Pen yr Ergyd Spit Evaluation – October 2018

A response to a request for information as to how the LIDAR data provided by Ceredigion County Council is utilised to further the understanding of the processes at work in the Teifi estuary.

Abstract – The purpose of this document is to summarise the changes that are taking place on the Pen yr Ergyd spit. Focus attention on the implications of such change and encourage debate as to potential schemes to manage the feature in terms of its preservation, or managed decline. A substantive period of intervention has provided credible data for such an evaluation. The recent impact of a high energy storm event gives an insight into the robustness of the spit and the intervention programme that maintains it.

Location - Pen yr Ergyd spit is situated on the Gwbert foreshore at Patch on the eastern side of the Teifi estuary. The current spit is rooted at its north eastern end in a broader and older spit structure. - 52° 06' 13.67" N, 4° 41' 10.92" W [216040. 248501.]. Both spits are attached to the sand dune complex at Patch, which is the historic Pen yr Ergyd promontory.

Fig 1. 2009 Pen yr Ergyd Aerial Photograph.
Source: The Central Register of Aerial Photography for Wales

Characteristics - The spit trends NE/SW [41°/221°] and has a 2017 length of 149.5m to the -0.7m OD contour. [Mean elevation of low water channel surface at this point in the estuary. - 2006 - 2017 Lidar extracted data]. This length has been exceeded, 2002 155.4m and 2016 150.4m

Its south east facing inner slope is steep and has been remarkably stable until 2013/2014. Storm derived debris flows have since advanced the inner face by up to 2.5m in places. The northward facing seaward slope is divisible into a steeper inner section and a gentler sloping apron to seaward. It attains widths of between 40m and 85m from crest to the -0.6m low water mark.

Prior to 2008, surface elevation of the crest was sub 4.0m OD. However, this has since increased incrementally, first to above 4.0m and then 5.0m plus at certain locations, following repair and maintenance work funded by ATFL.

The distal end of the spit exhibits a minor recurve feature that has become the target for repair material for the upper surface and an area of erosion on the seaward side of the spit's root.

The spit is constructed of a sand/pebble/boulder mix. The sand often forming distinct lenses. Many of the pebbles and boulders are glacial erratics derived from the late Quaternary deposits situated to the north and north east of the spit.

Aerial photographs first reveal evidence of a small southerly extension of the Pen yr Ergyd promontory in 1964, amounting to ~ 27.5m. However, by 1977 a distinct south westerly extension of sediment had occurred adding a further 50m. By 1995 the Pen yr Ergyd spit had extended to 133m [unknown tide height] from the 1946 coastline. The 2002 Lidar data places the then current spit length at 155.4m. However, the spit/water boundary is not securely determined in this data set. The 2006 water boundary [-0.6mOD] records a value of 146m from the 1946 coastline. 2016 data reveals a longer length of 150.4m. [2017 = 149.5m]

Spatial and Volumetric Study - The Pen yr Ergyd Spit during the 2002 - 2017 time frame has retained a low water footprint that has exhibited little change. [See Fig.2] The area of the spit investigated for this volumetric study has also shown modest fluctuations with a maximum area of 11,880m^2 and a minimum area of 11,630m^2. In contrast, the volume of sediment held within the spit survey area above -1.0m OD has shown more marked change. Maximum sediment content, in the order of 31,552m^3 occurred in 2014, while the minimum, 29,606m^3 was recorded in 2009. [See table in Fig 4]

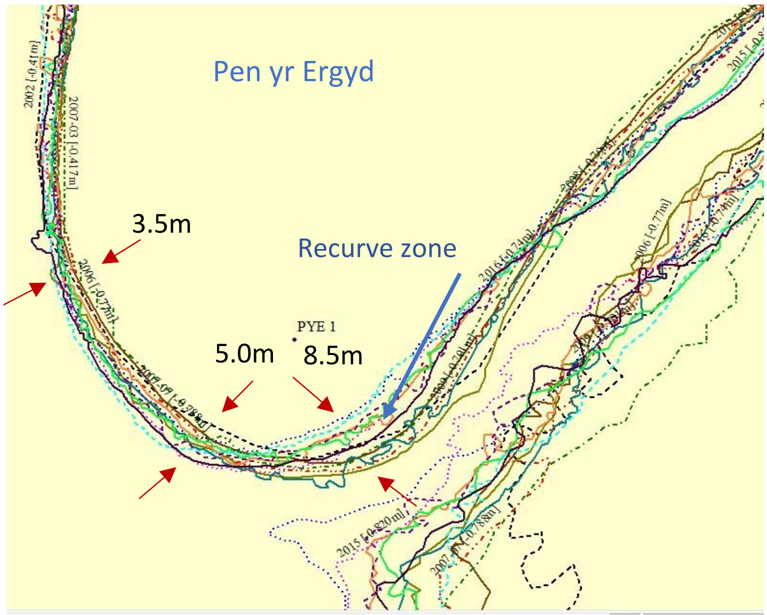

Fig 2. 2002 – 2017 Pen yr Ergyd Lidar Footprint Low Water Boundary TDW 2017.

Values recorded indicate the lateral change over the 02 – 17 period between the arrows.

Greatest variation exists around the recurve.

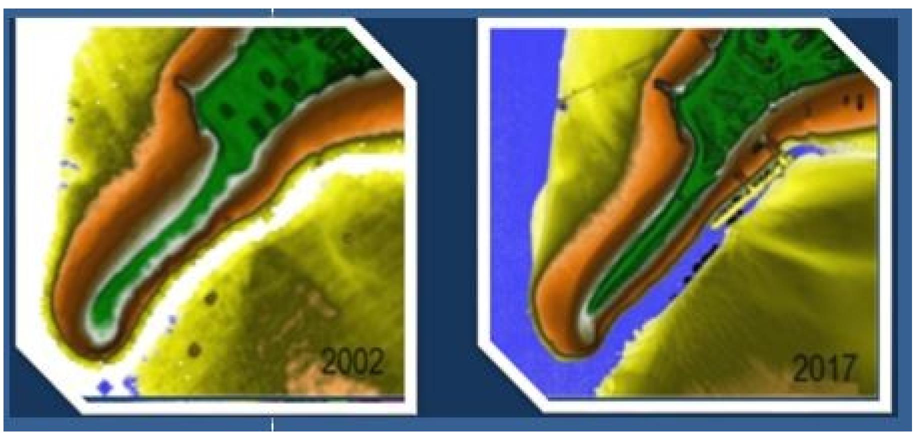

Fig 3. 2002 – 2017 Pen yr Ergyd Lidar extracts.

Source: Pen yr Ergyd Monitoring Data 2002 – 2017. TDW 2017

Sediment Transfer Trends – [see Fig. 4] The lidar data suggests that the spit lost more sediment than it gained between 2002 and 2007. 2008 revealed a modest gain, but by 2009 sediment was again being lost. The 2011 data shows a marked increase, which in the most part, reflects the work of the management programme. 2012 shows a larger sediment loss followed by an almost equal gain by 2013, which continues into 2014. From the high point of 2014 there has been a continual loss of sediment despite annual interventions to manage the spit profile. [See Fig.4]

	Data Footprint	Volume above -1m
	m²	m³
2017	11880	30190.47
2016	11730	30623.98
2015	11860	31149.77
2014	11880	31551.97
2013	11710	30425.27
2012	11630	29627.88
2011	11880	30517.35
2010	No Data	
2009	11850	29606.49
2008	11890	29977.47
2007 07	11830	29963.58
2007 03	11650	30515.87
2006	11880	30662.99
2003 - 05	No Data	
2002	11810	31448.17

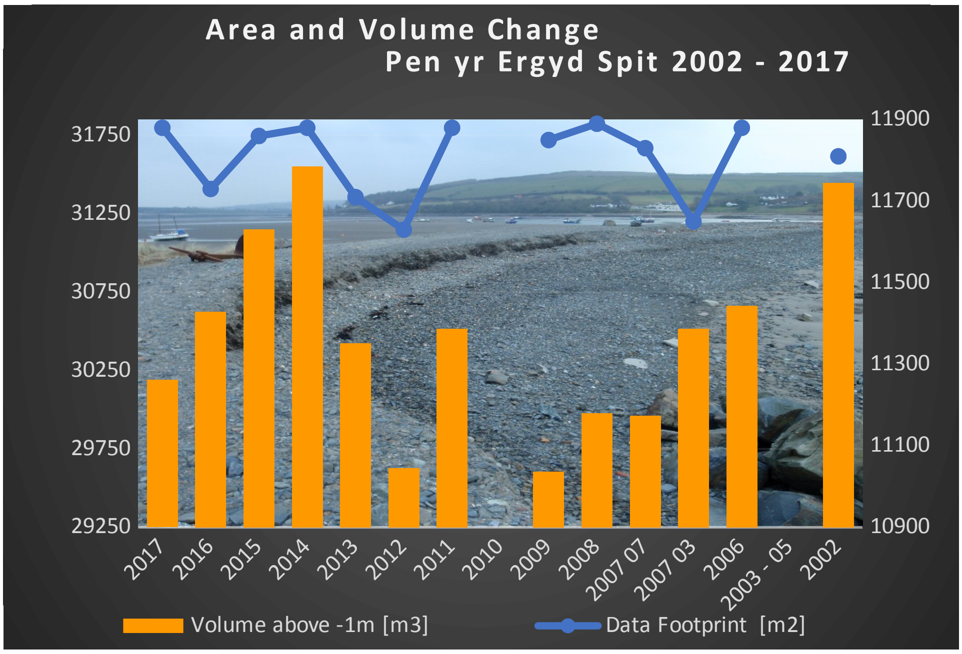

Fig 4. 2002 – 2017 Pen yr Ergyd Volume Change. Source: Pen yr Ergyd Monitoring Data 2002 – 2017. TDW 2017

Of note, the evidence suggests that the sediment lost to the spit is predominantly composed of sand.

Year	Loss/Gain [m³]	Year	Loss/Gain [m³]	Year	Loss/Gain [m³]	Year	Loss/Gain [m³]
2016 - 2017	433	2013 - 2014	1126	2009 - 2011	910	2007 -Mar - July	552
2015 - 2016	525	2012 - 2013	797	2008 - 2009	370	2006 - 2007 Mar	147
2014 - 2015	402	2011 - 2012	889	2007 - 2008	14	2002 - 2006	785

Fig 5. 2014 – 2017 Pen yr Ergyd Volume Loss. Source: Pen yr Ergyd Monitoring Data 2002 – 2017. TDW 2017

The trends illustrated here only provide a basic outline of the processes operating in the spit system. **Of note** – data is available illustrating sediment transfer at 1m increments. In addition, a large proportion of the total volume is held within the core of the spit. 39% of the spit's volume is contained below 0m OD [2017 data]

Further interrogation of the data reveals the volume of sediment on the move and links it to critical elevations across the spit. It is clear from the graphic below that the seaward foreshore [to the left] has been lowered compared to its 2002 elevation [see Fig. 7]. In addition, the gradient of the seaward spit face is now steeper. Apart from the extreme distal end of the spit the spit crest is substantially higher and narrower.

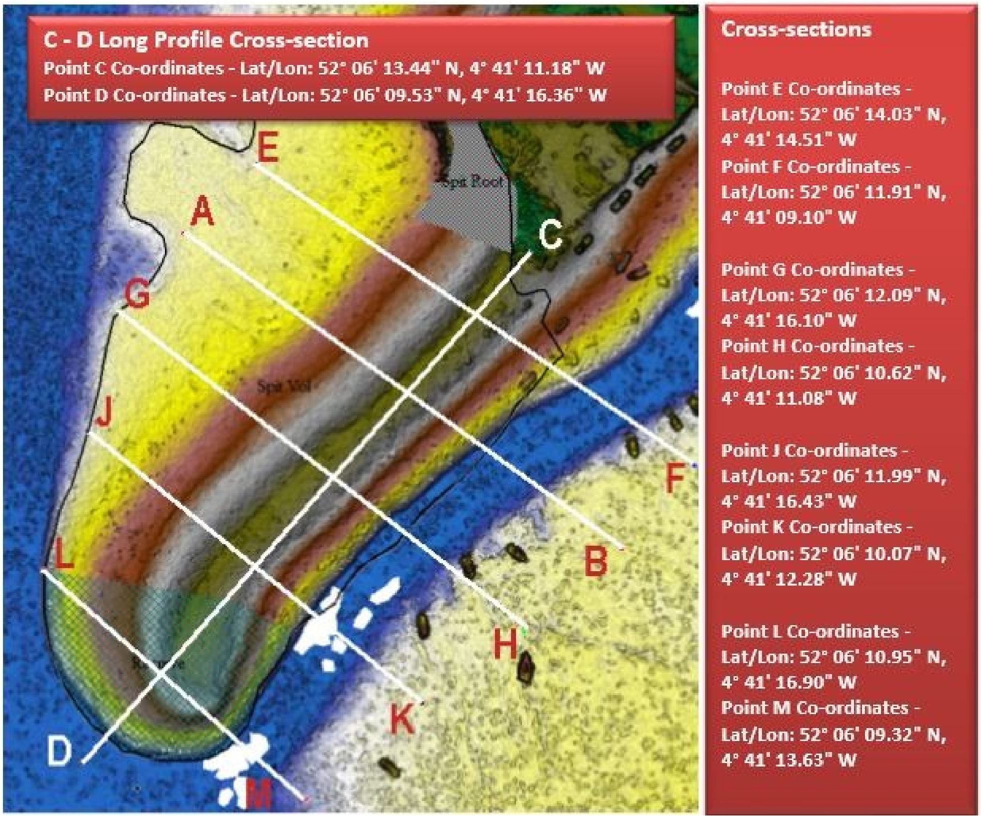

Fig 6. Pen yr Ergyd Lidar Extract indicating the location of the cross-sections contained in the following graphic. The data set permits year on year comparisons. Volumetric and spatial data linked to elevation footprints has also been collected for the spit on an annual basis to determine loss/gains at 1m increments. Source: Pen yr Ergyd Monitoring Data 2002 – 2017. TDW 2017

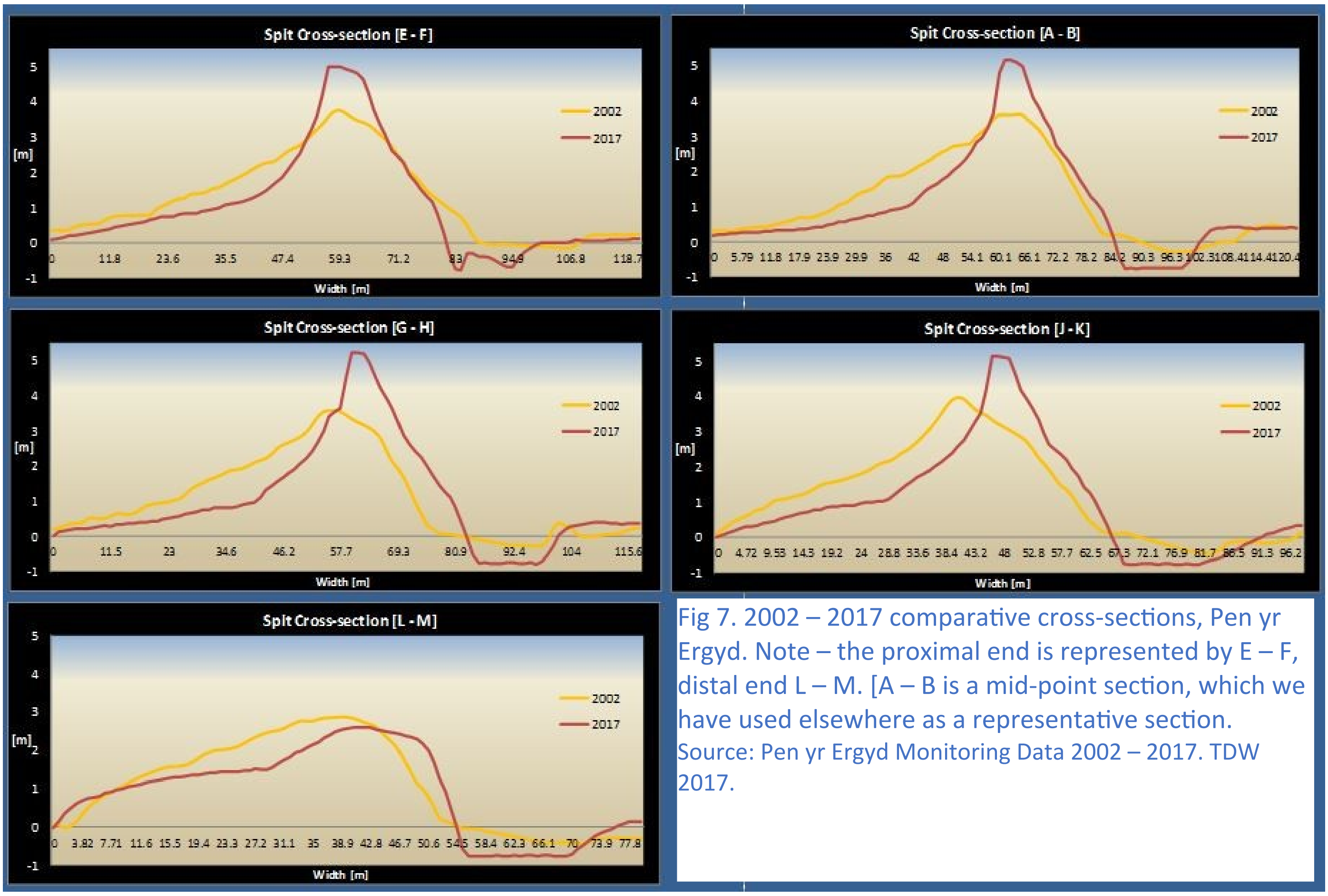

Fig 7. 2002 – 2017 comparative cross-sections, Pen yr Ergyd. Note – the proximal end is represented by E – F, distal end L – M. [A – B is a mid-point section, which we have used elsewhere as a representative section.
Source: Pen yr Ergyd Monitoring Data 2002 – 2017. TDW 2017.

The data highlights that the spit is unable to conserve volume.

It is possible, that by tweaking the management strategy this could be improved upon, as at present the strategy employed does contribute to some sediment loss.

For example; the steeper grading of the seaward spit slope illustrated in Fig 7., permits even modest waves to wash the sand out of the face. This in turn facilitates the collapse of the pebble component steepening the slope still further. Heavy rain has a similar impact.

The lowering of the foreshore deepens the water adjacent to the spit. Deeper water allows more energetic waves to attack the spit and increase erosion rates. More energetic wave action also encourages increased rates of longshore drift, moving sediment away from the spit foreshore. Some of the material is rapidly redeposited as a recurve, some is lost to the spit system totally.

Historically, the spit was a 60/40 sand to pebble, boulder mix. The proportions are changing as the engineered component of the upper spit is eroded. Both sand and pebbles are washed out of the scarp face and carried away. The lighter sand component is carried the furthest and deposited away from the spit. [Note Figs.8 – 12.]

The evidence above suggests that the spit has been deflating by 400m^3 or more per year over the 2015 – 2017 period. In light of the evidence available, piling material higher along the crest of the spit as a sustainable management strategy should therefore be reviewed. The timing and frequency of this undertaking should also be considered.

October 2018 - Current observations indicate that the deflation of the spit is continuing and unfortunately without lidar data it is, and will be difficult to quantify the scale of the loss. In the field it appears to be accelerating. The elevated length of the spit is now shorter than in the recent past, with an extended low-level apron at the distal end. The period 02/10/2018 to the 16/10/2018 illustrates the engineered upper spit's lack of robustness and gives little confidence to its long-term future.

Fig 8. 16/10/2018 Pen yr Ergyd Spit. Note the engineered upper surface ~5.2m OD. The near vertical erosional scarp along the reconstructed upper crest. Although this is post storm Callum there is no evidence of over-run or debris flows on the inner slope. The large feature on the spit crest is a tree root place there by the ATFL. Source: Chris Evans.

Fig 9. 02/10/2018 Pen yr Ergyd Spit. Erosional scarp in the reconstructed upper spit two weeks before. 7.5m wide crest reduced to 4m at the distal end.

Source: TDW.

Fig 10. 15/10/2018 Pen yr Ergyd Spit. Erosional scarp in the reconstructed upper spit. Crest 2m wide at distal end. Note absence of sand at the base of the freshly eroded scarp.

Source: TDW.

Fig 11. 15/10/2018 Pen yr Ergyd Spit Recurve. Newly expanded post storm Callum.

Source: TDW.

Fig 12. 15/10/2018 Pen yr Ergyd Spit – Distal End. The track down onto the recurve/foreshore has lost over 40% of its width in two weeks through erosion to its seaward face. Again, note the absence of sand.

Source: TDW.

Conclusion

The long-term LIDAR evidence indicates that the spit is continuing to lose sediment. The rate of loss however, has not significantly changed the low water spit footprint during this time. The greatest fluctuation to the low water footprint has been in the area of the spit's natural recurve. [see Fig.2] This may reflect the targeting of this area for repair material.

The LIDAR data from 2002-2017 described above provides measurable evidence of the changes to the spit form, infinitely more accurate than anecdotal views.

The work carried out by the ATFL has as its objective to maintain the stability of the feature for as long as is possible. To date, the spit's volume has only increased through artificially introducing material from adjacent areas. [E.g. TBC Gut]. The move to target the spit's recurve is utilising a continually diminishing resource. The narrowing crest, along with the reduction in the spit's length are the visible outcome.

The erosion that occurs daily produces a noticeable impact on the engineered form of the seaward scarp. The changes associated with the energy released in a storm event like 'Callum' are considerably greater and largely neutralise the AFTL's work.

Interestingly, no overtopping of the spit crest occurred during storm Callum, which reflects the offshore southerly wind direction experienced during the storm, countering the incoming wave energy. However, it does serve to flag up the inherent weakness in the structure. Any similar winter storms with a more northerly component will have the potential to overtop the crest. The steep slope gradients will assist in the rapid removal of part of the spit's crest potentially leading shortly afterwards to a breaching of the feature.

Our considered conclusion is that it is timely to review the current strategy. Specifically: -

- Examine if the ATFL's maintenance programme to the spit can be adjusted to prevent or at least limit the danger of breaching and feature loss.
- Investigate whether the lowering of the foreshore is a natural process, or the direct, or an indirect function of the interventions.
- Consider alternative grading techniques for the upper foreshore.
- Consider, the nature of the material that is used to replenish the spit: -
    - particularly avoid using sand grade material along key sections of the spit. [E.g. The seaward root area].
    - Strive to create a predominantly pebble faced seaward side to the spit.
    - Create slopes that imitate the natural angle of a marine generated upper foreshore.
    - Consider the merits of slope orientation in terms of reducing the disparity between swash and backwash.

Such a review requires the wider support of all stakeholders with an interest in the estuary and Ceredigon County Council, the ATFL and NRW should provide a prominent lead. External experts may be required to advise on appropriate techniques.

At present, the future of the spit as a coherent feature protecting the inner estuary and associated investments is again uncertain.

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