# Case Study D Longshore Drift

## Mechanisms

Longshore drift occurs where the prevailing wave direction is oblique to the alignment of the beach. At Holywell the predominant SW waves impact on the beaches at angles tending towards 45$^{o}$. This action pushed the beach sediments towards the NE side of the beach cell. These types of beaches are described as *drift aligned*.

There are two distinctive sediment types that are distinguished by their origin and colour; the larger grey flint cobbles, derived from local chalk scree deposits and the imported* orange-brown, rounded pebbles.

There is also a significant amount of sand within the upper beach sediments due to constant mechanical recycling. This effectively forms an unconsolidated conglomerate deposit which is easily redistributed within the mid reaches of the beach cell, resulting in a steep cross-beach profile along the entire length of the groyne barrier. See Figure 5.

The larger cobble clasts are displaced from the HW berm slope, drawn down by gravity and back wash, deposited lower down the beach where the influence of gravity is significantly reduced. These stranded clasts are washed back up the beach by the next set of storm waves towards the NE side of the beach cell. The drift deposit will eventually overtop the groyne structure and deposit on the adjacent beach, as seen in Figure 4.

The beach can be divided into three zones based on slope gradient. Blue is the HW berm slope, here breaking waves are the plunging type that are powerful enough to dislodge the cobbles allowing gravity to pull them downslope into the yellow zone. Within this section the effect of gravity reduces and cobbles generally remain stationary until moved back up beach by plunging waves.

Without any significant sand content, the cobbles and shingle are able to take up a more conducive angle of repose that promotes stability. However, with a proportion of sand (up to 20% by volume) the sediments will form an unstable vertical face, described as *cliffing*, that is easily eroded. See Case Study B.

****Imported deposits consist of reworked paleo-beach deposits washed up the Channel floor during the flooding of the basin and those dredged from the Owers Bank and other locations. They are distinguishable from the locally derived, irregularly shaped, grey flint cobbles, by their orange brown colour, relatively small size and rounded form***

The mobile sediments that exist with the tidal range sit on a near horizontal platform of bedrock or compacted Holocene sediments. The seabed slopes upwards very gently from MLW to the toe of the beach, defined as where the shingle meets the sand. The wave trains within this section are described as *spilling.* They break over a relatively long section of the lower beach, the energy contained within the wave is dissipated as the wave train passes over the low tide section.

As the tide rises the beach slope increase between the *beach toe* and the high-water berm, The breaking waves release their power over a much shorter distance and this concentration is sufficient to move even large cobble clasts. Smaller shingle and sand are moved

The beach below has stabilised due to a drift deposit of locally derived grey cobbles. The beaches extending west are also filled with these stable clasts that have sufficient *inertial energy* to resist a significant change of state i.e. move. Movement is restricted to within the high energy zone located along the high tide berm and if displaced by a wave energy vector will be drawn down slope by gravity and back wash.

If the beach slope is relatively flat made up of compacted fine pebbles and sands, the cobbles will be drawn down further until the beach slope levels off and gravity holds them in place. If there is sufficient supply then a deposit will form lower down and provide further protection against erosion of the fines.

If the HW water berm is composed of ballast with occasional cobbles, these are usually buried within the fines as the storm wave beach wash mixes with the smaller grains and forms a short-term turbidity current, that can have sufficient inertia to displace. The larger clast stranded by the effect of gravity on the lower slopes will eventually be washed back up slope by storm waves, which are predominantly from the SW. These build up long the NE side of the beach to the top of the groyne structure and then onto the adjacent beach. If the supply ceases, then eventually the drift deposit will be pushed up along the eastern groyne enclosing the beach cell. They are then drawn-down as the wave energy vector is dramatically altered by the vertical groyne structure enchaining the loss down slope. Wave energy vectors at lower levels of the beach are significantly less than within the high energy zone, and cobble size clasts are rarely moved back upslope before becoming assimilated within the lower section finer sediments.

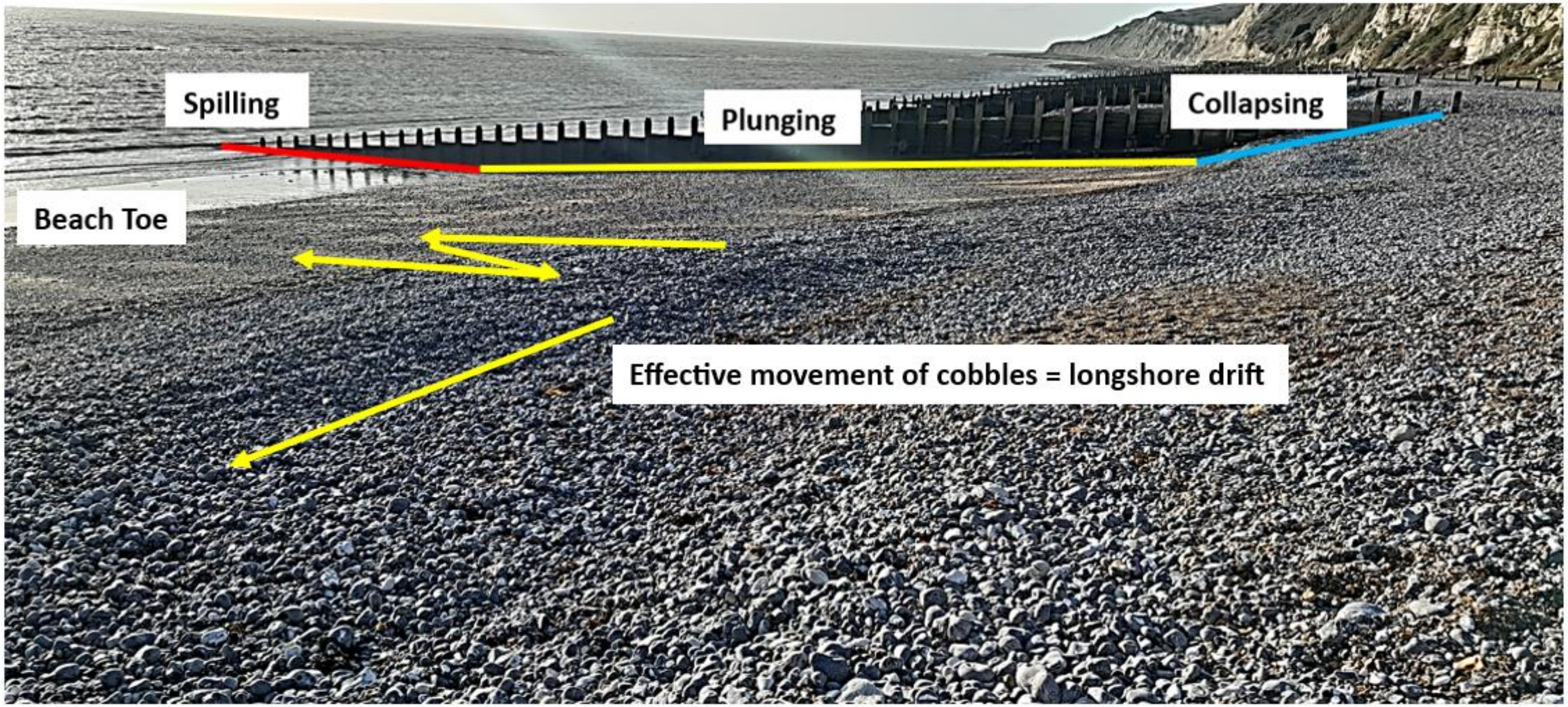


**Figure 1:** Stable beach at Holywell. The grey cobbles and shingle are the predominant clasts within the beach sediments. They have sufficient inertia to resist significant displacement when impacted by storm waves. The type of breaking wave is described by the dimensionless constant known as the Iribarren parameter, see Figure 2 and explanation below.

## Effect of seabed slope on breaking process

Depending on the wave properties and the angle of the bed slope, the process of breaking takes place in various different ways. Battjes (1974) showed that the Iribarren parameter guides this process. It is defined as follows:

$$\xi = \frac{\tan\alpha}{(H_0/L_0)^{1/2}}$$

ξ = Iribarren parameter a dimensionless constant that can be used to establish the nature of the breaking waves

α = beach slope   $H_0$= deep water wave height   $L_0$ = deep water wavelength

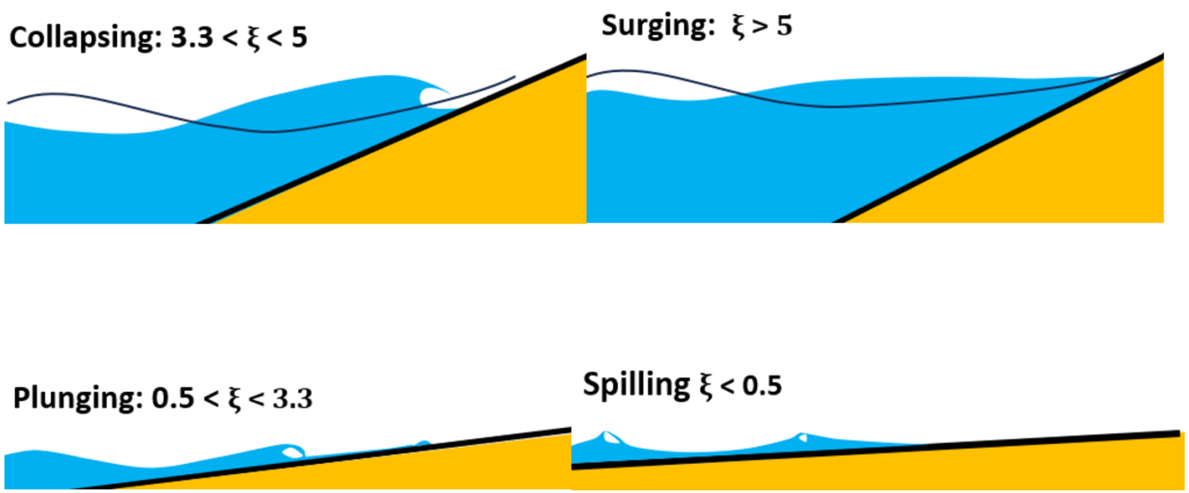


**Figure 2:** The four examples of breaking waves which depend on the beach slope

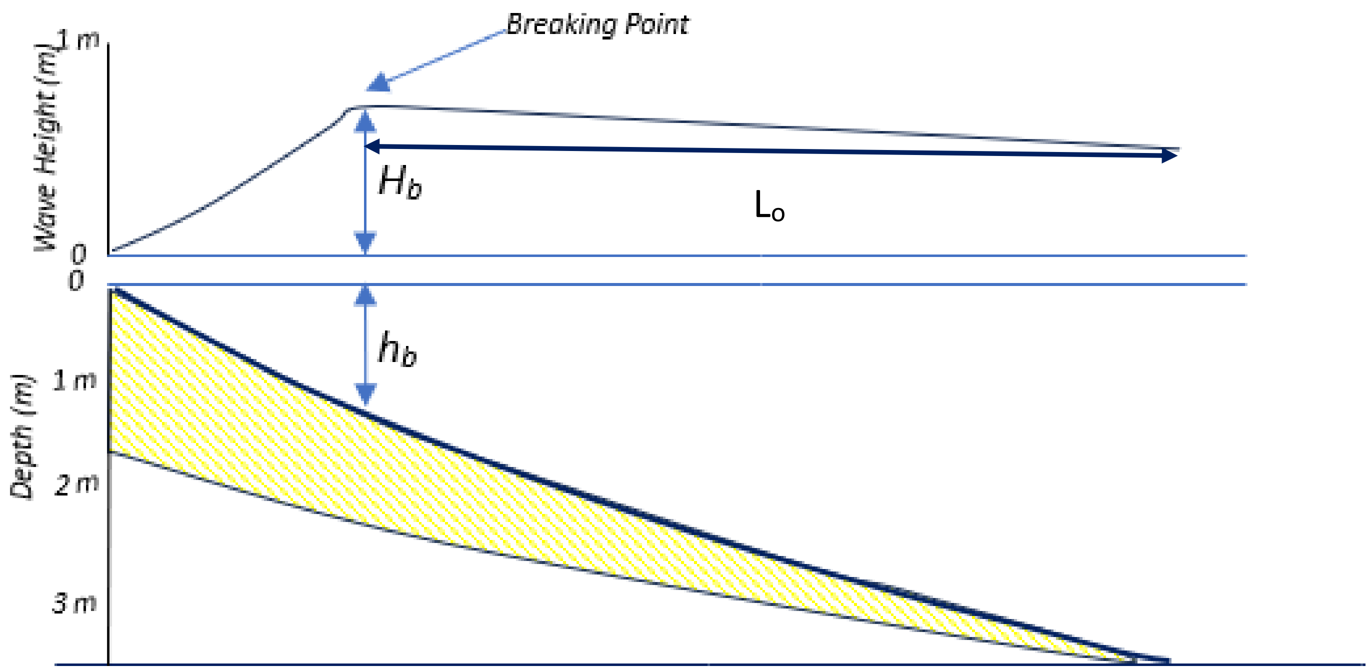


**Figure 3:** Relationship between water depth and wave height, the variables $H_b$, $h_b$ and $L_o$

| | |
|---|---|
| **Deep Water** | $h_b/L_o > 0.5$ waves unaffected by seabed |
| **Intermediate water and shallow water** | $h_b/L_o < 0.5$ waves affected by seabed |
| **Surf Zone** | $h_b < 1\ H_o$ (regular waves) OR $h_b < 2\ H_o$ (irregular waves) |
| **Swash Zone** | $h_b = 0$ |


**Figure 4:** Grey cobbles overtopping the eastern groyne of a beach cell. The cobbles on the eastern side (left) have been subjected to a short period of waves impacting from a E-SE direction, this has reversed the direction of prevailing drift.


**Figure 5**: The anthropogenic sediments, a chaotic mix of sand gravel and occasional cobble, are easily drawn down the beach and then pushed up against the eastern groyne by prevailing SW waves. The sediment level along the west side of the beach cell is in excess of 3m below the top of the groyne structure. The sediments slope up towards the east side to within 0.5m of the top of the groyne. Considerable stress is applied to the groyne by the weight of ballast and the smaller shingle will overtop the groyne further down than the larger grey cobbles.

## Case Study Beaches

Case studies of two sections of coast extending eastwards from the rock armour protecting the Holywell spring have been conducted using Google Earth images and in-situ photography.

The grey flint cobbles contrast with the orange-brown imported ballast and this contrast allows them to be easily tracked as they drift eastwards from Holywell rock armour.

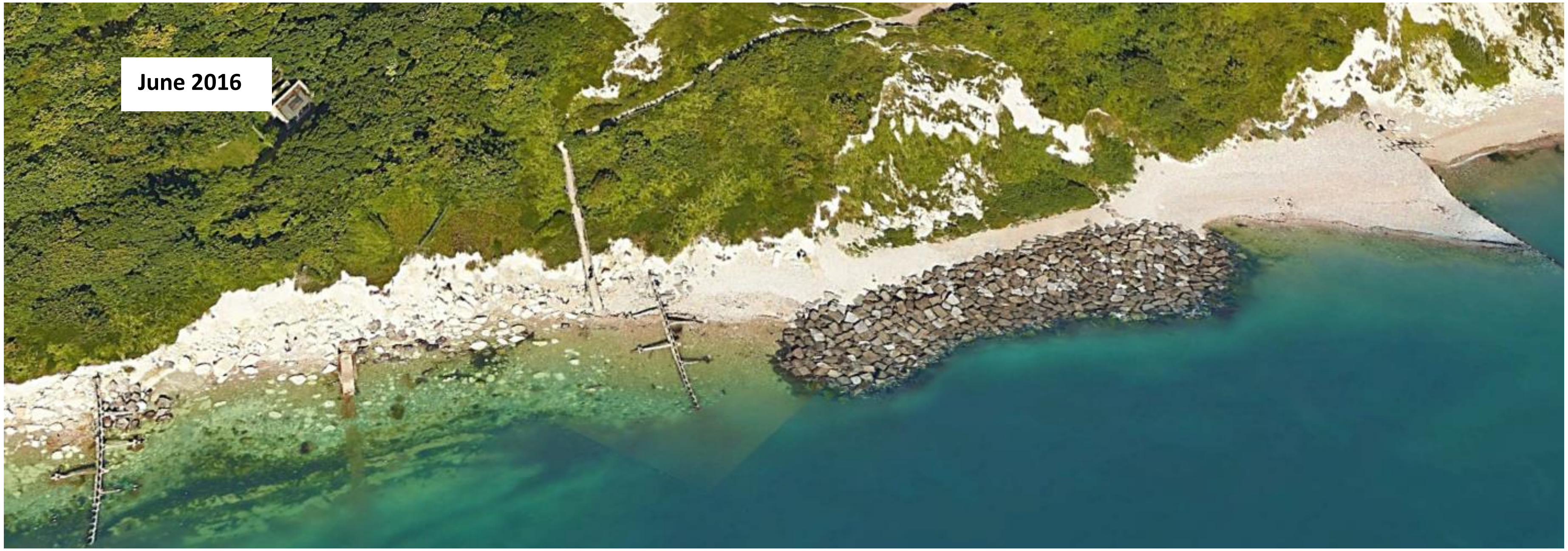


**Figure 6:** The beach to the west (left) of the Holywell rock armour is virtually devoid of grey cobbles in June 2016. There appears to be aa small deposit pushed up against the groyne to the east of the rocks.


**Figure 7:** In just under 4 years a significant deposit of grey cobbles has drifted from the west to stabilise these beaches. These originated from the chalk scree deposits left on the beach following cliffs falls in 1999 and 2001.

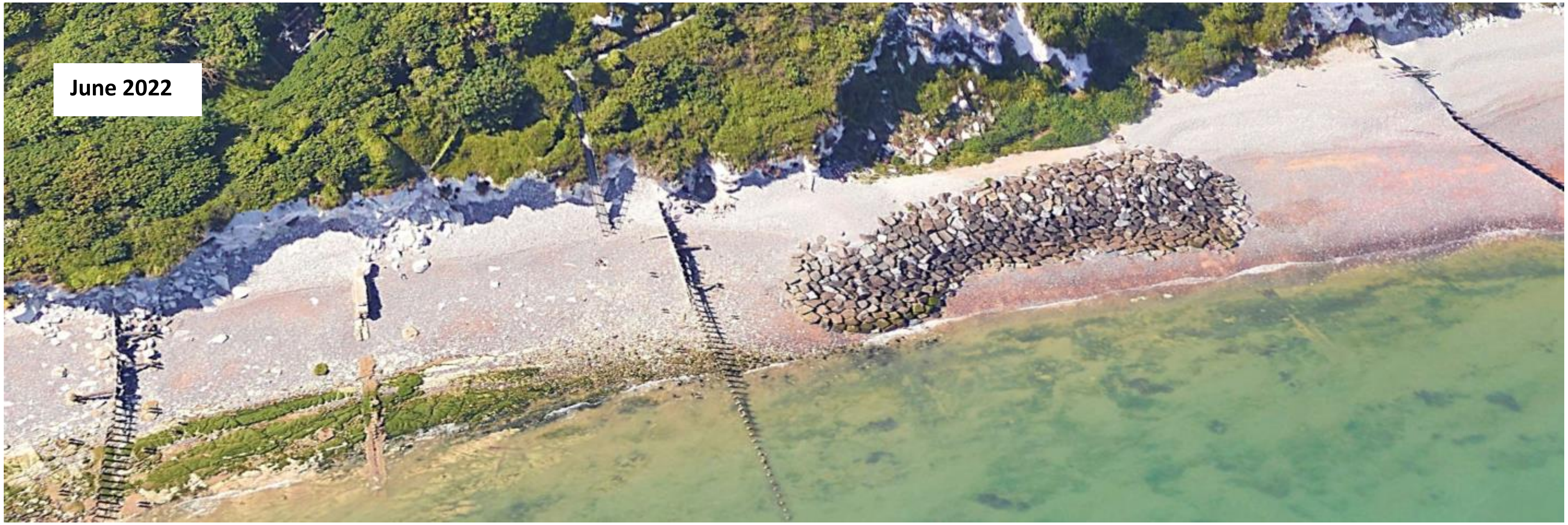


**Figure 7:** During the following two years the supply from the west has declined whilst the considerable load of the cobbles seen in 2020 have moved eastwards.

The following Google Earth images show how the deposit has drifted over a nine-year period to stabilise 12 beaches situated to the east of the rock armour.


**Figure 8:** The beaches along the entire subject coastline between beachy Head and Cooden were subject to storms waves in May 2015, generated by 60 mph winds.  The erosion pattern seen below the HW berms is evident along the entire 14km of subject coastline. There appears to be significant sediment loss due to draw-down and also longshore drift.


**Figure 9:** One year later the beaches appear to have been partially recharged with ballast. The beach plan-profile demonstrates the direction of longshore drift.

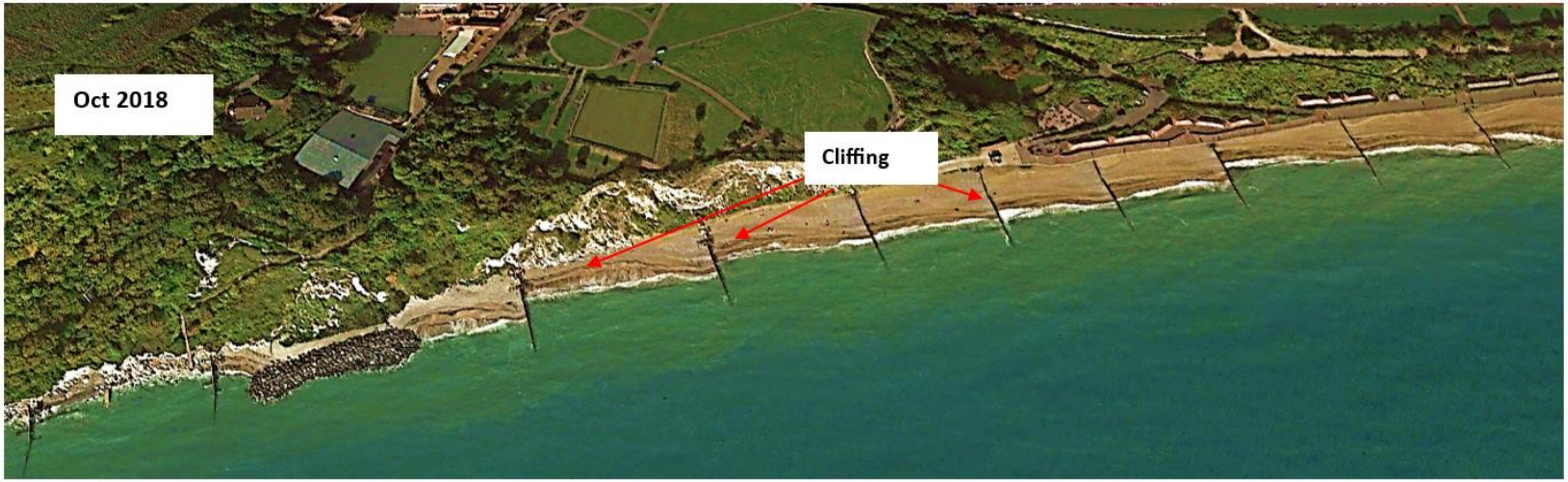


**Figure 10:** The beaches still appear to be predominantly filled with ballast although some cobbles have become assimilated within the mix.

Cliffing is apparent along the beaches, which strongly indicates that a significant sand content is present within the orange brown sediments. Some grey colouration increases from east to west as the cobbles are transported and assimilated within the beach load.


**Figure 11:** The drift deposit of grey cobbles that was eroded from cliff fall scree deposited after a cliff failure opposite Beachy Head Lighthouse in 1999 and another fall two years later at Devils Chimney. Wave action erodes the flint from the chalk and then pushes the clasts along the cliff base. The sporadic nature of these events means that the beaches deposits wax and wane in response to cliff falls. It appears to have taken over two decades for the waves and tide to erode the flint from the chalk scree and push it along the coast from Eastbourne Lighthouse to Holywell.


**Figure 12:** The grey cobbles and ballast have mixed within the high energy zone close to the HW berm and continue to drift eastwards and stabilise the beaches.


**Figure 13:** In under two years sufficient cobbles have drifted onto the beach and stabilised it. Only a relatively thin veneer 5m wide stretching across the entire beach is required to prevent erosion. Ther is actually a surfeit of cobbles on this beach with the excess above minimum load deposited below the HW berm. Cuspate features have been formed within the lower section.

## Evolution after Stabilisation


**Figure 14:** The beach above is becoming stable as further drifted cobbles are washed over the groyne on the western side of the beach cell. The *cliffing* apparent along this beach in October 2018 (see Figure 10) has been eliminated as the sand is washed out and larger grey angular clasts are introduced.


**Figure 15:** The beach adopts and undulating upper beach profile and the orange-brown ballast is displaced by grey cobbles indicating that the beach is becoming stable with the correct grade of sediment. The larger clasts eventually displace the ballast, further stabilising the beach.