Analysis of the storm event (11/02/2021-14/02/2021) along with the impact on Dawlish Warren (6bSU16-3) and Teignmouth (6bSU18-1)

1. Introduction

This report briefly identifies the hydrodynamic forcing cause by storm Darcy and their resultant morphological impact identified by a post storm survey undertaken at two survey units: Dawlish Warren and Teignmouth, both completed on 17th February. All hydrodynamic and meteorological data has been obtained from the Dawlish directional wave rider (DWR) buoy.

Storm Darcy was the fourth named storm by the Met Office for the 2020/2021 winter season, impacting the South East of Devon, from the 11th to the 14th February, with wind speeds reaching up to 52 mph and wind gusts reaching up to 55 mph at Dawlish Warren; wind speeds and wind gusts at Teignmouth reached up to 28.9 mph and 43.4 mph respectively.

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 brief background into the hydrodynamics occurring during this storm event period and an analysis into the changes to the beach's morphology.

2. Hydrodynamics

During Storm Darcy, between the 11th and 14th February 2021, the significant wave height (H_S) averaged 2.40 m (*Table 1*) and the maximum wave height (H_{Max}) averaged 3.82 m. When compared to the February average, the storm event recorded a 31% increase in H_S and a more south-easterly wave direction (Table 1). As can be seen in Figure 1, there were three distinct peaks throughout the period under analysis whereby the storm threshold (2.64 m) was exceed by H_S. The first lasted for a duration of 10.5 hours coinciding with the spring high tide on 11th February (18:58 at 4.2 m recorded at Dawlish; 18:44 at 4.3 m recorded at Teignmouth), the second lasted for a duration of 7.5 hours coinciding with spring high tide on 12th February (07:20 at 4.4 m recorded at Dawlish; 06:59 at 4.6 m recorded at Teignmouth) and the third lasted for 16 hours which coincided with the spring high tide on 14th February (08:26 at 4.4 m recorded at Dawlish; 08:11 at 4.6 m recorded at Teignmouth); see Table 1 and 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 (11/02-14/02)	2.40	7.25	5.15	131
February Average (2007-2019)	0.75	8.2	4.0	161
Storm Event Peak 1 (11/02 09:30 – 20:00)	2.71	7.7	5.39	121
Storm Event Peak 2 (12/02 03:30 – 11:00)	2.77	7.57	5.47	117
Storm Event Peak 3 (14/02 02:30 – 18:30)	2.92	7.84	5.78	157

The period under analysis recorded a maximum wave height of 3.49 m and a maximum H_{Max} of 6.32 m. The maximum values of H_S and H_{Max} can be seen to exceed the January average by around four times.

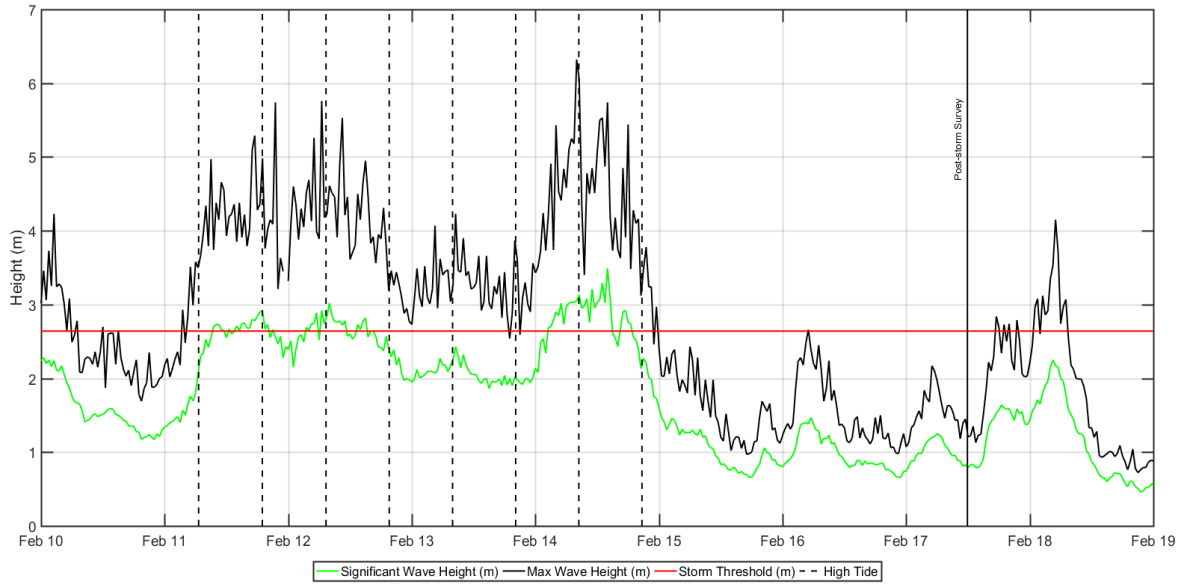
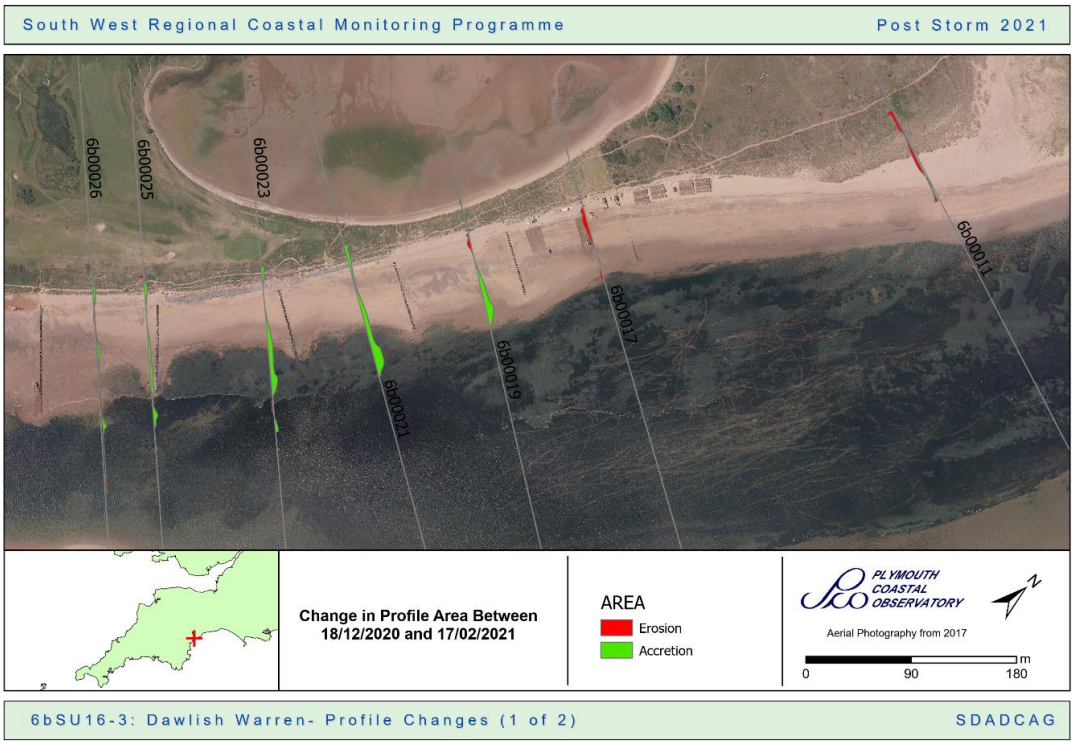


Figure 1 – Plot showing the significant wave height (H_S) and maximum wave height (H_{Max}) over a seven-day period, including the low-pressure event. High tide times during the study period are indicated with a dashed vertical black line. Data obtained from Chesil DWR.

3. Beach Morphology Change

3.1 Dawlish Warren

The post-storm survey consisted of thirteen survey lines which, in this report, are directly compared against the previous post st0orm survey (18/12/2020); see Figure 2.



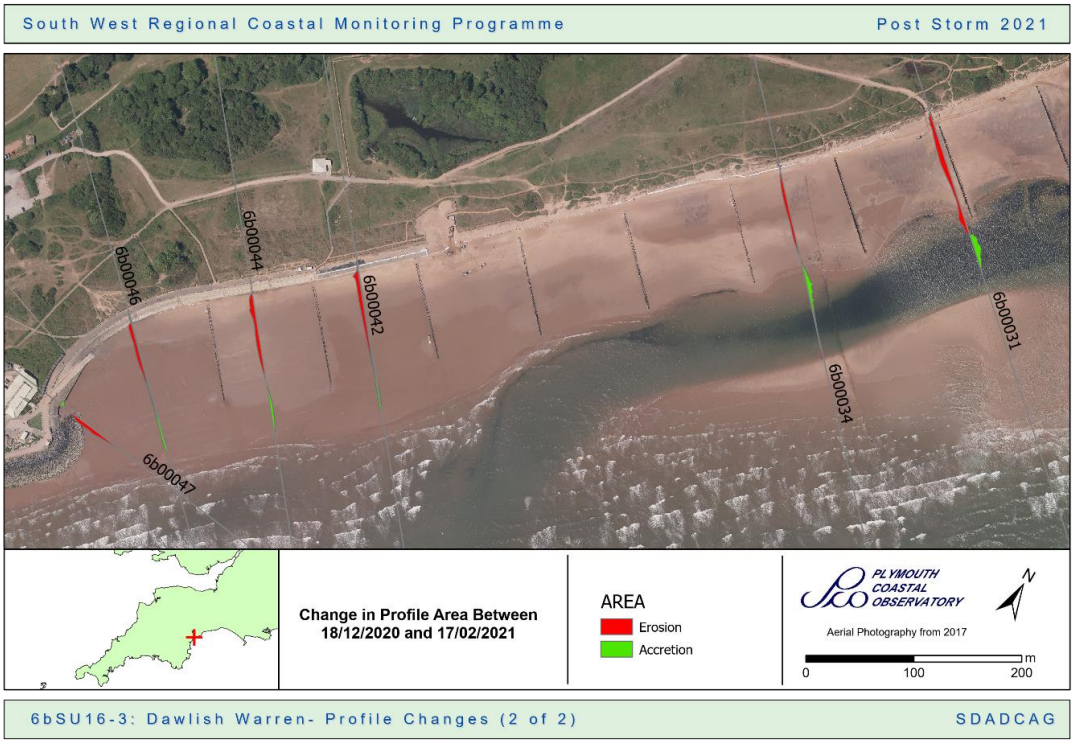


Figure 2 - Plot indicating the location of Dawlish Warren and the post storm profiles, along with an exaggerated overlay depicted where there has been erosion (red) and accretion (green) across each of the profiles since the previous survey (18/12/2020).

3.1.1 Erosion & Accretion Overview

Dawlish Warren, as a whole, lost 102 m^2 of material and gained 98 m^2 since the autumn survey. When comparing the cross-sectional area of the thirteen survey lines all profiles exhibited gains in material between the previous and most recent survey ranging from 1.43 m^2 to 40.10 m^2, similarly, all profiles exhibited loss of material on each profile ranging from -0.77 m^2 to -42.19 m^2 (see *Table 2*; see Appendix A); the loss of material is of similar magnitude to material gain. As illustrated in Figure 1, the profiles which had net accretion were located towards the centre of the survey unit.

3.1.2 Profile Erosion & Accretion

Profiles 6b00011, 6b00017, 6b00031, 6b00034 and 6b00047 show clear loss of material across the entire length of their profiles, with small amounts of accretion occurring near the top and/or lower beach (see Appendix A). In comparison, profiles 6b00021, 6b00023 and 6b00025 show a clear gain of material with small areas of erosion located along the leeward beach slope, lower beach and/or seaward beach face. Profile 6b00026 has a mixture of accretion and erosion, both will similar values for net gain/loss. Profile 6b00016 also has a mixture, however, accretion is more dominant. The location along the profile where accretion outweighs erosion is across the low tide terrace and along the back of the beach slope (see Appendix A). Profiles 6b00042. 6b00044 and 6b000464 have very similar profiles, with large erosion occurring between the top and mid beach with smaller rates of accretion occurring around the lower beach.

Table 2 – Overview of accretion and erosion rates at each post storm profile line, calculated from Topographic surveys between 18/12/2020 and 17/02/2021.

	Accretion (m^2)	Erosion (m^2)	Total (m^2)
6b00011	1.43	-13.23	-11.80
6b00017	1.77	-10.82	-9.06
6b00019	21.70	-4.98	16.71
6b00021	40.10	-0.77	39.32
6b00023	29.68	-2.55	24.43
6b00025	17.94	-1.44	16.50
6b00026	9.67	-8.23	1.43
6b00031	14.01	-42.19	-28.18
6b00034	14.64	-21.71	-7.07
6b00042	7.28	-20.68	-13.41
6b00044	7.83	-23.65	-15.82
6b00046	8.28	-14.17	-5.90
6b00047	2.26	-13.13	-10.86

3.1.3 GeoTube

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 40 m from the GeoTube. The 2021 and 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. Interestingly the peak above the GeoTube in 2020 is recorded 0.2 m higher than the 2007 baseline – this is the only profile where this occurs.

Profiles 6b00021, 6b00023, 6b00025 and 6b00026 demonstrate a similar pattern. When comparing the baseline to the 2021 survey, the dune crest decreases in height, the gradient of the seaward slope increases, and the toe of the dune is more defined (Appendix A). Furthermore, the beach crest in each consecutive survey can be seen to recede toward to GeoTube.

There has been extensive erosion around profiles 6b00021, 6b00023, 6b00025 and 6b00026 (see Figure 3) 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 20-40 m distance between the beach face and the geotube in 2007, to a ~-0.2 m distance in 2021. Additionally, since the exposure of the geotube, the height of sediment at the toe has increased since the last survey (See Appendix A; Profile 6b00021, 6b00023 and 6b00026). For example, when comparing the 17th February 2021 post-storm data for 6b00021 to the previous survey conducted on the 18th February 2021, the toe level has risen by ~20 cm.



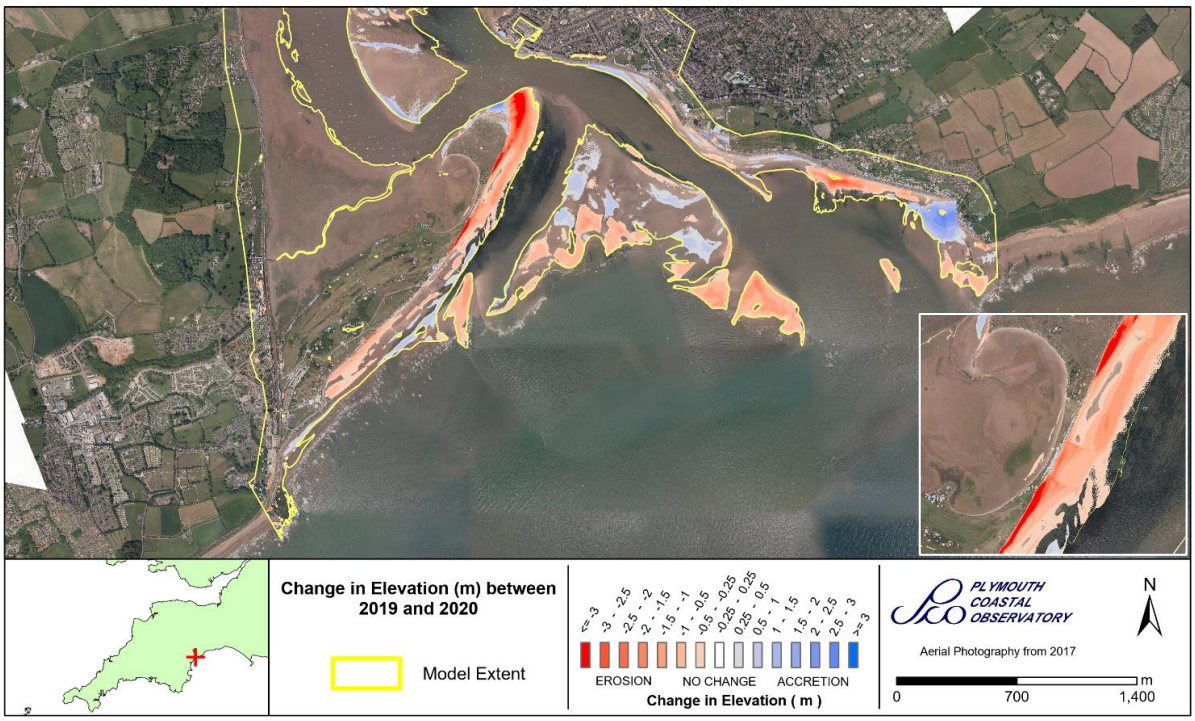


Figure 3 - Plot illustrating longer term elevation change from 2019 to 2020 at Dawlish Warren.

3.2 Teignmouth

The post-storm survey consisted of eight survey lines which, in this report, are directly compared against the autumn interim survey (21st October 2020); see Figure 4

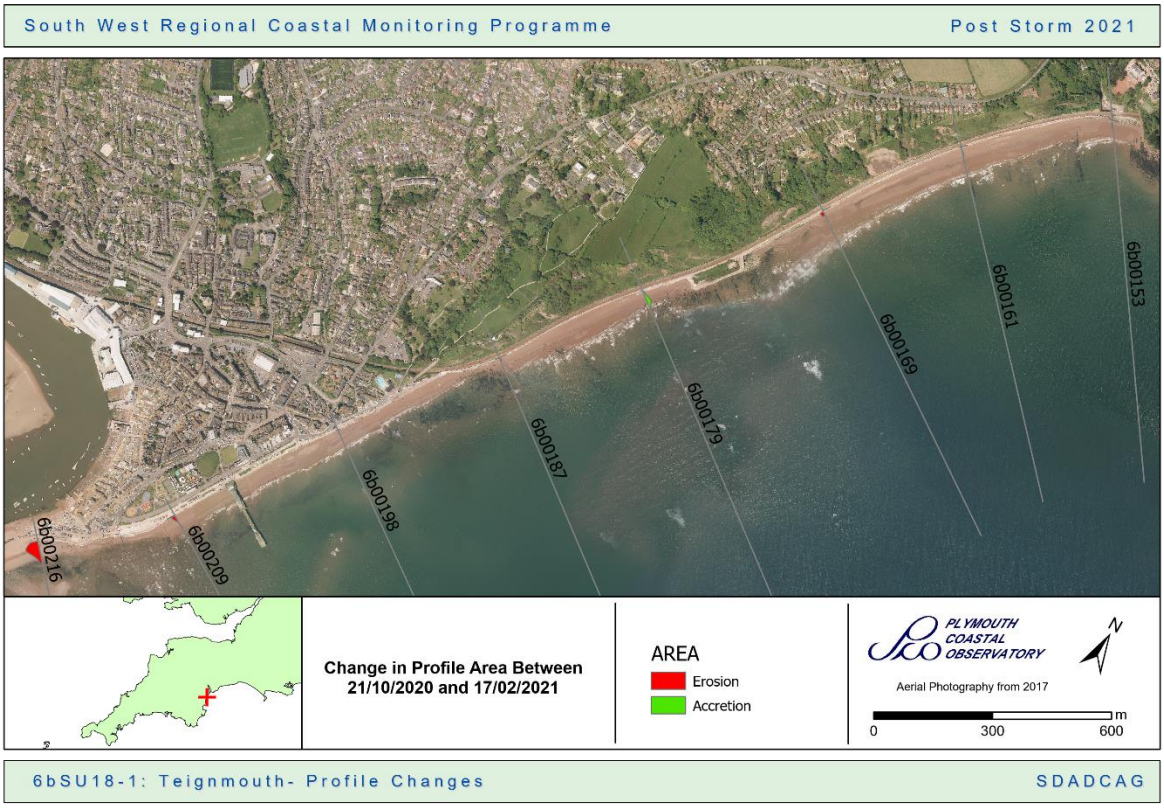


Figure 4 - Plot indicating the location of Teignmouth and the post storm profiles, along with an exaggerated overlay depicted where there has been erosion (red) and accretion (green) across each of the profiles since the previous interim survey (21st October 2020).

3.2.1 Erosion & Accretion Overview

Teignmouth, as a whole, lost 140.06 m^2 of material with the smallest net loss occurring on profile 6b00138 (-0.31 m^2) and the greatest net lost on profile 6b00216 (-117.70 m^2); see *Table 3*. When comparing the cross-sectional area of the eight survey lines all profiles exhibited minor gains in material between the interim and post-storm survey ranging from 0.02 m^2 to 30.29 m^2, however, the loss of material on each profile is significantly higher, ranging from -0.06 m^2 to -117.72 m^2 (see *Table 3*; see Appendix B). Interestingly, the profiles which show net accretion are located at the centre of the survey unit.

3.2.2 Profile Erosion & Accretion

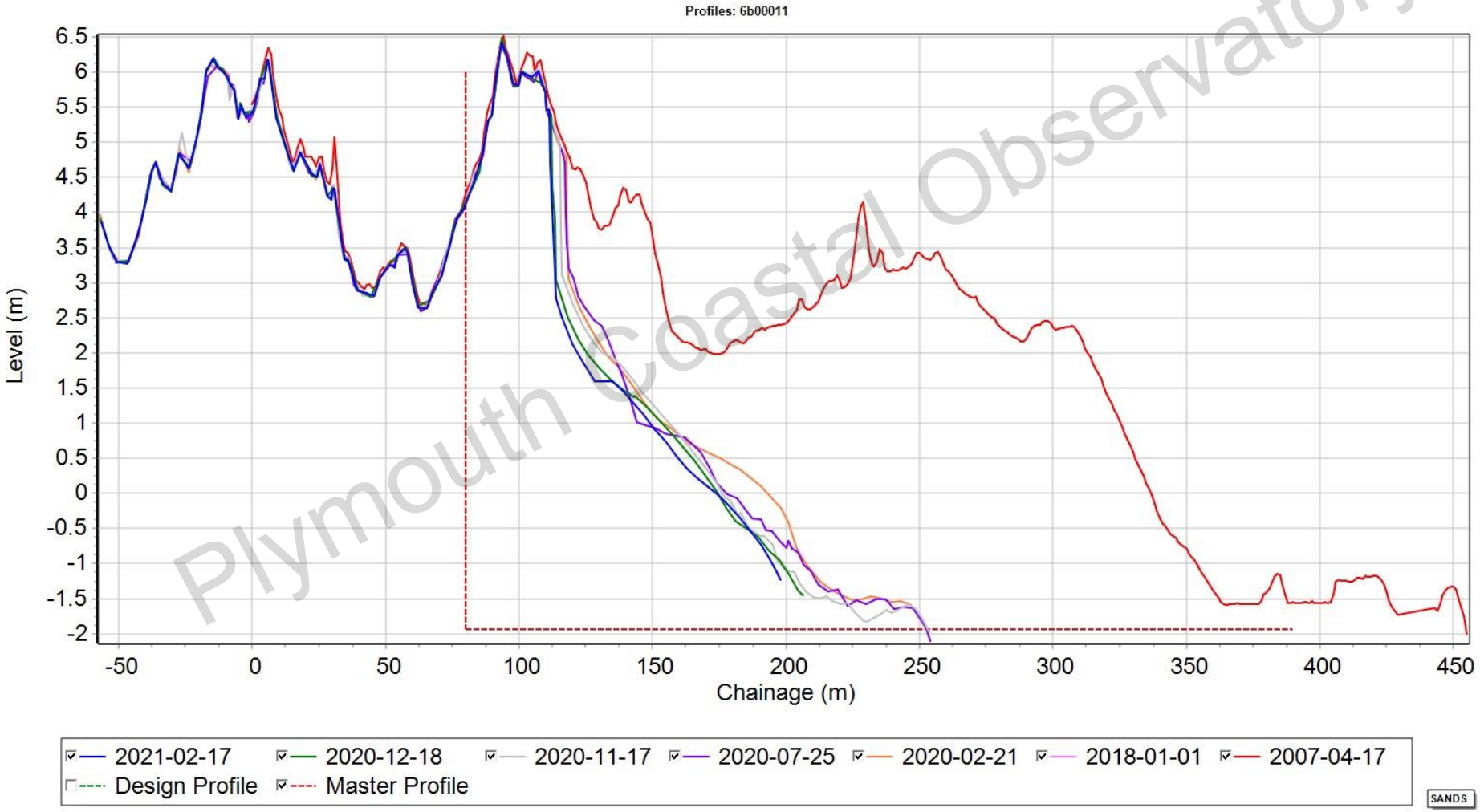
Profile 6b00216 shows a clear loss of material across the entire profile length. Profile 6b00198 shows a mixture of erosion and accretion along the profile, with accretion being dominant across the middle of the beach and erosion occurring on the upper and lower beach (see Appendix B). Profiles 6b00153, 6b00169 and 6b00209 demonstrate a net loss of material across the majority of their profiles. The location along the profiles where accretion occurs is at the top of the beach and/or at low beach around chainage ~25 m. In comparison, the remaining three profiles show net accretion, with erosion occurring around the lower beach at chainage ~112 m and at the top of the beach near the sea wall (see Appendix B).

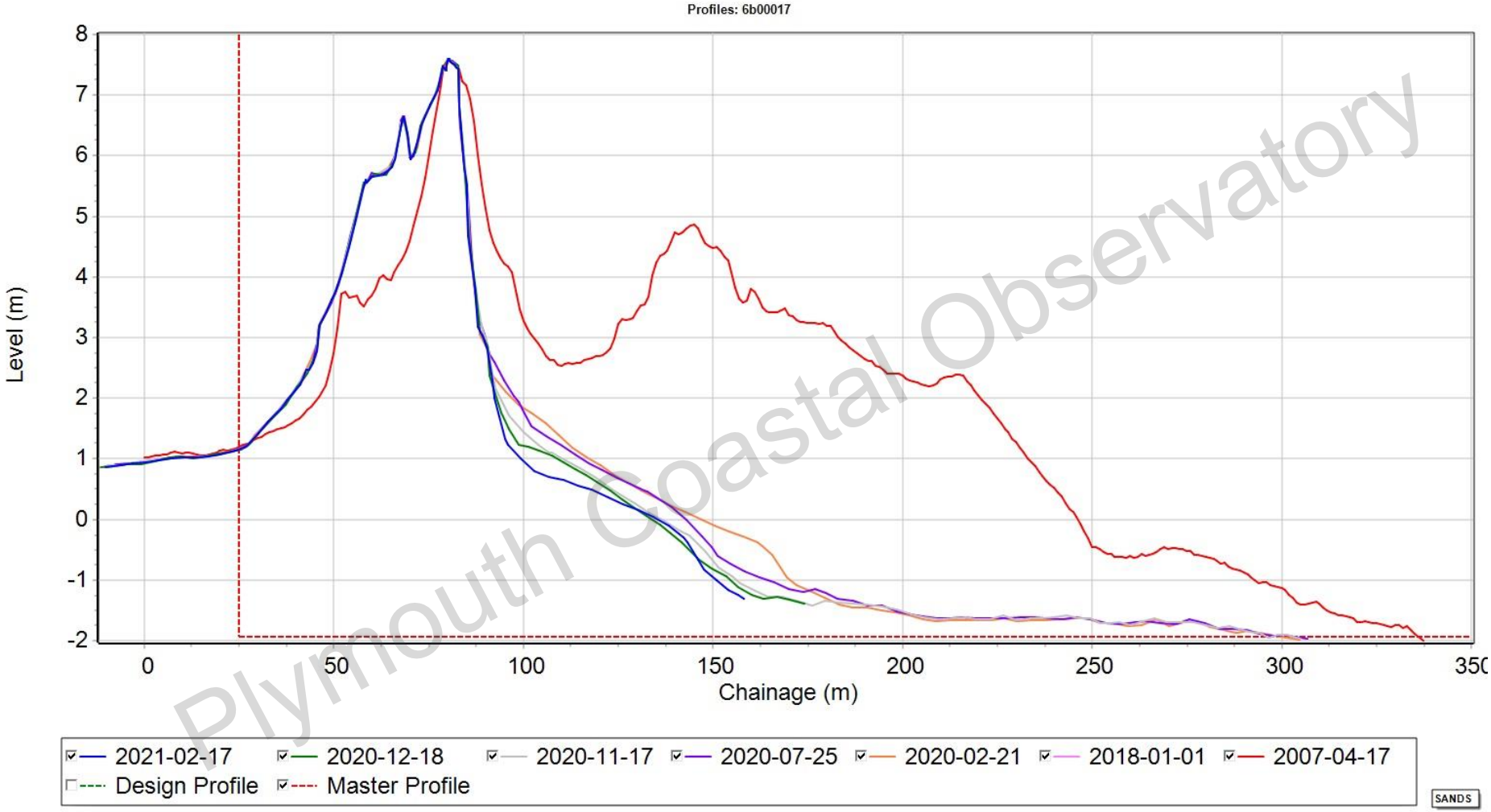
Table 3 – Overview of accretion and erosion rates at each post storm profile line, calculated from Topographic surveys between 21st October 2020 and 7th February 2021.

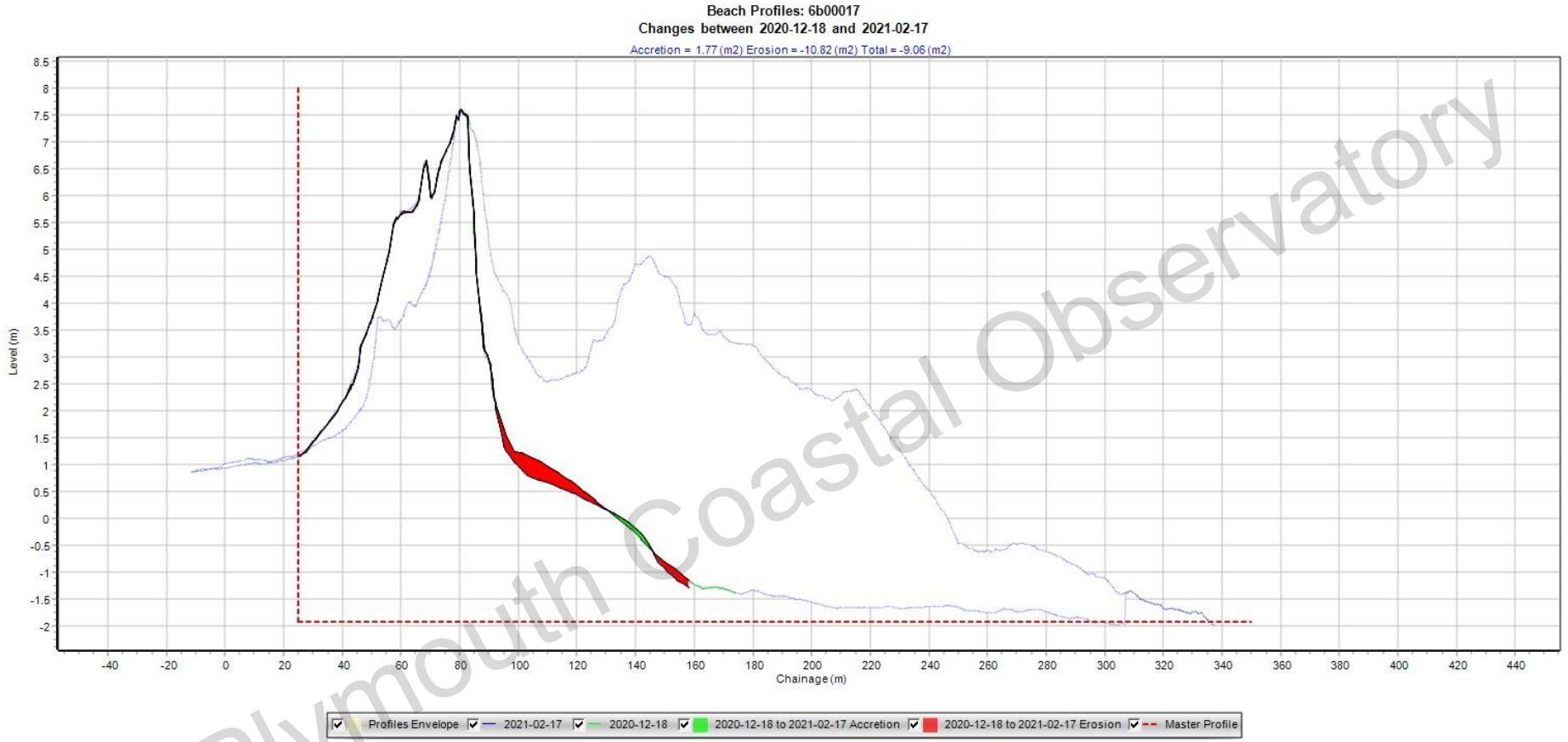
	Accretion (m^2)	Erosion (m^2)	Total (m^2)
6b00153	0.49	-4.46	-3.97
6b00161	3.37	-1.49	1.89
6b00169	0.47	-8.19	-7.71
6b00179	30.29	-0.13	30.15
6b00187	2.63	-0.06	2.57
6b00138	0.18	-0.49	-0.31
6b00209	1.71	-12.09	-10.37
6b00216	0.02	-117.72	-117.70

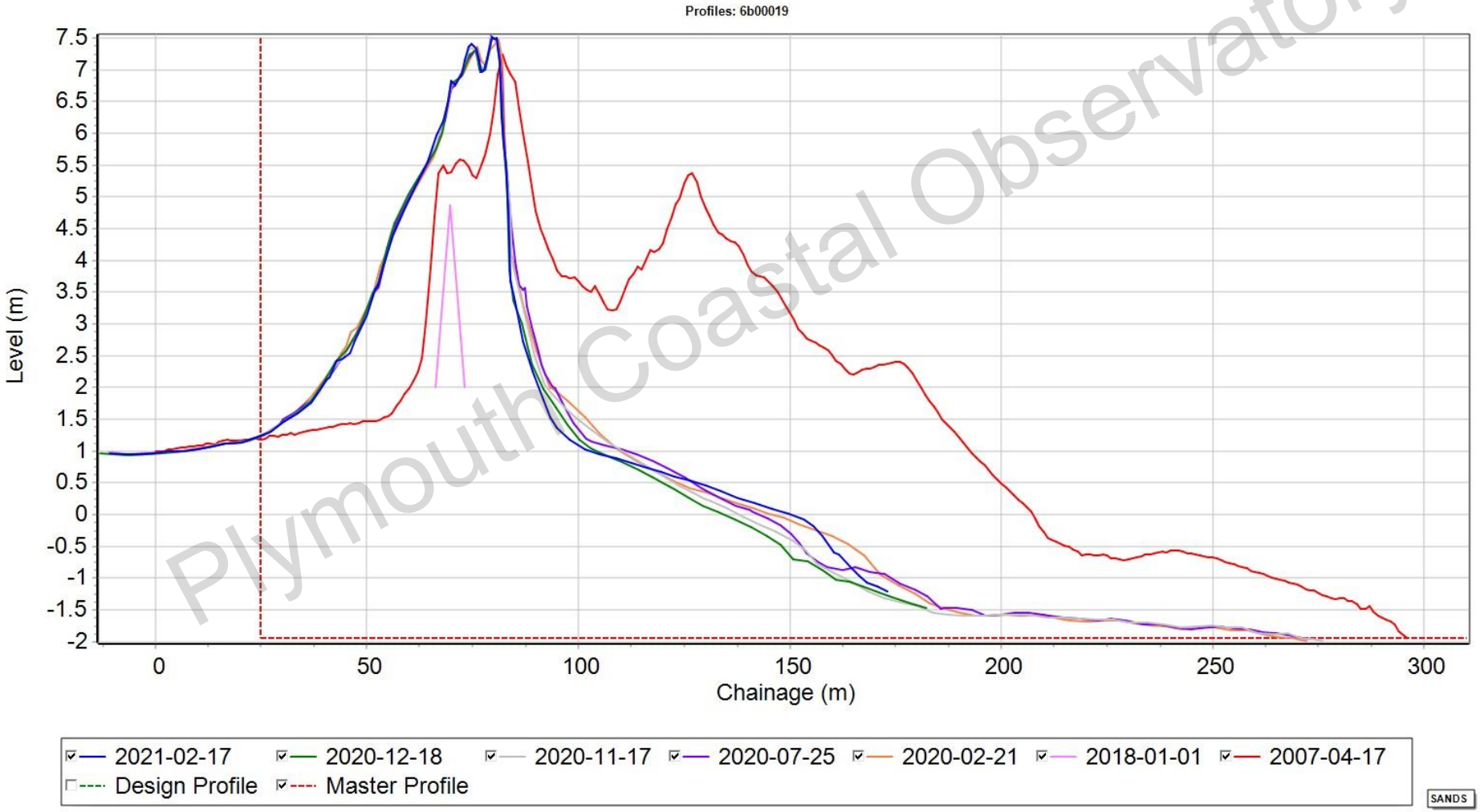
Appendix A – Dawlish Warren: Cross-sectional area change plots

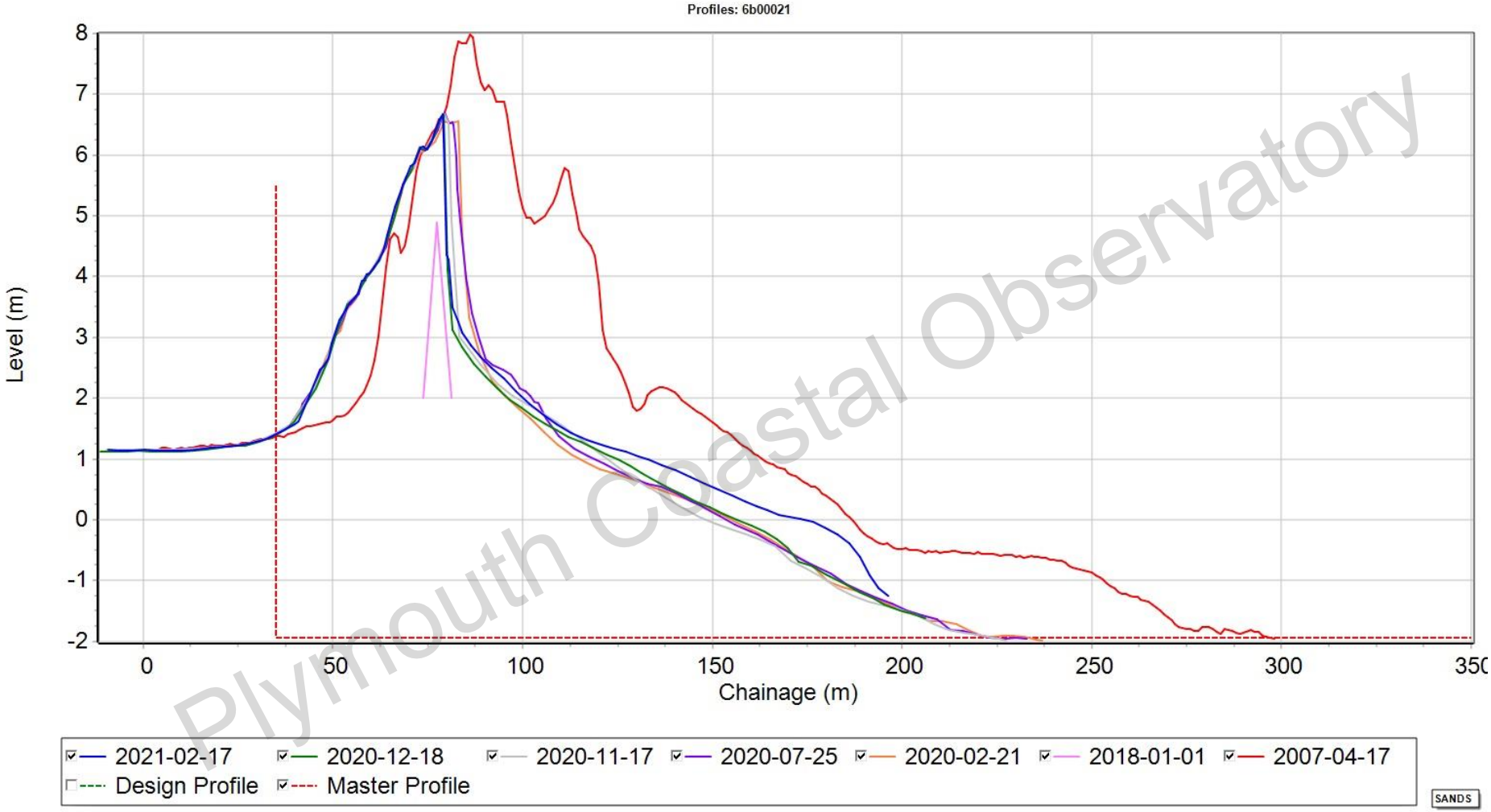
Each profile highlighted in Figure 2 is shown below, comparing the autumn interim and post-storm survey cross-sectional areas. Each plot has an accompanying profile change plot, displaying green as accretion and red as erosion for ease of visualisation.

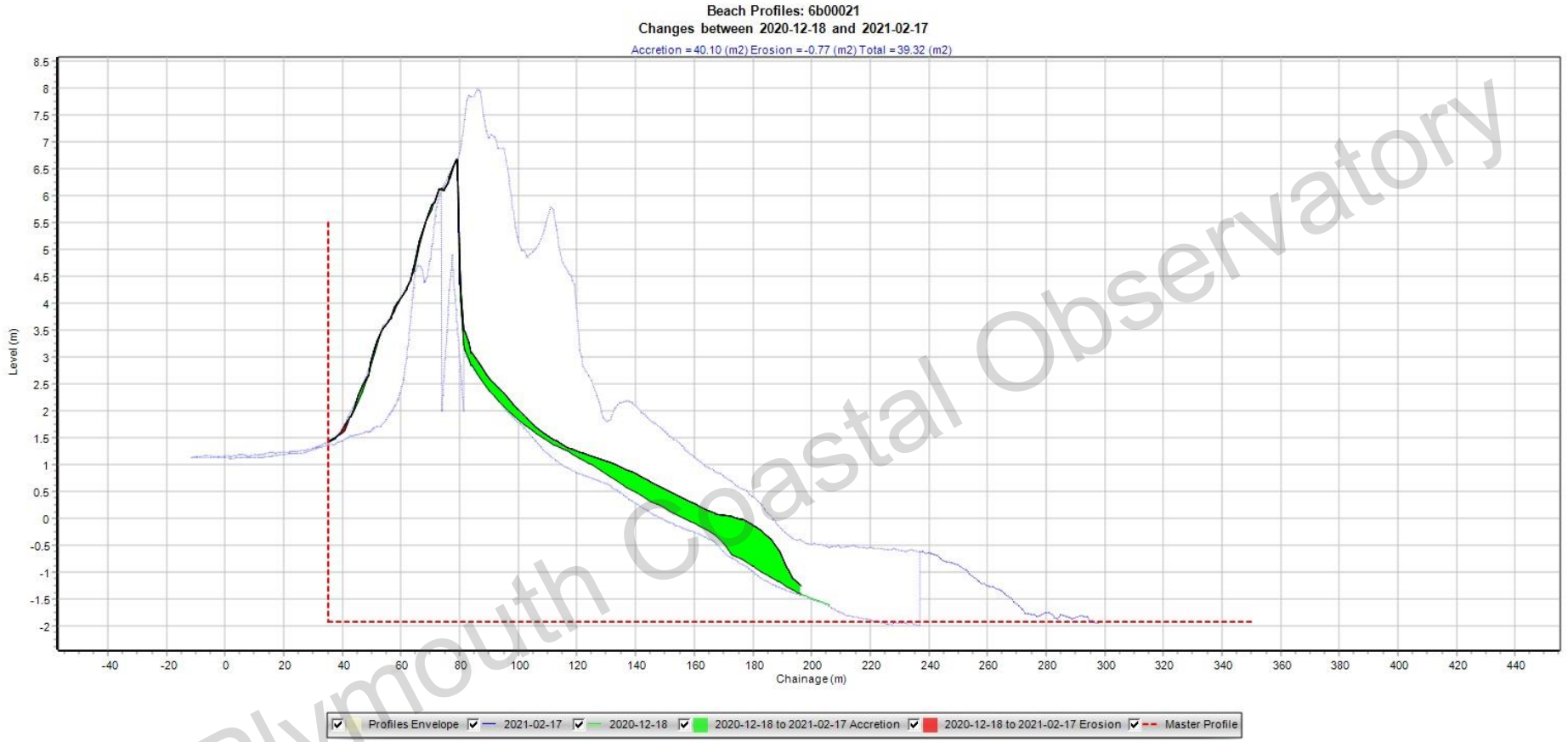


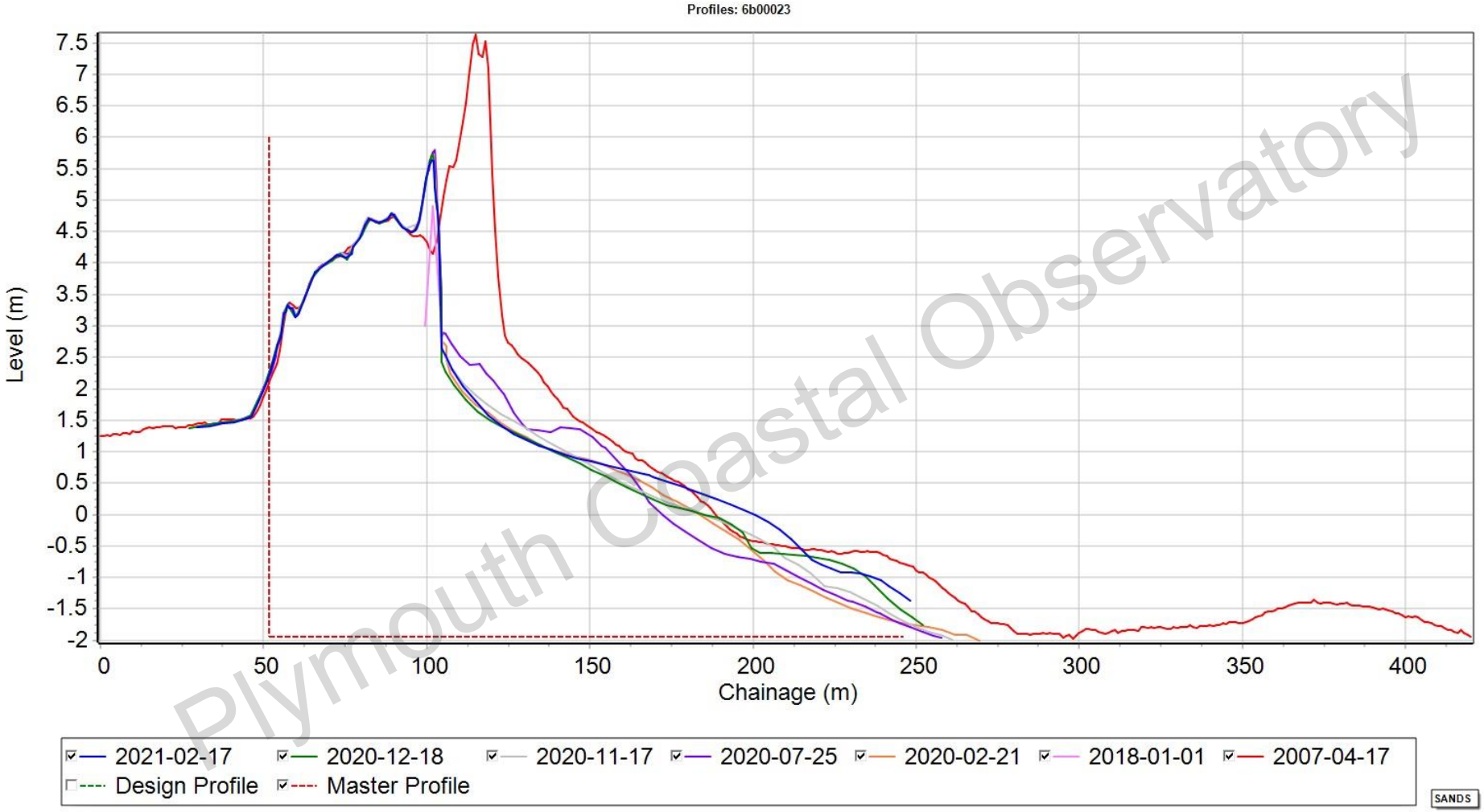


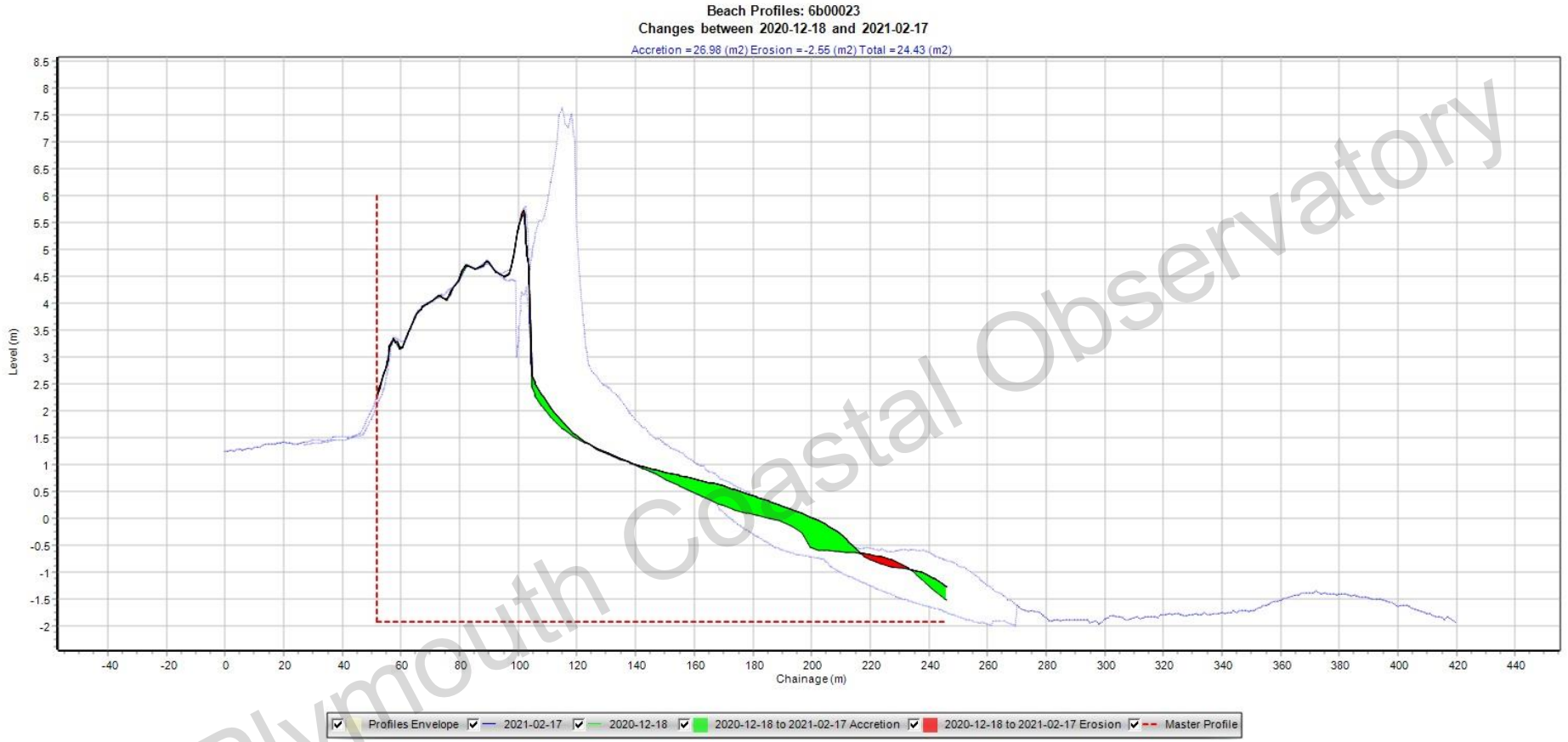


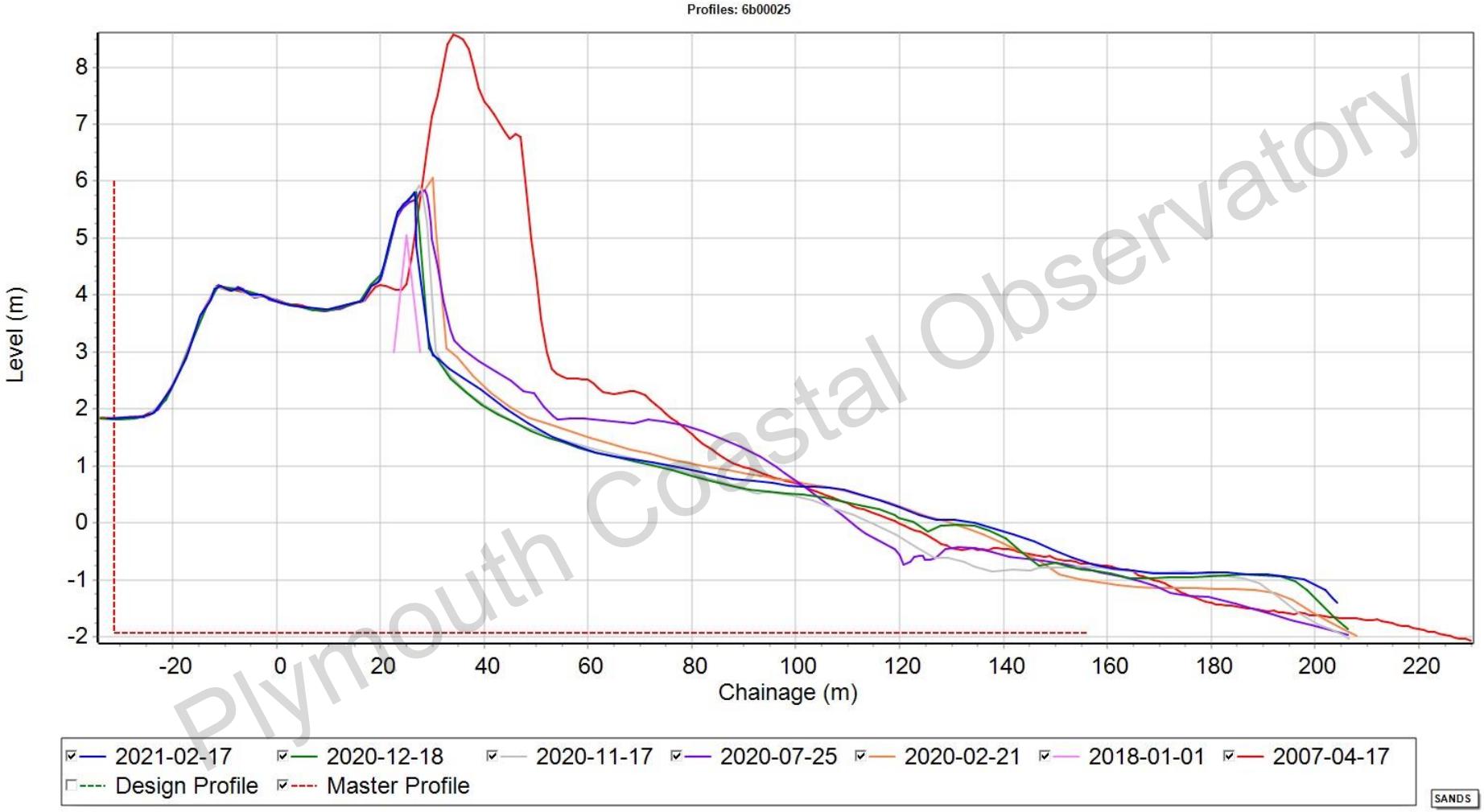


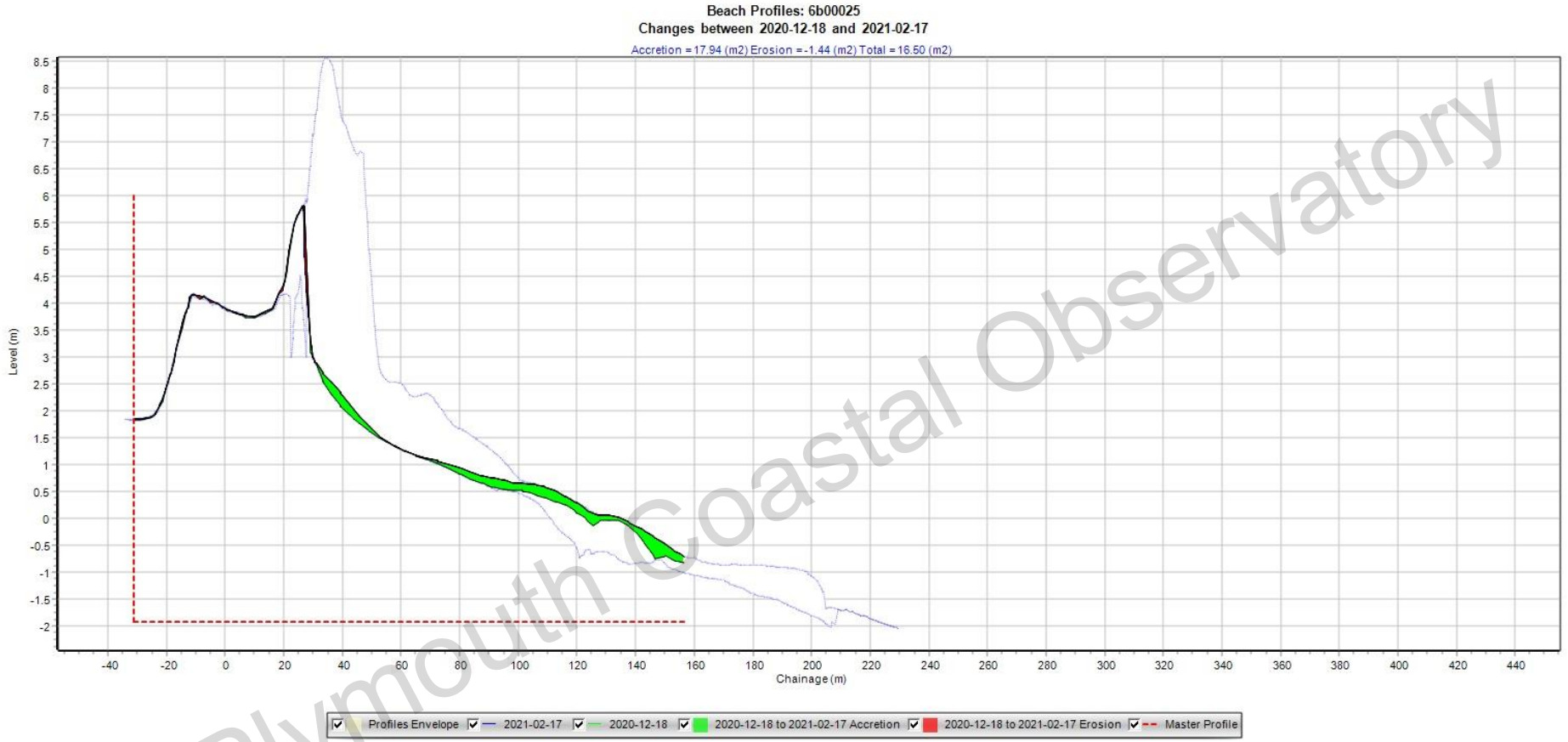


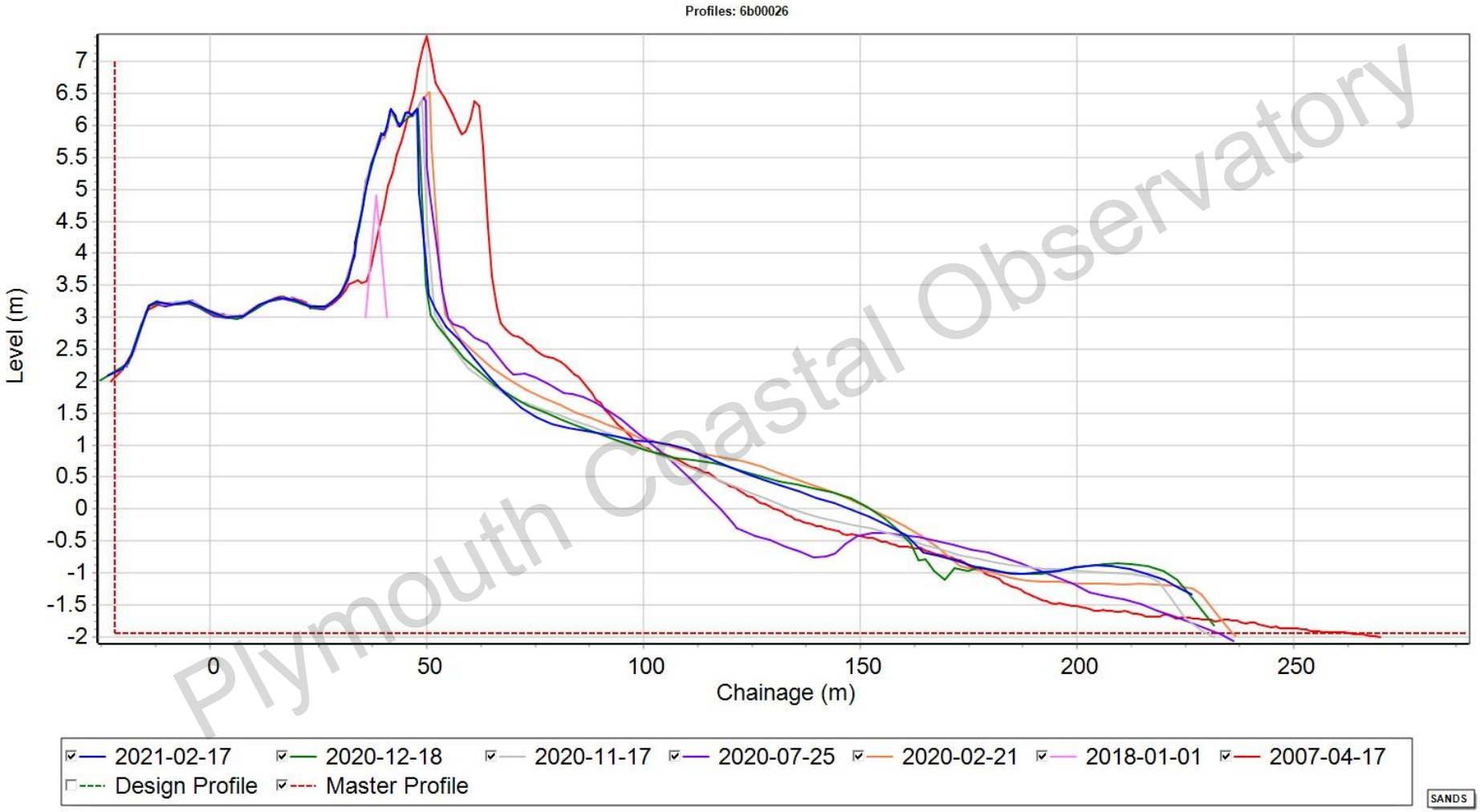


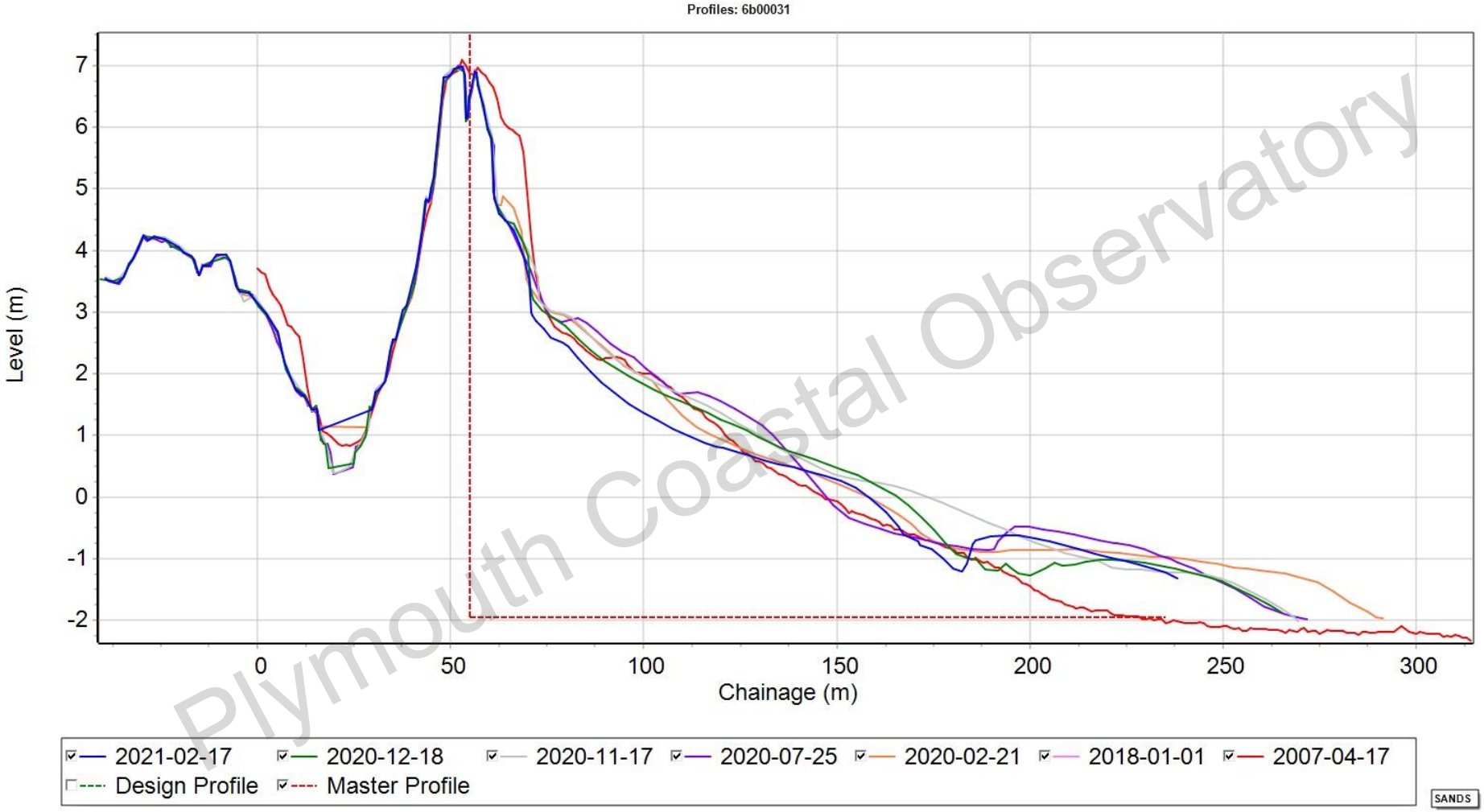


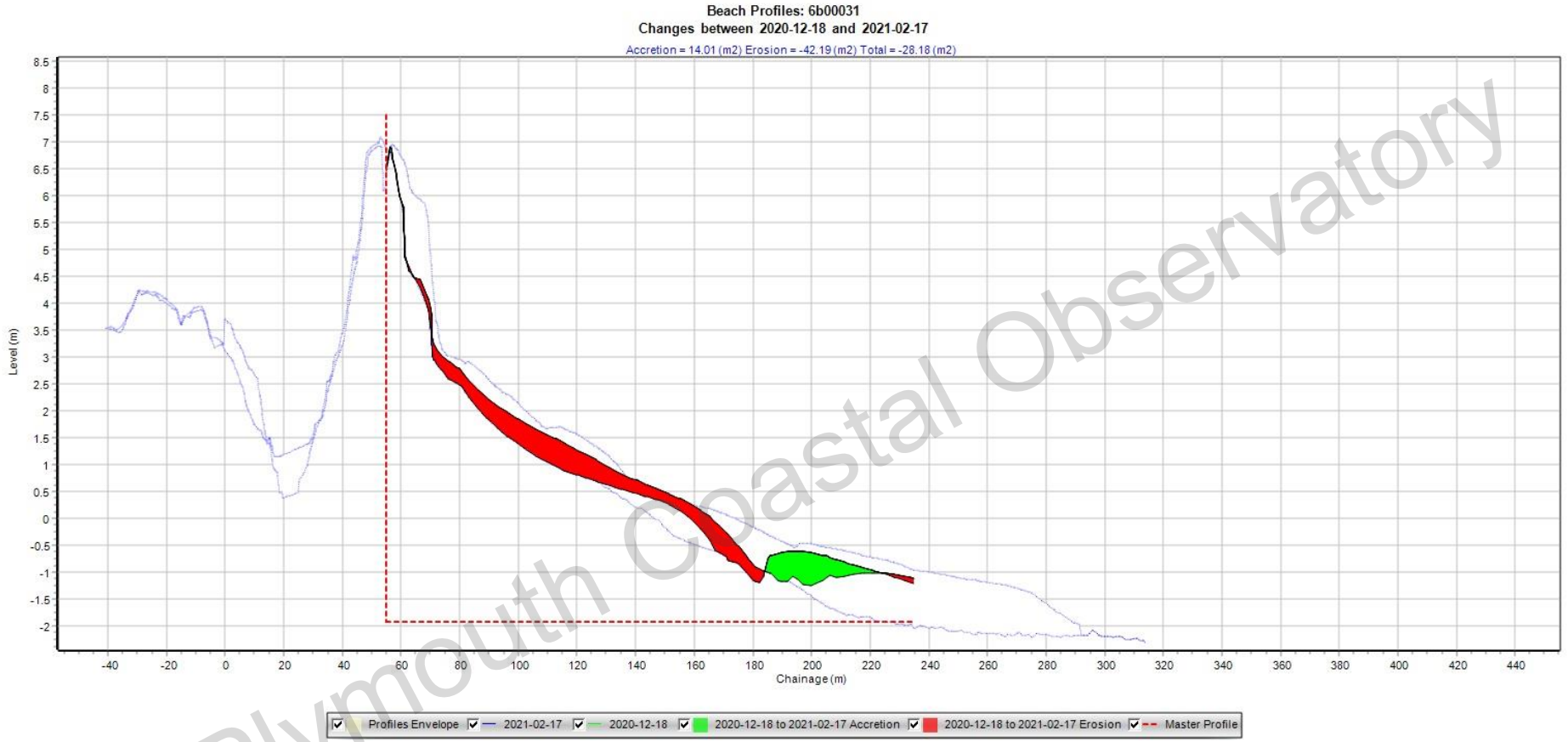


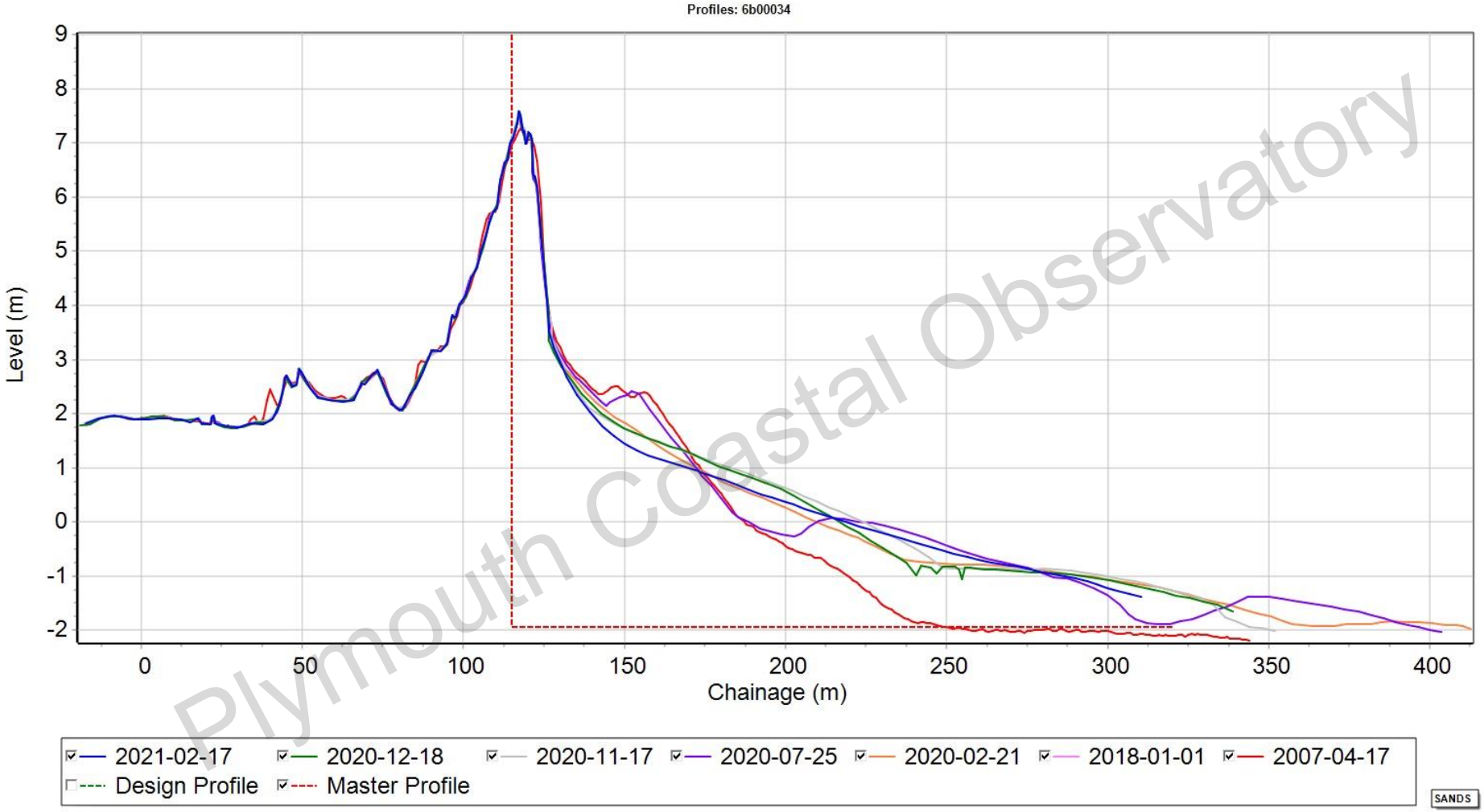


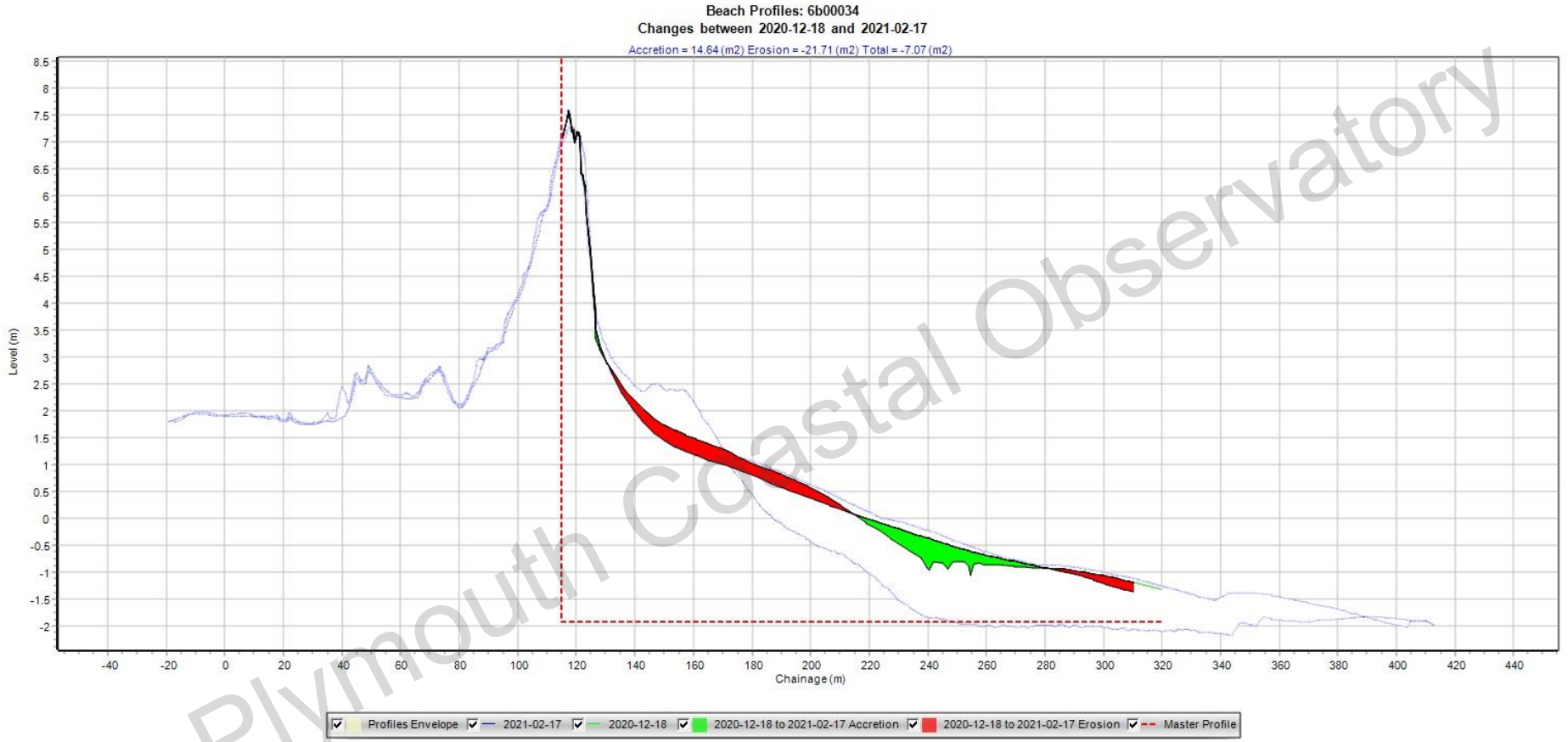


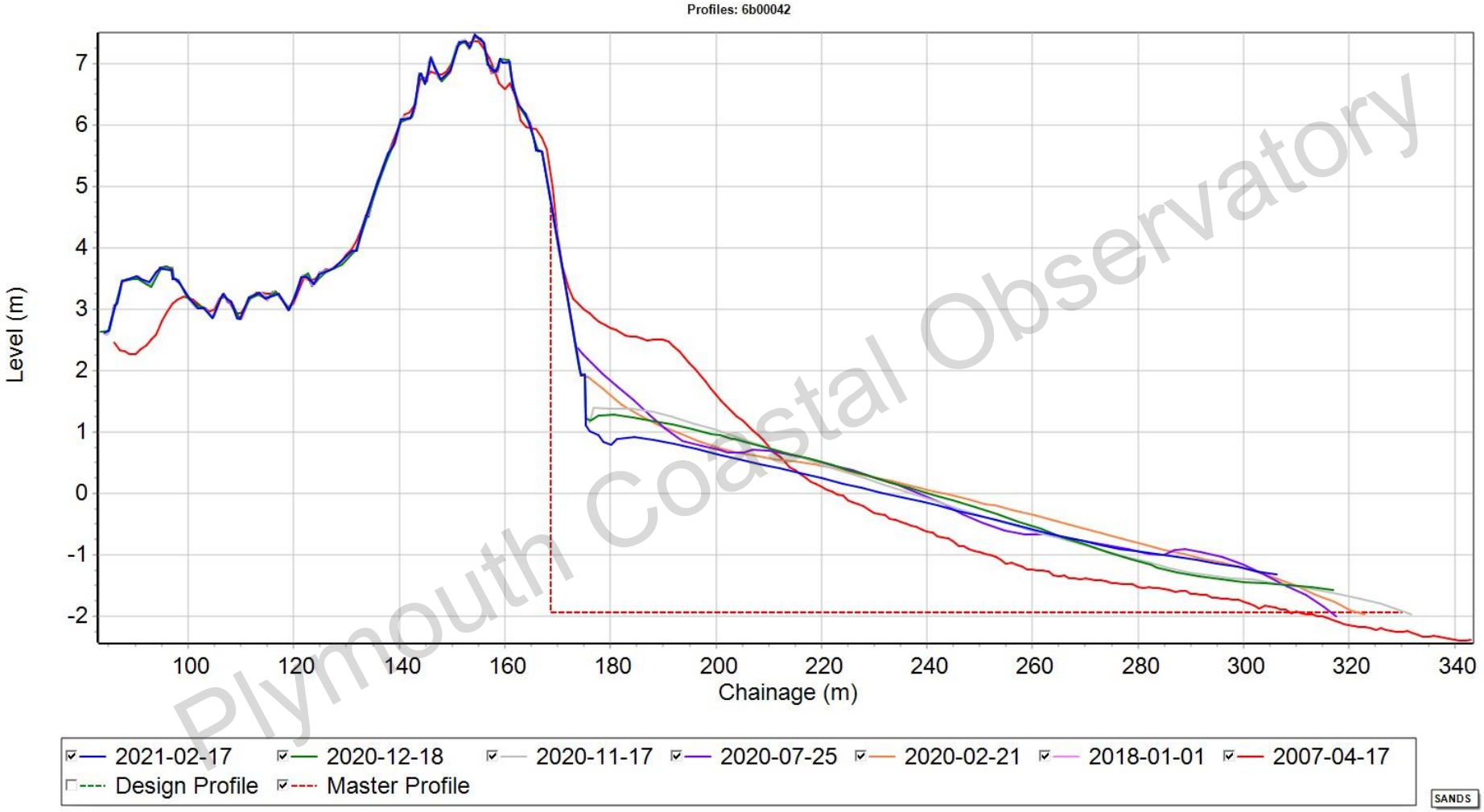


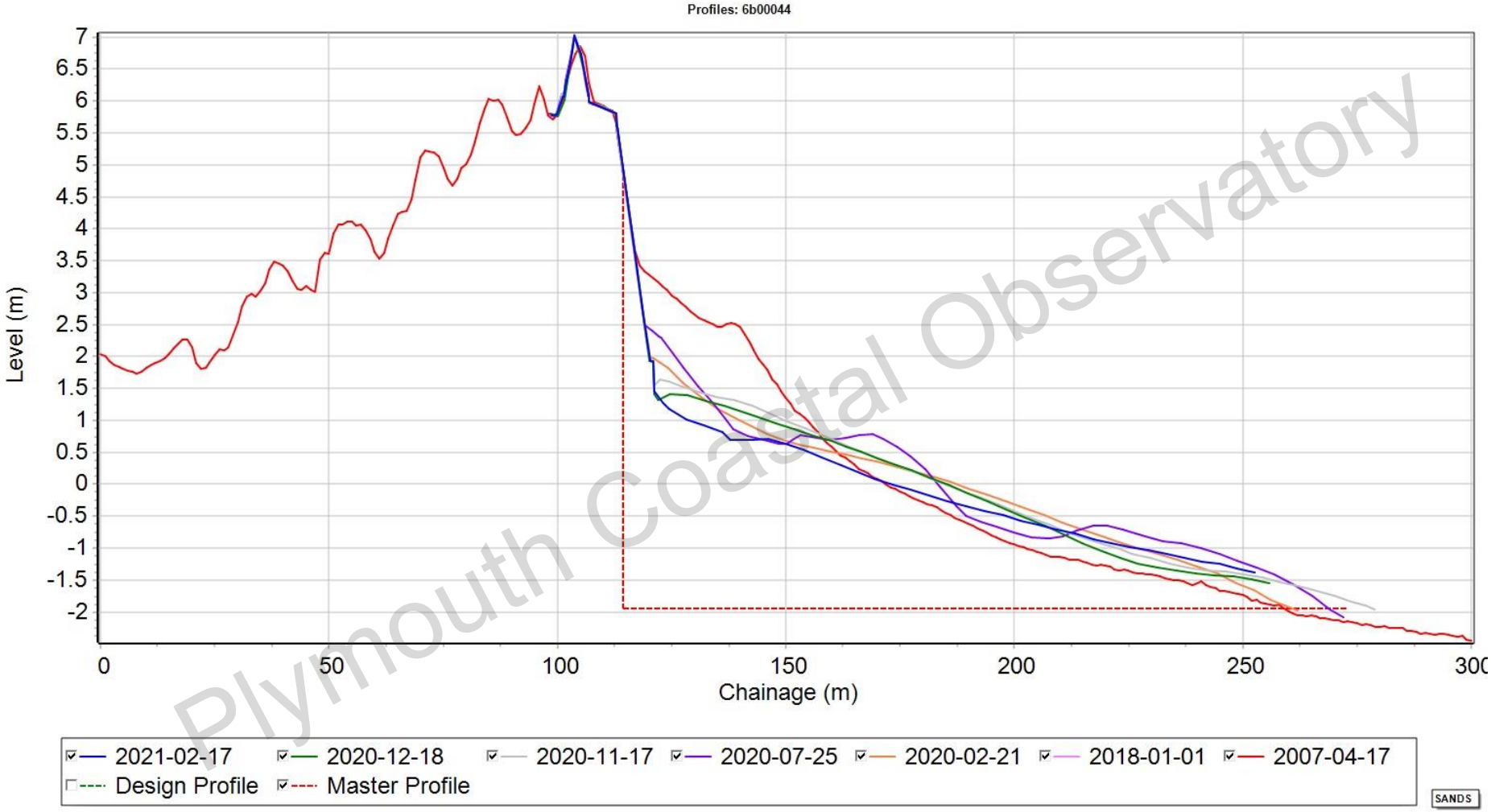


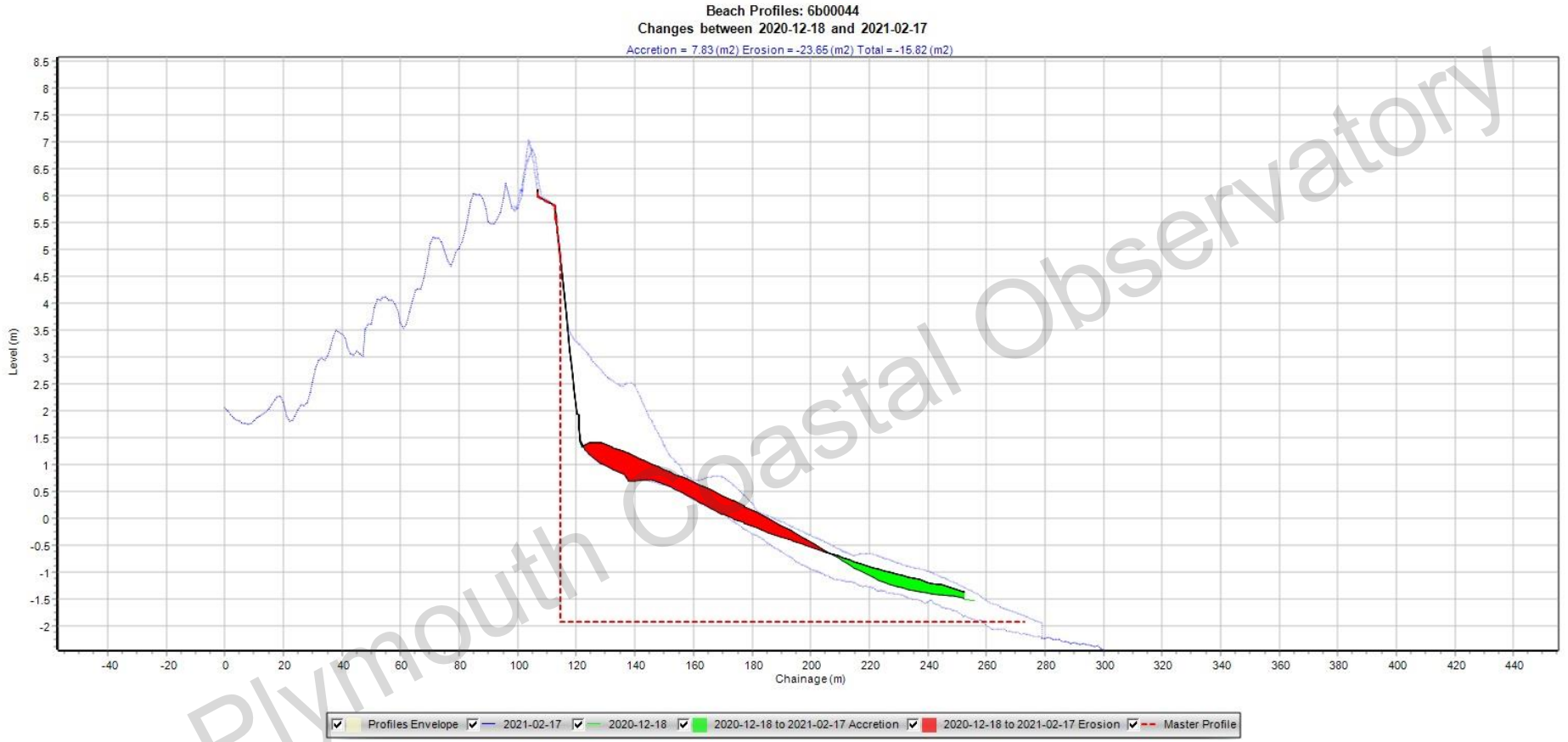


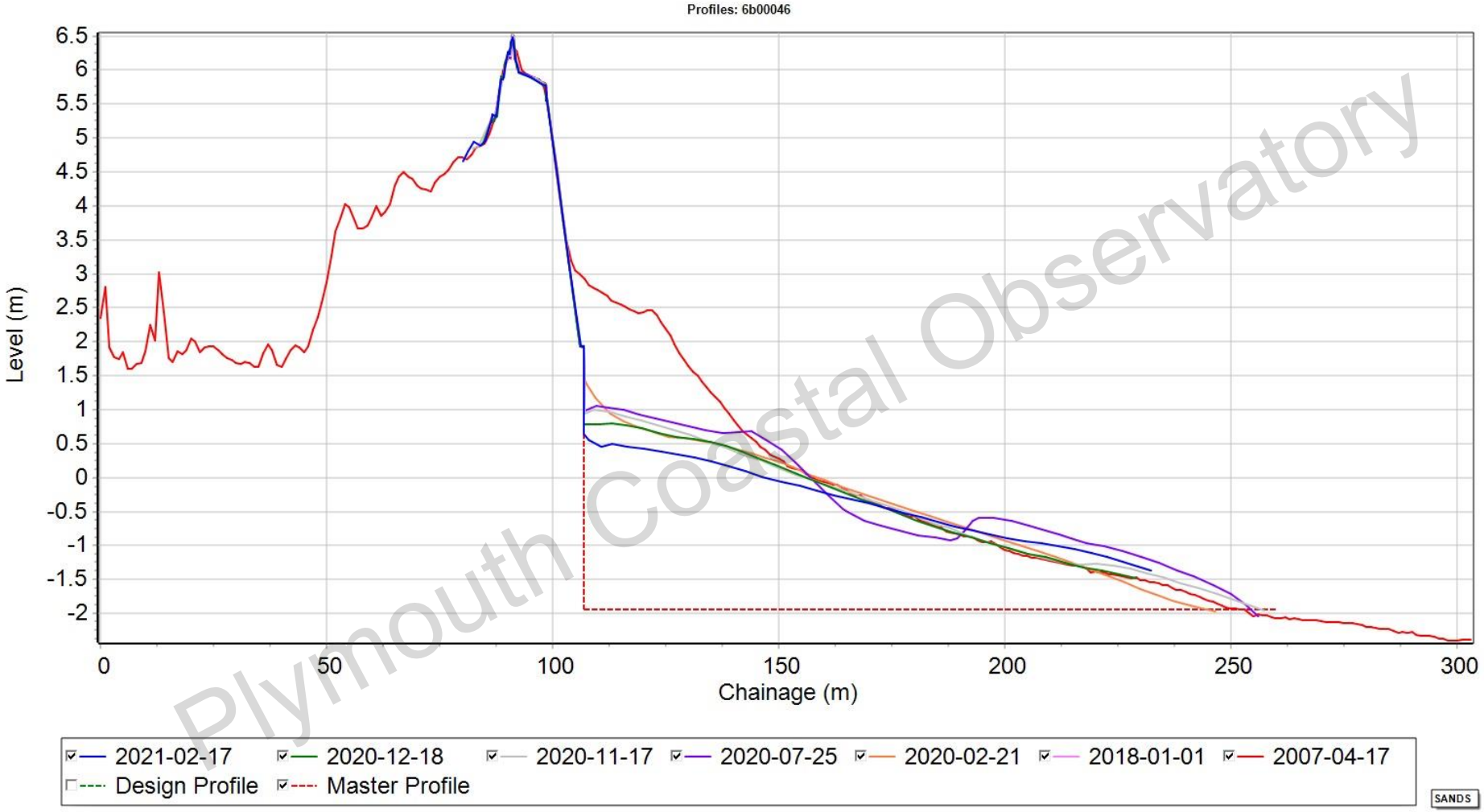


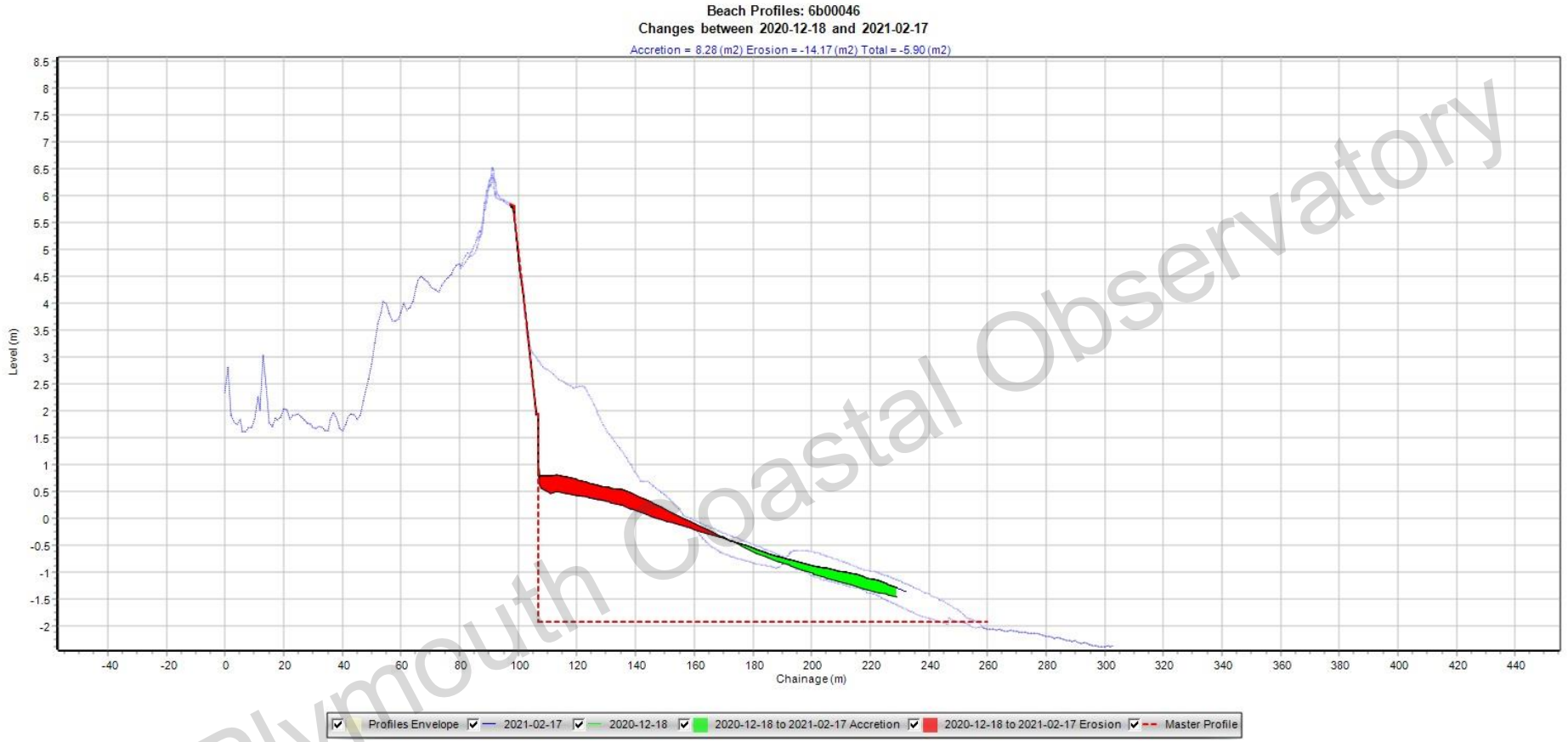


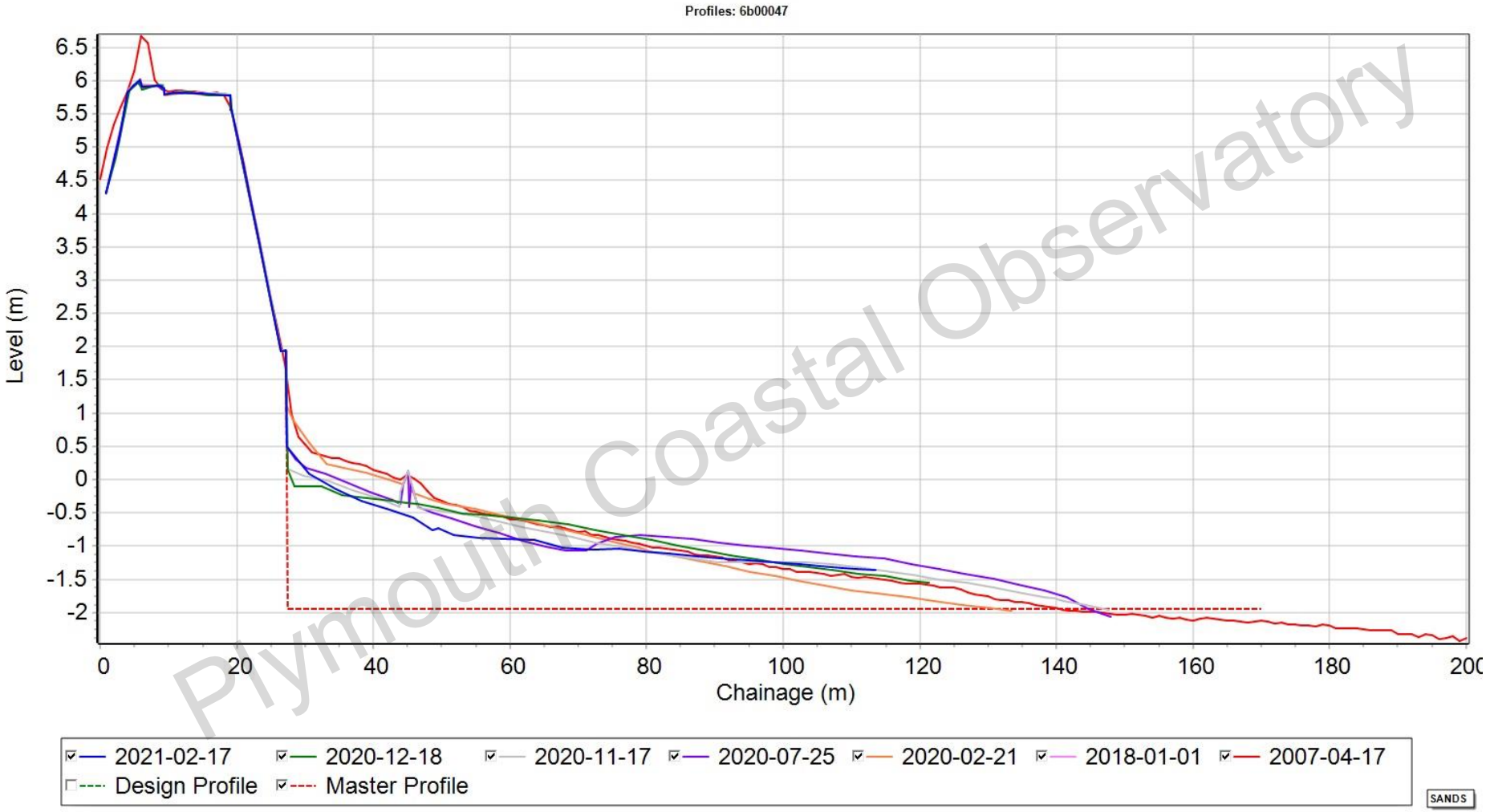












Appendix B – Teignmouth: Cross-sectional area change plots

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