SeaScapes 2030

Beach Sediment Dynamics

Case Study

Feb 22 to July 23

Eastbourne Pier

Case Study – Profiling of the Nearshore -V.1.1 03-08-

Case Study B-Sediment Dynamics within the Inter-Tidal Zone

Eastbourne and Pevensey Bay have a unique coastal margin compared to neighbouring Seaside towns of Hastings to the east and Brighton to the west. Brighton is built on rising ground along most of the promenade, therefore, much of the town is not at risk of flooding. Its coastline-prevailing waves alignment is 90 degrees, i.e., the waves break at right angles to the beach, and therefore, force the shingle up and down rather than to one side, as is the case for Eastbourne. The nearshore topography and geology are also different and may allow the beach deposits to be maintained for longer periods.

The coastal margin from Beachy Head to the Pier is is outcropping strata that dips below seabed level towards the east and is cover by marine and wetlands sediments, before outcropping again at Cooden. The sediment cover thickness is unknown, although marine sediments have been found at 5m depth inland at Northeye, suggesting it dips to at least this depth before rising towards Cooden. A shingle barrier beach extends from the Redoubt to Cooden enclosing the wetlands from the sea with its base resting on the top of the strata that extends below the sand from the Pier. The barrier beach has been stabalised with civil engineering and to the west of the Sovereign harbour wooden groynes slow down longshore drift.

The prevailing south-westerly waves are modified as they pass around Beachy Head and also over the shoaling grounds known as Willingdon Horse and Sovereign Shoals amongst others. Their direction is further altered whilst approaching the beach depending on the local topography within the tidal zone and nearshore bathymetry. Close to the beach the irregularities can bring waves onto particular beaches in a different direction, and therefore, cause different beach erosion patterns.

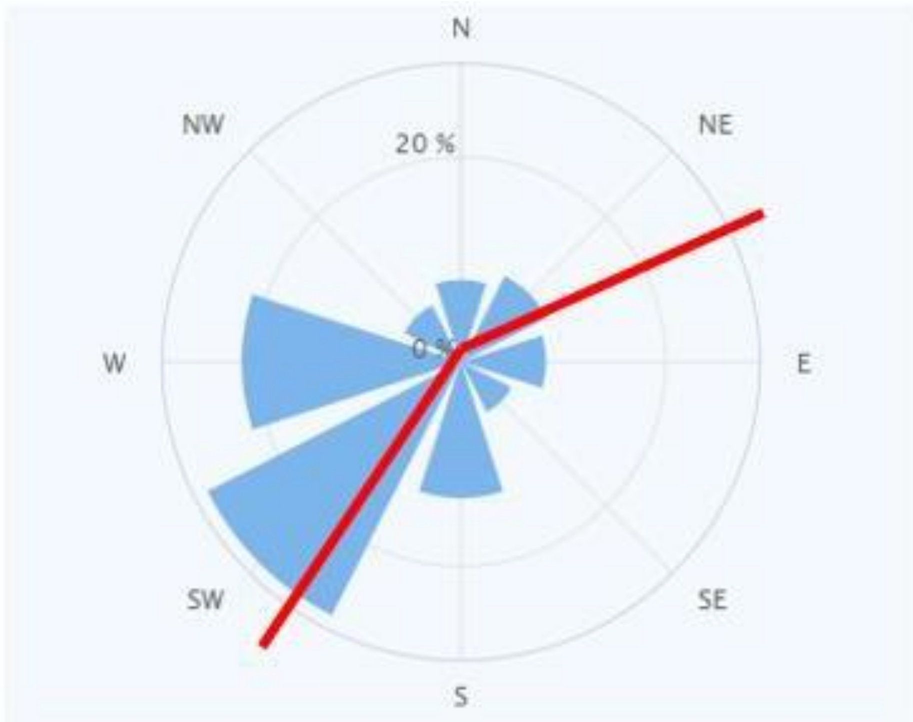

Figure 1: *The wind rose above shows the predominant direction for wind and waves is from a SW direction*.

The red line depicts the alignment of the coast and has two main sections that meet at Normans Bay. From Beachy Head to Normans Bay, about 11.5km, the coast mean alignment is 040^0. Between Normans Bay and Cooden Beach the beach alignment averages 065^0 for 3.35km. These two trends have been superimposed on the wind rose. The predominant south west wave would be diffracted around Beachy Head and further modified in local shoaling conditions approaching the beach. The two average trends have variations of beach alignment between 025^0 and 065^0 and appears have an impact on erosion rates looking the differences between sediment load along the coastline. Although the sediment size distribution appears to be having a much greater significance when assessing beach erosion rates.

Longshore Drift

The cross-shore beach satellite view demonstrates the longshore drift trend in a northeast direction along the Holywell promenade. The intervention of the wooden groynes and sea wall forces the shingle beach into the observed formations. The wave energy vectors, extracted from a wind rose data shows the predominant north east vector.

Figure 2: *Beach profiles show the shingle stacking up against the northeast side of the beaches along Holywell. The vector arrows are extracted from wind roses. Image Google Earth.*

The coastal alignment randomly varies from 025^0 to 065^0 between Beachy Head and Normans Bay. The predominant wave directions given on the wind rose, lie within this range, therefore, for much of the time, wave force vector is effectively pushing the shingle and sand along the coast against the solid geology sloping down from Beachy

Head and then into the formation of a cuspate foreland known as the Crumbles and now occupied by the sovereign harbour complex.

The other phenomenon affecting the shingle is draw down. Which where shingle rolls down the slope and is assimilated by the low-tide sands.


Figure 3

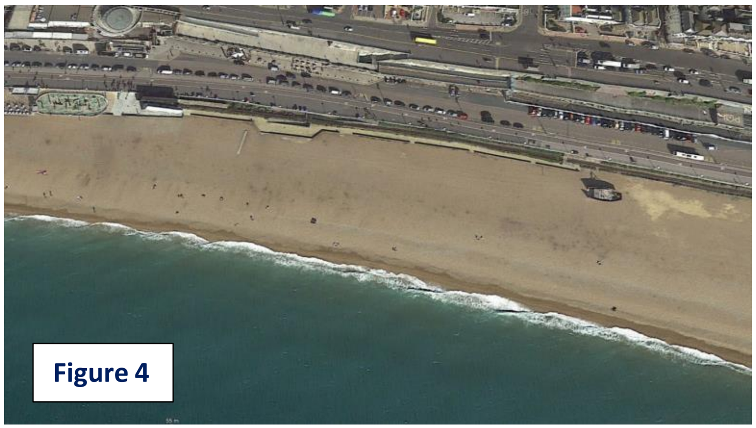
Figure 4


Figure 5

Brighton Beach

- The waves in the aerial photo are breaking perpendicularly to the shingle beach
- The longshore drift is not so vigorous and rock groynes appear to be maintaining the shingle. The beaches in Figures 4 and 5 are not showing signs if longshore drift.
- Another factor is a that only a relatively thin layer of shingle overlies sloping bedrock which cannot be subject to longshore drift and most of the cobble and shingle deposit is above high water. The light patches within the shingle in Figure 5 are exposures of the bedrock.
- *Image Google Earth and G. Caira*

Sediment Transport Along The seabed

Sand, Silt, Mud and even small gravel can be moved along the seabed by the tide and oscillatory wave motion (as water depth decreases to within 2 times the wavelength the oscillatory motion of the wave decreases exponentially with depth). The friction between the water and sediment grains is governed by the water velocity which has to reach a certain threshold before moving the grains. Faster flowing water will put the finer grains along with silt and mud into the water column to be transported further.

The dynamic for the fine sediments is different to that for the shingle, by virtue of being able to become suspended in the water column and transported in plumes by the tide. The fine sands and silts are put into suspension by breaking waves and transported by tidal currents, and then deposited where the water velocity slows enough for particles to fall out of suspension.

Bedforms also migrate, as grains of sand are forced to roll along the seabed by tidal currents and passing waves. Within the subject coast these mobile and often fleeting features vary in size from a few cm (as seen in the photo above) to tens of meters further offshore. See example in Figure 6, below.

Figure 6*: Sand between rocks at Holywell are formed into irregular sand waves several cm wavelength and 2-3 cm amplitude. The water is run-off from the shingle accumulated at high water. Photo G. Caira.*

Water current velocity and grain size are the main factors that control the distribution of sediment and the bedform types observed.

Tidal-Zone Sediment Dynamics

To illustrate fine sediment movement on a larger scale a survey of the low tide zone was conducted during the ebb tide on 18th February. Two wave trains were observed converging over the location of the exposed strata in Figure 7. Some hours after the tide had fallen to expose the intermittently exposed Gault and Sand. Also, there a shallow outcrop 270m offshore from the Pier head, or possibly the charted boulder bank, which could be responsible for deflecting adjacent wave trains into each other.

The outcrop in Figure 7 below is not always exposed at low water in the same location over the course of a year (see photos below collected over 15 months). The intermittent exposure of the Gault between the Wish Tower and north east of the Pier suggests that the wave energy is being concentrated along particular sections of the intertidal zone. As waves approach shoaling seabed, at an angle, they are diffracted. If the bathymetry is undulating then different sections along the wave train will be diffracted and re-profile the beach. See Figures 7 to 9 below.

These changes in nearshore seabed topography will impact on the distribution of wave energy vectors moving the sediments and therefore, result in variable erosion patterns and sediment sorting.

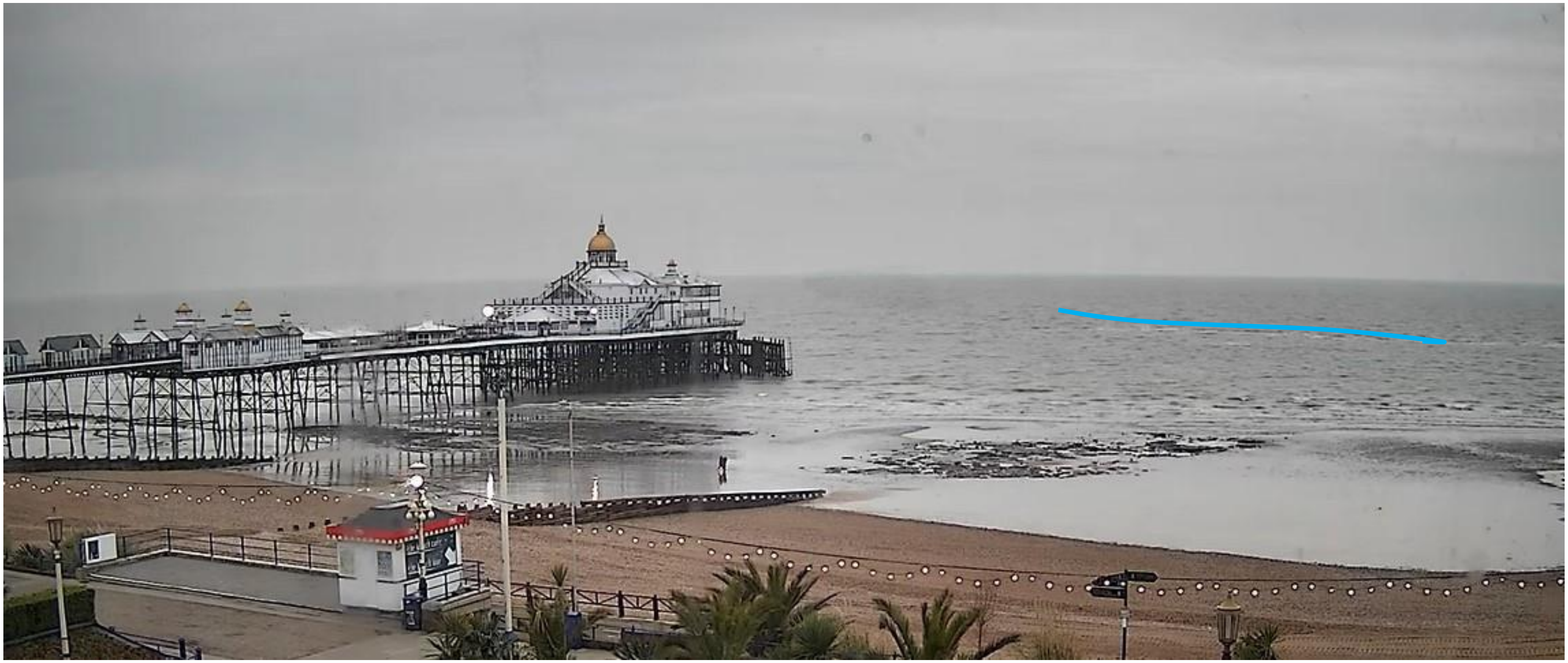

***Figure 7**: Beach southwest of the pier at low water. Feb 18th*

Intermittent Sand deposits and Gault outcrops effectively form a low amplitude, long wavelength sand wave moving laterally across the beach. Higher energy within the converging waves scours the sand exposing the Gault. The sediment is then deposited in the low energy environment either side of the outcrop. Image from beach camera at the end of Terminus Road.

The mechanism for this relies on sand being washed up into the water column by breaking waves and these suspend particles carried by the tide until they fall out of suspension.

Figure 8. *In the 13 months between the dates of the two photos the surficial cover of Sand has been eroded away exposing Gault. The groyne is also significantly more exposed compared to February 2022. Image from beach camera at the end of Terminus Road.*

Geomorphological processes of draw down and longshore drift are responsible for the losses. However, losses are accelerated by the shingle sand mix sprayed onto the beaches over the past 20 years and compacting of the sand shingle mix into hard sloping beach by the machines reprofiling the beaches.

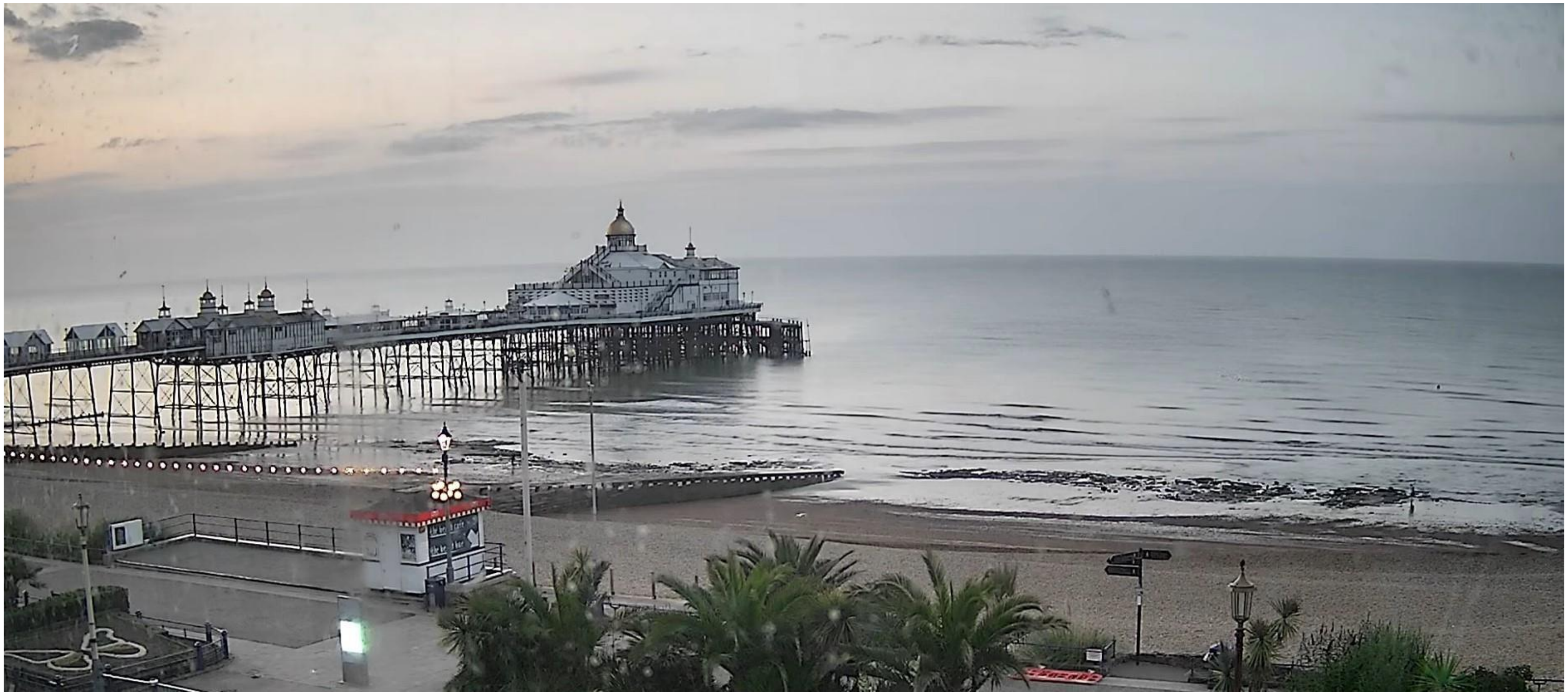

Figure 9: *Between 21st April 2023 and 2nd July 2023 a significant amount of sand and possibly small shingle has covered some of the Gault previously exposed on 21st April 2023. Image from beach camera at the end of Terminus Road.*

Figure 10: *Between 2nd and 23rd July 2023 a significant amount of sand and shingle has drifted down and across the beach. Compare the exposure of the wooden groyne in the center of the images with that in Figure 9, above. Image from beach camera at the end of Terminus Road.*

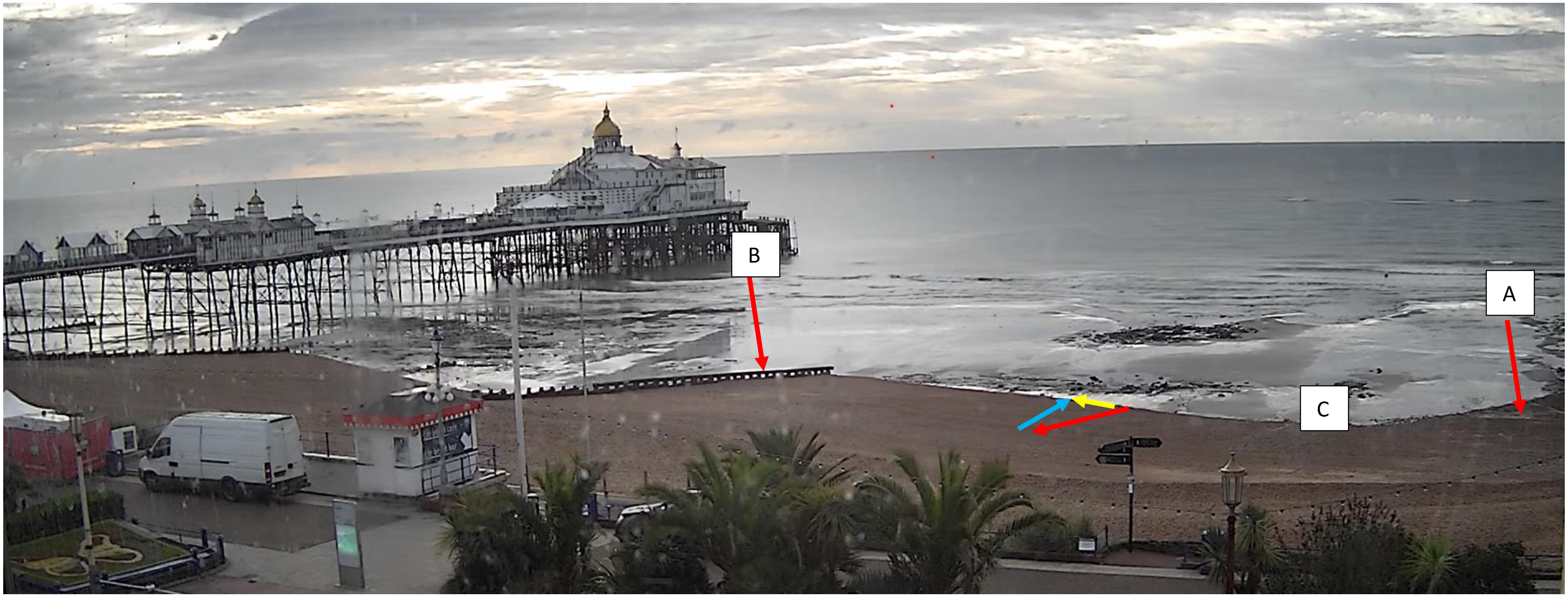

Figure 11: *Between 23rd July and 3rd August 2023 the areas of exposed rock have been covered by sand and other new exposures due to erosion. The sand and shingle along the beach at 'A' have been washed over or through the adjacent groyne. This barrier also weakens the wave energy, as it passes 'through' the groyne along this section and increases across the beach. (See section on breaking waves). The shingles is therefore pushed further up the beach, to point C. The shingle and sand are transported from west to east, A to B in a zig zag fashion; red arrow shingle movement due to wave vector, blue arrow is the drawn down shingle as the wave wash retreats back down the beach slope and the green the net transport per wave cycle, until the eastern groyne prevents further movement. The and accumulation until the level of the gaps in the structure allowing the shingle to fall onto the adjacent beach.*

Sand Transport by Tidal Currents

The trend of the coastline and seabed topography play a significant role in the transport of fine sediments. The tidal stream velocity will be influenced by the geomorphological features and small-scale gyres can form around headlands, as shown in Figures 10 to 12 below.

At times there are significant plumes of sands and silts within the nearshore section between the wish tower and sovereign harbour entrance, where two spiral plumes are set up as the tidal stream is interrupted by the entrance moles. The suspended sediments appear to be transported SW with the tide., but could be heading NE if the tide was flooding. This mechanism combined with the mass of the fine sediments keeping them in suspension means that there is an irregular distribution of these.

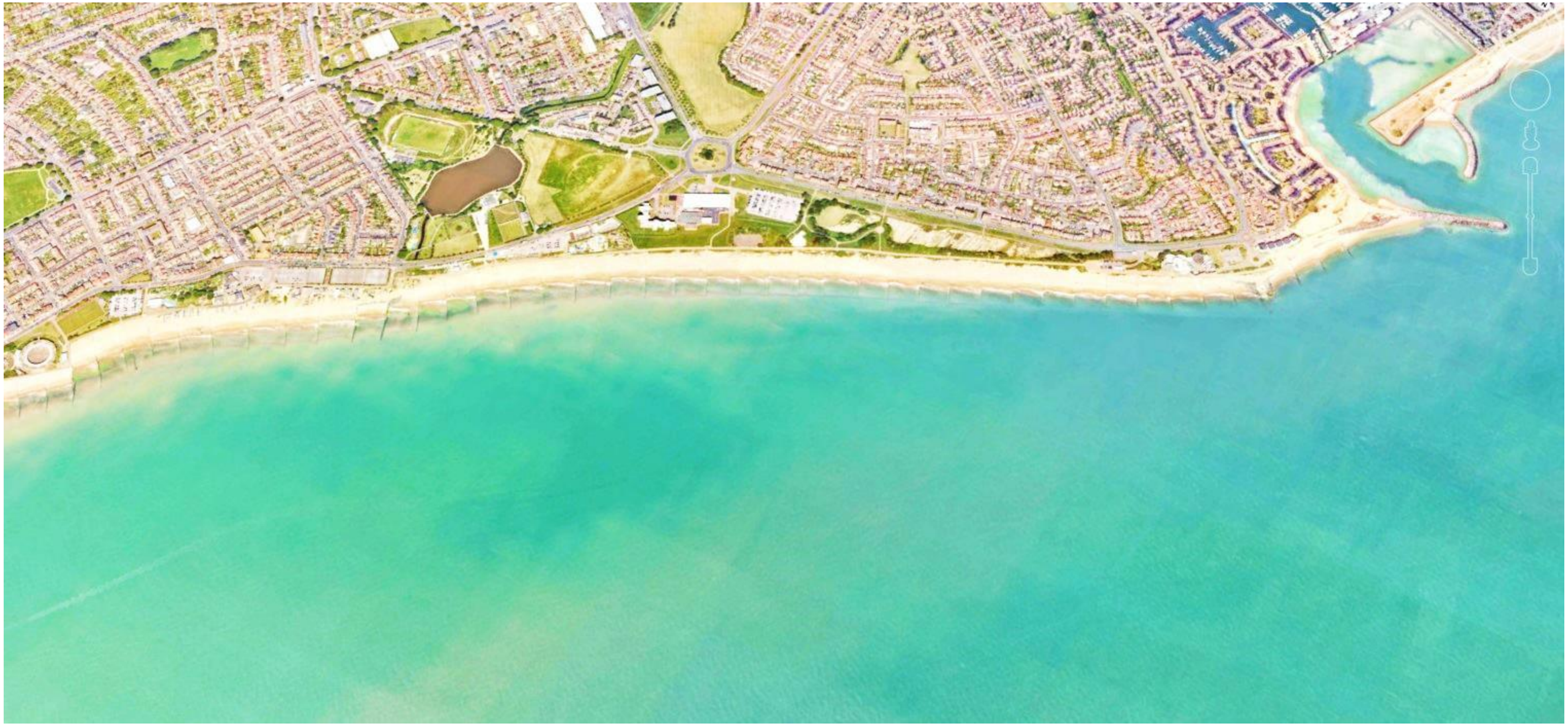

Figure 10: *A plume of fine sediments caught in the tide appears to be heading towards Langley Point. Image Google Earth.*

Figure 11: *The fine sediments appears to be within the water column, the light patches close to the coast between the harbour and Cooden. Image Google Earth.*

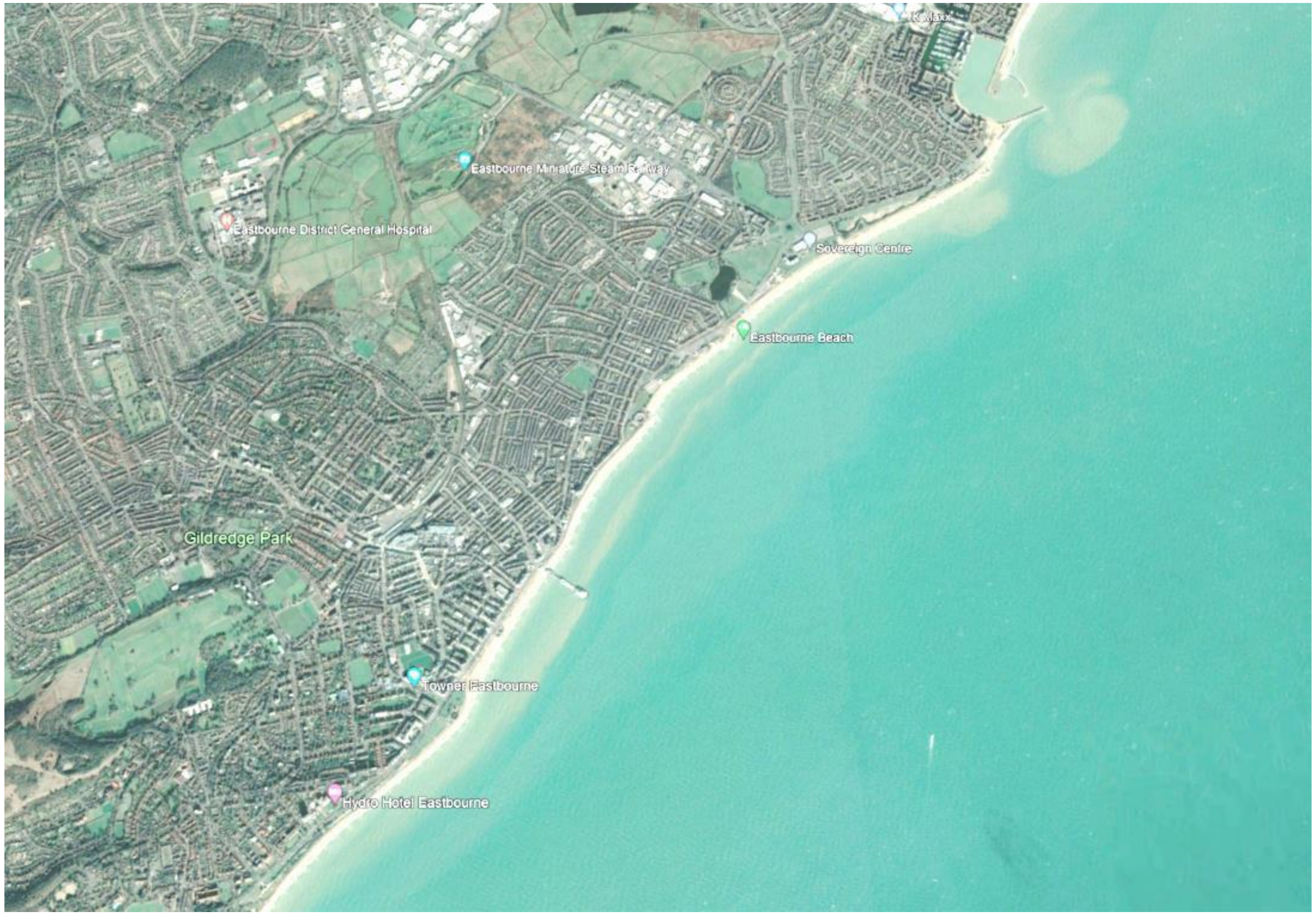

Figure 12: A line of suspended sediment runs almost parallel to the coast between Holywell and Langley Point. Two spiraling plumes can be seen at Langley point and the western mole*. Image Google Earth.*