Friends of the Earth
Suffolk Coastal

**Interested Party ID 20025904**

**EN010012 The Sizewell C Project**

# Comments on Nick Scarr's response to SoS's letter of 18th March 2022 concerning coastal processes and the implications for the proposed soft and hard coastal defences

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The following question was addressed to the Environment Agency, but Nick Scarr also responded to it, pointing out that the issues expressed in his previous papers regarding coastal processes are of direct relevance to the proposed coastal defences and their design and maintenance. Our members therefore wish to comment on Nick Scarr's response.

*5.1 The EA is asked to confirm if the Preliminary Design and Maintenance Requirements for the Sizewell C Soft Coastal Defence Feature ("SCDF") (Version 4) TR544 [REP10-124] provided by the Applicant at Deadline 10 satisfies its remaining concerns in relation to modelling and further analysis for the SCDF, and consequently the Hard Coastal Defence Feature, including any implications for resilience and the cumulative impact assessment. TR544 (version 4) did not satisfy our remaining concerns at the close of the examination.*

We are only too well aware of the dynamic, ever-changing nature of the Suffolk coastline and its inherent dangers. Erosion can be sudden and rapid, especially after storm surges. The consequences are plain to see, most recently at Thorpeness, where houses are at severe risk of being lost to the sea. Its closeness to Sizewell is alarming, especially considering the proposals for a third nuclear power station.

Local swimmers and sailors have noted how the offshore sandbanks change in position and elevation. They understand from experience that these banks are not immutable. We therefore have serious concerns that the Applicant should be depending on these banks for ongoing protection of the proposed nuclear plant for its entire life cycle including decommissioning. Our position therefore is very much along the lines of Nick Scarr as expressed in his various papers.

During the autumn of 2016 we spent three months researching the history of coastal processes and erosion along our shores and the formation of the offshore banks and were assisted in this by the Flood Hazard Centre of Middlesex University among others. As a result, we wrote a fully referenced paper and gave a public presentation during the time of EDF Energy's Stage 2 consultation. This paper we have since updated. We now submit it herewith as an attachment for your reference and information. At the time of our research we were unaware of Nick Scarr's work, yet our conclusions are strikingly similar. We are therefore writing in support of his response to the Secretary of State's question quoted above.

## Importance of historical events

Like Nick Scarr, we are deeply concerned that the Applicant pays so little attention to the history of erosion at Sizewell and fails to apply it to likely future scenarios. Rather, the supposition is made in nearly all of EDF's documents that the Sizewell and Dunwich banks will continue in their protective role for the whole lifecycle of the new station including long-term storage of spent fuel. Design and modelling of the soft and hard coastal defences therefore depend on this assumption.

History tells us otherwise. We refer you to sections 1 and 5 of our supporting document (attached). You will see from this that Sizewell used to be a thriving port of considerable size and importance, which, like Dunwich, became buried beneath the waves due to extensive erosion. During the 50 years following 1783 there was rapid erosion of Minsmere cliffs with a loss of about 100m of shoreline (see section 5), adding to the 200m already considered to have been lost in the Greater Sizewell Bay after 1736, as mentioned by Nick Scarr in REP2-393.

In his response Nick Scarr emphasises how the Applicant assumes the immutability of the Sizewell-Dunwich banks and that these will continue to offer protection to the power stations as long as is needed. Like him, we believe this to be a dangerous assumption. These banks only began to form relatively recently and there are several situations whereby they could disappear. Without the Sizewell-Dunwich banks, the nearby shore, defences and power stations would be at the mercy of the sea and resulting rapid erosion and flooding, just as occurred in the past.

Research suggests that their existence depends on the supply of sediment, which has changed over time (see section 6 of our paper). We have noted how the banks have lowered and altered position. As longshore drift is towards the south (see section 4), the Applicant has indicated that loss of sediment from the Dunwich-Minsmere cliffs, currently experienced, could be replaced by that from erosion of cliffs further north. However, according to Pye & Blott (2006) the offshore area between Southwold and Thorpeness is a 'closed system' (see our paper section 6), so this assumption seems to be unlikely. We have also noted how a 'saddle' has formed between the two banks, now allowing the larger waves to penetrate to the shore.

The more we have investigated our coastal processes, the more we realise how unpredictable they can be and how difficult it is to forecast how they will behave in future. Indeed, this cannot be done with any certainty.

## The proposed date of 2140 for final decommissioning

Here again, we agree with Nick Scarr that this date is unreasonable. We only have to look at the projections for Hinkley Point C nuclear power station, currently being built to the same design as that for Sizewell C. It seems that the Applicant has not allowed for the longer cooling period required for the high-burn-up fuel used in EPR reactors. After an enquiry by our colleagues in the group TASC (Together Against Sizewell C), the Nuclear Decommissioning Authority (NDA) estimates a date for removal of all spent fuel from the site as 2150-2155. Yet the construction of Hinkley Point C is already well advanced, with a projected on-stream date of 2025, whereas we still await a decision on the Sizewell plant. At least a further ten years would need to be added to the NDA date, taking it to 2165. Our own calculations are in excess of that with a final date of 2200 (see sections 10 and 11). This concurs with the figure suggested by the Nuclear Decommissioning Authority of between 2180 to 2230, as pointed out by Nick Scarr in his response under 2.2.

Bearing in mind climate change and sea level rise, with worsening storm surges, we fail to see how the safety of Sizewell C can be guaranteed for such a long period with the defences as proposed. Experts have already predicted that it will be surrounded by flood water within its operational lifetime (section 10). Yet, despite the Royal Haskoning report of 2010 stating that defences along the entire western edge of the platform would have to be built, there are no plans for rear defences. Why not? Nick Scarr too raises this point. Is it because it would mean taking yet more of Sizewell Marshes SSSI, in addition to the 9 hectares (or possibly as much as 12 ha) already destined to go under concrete? Does the Applicant believe that the new access road with bridge could be part of the defensive system? Yet by closing off the area beneath the bridge during storm conditions the main drainage route from Leiston town would also be closed off. (See section 9.) To put this in a large pipe or culvert would be unacceptable from a wildlife perspective and has already been discounted by the Environment Agency, ourselves and others (see our SoCG REP10-120).

## Conclusion

As the future of coastal processes in the North Sea along Suffolk's coastline remains so uncertain, it is clear that the safety of Sizewell C and storage of high-level nuclear waste cannot be guaranteed in the long term. We agree with Nick Scarr that the defences as proposed are inadequate and that the Applicant has failed to take proper account of future 'islanding' of the nuclear platform.  As local people we need to consider not just ourselves, but our descendants.  Our members therefore request that the Precautionary Principle is put in place and that the decision is made not to build another potentially dangerous and highly vulnerable nuclear power station on our insecure coastline.

## REFERENCES

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Suffolk Coastal Friends of the Earth (2016/2022).  'Coastal erosion and flooding around Sizewell nuclear power stations.'

Suffolk Coastal Friends of the Earth

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EN010012: The Sizewell C Project

# Comments on Nick Scarr's response to SoS's letter of 18th March 2022 concerning proposed defences and coastal processes:

## supporting document

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# Coastal erosion and flooding around Sizewell nuclear power stations

Suffolk Coastal Friends of the Earth

## Contents

## Abstract

**This paper surveys the history and geology of the Suffolk coastline, showing it to be dynamic and ever changing. Its main features are the soft sandy cliffs and beaches which are subject to marked erosion. With global warming the sea is predicted to rise, storm surges will increase in regularity and flooding and erosion will worsen. The paper considers whether Sizewell will in future remain a suitable site for nuclear power. Although fairly stable in recent decades, history of the site shows that it has sometimes been accreting, sometimes eroding, depending on the movement of the predominant longshore drift.**

**In particular, the paper considers the effects of construction of the proposed new power station, Sizewell C, on shoreline dynamics, along with the anticipated results of the hard defences. The review confirms that such works would increase erosion elsewhere.**

**Studies of the Minsmere Sluice, originally installed by 1830, show that its incidental effect is to act as some kind of holding feature in terms of sediment flow. Yet shoreline management policy of 'no active intervention' leaves its future uncertain. While the two offshore banks, known as the Sizewell and Dunwich Banks, seem to have been offering some protection to the Sizewell site, at least during storms, the literature indicates that this may not continue.**

**Bearing in mind the many uncertainties regarding the effects of climate change and the dynamic nature of the Suffolk coastline, the expert literature indicates that Sizewell is not sustainable in the future as a safe and suitable site for nuclear power stations and long term storage of radioactive waste.**

## 1. The Suffolk coast: its evolution

Local people are only too well aware of what can happen when new structures are introduced into this dynamic and ever-changing coastline, even within a human lifetime. It is crucially important, therefore, to put the proposals for Sizewell C into historical context. It is a concern that EDF Energy's documents are so sketchy in this respect.

The coastline of East Anglia, with its soft cliffs and sand and shingle beaches, is well known for its rapidly eroding coastline. Indeed, Brooks & Spencer (2011) describe the eroding cliff rates as some of the highest recorded globally.

The village of Dunwich, just 6.5 km/4 miles to the north of Sizewell, once an important town and port and now largely submerged, has a well-recorded history reaching back to the 13th century when Henry III gave £200 for flood defences (Robinson, 1980). (*Appendix no. 1.)* This allows researchers to study processes and effects over time and for comparisons to be made with more recent changes, in anticipation of being able to make future predictions, albeit cautiously. A certain number of geomorphologists have therefore been attracted to the area to study the processes which cause these changes to occur and several focus on the stretch between Lowestoft and Felixstowe. Sizewell lies approximately midway between these two ports.

Holt-Wilson (2014) gives a useful survey of the origins of Suffolk's landscape, which he describes as being 'at the frontier of change'.  Just 11,000 years ago Suffolk was an 'upland on the edge of a vast plain', which was known as Doggerland.  Globally, sea levels were approximately 100 m/300 ft below the present, the water being locked up in massive ice sheets.  As the climate warmed around 10,000 BP, due to variations in the Earth's orbit around the sun, ice melted and sea levels began to rise.  By 8,500 BP Britain had become detached from the continent.

By 7,000 BP Suffolk's coastline lay approximately 7 km/4½ miles to the east of its current position.  After a further 2,000 years it began to resemble its present character, with mudflats and tidal channels and creeks slowly spreading inland up the lower river valleys, and shingle banks and spits were being formed by tidal and longshore processes.

EDF's documents give the impression that the coastline became fairly stable at around 6,000 BP (Vol 2, App 20A).  They fail to mention, however, that our coastal environments have continued to fluctuate, most significantly around 1,600 BP when rising seas in north-west Europe forced coastal Anglian and Saxon tribal groups to migrate westwards.

We are now entering the Anthropocene Epoch, with human-induced climate change under way, causing yet more alterations to Suffolk's coastline.  The rate of sea level rise, rather than being constant, is predicted to accelerate over time (Brooks & Spencer, 2011).  In March 2020 the Environment Agency, as a guidance to developers, proposed that the following increases should be allowed for: 7mm p.a. from 2000 to 2035, a further 11.3mm p.a. from 2036 to 2065, 15.8mm p.a. from 2066 to 2095 and 18.1mm p.a. from 2096 to 2125.  The cumulative rise is therefore assessed at 1.6m between 2000 and 2125 (or 1.2m at the lower end).  However, in her introduction to 'Climate change impacts and adaptation' of 2018, Emma Howard Boyd, Chair of the Environment Agency, warned that 'our resilience will only be robust if we prepare for worse climate change scenarios [than a $2^0$C rise]'.

We also need to remember that approximately 0.61 mm p.a. of the rise can be attributed to the ongoing geological subsidence of eastern Britain, which has continued since the early/mid Pleistocene era (Cameron et al, 1992).

Forecasts of the overall amount of the rise by 2099 vary considerably from a conservative 50 cm to 240 cm at the higher end (Nicholls et al, 2011).  Bearing in mind that there has already been a gradual sea level rise over the past century, estimated at an average of 2 mm p.a. (Shennan & Horton, 2002; French & Burningham, 2003; Pye & Blott, 2006), and adding to this further human-induced warming through the burning of fossil fuels, and acceleration of the melting ice, the worst predictions can seem less extreme.  If, as is looking increasingly likely, the western Antarctic ice sheet collapses, then sea level rise will increase by at least 3 m/10 ft from this cause alone (Gramling, 2015.)  In addition, if the Greenland ice sheet were to melt completely, then the rise would be up to 7m/23 ft (Shukman, 2019).

A recent paper by the 'father' of climate science, James Hansen (2016), warns of the dangers of even a $2^0$C rise in global warming. When the earth's ice sheets melt, they place a freshwater lens over neighbouring oceans, which argues Hansen, causes them to retain extra heat. This in turn melts the underside of the large ice sheets fringing the oceans, resulting in even more fresh water being added to the lens, in a 'positive feedback' system. Moreover, all this added water could eventually shut down two key ocean currents off Greenland and Antarctica. Should this occur, much greater temperature differences between the tropics and north Atlantic will result, driving 'super storms' stronger than anything seen in modern times. He claims that sea levels could rise several metres beyond the official IPCC estimates and the rise would be much faster.

Whatever the future scenario, according to Brooks (2010) coastal retreat is likely to accelerate, particularly in places of characterised by high historic rates of change such as the Suffolk coast. The Sizewell C documents, however, fail to take such predictions seriously, focusing on what the Applicant perceives to be the stability of the Greater Sizewell Bay.

## 2. Geology of the Sizewell area

As far as the geology is concerned, the most directly relevant of the papers under review is the description provided by Pye & Blott (2006), which focuses particularly on the Dunwich to Sizewell area. The authors position this on the western margin of the Southern North Sea Basin, an area experiencing slow subsidence, as already mentioned, as a result of tectonic movements as well as the collapse of 'a proglacial forebulge'. Along with other authors, they cite the underlying geology as of mainly Pliocene and Pleistocene age sediments and weakly cemented sedimentary rocks, notably the Coralline Crag (Pliocene) and the iron-rich Red Crag and the Norwich Crag (Pleistocene). The term 'Norwich Crag' gives a false impression of something consistently solid, whereas this is a collective name for the Chillesford Sand (fine to medium grained), the Eastern Bavents and Chillesford Clays, along with the coarser gravel-dominated Westleton Beds (Pye & Blott, 2006; Brooks, 2010).

The northern part of the Dunwich cliffs, itself part of the 'Norwich Crag', consists mainly of soft sands interspersed with sandy gravel, and is therefore extremely vulnerable to erosion. Further south, at Thorpeness, the older Coralline Crag is locally cemented and more durable. This seems to account for the fact that the 'ness' here is more stable than those further north, although measurements taken by Robinson (1980) indicate that even here there has been a slight northward progression. Moreover, attributing this apparent stability to underlying Coralline Crag is an assumption based on the lumps of this material being found on the beach, rather than from any visible outcrops within the cliffs or along the shingle ridges (Holt-Wilson, 2014). However, borehole studies further south between Aldeburgh and Orford indicate its presence (Brooks, 2010), while recent Ordnance Survey sonar images show some rocky outcrops off Thorpeness at a depth of about 7.5-5m.

Onshore there are ‘drift’ deposits lying above the Norwich Crag consisting largely of ‘boulder clay’ and fluvial deposits belonging to the Lowestoft Till Formation. Within the modern valleys are deposits of Holocene alluvium and peat. This extends along the beach from Thorpeness, past Sizewell power stations and up to the Minsmere Cliffs. It also reaches into Sizewell Belts (proposed site for Sizewell C new nuclear power station) and along the valley almost to Leiston and underlies the whole of Minsmere reserve and river valley (British Geological Survey, 1996).

The Norwich Crag combination is also evident northwards of the Dunwich Cliffs in the cliffs of Easton Woods and at the southern end of the Covehithe Cliffs. The coarse sand and gravel deposits of the Westleton Beds along with rounded flints are particularly evident here in the cliffs of Covehithe, overlying Baventian clays. Above, appear the gravelly Kesgrave Formation and overlying Corton Sands, and here and there a capping of Lowestoft Till Formation. Covehithe suffers the highest rate of erosion in the UK, with 5.6m lost per annum between 1992 and 2006 (Hill, C., 2008). Northwards again in the cliffs of Benacre is the lower Baventian Clay topped by Westleton Beds, in turn overlain by Corton Sands (Brooks, 2010).

## 3. Tides, winds and surges

Along the Suffolk coast tides are semidiurnal (i.e. two high and two low tides per lunar day). Tidal levels within the North Sea Basin are generated by the tidal wave moving in from the Atlantic, which is then modified by the shape of the basin as it narrows towards the English Channel (Guthrie, 2009). Surges affect the height and duration of predicted tidal levels along the Suffolk coast. Because the astronomical tidal range is fairly small, surges have a proportionately large impact (Pye & Blott, 2006). Dr Xiaoyan Wei from the National Oceanography Centre agrees (2020), saying that our coast is ‘particularly vulnerable’ due to its low tidal range together with a long stretch of shallow sea over which the wind can ‘whip up’ the level. For example the storm of 31 January 1953 resulted in the highest high tide level at nearby Aldeburgh of 3.78m AOD, normally 1m less than this.

The flood tidal stream runs southwards, almost parallel to the coast (Admiralty, 2004). The ebb tidal stream runs almost northwards.

There is debate in the literature concerning the relative importance of residual currents. Robinson (1966) considered that they had a significant effect on the evolution of the shoreline, but modelling studies by Halcrow Maritime (2000) seemed to show that their impact was fairly small with a southerly direction. As far as sediment transport is concerned, Wallingford (2002) supports Robinson’s view, saying that, in coastal waters, this ‘depends primarily on the strength of the currents and the oscillatory velocities at the seabed produced by waves’. This leaves one wondering how accurate the modelling studies are.

Regarding the winds of the immediate Sizewell area, the nearest station is further north at Hemsby. Here, records between 1981 and 2000 show that prevailing winds are from the south west. Pye & Blott (2006) consider it unlikely that these cause transport of sand from the beach. They suggest that it is when winds blow from an easterly direction that this occurs.

The Meteorological Office calculated wind and wave speeds from a point 48 km east of Dunwich during 1986 – 1999. This showed that most waves approach from the north and north-east or south and south-west. Energy is classified as moderate with most waves (76%) being less than 2 m high. This may be an under-estimate, as the WaveNet site of the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) situated at West Gabbard recorded 'significant wave height' as 2.37 m on 9 March 2016, while at Sizewell it was just 1.98 m. The highest waves approach from the north and north-east, the direction of the longest fetch. Predicted heights of 1 in 100 years are 7.3 – 7.8 m respectively. However, Pye & Blott (2006) point out that inshore wave heights are controlled by the morphology of the coastline and offshore bathymetry. It has been well observed that whenever high waves combine with even moderately high tides, significant erosion occurs along beaches, dunes and cliffs (Pye & Blott, 2006).

Surges are relatively frequent along the Suffolk coast and can occur in any one of three ways: 1) a persistent northerly wind blowing over the North Sea which tends to pile up water levels in the southern area; 2) when a strong southerly wind is abruptly replaced by a strong northerly wind, releasing a wave or series of waves into the southern North Sea; 3) storm surges entering the North Sea from around the north of Scotland. These effects can occur in combination, depending on meteorological conditions. (Guthrie, 2009). This report emphasises that it is unwise to use general data when assessing joint probability of wave and water level, as no two surge events are alike. This indicates that it is not possible to make accurate predictions concerning storm surges.

Significant damage to flood defences, agricultural land, property and wildlife reserves and infrastructure have beeen caused by major surges, which have been well documented since the one in 1817, followed by those of 1883, 1897, 1912, 1928, 1938, 1949, 1953, 1976, 1978, 2007 and 2013. Fortunately the 2017 surge proved to be less damaging than expected. With global warming they are predicted to become more frequent and more severe (Lowe, 2006). Prior to the 19th century there are numerous historical references to major storm surges, although details of their effects on the coast are sketchy (Lamb, 1991). In recent times the 1953 storm is the largest surge recorded and was a major tragedy involving 307 deaths in England. It was almost matched in its ferocity by that of December 2013, but, while causing extensive damage to infrastructure, property, wildlife sites and stock, there were no human deaths, due to better advance warnings improved defences, and no following wind.

## 4. Longshore drift

The evolution of the Suffolk shoreline is characterised by longshore drift, whereby sediments, consisting of clay, silt, sand and shingle, are transported southwards along the coast. This is dependent upon prevailing wind and wave direction and the availability of transportable sediment. As already observed, the large waves generally approach from the north or north-east. These have generally picked up sediment from further up the coast. They swash into the shore at an angle. However, as they withdraw, they are pulled back by gravity at 90 degrees to the shore taking sediment with them. This results in a zig-zag movement southwards, resulting in either accretion or erosion of the shore as sand and shingle are either deposited or removed.

This is a very finely balanced system which is easily upset by any kind of intervention. As anyone who knows the Suffolk coast will have observed, wherever there is a groyne there is accretion on the northerly side and erosion to the south. This is the result of the predominantly southern movement of sediment.

## 5. Coastal erosion in the Sizewell area

The village of Sizewell currently consists of only a few cottages, yet in the past it has been a thriving fishing port, now largely under the sea, like Dunwich to the north. Indeed it was so important in 1497, that Henry VII called upon it, along with the other nearby coastal towns, to supply ships for his war against the Scots (Bacon & Bacon, 1979). It lies on a gently curving bay between the slight headland of Southwold and the ‘ness’ of Thorpeness. The bay is affected by the Minsmere Sluice, just to the north of Sizewell, which acts as a small promontory, creating in effect two minor bays either side within the larger one. The existing nuclear power stations, Sizewell A (being decommissioned) and Sizewell B, are directly adjacent to the north of the village. The site for the proposed Sizewell C lies to the north of A and B, as described in EDF Energy’s consultation documents (2019).

All nuclear power stations have to be adjacent to a very large and reliable supply of water, due to the need for constant cooling of the highly radioactive fuel rods. While in commercial operation, Sizewell A used up to 34 cubic metres of seawater per second. As for Sizewell B, this is permitted to extract and return up to 5 million cubic metres per day. In addition, this power station uses about 800 cubic metres of mains water per day where greater purity is needed. With its twin reactors and hotter fuel, Sizewell C’s usage is likely to be at least double these figures. Critics say that, with global warming and increasing likelihood of droughts in an area where restrictions are already often in place, there will be insufficient water to go round. (*Beccles & Bungay Journal*, 2010).

The coastal site at Sizewell for the present power stations was chosen because it was believed to be relatively stable, despite the history of erosion. In fact, in recent decades, the shore at Sizewell has been dynamic, sometimes accreting, sometimes eroding. Accretion depends on the availability of sediment, its consistency and its direction of transport.

Pye & Blott (2006) provide a useful historical record of the area. From this it can be seen that human involvement has contributed significantly to changes in the landscape, combining with natural processes. Prior to the early Middle Ages there was an estuary to the Minsmere River, which was a relatively large open water feature. Leiston Abbey was founded on its shore in 1182, after which the monks began to reclaim surrounding marshland with the construction of clay embankments. After the severe storm and flooding in 1347 and 1363 the Abbey was relocated further inland, leaving only the chapel on elevated ground near the estuary mouth (now a ruin). The small village of Minsmere was entirely lost to the sea by the 16th century (Bacon & Bacon, 1984).

Kirby's map of 1737 shows that the Minsmere River followed a similar course to the present New Cut drainage ditch, although more meandering. Around this time laterally continuous shingle barriers began to form along the coast. To the north the haven at Benacre became closed, forming the Broad. In the following decades the estuaries at Easton, Minsmere and Thorpeness also became blocked. At Minsmere the estuary became completely damned by 1780 (Axell & Hosking, 1977). After extensive fresh water flooding, an Act of Parliament of 1810 declared that the Minsmere Levels (site of the former estuary) should be drained and subsequently a sluice was created in approximately the same position as the old estuary mouth. A defensive earth bank was built parallel to the coast north of the sluice and another at right-angles running from Coney Hill.

Pye & Blott (2006) record that by comparing two maps, that of 1783 (Hoskinson) and 1837 (First Edition Ordnance Survey), significant changes can be seen in the shoreline between Dunwich and Sizewell. In the 50 years following 1783, the Minsmere cliffs apparently eroded very rapidly, the coastline moving about 100m landwards. The Minsmere to Sizewell shore also retreated, albeit at a slower rate than the cliffs.

After 1837 Pye & Blott (2006) identify two phases of coastal evolution between Minsmere and Sizewell. Up to 1903 the Minsmere Cliffs again retreated very rapidly by about 156m, averaging 2.3m p.a. The Minsmere frontage immediately north of the sluice also retreated landwards, but at a slower rate of about 1.1m p.a. In contrast the frontage south of the sluice began to experience accretion, moving about 83m seawards. In effect, therefore, the sluice was acting as a fulcrum for an anti-clockwise movement of the coastline.

Between 1903 and 1976 the rate of coastal change in the area declined. South of the sluice a dune ridge had formed by 1903. To the north of it a vegetated shingle ridge and low foredune ridge contributed to accretion of about 20m, but the Minsmere and Dunwich Cliffs continued to erode. In the 50 years between 1903 and 1953 this averaged 1.3m p.a., and in the following 50 years to 2003 this lessened to 0.6m p.a. Brooks & Spencer (2011) add that further falls have continued, erosion reducing to only 0.25m p.a. in 2008. This may in part be due to the marram grass planted after the 1953 floods along much of the low-lying area. In the last decade erosion from these cliffs has almost ceased (RSPB, 2019).

After the storm surge of 1938 there was significant erosion and flooding particularly north of the sluice. South of it this was more localised due to higher dunes. After 1976 the dune ridge along the northern end of the Minsmere Reserve retreated approximately 5m inland. South of the sluice, there was some further accretion up to the early 1990s, since when part of the dune frontage has started to erode, along with the first defensive bank fronting the power stations.

This has particular significance for the location of Sizewell C power station, which would be positioned at this point. Pye & Blott (2006) suggest that this new erosion could be related to changes in the nearshore and offshore morphology, in particular to the development of a gap between the crests of the offshore Sizewell and Dunwich Banks, allowing large waves to penetrate to the shore during storms. (*Appendix no. 2*.)

## 6. The Sizewell and Dunwich Banks

EDF Energy claims in its public consultation documents for the proposed new nuclear power station of Sizewell C, that these two offshore banks offer protection to the site and to the existing two power stations, and lessen the impact of storm surges (2019). This is however debatable. Brooks & Spencer (2011) emphasise that sandbank systems are 'dynamic' and that they change in volume and position according to the supply of sediment. They state that the precise interactions 'remain to be fully determined'.

A series of field studies between 1975 and 1983 were carried out on the two banks by the Institute of Oceanographic Sciences and supported by the Environment Agency. The final report, 'A study of nearshore sediment transport processes', was written by B. J. Lees in 1983. Lees describes that offshore from Sizewell the seabed slopes gradually to a mean depth of 15m below Chart Datum at about 4 km away. At the time of writing the sandbanks lay on this slope at about 2 km distant from the shore, in a linear formation more or less parallel to the coast, the Sizewell Bank occupying the southern half. Together they are described as approximately 11 km long and 1 km wide, stretching from Dunwich to Thorpeness, with mean slopes at that time of 1 in 60 to the west and 1 in 200 to the east. A central col lies between the two banks. The channel inshore reached a mean depth of just over 9m below Chart Datum (Lees, 1983), although there has since been some infilling. The banks are composed primarily of very fine to medium-grained sand (Robinson, 1980).

The hydrographic charts of the 19th century show initially two small banks opposite Sizewell and Dunwich respectively. Between 1918 and 1922 there was significant accretion to the southern part, with the bank rising to 2m below Chart Datum. There was also accretion to the foreshore south of Sizewell, at Thorpeness.

Over time the Sizewell Bank grew northwards, while the bank at Dunwich declined until it became incorporated into the northern end of the Sizewell Bank at around 1921/2. Robinson (1980) adds that the banks again separated in 1965, although Pye & Blott (2006) say the division is already evident on the chart of 1960. (*Appendix no. 3*.) During the period up to 1965 the northerly progression was significant at approximately 49m p.a.. Lees (1983) highlights an apparent contradiction between the northern growth of the banks and the fact that sediment transport is predominantly to the south. The explanation offered is that the suspended mode of transport is dominant over that of the bedload (which is in the opposite direction) 'by two orders of magnitude'. Pye & Blott (2006) point out that once the particles are in suspension they are moved mainly by tidal currents, although there may be a net movement of sediment in shallow water due to wave action. At the same time these authors stress that the interactions between wave and tidal currents are still 'poorly understood' and that any prediction based on such theories 'can be grossly in error'.

The simplest explanation of the northern progression is that erosion of onshore cliffs to the north provides sediment which has been building up on the northern part of the banks, but this remains unproven. Pye & Blott consider that the sediment might also be swept there from offshore (2006). Equally, other studies seem to indicate that there is a transfer of sediment from the beach especially during stormy weather (McCave, 1978), which may then be replaced in calmer times (Blackley, 1979).

Surveys carried out by Robinson (1980) seemed to demonstrate a considerable overall loss in volume to the banks after 1930 up to 1965 of about 23%. This implied a net sediment loss to the Sizewell bay. However this contradicts Pye & Blott's calculations from hydrographic charts which indicate that between 1940 and 1960 the banks actually increased in volume by about 18%. According to these charts, sediment was lost later, after 1960. Clearly, it is difficult to form accurate conclusions from the study of charts alone. However, it is important to note that erosion of the banks has continued consistently since 1960, while at the same time they have spread out along the eastern contour. It should be borne in mind that the '60s were the period during which Sizewell A was being constructed and became operational.

The movement of the two banks has been considerable. In addition to the northern growth, they are shifting westwards towards the shore, recorded and calculated at a maximum rate of 10.7m p.a. between 1867 and 1965 (Lees, 1983). Pye & Blott reckon that the Dunwich Bank migrated landwards about 800m between 1940 and 1960, after which there was a pause. During the 1980s both banks migrated a further 200m inshore. Then there was additional landward migration of up to 200m between 1992 and 2003. If this continues, then dredging would have to be carried out to keep the way clear to the beach landing facility proposed for Sizewell C. Not only would this reduce any protective effects the banks might be having, but the dredging itself would be extremely disturbing to coastal processes. (Otay et al, 2009.)

Crest heights have changed over time. By 1940 the banks averaged 4 – 5m below Chart Datum, so there was a lowering of the southern end from 2m below CD, while the northern part had grown in height. It was noted by researchers that erosion of the shore and cliffs at Dunwich had gradually lessened during the northern growth of the offshore bank, and this gave the idea that the bank might be having a 'sheltering effect' (Pye & Blott, 2006).

Brooks (2010) picks up on this possibility. With the use of ArcMap software for analysis, she also notes the more recent slowing of retreat of the Dunwich-Minsmere cliffs. In addition to the 'possible' sheltering effect of the Sizewell-Dunwich bank, she cites the development of a coarse-grained protective beach from material released from the cliffs. She believes that these cliffs have been 'potentially significant' in past years, but that the process has 'declined in significance more recently'. It has been proposed that erosion of cliffs further north could make up for this deficit, but Pye & Blott's work indicates that the offshore area between Southwold and Thorpeness is a 'closed system' (2006).

The field studies carried out by the Institute of Oceanographic Sciences between 1978 and 1982 included installation of two Waverider buoys, one each side of the Dunwich Bank. This showed that high waves do in fact break on the bank, thereby diminishing the effect on the shore, but with smaller waves there is little or no difference (Lees, 1983). Yet computer modelling by Halcrow Maritime (2001) suggests that the banks are not very important in terms of the energy that reaches the shoreline under moderate wave conditions. Results showed that the banks locally reduce wave heights by up to 0.5m, but their effect on wave heights at the shoreline was predicted to be negligible. Pye & Blott (2006) suggest that while the banks may have little influence under typical weather conditions, they may have sheltering effects during storms.

During the storm surge of December 2013, it was notable that Sizewell remained unaffected, while other nearby defensive banks were breached. This should, however, not be attributed to any protective effects of the Sizewell and Dunwich Banks. The reason for this was predominantly to do with timing, as Spencer et al (2015) explain. Wave heights at Sizewell declined from a peak of 1.81m at 12.30 to 1pm, a full 10 hours before maxiumum water level. If these wave heights had coincided with highest water level, then the outcome would have been very different.

The northern progression of the banks combined with the erosion to the southern part of the Sizewell Bank could mean that any sheltering effect currently offered to the nuclear power stations would in future be lost. If the trend continues at the present rate, then this could occur within 40 years, i.e. during the projected life of the planned Sizewell C, leaving this third power station at the mercy of sea level rise and storm surges, along with its stored radioactive waste in cooling ponds and casks.

## 7. Impacts of new hard defences

While EDF Energy claims that engineered defences will protect nuclear power stations indefinitely at Sizewell, they do not investigate the impact that hard defences here would have on the Suffolk coastline. The Shoreline Management Plan admits that, with projected coastline erosion, the secondary defensive bank fronting A and B would eventually have to be strengthened (Royal Haskoning, 2010). Similarly this would apply to Sizewell C. In the long term, especially with worst case climate change scenarios, hard defences would have to be built, both along the sea front, as now planned, and around to the rear of the stations, forming a concrete encircled 'nuclear island'. The length of such defences would be approximately 3.5 – 4 km/2¼ - 2½ miles. Yet the Developer's proposals do not provide for rear defences, which we consider to be a serious omission.

A certain amount of literature exists concerning the effects of building hard defences, most particularly from the United States of America, where 'shoreline armoring' has become an increasing problem. Among its most direct effects are changes to sediment dynamics and an increase in erosion. Dugan et al (2011) state that, starting from first principles, 'any engineered structure placed in a coastal setting will alter hydrodynamics and modify the flow of water, wave regime, sediment dynamics, grain size, and depositional processes'. They go on to explain how the hardened faces of alongshore structures, such as sea walls and revetments, when placed on beaches, reflect wave energy and constrain natural landward migration of the shoreline. This leads to 'squeeze' with loss of beach area and width. It also brings about 'flanking erosion' to adjacent shoreline, especially where this is soft sand – as at Sizewell, both north and south of the stations.

We have already seen this process at work nearby, where the historic Martello Tower at Slaughden was recently protected with rock armouring and groynes. This has greatly exacerbated erosion either side, just where an entire village has already been lost to the sea.

Reflection rather than dissipation of wave energy causes both active and passive erosion. Impacts of active erosion include scour of the beach immediately in front of the structure, along with flanking erosion associated with increased wave reflection and the narrowing of the surf zone during storms (Griggs, 2005). Passive erosion occurs when shoreline retreat is inhibited and the beach in front of the structure drowns as adjacent shorelines migrate landward (Dugan et al, 2011).

It can therefore be anticipated that construction of seawalls to defend the power stations at Sizewell will result in the hastening of erosion at Minsmere to the north, where there is an internationally important bird reserve, and the loss of beach and sandy cliffs to the south, most particularly at Thorpeness where several cliff-top properties are already at severe risk. (*Appendix no. 4*.) If, as a result, hardened defences have to be installed here also, in addition to the recent revetment, then that will have a knock-on effect at Aldeburgh immediately to the south, where sandbags can even now be seen defending front doors every winter.

## 8. The Minsmere sluice

As we have seen, this concrete structure, lying just over 2 km/1¼ miles to the north of Sizewell power stations, has had a marked effect on the beach profile immediately to the south. Most of the accretion occurred between 1836 and 1883, after which time there has been relatively little change. It may be, however, that the sluice, rather like a small headland, is acting as a holding feature. The Royal Haskoning report (2010) suggests that the structure 'is believed to act to strengthen the coast at this location', with a tendency to encourage 'the overall retention of material towards the centre of the Minsmere valley'. Whether or not this is entirely due to the sluice is uncertain, but it does seem to provide some sort of underlying geomorphological control. Nevertheless the sluice is 'considered to be an important feature' (Royal Haskoning, 2010). What if it were to be moved or to become redundant and taken down? EDF Energy acknowledges in its consultation documents that the future of the sluice would be a 'key issue' for the Sizewell C project (2019).

The Shoreline Management Plan (SMP) for Suffolk admits that ultimately, with climate change and ocean level rise, the sea cannot be kept back and that natural functioning of the coast should be allowed wherever possible. Some stretches of the coastline, therefore, have been designated for 'no active intervention' or for 'managed realignment' of its defences, with 'hold the line' only where absolutely essential. The current overall policy for the stretch from Dunwich Heath to North Sizewell is to allow retreat, but it is divided into three sections as follows: Minsmere north 'managed realignment', Minsmere Sluice 'hold the line', and Minsmere south 'no active intervention'. This remains under review, however. (Royal Haskoning, 2010.)

At present the Minsmere Sluice is closed during high seas in order to protect the freshwater habitats of the RSPB Reserve, where there are designated sites of both international and European importance, Ramsar, Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). It has been agreed to save what is possible of these sites for as long as is feasible, while offering compensation further inland for those areas that cannot be saved. To this end, a defensive North Wall has been constructed that should protect most of the reserve until 2062. Nevertheless, as the sea rises, some of the freshwater habitats will become salt marsh, particularly where the policy is 'no active intervention' (NAI).

Reinforcement to the Minsmere Sluice has recently been carried out, subsequent to the Royal Haskoning report of 2010, which anticipated that it would fail in the short to medium term. The report acknowledges that holding the line here will become increasingly problematic as the coast either side rolls back with the anticipated ongoing erosion. This could result in the sluice becoming a sediment barrier, causing erosion to the south towards Sizewell, but slowing it to the north. It would then potentially increase the likelihood of invasion by the sea into the low-lying Sizewell Belts immediately behind the site for Sizewell C and the two existing power stations A and B. The result of this would be a 'nuclear island'. In any case, official Environment Agency forecasts show that the power stations would be surrounded by water within the next 100 years, even with fairly conservative estimates of sea level rise due to climate change of just 1m. (*Appendix no. 5*.)

## 9. The Shoreline Management Plan (SMP) – preferred policy

In the long term, the preferred policy is to maintain the Minsmere Sluice, as long as it does not act as a sediment barrier. Ongoing managed realignment would be developed to the north end of Minsmere. In the medium term it is anticipated that fresh water flooding to the Minsmere Valley would increase, resulting in the need for further defences to some properties, especially at Eastbridge. It is considered that this would be more economically viable than attempting to keep the sea back with improved shoreline defences.

What if the sluice is found to be causing an obstruction to sediment flow? In this case it might have to be abandoned, resulting in an initial flattening of the coast and failure of the 'soft' defences behind. A tidal inlet would then form. The Royal Haskoning report claims that such an inlet would have a similar effect on sediment transport as the sluice, but there is no explanation to back this up (2010). Indeed, the overall effect on the coast and the low-lying areas inland remains unclear.

The Developer claims that both the existing power stations and Sizewell C could be defended against the encroaching sea for the complete life cycle of the new power station. The DCO documents for Sizewell C allow for sea protection as part of the permanent development, with graduated defences rising to the height of the proposed station platform, underpinned by rock armouring. Even so, it is difficult to see how, in the long term, the sea can be prevented from washing in at the low point to the north of the stations and invading the Sizewell Belts to the rear of A and B - and C should it be built. It is worrying that a bridge to cross the Leiston and Sizewell Drains is amongst the latest proposals, with a sluice beneath to block off the invading sea when necessary. As this is the only drainage route from Leiston town and the existing power stations, it is not known what the effect would be on the Sizewell Marshes Site of Special Scientific Interest (SSSI). However, the Royal Haskoning report does state that defences along the whole of the western edge of the existing stations would eventually have to be built (2010). This presumably would be extremely expensive.

It is noticeable that the management plan allows for slow erosion at the present rate. Within 100 years, under this scenario, the sea would lie at the toe of the existing back defensive bank immediately in front of the present nuclear power stations. Indeed, the map indicates that this could happen within 50 years or less. *(Appendix no. 6.)* There is an acknowledgement in the report that there would be a need for extra support to this defence (Royal Haskoning, 2010).

An obvious omission is the increasing likelihood of extreme events as the climate changes and warms up. Already we have seen how wrong official projections can be. The view has been that Thorpeness was relatively stable, but the storm of December 2013 resulted in the gouging out of the cliffs immediately below the northern line of properties. The SMP was then hurriedly updated for Thorpeness from no active intervention to managed realignment. Meanwhile the vulnerable cliffs were reinforced with a gabion revetment, but this has not been a success, with gabions already corroding and the huge sandbags tossed around with the power of the waves. (*Appendix nos. 4 & 5.)*

Clearly the plan can at best only be provisional, or as the Royal Haskoning report admits merely 'indicative' (2010).

## 10. **Emergency planning**

It is noticeable from the flooding maps within the SMP that sea intrusion is anticipated into the Sizewell Belts within the next 100 years, or sooner. Not only would the entire area behind the nuclear power stations be flooded, but also Sizewell village, and, most importantly, Lover's Lane, the road leading to the village and the main entrance to the power stations. If, therefore, there should happen to be an emergency at the stations coinciding with a storm surge and serious flooding event, then this route would be under water. Even the proposed new access road would be of little help to villagers, lying past the nuclear power stations on the northern side.

Lover's Lane would also be flooded to the west of the stations at its lowest point and where there is a culvert, currently old and in need of repair. Running through here is the Leiston Beck which takes the water from the sewage works under the road into Sizewell Belts. This eventually finds its way to the sea via the Minsmere Sluice. It seems extraordinary that this problem should not be highlighted in the Royal Haskoning report (2010), one which is potentially very serious should the power stations and village need to be evacuated. It would also impede emergency services from entering the site and dealing with any problem.

When considering nuclear power stations, it is necessary to think in the long term. Sizewell A is currently being decommissioned, with the anticipation that workers will remain on site until 2027. Due to the radioactivity, it will not be finally taken down for a further 85 years, i.e. around 2112. Sizewell B will be on stream until 2035, with anticipated extended life of a further 20 years, up to 2055. To this, 105 years needs to be added for decommissioning, taking the date to around 2160. If the proposed Sizewell C were to go ahead, it is unlikely to be actively producing electricity before 2035. Predicted life is 60 years, by which time, according to Environment Agency projections, the site is likely to be surrounded by flood water. Adding 105 years to that, the date we arrive at before it is finally removed would not be before 2200. To have a shoreline management plan that extends for only 100 years is therefore totally inadequate.

## 11. Radioactive waste management

It is not generally realised that high level radioactive waste is stored at Sizewell. The cooling ponds now being full, a 'dry fuel' (i.e. waste) store has been constructed at Sizewell B. It seems that, in addition, a new reactor fuel pool would be constructed for Sizewell C to take the spent fuel from the two reactors for an initial period. After this the waste fuel assemblies would be transferred to the separate on-site interim spent fuel store (ISFS), which would have a life of 100 years, extendable if necessary. Here they would be stored until a UK geological disposal facility becomes available (EDF Energy, 2019). However, the government has been trying to find a site for such a facility for decades without success. The fact that the ISFS would have a design life of at least 100 years seems to be an admission that there would be no geological disposal facility available at least within the next century. Intermediate level waste (ILW) would also be stored on site for the working lifetime of the station, i.e. until 2095. While there remains no solution to long-term disposal or storage of high level nuclear waste, then it could be left at Sizewell indefinitely, for thousands of years, by which time it is unlikely that there would be any dry land remaining. In the long term, therefore, this site is not sustainable for the safe operation of nuclear power with its concomitant radioactive waste storage.

## 12.Development plans for Sizewell C nuclear power station

The site for this third nuclear power station lies directly to the north/north-west of Sizewell B, which is almost entirely within Flood Zone 3 together with a small coastal stretch of Flood Zone 2. The current Environment Agency online flooding map shows the site as being at 'high risk', with greater than or equal to a 1 in 200 chance of being flooded in any given year. It would be built, together with the proposed new access road, across the north-east portion of Sizewell Marshes Site of Special Scientific Interest (SSSI). The wildlife implications are beyond the scope of this report. What does need to be considered here, however, in addition to the risks of flooding to the site, are the likely impacts of the development on flooding to areas in the immediate vicinity.

As there would be two new reactors, the size of the permanent site would be more or less the same as the existing two stations, although construction areas, needed for at least a decade, would be extensive. To avoid flooding to the main site, it is envisaged that it would be built on a platform at 7m above Ordnance Datum, slightly higher than Sizewell B at 6.4m (EDF Energy, 2019). There would also be permanent 'flood defence and coastal protection measures'. Around the platform there would be a 'cut-off wall'. The north-west part of the main site would cross directly over Leiston and Sizewell Drains, the main sources of drainage from the sewage works of Leiston town and from the power stations, together with the collective water from the low-lying Sizewell Belts and Marshes. As already mentioned, this finally drains into the sea at Minsmere Sluice. The plan is to build a causeway for the new access road with a bridge to the station platform, under which the drainage water would flow. The road would run along the higher ground of Goose Hill, eventually joining up with the B1122 (EDF Energy, 2019).

Even during times of average rainfall, especially in winter, the Leiston Drain frequently overflows its banks and all surrounding land is saturated. Moreover, in addition to the sewage works at Leiston and Sizewell B, further drainage would have to be put in place to take the effluent generated by the estimated 5,600 people working on site during the construction of Sizewell C. There is already a 'pinch point' where the Leiston Drain runs between the elevated land of Goose Hill and the proposed Sizewell C platform. It is hard to envisage how the restricted space beneath the bridge would be capable of taking so much extra water. The Environment Agency had requested a completely open, three-span structure, which we and other groups had also called for, but the Developer could not justify the extra expense, which we consider to be a mistake.

At present the marshes act like a 'sponge', soaking up the water that drains off the surrounding land. What therefore would be the consequences of replacing significant portions of this with hard concrete surfaces, even if some are semi-permeable? Moreover EDF Energy are planning to cut down most of the trees around the development site. It is estimated that where trees are planted, run-off is reduced by up to 78% as compared with pasture. When trees are removed, therefore, then so is this natural ability to protect from flooding and soil erosion. (Juniper, 2015.) The total land take during the construction period, including the campus for workers, would be almost twice the size of Leiston, a market town with a population of just over 5,500. With climate change, extra precipitation is already being experienced and this is likely to worsen, especially with the predicted sudden deluges. (Defra/Environment Agency, 2015). It remains unclear how this larger volume of water would be managed.

Residents of Leiston town are anxious about possible back-up flooding. As we have seen, the Shoreline Management Plan proposes that the Minsmere Sluice is kept in place for as long as possible to protect the RSPB reserve, part of which is directly adjacent to the proposed Sizewell C development site. During high seas, therefore, the sluice is closed. All the drainage water from Leiston sewage works, together with that from the Sizewell power stations, finds its way into the Leiston Drain, which exits into the sea via the Sluice. So does the New Cut channel, which takes all the water flowing from Eastbridge and the Minsmere Levels, itself also frequently overtopping its banks. At present the marshes have been able to absorb this extra water, but with the loss of a significant amount of this land to concrete, the additional sewage drainage from another 5,600 workers, combined with extra precipitation and rising sea levels due to climate change and an increase in storm conditions, how then will the remaining marshes cope when the Sluice is closed? Sizewell Belts could quickly fill with water which would then take the lowest route along the valley over Lover's Lane and into the new reserve at Aldhurst Farm, causing flooding not only to the adjacent Leiston properties, but to the sewage works itself, which is low-lying. This stretch is currently classed progressively as Flood Zone 3, 2 and 1. The same would be true of the Minsmere Levels, putting properties at Eastbridge at increased risk. So far neither the Environment Agency nor EDF Energy have properly addressed these concerns.

## 13. **The beach landing facility (BLF) and cooling water infrastructure**

Sections for the Sizewell C reactors, described as 'abnormal indivisible loads', would be too large to transport by road or rail, so the only option is to bring them by sea (EDF Energy, 2019). This necessitates building an offloading facility or BLF, which would be permanent, along with more temporary marine structures.

Discussion of the Minsmere Sluice above has shown how even a very small built feature on the Suffolk coastline can have a very significant effect on sediment transport within the predominant longshore drift, thereby causing either accretion or erosion. What therefore might be the effect of the BLF? There is no doubt that this would bring about changes. As Dugan et al (2011) state '… offshore structures such as jetties, groynes, and breakwaters, can affect erosion and accretion of adjacent shorelines, as well as sediment transport and deposition'. They continue to explain how these cause abrupt discontinuities to shoreline orientation, resulting in shoreline erosion which can be 'greatly accelerated'. Nordstrom (2000) reports long-term erosion rates of 6 – 11m p.a. down-drift of groynes and jetties. Such structures also change wave regimes and surf zone circulation, creating new rip currents. The benthic topography of the sea floor becomes altered, with features such as deep holes and depositional lobes forming adjacent to the structures (Dugan et al, 2011). Regular dredging may be needed in such cases, which in turn creates further changes.

Maps illustrating EDF Energy's Stage 3 consultation documents (2019) show the area projecting into the sea in which the proposed BLF for Sizewell C would be built. This would be from the beach at the northernmost part of the site. Even though this would be an open structure, built from the shore on approximately 20 piles, its projection into the sea would nevertheless affect sediment transport. It is well known that any structure on Suffolk's dynamic coastline very quickly has a negative impact on nearby shoreline. Royal Haskoning (2010) points out how crucial it is to continue to allow the present variation in sediment drift across the frontage of the Sizewell power stations and village. The report states: 'This was seen to be critical during recent construction when a barrier to this movement resulted in sudden local erosion.' This 'barrier' was in fact the jetty built for the construction of Sizewell B, which was acting like a groyne. (Suffolk County Council forced British Energy to remove it, as it was described as 'temporary' in the planning consent.) Yet the proposed site for the new BLF is at the northern end of the Sizewell C site, thus affecting sediment drift right across the frontage of stations C (if built) and B and A and also the village houses. It is likely, therefore, that erosion will be hastened both here and further south, putting at increased risk properties along Sizewell cliff top, and most particularly those at Thorpeness, which are already in a perilous position.

In addition to the BLF, cooling water infrastructure would have to be put in place. Two intake tunnels and would be bored under the offshore banks, some 3km/2 miles out to sea, along with one outfall tunnel with two outfall heads closer to shore. The velocity of the outflow would be very considerable at 125m3s-1, two and a half times that from Sizewell B. (EDF Energy, 2014.) It is therefore likely that the disturbance caused would have an impact on the nearby bank, which consists of soft sand and mud. Moreover, it is known that a large volume of water moving at speed within the sea can have an effect similar to that of a groyne in terms of impeding sediment flow.

It appears that the BLF would be retained throughout Sizewell C's operational life, to receive deliveries of Abnormal Indivisible Loads by sea. This therefore would be a structure built to last 60 years, plus the 10-12 years' construction time. Even supposing this were to begin in 2022, the landing facility would be expected to last until 2094, yet by this time the sea would have risen and the coastline withdrawn. Here again, such a structure would impede the flow of sediment, causing even more erosion.

In North Carolina, where there is a coastline similar to that of Suffolk with predominant longshore drift, a ban has been put in place on all hard structures since 2003, to protect the beaches from further erosion. It is now forbidden to build sea walls, jetties or groynes here because of the damage these have caused to the shore (Jack, 2015).

## 14. Flooding at nuclear power plants

As part of a major investigation into the impacts of climate change, officials at the Department for Environment, Food and Rural Affairs (Defra) produced a summary report in January 2012. In this the nuclear industry was referred to, but no individual sites were mentioned. After a freedom of information request by a *Guardian* journalist, the full analysis was finally released two months later. This revealed that as many as 12 of Britain's 19 civil nuclear sites are at risk of flooding and coastal erosion by the 2080s. Nine of the sites are assessed as being vulnerable now, with others in danger from rising sea levels and storms in future decades. They include all of the eight sites proposed for new nuclear power stations around the coast, as well as several radioactive waste stores, operating reactors and defunct nuclear facilities. Most notable is the fact that three nuclear sites are said to have a 'high risk' of flooding and erosion now: Sizewell in Suffolk, Hartlepool in County Durham and Dungeness in Kent. (Edwards, 2012.)

Just one year later, in 2013, the nuclear reactor at Dungeness was quietly shut down for five months. It transpired that urgent repairs were needed to sea walls around the site to prevent it from being inundated by water and causing a 'Fukushima-style disaster'. Yet the public was not informed until a report appeared in *The Independent* the following year (Thomas, 2014). Clearly, wider transparency is needed in the nuclear industry.

The number of incidents involving ingress of water at nuclear power plants is extremely worrying. Dave Lochbaum (2015) picks out just 20 typical cases from a great many more in the US alone. Combined with natural events, the most remarkable features are simple human mistakes involving, for example, missing seals to pipes, insecure ventilation covers, careless workers breaking a fire hydrant or causing a spark and setting off a fire, a worker either opening or turning off the wrong valve, a hole in a flood barrier remaining unnoticed, not realising that a pump had broken down, forgetting to close a water-tight door and so on. Yet these basic errors in each case led to a series of events which allowed water into the wrong place, either disabling electrically controlled safety systems, a loss of cooling of highly radioactive elements or serious flooding of the containment building.

Here at Sizewell A during decommissioning in 2007, a part-time worker noticed some water on the floor when he went to the utility room to use the washing machine. Tracing its source, he discovered that water was leaking from the cooling pond, yet the alarm system had been switched off. Emptying of the pond would have triggered a highly radioactive fire from the stored fuel rods. It was only by chance that this was prevented.

In 1999 a major catastrophe was narrowly avoided at EDF's Le Blayais nuclear power station in France, when a combination of the incoming tide and high winds resulted in a storm surge which overwhelmed the sea defensive dykes, causing parts of the plant to be flooded, including below-platform rooms sheltering safety equipment. This resulted in the loss of the station's off-site power supply and the disabling of several safety-related back-up systems. This meant that two of the four reactor units were unprotected. The result was a 'level 2' event. This storm surge had exceeded the predicted 'worst-case scenario'. (Richard, 2000; Vial et al, 2005.)

Of course the worst catastrophe by far involving flood water was the disaster at Fukushima's Daiichi plant in Japan in 2011. Seas of almost 15m/50 ft, caused by an earthquake and tsunami washed over the nuclear power station, knocking out the electricity needed to run its cooling systems. A final-resort bank of batteries lasted only eight hours. As a result three of the four reactors suffered a partial meltdown, leaking radiation into the air and ocean. Hundreds of thousands of people had to be evacuated. It will be impossible to farm the surrounding land for generations, if ever.

Could a tsunami happen here in Suffolk? It would not be the first. Three massive underwater landslides at the edge of Norway's continental shelf, known as the Storegga Slides, sent giant waves towards the British Isles. The last was some 8,000 years ago when coastal areas around Doggerland were inundated, with catastrophic consequences to the Mesolithic population. (Bondevik et al, 2007.) Norwegian landslides into fjords continue to be relatively frequent, causing a considerable number of deaths to local populations.

Dr Simon Day of the Benfield Greig Hazard Research Centre at University College London warns of an impending volcanic eruption of Cumbre Vieja on the island of La Palma, causing a mountain twice the size of the Isle of Man to plunge into the Atlantic. The resulting tsunami will hit Britain at 500 mph, causing total devastation to the south-west, but also rushing up the English Channel and into the North Sea. The wave would be 1km/½ mile high and tens of kilometres long. He believes this could occur within the next few decades, which would be within the lifetime of Sizewell C, and most certainly before high-level nuclear waste has decayed to a safe level. In 1949 it moved 3.5m/12 ft in two days (Uhlig, 2001). The mountain has recently shown serious signs of instability, with a major volcanic eruption.

All this may seem extreme and too hypothetical to consider, but the reality is that the nature of accidents is that they are not foreseeable, and often consist of unexpected natural events combined with human error, as at Fukushima. As the Japanese Prime Minister Naoto Kan at that time has famously said, the greatest error was in deciding to build the nuclear power station there in the first place (Biello, 2013).

## Conclusion

The expert literature asserts that, as a result of climate change, sea levels will rise, there will be an increase in precipitation and in high winds and storms and extreme weather events. Sizewell lies on the western edge of the Southern North Sea basin, an area historically prone to storm surges. The predictions are that these will worsen and become more frequent. While the shoreline at Sizewell has during recent decades been relatively stable, this has not always been the case and is not likely to continue over time.

EDF Energy claims that the Sizewell and Dunwich Bank system offers protection to the Sizewell site and will continue to do so at least during the lifetime of Sizewell C, if built. Yet the review of the scientific literature does not support this. While there is currently some lowering of shoreline waves during storms, this effect is likely to lessen in future due to the northward progression of the banks and the widening of the gap between them, through which high waves can penetrate. Moreover, sediment transport from the cliffs at Dunwich, thought to be mainly responsible for replenishment of the sand banks, has lessened significantly in recent decades. It could be that erosion of cliffs further north may offer alternative replenishment, but this remains unproven. Moreover, it is now known that Thorpeness, previously thought to be stable and offering some sort of 'anchor' to the Sizewell Bank, is now suffering ongoing erosion from the beach and cliffs.

It is very clear from the literature that the Suffolk coastline continues to be dynamic and constantly changing. Reliance cannot be placed upon shifting sandbanks to protect a site supporting highly vulnerable nuclear power stations.

It seems that the Minsmere Sluice has been performing as some kind of holding feature in terms of sediment transport, but with the policy of 'no active intervention' here its future remains uncertain. This therefore cannot be depended upon to continue with this protective function. EDF Energy admits that this is a 'key issue'.

As a result of climate change, official conservative estimates state that Sizewell will be surrounded by water within 100 years, with all low-lying parts of the estate permanently flooded. There is no guidance whatever among the expert literature to suggest what may happen beyond that time frame. Yet the present indications are that power station A will not have been finally taken down, nor will Sizewell B, while Sizewell C (if built) would be highly radioactive and in the early stages of decommissioning. There would still be stored radioactive waste on site, some of it high level, and most probably in old and deteriorating casks.

EDF Energy claim that they can guard against predicted flooding during the lifetime of Sizewell C by building defences, which could be heightened as necessary. Even if this were the case, the scientific literature indicates that such structures will have deleterious effects on the surrounding coastline, causing even more erosion and flooding damage. Sea defences will cause flanking erosion and the scouring of the beach immediately in front, structures projecting into the sea, such as the BLF, will act as barriers to longshore drift, while any offshore breakwaters also cause erosion by altering the movement of sediment. Equally, construction of the cooling water infrastructure, together with any necessary dredging, will change the shoreline dynamics and lead to erosion elsewhere.

Altogether this will put at increased risk not only properties at Thorpeness, already threatened, but those beyond at Aldeburgh and Snape, where there is the famous concert hall, and at the village of Waldringfield. Designated sites immediately north at Minsmere, of both European and international importance and very popular with visitors, will also be under increased threat of erosion and incursion by the sea due to the construction activities and the building of defences. Tourism, vital to Suffolk's economy, will be seriously affected.

While so many uncertainties abound, it is the view of the present authors, having studied the expert literature, that Sizewell cannot be considered to be a suitable site for nuclear power.  The indications are that it is unsustainable in the long term.

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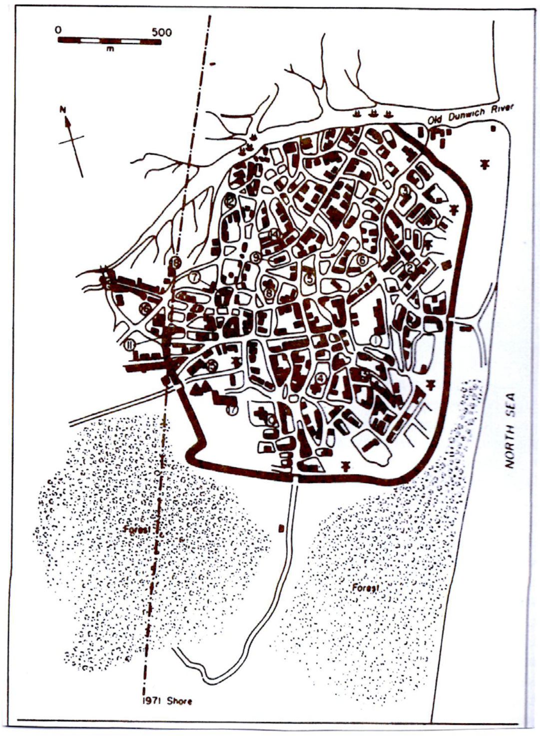
## Appendix – Illustrations



*1. Dunwich about 1100 A.D. The dotted line indicates the shoreline in 1971. (Bacon, J. & S., 1979.* The Search for Dunwich, city under the Sea. *Segment Publications.)*

*2. Wave erosion to the first defensive bank just to the north of Sizewell B, opposite the proposed site for Sizewell C. (Photo: R. Fulcher, March 2016.)*

*3. Sketch showing movement of the Sizewell and Dunwich Banks. (From Pye & Blott, 2006.)*

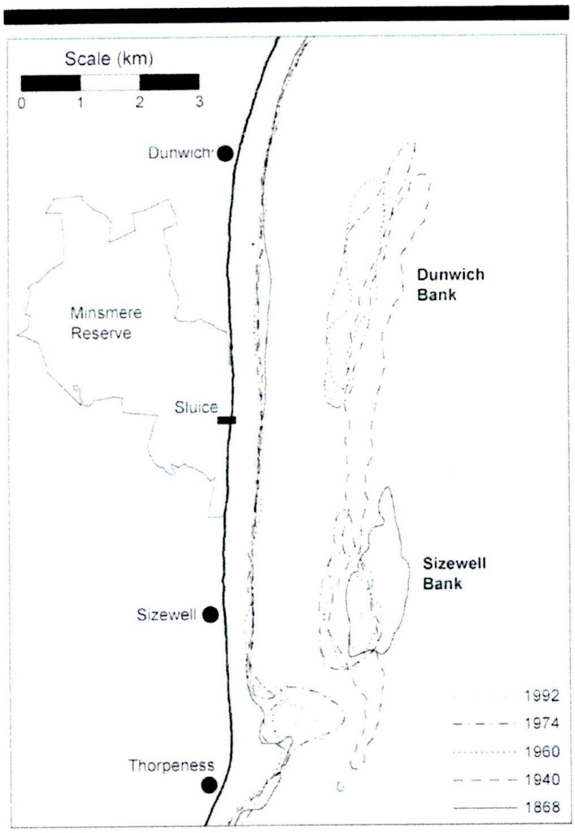
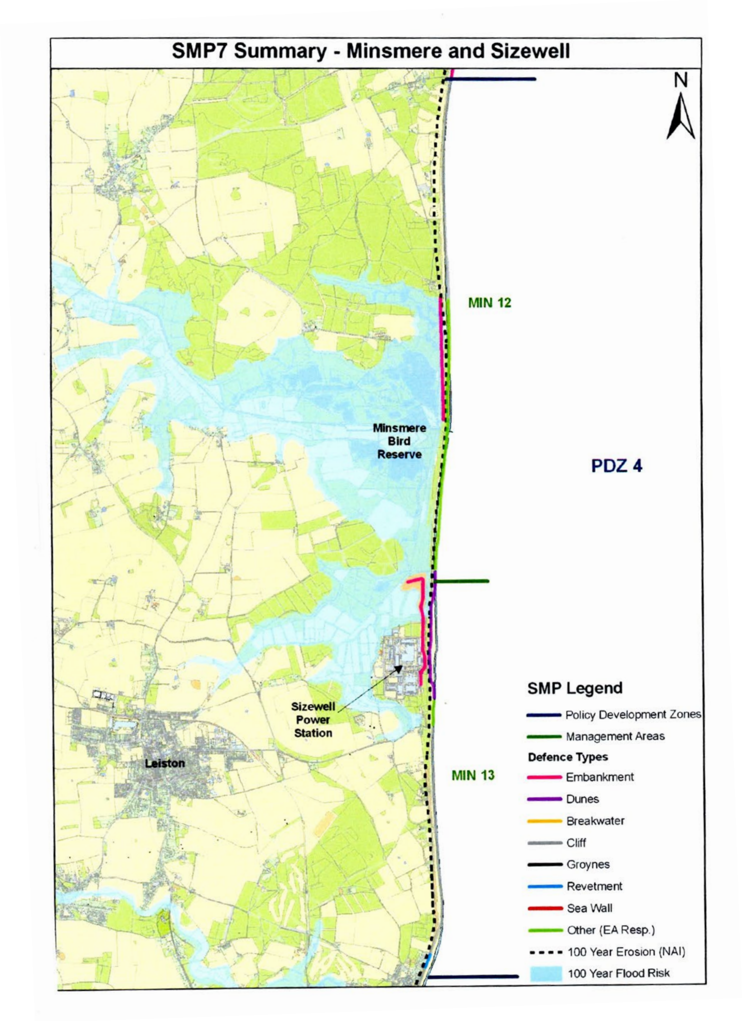


**Figure 13.** **Changes in the position and shape of the Sizewell-Dunwich Banks between 1868 and 1992, based on Admiralty surveys.**

*4. Thorpeness beach with revetment.  Sizewell to the north. (Photo: Fran Crowe.)*

*5.  Thorpeness, showing cliff erosion.  (Photo: Fran Crowe.)*



*6. Projected 100 year flood risk at Sizewell and Minsmere. (Shoreline Management Plan, Royal Haskoning, 2010.)*

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