JBA consulting

Review of Managed Realignment Area for Charmouth, Dorset.

Final Report

July 2018

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This report describes work commissioned by Henry Middleton, on behalf of West Dorset District Council, by an email dated 16th January 2018. Paul Bowerman and Anne-Marie Moon of JBA Consulting carried out this work.

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Purpose

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Executive summary

JBA have undertaken a review of Section 29 of the Managing Coastal Change: Coastal Risk Planning Guidance (CRPG) document (2013), which sets out the managed realignment zone for the River Char area of Charmouth. This review considered the following key stages:

- Assess the approach used to determine the extents of the managed realignment zone and the expected cliff recession zones with regards to current best guidance.
- Identify and collate more recent information and data that may help inform cliff recession rates and the extent of the managed realignment zone.
- Review the nature of the risks, the potential extent of the risks and the existing assets at risk with regards to the managed realignment zone and the cliff recession bands.

It was concluded that the approach used to determine the cliff recession rates was appropriate considering the complex nature of the cliff systems around Charmouth, and that it followed the current guidance documents. Following a review of the geomorphology of the area it was concluded that the identified Managed Realignment Zone was appropriate and that no further assessment was required.

This assessment was conducted under the assumption that the existing coastal defences had failed and that beach roll back had occurred. It also assumed that a management plan of No Active intervention was adopted along the River Char; an assumption that is recommended in the guidance documents.

Additional data was available in the form of twice yearly surveys along established profiles. Overall, these surveys indicated a mixture of accretion and deposition over various periods, however there were generally no identifiable long-term trends evident. Therefore, it was considered that this information would not influence the cliff recession assessment approach and no additional assessments are required.

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Abbreviations

CBU	Cliff Behaviour Unit
CCO	Channel Coastal Observatory
CRPG	Coastal Risk Planning Guidance
DEFRA	Department of Environment, Food and Rural Affairs
HAT	Highest Astronomical Tide
EA	Environment Agency
GIS	Geographic Information System
HTL	Hold The Line
JBA	JBA Consulting
LAT	Lowest Astronomical Tide
LiDAR	Light Detection and Ranging,
m	metres
MDSF	Modelling and Decision Support Framework
mm/yr	millimetre per year
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MSL	Mean Sea Level
mODN	metres (Ordnance Datum Newlyn)
NAI	No Active Intervention
NCERM	National Coastal Erosion Risk Mapping
RACE	Risk Assessment of Coastal Erosion documents
SCOPAC	Standing Conference On Problems Associated with the Coastline
SDADCAG	South Devon and Dorset Coastal Advisory Group
SMP	Shoreline Management Policy
UKCP09	UK Climate Change Projections
WDDC	West Dorset District Council

1 Introduction

JBA Consulting (JBA) were contracted by West Dorset District Council (WDDC) to conduct a review of Section 29 of the Managing Coastal Change: Coastal Risk Planning Guidance (CRPG) document (2013), which sets out the managed realignment zone for the River Char area of Charmouth.

The aim of the review is to affirm the extents of the managed realignment zone and the expected cliff recession buffer zones, using the data identified in the CPRG and any more recent data that has become available.

The review was conducted using the following key stages:

- Assess the approach used to determine the extents of the managed realignment zone and the expected cliff recession buffer zones with regards to current best practice guidance.
- Identify and collate more recent information and data that may help inform cliff recession rates and the extent of the managed realignment zone.
- Review the nature of the risks, the potential extent of the risks and the existing assets at risk with regards to the managed realignment zone and the cliff recession bands.

This document presents the findings for each key stage.

2 Charmouth baseline conditions

In order to review the potential future impacts at Charmouth it is important to understand the present day (baseline) coastal processes influencing the coastline. The following sections present some of the key processes that need to be considered when predicting future change.

2.1 Cliff systems

The coastline at Charmouth is dominated by the Black Ven and Stonebarrow cliff systems. These systems account for large sections of the south west coastline and dominate the coastline immediately east and west of Charmouth respectively. Their approximate extents, with respect to Charmouth (based on 2016 aerial imagery from Google Earth) are shown in Figure 2-1.

Figure 2-1 Cliff systems within the vicinity of Charmouth

2.1.1 Black Ven

Black Ven, located to the west of the study area, is one of the largest and most active coastal landslides in Europe. The mass movement system is characterised by a steep upper backscar, and a series of terraces separated by scarps that extend down towards the foreshore. Material released from the backscar is transported over these terraces towards the sea by a series of mudslides, which form large lobes on the foreshore. Instability results from a combination of geological and hydrogeological factors coupled with continuous basal removal of material by marine erosion (SCOPAC 2018[1]). The Black Ven system can be divided into three areas according to the intensity of landslide activity: (i) a highly active central area characterised by rotational backscar failures that feed two major mudslides on the upper and mid benches; (ii) a west-central area where instability has migrated inland to the formerly inactive backscar and is generating renewed failures, and (iii) a zone of increasing reactivation along the upper platform towards Timber Hill and the Spittles where the backscar is becoming unloaded and renewed failures are likely in the near future (SCOPAC 2018[1]).

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[1] Standing Conference On Problems Associated with the Coastline (SCOPAC). Lyme Regis to Portland Bill. http://www.scopac.org.uk/scopac_sedimentdb/chesl/chesl.htm.

Figure 2-2 View west from coastal defences showing Black Ven

2.1.2 Stonebarrow

The cliff retreat at Stonebarrow has been reported as being intermittent but repetitive, with relatively brief phases of major land sliding activity occurring every 50-100 years (SCOPAC, 2018[1]). These 'active phases' are separated by long periods of slow retreat by small-scale processes, as the products of the preceding active phase of land sliding are evacuated from the upper platform. It has been suggested that over a 100-year period, the mean rate of backscar retreat is constant and equivalent to the rate of sea-cliff retreat; approximately 0.39myr^{-1} (SCOPAC, 2018[1]).

Figure 2-3 View east from River Char showing Stonebarrow complex

2.1.3 Cliff classifications

The Stonebarrow and Black Ven cliff systems are characterised as being complex. This means that they are typified by strongly coupled sequences of scarp and bench sub-systems, with each having their own sediment inputs, storage and outputs. Where the output from one system forms a cascading input into the next, resulting in close adjustment of the process and form with complex feedbacks. The subsystem storage results in significant buffering against the immediate effects of toe erosion, although elevated groundwater levels can trigger major events that can transform the behaviour of the whole system (e.g. major mud-sliding episodes). Therefore, complex cliffs behave in a non-linear way with multi-tiered landslides that are difficult to predict through simple extrapolation of historical recession rates. This has meant that the cliff systems around the River Char has been excluded from conceptual models developed for studies such as the National Coastal Erosion Risk Mapping (NCERM) project. Instead, rates of cliff recession need to be based on a site-specific review of cliff behaviour.

Section 2.1 CRPG compliance review
Section A.5.2 of the CRPG indicates that the recession potential estimates were derived for complex cliffs. Thereby confirming that the classification of the cliff system and the approach adopted for the cliff erosion calculations is appropriate for Charmouth. Conclusion: Compliant

2.2 Fluvial inputs

The River Char provides the only fluvial input to the Charmouth foreshore. The river channel crosses the foreshore, however banks of gravel deposited by marine processes always restrict its discharge. Thus, the river is usually "ponded" for up to 300m inland during the summer when it percolates through the beach. Any bedload carried by the river would be deposited in this area and could not be supplied to the foreshore without a flood event (SCOPAC 2018[2]).

The mouth of the river has become dammed in the past through the deposition of sediment, which has caused the river to periodically cut a new channel to the east. This has been prevalent in the past during times of low rain fall or during periods when the spring high tides have coincided with strong winds from the south to southwest. During the winter of 2014/15 the River Char diverted along the edge of the lower parts of Evans Cliff, seeking an easier exit route to the sea near the Soft Rock Café.

The River Char catchment exhibits several flood enhancing qualities including its dendritic pattern of tributaries, impermeable Lias clay geology and steep channel gradients. There are records of the River Char flooding during exceptional circumstances; with one such event occurring in 1985 (SCOPAC, 2018[1]). There are no gauge stations on the River Char, and therefore there are no records of mean or peak flow data available. Therefore, estimates of return periods of flooding events are also not available.

Data from a monitoring station located to the south of the A35 (The St) indicates that normal levels within the River Char are between 0.05m and 1.18m (EA, 2018)[3]. The highest level recorded is 3.76m, which was reached on 7th July 2012.

Section 2.2 CRPG compliance review
Section 29.2 of the CRPG makes reference to the river periodically blocking and the occurrence of ponding. This indicates that the river behaviour has been considered in the assessment. The 2014/15 diversion of the channel would not have been considered in the assessment, but there have been several flooding events prior to 2013 (CRPG production) that would have been available for consideration. The primary relevance of this information to the CPRG would be the susceptibility of the lower reaches of the river to flooding. Conclusion: Compliant

2.3 Sea levels

Table 2-1 provides the tidal levels (mODN) for a station at Lyme Regis, which is located approximately 2.4km west of Charmouth. These are predicted tidal levels based on the astronomical tidal forcing only. The actual observed tidal levels are likely to vary from this value due the positive or negative influence of a tidal surge component. This surge component is generated through local meteorological

[2] Standing Conference On Problems Associated with the Coastline (SCOPAC). Lyme Regis to Portland Bill. http://www.scopac.org.uk/scopac_sedimentdb/chesl/chesl.htm.
[3] Environment Agency. Flood information service. https://flood-warning-information.service.gov.uk/station/3286

conditions (i.e. high or low-pressure weather systems) or through the influence of distant storms.

Table 2-1 - Tide levels for Lyme Regis (Source: Admiralty TotalTide Software)						
Highest Astronomical Tide (HAT)	Mean High Water Springs (MHWS)	Mean High Water Neaps (MHWN)	Mean Sea Level (MSL)	Mean Low Water Neap (MLWN)	Mean Low Water Spring (MLWS)	Lowest Astronomical Tide (LAT)
2.45	1.95	0.75	0.09	-0.65	-1.75	-2.15

Figure 2-4, taken from the South West Regional Coastal Management Programme 2017 Annual Report for Portland Bill to Exmouth, shows the observed MHW and MLW contour extents for selected periods. In general, the MHW contour extends up to the footbridge, with the notable exception of March 2016, where the contour extended further upstream of the River Char. There is insufficient information in the annual survey reports to determine the cause of this variation in MHW extent; but it did occur after a recorded 10-15m recession in beach profile nearest to the river mouth (SDADCAG, 2016[4]). The contours also show the variability of the river channel orientation with respect to the beach.

The long-term management policy for Charmouth is one of natural beach roll-back (see Section 2.5), therefore it may be expected that there will be a general increase in tidal levels within the lower reaches of the River Char.

The Environment Agency's Coastal Flood Boundary Conditions Database (CFBCD)[1] database provides predictions of extreme water levels for various return periods, for a baseline of 2008. Table 2-2 provides the predicted levels adjusted to a 2018 baseline using the UKCP09 medium emissions scenario (95th percentile).

Table 2-2 – Predicted extreme sea levels from the CFBCD (chainage 4794)					
Base Year	**Extreme sea levels (m) for return periods(T)**				
	T1	**T2**	**T20**	**T50**	**T100**
2018	2.58	2.81	2.98	3.1	3.12

Section 2.3 CRPG compliance review
Section 29.2 of the CRPG makes reference to the tidal limit of the River Char, however, there is no indication that past levels have been reviewed. This is not considered essential to either the cliff erosion calculations or the defining of the managed realignment area, as these will be influenced by future levels.

[4] South Devon and Dorset Coastal Advisory Group (SDADCAG). Shoreline Management Plan Review (SMP2) Durlston Head to Rame Head. Shoreline Management Plan (Final). June 2011.
[1] Environment Agency. Flood and Coastal Erosion Risk Management Research and Development Programme. Coastal flood boundary conditions for UK mainland and islands. Project: SC060064/TR3: Design swell waves

Section 2.3 CRPG compliance review
Conclusion: Compliant

Figure 2-4 MHW and MLW contours (Source: SDADCAG, 2017[5])

2.4 Climate change predictions

The 2009 UK Climate Projections (UKCP09[6]) provides estimates of extreme sea levels for various emission scenarios (low, medium and high); accounting for the differences between global climate models.

Figure 2-3 shows the relative sea level change predictions relative to 2018. The predictions are provided up to the year 2100 (83 years from present), therefore the trendline has been continued to 2118 (100 years) using linear extrapolation. The predicted sea level rise under the medium scenario (95th percentile) would be 0.759m by 2118.

Table 2-3 shows the predicted extreme sea levels for a number of return periods for present day and those predicted for 100 years of sea level rise, based on UKCP09 medium emissions scenario (95 percentile).

[5] Plymouth Coastal Observatory, South West Regional Coastal Management Programme, 2017 Annual Report, Portland Bill to Exmouth (http://www.channelcoast.org/)
[6] Lowe, J. A., Howard, T. P., Pardaens, A., Tinker, J., Holt, J., Wakelin, S., Milne, G., Leake, J., Wolf, J., Horsburgh, K., Reeder, T., Jenkins, G., Ridley, J., Dye, S., Bradley, S. (2009), UK Climate Projections (UKCP09) science report: Marine and coastal projections. Met Office Hadley Centre, Exeter, UK.

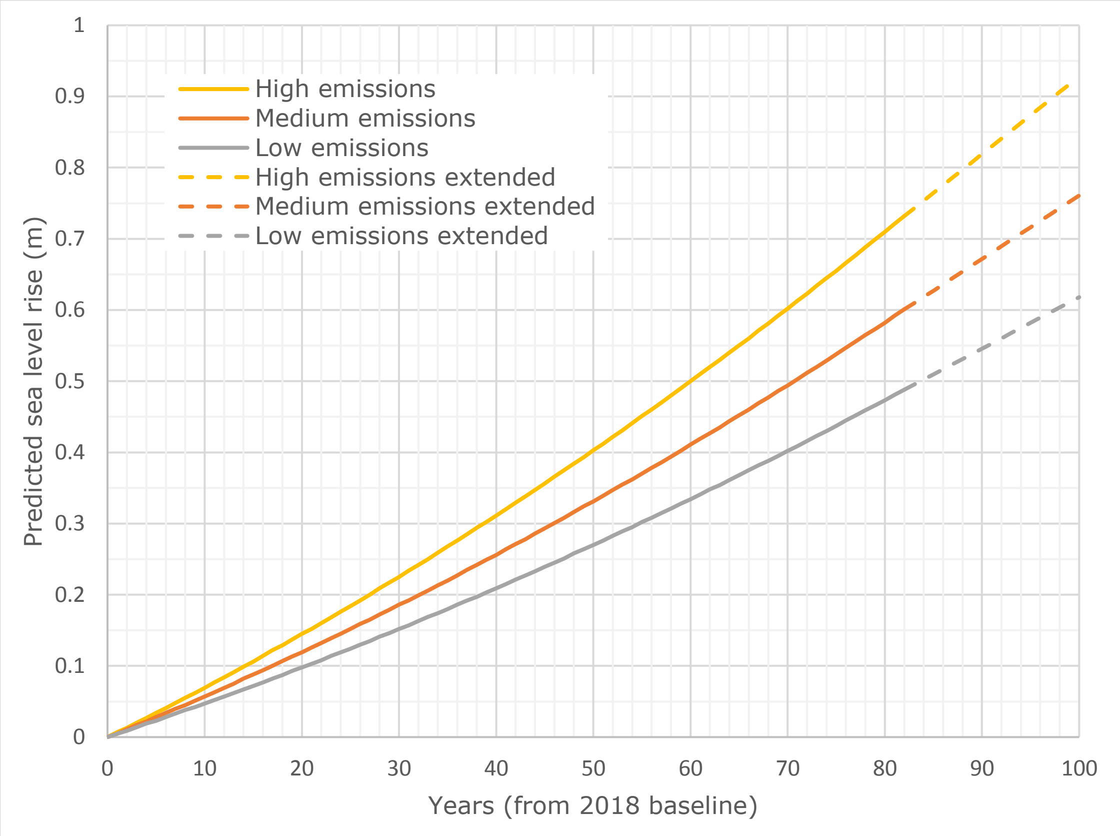


Figure 2-5 UKCP09 relative sea level rise predictions (95%ile)

Table 2-3 – Predicted extreme sea levels from the CFBCD (chainage 4794)					
Base Year	**Extreme sea levels (m) for return periods(T)**				
	T1	**T2**	**T20**	**T50**	**T100**
2018	2.58	2.81	2.98	3.1	3.12
2118	3.35	3.58	3.75	3.82	3.89

As indicated in Section 2.3, there are two components that need to be considered with regards to sea levels, namely the astronomical tide and the surge tide. In addition to the relative sea level change projections, UKCP09 also provides projections for changes to the skew surge, these are provided in Table 2-2 for selected probabilities and return periods.

Table 2-4 - UKCP09 Skew surge projections				
Probability (%)	Long-term linear trend in skew surge (1951-2099) for return levels (mm/yr)			
	2 years	10 years	20 years	50 years
95	0.156	0.24	0.268	0.303
50	0.275	0.431	0.486	0.555
95	0.394	0.622	0.705	0.807

Section 2.4 CRPG compliance review
Best practice climate change guidance and sea level rise estimates have not been updated since the CRPG assessment was undertaken. Section 29 of the CRPG refers to sea level rise throughout, and the UKCP user interface is included in the reference in line with current best practice guidance. It is not stated which data was used in terms of emissions scenario or percentile. Figure 2-2 indicates that the variation in levels between scenarios could be up to approximately 0.3m after 100 yrs. The CRPG calculations would have been based on baseline year, of 2013, the time at which the work was undertaken. Updating to a new baseline of 2018 would increase water levels by approximately 0.03m. This would have negligible effect on the outcome of the work. Conclusion: Compliant, although justification for emission scenario and percentile applied should be included in the document.

2.5 Waves

Waves have the potential to transfer large amount of energy into the coastal system. This energy can potentially undercut coastal defence structures and cliff faces leading to erosion, transfer water inshore through the action of wave runup or provide the means for water to overtop coastal defence systems. Waves act upon the water levels and, much like skew surge discussed in Section 2.4, will have most impact when they occur during periods of high water levels.

Figure 2-6 provides the significant wave height data[7] for a point located approximately 4km offshore from Charmouth. This wave rose is based on data from NOAA's WAVEWATCH III® 30-year Hindcast Phase 2 model for NW Europe. It shows that waves are predominantly (approximately 64% of data record) from the south-west and reach heights greater than 2m for approximately 2.9% of the time (estimated from the wave rose). The mean wave height is indicated as being approximately 0.8m.

[7] Data Explorer. 2018. ABPmer. 21st June 2018. https://www.seastates.net.

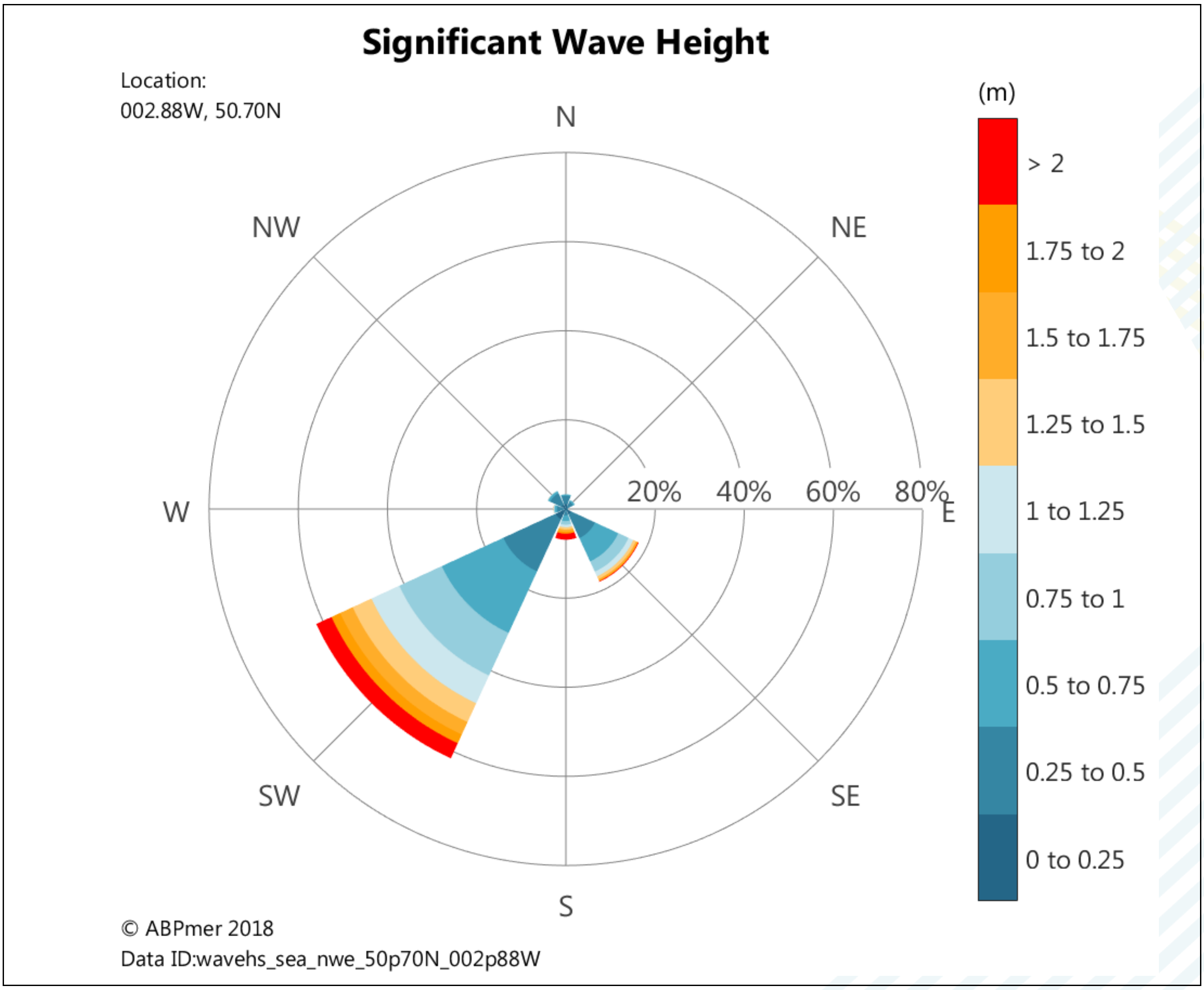


Figure 2-6 Wave Rose data for a point offshore from Charmouth

Source: SAESTATES, 2018

General models of projected variations in wave heights are available, however there are currently a number of uncertainties within these projections. Climate change may result in the prevalence of high and low-pressure systems, storm tracks may shift in latitude and become more or less intense. The effect of climate change on waves is an integration of the effects of wind speeds, fetch and durations.

The general accepted guidance is that in the future, seasonal mean and extreme waves are expected to increase in the south west of the UK and reduce in the north. Changes in the winter mean wave height are projected to be between −35 and +5 cm. Changes in the annual maxima are projected to be between −1.5 and +1 m.

Section 2.5 CRPG compliance review
There is no specific mention of waves in the CRPG document. The impact of waves on erosion will have been included through the inclusion of cliff recession rates. It is not clear whether the impact of waves following beach roll back has been considered with respect to the managed realignment area, or whether any consideration has been given to future predicted increases in wave height. The identified area in the CRPG is considered to be sufficient to mitigate against any future wave impacts. The uncertainty in the potential future changes in wave height means that this is generally not included in similar studies. Conclusion: Compliant

2.6 Sea defences

The sea defences at Charmouth are limited to a small section, approximately 130m, of sea wall and promenade. Additional protection is provided by a rock groyne at the western edge of the promenade (Figure 2-7) and a rock revetment in front of the car park (Figure 2-8). The rock groyne at the western end of the sea wall is restricting sand supply in front of the defences and has led to a noticeable narrowing of the beach at this location. The loss of beach material has exposed the sea wall and there is some evidence of undermining of the structure. Additional rock material has recently been placed in front of the wall in places to provide some toe protection.

Figure 2-7 Coastal defences to west of River Char showing stepped revetment with exposed sheet pile toe in places and placed rock for additional protection

Figure 2-8 Coastal defences to front of car park, immediately west of River Char

Section 2.6 CRPG compliance review
The existing coastal defences and their predicted life-span has been considered in the CRPG calculations. This is evident in the predicted beach roll back and the proposed managed realignment area. Conclusion: Compliant

2.7 Shoreline Management Plan (SMP2)

The SMP2 policy for Charmouth is to 'Hold The line' in the short term with ongoing maintenance of the defences to extend the residual life of the defence. It is possible that these defences may become outflanked by the continued erosion of the undefended cliffs (Section 2.1.1).

In the medium term, as the existing defences reach the end of their effective life they will become more difficult to sustain. The management policy for this section will then become 'No Active Intervention'. During this time the defences will continue to provide some protection, but this will diminish over time. As the defences fail there will be an increase in erosion risk to property and infrastructure in the western part of Charmouth. The initial short term HTL policy will enable measures to be put in place to facilitate the medium to long term transition to a policy of Managed Realignment.

A policy of 'Managed Realignment' in the medium to long term within the River Char would enable the beach to roll-back and adapt naturally into the river channel in response to rising sea levels, allowing a beach to be maintained within the embayment that would form. As part of the Managed Realignment policy, flood protection measures would be required in the River Char to accommodate the beach roll back. This review has not considered the impact of any potential future flood protection strategies.

Section 2.7 CRPG compliance review
The SMP2 policy has not been updated since completion of the CRPG and hence no update to the CRPG would be required. Section 29.3 of the CRPG document describes the shoreline management plan policy for Charmouth and this policy has been accounted for within the cliff recession calculations. Conclusion: Compliant

3 Applicable best guidance documents

The Risk Assessment of Coastal Erosion(RACE) documents (Defra, 2007[8]) provide methodologies for assessing the hazard and risk of coastal erosion, developed during a joint Department of Environment, Food and Rural Affairs (Defra) and the Environment Agency (EA) flood and coastal erosion risk management research and development programme. It contains a range of analytical techniques to be employed dependent on the level of detail required and the extent and quality of data that is available. It outlines five different techniques that can be applied to determine recession rates. A brief overview of these techniques is shown in Table 3-1.

Table 3-1 - Recommended techniques for determining coastal recession rates (Source: Risk assessment of coastal erosion[8])

Technique		General Description	Main Points
1	Technical Judgement	Experience based assessment for use with minimal data	Quick and easy method. Crude examination.
2	Futurecoast Assessment	Uses data from the Futurecoast cliff database	Consistency of available data lends itself to national application. Data not available for dune frontages.
3	Site Specific Assessment	Combines data from Futurecoast with real data	More accurate than Technique 2, although some aspects remain imprecise. Some Local Authorities may already have such studies available.

[8] Department of Environment, Food and Rural Affairs, 2007. Risk Assessment of Coastal Erosion (Parts One and Two). R&D Technical Report FD2324/TR1.

Table 3-1 - Recommended techniques for determining coastal recession rates (Source: Risk assessment of coastal erosion[8])			
4	Single Recession Rate method	Uses purely real data and methods recommended by the soft rock cliffs manual[9] to calculate single recession rates	Very robust method that will deliver reliable results. Data requirements exceed Technique 1 to 3. Methods require extensive data and expert input.
5	Probabilistic Method	Uses purely real data and methods recommended by the soft rock cliffs manual[2] to calculate single recession rates	Likely to provide most accurate output. Methods require extensive data and expert input.

The shoreline management plan guidance (Defra, 2006[10]) indicates that features at risk of flooding can be identified through a baseline assessment of coastal erosion or flooding. This assessment should be conducted under a scenario of 'No Active Intervention'. Lee and Clark (2002[9]), referred to as the 'soft rock cliff manual', provides information on the measurement and monitoring of cliff recession rates. This highlights the importance of considering the cliff system as a number of Cliff Behaviour Units (CBU) or cliff units. These CBUs span the nearshore to the cliff top and are coupled to adjacent CBUs. It states that, due to the variable and uncertain nature of the cliff recession process it is essential that recession rates are considered within the contemporary behaviour of the CBU. It indicates that a range of approaches are available that provide information on various aspects of cliff behaviour, including:

- measurement of historical recession rates;
- measurement of current recession rates;
- assessment of contemporary cliff behaviour;
- monitoring of current cliff behaviour.

It should be noted that Halcrow Group Limited (now Jacobs), the authors of Section 29 of the CRPG document, were involved in producing both the risk assessment of coastal erosion[1] and the Shoreline Management Plan[2] guidance documents.

4 The Coastal Risk Planning Guidance (CRPG)

4.1 Identified risks

The primary risk identified in the CRPG was from flooding to the low-lying areas. This risk comes from both overtopping of the defences and from the combined tidal/fluvial flooding via the River Char. The beach along the mouth of the River Char is expected to roll-back landwards into the channel, both in response to the retreat of the

[9] Lee E. M. & Clark A. R., 2002. The Investigation and Management of Soft Rock Cliffs. Thomas Telford.
[10] Department of Environment, Food and Rural Affairs, 2006. Shoreline management plan guidance. Volume 2: Procedures.

adjacent undefended cliffs and as sea levels rise. The loss of beach material will also result in increased risk of flooding in the upstream areas.

The coastal change risk map for the River Char that was produced following the CRPG cliff recession assessment is provided in Figure 4-1. This indicates a potential 100-year erosion risk area that encompasses the visitors centre, the car parks on the western bank of the River Char, lower Charmouth and along the channel of the River Char up to the Seadown Holiday Park. The 50-year erosion risk contour generally covers the current flood plain area and the car parks; but it also includes some private land behind River Way comprising residential property and gardens. The majority of this area is below 5mODN, based on the 2009 LiDAR data (Figure 4-2).

The complex cliff systems around Charmouth mean that estimating erosion rates is not possible through simple regression techniques, as erosion tends to be episodic in nature and tend to be responsive to storm events etc. The analysis therefore needs to consider the cliff system as a number of interactive units and needs an understanding of the processes involved along with expert judgement to identify the cliff recession zones.

The cliff recession assessment undertaken for the CRPG was completed using detailed site-specific information available for historical landslide behaviour on the Lyme Regis/Charmouth coastline, alongside data and analysis held within the Futurecoast database.

The Futurecoast project used an approach that conceptualised the factors affecting coastal change and is still viewed as good practice. Futurecoast, published in 2002, was commissioned by Defra and carried out by a team lead by the Halcrow Group Limited.

For the CRPG, potential cliff recession rates based on Futurecoast data were estimated through the following steps:

1. Estimate the recession potential of the site by multiplying the magnitude of each recorded event by its frequency.
2. The magnitude of each event was assumed to be 5m, 25m and 50m for low, medium and high activity cliffs respectively, based on expert judgement.
3. The frequency of each event was assumed to be:
   - For events that occur every 1 to 10 years = 20 events in next 100 years.
   - For events that occur every 10 to 100 years = 5 events in next 100 years.
   - For events that occur every 100 to 250 and 250 to 1000+ years = 1 event in next 100 years.
4. Derive 5% and 95% probabilities by adding and subtracting 20% from the central (50%) projection.
5. If the Shoreline Management Plan (SMP) policy is "Hold the Line" (HTL) over the next 100 years, headscarp recession was assumed to be 50% of the central projection. This recognised that toe erosion will be halted (by continued defence of the toe), but that other effects, such as system lags or elevated groundwater levels, may continue to promote instability.
6. The 20 and 50-year projections are simply derived by factoring down the 100-year projection.

This cliff recession zone assessment is considered appropriate for use at Charmouth, as it follows the relevant guidance documents and considers the complexity of the coastal cliff systems. The adopted method is predominately consistent with Technique 3 in the Defra RACE document (Table 3-1) as it combines real data with the Futurecoast cliff data. In consideration of the regional geology and the natural processes it is considered that the approach adopted to undertake the cliff recession assessment is appropriate and in accordance with best practice guidance.

Futurecoast separates the coastline into sections of similar characteristics, and therefore should conform with the use of CBUs recommended within the soft rock cliff manual (see Section 3). Although Futurecoast is thought to use the CBU approach, it has not been possible to attain a copy to attain sufficient detail to confirm its full conformity.

The adopted cliff recession assessment in the CRPG makes an allowance for the SMP2 policy of HTL for 100 years. At Charmouth, this is relevant to the coastal defences in front of the visitor centre and car park; an area that is considered important with respect to the extent and timing of the predicted beach rollback. The inclusion of the SMP2 policy in this way is in line with current FCERM policy and ensures that the prediction takes into account the adopted coastal management policies and existing defences into account and doesn't overestimate the risk.

A comparison of the recession rates derived from the historical landslide behaviour and Futurecoast indicated that Futurecoast projections were approximately 20% higher than those based on the historical landslide rates. It was therefore decided that precautionary Futurecoast rates would be adopted.

The incorporation of historic data into the recession rates and comparison against the Futurecoast predictions helps provide confidence in the results, although there is no description of how the historic data was incorporated or what data was used. Due to the unpredictable complex cliff systems surrounding Charmouth and the fact that the difference between the FutureCoast and historic data based predictions was reasonable in consideration of the inherent uncertainty involved in cliff recession predictions, it would be most appropriate to apply the more conservative FutureCoast predictions for the Coastal Risk Planning Guidance.

The coastal change risk map for the River Char produced following the CRPG cliff recession assessment is provided in Figure 4-1. This indicates a potential 100-year erosion risk area that encompasses the visitors centre, the car parks on the western bank of the River Char, lower Charmouth and along the channel of the River Char up to the Seadown Holiday Park. The 50-year erosion risk contour generally covers the current flood plain area and the car parks; but it also includes some private land behind River Way comprising residential property and gardens. The majority of this area is below 5mODN, based on the 2009 LiDAR data (Figure 4-2).

Both the 1:50-year and 1:100 extreme sea levels predicted for 2118 (Table 2-3) are above 3.8m. If the predicted skew surge (Table 2-4) and waves are included on these levels then it is reasonable to consider that future levels will impact much of the present flood plain and car park areas. The predicted roll-back of the beach will further impact these levels as it will open the shoreline to coastal processes.

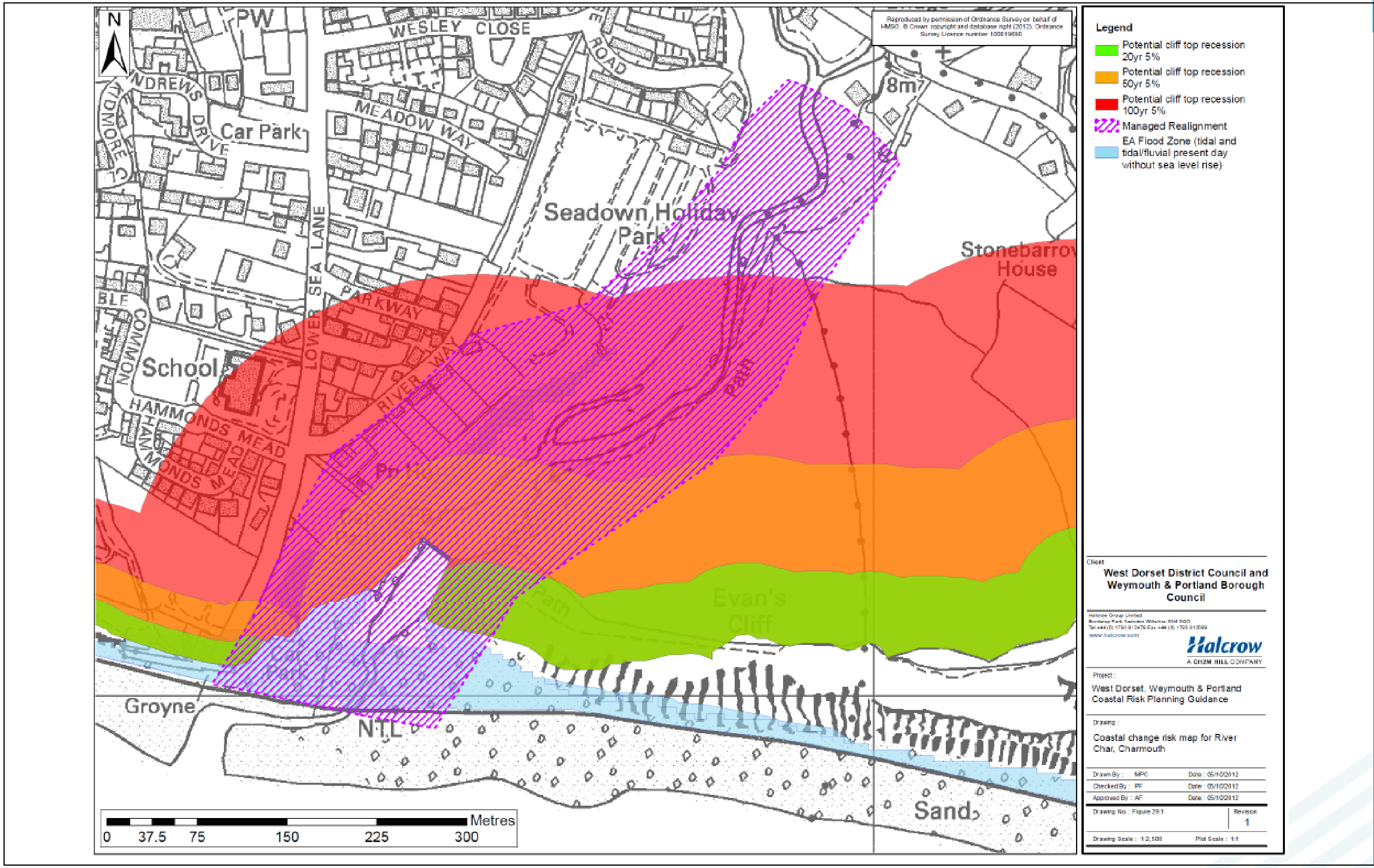


Figure 4-1 Coastal change risk map for River Char, Charmouth (Source: CRPG (Halcrow, 2013) Note: Although the term cliff erosion rate is used this also encompasses coastal erosion rates.

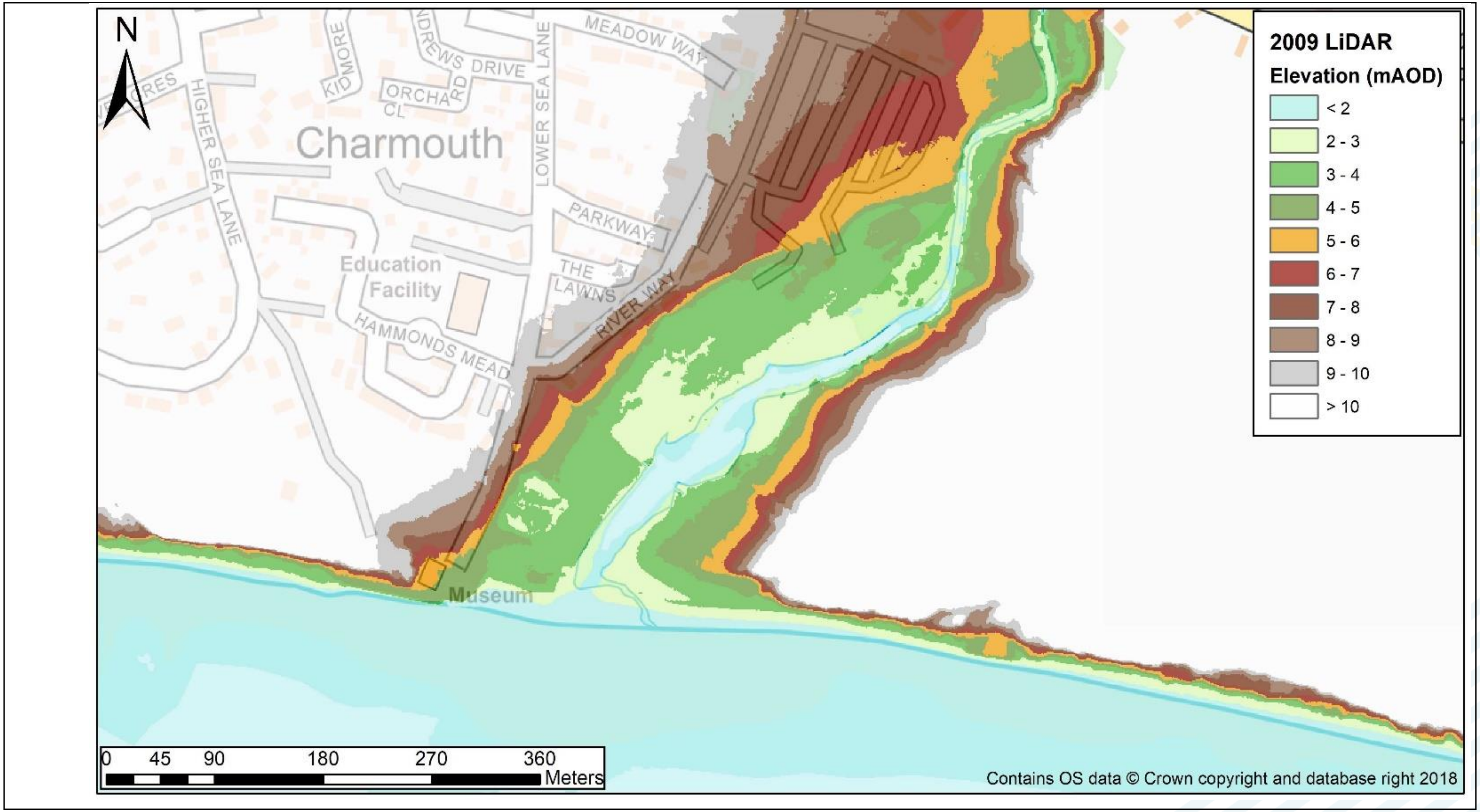


Figure 4-2 Charmouth LiDAR data: 2009 (Source: CCO)

4.2 Managed Realignment Zone

The coastal change risk map for the River Char provided in Figure 4-1 presents a Managed Realignment Zone. This zone extends approximately 0.65km upstream from Charmouth beach. The lower western extent is bounded by Lower Sea Lane, and covers the car parks. Most of the car park areas on the western bank of the River Char are below 5m ODN, and are built upon the historical River channel (pre 1906[11]). The managed realignment area approximately follows the 7mODN contour before it intersects with the River Way, where the realignment area follows the road to a point located beyond the permanent housing on the southern side of the road. The houses on this section, and side, of River Way are located between 7-8mODN based on 2009 LiDAR data. Figure 4-2 presents the most recent LiDAR elevation data (2009) for the study area and shows how the Managed Realignment Zone coincides with the low-lying areas which are more vulnerable to flood and erosion risk now and into the future as climate change takes place and the coastline rolls back in response.

The Managed Realignment Zone presented covers much of the existing or historical flood plain area (Figure 4-3), and is therefore land which could be susceptible to future flooding following climate change, sea level rise or potential beach roll back. Beach roll-back will also increase the potential for waves and tides to influence further upstream within the River Char.

[11] Geology of the Wessex Coast of Southern England: Charmouth east to Stonebarrow Hill. Ian West. http://www.southampton.ac.uk/~imw/Charmouth-East-Stonebarrow-Hill.htm

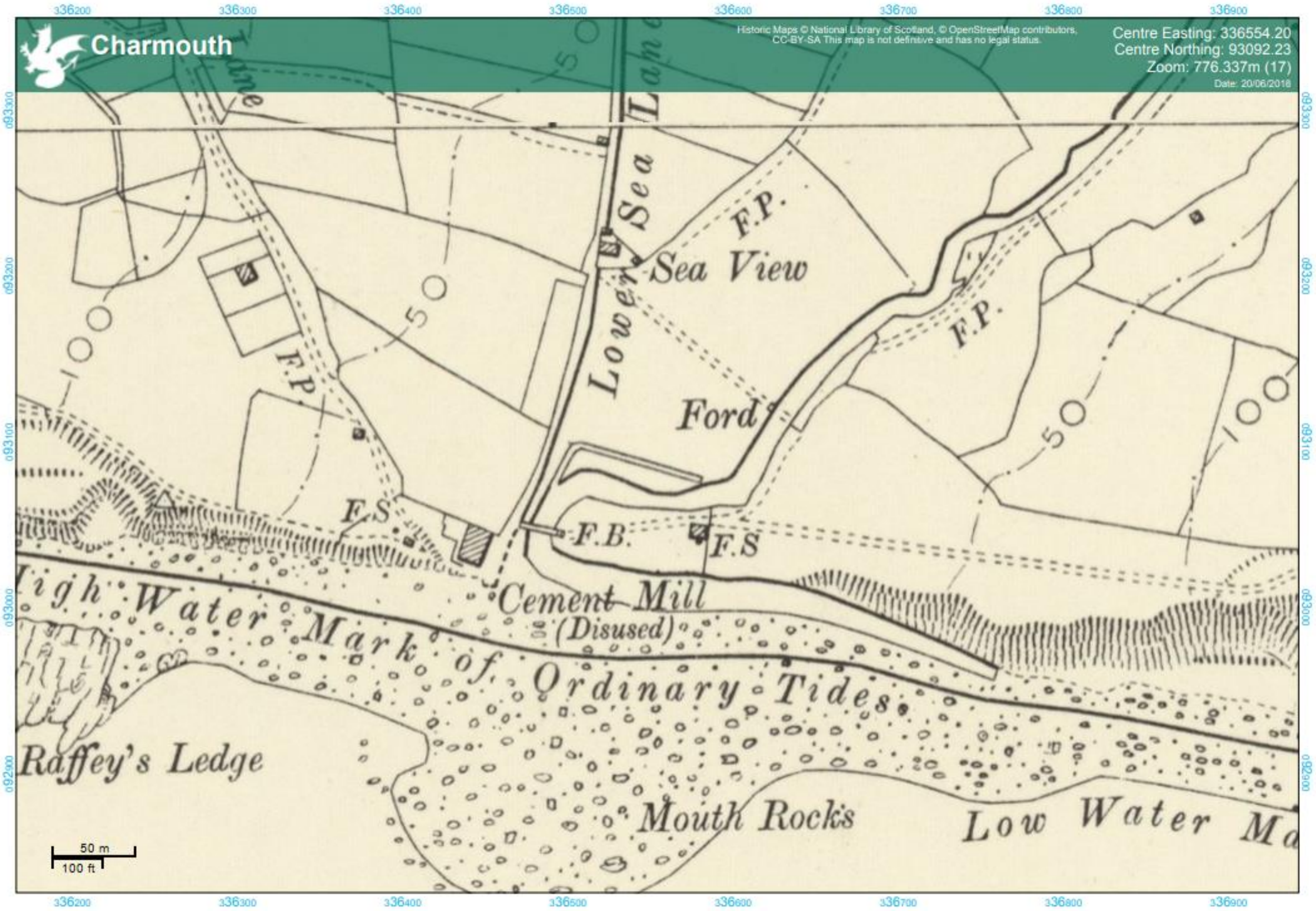


Figure 4-3 River Char channel course: 1888-1913 (Source: DorsetExplorer)

Much of the realignment area presented is below approximately 7mODN (Figure 4-2) with the notable exception of the residential properties along the southern side of River Way (Figure 4-1), where elevations increase up to around 8mODN. Properties along this section of road however have gardens which slope down towards the river with an elevation of less than 4mODN, and the LiDAR data and Ordnance Survey Map contours for this area show that land elevations fall to less than 5mODN within 45m to 17m (southwest to north east alignment) of properties. Considering sea level rise (Table2-3) and wave climate, it is therefore considered reasonable that properties along the riverward side of the road could be impacted by predicted beach roll back, waves and increased water levels, as gardens are lost over time and properties become exposed to waves and tides.

Also of consideration is the bedrock in this area. If the combination of land roll-back and increased water levels (astronomical + surge tides) results in regular coverage of the flood plain then the mudstone bedrock[12] that underlays this area will be susceptible to continual erosion. Increased access of waves and tides to the mudstone bedrock could lead to further cut back and recession and potential undermining of assets.

The defining of the realignment area needs to consider the impact of future processes to the coastal system, based on acceptable realistic predictions and expert opinion on

[12] British Geological Survey. Geology of Britain viewer. http://mapapps.bgs.ac.uk/geologyofbritain/home.html

how these changes will impact the area, whilst also considering the inherent uncertainty in the prediction of coastal recession. The 2015 storm event has demonstrated that the river channel is susceptible to short term changes to the coastal system, and therefore will be impacted by the predicted long-term changes. The expectation that the beach will roll back following the loss of the current defences is considered appropriate; especially in consideration of the erosion processes evident to the east of the river.

In consideration of the coastal processes, the predicted loss of the existing coastal defences and the projected climate change impacts, a realignment area up to the predicted 7mODN contour is considered realistic. However, there is the potential that this may need to be extended in the nearshore region if cliff erosion exceeds the expected level in that area. The extent of the outlined zone includes the existing flood plain and a buffer zone; which initially looks to have been selected to align with the existing road (Figure 4-1). Given that beach roll back will open the current flood plain area to more coastal/erosional processes, and the bedrock being mudstone, this assumption is not considered excessive. The previous flooding of Seadown Holiday Park would indicate that the realignment area is justified to include this area, however, given the elevations in this area (Figure 4-2) the alignment area here may need to be extended in the future.

The location of the managed realignment area to the eastern side of the River Char coincides with an area of steeper rising land which provides a natural boundary extent to recession.

It should be noted that the designated flood realignment area does not consider any potential future flood defence schemes on the River Char. It is understood that these are being considered but no design/planning has been undertaken at present.

5 Additional data availability

The CRPG document was produced in 2013. In order to assess the validity of its findings a desk based study was undertaken to identify any more recent data which has become available since the initial assessment was undertaken.

5.1 Beach Monitoring Data

The Channel Coastal Observatory (CCO) undertake beach profile surveys along fixed profiles to monitor changes in beach levels in front of Charmouth. Baseline profiles are surveyed once a year, with a smaller number of interim profiles measured on a twice-yearly basis. These profiles have been collated and reviewed for the periods pre- and post-2013 to identify any significant trends since the original assessment, that could influence the erosion predictions.

Figure 5-1 shows the locations of the CCO profile lines. Survey periods are not consistent between profiles, and available data sets are presented in Table 5-1. Profiles 6a00900, 6a00901, 6a00902, 6a00908, 6a00909 and 6a00910 have been added in at Phase 3 of the monitoring programme and as such only recent surveys are available. Profile 6a00907 has only been surveyed in 2012 and 2017.

Figure 5-1 Available survey profiles at Charmouth (Source: CCO, 2018)

Table 5-1 - Available CCO surveys

Survey reference	Available dates
6a00900	2016 to 2018
6a00901	2017 (13/04/17)
6a00902	2016 to 2018
6a00903	2012 (09/05/12) 2017 (13/04/17)
6a00904	2012 to 2018
6a00905	2012 to 2018
6a00906	2012 (09/05/12) 2017 (13/04/17)
6a00906A	2012 to 2018
6a00907	2008 to 2017
6a00908	2016 to 2018
6a00909	2017 (13/04/17)
6a00910	2016 to 2018

Survey data for key profiles are provided in Appendix A. It should be remembered that the processes along this section of coastline vary in response to forcing conditions such as storms, water levels and waves. Therefore, the timing of the survey is important and it is the long-term trends that are key to the region. An annual trend of beach lowering in winter, with a period of build-up and recovery in summer is expected to occur within any long-term trends. It should also be remembered that any increase in beach volume at a specific site, either short or long term, is most likely to be due to either the west to east longshore transport of material, or the seaward migration of cliff/land material. Both of which will be the result of erosion processes.

Profiles 6a00900 and 6a00902 are located to the east of the River Char. These profiles are recent additions to the monitoring programme, are limited to two years of data and show a mixture of erosion and deposition.

Profile 6a00904 is in front of the visitor centre car park, and again shows a mixture of erosion and deposition between surveys. Although, there is some indication of a general trend of material erosion directly in front of the car park since 2013.

Profile 6a00906A has been selected as it fronts the coastal defence wall. This profile shows a short-term build-up of material in front of the wall in 2014, but a general loss of material at the toe of the defence wall in all other surveys. This loss of material at the toe which would indicate that the wall is impacted by wave action and will be susceptible to increased wave action and increased water levels leading to undermining of the structure over time.

Profile 6a00908 is located to the west of the rock groyne, west of the Char. The data is limited to a two-year period but shows deposition of material, which would be expected given the proximity to the groyne. The back shore shows some variability, most likely due to material input from the cliff system directly behind this section.

Profile 6a00910 is the furthest west available profile. This profile indicates a general depositional trend over the available 2-year data period. The greatest increase occurs between the six-monthly surveys in 2017. There is insufficient data available to indicate whether this is a long term or short term.

5.1.1 Summary

The survey profile at the beach defences (6A00906A) does indicate that there has been a general trend of beach lowering at the toe of the coastal defence structures since 2012. This supports the SMP2 policy description that the beach lowering and wave action are likely to lead to failure of the coastal defence in the short to medium term. This in turn supports the managed realignment and erosion predictions of the CRPG.

The available survey data at other profile locations shows a general mixture of accretion and deposition in the short term, with most beach accretion most likely being linked to cliff erosion events releasing material onto the beach. There is generally insufficient data available to identify any long-term trends in beach levels in these areas.

6 Conclusions

JBA have undertaken a review of previously identified cliff recession buffer zones and the resultant managed realignment zone. This review has considered the geomorphology of the area and best practice guidance applicable to undertaking cliff recession analysis for the identified conditions.

It is considered that the previous approach adopted to assess the cliff recession rates is appropriate for the area being assessed and is consistent with the available guidance documents.

Additional data that has become available since the initial assessment does not significantly impact the findings of the original assessment and beach level data in front of the coastal defences goes someway to support the assumptions that defences will fail and recession will occur.

It is therefore concluded that the findings of the original study are considered valid and no additional assessment is required at this time.

The identified managed realignment area considers the impact of the loss of the existing coastal defences and the subsequent roll back of the beach. In consideration of the elevation of the land and the potential future risks to the area identified in this report, it is considered that the managed realignment zone is appropriate; and therefore, no recommended changes have been identified in this report.

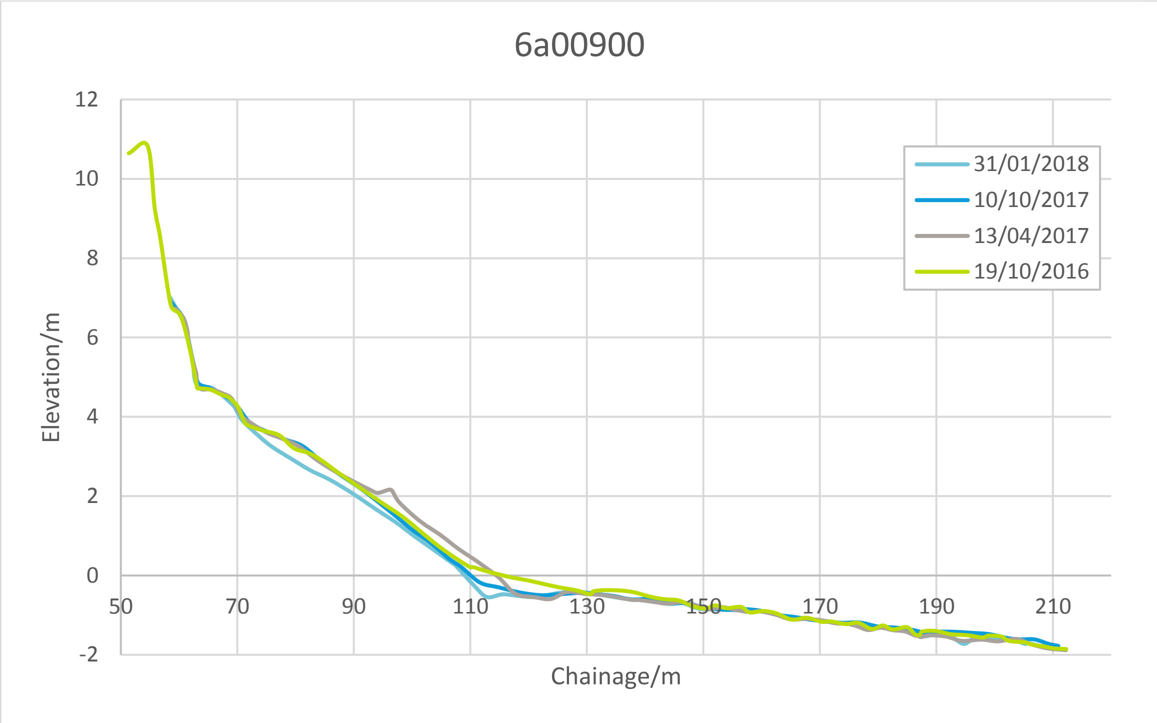
A review of the CRPG compliance has been provided after each section of the report. The key points are summarised below:

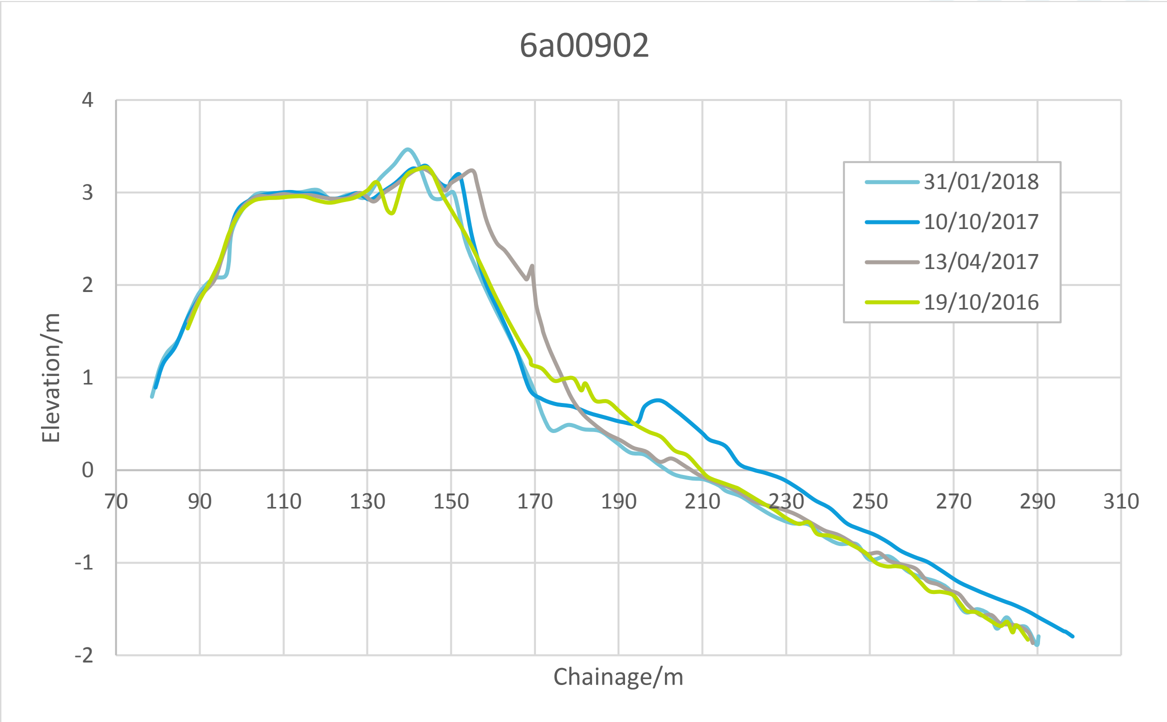
- The complex cliff systems around Charmouth mean that estimating erosion rates is not possible through simple regression techniques, as erosion tends to be periodic in nature and tend to be responsive to storm events etc
- The cliff recession assessment undertaken for the CRPG was completed using detailed site-specific information available for historical landslide behaviour on the Lyme Regis/Charmouth coastline, alongside data and analysis held within the Futurecoast database.
- Futurecoast separates the coastline into sections of similar characteristics, and therefore should conform with the use of CBUs recommended within the soft rock cliff manual (see Section 3). Although Futurecoast is thought to use the CBU approach, it has not been possible to attain a copy to attain sufficient detail to confirm its full conformity.
- The adopted cliff recession assessment in the CRPG makes an allowance for the SMP2 policy of HTL for 100 years, which is consistent with current FCERM policy.
- Section A.5.2 of the CRPG indicates that the recession potential estimates were derived for complex cliffs. Thereby confirming that the classification of the cliff system and the approach adopted for the cliff erosion calculations is appropriate for Charmouth.
- Section 29.2 of the CRPG makes reference to the river periodically blocking and the occurrence of ponding. This indicates that the river behaviour has been considered in the assessment.
- Section 29.2 of the CRPG refers to the tidal limit of the River Char, however, there is no indication that past levels have been reviewed. This is not considered essential to either the cliff erosion calculations or the defining of the managed realignment area, as these will be influenced by future levels.
- The existing coastal defences and their predicted life-span has been considered in the CRPG calculations. This is evident in the predicted beach roll back and the proposed managed realignment area.

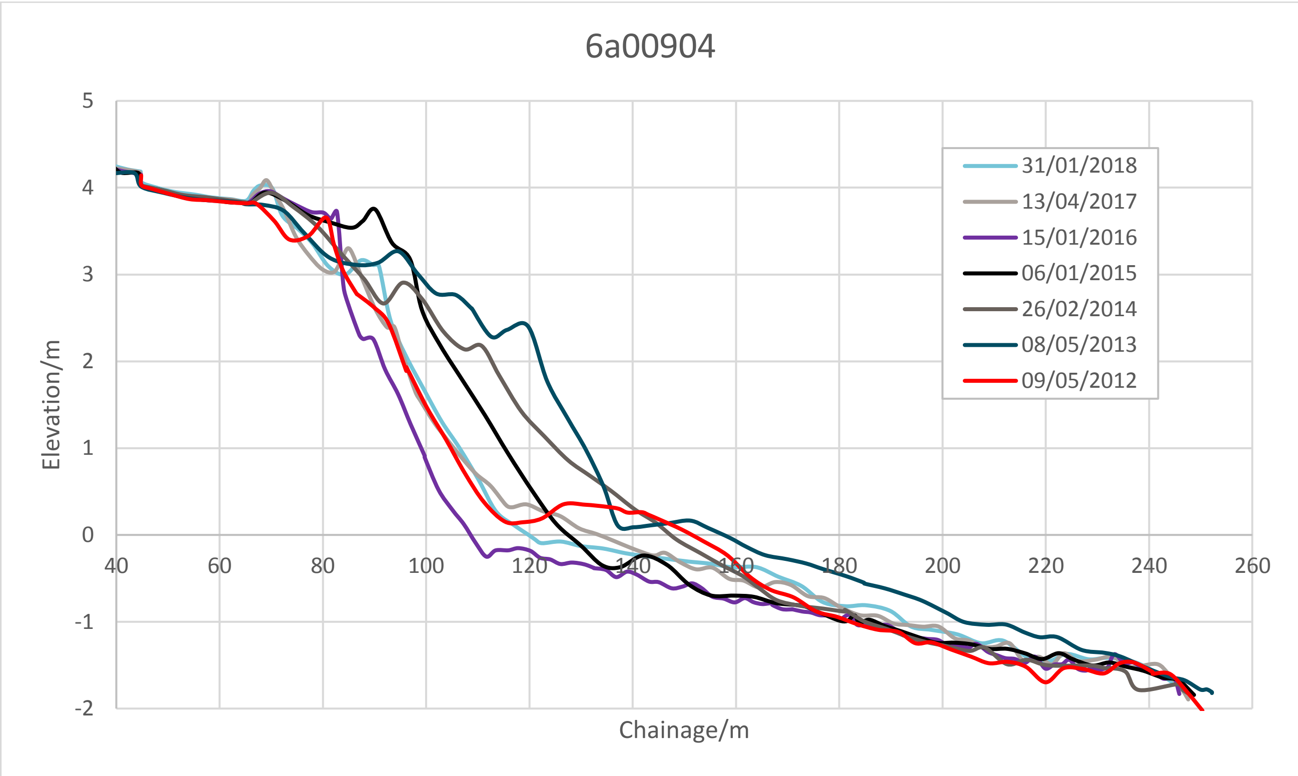
- The CRPG refers to sea level rise throughout, and the UKCP user interface is included in the reference in line with current best practice guidance. It is not stated which data was used in terms of emissions scenario or percentile.
- Best practice climate change guidance and sea level rise estimates have not been updated since the CRPG assessment was undertaken.
- There is no specific mention of waves in the CRPG document. The impact of waves on erosion will have been included through the inclusion of cliff recession rates. It is not clear whether the impact of waves following beach roll back has been considered with respect to the managed realignment area, or whether any consideration has been given to future predicted increases in wave height.
- The predicted 2118 extreme water levels for return periods of 50 and 100 years are both above 3.8m.
- Waves at Charmouth are predominantly from the southwest, with significant wave heights for an offshore location reaching 2m and above, with mean wave heights being approximately 0.8m.
- The 50-year erosion risk contour generally covers the current flood plain area and the car parks; but it also includes some private land behind the River Way comprising residential property and gardens. The majority of this area is below 5mODN, based on the 2009 LiDAR data.

Appendices

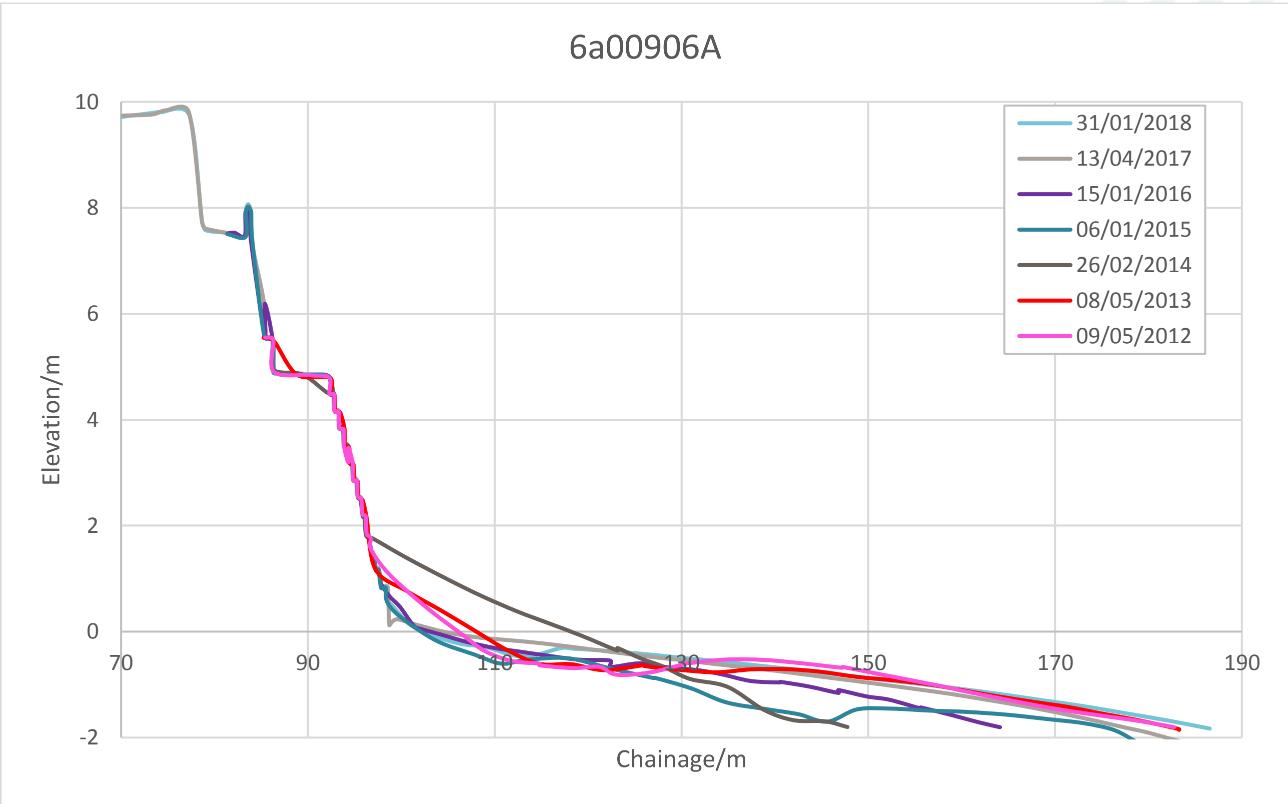
A Selected CCO survey profiles



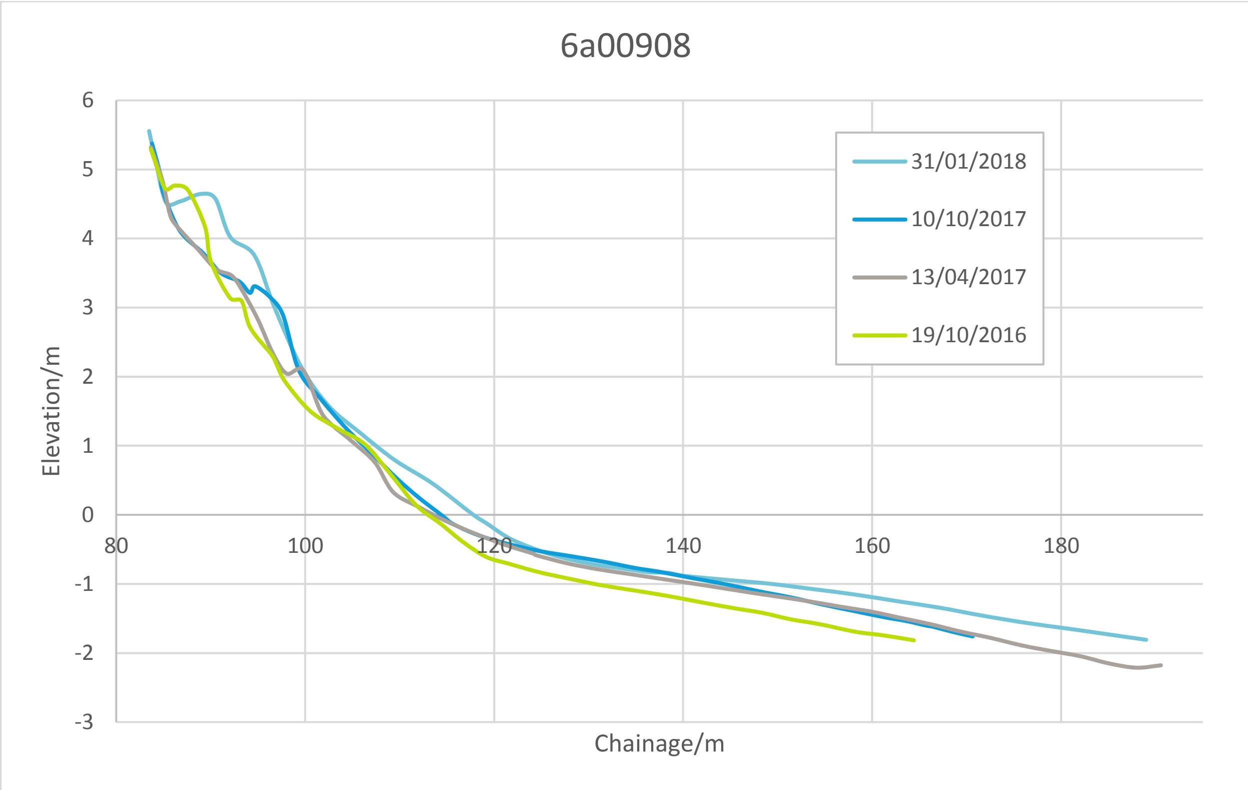


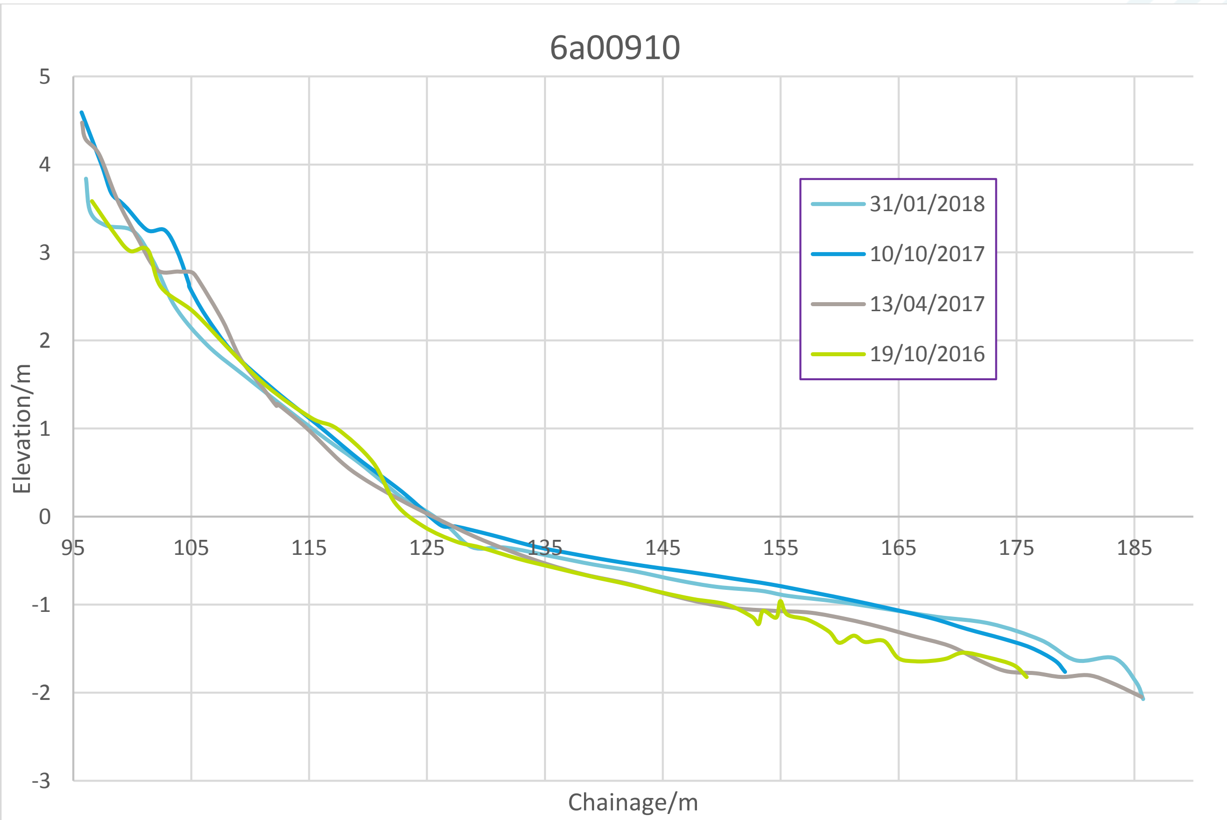


6a00904
Elevation/m
Chainage/m
31/01/2018
13/04/2017
15/01/2016
06/01/2015
26/02/2014
08/05/2013
09/05/2012



6a00906A
Elevation/m
Chainage/m
31/01/2018
13/04/2017
15/01/2016
06/01/2015
26/02/2014
08/05/2013
09/05/2012


6a00908
6
5
4
3
2
1
0
-1
-2
-3
Elevation/m
80
100
120
140
160
180
Chainage/m
31/01/2018
10/10/2017
13/04/2017
19/10/2016


6a00910
5
4
3
2
1
0
-1
-2
-3
Elevation/m
95
105
115
125
135
145
155
165
175
185
Chainage/m
31/01/2018
10/10/2017
13/04/2017
19/10/2016

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