Analysis of the storm event (16/12/2020) along with the impact on Dawlish Warren: 6bSU16-3

1. Introduction

This report briefly identifies the impact of the storm event on Dawlish Warren - survey unit 6bSU16-3, with particular focus on the GeoTube. The storm event occurred on the 16th of December, bringing wind speeds of up to 49.7 km/h, wind gusts of up to 73.4 km/h and pressures as low as 992hPA to the SW coast of England.

Data obtained for this report includes topographic profile data for baseline surveys collected on the 17/04/2007, 01/01/2018 and 25/07/2020, and post storm surveys collected on the 21/02/2020, 17/11/2020 and 18/12/2020. Analysis and comparisons within this report is only undertaken on the profiles which were captured in the post-storm survey for consistency.

The following sections will provide a background into the hydrodynamics occurring during this storm event period and an analysis into the changes to the beach's morphology.

2. Hydrodynamics

During the storm event, on the 16th of December 2020, the significant wave height (H_S) averaged 1.89 m (*Table 1*) and the maximum wave height (H_{Max}) averaged 2.92 m. The storm event recorded a 170% increase in H_S when compared to the December average. Interestingly, the average wave direction during the storm event was more easterly when compared to the December average, however, during the storm peak the wave direction was more southerly. There was one distinct peak during the day whereby the storm threshold (2.64 m) was exceeded by H_S (*Table 1*) which lasted for a duration of 5 hours, coinciding with the spring high tide on 16/12/2020 at 07:25 (4.4 m, recorded from Dawlish) as demonstrated in *Figure 1*.

Table 1 – Hydrodynamic statistics recorded from Dawlish directional wave rider. H_S is wave height (m), Tp is peak wave period (s), Tz is mean wave period and Dir. is wave direction (°).

	Hs (m)	Tp (s)	Tz (s)	Dir. (°)
Storm Event Average (16/12)	1.89	7.3	5.1	162
December Average (2010-2019)	0.70	7.8	4.0	167
Storm Event Peak (16/12/2020 04:00-09:00)	2.91	7.5	5.5	171

The period under analysis recorded a maximum wave height of 3.18 m and a maximum H_S of 5.25 m. The maximum values of H_S and H_{Max} can been seen to exceed the December average by fourfold. The timings of the baseline survey, previous post-storm survey and this post-storm survey sufficiently capture either side of storm event and its effect on Dawlish Warren.

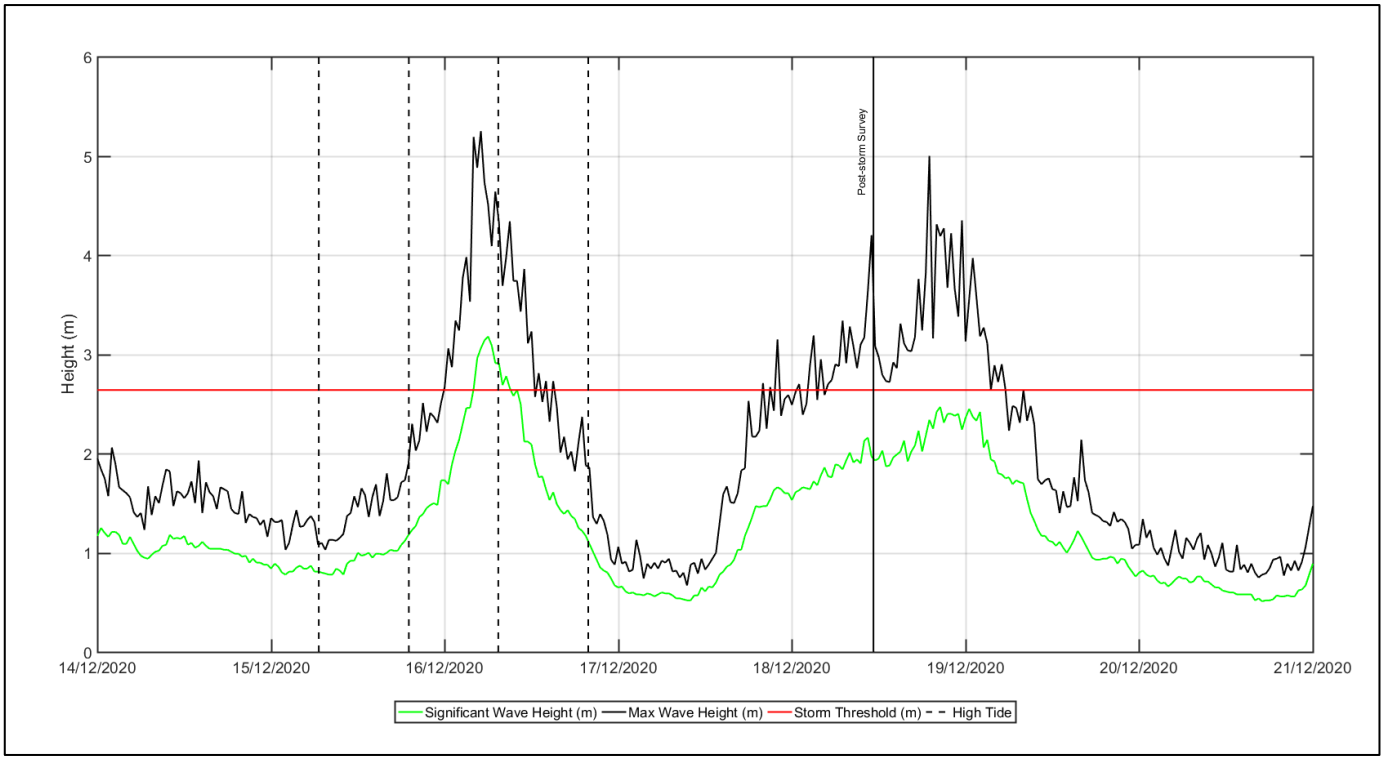
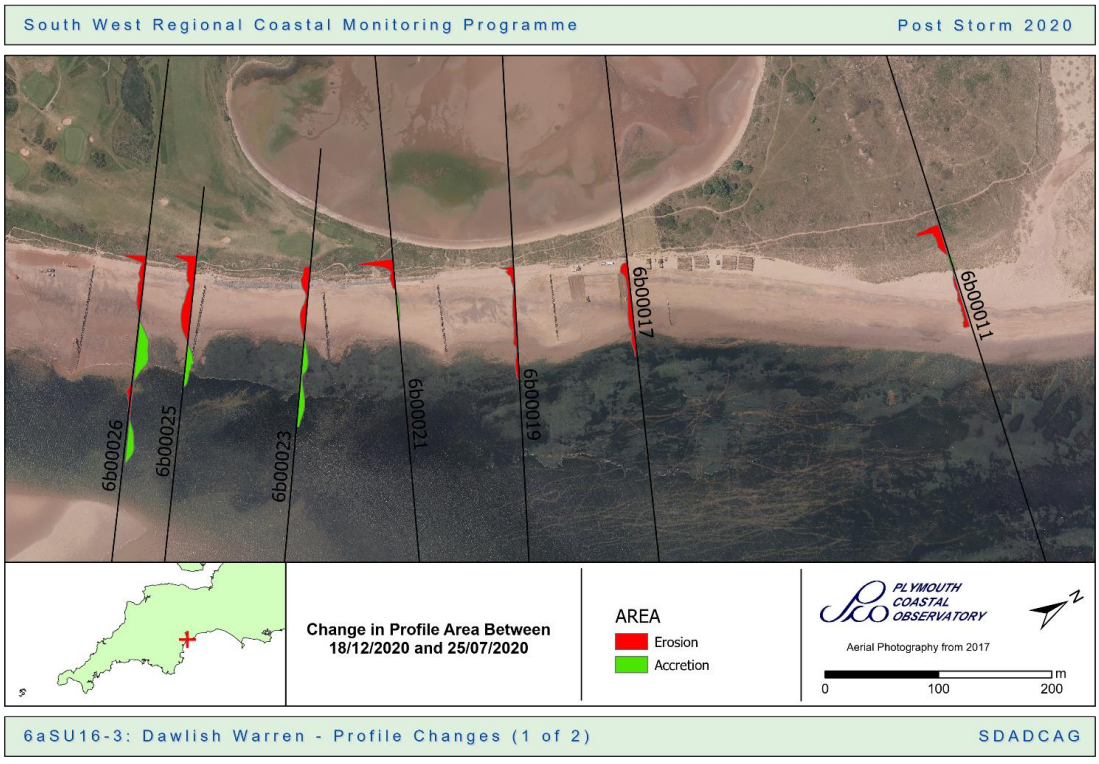


Figure 1 – Plot showing the significant wave height (H_S) and maximum wave height (H_{Max}) over a seven-day period, including the low-pressure event. High tide times during the study period are indicated with a dashed vertical black line. Data obtained from Dawlish DWR.

3. Beach Morphology Change

The post-storm survey consisted of thirteen survey lines which, in this report, are directly compared against the repeat baseline survey (25/07/2020); see Figure 2.



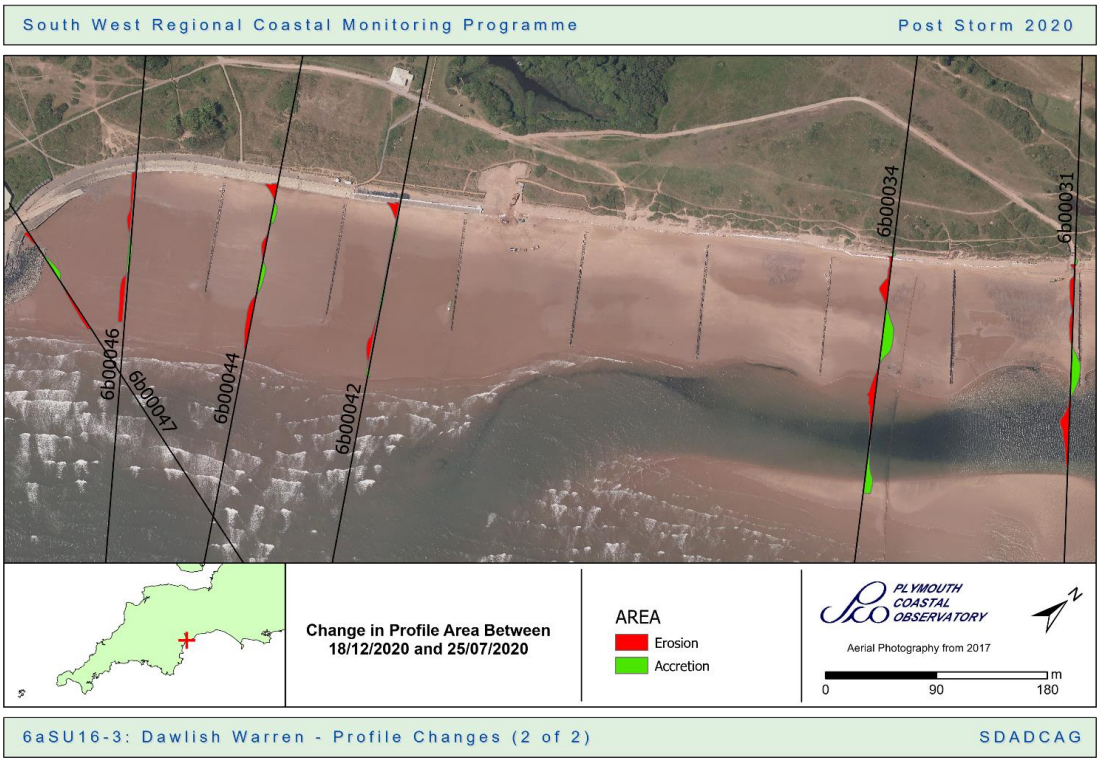


Figure 2 - Plot indicating the location of Dawlish Warren and the post storm profiles, along with an exaggerated overlay depicted where there has been erosion (red) and accretion (green) across each of the profiles since the previous baseline survey (25/07/2020).

3.1 Erosion & Accretion Overview

Dawlish Warren, as a whole, lost 202.18 m^2 of material and gained 22.48 m^2 since the autumn baseline survey. When comparing the cross-sectional area of the thirteen survey lines, overall, profiles 6b00011, 6b00017, 6b000179, 6b00021, 6b00025, 6b00031, 6b00042, 6b00044, 6b00046 and 6b00047 saw an overall loss in material between the interim and post-storm survey ranging from -54.42 m^2 to -11.97 m^2 whereas profiles 6b00023, 6b00026 and 6b00034 saw an overall gain in material ranging from 0.46 m^2 to 54.12 m^2 (see *Table 2*; see Appendix A).

3.2 Profile Erosion & Accretion

Profiles 6b00011, 6b00017 and 6b00019 show a clear loss of material from the low tide terrace and/or upper beach face. In comparison, profiles 6b00021, 6b00023, 6b00026 and 6b00034 show the most expected change of material, with a loss from the beach face and minor gains along the low tide terrace (see Appendix A). The location along the profiles, where accretion outweighs erosion, generally occurs around the lower beach – around ~120 and ~180m chainage (see Appendix A).

Table 2 – Overview of accretion and erosion rates at each post storm profile line, calculated from Topographic surveys between 18/12/2020 and 25/07/2020.

	Accretion (m^2)	Erosion (m^2)	Total (m^2)
6b00011	3.69	-34.90	-31.21
6b00017	0.46	-30.55	-30.09

6b00019	1.29	-27.17	-25.87
6b00021	6.89	-23.49	-16.59
6b00023	28.61	-28.39	0.22
6b00025	16.92	-54.42	-37.60
6b00026	54.12	-38.08	16.04
6b00031	20.63	-37.38	-16.75
6b00034	39.96	-33.75	6.22
6b00042	9.80	-15.51	-5.71
6b00044	12.30	-27.11	-14.81
6b00046	6.56	-25.10	-18.53
6b00047	6.95	-11.97	-5.02

3.3 GeoTube

The 470 m GeoTube defence installed at the Warren's narrowest point within the dune spans from profiles 6b00019 to 6b00026 (see *Figure 2*; see Appendix A - pink line). As seen in Appendix A, all the profiles along the GeoTube show the beach to be receding, the crest of the beach moves between ~10 m and ~40 m landward. The rate of retreat becomes larger around profiles 6b00021, 6b00025 and 6b00026. In recent surveys, the crest of the beach can be seen to have positioned itself above the GeoTube (see Appendix A).

When comparing the baseline survey to the 2020 surveys, there is a clear recession of material on the seaward side of the dune. Furthermore, when comparing the leeward side, the dune slope also illustrates a subsidence. This indicates that the GeoTube aids the accumulation of sediment leeward but does not hinder sediment erosion seaward.

As seen in Appendix A, the baseline survey shows profile 6b00019 to have two dunes, the primary dune crest reaching 5.3 m and the secondary crest reaching 7.2 m. The dune slope is located around 40m from the GeoTube. The 2020 surveys show a ~15 m shift towards the GeoTube and the destruction of the primary dune. The leeward slope has gained ~1.2 m in height.

Profiles 6b00021, 6b00023, 6b00025 and 6b00026 demonstrate a similar pattern. When comparing the baseline to the 2020 surveys, the dune crest decreases in height, the gradient of the seaward slope increases, and the toe of the dune is more defined (Appendix A). The beach crest in each consecutive survey can be seen to recede toward to GeoTube, however, the July survey can be seen to have accreted in some areas around the dunes toe, when compared to the February survey.

Furthermore, there has been extensive erosion around profile 6b00023 which is illustrated by the geotube being exposed in recent surveys (see pictures below). A significant proportion of sediment has moved from directly in front of the geotube, which is accompanied by a retreat of sediment from a 20 m distance between the beach face and the geotube in 2007, to a ~-0.5 m distance in 2020. Additionally, since the exposure of the geotube at profile 6b00023, the height of sediment at the toe has been decreasing (See Appendix A, Profile 6b00023). When comparing the 18/12/2020 post-storm data for 6b00023 to the summer baseline conducted on the 23/07/2020, the toe level has lowered by

~80 cm, whereas in comparison to the previous post-storm conducted on 17/11/2020 the sediment toe at the geotube has lowered by ~20 cm.

3.4 Contours

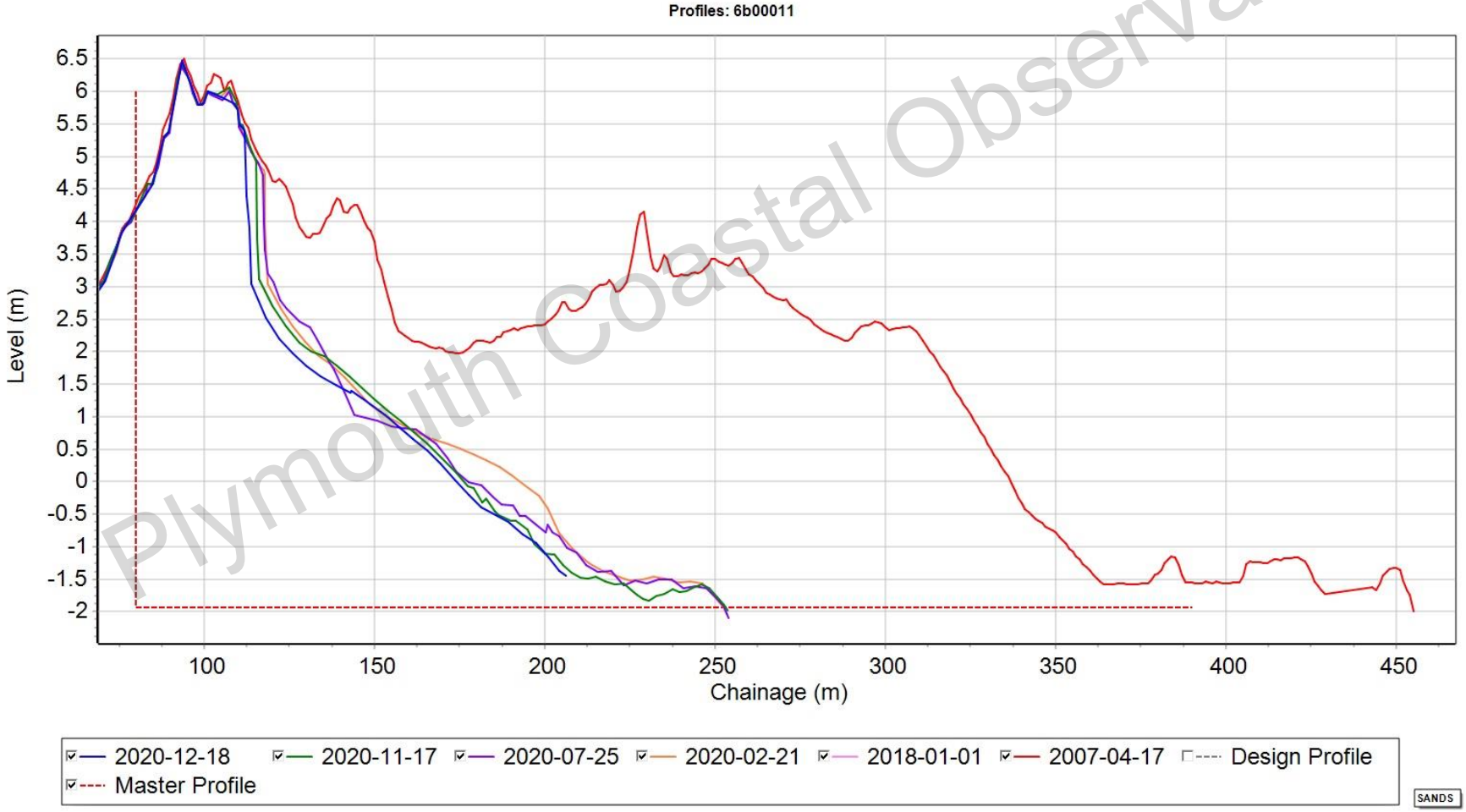
Mean high water elevation at Dawlish Warren is 1.56 m OD. This contour moves further inland as illustrated during more recent surveys (Appendix B). When comparing the 2019_07 baseline survey to the 2020_07 baseline survey the contour line has moved ~15 m landward. There are greater effects on the dunes and GeoTube with high water elevation reaching further inshore due to high water heights reaching further inshore; thus, supporting the evidence of erosion of the dune slopes.

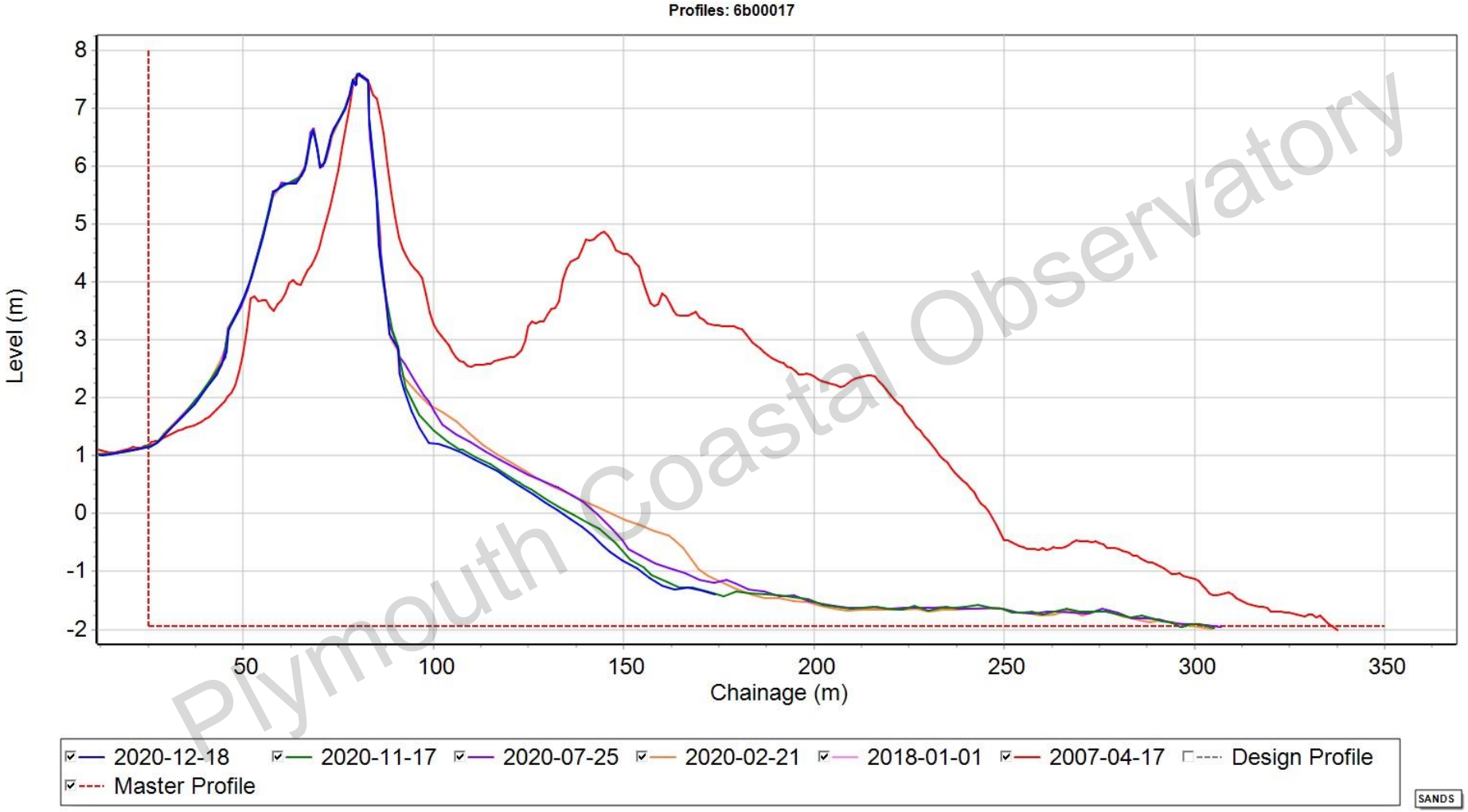
3.5 Comparison to 17/11/2020

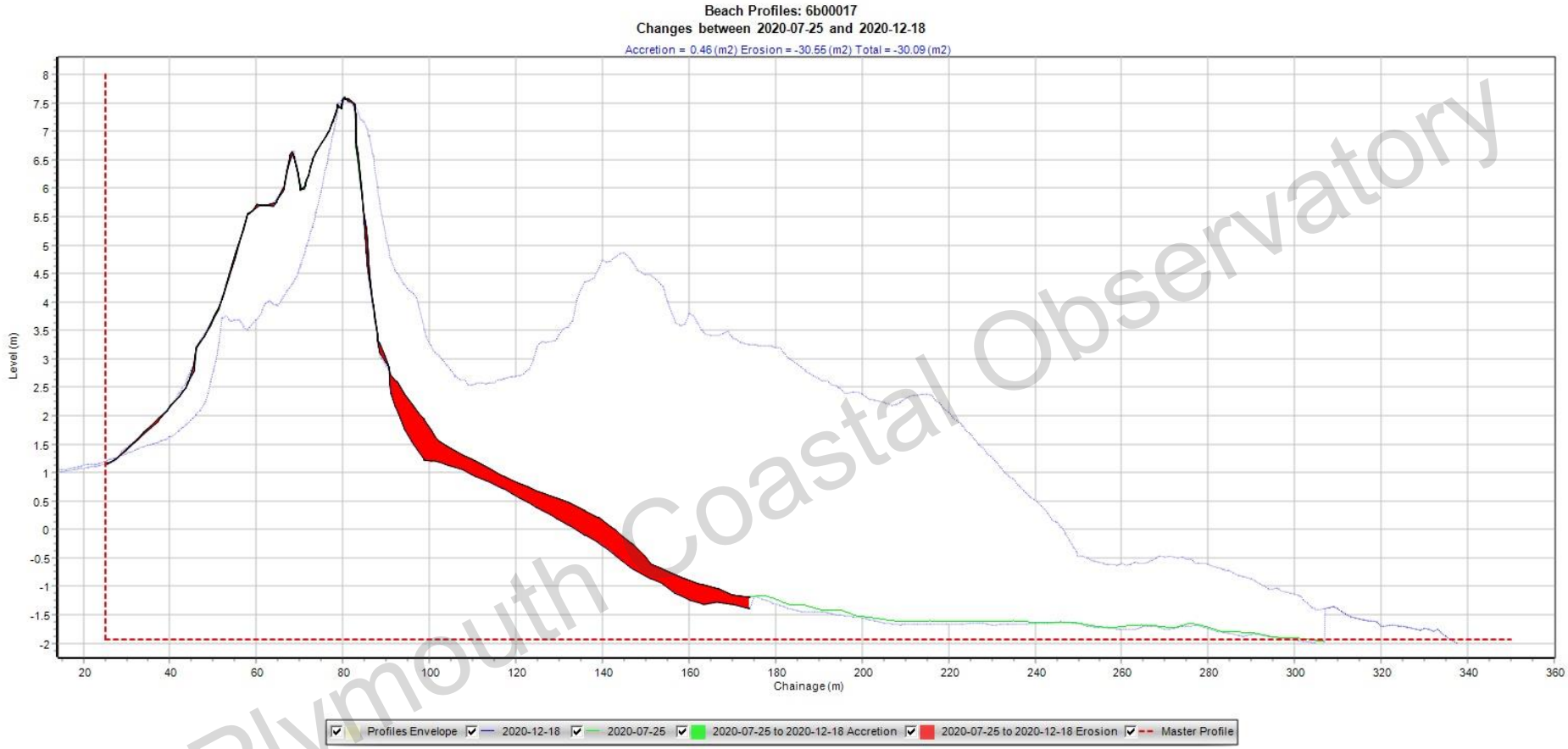
When comparing this post storm survey (18/12/2020) to the most recent previous survey (17/11/2020), Dawlish Warren in total lost 105 m^2 and gained 22.48 m^2. If you compare these figures with those in section 3.1 you can see that overall, Dawlish Warren has followed the pattern and eroded more than it has accreted. However, more sediment was accreted than when comparing to the baseline-post storm comparison . Erosion and accretion along the 13 profiles occur at similar locations when compared to the baseline-post storm comparison. Difference to the profiles occur when analysing total accretion and erosion at individual profiles; profiles 6b00021, 6b00025 and 6b00047 accreted more than eroded and profiles 6b00023 and 6b00034 eroded more than accreted – this is different to the rates shown in *Table 2*.

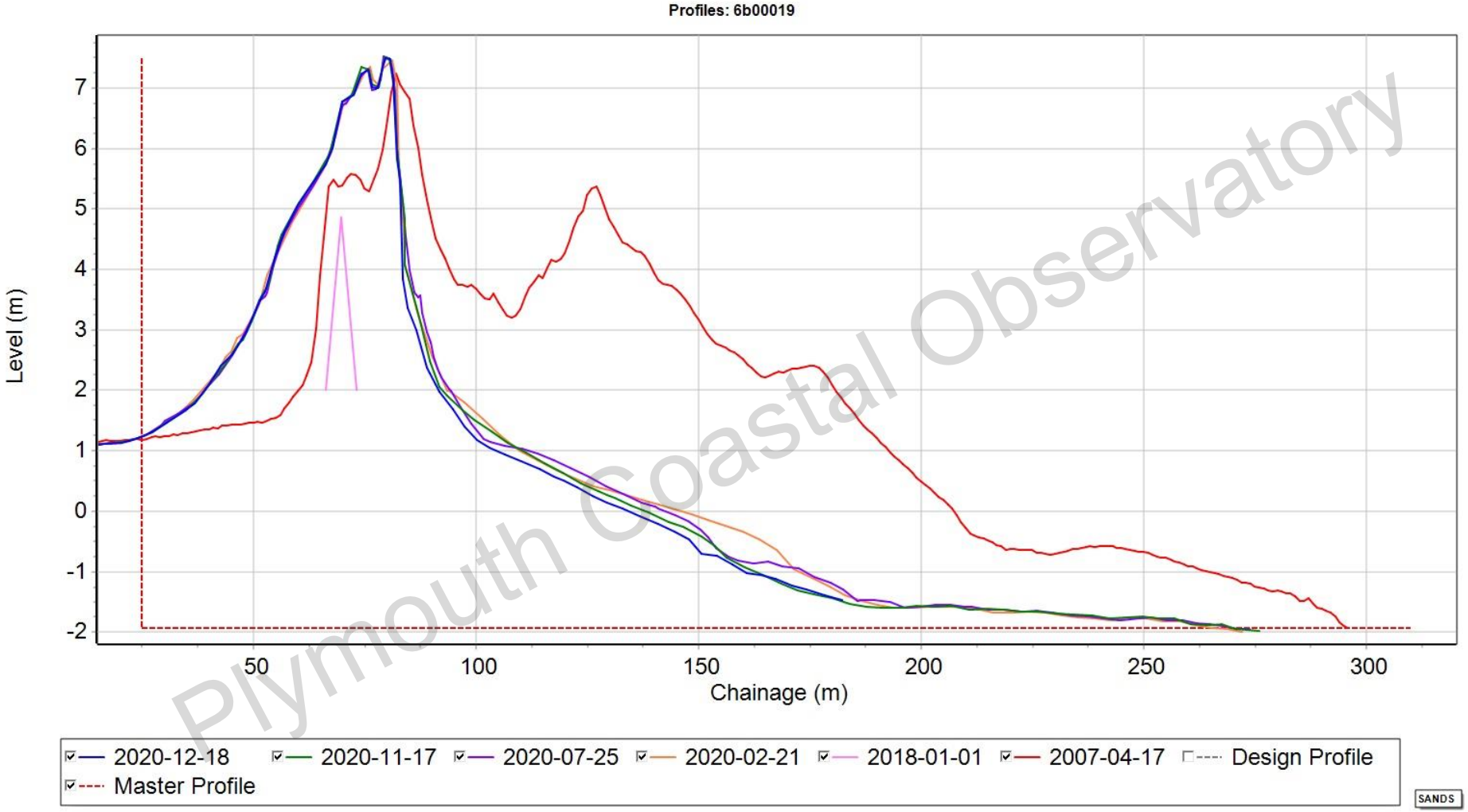
Appendix A – Cross-sectional area change plots

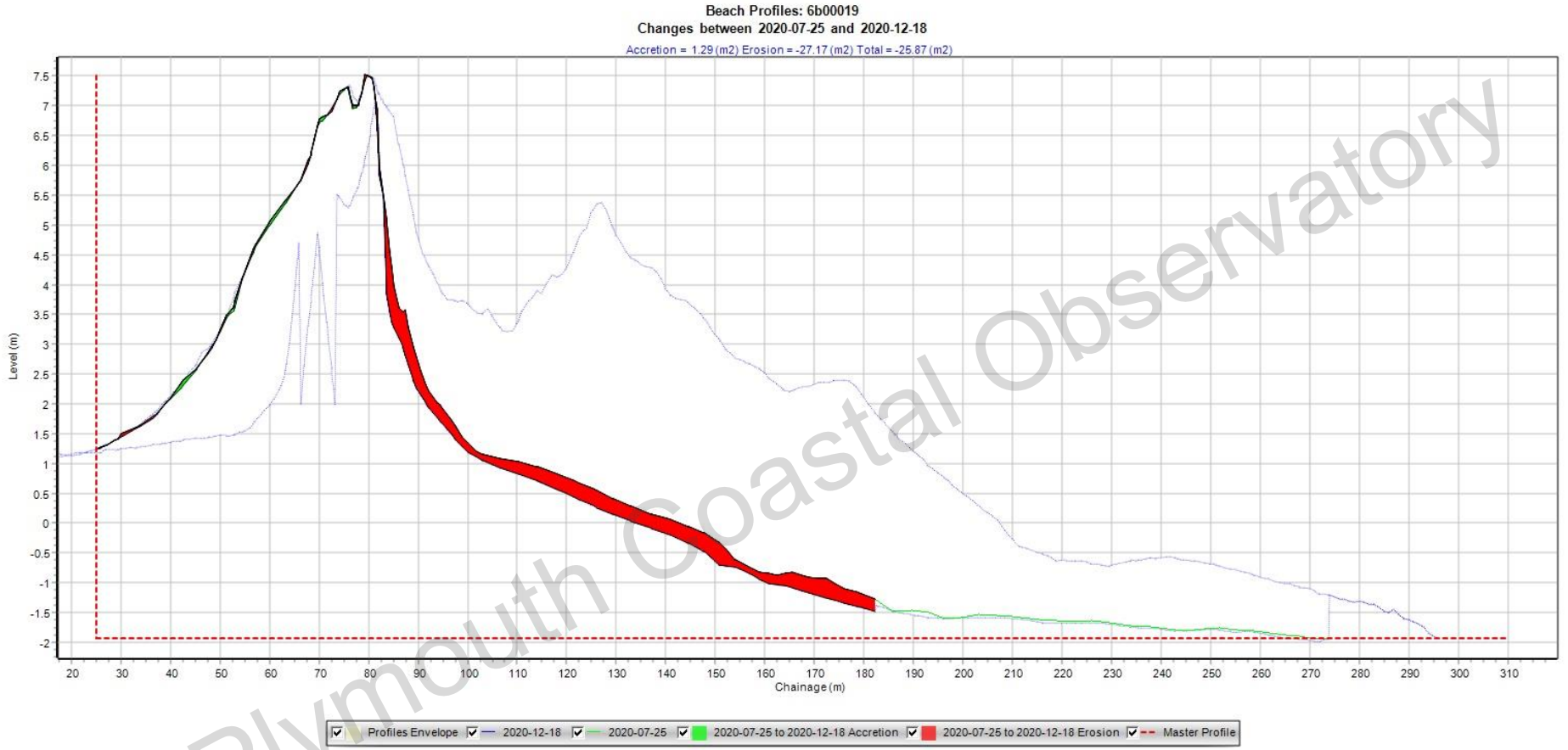
Each profile highlighted in figure 2 is shown below - comparing the 2007 baseline, 2018 GeoTube survey, 2020_02 post storm, 2020_07 baseline, 2020_11 post storm and 2020_12 post storm cross-sectional areas. Each plot has an accompanying profile change plot comparing the baseline and post-storm survey cross-sectional areas, displaying green as accretion and red as erosion for ease of visualisation. Each plot where the GeoTube exists, indicated by a pink line, has another additional profile change plot which concentrates on the GeoTube area more in depth.

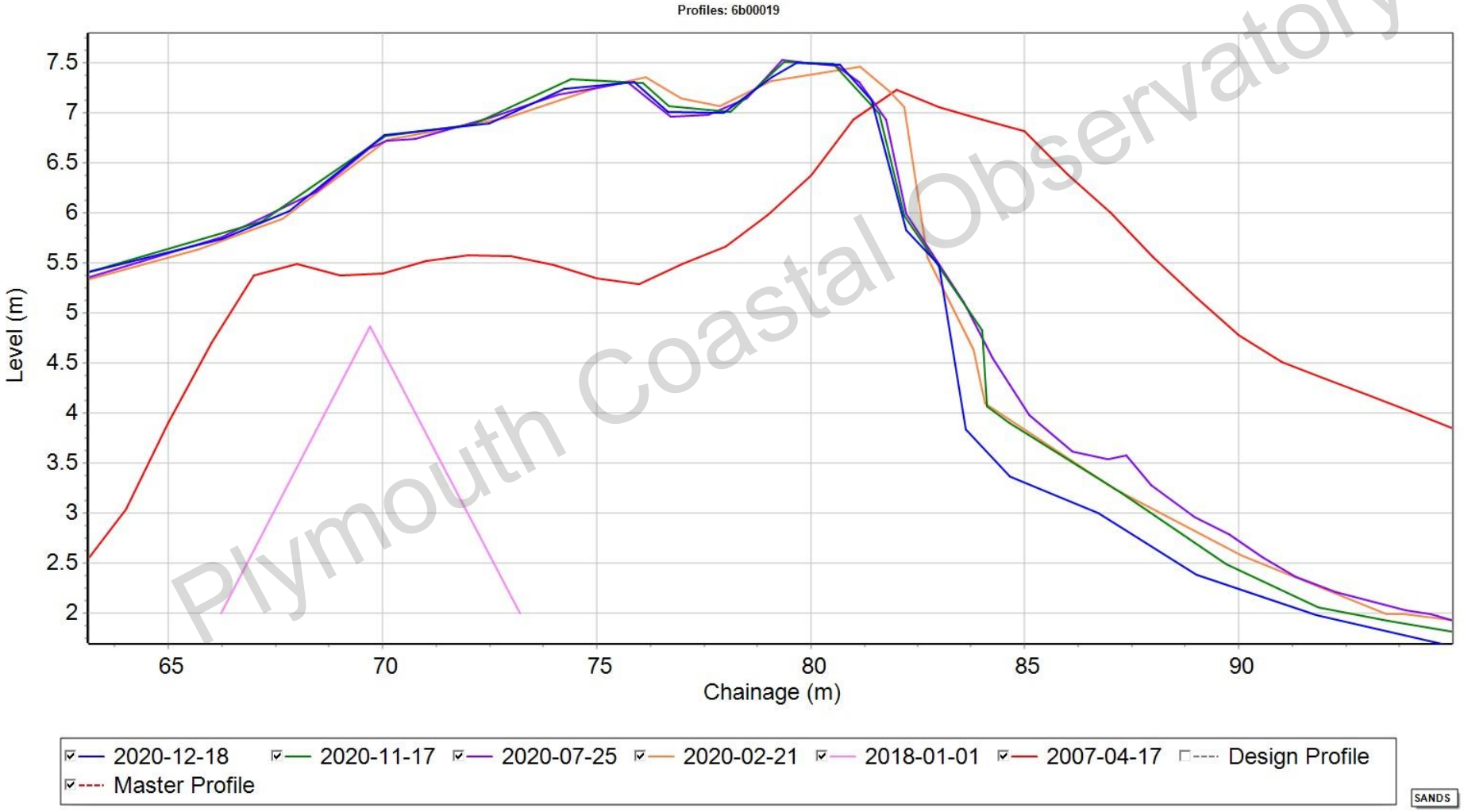


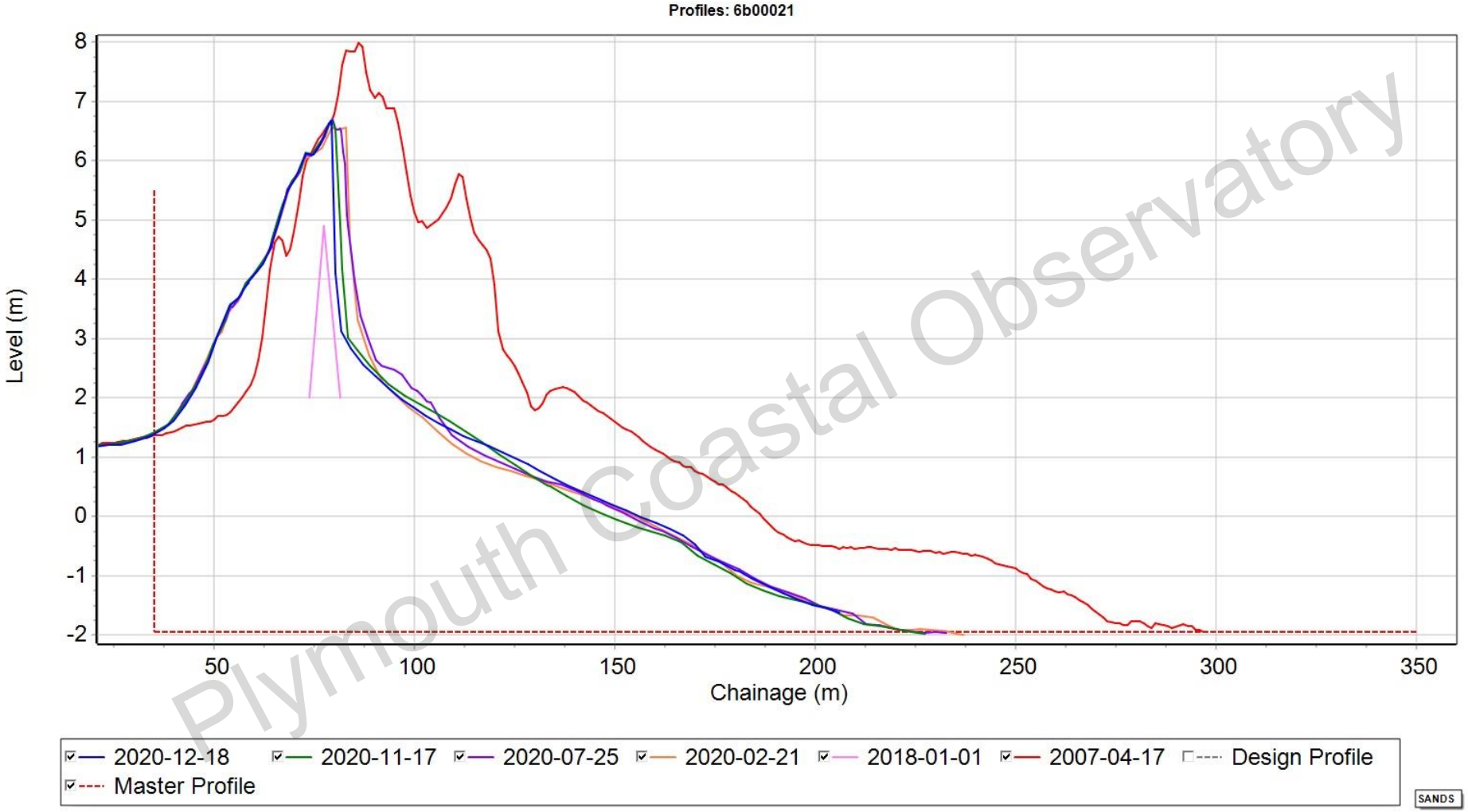


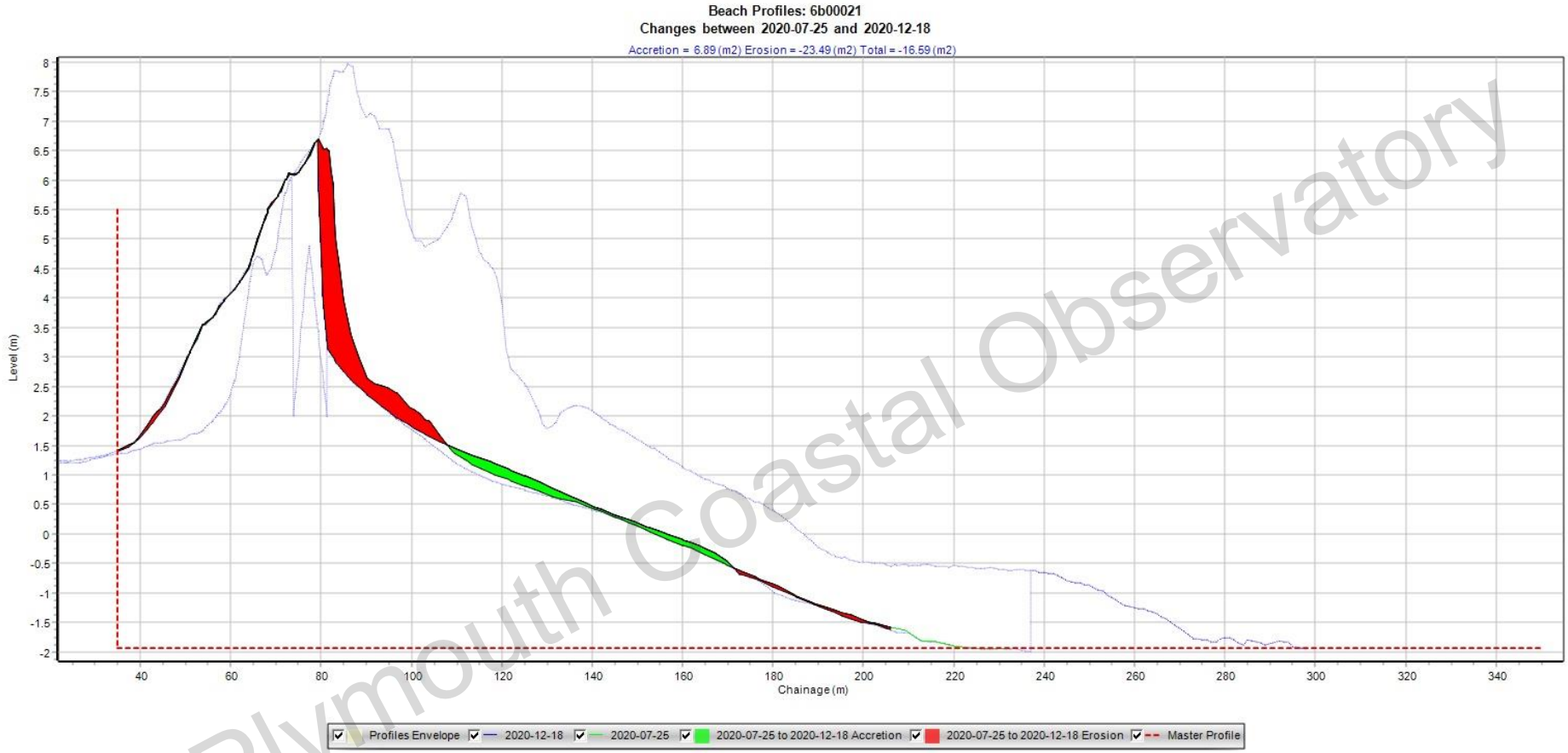


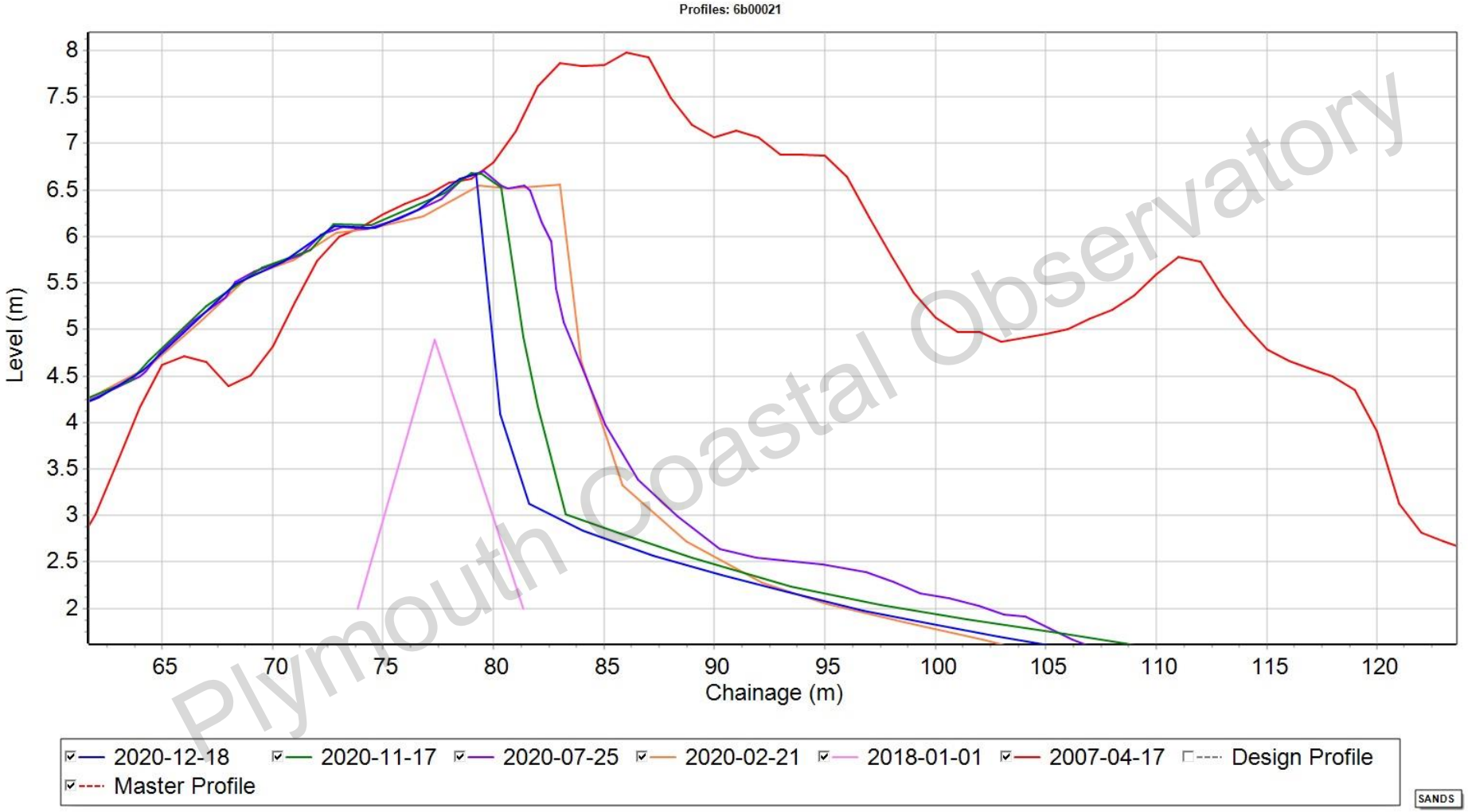


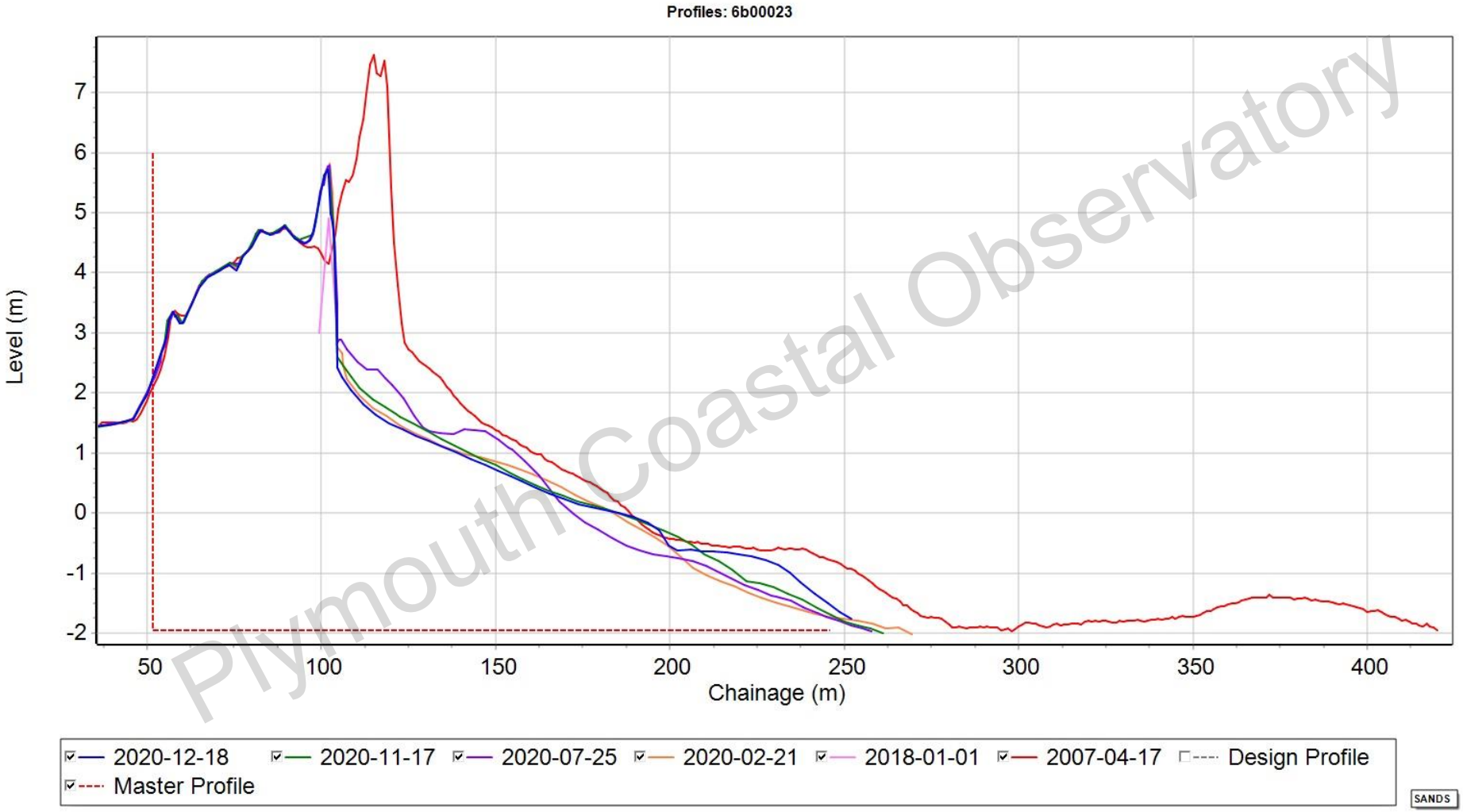


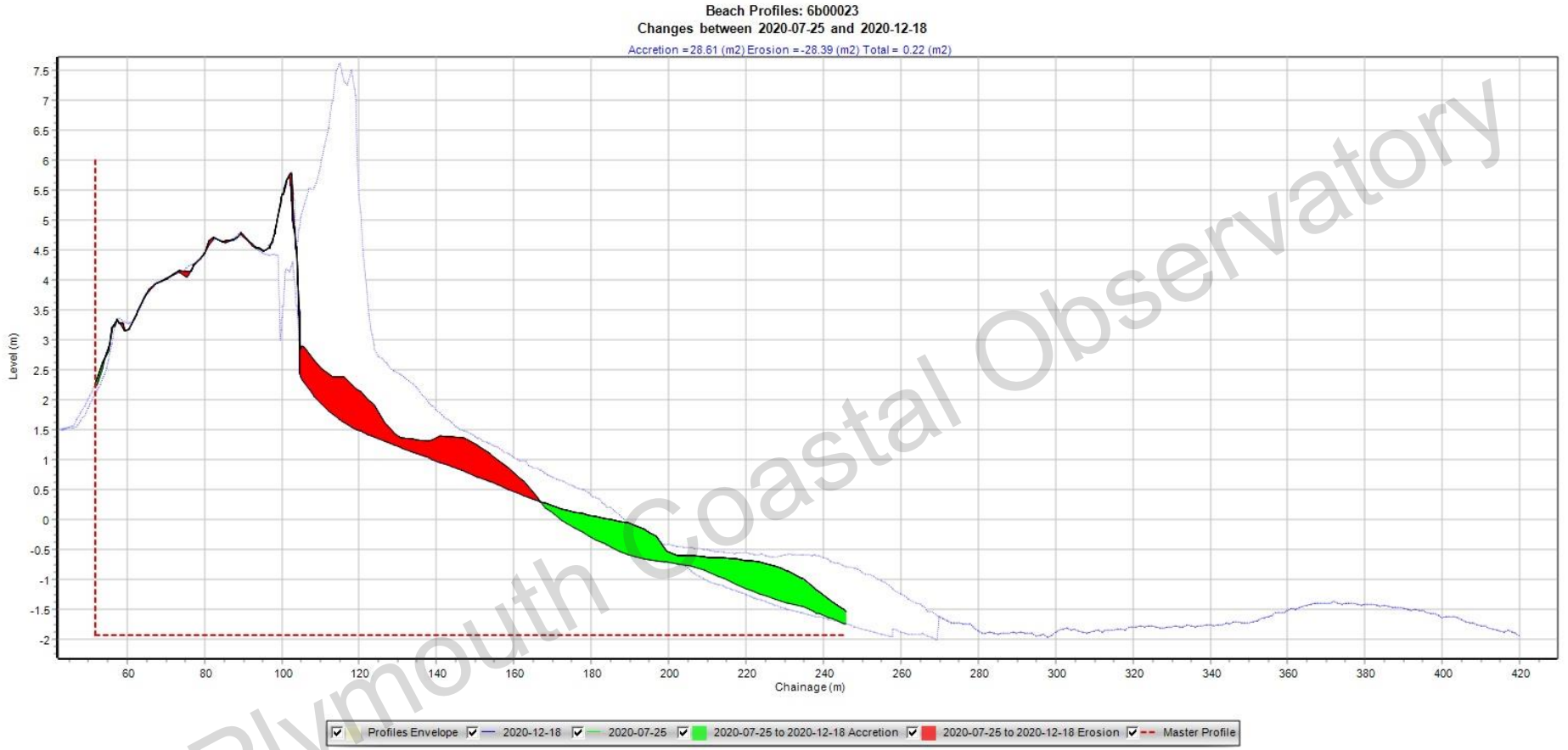


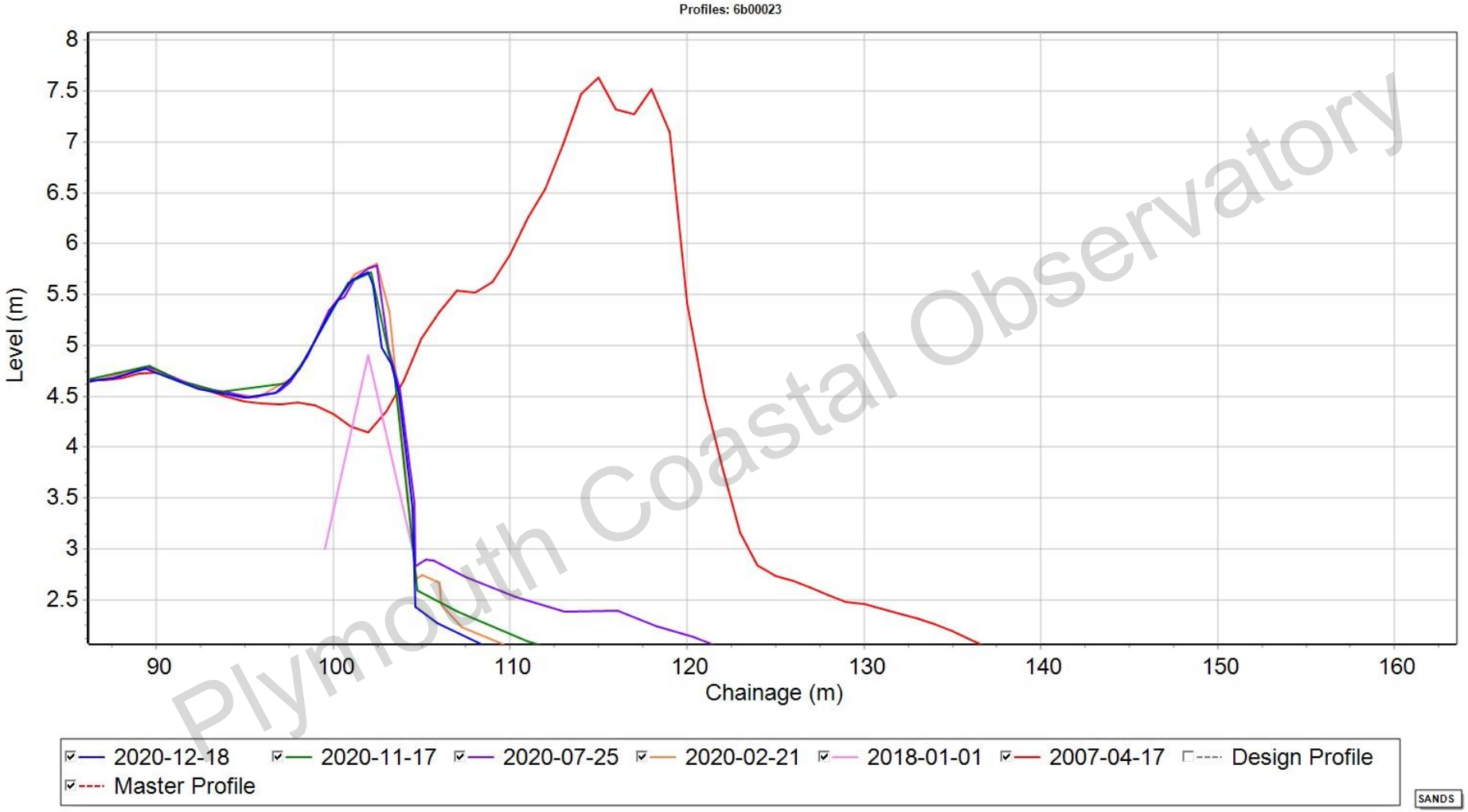


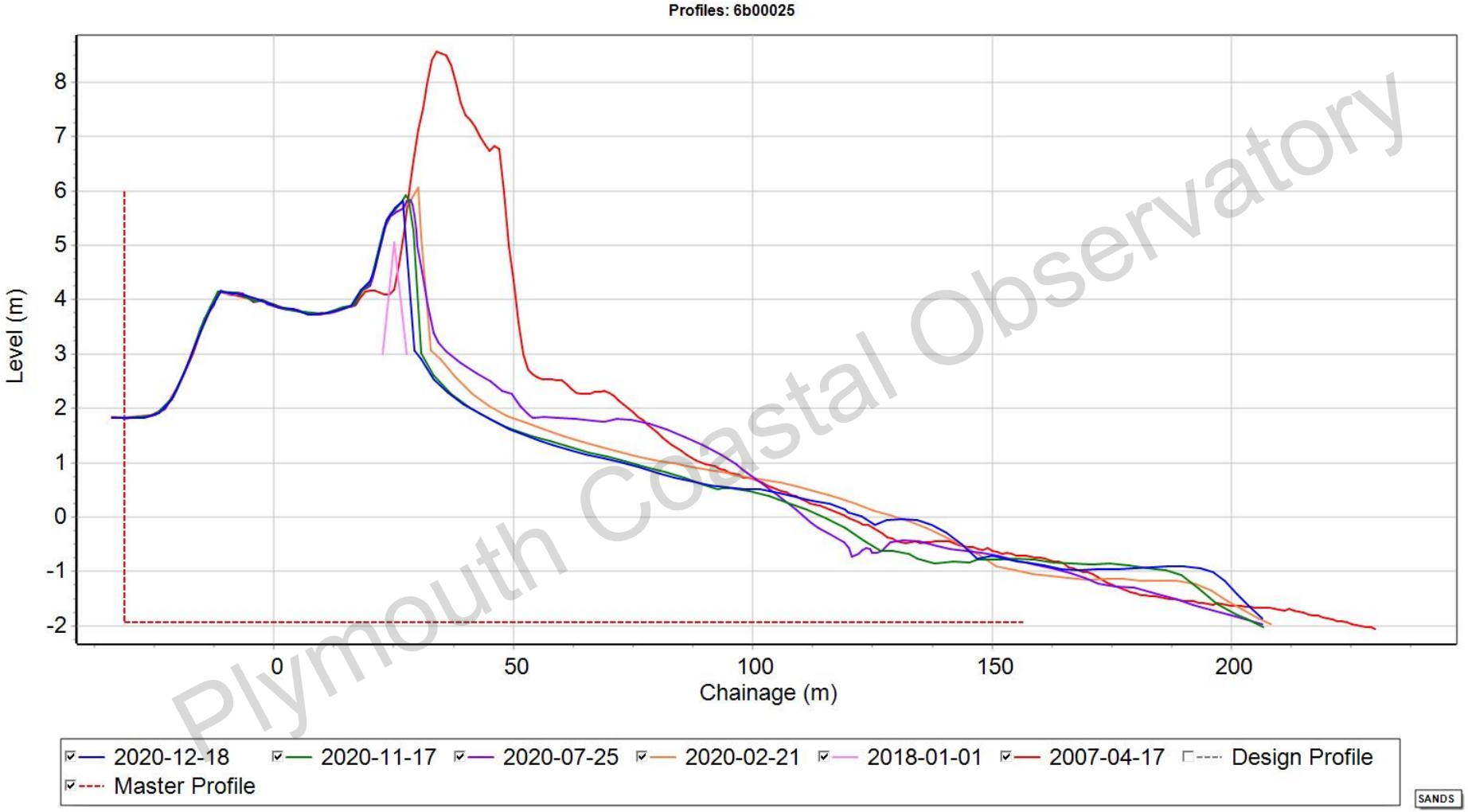


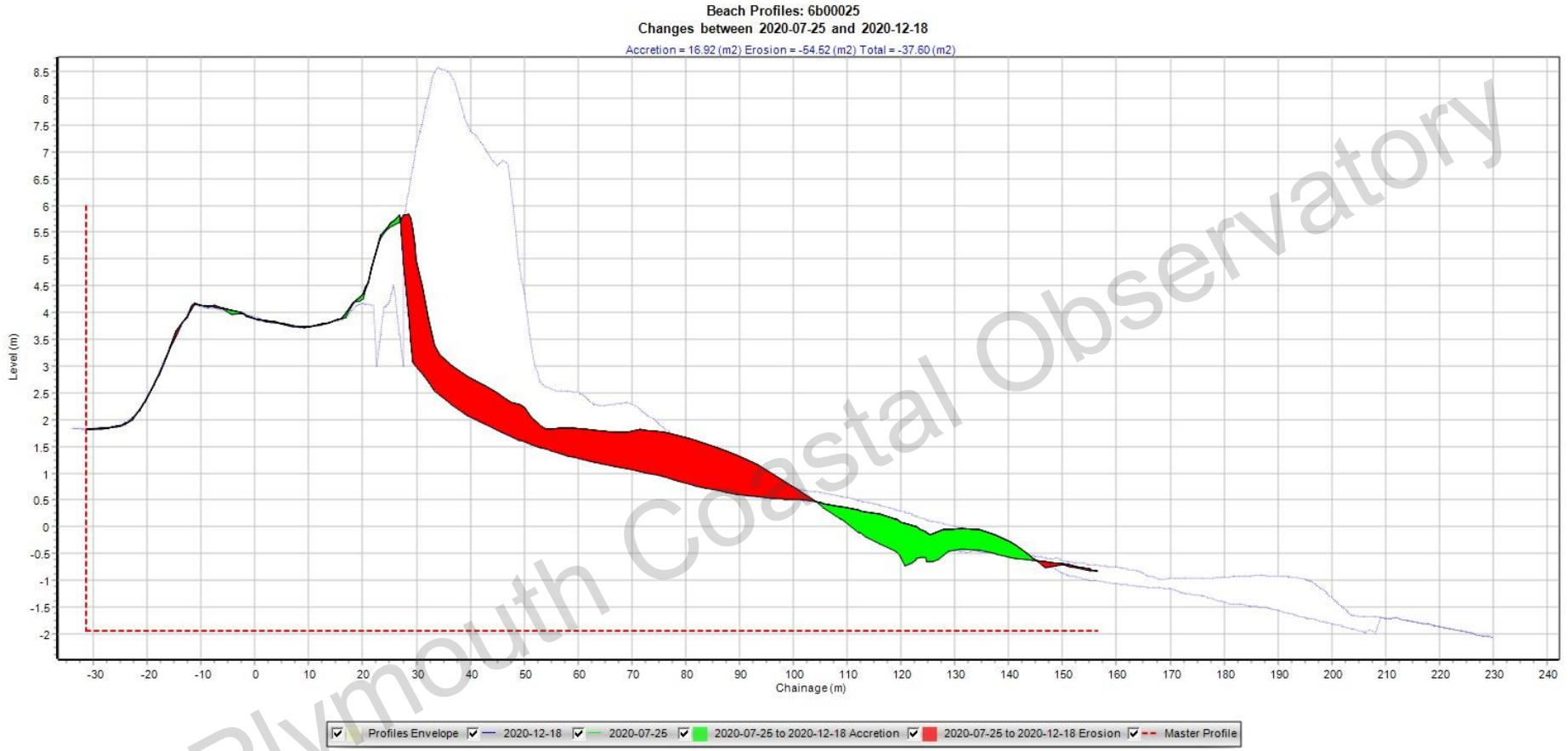


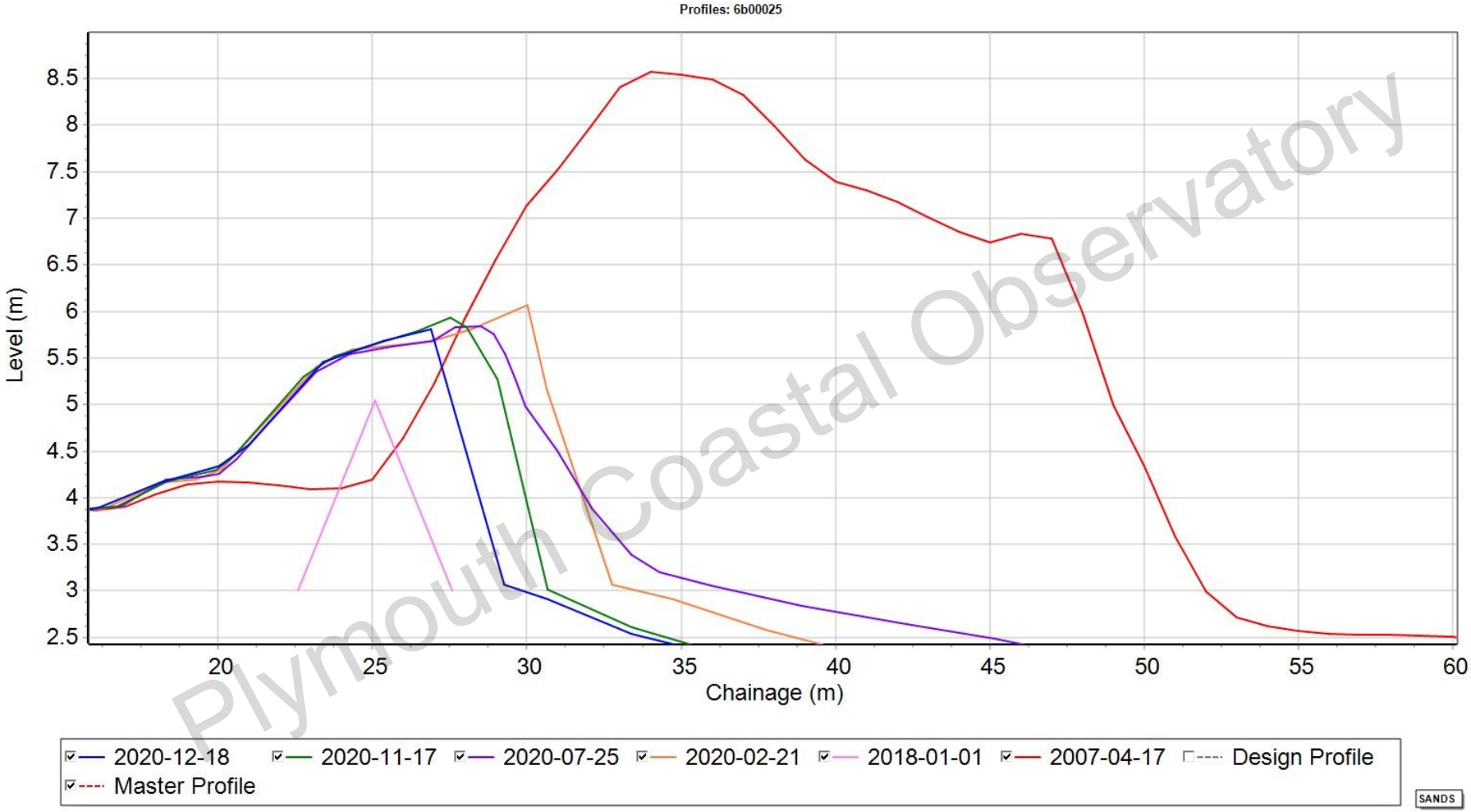


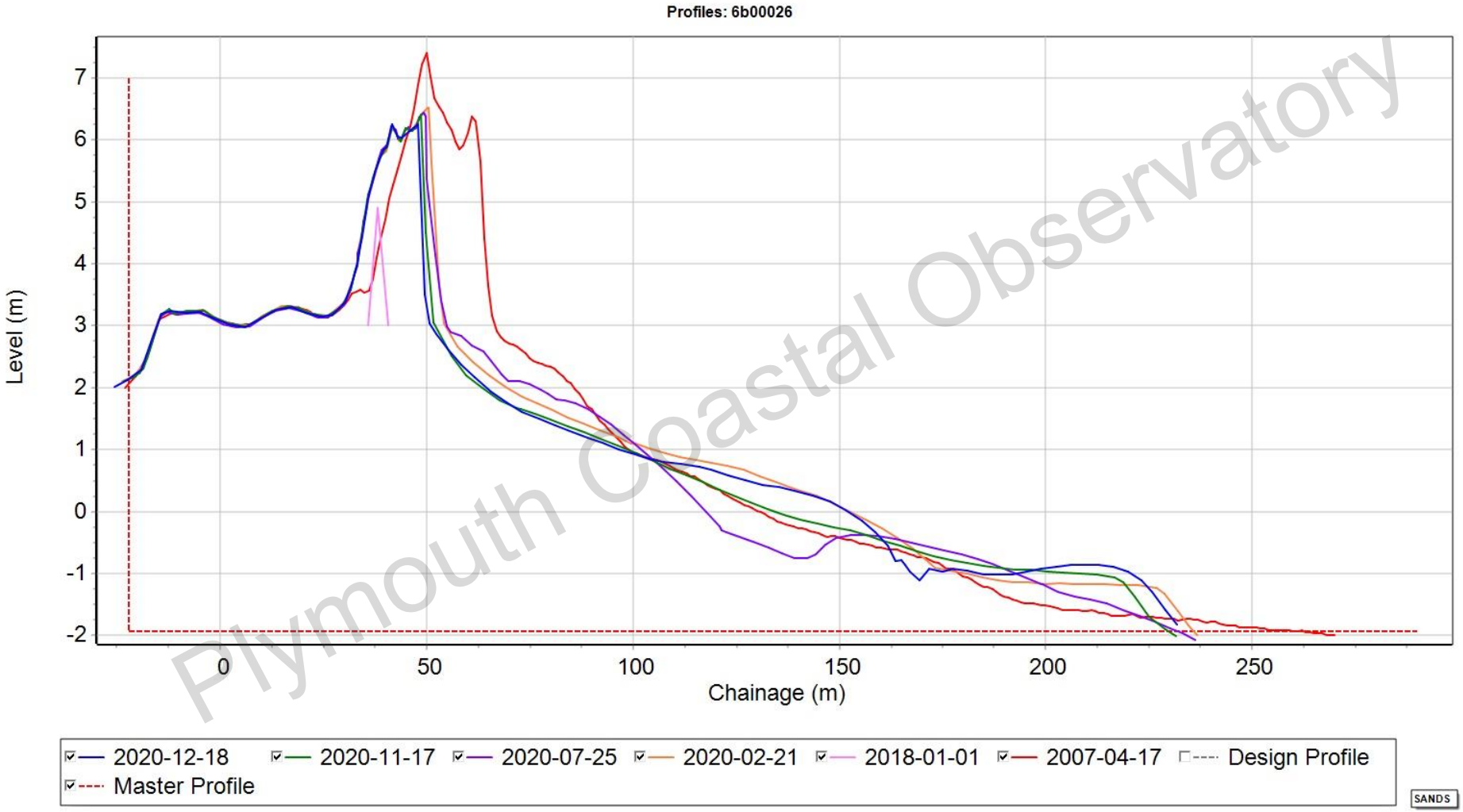


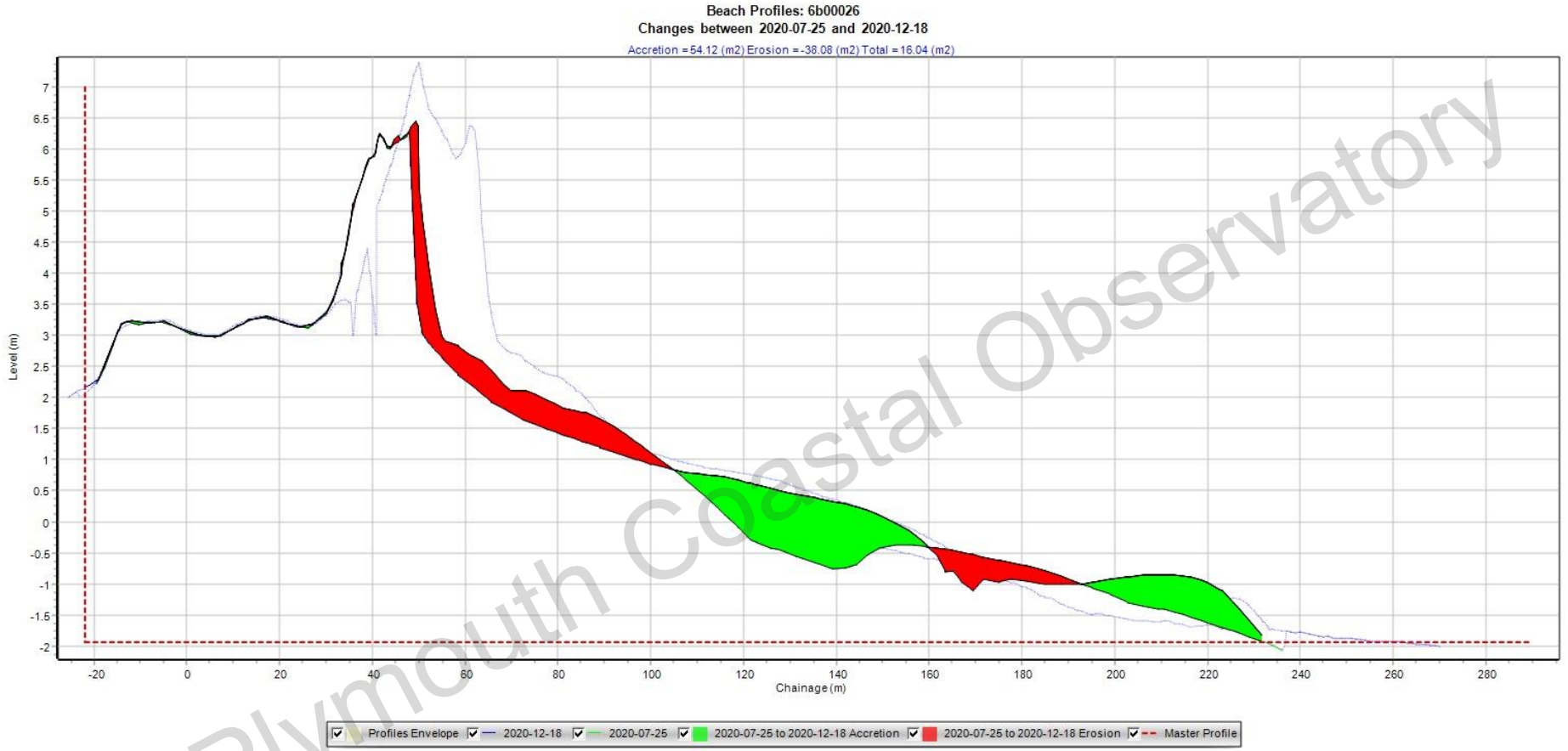


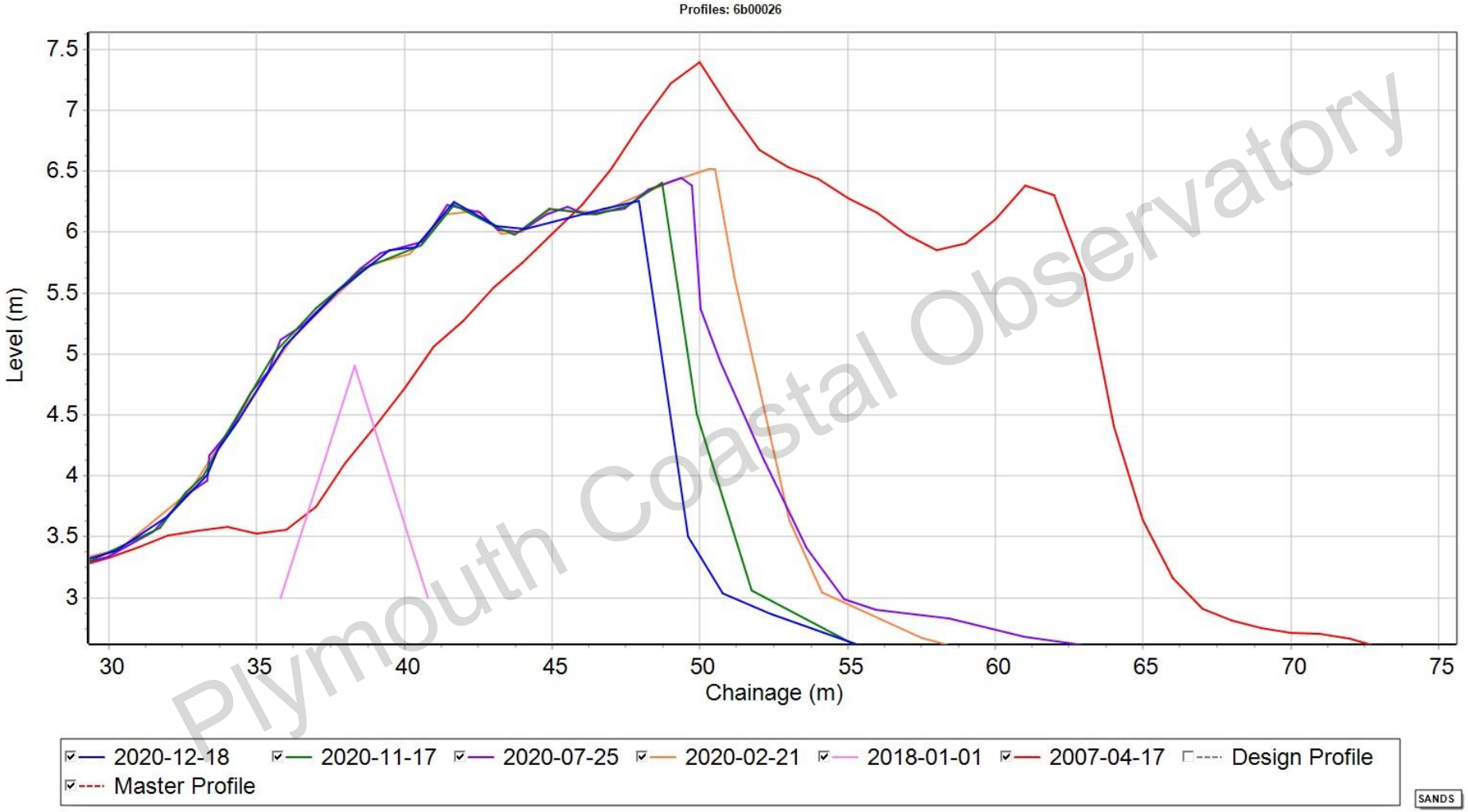


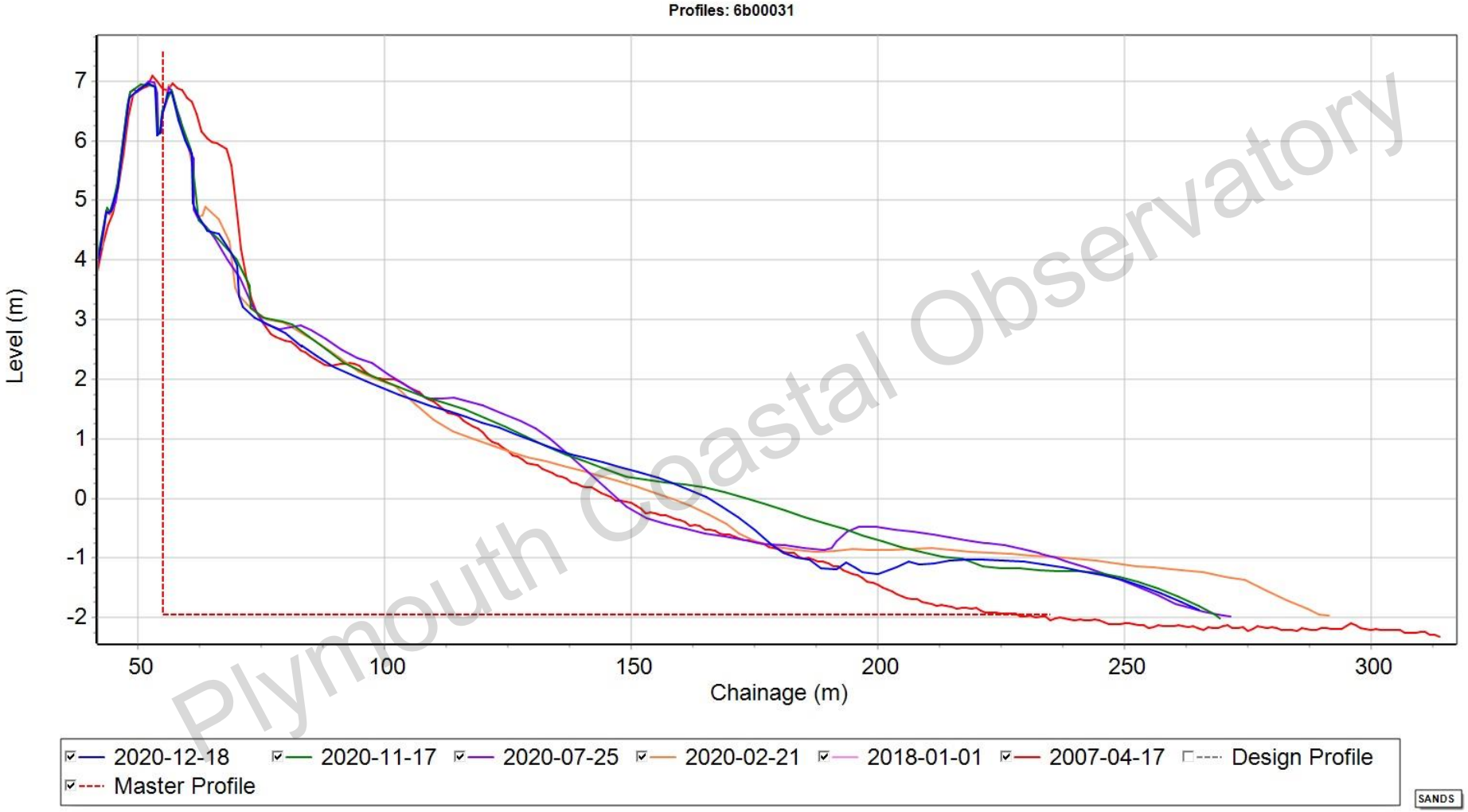


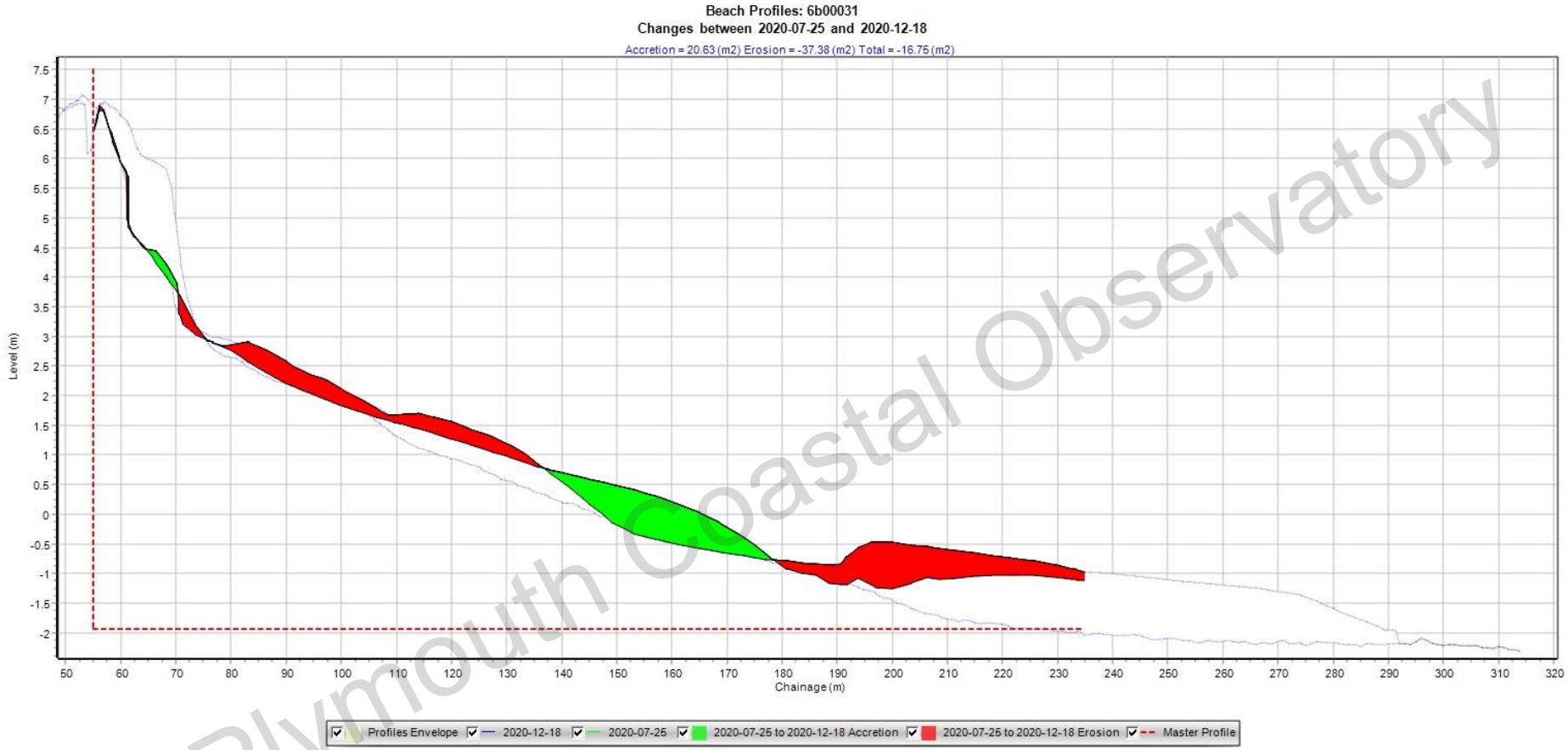


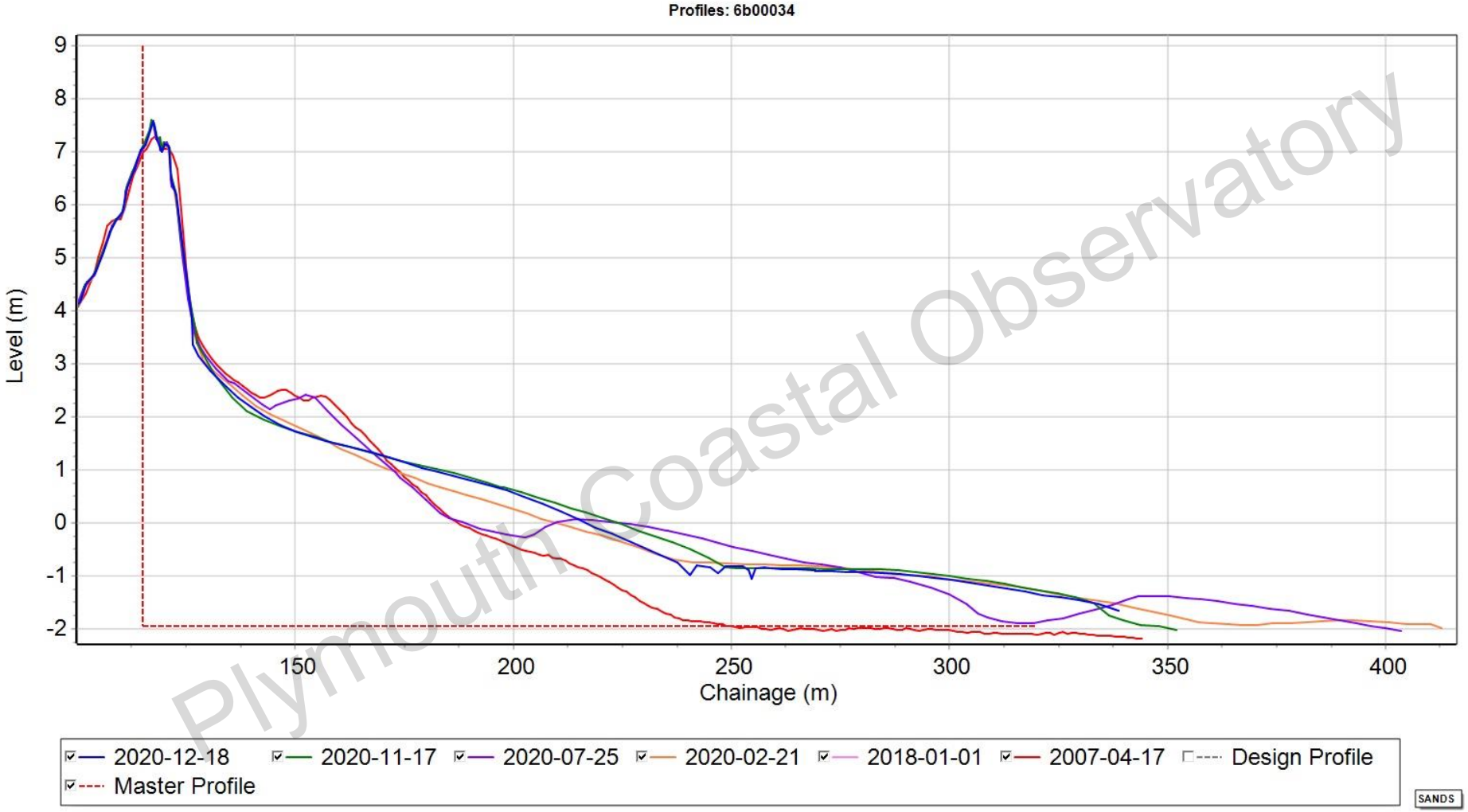


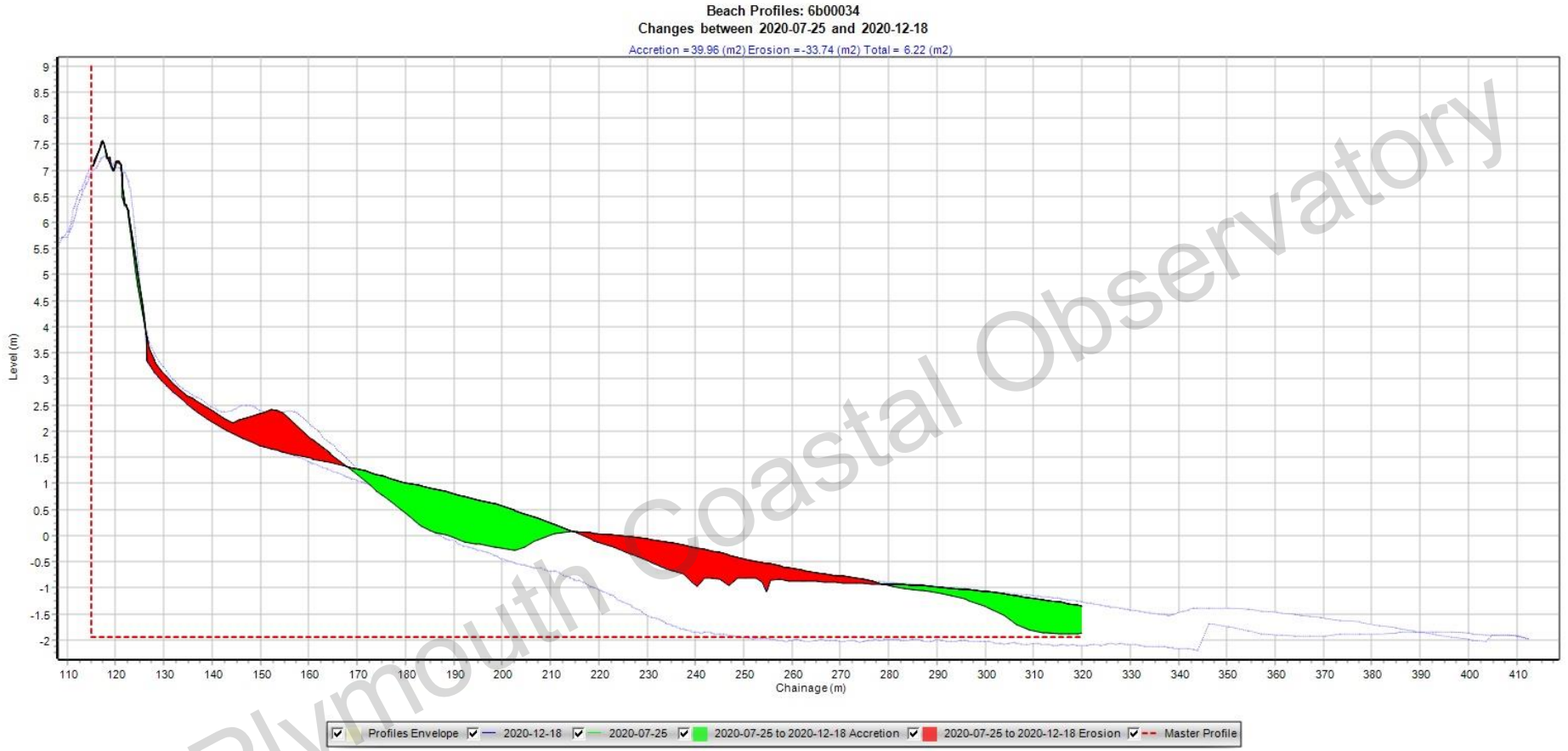


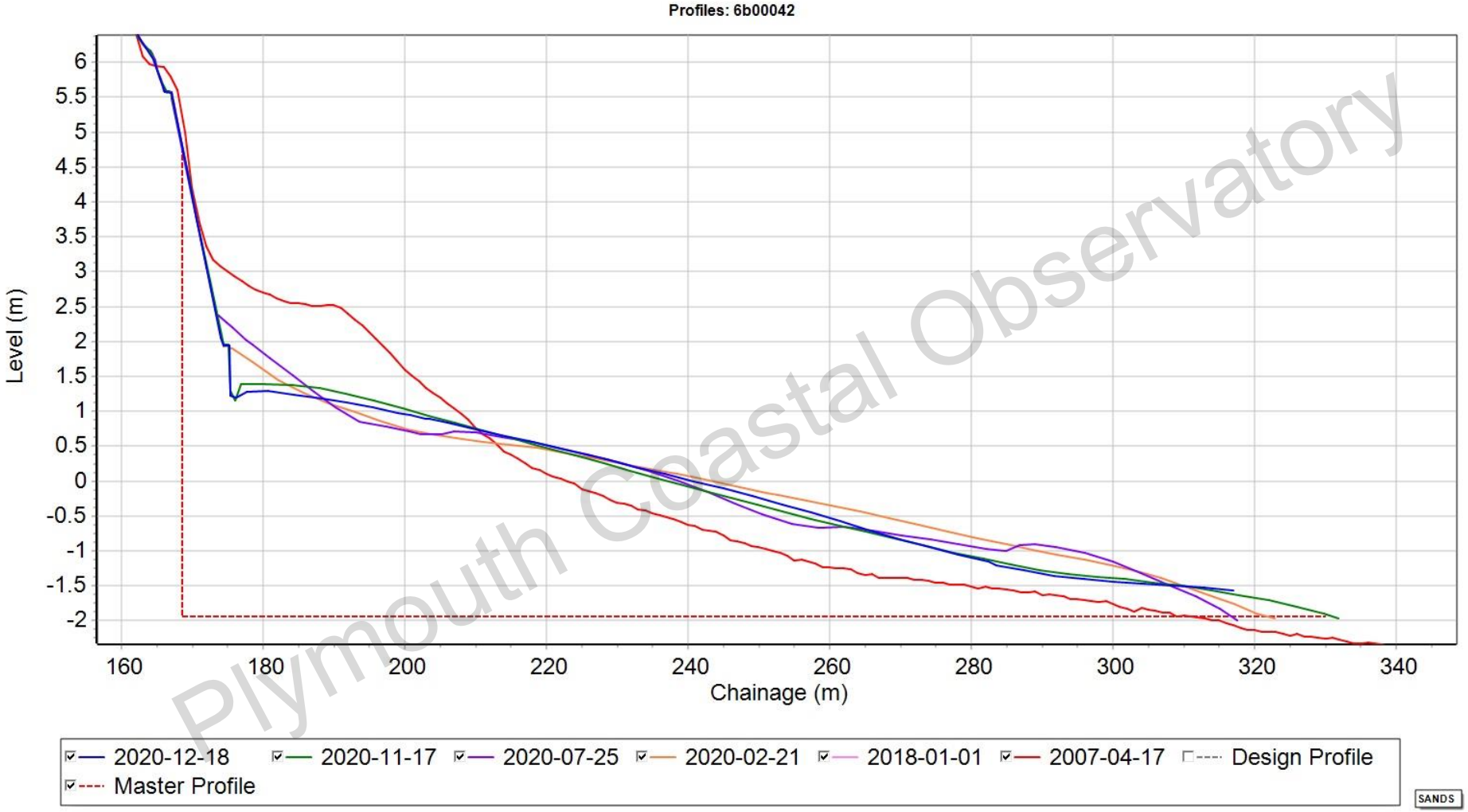


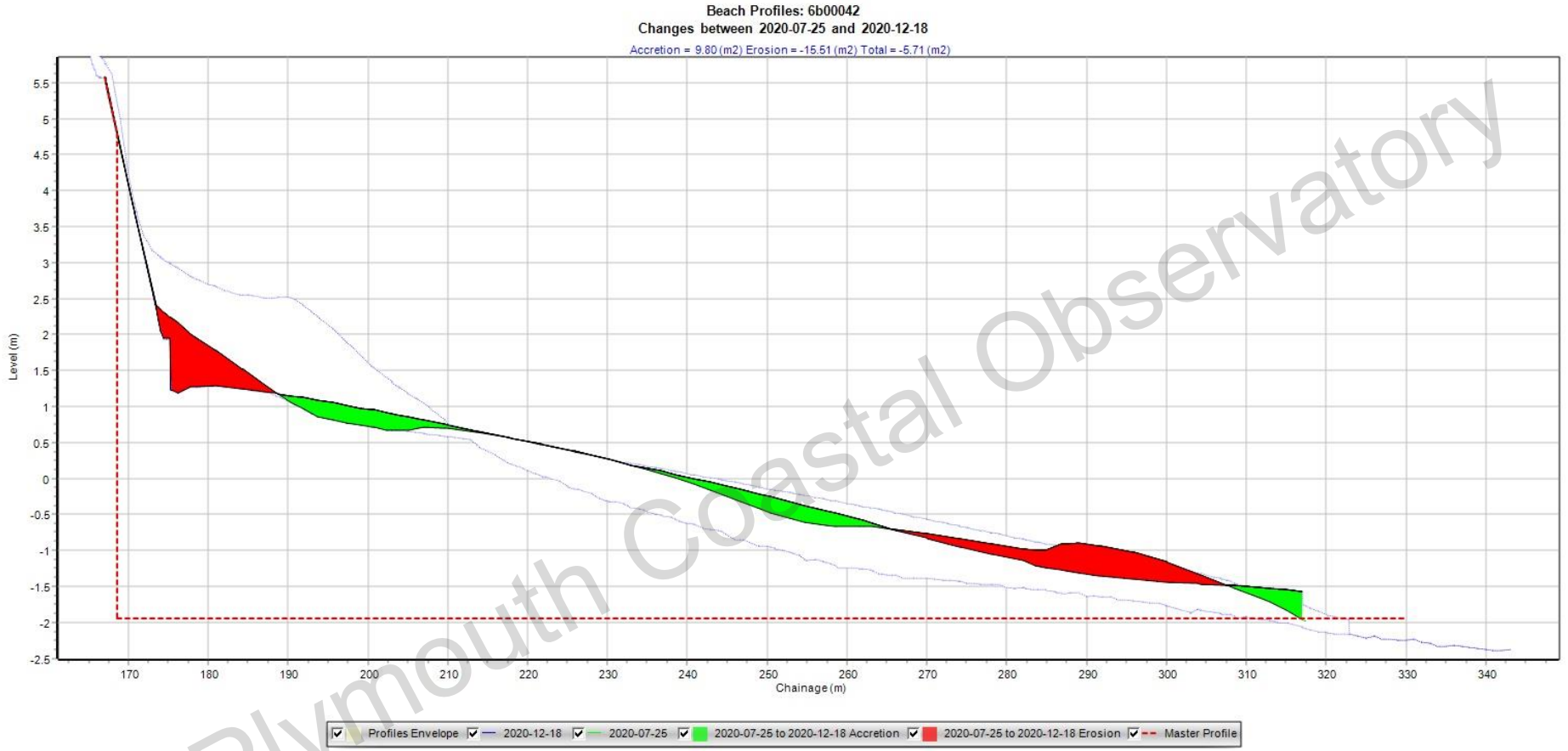


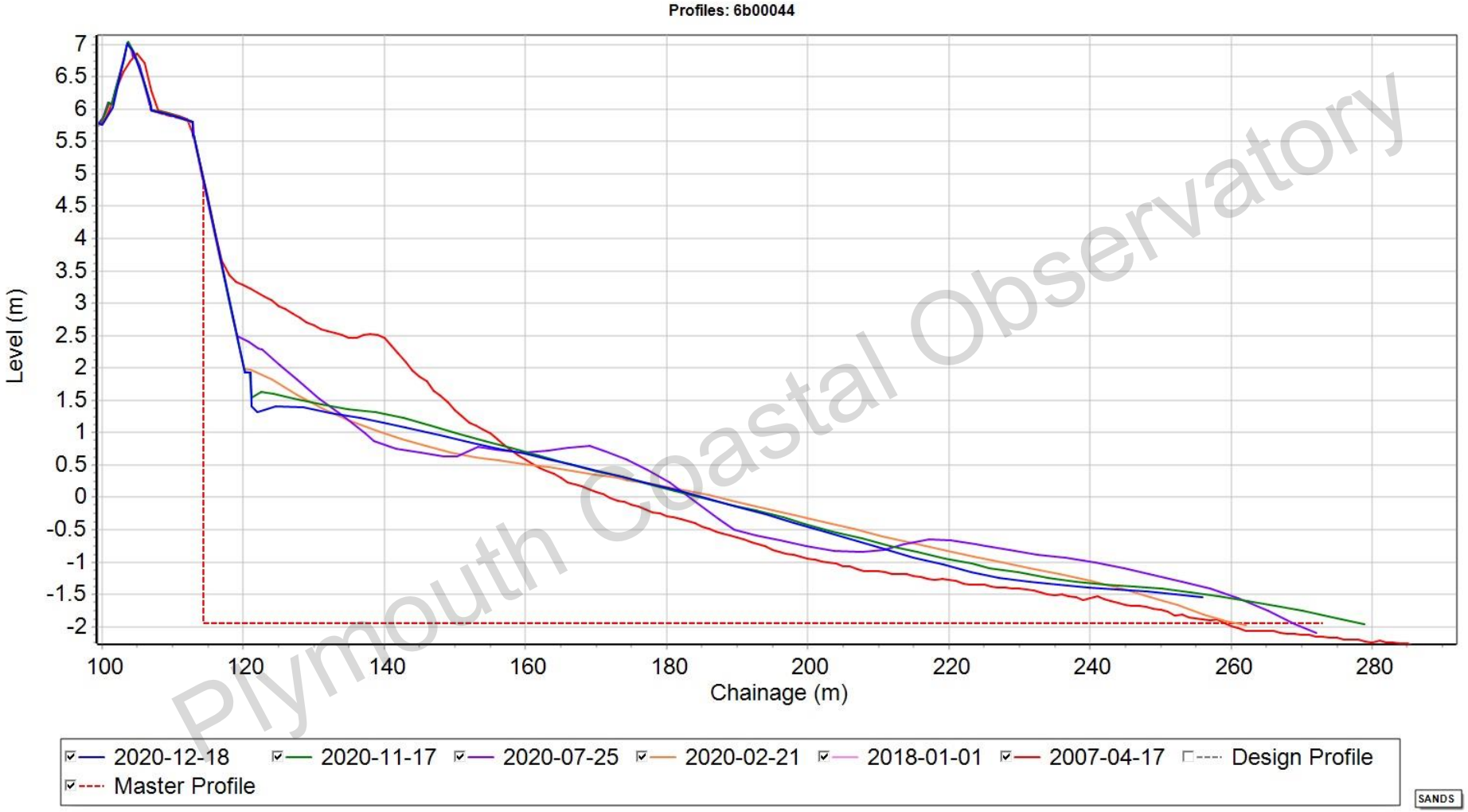


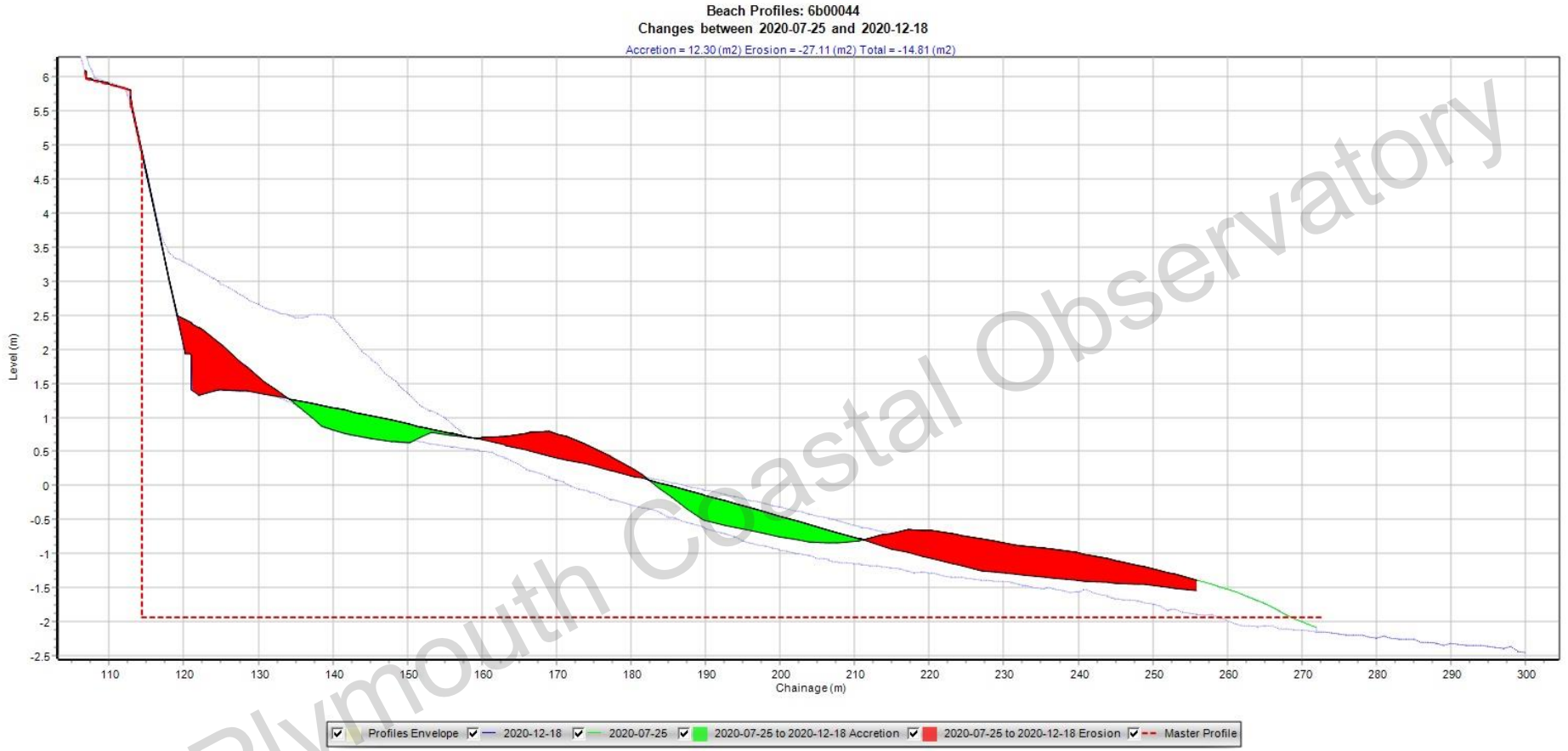


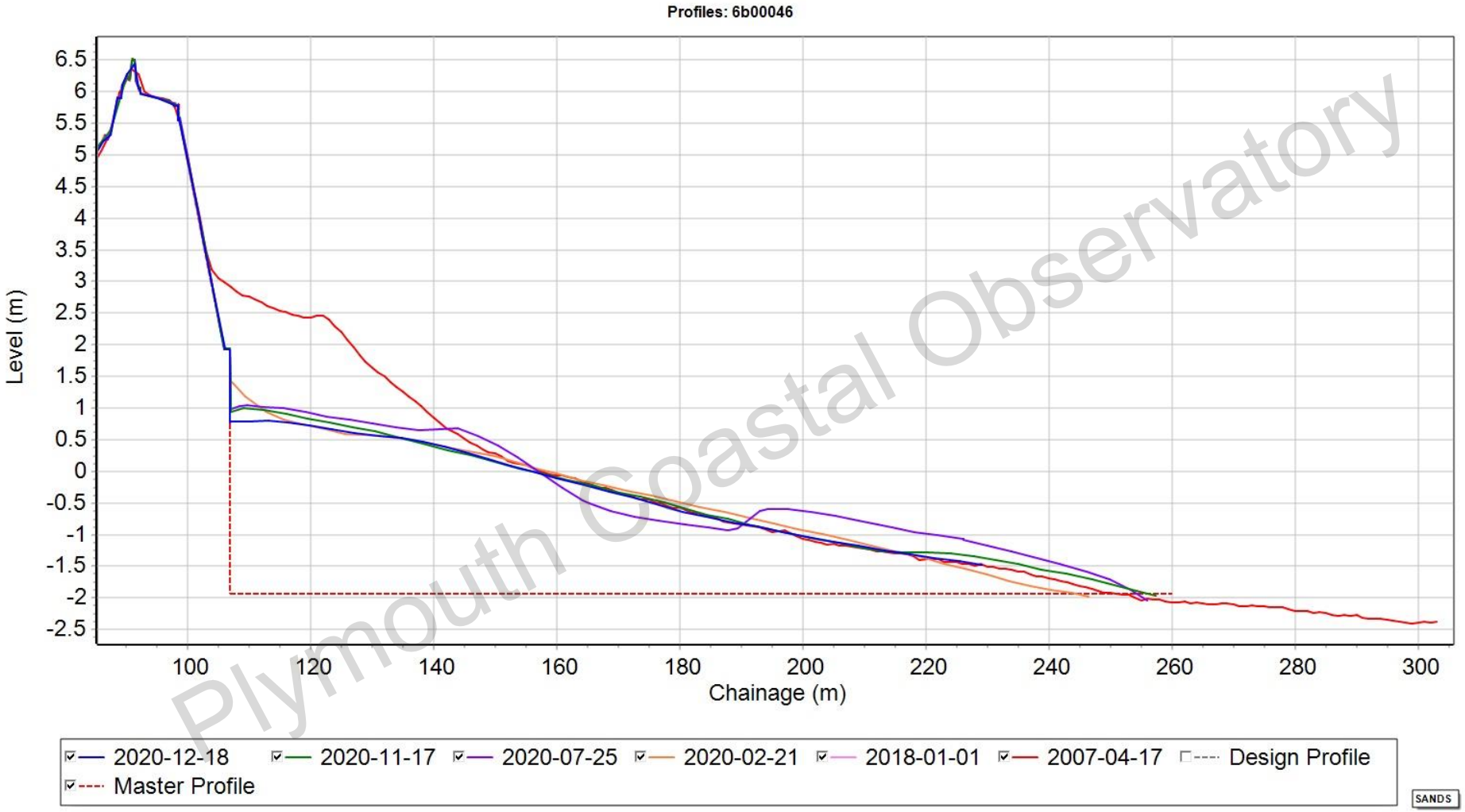


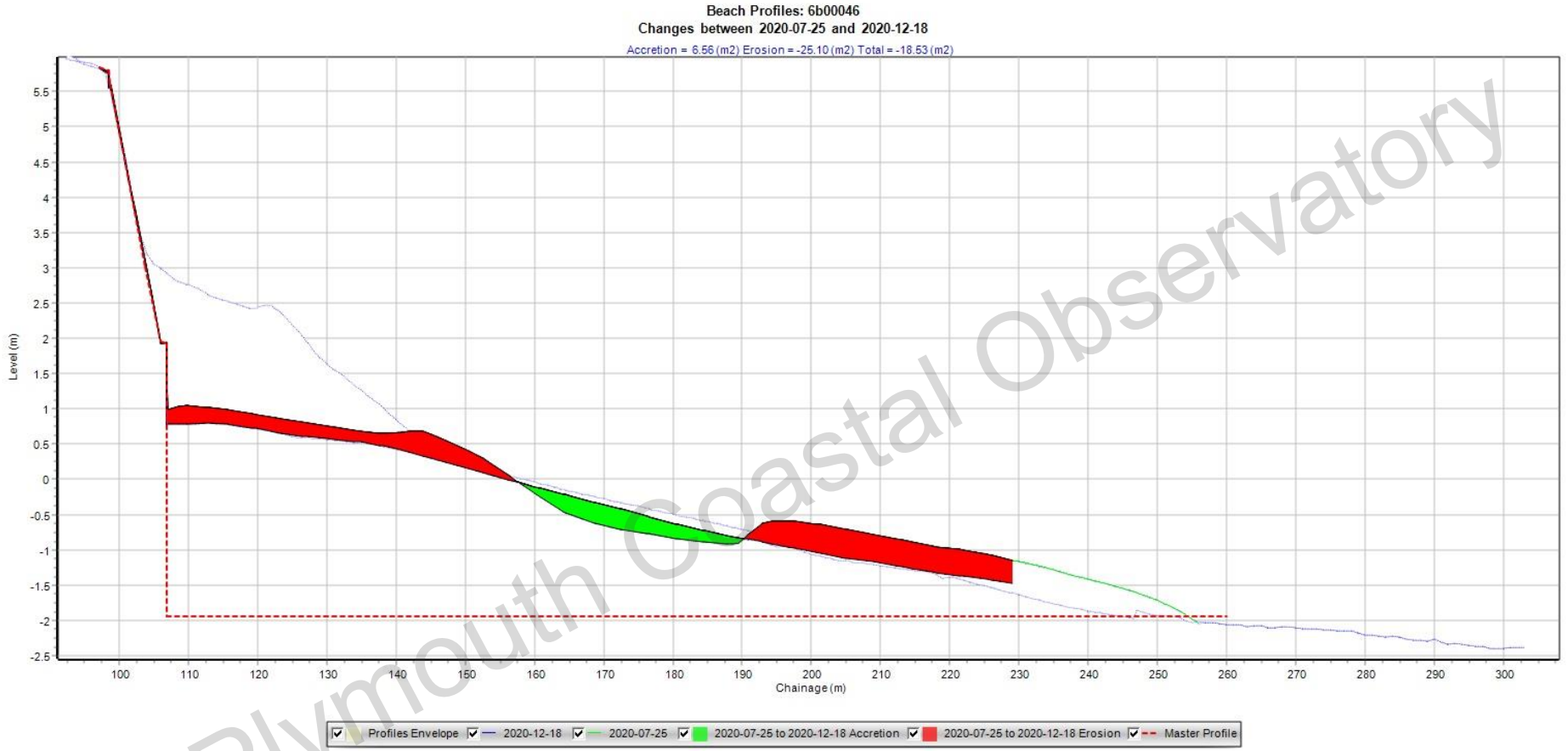


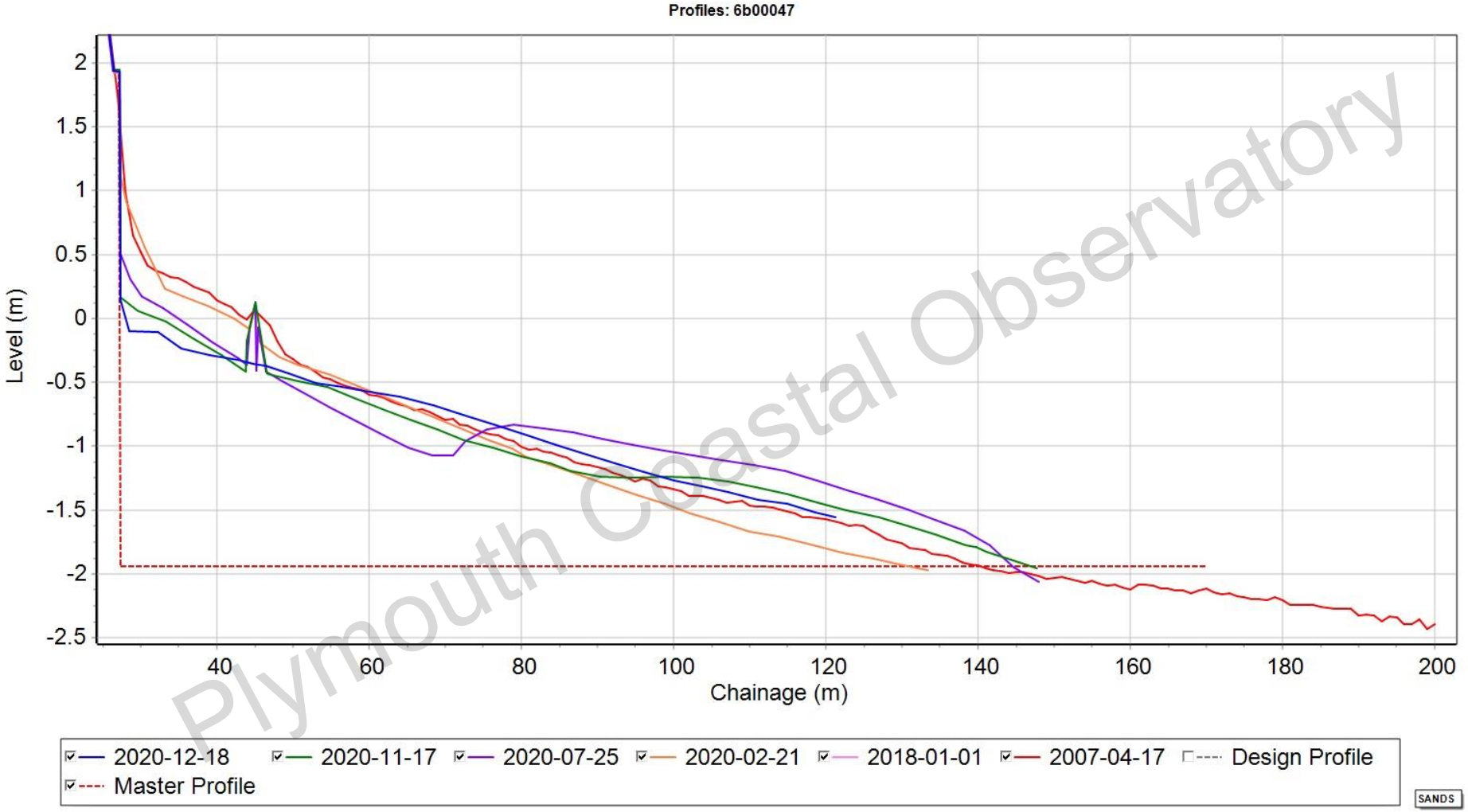






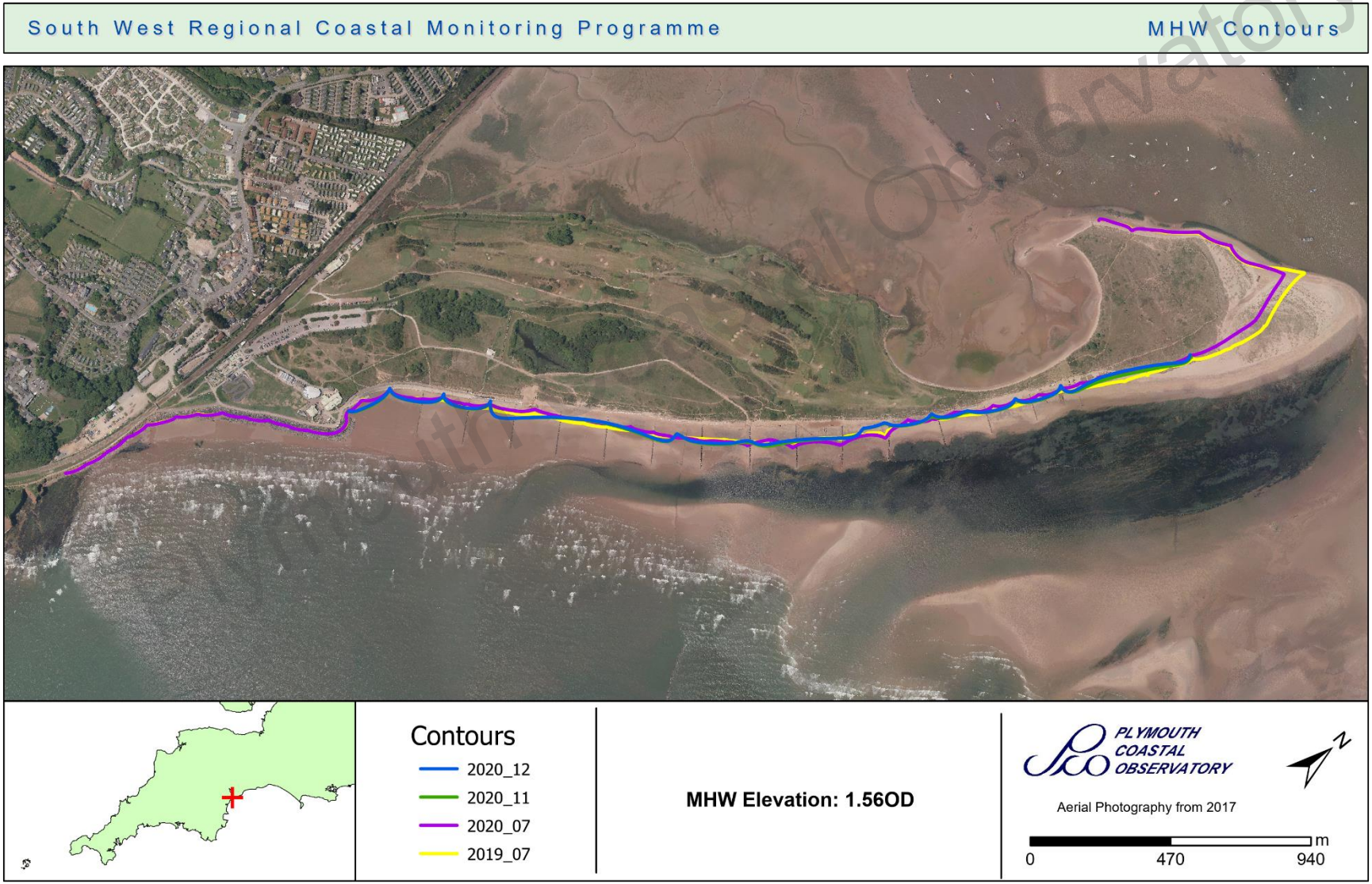






Appendix B – Contours plot

MHW contours are show below for Dawlish Warren, comparing the 2019 baseline, the 2020 baseline, the 2020_11 post storm and the 2020_12 post storm. The first plot is accompanied by a second which concentrates on the GeoTube.

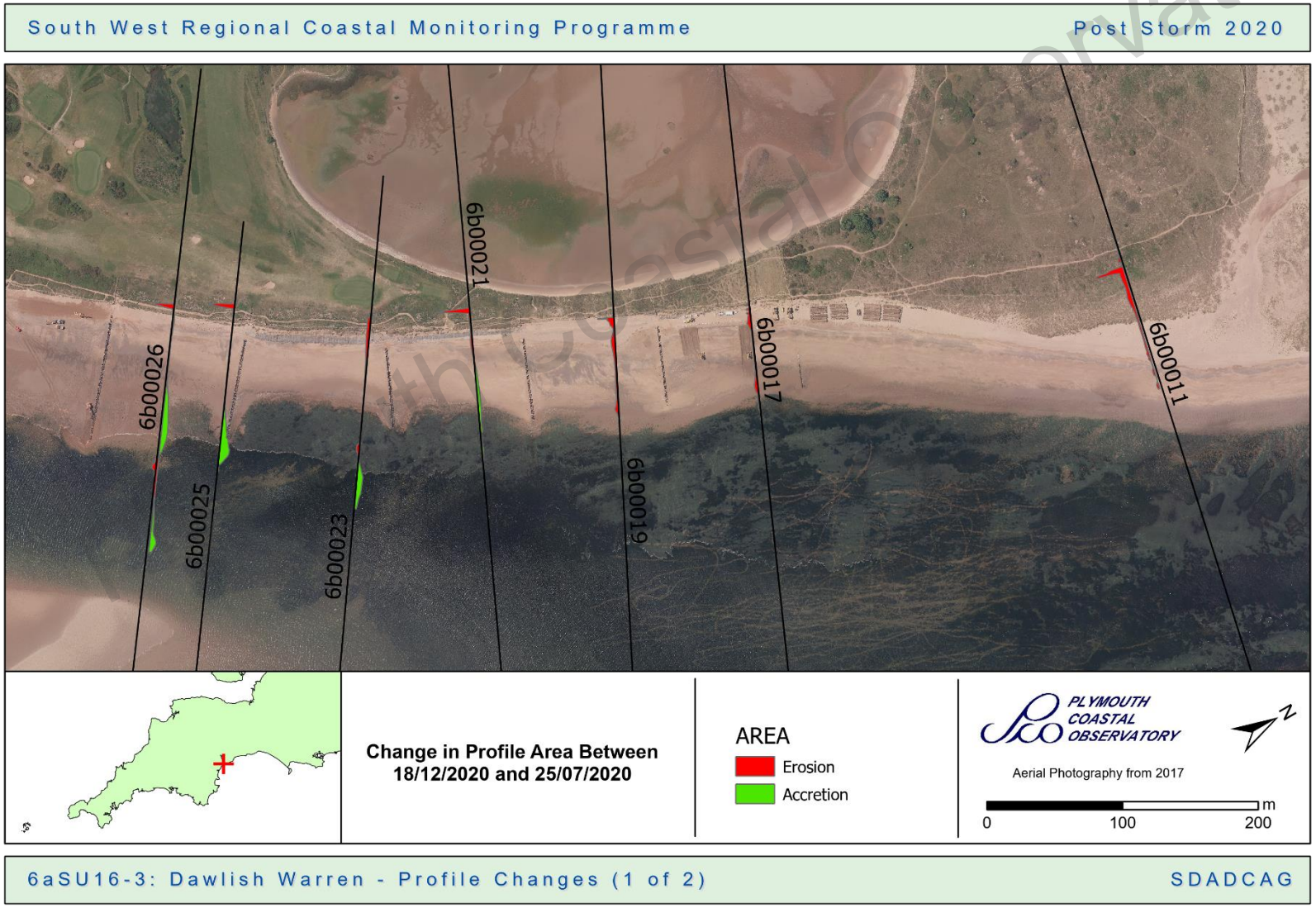


South West Regional Coastal Monitoring Programme — MHW Contours

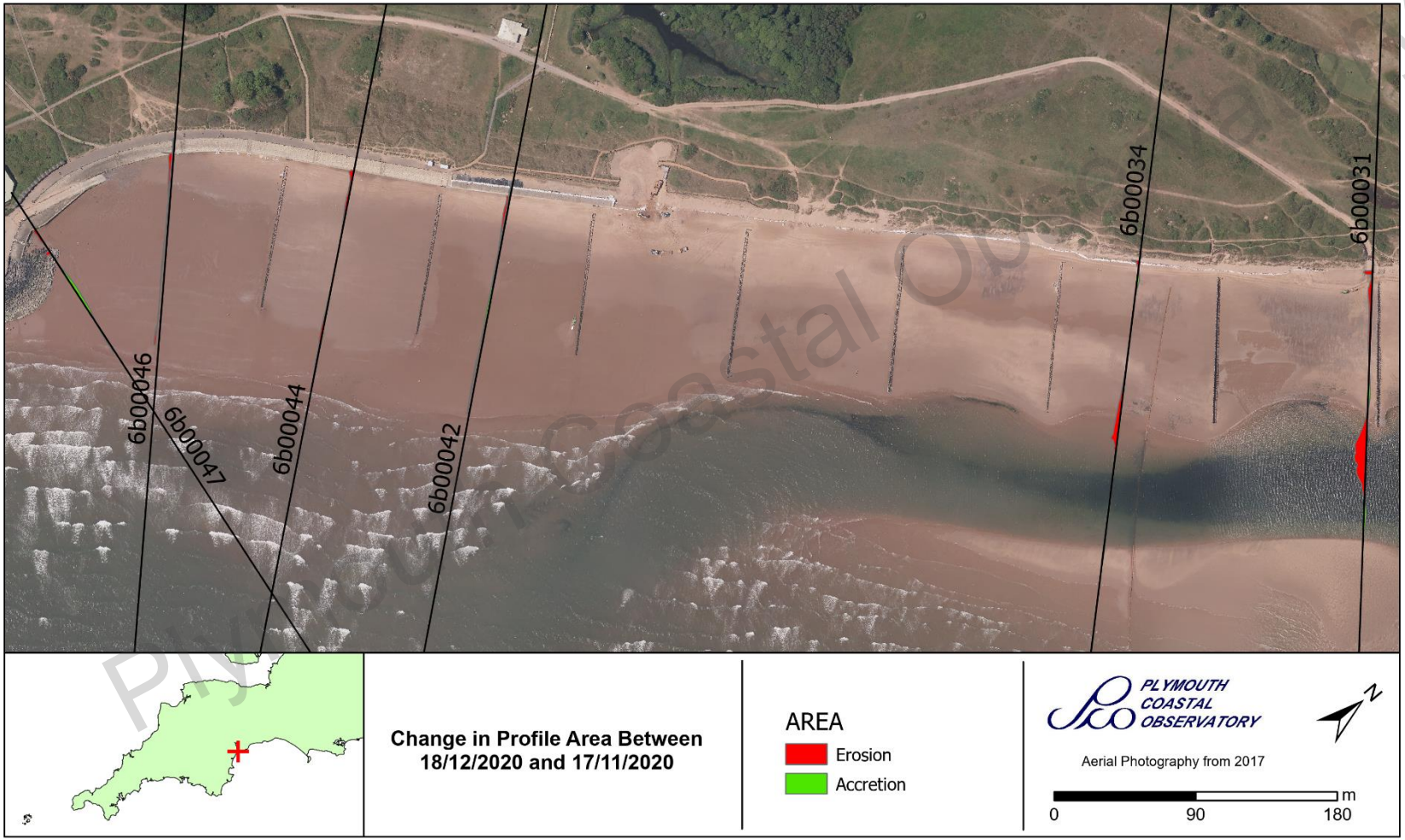
6aSU16-3: Dawlish Warren — SDADCAG - South Devon

Appendix C – Cross-sectional area change maps comparing the two most recent surveys

Plots indicating the location of Dawlish Warren and the post storm profiles, comparing the post storm survey (18/12/2020) with the most recent survey completed before this event which happened to be a post storm survey (17/11/2020). An exaggerated overlay depicts where there has been erosion (red) and accretion (green) across each of the profiles since the previous survey (17/11/2020).



South West Regional Coastal Monitoring Programme — Post Storm 2020



6aSU16-3: Dawlish Warren - Profile Changes (2 of 2) — SDADCAG