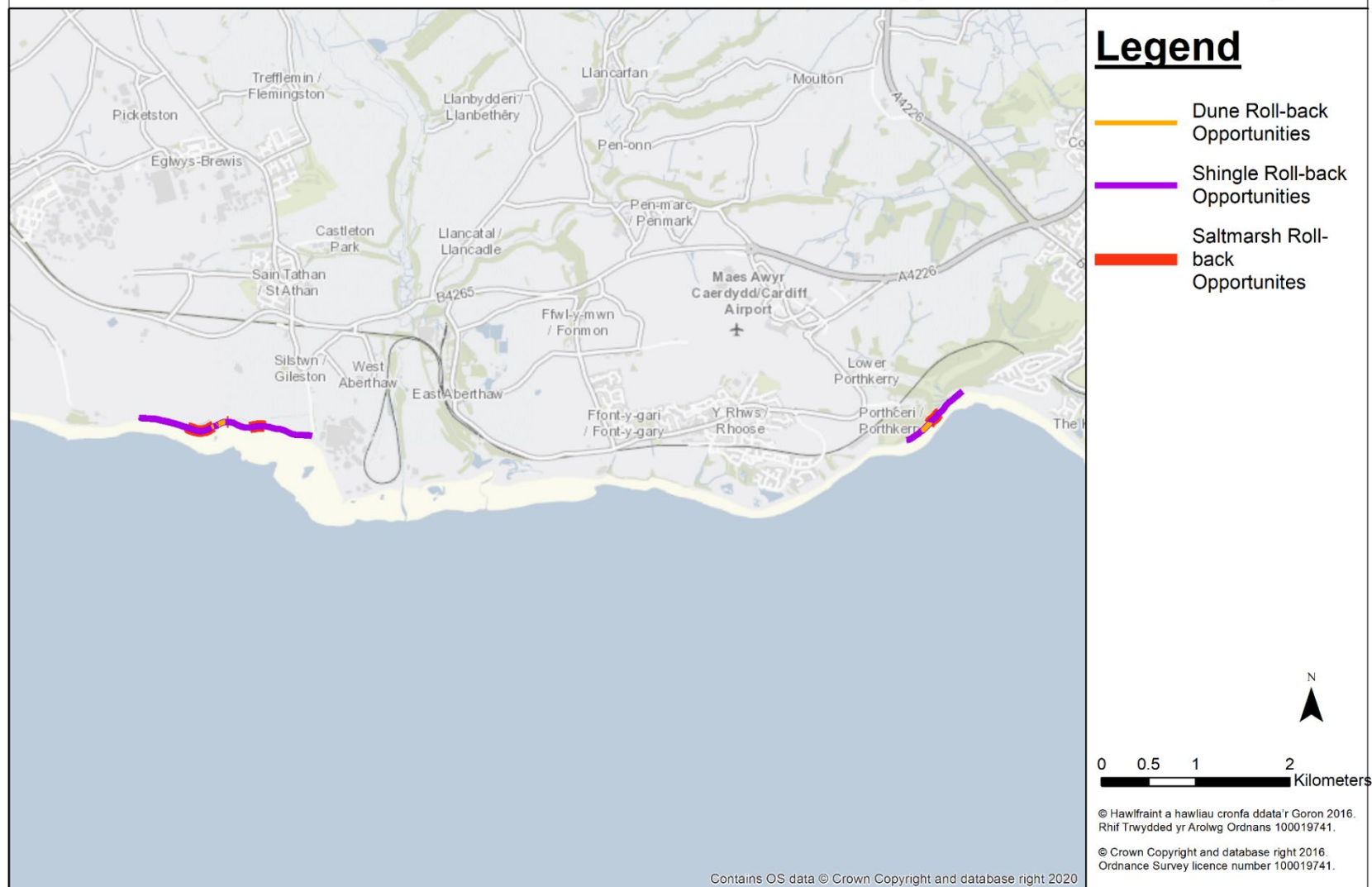


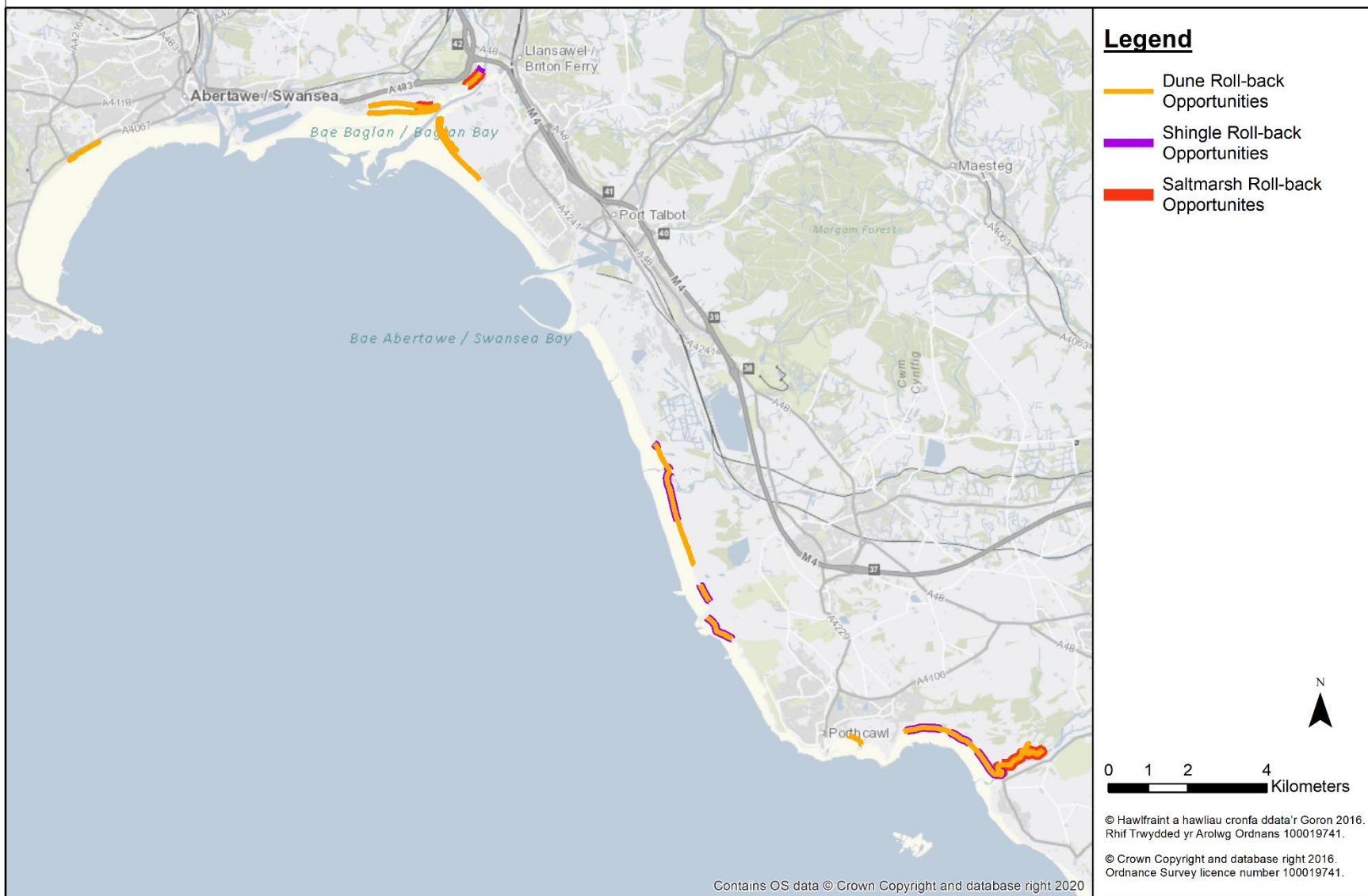
Appendix B: Fine scale maps of roll-back opportunities

On the following pages, higher resolution maps of the Welsh coast are presented showing the areas of opportunity for habitat roll-back. All habitat opportunities are displayed on the same maps, the lines denoting opportunity are different widths so that multiple habitat opportunities in the same location can be seen. Note that the scale of these maps is not constant and that due to there being large stretches of coast with no mapped opportunity, the whole coast is not covered. The maps go from the southeast, in a clockwise direction around the Welsh coast, to the north-east. The maps are:

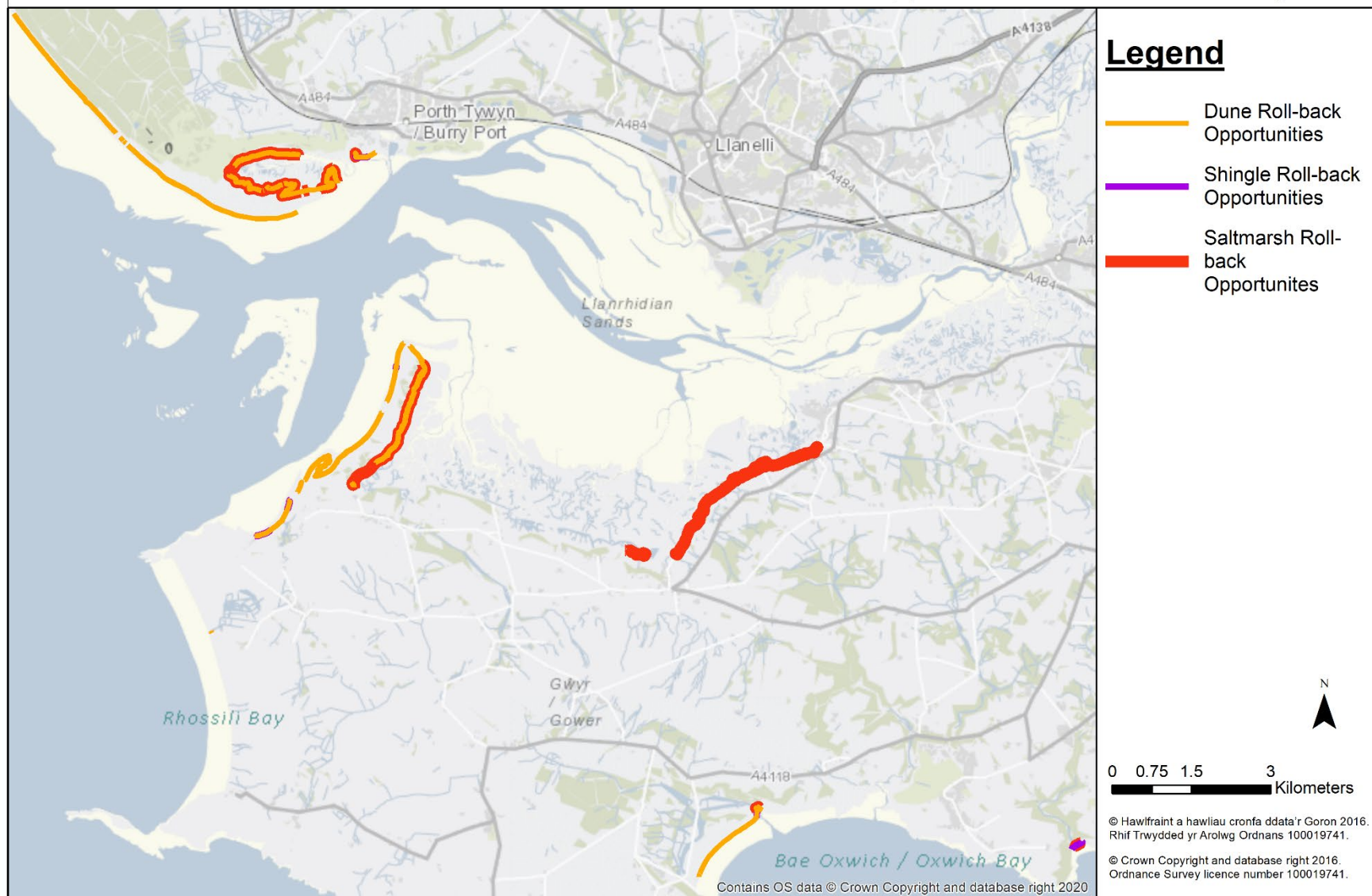
- B1: Roll-back opportunities, Vale of Glamorgan
- B2: Roll-back opportunities, Porthcawl and Swansea Bay
- B3: Roll-back opportunities, Gower and Burry Inlet
- B4: Roll-back opportunities Three Rivers Complex
- B5: Roll-back opportunities, Western Carmarthen Bay
- B6: Roll-back opportunities, St David's Peninsula
- B7: Roll-back opportunities, Newport to Cardigan
- B8: Roll-back opportunities, Aberaeron
- B9: Roll-back opportunities, Aberystwyth
- B10: Roll-back opportunities, Ynyslas and Tywyn
- B11: Roll-back opportunities, Barmouth and surrounds
- B12: Roll-back opportunities, Morfa Dyffryn to Criccieth
- B13: Roll-back opportunities, South-east Llyn Peninsula
- B14: Roll-back opportunities, Trefor to Newborough
- B15: Roll-back opportunities, Western Anglesey and Holy Island
- B16: Roll-back opportunities, Northern Anglesey
- B17: Roll-back opportunities, Menai Straights and Red Wharf Bay
- B18: Roll-back opportunities, Conwy Estuary
- B19: Roll-back opportunities, Dee Estuary

B1: Roll-back opportunities, Vale of Glamorgan

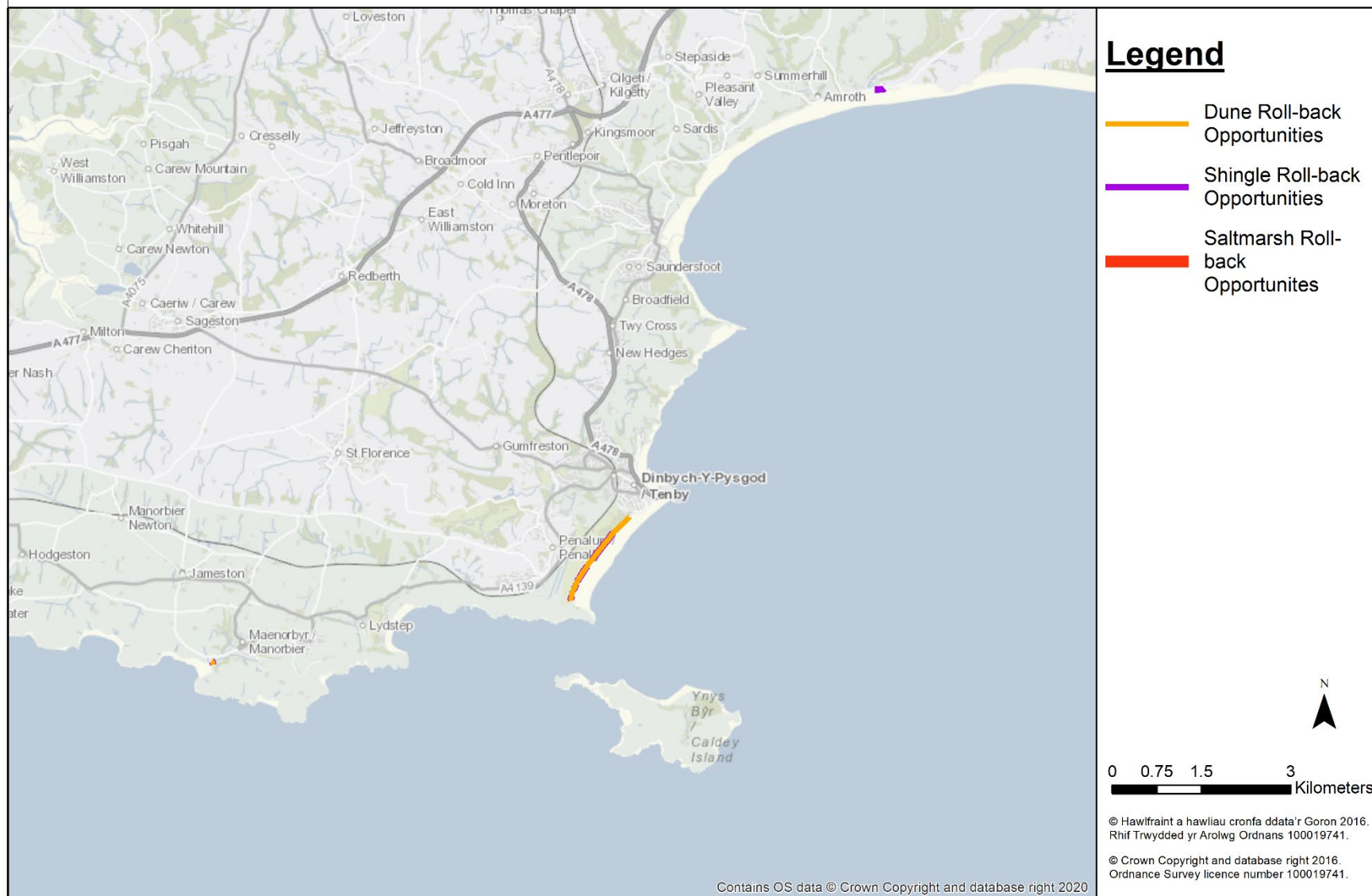


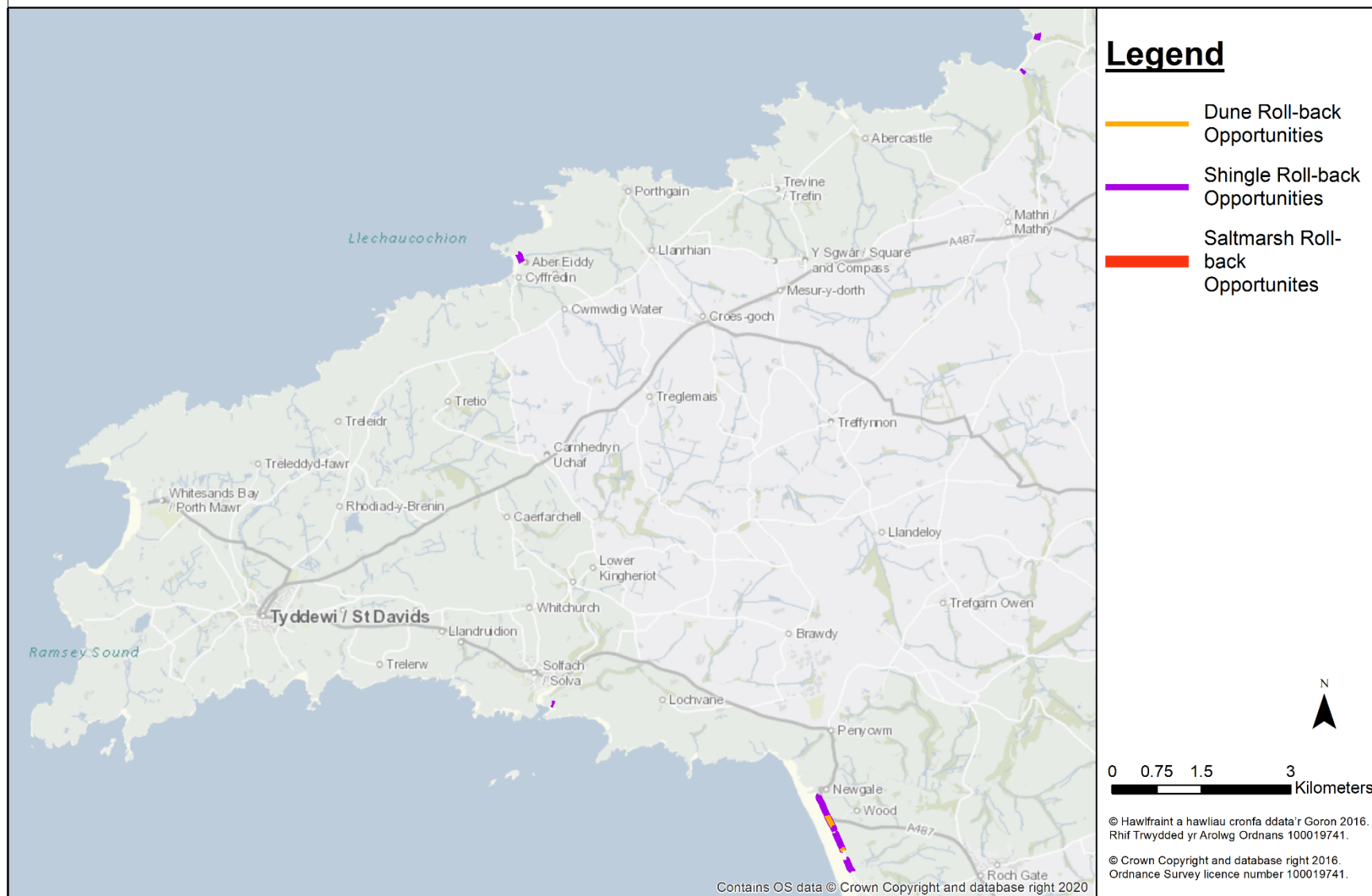


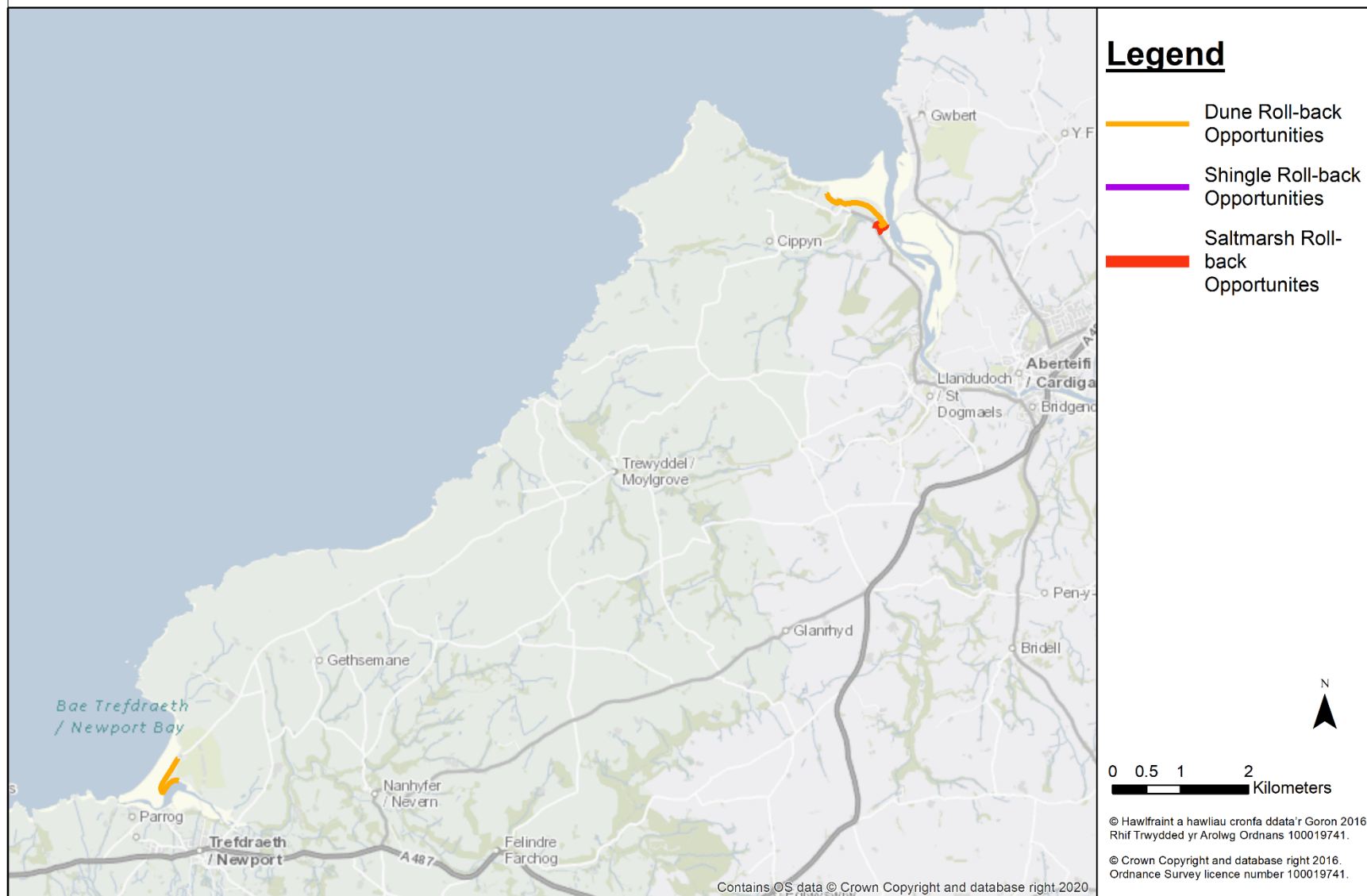
B3: Roll-back opportunities, Gower and Burry Inlet



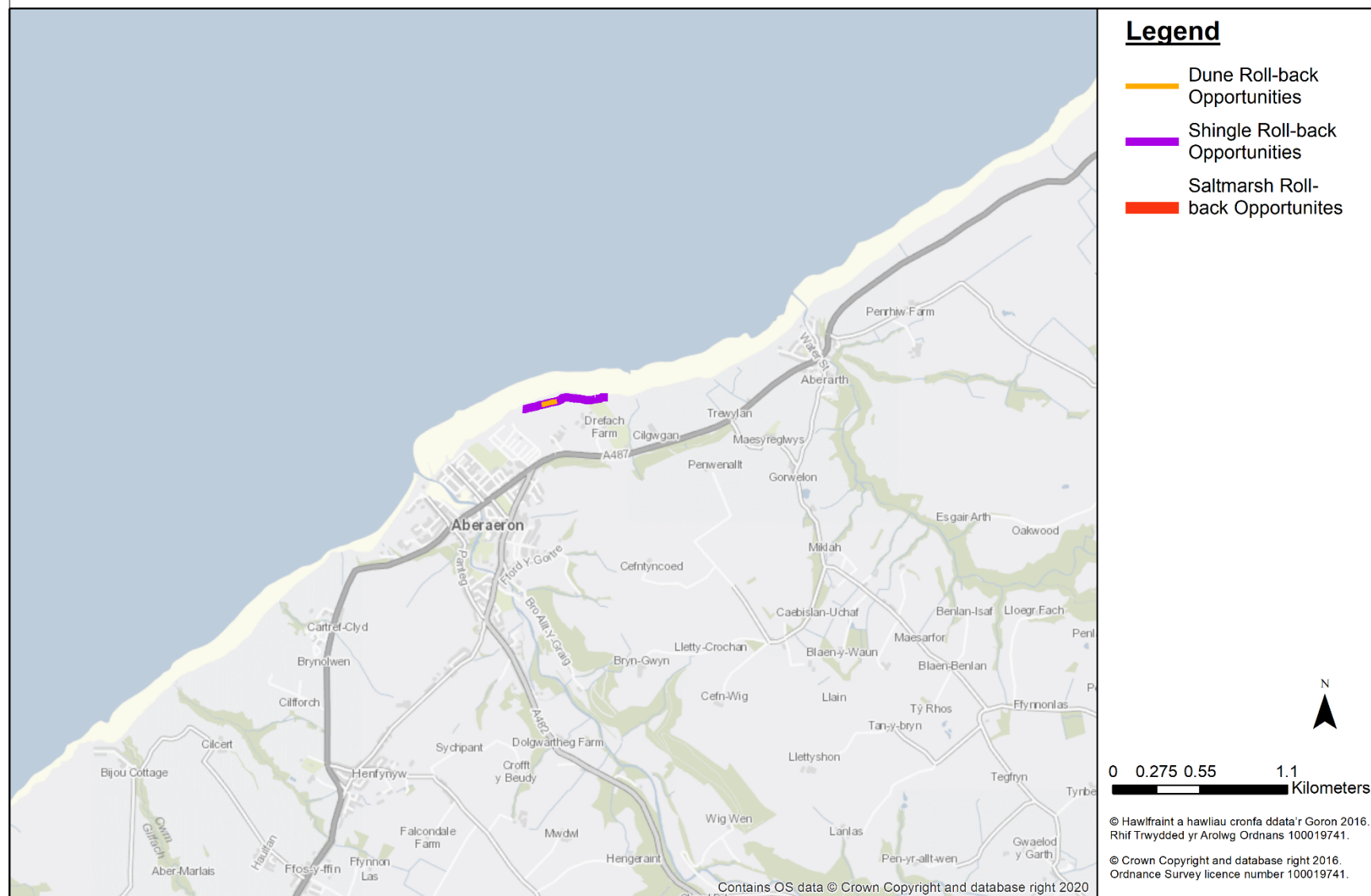




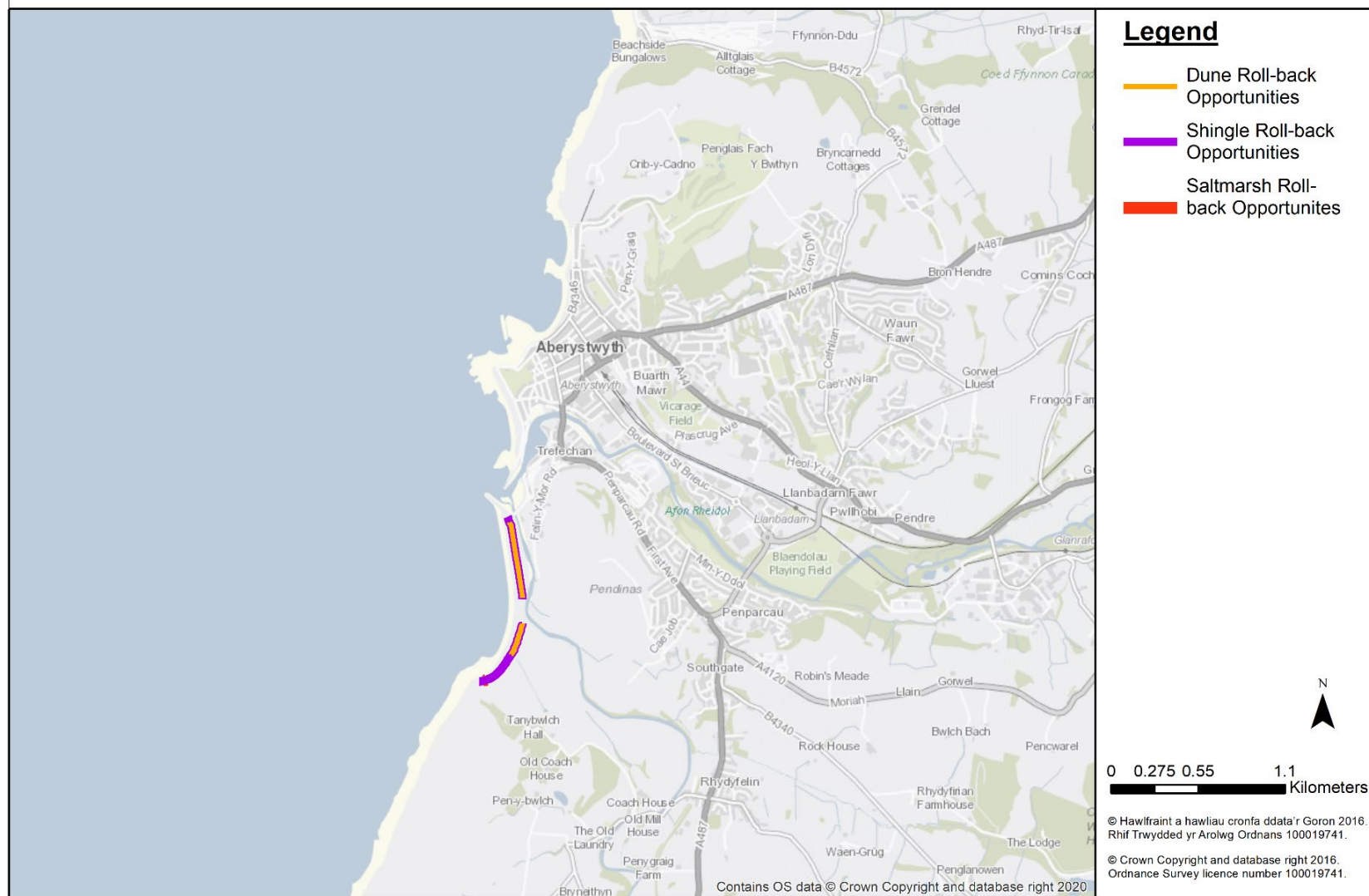




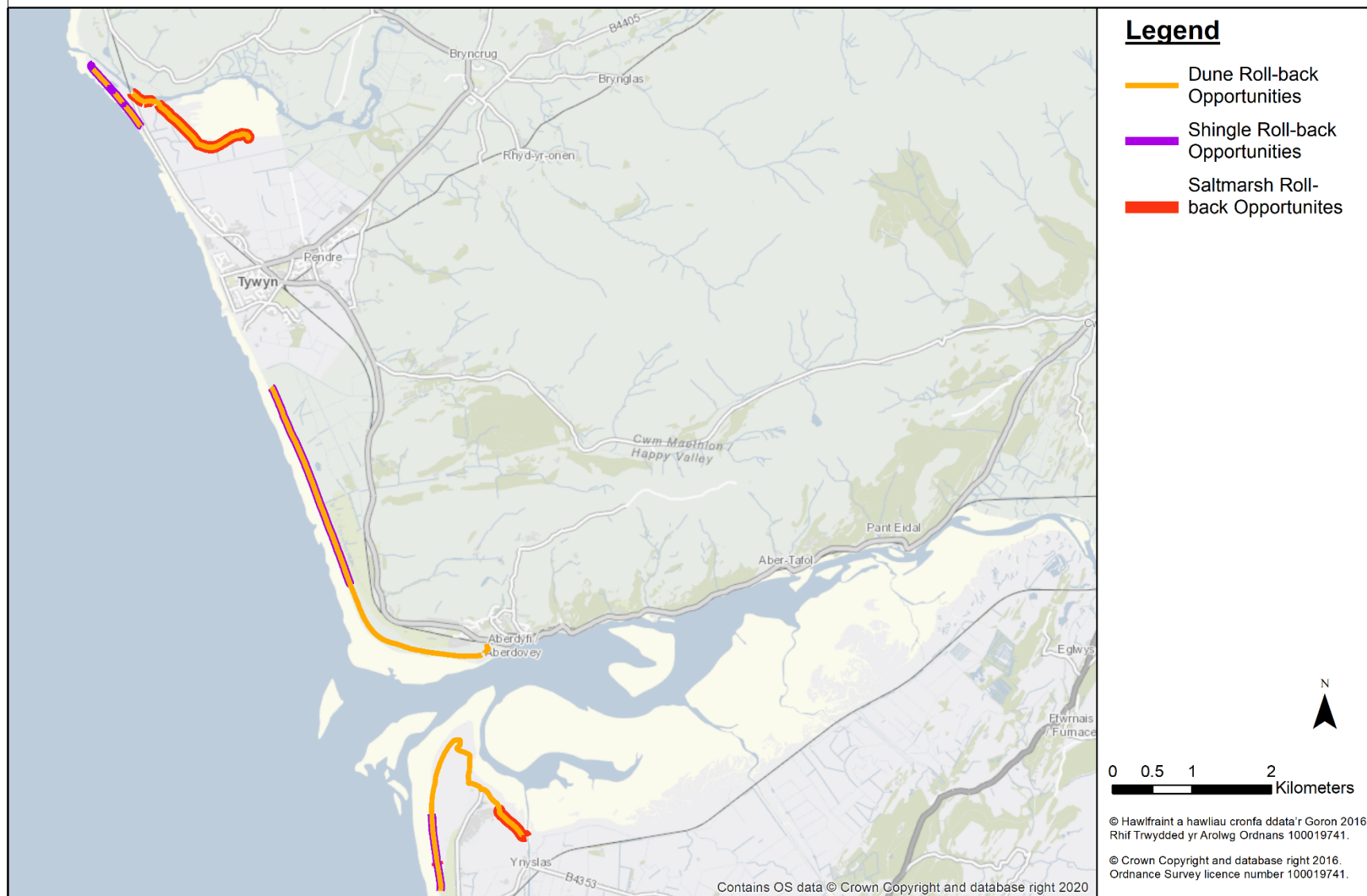
B8: Roll-back opportunities, Aberaeron

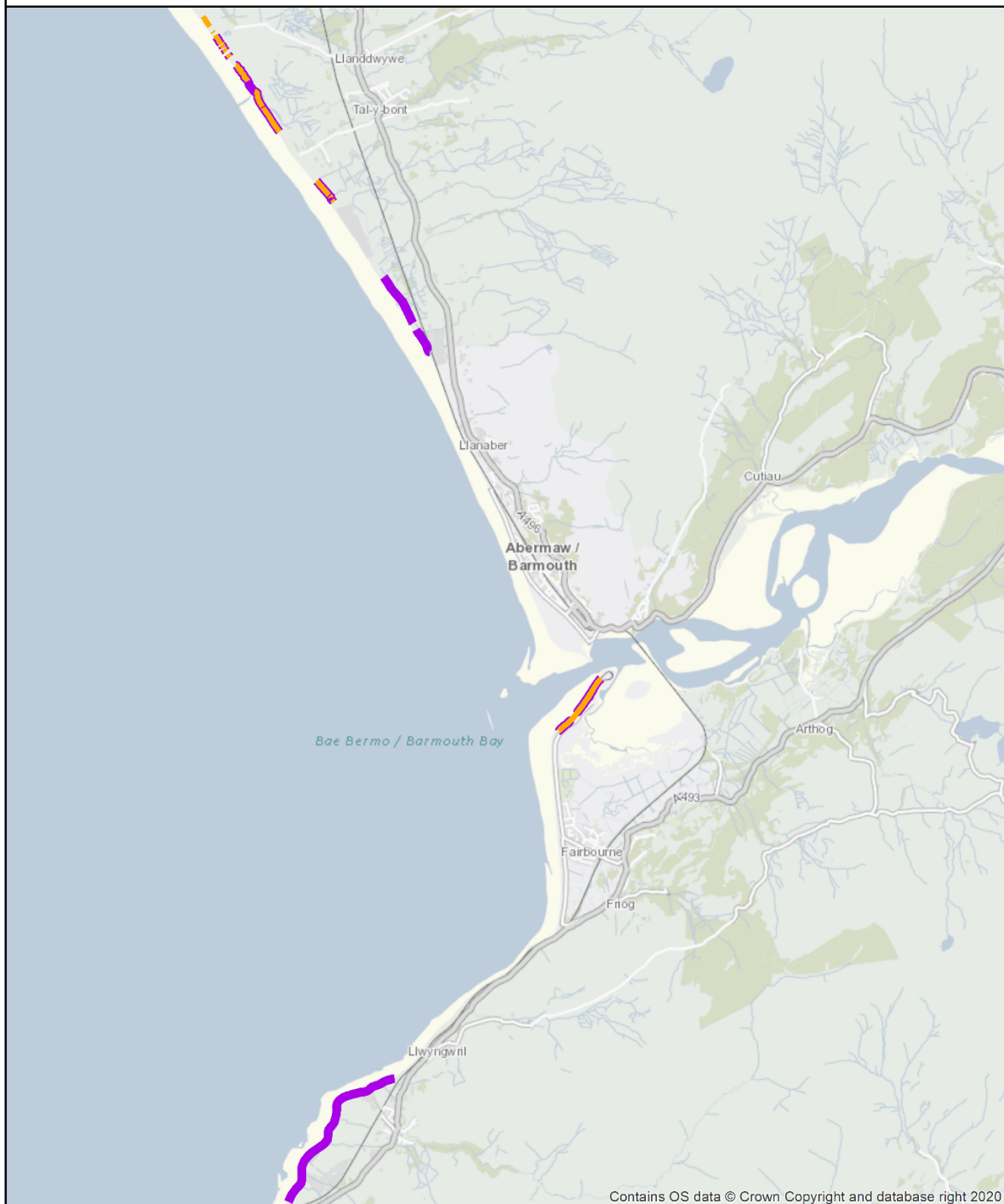


B9: Roll-back opportunities, Aberystwyth



B10: Roll-back opportunities, Ynyslas and Tywyn





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Legend

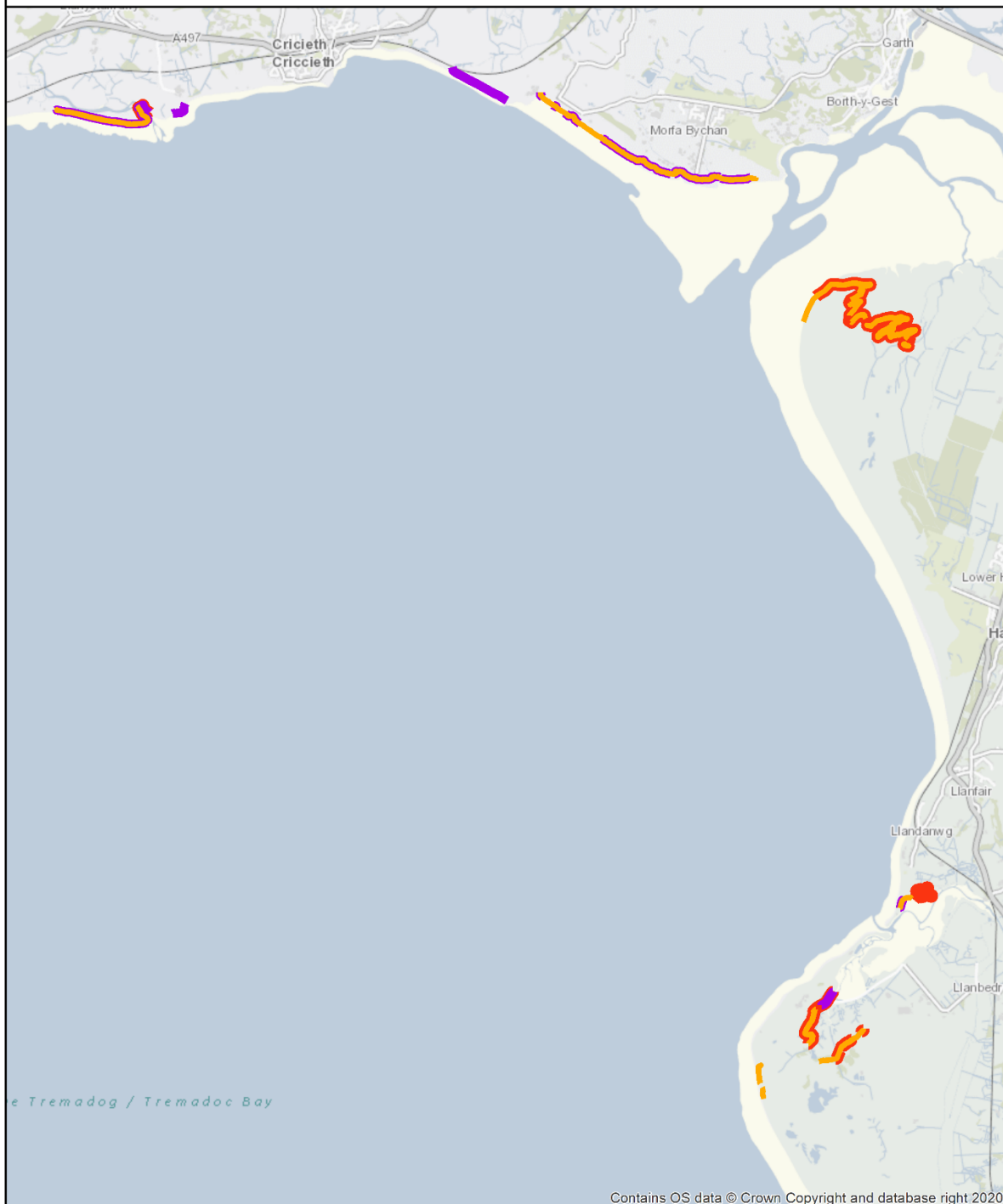
- Dune Roll-back Opportunities
- Shingle Roll-back Opportunities
- Saltmarsh Roll-back Opportunities

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Legend

- Dune Roll-back Opportunities
- Shingle Roll-back Opportunities
- Saltmarsh Roll-back Opportunities

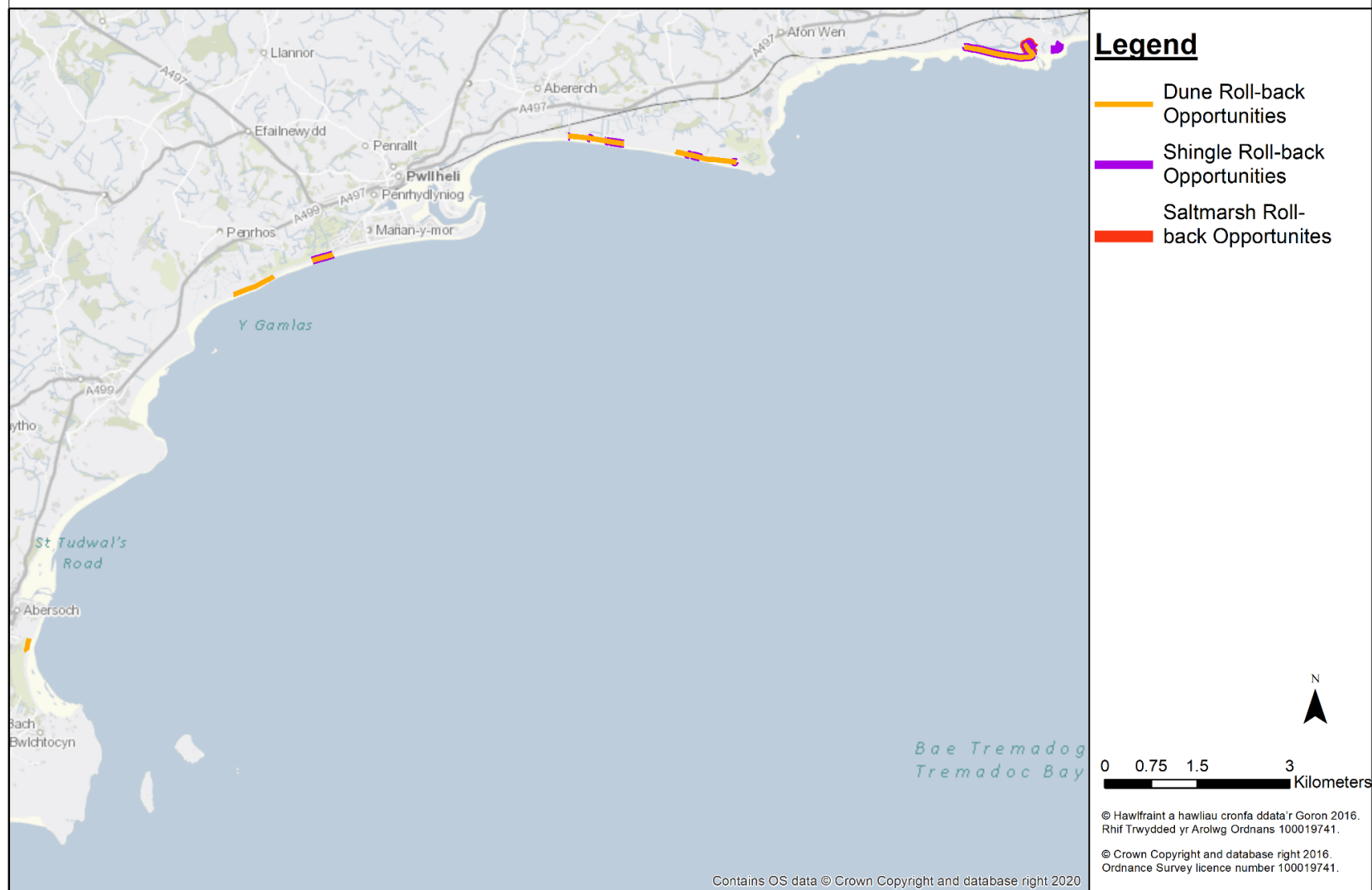
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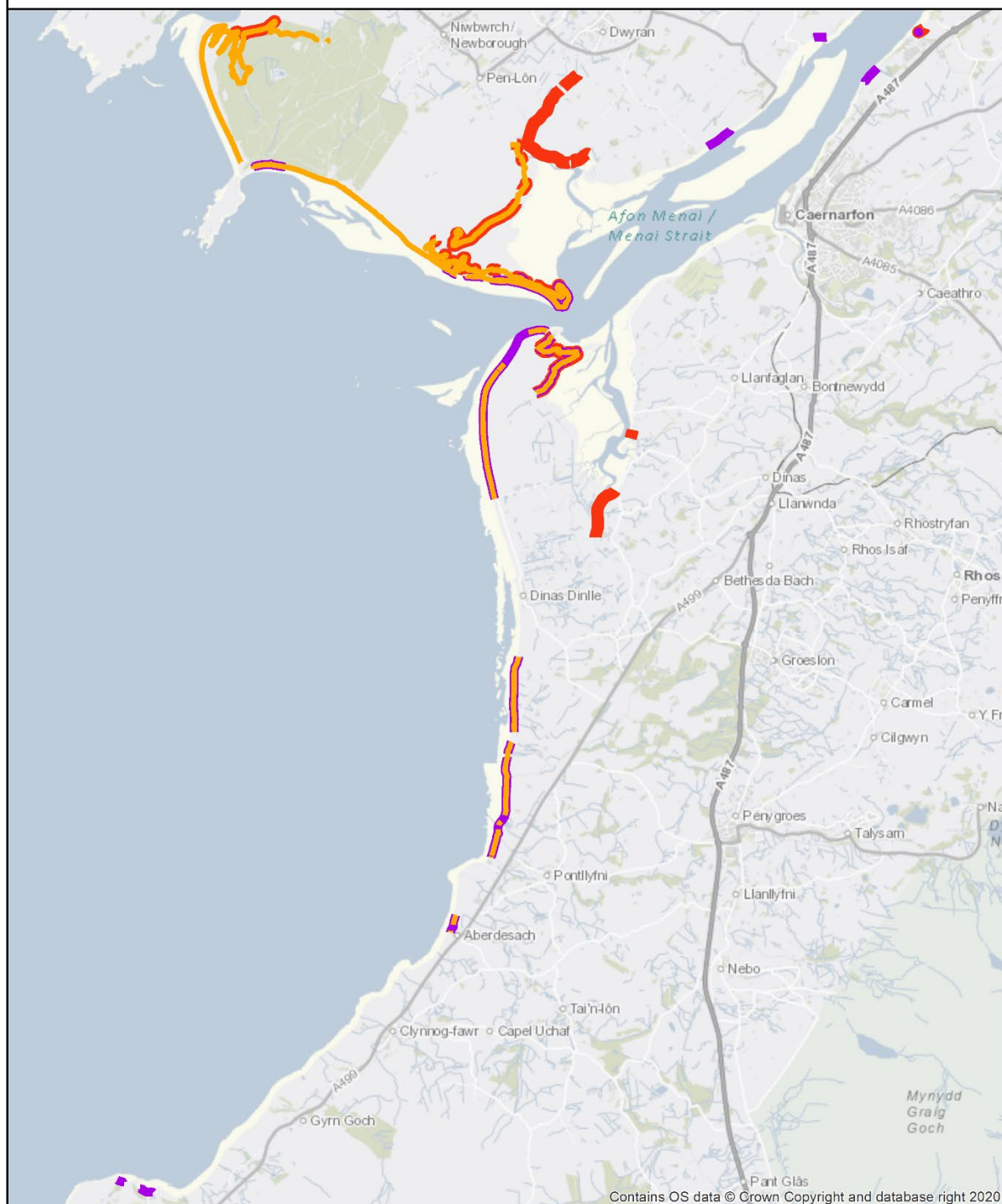
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B13: South-east Llyn Peninsula





Legend

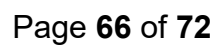
- Dune Roll-back Opportunities
- Shingle Roll-back Opportunities
- Saltmarsh Roll-back Opportunities

0 0.5 1 2
Kilometers

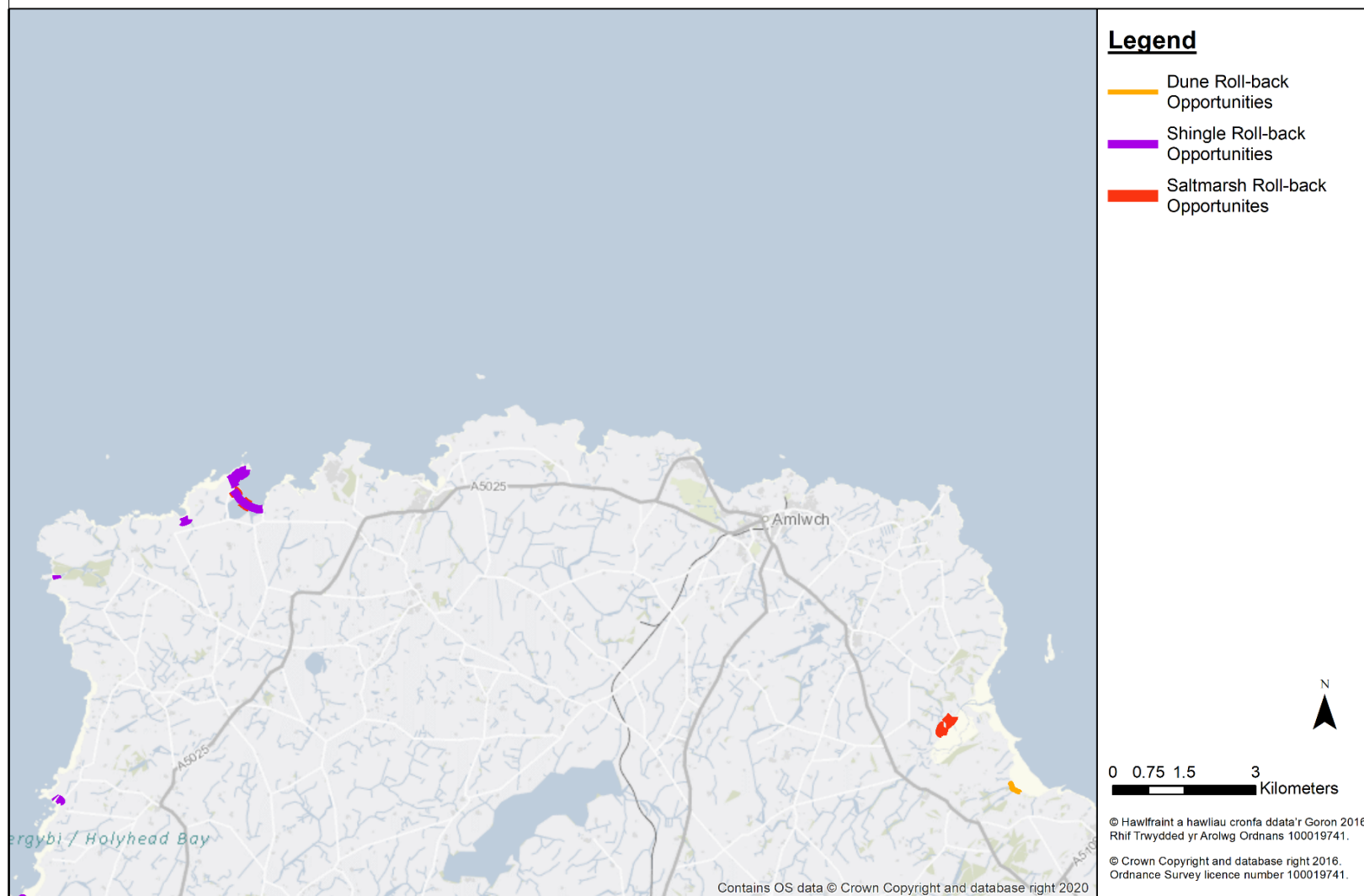
© Hawlfraint a hawliau cronfa ddata'r Goron 2016.
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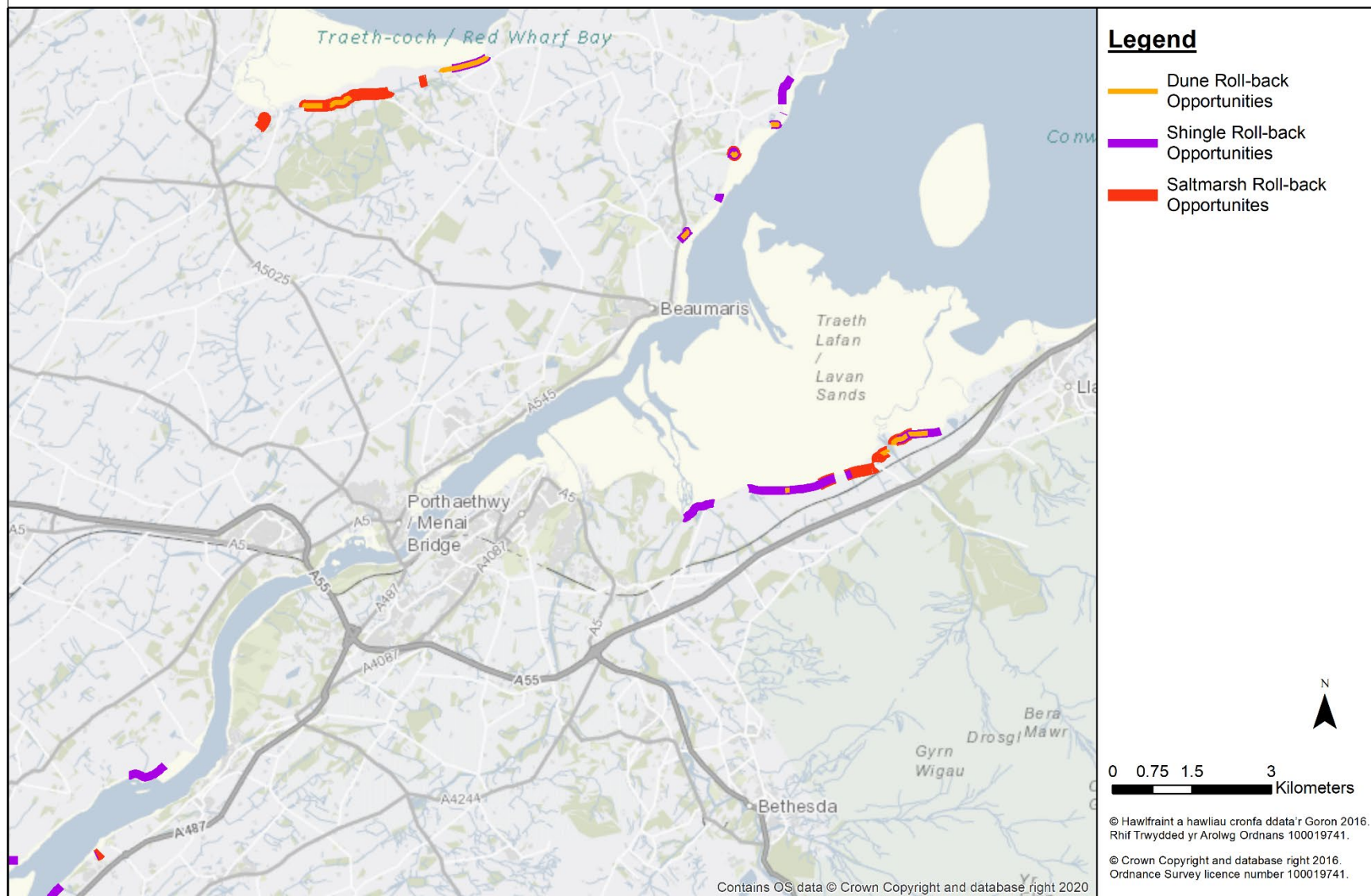
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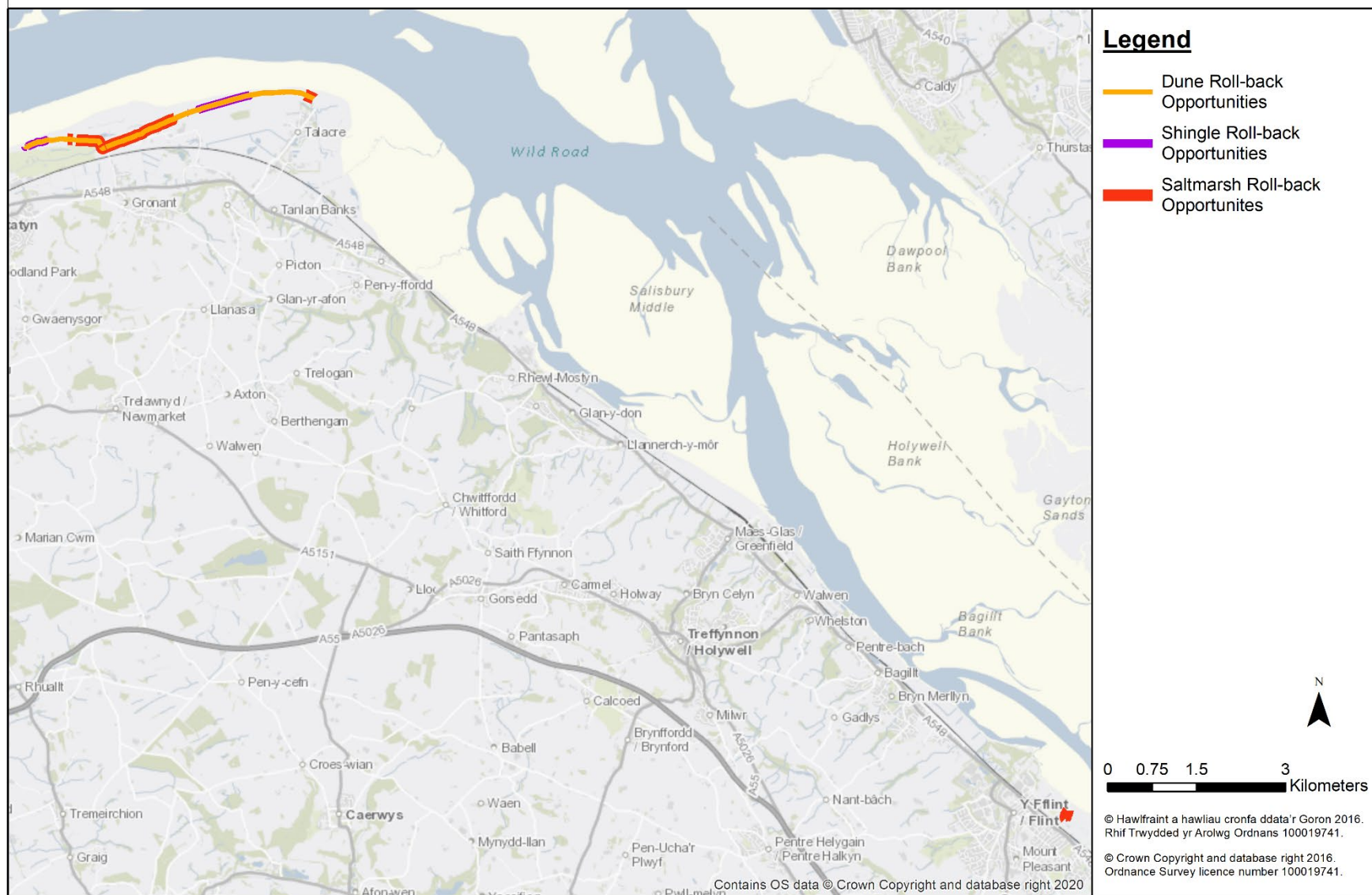


B16: Northern Anglesey









Appendix C: Data Archive Appendix

Data outputs associated with this project are archived in the X: drive on server-based storage at Natural Resources Wales.

The data archive contains a ArcGIS geodatabase (Rollback_data_report_859.gdb) holding a series of GIS features developed during the project on which the maps and analysis in the report are based. The process through which the various features were derived is described in the main report.

The geodatabase holds the following features:

- Dune_Buffer25m (polygon)
- DuneConstraint (line)
- DuneConstraintInUrban (line)
- DuneOpportunity (line)
- DuneOpportunityInUrban (line)
- Saltmarsh_Buffer25m (polygon)
- SaltmarshConstraint (line)
- SaltmarshConstraintInUrban (line)
- SaltmarshOpportunity (line)
- SaltmarshOpportunityInUrban (line)
- Shingle_Buffer25m (polygon)
- ShingleConstraint (line)
- ShingleConstraintInUrban (line)
- ShingleOpportunity (line)
- ShingleOpportunityInUrban (line)
- Urban_Buffer25m (polygon)

Metadata for this project is publicly accessible through Natural Resources Wales' Data Discovery Service <https://metadata.naturalresources.wales/geonetwork/srv> (English

version) and <https://metadata.cyfoethnaturiol.cymru/geonetwork/cym/> (Welsh Version).
The metadata is held as record no NRW_DS161369

Note that the Coastal Squeeze data that fed significantly into this project has a metadata record number of NRW_DS161284

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Further copies of this report are available from library@cyfoethnaturiolcymru.gov.uk