Interested Party number 20025524. Nick Scarr. Deadline D6

Part 1

This document is a response to the ExQ1 Part 3 of 6 (*The Examining Authority's written questions and requests for information (ExQ1) ExQ1 PART 3 OF 6 REP5-129*) and refers to my submitted documents, REP3-119 (REP2-393) and REP5-253.

The Applicant has seemingly responded to my detailed concerns of the incompleteness, in my view, of its existing Flood Risk and Shoreline Change Assessments including the EGA, as follows:

> *"The CPMMP (Doc Ref. 6.14(A)) addresses impacts from Sizewell C to the environment, and not the reverse, hence it is tailored to the scale of outward impacts, not the external forcing.* ***It is an adaptive plan*** *and will remain a live document throughout the operational and decommissioning period, allowing for the recognition of possible expansion or contraction of effects due to the localised impacts over time."* Page 31, ExQ1 referenced above.

I respectfully suggest that the above reply, does not, in fact, appear to cover ***any*** of the detailed and referenced geomorphological points that I have raised in my papers REP3-119, (REP2-393) and REP5-253. The CMMP (*6.14 Revision: 2.0 Applicable Regulation: Regulation 5(2)(q) PINS Reference Number: EN010012 Coastal Processes Monitoring and Mitigation Plan*) referred to by the Applicant also does not appear to relate to my papers' concerns.

In my opinion, the safety of Sizewell C cannot be entrusted to an 'adaptive plan' if indispensable geomorphological receptors are not within the control of human agency. I have not seen any suggestion that it would be possible to maintain the integrity of a depleting or restructuring offshore geomorphology, particularly the Dunwich bank, *a bank that is of 'critical importance' to Sizewell shoreline stability and security according to EDF in its pre-DCO research.* This is covered in my document REP5-253, '*Response to Sizewell C Development Consent Order (DCO) Issue-specific hearing 6 (ISH6) Coastal geomorphology, 14th July 2021*'. It is also covered in the following paper REP3-119 (REP2-393).

Overall and in my view, EDF's pre-DCO assessment of the role of the Dunwich bank is correct—it represents a key driver to Sizewell shoreline security. EDF's decision not to model any changes or degradation of the Sizewell-Dunwich banks in the main Flood Risk and Shoreline change assessments could represent a compromised overall design and considerable understatement of flood and erosion risk to Sizewell C. Major degradation of the Dunwich bank—currently showing notable loss and instability—could reasonably be expected to risk returning the Sizewell shoreline to its previous state of severe erosion, a premise that is validated by historical precedent. This contingency would then place the exposed landward side of the main nuclear platform at increased flood risk and the northern defences, built on soft Holocene alluvium, could be vulnerable.

Based on careful research accredited by expert review, my document illustrates that **Sizewell C's safety appears to unreasonably rely on the continued stability and integrity of an unpredictable offshore geomorphology, a geomorphology that, as stated, is outside the control of human agency and hence outside the control of any 'Adaptive plan'.**

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Part 2

I noted that Mr Hereward Philpott, for the Applicant, at the Issue Specific geomorphology meeting (ISH6) 14th July 2021 emphasised the significance of the academic status of his technical advisor. This can be found in the transcript of the meeting: '*EN010012-005971-TRANSCRIPT ISH6 Session 2 14072021.pdf*' Document Ref EV-126 at location 20:26, page 5.

It therefore seems important to enclose a review of my document REP3-119 (REP2-393) (*Sizewell C – Coastal morphology, climate change and the effectiveness of EDF's Flood Risk and Shoreline Change assessments. May 2021)* by two **professors of geomorphology**, a review that clarifies the credibility and accuracy of my papers.

Professorial review of paper: Sizewell C – Coastal morphology, climate change and the effectiveness of EDF's Flood Risk and Shoreline Change assessments. May 2021

[**Note:** Reviewing comments in red from Professors A and B where appropriate]

Reviewing Author Credentials:
Professor A [redacted] and Professor B [redacted] July, 2021

The authors are specialist researchers in the field of coastal geomorphology and coastal management, each with >30 years research experience. Professor [redacted] Fellow of Geological Society [redacted] and Fellow of the [redacted], has published 230 peer-reviewed journal articles, 45 book chapters and 12 books. Professor [redacted], a Member of the [redacted] Fellow of [redacted] and peer-review college member for the UK's [redacted], has published 140 peer-reviewed journal articles, 18 book chapters and 3 books.

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[redacted] and I have both went through Nick's report and we felt the clearest way for us to report on this is to respond in red where appropriate the points that needed mentioned/reinforced/clarified. **Note absence of 'concur' or a response from us does not reflect our disagreement with the particular point.** There is a little repetition of the points on the offshore banks in the second half of the report, but it will do no harm to retain as it reinforces. Nick's report is really good, thorough and covers excellent points.

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Nick Scarr

Summary

This paper is a response to EDF's Sizewell C Flood Risk Assessment and approach to shoreline change and offshore geomorphology as presented in the Development Consent Order (DCO) application.

The paper updates and replaces all previous associated papers including *'Sizewell C – Development Consent Order Response. The environment, coastal morphology and climate change - a 2020 perspective. 30 October 2020 14:44'* published on the PINS website 25th November 2020.

See explanatory 'Notes' on page 15.

The offshore geomorphology of the Greater Sizewell Bay is dominated by the Sizewell-Dunwich banks. The banks act as a natural offshore 'breakwater' limiting storm wave energy onto the Sizewell foreshore and have provided recent historical stability and protection to the existing nuclear installations. The banks, however, are largely formed from unconsolidated sand and mud deposits and the northern, Dunwich section is currently indicating marked instability.

This is particularly so at the water depths that the banks are located where wave induced breaking is maximised in terms of wave length to water depths. It also seems that the directionality of incoming waves is important in terms of how they interact with the bank topography. The detailed surface topography of the banks in relation to wave parameters will influence their role in protecting, or under certain circumstances, exacerbating the effects of incoming waves.

EDF appears to have limited the scope, and hence the underlying principles, of its Flood Risk and shoreline change assessments—including the Expert Geomorphological assessment (EGA)—by treating the Sizewell-Dunwich banks as an *immutable and permanent wave energy relief feature* in its modelling scenarios.

Agreed, no scenarios of depleted Sizewell-Dunwich banks in the future have been factored into nearshore wave behaviour especially during storm conditions. Similarly, the short-term change sin bank morphology documented on adjacent systems have been overlooked. Most importantly, the relationship between the banks and the adjacent shoreline has not been established, even in concept.

This assumption is counter to received knowledge from bathymetric surveys. It is not consistent with authoritative, geomorphological orthodoxy—*an orthodoxy validated by EDF's own research* in its 'BEEMS' technical documents obtained under 'Freedom of Information' and referred to extensively in this paper.

There is certainly a difficulty addressing the potential consequences of the loss or major compromise of the Dunwich bank: the 'soft' Sizewell shoreline could return to the '***most eroded coastline on record***', *as it was between 1736 and 1836 before the development of the Sizewell-Dunwich bank northwards*. The subsequent shoreline recession, wave breaking over the Minsmere levels and flooding of the contiguous Sizewell marshland would then increase the flood risk to the Sizewell C main nuclear platform landward side.

This would require additional wave modelling work to validate but in principle we concur with this statement.

Nevertheless, coherent flood risk and shoreline change assessments, and hence the flood design parameters, for Sizewell C must include, and be informed by, the three most recent and documented '100-year' major episodes in coastal processes recorded for Sizewell. There should also be a full consideration to offshore morphological change and the implications of the loss or major compromise of *at least* the Dunwich bank and nearshore bars over the lifetime of the development.

We concur, over the lifetime of the development such scenarios are indeed possible (in fact probable) therefore factoring them into future longer timescales is a sensible approach and one not currently undertaken.

I am unable to locate evidence that EDF has considered these scenarios and therefore, in my view, EDF's FRA and shoreline change assessments are not acceptable or sufficient in their present form.

The Executive Summary briefly details what I consider to be these critical limitations in EDF's Flood Risk Assessment and shoreline change assessments. This includes EDF's approach to climate change data, 'tolerable' overtopping levels, and the length of time that flood resilience is required for the nuclear site. All statements made are referenced and justified in the main body of the paper from authoritative sources—EDF's pre-DCO reports, the DCO documentation itself, BEEMS documents as stated, and accredited academic studies.

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Executive summary

1. Offshore morphology and coastline stability—EDF's Flood Risk Assessment (FRA) and impacts on coastal processes.

1.1 The off-shore Sizewell-Dunwich banks have provided recent historical stability and security to the Sizewell coastline and its existing nuclear installations by providing storm protection and a lower energy inshore wave climate.

- This view is fully recognised and accepted by EDF itself in its DCO Geomorphological documents and in pre-DCO documentation where EDF states that the Sizewell Dunwich banks *"...provide stability for the Sizewell coastal system."* See sections 2 and 6.

1.2 However, there are now acknowledged concerns over the stability and morphology of the protective, offshore Sizewell-Dunwich banks themselves:

- Beyond the limited area of erosion-resistant coralline crag in the Thorpeness outcrop, seabed samples indicate that the Sizewell-Dunwich banks are uncemented deposits. Historically, records show them to be capable of notable change. See section 2.

- EDF acknowledges significant recent lowering of crest height and contour changes to the Sizewell-Dunwich banks northern section above 267000N and it is reasonable to conclude its continued presence cannot be assured. This will, in my view, expose the Sizewell C site to a greater extent than the existing Sizewell A or B sites. See sections 2 and 6.
- This observation highlights the lack of knowledge of the relationship between the banks and adjacent shore- are they sources or sinks of sediment? Are they transient or permanent features? How do they respond to sea-level change? These are questions we have raised in our report and for which there are no available answers, yet this relationship underlies the understanding of the entire coastal system.
- It should also be noted that the changes may vary spatially and therefore some sections may be higher or lower (relative to present) with subsequent consequences for wave attenuation over these alterations. Lowering relative to present levels will result in less attenuation and higher wave energy deliver to the shoreline and vice versa. Changes to energy zones along coastlines with set up new longshore current regimes, depending on the extent of energy

increases involved. Energy always travels (in the form of a longshore current) from high to low energy levels, bringing sediment along the coast in that direction. This has not been assessed in any modelling at the site to date.

- EDF/Cefas, in their 'BEEMS' technical documents obtained under FoI, confirm this view: *"…if the lowering and reduction in Dunwich Banks northern extent continued, the extent of shoreline exposed to higher wave energy from the northeast sector would be expected to expand to the south accordingly"* i.e., affect the proposed Sizewell C site. See Sections 2, 6.

- EDF's concern for any offshore geomorphological change is highlighted by its stipulation to Scottish Power Renewables that its wind farm cable-laying activities must not cause any damage to the Sizewell-Dunwich banks. See section 6.

Concur with these former two points. The relative importance of the banks appears to be "underhighlighted" ([redacted]) by EDF.

1.3 The threat to the stability of the Sizewell coastal system by loss or compromise of the Sizewell-Dunwich banks has certainly been recognised by EDF in its previous documentation.

In the DCO FRA, however, EDF relegates the importance of the Sizewell-Dunwich banks from primary wave energy receptors and key geomorphological driver to a 'minor' role:

- In the twenty-two DCO main Flood Risk Assessment and fourteen FRA Addendum documents the Sizewell-Dunwich banks do not appear to be explicitly named. See section 7.
- Concur

- I could not locate bathymetric survey data of the Sizewell-Dunwich banks in the DCO FRA. The only bathymetric surveys undertaken by EDF of the Sizewell-Dunwich banks appear to have been partial in 2008/9 and full in 2017. EDF's explanation is that the Sizewell-Dunwich bank is *"…not regularly surveyed…due to its large size".* See section 6.

- EDF, in its January 2012 EU flood risk 'stress test' analysis for Sizewell **B,** states clearly the importance of the Sizewell-Dunwich banks for wave energy relief. No other receptors appear to be referred to in 2012 nor in the main Public Consultation documents until a 2019 'Scoping' report. See sections 2,6,7.

- However, EDF introduces into the DCO FRA two minor nearshore, longshore bars and the '*shingle beach and vegetated sand dunes'* as authentic wave energy relief features. EDF then adopts AMAZON modelling software rather than the industry standard *EurOtop* modelling, in order to use these features as wave receptors. Unlike the Sizewell-Dunwich banks, the minor nearshore bars are afforded extensive bathymetric analysis in the DCO. See section 6 for a comparative map of these features. See section 6, 7.

- Might need to explain what the disadvantages are in the use of AMAZON over other options. It is most likely a question of convenience. SWAN modelling is commonly used for shallow water wave modelling.

1.4 EDF might be expected to validate its position that the Sizewell-Dunwich banks are no longer a key driver for Sizewell C flood and erosion risk by offering Flood Risk Assessment modelling scenarios with the Sizewell-Dunwich banks removed or compromised, but such modelling does not appear to have been provided:

- EDF's FRA states: *"…the baseline scenario was taken forward for wave overtopping assessment for the Sizewell C FRA."*

    - EDF somewhat obliquely defines *"baseline scenario"* as meaning *"with sand bar"*. Close study of the texts reveals that in this context *'with sand bar'* = *'with the Sizewell-Dunwich banks in situ.'* See section 7.
    - concur

    Close study is required because in the immediate, preceding paragraph EDF uses the term '*sand bar*' to refer to the *nearshore bars*. EDF, as stated, chooses not to explicitly name the Sizewell-Dunwich banks in the document. See section 7.
    Bizarre.. Perhaps this is [redacted].

- EDF and its partner Haskoning, supported by wave data and recommendation from Cefas, affirms what I consider to be the most perplexing aspect of the FRA—EDF/Haskoning/Cefas state that the *'baseline scenario*' (i.e., with the Sizewell-Dunwich banks in situ) *"predicted slightly higher nearshore waves".*

    - '*Higher nearshore waves'* is then extended to suggest that modelling with the '*baseline scenario*' would be "*more conservative"* (*i.e., worst-case*). I cannot locate the use of any other geo-scenario in EDF's modelling. See section 7.

    - This approach appears to contradict the geomorphological, authoritative orthodoxy of academic and empirical research which affirms that the wave-breaking Sizewell-Dunwich banks protect the shoreline from storms by creating a *lower* inshore wave climate—*an orthodoxy that is validated by EDF's own research pre-DCO.* See section 7.
    Concur. However, the wave-seabed interaction is strongly non-linear and wave focussing, merging etc could potentially produce counter-intuitive results. These should, however, be shown in the report/s.
    - EDF's modelling is therefore seemingly using a best-case geomorphological scenario (the Sizewell-Dunwich banks in situ) *while suggesting the modelling to be reflecting a safety case of 'conservative,' 'worst-case' modelling.* In anything from moderate to storm conditions, I consider that this is a flawed approach. See section 7.
    - Agreed. Yet, the historical record of shoreline change is not just reliant on wave arrivals- sediment supply from alongshore, onshore and offshore is a more likely key determinant of shoreline behaviour.

    - EDF's 'FRA Addendum' does not appear to offer any further explanation and states that modelling methodology remains the same as the original FRA. Again, in the FRA Addendum, the Sizewell-Dunwich banks are not mentioned by name. See section 7.

In my opinion, the wave modelling methodology appears to be based on a fundamentally false premise from BEEMS TR319, the technical document that underpins the exercise. This is explained in section 7. Modelling conducted to produce an optimal result as with most coastal engineering approaches

1.5 EDF acknowledges flooding of the main nuclear platform from the landward/marshland side in its DCO FRA:

- *"The main platform area would be inundated by water ingress from the land side due to significant inundation of the existing sand dunes/shingle defences to the north and south of the site..."* See section 4.

EDF's table below shows flooding of the main nuclear platform for still water levels and including wave overtopping:

Return period	2090 epoch		2140 epoch		2190 epoch	
	RCP8.5	H++	RCP8.5	BECC	RCP8.5	BECC
200-year	4.58	5.19	5.48	7.58	6.31	8.48
1,000-year	5.12	5.73	6.02	8.12	6.85	9.02
10,000-year	5.98	6.59	6.88	8.98	7.71	9.88

The figures in the table are sea level in metres AOD around the main nuclear platform. The red figures are marked by EDF as being significantly over the main platform height of 7.3m. RCP8.5, H++ and BECC are climate change scenarios explained in section 4. Note that BEEMS TR322 shows still water flooding of the main platform in 2090 at 1:10,000. See section 4.2.

- On inspection of the data in EDF's table above, the wave overtopping component turns out to be a small fraction of the overall level (0.1-0.5m). This is presumably because wave overtopping is considered by EDF to be controlled by the raised height of the Hard Coastal Defence Feature design submitted in the FRA Addendum. See section 7.

- However, should the Dunwich bank or its northern section be lost—i.e., orthodox and reasonable worst-case scenarios—then unbroken storm waves (the significant 1:100 offshore wave heights are 7.3- 7.8m from the N –NNE sector) will presumably be expected to break over the 'soft and erodible' Sizewell/Minsmere foreshore. *Even if the Sizewell-Dunwich banks were to remain as they are, at the water levels shown in the chart, most storm waves would freely pass over the banks to break over the Sizewell/Minsmere foreshore or Minsmere levels.* See section 2, 6.
- Concur. However, note that without additional modelling the extent of this increase cannot be accurately stated yet.

- Flood conditions then, could allow waves to break over the low-lying marshland of the South Minsmere levels and therefore increase water volumes in the Sizewell marshes around the main nuclear platform landward side. See sections 2, 6.

- Avoid use of the work 'break' as its more likely in the form of wave run-up as the wave breaking per se will likely have taken place at nearshore bars- rather, water may flood the marshland.

- EDF confirms in its FRA that: "*the main platform could potentially be inundated via overtopping of the defences to the north and south rather than the proposed sea defence alongside the main platform itself.*" See the following and sections 4, 4.2, 6,7.

Although EDF recognises the landward side risk and discusses "*horizontal projection of the extreme still water levels"* in late scenarios, in my opinion the FRA does not appear to fully consider the possibility of increased water volumes of the low marshlands from wave action in flood conditions. As stated, there does not appear to be consideration of the loss or compromise of the Dunwich bank. This is of particular relevance when the possibility of shoreline change is more fully addressed. See Executive Summary below; sections 2 to 7 and Recommendations.
Concur

1.6 Historical precedent indicates that the implications of the loss or major compromise of the Sizewell-Dunwich banks could have major impacts on coastal processes.

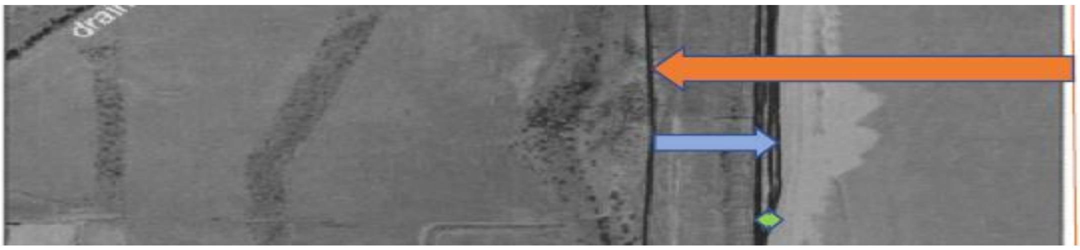
The Sizewell-Dunwich banks have limited inshore wave heights to an approximate maximum of 2.2-2.4m and provided storm protection to the nuclear foreshore. Compromise of the banks combined with climate change sea level rise and coastline energy supply will result in persistent erosional stress to the nuclear shoreline and the South Minsmere levels. See below and sections 2, and 6.

- East coast shoreline change is 'episodic' and cogent studies of impacts on coastal process should consider each of the **three** '≈100-year' major episodes recorded for Sizewell:

  1 Erosion 1736-1836: The Sizewell shoreline between 1736 and 1836 is the ***'most eroded shoreline on record'*** according to EDF in BEEMS TR058. It appears that the 1836 shoreline had eroded approximately 300m in one century to just 20m seaward of the present-day Sizewell B. The orange arrow represents this period. See section 2.

  2 Accretion 1836-1920: **The Sizewell-Dunwich bank grew after 1824 and protected the shoreline**; between 1836 and 1920 the Sizewell shoreline accreted 80-90m to roughly its present location. The present shoreline is therefore notably 'soft and erodible'. See section 2. The blue arrow represents this period.

  3 Stability 1920-2000: **1920- present day**, relative stability. The green double arrow represents this period. See section 2 for the full chart shown below.



1836 1920-present 1736

- I would have expected the DCO to show detailed study of these three periods as they are elemental to understanding impacts on coastal processes at Sizewell. However, I can only locate brief acknowledgement in EDF's DCO geomorphological papers—and EDF/Cefas's BEEMS TR311 which underpins the work—which suggest: *"The Sizewell shoreline has experienced two distinct phases in the past 180 years*." See section 2.
- **Concur and it may be obvious why they didn't show this – it would have added to the importance of any ensuing changes to the configuration of the Sizewell-Dunwich Banks on coastline erosion potential. Once again, it also points to some relationship between bank**

morphology and shoreline change, and the potential role of sediment inputs from alongshore or offshore

- The Institute of Oceanographic Sciences has raised a possible insight into why the Sizewell shoreline in particular should have been vulnerable to its historical, acute erosion: "***a concentration of [wave] energy in the Sizewell [offshore] area… energy foci [points] along the coast, notably between Sizewell and Thorpeness…especially for wave headings between 230 - 300 degrees."*** This concentration of wave energy will presumably act on the Sizewell/Dunwich foreshore in event of loss or compromise of the Sizewell-Dunwich banks. See section 2.

Yes

- The accretion period after 1824 *occurs between Sizewell and Minsmere sluice and coincides with the development of the Sizewell-Dunwich bank to the north* as noted in BEEMS. This is discussed in sections 2 and 6.

    - ***In my view this affirms the Dunwich bank's importance to Sizewell C and Minsmere's shoreline stability.*** See section 2,6.

EDF acknowledges change and lowering of the Dunwich bank as referred to earlier. See sections 2 and 6. Should this change in the Dunwich bank develop into significant compromise or loss then It must reasonably be accepted that the extreme erosion that has occurred prior to its development may return (potentially yes). The current Sizewell – Minsmere shoreline is not characterised by resistance to erosion:

- The Sizewell foreshore comprises recently accreted material, hence the shoreline must be 'soft and erodible', as EDF acknowledges. The longshore bars, now regarded by EDF as wave energy relief features, are a constituent part of this shoreline. See section 2 and 6.
- 'nearshore' is better terminology than 'coastline'

- The loss or significant compromise of the Dunwich bank will result in increased storm damage to the Minsmere shoreline and hence flooding to the flat marshlands—the South Minsmere levels—immediately northwards of the proposed Sizewell C:

    - **EDF's own research in pre-DCO, BEEMS documents states**: *"Studies… have shown that even moderate storms…have caused significant flooding … and… dune erosion between Sizewell B and Minsmere Sluice... The main reason for this long-shore variation in storm susceptibility appears to be* ***the morphology of the Sizewell-Dunwich Bank [which] is therefore of critical importance with regard to the risk of erosion and flooding between the proposed Sizewell 'C' site and Minsmere Sluice****."* See section 2.

    - According to the Environment Agency's recently released climate change work, flooding of low-lying wetlands, presumably such as the South Minsmere levels and the contiguous Sizewell marshland on the landward side of the main nuclear platform, will have a cumulative effect: ***'Nearshore waves will be higher and break later, increasing flood water volumes in areas already affected by coastal flooding.'*** See section 4.

    - These '*nearshore [onshore] waves…increasing flood volumes'* then, will be a consequence of the loss or compromise of the Sizewell-Dunwich banks combined with climate change coastline energy supply—both drivers would feed Sizewell C's ***"…primary mechanism for flooding…water ingress onto the platform from the land side."*** See section 2, 4.

It is important to consider that the loss or compromise of the Sizewell-Dunwich banks will disproportionately affect the early epochs (between 2030 and 2100 during the operational lifetime of Sizewell C. See sections 6.1 and 7.

Just a note of caution here as this is very speculative. There is no evidence that the banks will uniformly degrade in a spatial (or indeed temporal) sense. Variations in how any degradation plays out will dictate the levels of wave energy inundation to the coastline. Many scenarios could play out and this is not predictable to any accurate level. The main point, however, is that these relationships have not been adequately considered

Despite the evidence of the above, EDF suggests—in a DCO Geomorphological Appendix—that *"reductions in Dunwich Bank are **not considered** to be a worst-case scenario for Sizewell C".* This statement (which is discussed in section 2) is based on a reliance of sediment transfer replacing lost material in the system. *EDF claims that accelerated cliff erosion at Easton-Benacre will maintain both the Sizewell foreshore and the Dunwich bank.* Besides being an unsupportable premise of itself (no assumptions can be made of sediment deposition in pre-determined places or that sediment will even remain on the shoreline), it is not supported by EDF's own research which confirms:

- "*The last 2 to 3 decades of strong erosion at Dunwich were not matched by ongoing accretion in the south*." BEEMS TR223 Table 12, shows net erosion of the Sizewell C foreshore since 1993. See section 2 and 6.

  The statements from EDF on reductions in extent and volume of Dunwich Bank from marine erosion being a 'worse case scenario' are again in the category of pure speculation with no modelling carried out to support this.

Additionally, EDF's assumption is not consistent with the following:

- As stated earlier, EDF's analysis in BEEMS states that the Dunwich bank's morphology is of *'critical importance'* to erosion and flooding between Sizewell C and the Minsmere levels. See sections 2, 6.

- The historical accretion and stability periods specified above are particular to the Sizewell foreshore. It is not generalised along the coast, ergo the Sizewell-Dunwich bank is of critical importance to shoreline change processes. See section 2.

- EDF's evaluation of bank dynamics obtained from a BEEMS document obtained under FoI suggests a scenario that can only be described as worst-case: *"Rapid changes in bank form are thought to be linked to downstream bank-to-bank interactions in a sand bank complex… changes at Dunwich bank could have knock-on effects at Sizewell [bank]—There will be a tipping point…and could result in large scale reconfiguration".* See sections 2 and 6.

EDF's statement that '*reductions in Dunwich Bank are not considered to be a worst-case'* for Sizewell C appears to be misleading. In my view, any notable reductions in the Dunwich bank could represent increased, and unaccounted for, erosion and flood risk to Sizewell C.

EDF's Flood Risk and shoreline change assessments, by relying on the Sizewell-Dunwich banks as an immutable wave-relief feature in its modelling scenarios, suggest the banks' highly significant importance to flood risk and coastal processes and consequentially, confirms the profound risk of not considering the consequences of their instability and loss.
All good points above, so concur- again, other factors such as sediment inputs are not considered.

2. EDF's Expert Geomorphological Assessment [EGA]'s objective is to establish Sizewell C's future shoreline change processes and thereby show Sizewell C to be 'future proofed'—a claim that appears to be invalidated by its limited remit.

The EGA modelling studies of the coastline to achieve EDF's claimed '*very best assessment of long-term coastal change*' appears to me to be greatly limited in scope when assessing Sizewell C's potential vulnerabilities:

- EDF's EGA assessment ***ends in 2070***. This is not long-term. Sizewell C's end-of-life is 2190.

agreed

- The specified consensus of EDF's 'seven Expert Geomorphological Assessors' was a decision to adopt an unchanging wave climate and therefore unchanging Sizewell-Dunwich banks, a similar methodology to the FRA. This is despite both the knowledge of crest height and contour change of the northern section of the Sizewell-Dunwich banks and EDF noting that "*… changes to the broad coastal regime and coastal processes may occur within the station life."* See Section 5*.*
- agreed
- It is not clear to me how an analysis of shoreline change processes at Sizewell can be undertaken without fully acknowledging each of three defining periods: acute erosion between 1736-1836; accretion 1836-1920 and subsequent comparative stability. *There is a requirement to understand why the erosional episode would not be expected to repeat itself faced with climate change sea and energy level rise and any loss of the Sizewell-Dunwich banks.* See section 2.
  Shocking omission. Concur. To properly understand this, it should also be viewed in the context of the wider coastal system- i.e. beyond Greater Sizewell Bay.
- EDF's EGA states that it is *ignoring the possibility* of 'extreme events': *"A projection based on the 'reasonably foreseeable' conditions was considered the most appropriate method of reaching consensus as 'extreme events' that could occur have a low (or poorly-determined) chance of occurrence and geomorphic systems tend to be shaped by more frequent moderate events (Wolman and Miller, 1960)."* See section 5.
    - EDF/Cefas's approach is contrary to the authoritative, independent expert advice from the IPCC (Intergovernmental Panel on Climate Change) which states that 'extreme events' will become much more frequent in many areas by 2050. See section 4 and 5.
    - Agreed to a point but 'many areas' is vague and can be used against you

EDF's statement that it is explicitly *ignoring the possibility* of extreme events and has a reliance on geomorphological, offshore stasis are, in my opinion, formally invalid arguments, evidence of the unsuitability of the EGA and sufficient cause for rejection of the study. I suggest that the opportunity and capacity within which the review has taken place combined with one of the expert geomorphological assessor's explicitly stated view that the Sizewell C forecasts *cannot extend reliably beyond 10 years*, fully makes the case for an independent, re-appraisal of shoreline change processes. See below and section 5.
Agreed- it also emphasises the lack of knowledge on the effect of episodic events on this coastal system.

3. The geomorphological assessment requirements of government's National Policy Statement for Nuclear (EN-6) and National Policy Statement (EN-1) do not appear to have been met.

EN-6: Government's 'National Policy Statement (NPS) for Nuclear Power Generation' (EN-6) instructions and guidance on geomorphological issues, defined in its 'Appraisal of Sustainability', are as follows:

> *"3.8.3 In light of the findings of the Nuclear AoS [Appraisal of Sustainability], applicants should assess the site's geology… and geomorphological processes in order to understand the ongoing…coastal and geomorphic processes."*

In my opinion, EDF's compromised geomorphological shoreline change appraisal, insufficient full bathymetric surveys of the Sizewell-Dunwich banks and untenable reliance on offshore geomorphological stasis do not seemingly meet these requirements in their present form. See section 9.
Agreed. Additionally, they have also ignored the seabed environment seaward of the Dunwich Banks. Wave attenuation will also take place here even before reaching the Dunwich Banks and therefore processes there have not been assessed.

EN-1: EN-1 (July 2011, 4.8.6) states that *"..applicants for new energy infrastructure have taken into account the potential impacts of climate change.. [for] the estimated lifetime of the new infrastructure."* EDF's EGA does not go beyond 2070.

4. Climate change—energy-level and sea-level rises.

4.1 Energy-level rise:

- The increasing rate of storm delivery, particularly from 2050, affirmed by accredited sources such as the IPCC, will result in greater overall energy level delivered to shorelines. This will have more relevance to 'soft' coastlines such as Sizewell. It is not clear that EDF and its advisors have used the latest modelling techniques—such as Accumulated Excess Energy—in their shoreline assessments. See section 5.

4.2 Sea-level rise (still water flood risk):

- EDF states that, "*The level of the platform (7.3m AOD) was designed such that it was located above the extreme still water levels up to the 1,000-year event 2190 epoch (end of life) under the **reasonably foreseeable** climate change scenario".* See section 4.2.

  This means that the platform was designed to withstand a 1953 flood level based on the RCP8.5 sea-level rise climate scenario—in this case the water would be just under 1m from flooding the main nuclear site with no wave action considered. See section 4.

agreed

- If the 'BECC Upper' climate change scenario of sea-level rises is considered—a scenario closer to extrapolated 'H plus plus'— then main platform flooding would be significant (1.14m) with a 1953 flood level. See section 4, 4.2.

    - H++ is the climate scenario defined and recommended by UKCP18 to be used by planners, but no data have been supplied beyond 2100. See section 4.

- EDF in BEEMS TR322 suggests a 1:10,000 still water flooding of the main platform 100 years earlier in 2100 at 7.63m instead of 6.59m listed in the main DCO documents. See section 4.2.
    - It is therefore not clear to me why Sizewell C is regarded as meeting ONR requirements for flood resilience. See section 9.2.
    - agreed

The suitability of a 'reasonably foreseeable' climate change scenario and a 1953 flood level as the defining design parameters for flood risk, does not, in my opinion, provide reassurance. See section 4, 7.
Agreed, weak statement from them.

5. Overtopping levels. EDF's 'tolerable' wave overtopping levels of the main nuclear platform do not appear to be independently validated.

After changes in the permanent sea defence crest heights, EDF has modified its position in the FRA Addendum for its 'tolerable' wave overtopping levels onto the main platform:

- In the original FRA, EDF stated that its 'tolerable' overtopping level of *"…**5 l/s/m** should be considered very conservative [safe]."* This figure was not independently validated by any means that I am aware of. See section 7.

- Despite EDF's claim that 5 ls/m was very safe, in the FRA Addendum EDF reduced its 'tolerable' overtopping level to 2 l/s/m, a figure seemingly extrapolated from coastal defence design tolerance data and is therefore ambiguous. In some instances, EDF uses 1 l/s/m in the FRA Addendum as the acceptable limit. See section 7.

The change is welcome but shows a degree of variance and uncertainty. Independent expert opinion affirms that *"…overtopping rates became a danger to vehicles [and people] when the mean discharge exceeds 0.2 l/s/m"* and less than 1 l/s/m to prevent overtopping flood damage occurring to equipment set back 5-10m from the seawall. See sections 7 and 10.

6. Permanent Sea Defence (HCDF) crest height—EDF's proposed sea defence redesign submitted during the DCO process 'for increased flood resistance'.

EDF has submitted an extensive redesign of the permanent sea defence crest height (Hard Coastal Defence Feature -HCDF) from the originally planned 10.2m AOD.

According to the original FRA:

EDF's original FRA submitted in June 2020 that heights would be **10.2m** AOD with adaptive change to **14.2m** AOD**.** See section 7.

According to the Project Consultation Document released by EDF informing details of the intended FRA Addendum:

In its *'Sizewell C Project Consultation Document on Proposed Changes Nov-Dec 2020'* EDF proposed it would become **14m** AOD, with adaptive change to **15m** AOD. (Paras 4.8.8, 4.8.12).

According to the FRA Addendum itself:

The FRA Addendum of January 2021—in order to achieve a more *"conservative tolerable overtopping rate"*—changed this to become **12.6m** AOD (with landscaping to **14.6m** AOD) and adaptive change to **16.4m** AOD (with landscaping to **18m** AOD)**.** See section 7.

These somewhat precipitate changes are welcome but concerning in their variance and uncertainty. An independent Flood Risk Assessment could verify and confirm that EDF have now correctly assessed the permanent sea defence height and unchanged main platform level. See section 7.

- The Hard Coastal Defence feature protects the seaward aspect of the proposed Sizewell. The landward aspect of the nuclear platform is exposed to the low-lying Minsmere levels and SSSI.

EDF states in its FRA Addendum that the 'adaptive' raised crest height of 14.2m—suggested as a 'potentiality' in the original FRA would, in fact, have been required by 2046 – little more than a decade after plant completion. EDF also affirms that it was aware of this requirement at the time, however:

- The newly proposed Addendum Hard Coastal Defence Feature, landscaped to 14.6m, reduces to 10m as it meets the adjoining defences for Sizewell B—presumably a risk to both Sizewell B and Sizewell C stations by 2046 according to EDF's statement above. Sizewell B will not reply to my correspondence. See section 7 and 10.
- agreed

7. Other professional bodies have concluded the Sizewell site is vulnerable:

Based on the international consensus of scientific projections found in the IPCC and UKCP18 reports, the Institution of Mechanical Engineers (IME), the Environment Agency and DEFRA each variously suggest that the Sizewell location is vulnerable to risk from flood or coastal processes. The IME suggests that 'abandonment and relocation' of Sizewell power stations could be required. See Section 9.

8. Spent fuel and the date it will be removed from site—EDF's flood resilience timescale needs independent validation.

I consider the single most important factor in environmental risk for Sizewell C relates to the onsite cooling and storage of spent fuel in the face of risk from climate change sea level rise, storm events and the loss or compromise of the Sizewell-Dunwich banks. **It must be clearly understood that Sizewell C will be a nuclear waste storage facility until at least 2150 and possibly much later**:

agreed

The Nuclear Decommissioning Authority (NDA) states that the Sizewell C spent fuel will require 140 years to cool to 100°C (the required limit for geological disposal) based on four fuel assemblies per canister with a 65 GWd/tU burn rate. The NDA continues by saying that if the number of fuel rods per canister are reduced or 'inventory refinement' is adopted this period might be reduced to 90 years. See section 11.

- EDF, however, *assumes* that the Interim Spent Fuel Store will be decommissioned much earlier, seemingly by either 2140 or 2150. EDF's assumption does not therefore appear to be independently validated. See section 11.

- The NDA confirmed cooling period suggests an 'interim fuel store decommissioning' date of 2180/2230. See section 11

Recommendations

FRA modelling and studies of coastal processes must be obliged to consider the transient nature of the offshore geomorphology. In my view, faced with the difficulty of addressing these concerns, EDF and its advisors limited the scope of the Flood Risk and Expert Geomorphological Assessments.
If the ExA wishes to proceed with the DCO application, then I suggest the following points could be actioned by the Examiners:

1. Flood Risk Assessment (FRA):

There is a requirement for clarity regarding the data and methodology of the EDF/Cefas/Haskoning FRA modelling and its treatment of the offshore geomorphology as discussed in this paper. EDF/Cefas could be asked to respond to the following:

1.1 Explain how the wave energy relief features—primarily the Sizewell-Dunwich banks but including the nearshore bars—have they been used in its FRA wave overtopping modelling. Has offshore morphological change been considered? If any aspect of the current FRA is found to be dependent on offshore geomorphological stasis to any temporal degree, then:

Agreed, must be all-inclusive

1.1.1 Provide a Sizewell C Flood Risk Assessment that respects the geomorphological orthodoxy of offshore instability and change. This should include a compromised Sizewell-Dunwich bank and missing longshore bars over all epochs.

Agreed

1.1.2 Provide the reassurance of using the industry standard ***EurOtop*** modelling package instead of the *Amazon* modelling used in the DCO application. There is a requirement for a full analysis, for all epochs, of increased water volumes caused by waves breaking onto the South Minsmere levels feeding the contiguous Sizewell marshlands and consequent risk to inundation of the nuclear platform from the landward side. The extent and application of EDF's current 'horizontal projection' is not clear.

Needs to say what is <u>not</u> being delivered by using AMAZON perhaps?

1.1.4 Explain Cefas' Tomowac wave transformation data which appear to have limited compliance with the orthodox, academic, and empirically validated position that the Sizewell-Dunwich banks create inshore stability through a lower energy wave climate.

- An independent expert review into these data would be required if they are to be used to support the new FRA model.

  Agreed

1.2 Confirm that it is certain that 'reasonably foreseeable' climate change projections are the sufficient and defining arbiter of flood risk resilience.

Agreed

1.3 Explain why the Sizewell-Dunwich banks—acknowledged by EDF to be '*critical*' to the Sizewell and Minsmere coastline stability and security— were downgraded in importance in the FRA and not clearly and openly named and referenced.

Agreed

1.4 Confirm its view on the stability and resilience to erosion and change of the Sizewell and Dunwich banks and the nearshore longshore bars.

Agreed

1.5 Explain why it is '*logical to focus the majority of subsequent work (e.g., wave run up studies) on present bathymetry'* because *'present bathymetry'* has been '*accurately surveyed'.* Ask Cefas to explain exactly what they mean by 'present bathymetry', namely, what features are deemed to be its constituent parts, where are the 'accurate' bathymetric data and when were they established? See section 7.

Agreed, 'present' needs to be associated with a date

1.6 Explain fully how the 'Baseline Scenario' (the Sizewell-Dunwich banks in situ) resulted in its claim that this would represent a higher inshore wave climate (and hence its subsequent claim to conservative, worst-case modelling conditions). *Ask EDF/Cefas to particularly consider moderate waves to storm condition waves in early epoch (to 2100) in low return period water levels—1:10 to 1:500.*

2. Expert Geomorphological Assessment (EGA) and shoreline change:

2.1 I suggest the Examiners ask the seven geomorphological experts—they are named by EDF in the DCO—to explain the apparent limits on the opportunity and capacity of their work on shoreline change processes. In my opinion there is a requirement for a re-assessment—or independent assessment—that respects the geomorphological orthodoxy of offshore instability and change. This should include a missing Dunwich bank and longshore bars and be based on H++ or at least high percentile RCP8.5 climate data *to end of station life.*

Agreed- given work that we cited in our report about the alongshore and long temporal reach of hard defences, there is no justification for the current spatial and temporal restriction of the EGA. A wider and longer-term historical perspective e is also needed to place Sizewell in proper geomorphological context.

Ask EDF/Cefas the following:

2.2 What is the justification in the statement that loss of the Dunwich bank would not represent a worst-case scenario for Sizewell C. EDF's premise is based on *'cliff erosion and increased sediment supply minimising the chance or degree of exposure of the HCDF'*. This does not appear consistent with its own evidence: *"The last 2 to 3 decades of strong erosion at Dunwich were not matched by ongoing accretion in the south*." See Section 2 and 6.

Yes, this evidence shows the lack of a simple relationship between erosion and accretion

2.3 Fully justify the surprising premise that Easton-Benacre cliff erosion will supply and maintain the Sizewell shoreline, the Dunwich banks and the longshore bars as claimed. See section 2.

2.4 Explain its '*plausible time window'* for the *'exposure'* of the Hard Coastal Defence Feature HCDF by 2053 – 2087— is this forecast assuming a stable Dunwich bank?

2.5 Explain why does BEEMS TR311 *'Synthesis for Environmental Impact…and coastal geomorphology'*, a document that underpins the geomorphological studies, and EDF's Geomorphology studies in the DCO itself, does not consider the period of extreme Sizewell shoreline erosion, 1736-1836—a period that seems pivotal in understanding the impacts on coastal processes.

2.5.1 Explain why this period of extreme erosion is not expected to repeat itself in event of climate change and the loss or compromise of the Sizewell-Dunwich banks, particularly the Dunwich bank.

2.6 Has climate change coastline energy supply change been considered in their shoreline change assessments. It appears that dated, simplistic models (Wolman, Miller) have been relied on.

2.7 Explain their mandate that "*extreme events' that could occur have a low (or poorly-determined) chance of occurrence".* Please explain with clear reference to climate science predictions of greatly increased storm frequency.

2.8 Explain why their assessment is limited to 2070; *end of plant life is 2190.*

2.9 Explain the spatial restriction of the assessment to a 3km stretch of coastline when it is well understood that geomorphic systems are linked, and longer-range impacts must be understood.

Agreed for 2.2 – 2.9

3. Explain the inconsistency of sea defence height requirements. The adjoining Sizewell B has a 10m AOD sea defence crest height when Sizewell C requires a 14.6m adaptive to 16.4m AOD defence crest height. (EDF has stated the Sizewell C would have a requirement for a 14.2m height by 2046 and therefore the 10m AOD defence crest height of Sizewell B must represent an overtopping risk to both stations.) EDF at Sizewell B will not respond to my correspondence; the ExA could make these enquiries.

4. Request EDF to clarify why it has not undertaken regular, full bathymetric surveys of the Sizewell-Dunwich banks. EDF's statement that the banks are 'too large to be surveyed' lacks substance. Alternatively, if EDF/Cefas have in fact made regular, full bathymetric surveys, to explain why the information is not available in the FRA. There should also be an assurance from EDF that it will regularly perform full bathymetric surveys of the banks during station lifetime.
   Note that these environments are notoriously difficult to survey for bathymetric info due to wave breaking in the relatively shallow water making the boat work (multibeam) or airborne (LiDAR) very opportunistic. They may justify why therefore extensive bathy may not exist.

5. Establish whether EDF's approach to the Sizewell-Dunwich banks and its FRA and EGA methodology meets the geomorphological standards and requirements of government's 'Appraisal of Sustainability' defined by the National Policy Statement (NPS) for Nuclear Power Generation' (EN-6).

6. Ask EDF to verify the date when it expects the Spent Fuel Store decommissioning *to be completed*. Ask EDF to explain the timing with reference to the Nuclear Decommissioning Authority (NDA)'s guidance on spent fuel cooling requirements and obtain independent confirmation of these dates from the NDA.

7. Establish by independent expert views what constitutes 'tolerable' wave overtopping flood levels of the Sizewell C main nuclear platform from the perspective of safety of nuclear buildings, equipment and people and ask EDF to confirm how it extrapolated and validated its varied 'tolerable' overtopping limits.

Making sure that surge is also factored in for onshore-directed storms

The following points also need consideration:

- EDF's commitments made in its public information DCO Newsletter, '*Doing the Power of good to Britain*', quoted in the next section do not appear to have been met. Statements that could be seen as misleading should reasonably be corrected. See section 5.

- Academic papers and variables used and referred to in EDF's DCO documents that are proprietary must be *clearly* placed in the public domain—papers such as British Energy (BEEMS) Technical Reports: TR252, TR322, TR319, TR223, TR403, TR139, TR317, TR058, TR500, TR107, TR308, TR357; 'BECC Scoping Paper, *How to Define Credible Maximum Sea Level Change Scenarios for the UK Coast*. *January 2014;* Cefas TOMOWAC modelling spreadsheet *'2110_HS_WL_boundary conditions.xlsx'* which defines flood modelling variables such as 'Cefas codes', 'Combination Codes' and 'JP codes'.

  Note: I have obtained these documents under Freedom of Information (FOI). The documents have proved vital in understanding aspects of the DCO documentation considered by this paper. Some BEEMS documents in whole or part are embedded in the DCO (See Note 2 below).

- There is a need to establish how extreme sea 'return periods' should be considered beyond 2050. The IPCC states that "*Extreme sea level events that are historically rare (once per century in the recent past) are projected to occur frequently (at least once per year)".* When the probability of an event occurring increases, it means that it becomes more likely and therefore the return period for that event decreases. There is a lack of clarity on how and whether this decreasing return period is appraised. Independent experts could advise.

agreed

- The Met Office UKCP18 *'…recommends that decision makers make use of multiple strands of evidence, including H++'.* Coastal nuclear planning requires independent, authoritative H++ sea-level and energy-level parameters towards the end of the 2100s for an effective FRA yet only 'Exploratory data' are available beyond 2100. The ExA could ask the Met Office and the EA to clarify the position. See section 4, 4.1.

Notes

1. EDF pledges to *"… make sure we provide the best opportunities we can for people to engage with the application when it is submitted."* This paper engages with the Development Consent Order (DCO) application and is an independent appraisal. The paper's worthiness must be established by expert bodies notwithstanding the considerable effort expended to substantiate all relevant parts of the case made. It must be noted, however, that this exercise is hampered by EDF's narrative which can be opaque in critical areas and makes references to many related documents, not all of which are available. See Note 3. Statements made in this document are my opinions, there is a basis to those statements and are therefore statements that any honest person could make.

2. Sizewell C timeline according to EDF from the DCO documents:
   - 2022: start of construction.
   - 2034: end of construction and start of operation (sometimes quoted as 2030).

   [EDF's Assessment of shoreline change ends 2070]
   - 2090: end of operation.
   - 2140: interim spent fuel store decommissioned. [NDA data suggest 2180-2230]
   - 2190: theoretical maximum site lifetime.

   DCO: Main Development Site Flood Risk Assessment. Op cit., section 1.2.16. Page 18.

The above dates are confirmed in the FRA Addendum in the same format but 'decommissioned' is changed to 'decommissioning'. See Section 11.

3. BEEMS 'British Energy Estuarine & Marine Studies' including BECC 'British Energy Climate Change', are technical documents produced and commissioned by the nuclear energy industry to research coastal processes. British Energy has been a wholly owned subsidiary of EDF from 2009. The reports were not in the public domain; some have appeared embedded in DCO documents. These documents are used as defining references by EDF in the Sizewell C DCO and, having been obtained under FOI, are therefore extensively referred to and quoted in this paper.

3.1) The BECC report, '*How to define credible maximum sea-level change scenarios for the UK coast',* is the main climate change reference document used by EDF in its Flood Risk Assessment for all later epoch flood risk scenarios, however, this document, along with certain other essential BEEMS documents are '*not held by the Environment Agency'*.
I consider this a matter of concern. Ref: EA letter: EAn/2020/177503, 12/8/2020.

4. Cefas describes itself as 'Government's marine and freshwater science experts'. Cefas, in tender documentation, states that it *'supports the construction of Sizewell C nuclear power station (SZC) by monitoring changes in the shoreline position and the geomorphology of nearshore features using a range of methods.'* Cefas has prepared, or partnered, many of the BEEMS publications and supplied much of the FRA modelling data to EDF.

5. Levels: AOD (above ordnance datum), OD (ordnance datum) and ODN (ordnance datum at Newlyn) are to all intents and purposes the same reference level. In Britain, the datum is mean sea level (MSL) defined as the mean sea level at Newlyn Cornwall between 1915 and 1921. The difference between MSL Newlyn and MSL Sizewell is +0.14m AOD. (See Mott Macdonald op.cit., p 12 which states 0.12-0.16m).

6. Block quotes in the paper carry quotation marks to make clear they are direct quotations. Any bold typeface within a quotation has been added by me for emphasis.

7. Sources: All documents cited in this paper are from the public domain, obtained under Freedom of Information as stated and, in the case of academic documents, purchased (from Elsevier, JSTOR and Inst. Ocean. Sciences) No proprietary information has been referred to or accessed at any time.

8. The Environment Agency and the Office for Nuclear Regulation have been regularly updated with copies of this paper and its periodic revisions. The pre-Addendum version of this paper has also been uploaded to the Sizewell C Planning Inspectorate public domain website at the earliest possible opportunity (November 2020). A pre-application version of this paper was sent to EDF including Julia Pyke in May 2020. The paper has been regularly updated as changing circumstances and information are made available. Clear and open explanation and justification of points made has been attempted at all times so that nothing comes as a complete surprise throughout the examination process to the applicant or the linked statutory consultees noted above.

9) Wave overtopping: the volume of water that 'overtops' a sea defence is measured in litres per second over a one metre length of sea wall (hence the unit l/s/m).

10) EDF's initial Flood Risk Assessment (FRA) was published on the Planning Inspectorate (PINS) website in June 2020 followed by a Flood Risk Assessment Addendum (FRA Addendum) in January 2021.

1. Introduction.

This paper is an independent appraisal. It is neither pro nor anti-nuclear as an ideological stance and does not address this idiom.

The paper concerns itself with the long-term safety of the project from flood and geomorphological processes on what is universally deemed an erodible coast. Assessments of these criteria are of particular importance to the examination of the Sizewell C DCO application as the site requires an extended period of protection to cool and store the high burn-up spent fuel created during the lifetime of the plant.

The paper studies stability at the Sizewell site and how it is related to the protective nature of the offshore Sizewell-Dunwich banks. It considers the geomorphology and historical bathymetry of these banks, the effect of climate change and whether they can be relied upon to be sufficiently stable until at least 2150.

The paper considers EDF's references to the Sizewell-Dunwich banks in the Flood Risk Assessment (FRA) and its shift in emphasis pre-DCO to DCO documentation by the introduction of new wave energy receptors. It also looks at the FRA modelling undertaken by EDF in the DCO and considers the overall adequacy of EDF's approach and analysis of the stress to the Sizewell foreshore and hence the risk to the Sizewell C nuclear complex.

In EDF's Sizewell C 'Latest News', '*Doing the Power of good to Britain*', released after the Development Consent Order application was accepted for examination, EDF states:

> *"The plans we have developed for Sizewell C need to be 'futureproof', so we have undertaken extensive studies of the coastline. We modelled potential future scenarios along the Sizewell coast, with and without Sizewell C, to fully assess the effect of the station on coastal processes (and vice versa). We included the highest plausible, Sizewell-specific climate change predictions in the current guidance from the Met Office Hadley Centre Climate Programme, usually referred to as UKCP18. Independent experts were asked to critique the forecasts to provide the very best assessment of long-term coastal change."*

This paper examines whether EDF's DCO documentation is consistent with the stated goals.

2. Overview of Sizewell coastal erosion, morphology and stability. The importance of the Dunwich bank to coastal processes.

The Greater Sizewell bay, the proposed location for Sizewell C, is located between Thorpeness and Dunwich. Historical erosion on the Suffolk coast is known to be **'episodic'** and particularly noticeable in Thorpeness, Dunwich, Aldeburgh, Corton, Easton Bavents, Pakefield and Felixstowe. The drivers for this erosion are forces impacting on unconsolidated geology and, according to published papers there is: "… an average recession rate of 1.49 m per year for the Minsmere and Dunwich cliffs." 'PYE, K. and BLOTT, S.J., 2006. Coastal processes and morphological change in the Dunwich-Sizewell area, Suffolk. p.468.

> Note: 'Episodic' is an observation from historical data of the coastal processes and tends to be a given for many erosion patterns. It also suggests an underlying lack of predictability as mechanisms behind the change in the cycles have not been explained. 'Thorpeness Coastal Erosion Appraisal, Final Report, December 2014', Mott Macdonald. Page 9.

2.1 Coastal processes at Sizewell—three major 'episodes'.

EDF's BEEMS report TR058, quoting Pye and Blott, states:

> *"The 1836 [1736-1836] shoreline at Sizewell is the most eroded shoreline in the records assembled by Pye and Blott (2005), being some 60 – 100 m landward of its current position and just 20 m seaward of the present location of the Sizewell B cooling-water pump house. By 1883, the shoreline had advanced by up to 130 m, presumably as a result of the increased sediment supply from the cliffs to the north."*
> BEEMS Technical Report Series 2009 no. TR058, Sizewell: *Morphology of coastal sandbanks and impact to adjacent shorelines*. Page 40.
>
> *"Major changes have occurred along the coastline in the last 1000 years, with coastal projections north of Southwold, at Southwold itself, at Dunwich and at Thorpeness all having been eroded by significant distances (up to over 1 km)".* BEEMS TR139, Edition 2: A Consideration of "Extreme Events" at Sizewell, Suffolk, With Particular Reference to Coastal Morphological Change and Extreme Water Levels. Page 4 of 301.

For details of erosion/accretion described in the following, see: *Coastal Processes and Morphological Change in the Dunwich-Sizewell Area, Suffolk,* UK Author(s): Kenneth Pye and Simon J. Blott (May, 2006), pp. 453-473. See also Pye Blott, 2005, *Coastal Processes and Morphological Evolution of the Minsmere Reserve and Surrounding Area, Suffolk*.

Three 'approximately 100-year' episodes are recorded for Sizewell:

1. **Erosion:** As stated above, the Sizewell shoreline between 1736 and 1836 is *"the most eroded shoreline in the records"* according to BEEMS TR058 quoting Pye and Blott (2005). It appears that the 1836 shoreline had eroded approximately 300m in one century and was just 20m seaward of the present-day Sizewell B. Orange arrow in the air photo below.

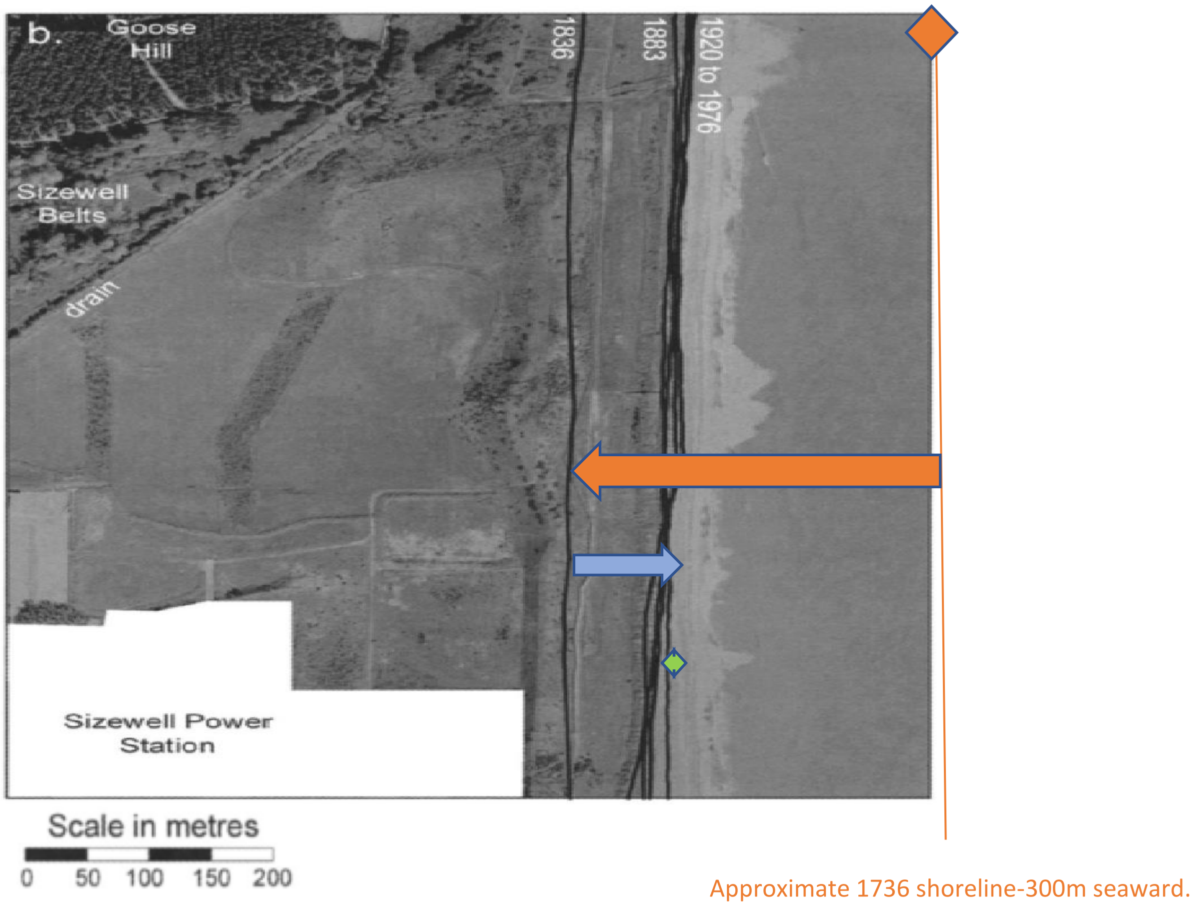
2. **Accretion:** The Sizewell-Dunwich bank grew after 1824 and protected the shoreline; between 1836 and 1903/1920 the Sizewell shoreline accreted by 83m with sediment from cliffs to the north, particularly Dunwich, to roughly its present location. The present Sizewell shoreline is hence 'soft and erodible'. Blue arrow on the air photo below.

    - BEEMS states, however, *"The last 2 to 3 decades of strong erosion at Dunwich were not, however, matched by ongoing accretion in the south".* BEEMS TR223 op cit., Page 119, Table 12 on p. 115.

3. **Stability:** 1920- present day, relative stability. Green arrow on the photo below.

The following 'air photograph' taken in 2000 showing imposed historical coastline positions and Sizewell B power station shows the three episodes:

Three major 100-year episodes of erosion, accretion and relative stability of the Sizewell shoreline discussed earlier on a large-scale air photograph:

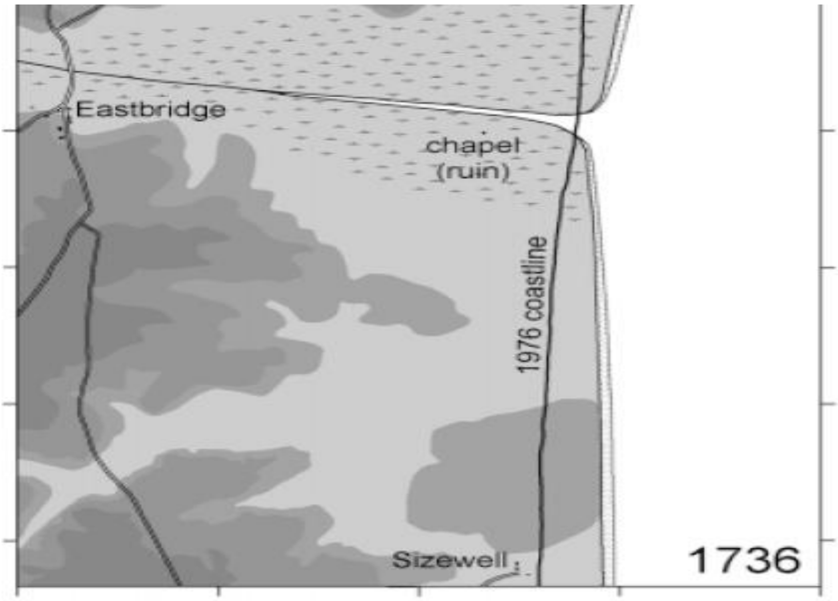


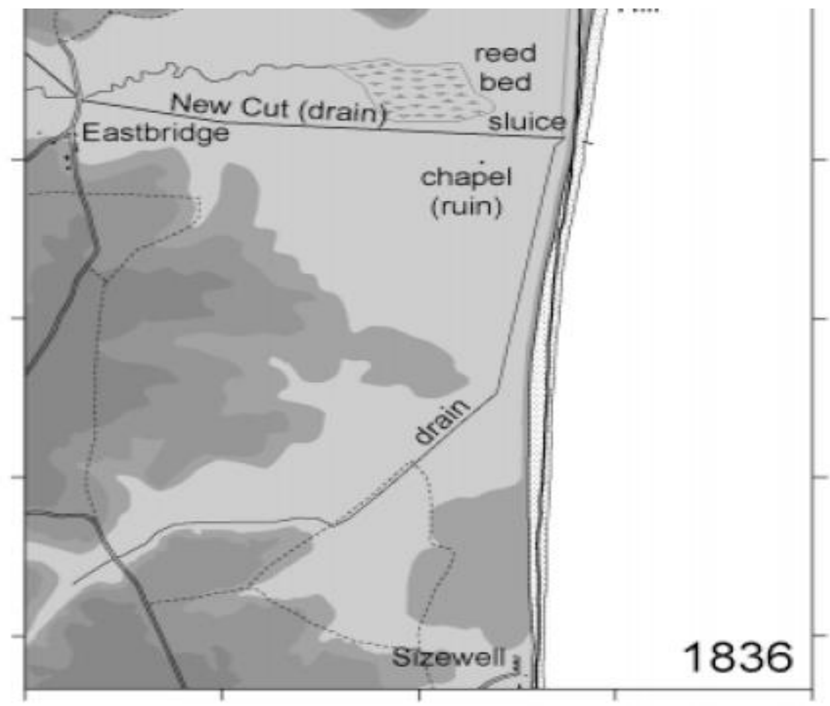
'Coastal Processes and Morphological Change in the Dunwich-Sizewell Area, Suffolk', UK Author(s): Kenneth Pye and Simon J. Blott Source: Journal of Coastal Research, Vol. 22, No. 3 (May 2006).

1. Orange arrow shows erosion period 1736-1836.
2. Light blue arrow shows accretion period post the development of the Sizewell-Dunwich banks, 1836-1920.
3. Light green double arrow shows the relative stability period 1920- present.

The following two historical maps illustrate the coastline in 1736 and 1836. The 1736 shoreline according to Pye and Blott appears to be approximately 300m-350m to seaward of Sizewell B and as stated earlier is *"…the most eroded shoreline in the records assembled by Pye and Blott (2005)".*

"Historical maps showing coastal changes at Minsmere since 1736, based on maps by Kirby (1737), Hodskinson (1783), and the Ordnance Survey (1837, 1883–84, 1928, and 1976–82). The position of mean high water in 1976 is displayed as a solid line on each map for reference. Topography is shaded at 5m intervals." See: 'Coastal Processes and Morphological Change in the Dunwich-Sizewell Area, Suffolk', UK Author(s): Kenneth Pye and Simon J. Blott Source: Journal of Coastal Research, Vol. 22, No. 3 (May 2006). Page 462





Squares are 1km scale.

My own measurements, which are not included in this document, using modern Ordnance Survey and maps drawn of the Suffolk Coast in 1737 by John Kirby et al., and allowing for major errors, suggest erosion at Sizewell *far greater* than 350m in this period 1736-1836. This is consistent with other observations on this coast such as Benacre cliffs: *"the mean rate of retreat of the Benacre Cliffs was 7.02 meters per year"* BEEMS TR311, 2.3.3.

This extreme erosion that has particularly occurred at Sizewell may be explained by the following statement that wave energy coefficients are not constant along this length of coast:

> *"Indeed [wave energy coefficients] suggest a concentration of energy in the Sizewell area, [offshore of the Sizewell-Dunwich banks] especially for wave headings between 230 and 300 degrees. Wave refraction calculations also suggest that, particularly with waves come from the direction of maximum fetch (210 degrees), there are energy foci along the coast, notably*

between Sizewell and Thorpeness." Institute of Oceanographic Sciences, Sizewell-Dunwich banks field study, Topic Report 6, Carr, King, Heathershaw and Leeds. Page 15

2.2 EDF's consideration of Sizewell coastal 'episodes'.

EDF/Cefas, in its consideration of the impacts on coastal processes appear to overlook the much of the detail of these events briefly commenting on only two distinct phases:

- In the BEEMS TR311 historical backdrop it states: *"The Sizewell shoreline has experienced two distinct phases in the past 180 years*." BEEMS TR311 Sizewell Coastal Geomorphology and Hydrodynamics Syntheses. Section 2.3.6/2.3.6.1.

- This is repeated in EDF's main geomorphological DCO documents: "*The Sizewell shoreline has experienced two distinct phases in the past 180 years."* DCO: Appendix 20A Coastal Geomorphology and Hydrodynamics: Synthesis for Environmental Impact Assessment, Page 37.

2.3 The development and importance of the Sizewell-Dunwich banks.

In my view the development of the Sizewell Dunwich banks was pivotal in the ending of the erosion period and the change to accretion and relative stability. *I am unable to locate periods of significant (approximately 80 m), non-transient accretion on this section of coastline from 1836 anywhere except at Sizewell. I suggest this affirms the ineluctable importance of the Sizewell-Dunwich banks to Sizewell shoreline stability.*
This all seems quite consistent as a set of observations of shoreline change and bank morphology **It is surprising that such a straightforward historical analysis wasn't presented by the EGA.** The links between bank and shoreline behaviour, are unlikely to be straightforward, but the observations reported here do draw attention to the shortcomings of the EDF reporting. Further, while this is a reasonable view of the possible relationships modelling would need to be conducted under the scenario of multiple offshore bank configurations and resulting wave modelling run over these to the shoreline. This has not been undertaken so both sides are still strongly in *supposition mode* when stating the viewpoints, leaving various counter arguments until proven otherwise.

The following points support this view:

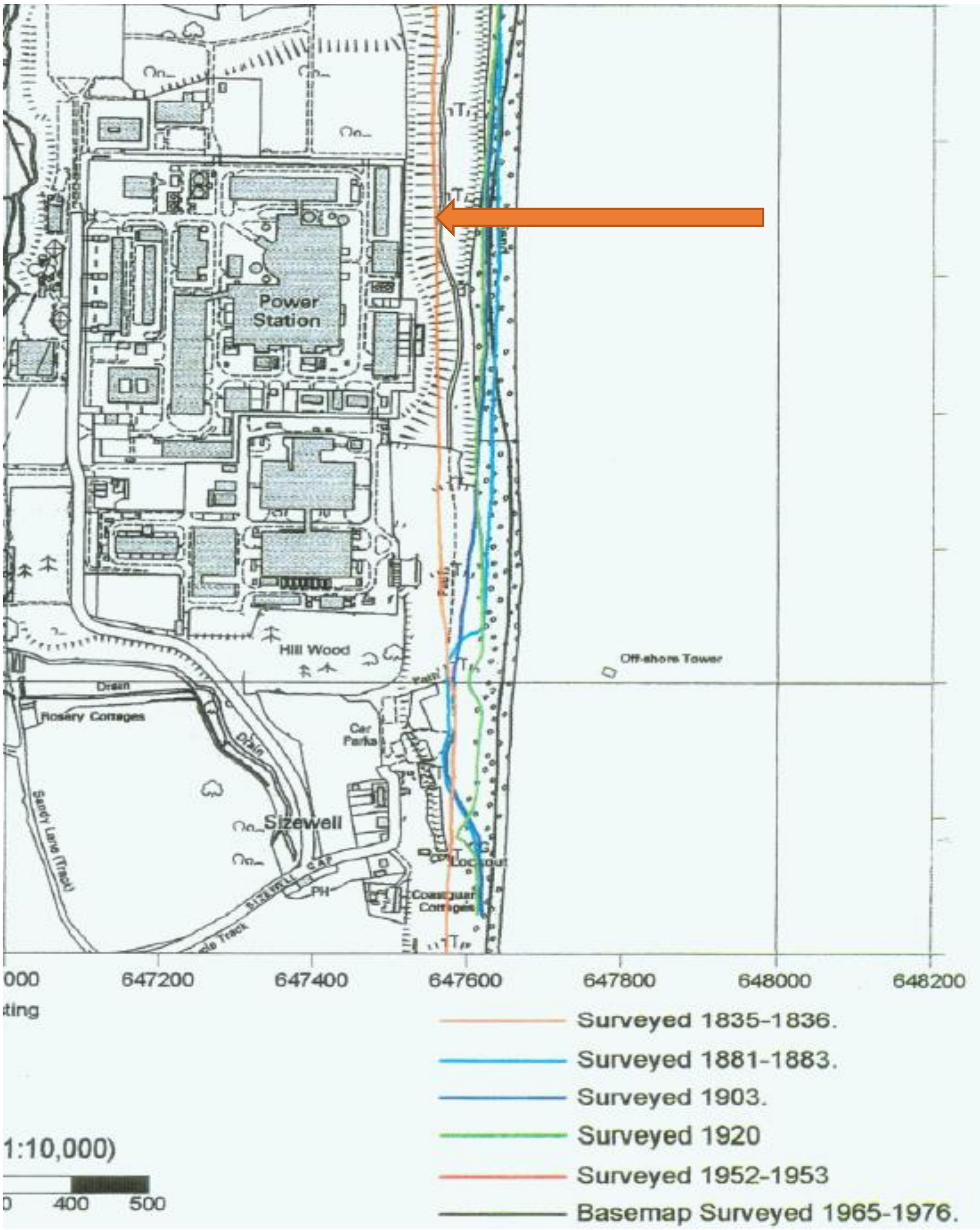
- *"Between 1835 – 1930 the northern part of the Sizewell – Dunwich Bank system grew significantly in size"* BEEMS TR223 Page 137.

- *"Evidence from historical marine charts and maps suggests that Sizewell Bank was in existence at least by the 1820's, but the bank extended northwards rapidly towards Dunwich during the period 1824 to 1930."* BEEMS TR107, Page 83

- *"Growth of the Sizewell-Dunwich Bank after 1824 probably also played a role"* BEEMS TR139, page 1. Many references to bank growth of the bank in this period in this paper.

- *"The present regime is considered to be the result of: …an overall reduction in inshore wave energy due to growth of the Sizewell – Dunwich Bank (elevation, width and extent), which is thought to have been a sink for some of the material eroded from Minsmere – Dunwich Cliffs during its 19th Century erosive phase"*
EDF DCO: Coastal Geomorphology and Hydrodynamics, Appendix 20A. Page 19.

The following two charts '*Changes in coastline position and MLW position from historical OS maps*' clearly show the geographical location of the period of accretion being coincident with the development of the Dunwich bank after 1824. The shoreline beyond the protection of the Dunwich bank did not accrete and continued eroding.

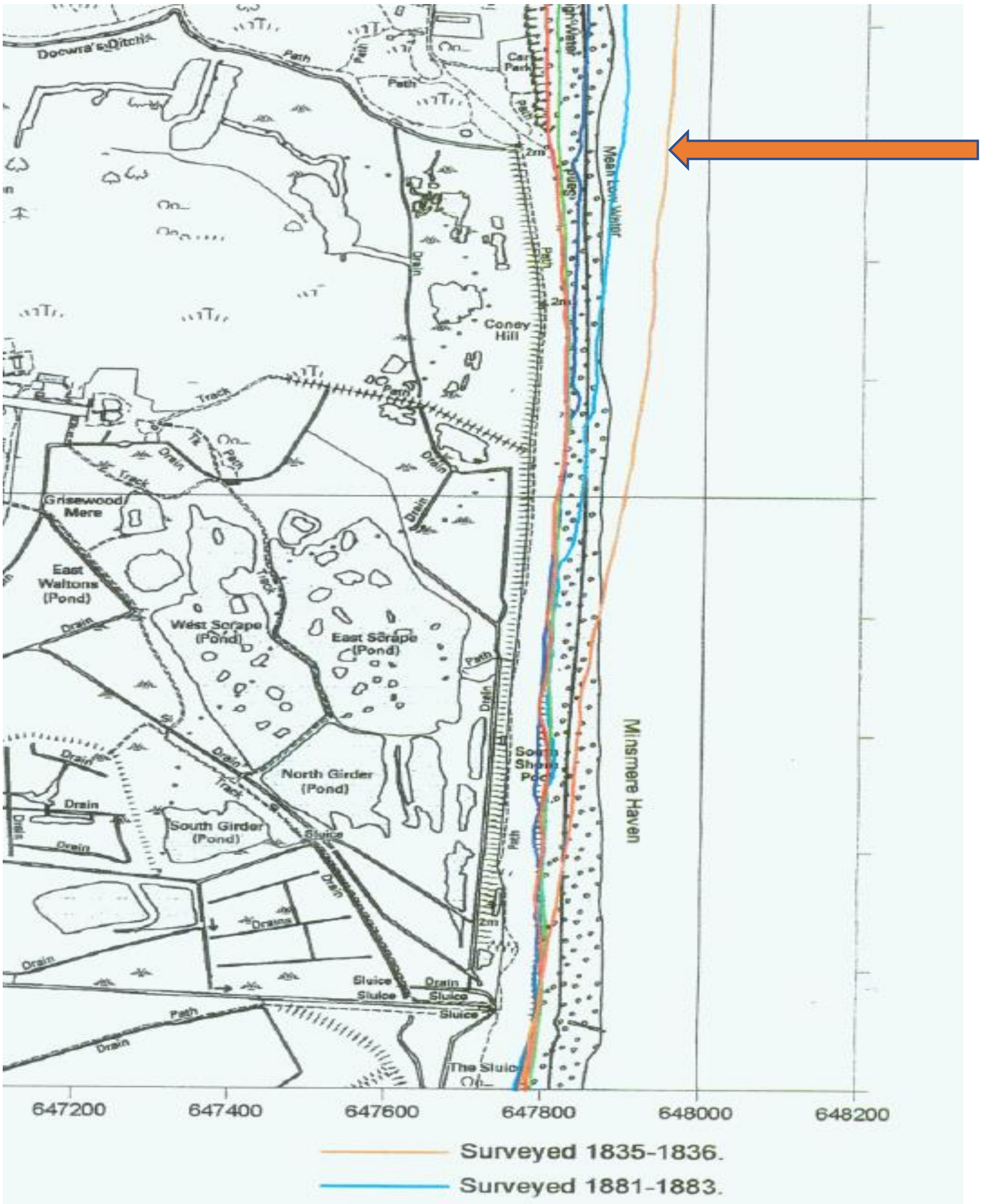


Pye, Blott, 2005 Coastal Process and Morphological Evolution of Minsmere. RSPB.

The 1952-3 survey is not shown and starts further North. The orange arrow shows the 1836 survey line in both charts.

"Changes in coastline from historical OS maps". Map 1 – Sizewell.

Note that the 1835-6 survey line is further ***landward*** than present at Sizewell. *(Hence, protected by the development of the Dunwich bank from 1824, the shoreline accreted approximately 80m between 1836 and 1920)*
The link may not be so straightforward, but the conjunction of the bank and shoreline changes is certainly ***intriguing and worthy of further study.***



Pye, Blott, 2005 Coastal Process and Morphological Evolution of Minsmere. RSPB.

"Changes in MLW position from historical OS maps". Map 2 – North of Minsmere sluice.

Note that the 1835-6 survey line is further ***seaward*** north of Minsmere sluice. *(Hence, unprotected by the Dunwich bank, erosion continued between 1836 and 1920).*

A technical paper, *Cumulative versus transient shoreline change: Dependencies on temporal and spatial scale* Eli Lazarus et. al., offers a scientific validation of the shoreline—offshore bank relationship and suggests that long-term shoreline behaviour may be partly explained by "*hydrodynamic interactions with nearshore geologic bathymetric structures*" (i.e., the Sizewell-Dunwich banks in our case). This paper is freely available at the following location: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2010JF001835

In summary, it seems reasonable to suggest that the accretion/stability period is geographically coincident with the development of the Dunwich bank and therefore if the Dunwich bank were to be lost or compromised, that the shoreline at Sizewell could return to a period of extreme erosion. agreed

2.4 The stability afforded to the coastline by the Sizewell-Dunwich banks.

EDF, in pre-DCO documents, states that the Sizewell Bay currently benefits from a stability which has been recognised as related to the offshore Sizewell-Dunwich banks, a complex as noted, started to grow after 1824 (BEEMS TR139 op, cit., Page 1). EDF, in its pre-DCO Scoping document, for example, states:

> *"The [Sizewell-Dunwich] bank represents a natural wave break preventing larger waves from propagating inshore and thus reducing erosion rates along this shoreline.* ***As a result, the Bank forms an integral component of the shore defence and provides stability for the Sizewell coastal system****".* 'Sizewell C proposed Nuclear Development, Sizewell C EIA Scoping Report, April 2014, Planning Inspectorate Ref: EN010012, Page, 150.

BEEMS TR139, obtained under FOI, confirms the reliance on the Sizewell-Dunwich banks for foreshore stability:

> ***"Although the Sizewell shoreline has been relatively stable during the past 150 years, a return to erosion could occur if there is an overall reduction in the size or crest height of the Sizewell-Dunwich Bank****, an increase in the size of the 'saddle' between the high crestal areas towards the two ends of the Bank, a significant increase in sea level (> 0.5 m), or a significant increase in the frequency, strength and duration of northerly and northeasterly winds."* TR139, Edition 2: A Consideration of "Extreme Events" at Sizewell, Suffolk, With Particular Reference to Coastal Morphological Change and Extreme Water Levels, Page 3.

I have noticed that in the DCO documents the term 'stability' of the Sizewell coastline tends to be replaced by the phrase 'present regime'. The following quote is an example:

> *"****The present regime*** *is considered to be the result of a change from the energetic NE unidirectional wave climate…an overall reduction in inshore wave energy due to growth of the Sizewell-Dunwich Bank (elevation, width and extent)… and the presence of headlands at natural and man-made hard points – Thorpeness' Coralline Crag, Minsmere Outfall and the Blyth river mouth jetties –* ***within an otherwise soft and erodible coast."***
> DCO: Coastal Geomorphology and Hydrodynamics Appendix 20A, Page 19.
>
> *"It was noted that significant attenuation of storm surge waves occurred over the Dunwich bank."* EU Stress Test, Sizewell B. Jan 2012. Page 62. ONR: European Council "Stress Tests" for UK nuclear power plants National Final Report December 2011.

The current limit to the protection of the Sizewell-Dunwich banks northward of the Sizewell A and B stations is noted below. Sizewell C, as well as being built further seaward, will be facing this northerly low-lying flood land (Sizewell A and B being slightly better protected):

> *"…the area north of Sizewell Power Station is still experiencing periodic storm erosion. This may be related to changes in the nearshore and offshore morphology, including the development of a gap between the crests of the Sizewell and Dunwich Banks through which waves are able to penetrate"*. Op cit., PYE, K. and BLOTT, page 464.

2.5 The Sizewell-Dunwich bank morphology.

I consider it is important for Examiners to understand the offshore morphology:

> *"The Sizewell–Dunwich Bank is a single sedimentary feature, 8 km in length and with a landward flank located 1.2 – 1.7 km from shore. Its higher north and south ends, often referred to as Dunwich Bank (-4 to -5 m elevation) and Sizewell Bank (-3 to -5 m elevation) respectively, are joined by a lower elevation saddle (-7 m elevation). The Sizewell-Dunwich bank must not be confused with the inner and outer longshore bars: "…the inner longshore bar is 50 – 150 m from shore of -1.0 to -3.0 m (ODN) elevation, as well as a larger outer bar 150 – 400 m from shore of -2.5 to -4.5 m (ODN) elevation".* DCO, Appendix 20A, op.cit., Page 21. <u>Section 6 has a chart of these features</u>.

Historical hydrographical surveys show that the offshore Sizewell-Dunwich bank complex has been dynamic and capable of notable structural change. This is consistent with seabed analysis undertaken by the Institute of Oceanographic Sciences. **Their survey shows that offshore and northwards of the proposed location of Sizewell C seabed samples show unconsolidated gravel, sands, intercalated sands and clay—with no erosion-resistant coralline crag in evidence.** For full information see: Lees,B J, Sizewell-Dunwich Banks field study Topic Report 88, Institute Oceanographic sciences, 1980.

The work of Lees is fully accepted by EDF:

> *"4.6.6 The majority of the seafloor within the study area is characterised by fine sands, with muddy sediments in areas of deeper water. Analysis of …. new and existent grab sample data (e.g.Lees 1980), has provided a detailed picture of the seabed surface sediments. Most of the survey area is characterised by sands at the seabed surface, in accord with the findings of other researchers (Lees, 1980; 1983)."*
> DCO: Chapter 23 Marine Historic Environment, Appendices 23A - 23C.

In recent years it has been realised that the northern part of the Sizewell-Dunwich bank—specifically, the Dunwich section north of 267000N—has shown loss of crest height and seaward contour change. In my view, the importance of this cannot be ignored. This is discussed further in Section 6 including a chart.

2.6 The South Minsmere levels and the importance of the Dunwich bank.

Sizewell C will be surrounded by the low-lying land of the Sizewell and Minsmere levels. Much of the land across Minsmere Level and Leiston Marsh (extending up to 3 km inland) lies between 0.6 and 0.7 m OD (OD = Ordnance Datum). Areas to the north of the Minsmere Old River and Coney Hill are slightly higher, at ca. 1.5 m OD. Pye and Blott, op.cit., Page 469.

EDF's BEEMS TR139, obtained under FoI, explains that even moderate storms will produce notable erosion and flooding of the low-lying areas faced by the proposed location for Sizewell C:

> *"Very extreme tide plus surge conditions, or tide plus surge plus waves, are not necessary to cause significant erosion and flooding of low-lying areas.* ***Studies to the north [the South Minsmere Levels] and south of Sizewell have shown that even moderate storms, with estimated return periods of 1 in 5 to 1 in 10 years, have caused significant flooding*** *as a result of breaching of shingle ridges, narrow dunes and earth embankments (e.g. Pye & Blott, 2006, 2009). The outer defence at the northern end of the Minsmere frontage was breached, and the inner defence partially overtopped, during moderate storms in 2006 and 2007.* ***These events also caused significant dune erosion between Sizewell B and Minsmere Sluice but*** *had relatively little effect on the beach and dunes in front of the 'A' and 'B' power stations****. The main reason for this long-shore variation in storm susceptibility appears to be the morphology of the Sizewell-Dunwich Bank.*** *Waves from the NNE are refracted across the northern end of Dunwich Bank and focused towards the shore at the northern end of the Minsmere frontage. Refracted north-easterly waves also pass through the saddle between Dunwich Bank and Sizewell Bank. The size, depth and position of this 'saddle' is* ***therefore of critical importance with regard to the risk of erosion and flooding between the proposed Sizewell 'C' site and Minsmere Sluice."***
>
> TR139, Edition 2: A Consideration of "Extreme Events" at Sizewell, Suffolk, With Particular Reference to Coastal Morphological Change and Extreme Water Levels, Page 5

If the location of the Sizewell-Dunwich banks' saddle (the gap between the two banks) is 'of critical importance' then the loss of the Dunwich bank— or a major section of— cannot reasonably be regarded as 'not worst case' as suggested by EDF/Cefas. See section 6.

- The map in section 6 of the Sizewell-Dunwich banks shows the locations of two breaches in 14-5/12/03 and 14/2/05. *"This 200 m section is the most vulnerable stretch of coastline between Dunwich and Sizewell and represents the most likely location of a major breach occurring during a future storm surge."* Pye and Blott 2005, Coastal Processes and morphological evolution RSPB, page 154 of 160. Page 28/160

2.7 EDF, however, *dismisses the importance of the Dunwich bank and its effect on coastal processes and claims it will be maintained by erosion from Easton-Benacre cliffs.*

Despite the above, EDF *dismisses the importance* of the Dunwich bank as critical to coastal processes at the Sizewell C foreshore and that it will be perfectly maintained anyway*:*

> ***"Reductions in Dunwich Bank are not considered to be a worst-case scenario for Sizewell C as they would eventually lead to cliff erosion and increased sediment supply, minimising the chance or degree of exposure of the HCDF (or the amount of mitigation required to prevent this)."***
> DCO: Geomorphology Appendix 20A, op cit., Page 52 of 167.

EDF further explains how climate change sea level rise will *benefit* the Sizewell shoreline and Dunwich bank:

> The Easton-Benacre cliffs are "***likely to remain unprotected***" and therefore ***"cliff exposure will rise with rising sea levels. The likely consequence is a rise in, or maintenance of, sediment supply [to Sizewell and] will slow rates of shoreline retreat and potentially increase accretion rates where it occurs, and over a long period of time it could counter shoreline retreat."***
> BEEMS TR311 2.4.3.1. DCO: Geomorphology Appendix 20A, op cit., Page 52 of 167

The effect of sea level rise on Easton-Benacre cliff erosion will not only apparently protect the Sizewell shoreline but ***"will result in slow growth of the Sizewell – Dunwich Bank. A growing bank that keeps pace with sea level rise will deliver similar patterns of inshore waves and shoreline change to those presently experienced."***

> BEEMS TR311 2.4.3.1. DCO: Geomorphology Appendix 20A, op cit., Page 135 of 167

These suppositions of the benefit of sea level rise resulting in the convenient relocation of sediment supply from Easton-Benacre cliffs to the Sizewell shoreline and the Dunwich bank are, in my opinion, unsupportable. Any assumption that eroded sediment will settle in pre-determined places, or even anywhere onshore, has little or no validity:

EDF states in BEEMS TR223 obtained under FoI, for instance:

- ***"The last 2 to 3 decades of strong erosion at Dunwich were not, however, matched by ongoing accretion in the south***." BEEMS TR223 Table 12, shows a net erosion of the shoreline at Sizewell C foreshore since 1993. BEEMS TR223 Shoreline variability and accretion / erosion trends in Sizewell Bay Edition 3: Updated with 2011 – 2018 data. Page 119. See also Table 12 on Page 115.

The DCO claim that "*reductions in Dunwich bank are not worst-case for Sizewell C*" is also not consistent with the following:

1. BEEMS report TR058, obtained under FOI, for example, states: *"**Rapid changes in bank form are thought to be linked to downstream bank-to-bank interactions in a sand bank complex** (Dolphin et al., 2007 and Thurston et al., 2009). **This model may have application at Sizewell-Dunwich [bank] as it is feasible that changes at Dunwich bank could have knock-on effects at Sizewell.** In addition, the narrowing of the tidal channel with shoreward advance of the inner flank will alter the local tidal flows and may lead to relatively rapid system adjustment. **There will be a tipping point beyond which further shoreward migration will significantly alter bank hydrodynamics and could result in large scale reconfiguration of the bank** (assuming the bank is not underpinned by coralline crag)."* BEEMS Technical Report Series 2009 no. 058, Sizewell: *Morphology of coastal sandbanks and impact to adjacent shorelines*. Page 45-6. The report is authored by University of East Anglia and Cefas.

2. EDF's analysis in BEEMS TR139 indicates that the Dunwich bank's morphology is of "critical ***importance with regard to the risk of erosion and flooding between the proposed Sizewell 'C' site and Minsmere Sluice."*** As discussed in section 2.6.

3. The historical accretion period discussed in this section coincided with the development of the Sizewell-Dunwich bank and is particular to the Sizewell foreshore. It is not generalised along the coast, ergo the Dunwich bank is of critical importance.

In my view, EDF's statements that the Sizewell shoreline and the Dunwich bank will be maintained by accelerated erosion from Easton-Benacre cliffs is an unreasonable assumption and that '*reductions in Dunwich Bank are not considered to be a worst-case'* for Sizewell C is misleading.

Notable reductions in the Dunwich bank could represent increased, and unaccounted for, erosion and flood risk to Sizewell C and a return to extreme erosion rates that occurred prior to the development of the Dunwich bank.
Agreed. All of this is important observation that highlights the need to expand the study area and to take account of alongshore and offshore sediment inputs. The fate of sediment from Easton-Benacre is not at all certain and to suppose that it will accrete exactly where it is most beneficial to the development is fanciful

3. Historical Flooding.

The floods of 1953 that submerged large areas of this part of Suffolk were caused by a pronounced storm surge associated with a high astronomical tide. The resulting water levels will be more frequently attained in the future due to predicted higher median baselines sea levels. It is the case that Sizewell A (built in the 1960s) and B (finished in 1995) have been subjected to and survived tidal surges but these have not been on the scale of the 1953 surge at 3.5m OD.

EDF, in the Main Development Site Flood Risk Assessment Document reports four main storm surges:

"• 1927 with tide level of 3.10m AOD;
• 1938 with tide level of 3.25m AOD;
• 1949 with tide level of 3.00m AOD; and
• 1953 with tide level of 3.44m AOD."
DCO: Main Development Site FRA, op cit., Page 65, Paragraph 5.14. AOD = Above Ordnance Datum

Pye and Blott, however list many more: "

- *"Large surges combined with high tides occurred in 1817,1883, 1897, 1912, 1928, 1938, 1949, 1953, 1976 and 1978 [and 2013] and caused regional damage to flood defences."*
  Pye Blott, 2005, Coastal Processes and Morphological Evolution of the Minsmere Reserve and Surrounding Area, Suffolk. Page 5.

The more recent major storms raised water levels as follows:

- 3 January 1976 — 2.5m OD
- 11 January 1978 — 2.5m OD
- 5-6 December 2013 — 2.75m OD

Extreme water levels expressed as 'Return events' are as follows:

The nearest Environment Agency chainage point at Sizewell is 4192. (Newlyn is chainage point zero). The applied extreme water level data at 4192, which do not incorporate any climate change sea-level rise, are:

1:200	3.13m	± 0.3m	
1:500	3.36m	± 0.3m	
1:1,000	3.55m	± 0.4m	(The 1953 level was 3.44m/3.5m)
1:10,000}	4.21m	± 0.6m	
1:10,000}	5.73m	± 0.29m	See below.

1. BEEMS TR252: Estimation of extreme sea levels at Sizewell. Page 10. Water levels Ordnance Datum (equivalent to AOD). For water levels before 2006 see: Pye and Blott 2006, op.cit., Page 457. For 2013

see: 'A comparison of the 31 January–1 February 1953 and 5–6 December 2013 coastal flood events around the UK' Matthew P. Wadey. Et al. 'Frontiers in Marine Science', 6th Nov 2015

2. *"Statistical estimates of the 1 in 10,000-year high water level for present conditions range from 3.61 m OD (Joint Probabilities Method) to 5.05 m OD (Generalised Pareto Distribution Method). A 1 in 10,000-year value of 4.26 m OD was obtained using the method of Dixon & Tawn (1997) and a 1 in 1 year level for Sizewell of 2.21 m OD"* BEEMS TR139 Op cit., Page 3.

It is interesting to note a consideration of the 2013 surge—a reassessment of the assumption that there is a low probability that maximum surges will coincide with predicted high water:

- *"Differences in the extreme water levels estimated in this report [TR322] and in TR252 are due primarily to the inclusion of this large surge event [Dec 5th 2013—The 5th December 2013 surge was only 30 minutes from the prediction of high water] …The results of this analysis further emphasise the relatively large effect on predicted extreme values of including even a single high magnitude event."* The 1:10,000 level of 5.73m is found in the DCO document: The Sizewell C Project 6.12 Revision: 1.0 PINS Reference Number: EN010012, *Reports Referenced in the Environmental Statement*. Page 71-2 of 389. This is a PDF page number.
  See BEEMS TR322 introduction.

It should also be noted that, as Pye and Blott suggest: "*Because the astronomical tidal range is small along this part of the coast, surges can have a proportionally large impact on the resultant tidal levels."* PYE, K. and BLOTT, S.J., 2006. Op.cit., pp.456-7
Totally agree with this – focussed in a narrow vertical range allowing more residential time for water levels and therefore erosion potential

4. Climate change sea-levels: expert opinion.

Climate induced sea-level rise is caused by melting glaciers (ice sheets) and thermal expansion of water due to rising global temperatures. Climate change also affects storm magnitude and frequency which changes the overall energy supplied to the coast as well as the direction it approaches the shore.

The UK Government has two main accepted reference documents for sea level change, **UKCP 18** (UK Climate Predictions UKCP18) and the **2019 IPCC (Intergovernmental Panel on Climate Change)** report.
EDF also commissioned a 'British Energy Climate Change (BECC) working group' report for their climate change and flood modelling in the 2100s. The '*BECC Scoping Paper: How to Define Credible Maximum Sea Level Change Scenarios for the UK Coast*. *January 2014*' is not in the public domain. UKCP18, the Met Office document for climate projection, confirms the accepted science of median sea level rises into the next century linked to different emission scenarios (RCPs). The IPCC (Intergovernmental Panel on Climate Change) report of 24 September 2019 stated that extreme sea level events that are rare (once per century) are projected to occur much more frequently by 2050 in many places.

According to the IPCC report:

> *"Sea level continues to rise at an increasing rate. Extreme sea level events that are historically rare (once per century in the recent past) are projected to occur frequently (at least once per year) at many locations by 2050 in all RCP (Representative Concentration Pathway) scenarios, especially in tropical regions (high confidence). The increasing frequency*

> *of high-water levels can have severe impacts in many locations depending on exposure (high confidence). Sea level rise is projected to continue beyond 2100 in all RCP scenarios."*

The IPCC report continues:

> *"Under the same assumptions, annual coastal flood damages are projected to increase by 2–3 orders of magnitude by 2100 compared to today (high confidence)".* The report continues: *"For example, extreme sea levels (e.g., the local "hundred-year flood") now occurring during storms that are historically rare are projected to become annual events by 2100 or sooner at many low-lying coastal locations."*
> IPCC: '*The Ocean and Cryosphere in a Changing Climate This Summary for Policymakers was formally approved at the Second Joint Session of Working Groups I and II of the IPCC and accepted by the 51th Session of the IPCC, Principality of Monaco, 24th September 2019*. Pages spm-22, spm-32 and 1-44.

UKCP18 states: *"We cannot rule out substantial additional sea level rise associated primarily with dynamic ice discharge from the West Antarctic Ice Sheet.* ***We recommend that decision makers make use of multiple strands of evidence, including H++ [high-end sea-level rise scenarios] when assessing vulnerabilities to future extreme water levels****."* UKCP18, op cit., Page 5.

However, these 'High End' climate sea-level rise data are not yet decided beyond 2100: *"..work to develop updated 'high end/H++' scenarios for sea level rise over the coming centuries is being explored at the Met Office in collaboration with the wider research community"*. DEFRA/EA: Exploratory sea level projections for the UK to 2300 SC150009. Page 4.

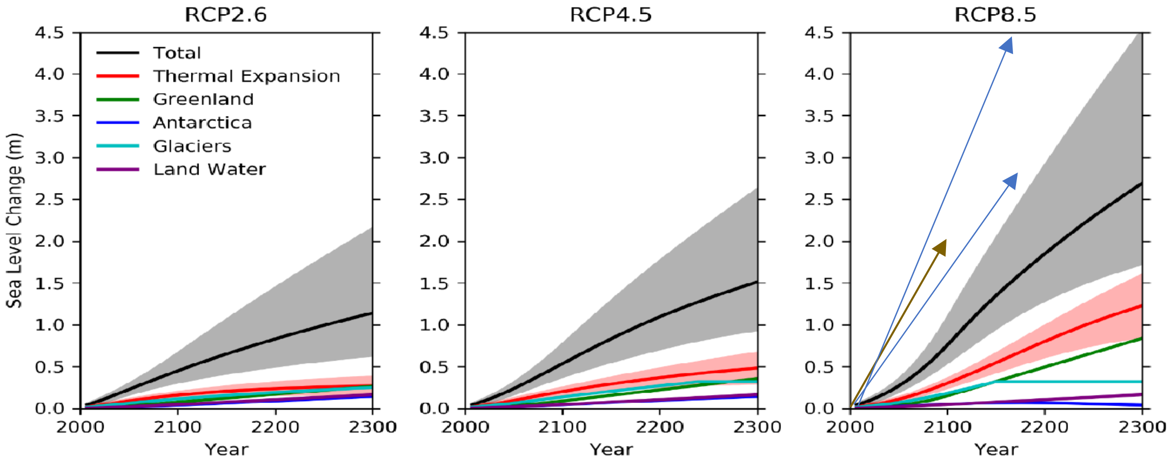
The Environment Agency document '*USE OF UK CLIMATE PROJECTIONS 2018 (UKCP18) POSITION STATEMENT – NOVEMBER 2020*' recognises that nuclear licensed sites and sites for storing or disposing of radioactive waste may have lifetimes extending well beyond 2100. It has therefore produced some extended projections for sea level rise beyond 2100 for RCP 2.6, RCP 4.5 and RCP 8.5 – and these are referred to as '*exploratory post-2100 sea level rise scenarios*'. In my opinion the EA document is not completely clear and does also not provide data for Sizewell.

Key findings, nevertheless, of the Environment Agency in its Exploratory Projections are as follows:

- *Higher sea levels will cause waves to carry greater energy to the shore, which will have an impact on sea defences. Nearshore waves will be higher and break later, increasing flood water volumes in areas already affected by coastal flooding. This will have implications for the expected lifetime and continued performance of coastal defences, likely requiring greater investment in flood and coastal erosion risk management to maintain current defence lines and standards of protection.*

- *There is a large degree of unquantified uncertainty with these projections, which must be recognised by anyone using the research's findings. The uncertainty is associated mostly with the potential for accelerated ice loss from the West Antarctic ice sheet"*
  The Defra/ Environment Agency document '*Exploratory sea level projections for the UK to 2300 SC150009*', ISBN: 978-1-84911-428-8. Pages iv-v.

The sea level extrapolations are shown below for the different climate change scenarios:



RCP scenarios above from: 'Exploratory sea level projections for the UK to 2300 SC150009'. Page 11

H++, shown by the brown arrow (1.9m at 2100) is the scenario 'recommended for planners'—no data, however, have been provided beyond 2100.
BECC's 'credible maximum' approximately shown by the blue arrows appears to correlate with H++. See 4.2 below.

Higher-end climate scenarios are becoming more generally accepted as a plausible as this article suggests:

- *"The US National Oceanic and Atmospheric Administration projected in 2017 that global mean sea level could rise five to 8.2 (2.5m) feet by 2100. Four years later, it's clear that eight feet is in fact a moderate projection. And regional influences — subsidence, changing ocean currents, and redistribution of Earth's mass as ice melts — will cause some local sea level rise to be 20 to 70 percent higher than global." (The red arrow)*
  See: https://www.theguardian.com/environment/commentisfree/2021/apr/13/sea-level-rise-climate-emergency-harold-wanless?CMP=Share_AndroidApp_Other

4.1 Polar (West, East Antarctic, and Greenland) ice sheet contributions to future High-end sea-level rise.

A major difficulty with providing high-end data appears to be the predictive capability of ice-sheet models to climate change sea-level rise, particularly in more extreme scenarios where probabilities have long 'upper tails'. The ice sheets: West Antarctic **(WAIS)**, East Antarctic **(EAIS)** and Greenland **(GrIS)** are regarded as the primary contributors. If we consider '*Ice sheet contributions to future sea-level rise from structured expert judgement*' Bamber, Oppenheimer, Kopp, Aspinall, Cooke, School of Geographical Sciences Uni. of Bristol, April 8th, 2019, we find the following:

> *"As a consequence, the potential contributions of ice sheets remain the largest source of uncertainty in projecting future SLR…Our findings support the use of scenarios of 21st century global total Sea Level Rise (SLR)* ***exceeding 2 m for planning purposes. Beyond 2100, uncertainty and projected SLR increase rapidly. The 95th percentile ice sheet contribution by 2200, for the +5 °C scenario, is 7.5 m as a result of instabilities coming into play in both West and East Antarctica."***

'Structured Expert Judgement' (SEJ) appears to be validated by the consensus of 22 experts, the major finding being that large amplitude, non-linear instabilities could be triggered at higher temperature climate change pathways, even by 2050. The SEJ states that the '*High-temperature scenario is roughly equivalent to business as usual*'. See Notes below the 'Summary Table'.

4.2 EDF's assessment of still water flooding of the main nuclear platform (7.3m AOD).

Inundation of Sizewell C from still water levels will be from the landward side, a fact acknowledged by EDF:

> *"4.3.9 As discussed in* ***Section 2.4****, for scenarios with extreme still water levels that are above the platform height (7.3m AOD)* ***the primary mechanism for flooding was identified as water ingress onto the platform from the land side due to significant inundation of the existing sand dunes/shingle defences to the north and south of the site."*** FRA ADDENDUM: EN010012 Main Development Site Flood Risk Assessment Addendum.
>
> *"4.3.17 Assessment of the extreme still water levels above main platform height (7.3m AOD), presented in* ***Table 4.2****, shows that for the 1 in 10,000-year event at 2190 epoch the flood depth on the platform is greater than the building threshold set in the design parameters and for the credible maximum climate change scenarios (i.e. BECC Upper) flood depths are significantly above the main platform height and threshold of the buildings. However, it is anticipated that by this time i.e. 2190, there will be very limited (if any) activities on site and most buildings would be decommissioned and demolished. [This depends on spent fuel cooling times—the NDA has suggested 140 years taking spent fuel decommissioning and removal to 2230] Also, the inundation would be limited to the peak of the surge event only, for a period of approximately 3 hours, and therefore the risk would also be time limited."* FRA ADDENDUM: EN010012 Main Development Site Flood Risk Assessment Addendum. 4.3.17
>
> *"2.4.4 As such, the main platform area would be inundated by water ingress from the land side due to significant inundation of the existing sand dunes/shingle defences to the north and south of the site (which are much lower than the proposed sea defences for the Project and the defences for the existing power stations). On this basis, the main platform could potentially be inundated via overtopping of the defences to the north and south rather than the proposed sea defence alongside the main platform itself."* FRA ADDENDUM: EN010012 Main Development Site Flood Risk Assessment Addendum

Table 4.2: Assessed flood depth on the main platform for scenarios with extreme still water level above platform height

Return Period	Epoch	Climate Change	Extreme Sea Level (m AOD)	Main Platform Level (m AOD)	Flood Depth on the Main Platform (m)
200-year	2190	BECC Upper	8.00	7.3	0.70
1,000-year	2140	BECC Upper	7.94		0.64
	2190	BECC Upper	8.84		1.14
10,000-year	2140	BECC Upper	8.85		1.55
	2190	RCP8.5 / 95%ile	7.58		0.28
	2190	BECC Upper	9.75		2.45

FRA ADDENDUM: EN010012 Main Development Site Flood Risk Assessment Addendum. Table 4.2.

However, EDF claims that under '*reasonably foreseeable'* climate change scenario there will be no flooding of the main platform up to the 1000-year event.

> *"4.3.8 The level of the platform (7.3m AOD) was designed such that it was located above the extreme still water levels up to the 1,000-year event 2190 epoch (end of life) under the reasonably foreseeable climate change scenario.* ***Therefore, it is considered that there is no risk of inundation to the platform from these events****."*
>
> FRA ADDENDUM: EN010012 Main Development Site Flood Risk Assessment Addendum

EDF in BEEMS TR322 and in the DCO, suggests a still water flooding of the main platform 100 years earlier in 2100 using H++ sea level rise as 7.63m (5.73m + 1.9m) instead of 6.59m for the 1:10,000 return period listed in the main DCO documents.

EDF's calculations in its Table 4.2 above are based on British Energy Climate Change (BECC) report data which offers the following for 'credible maximum' levels:

Year 2100 sea level rise 1.55m to 3.2m
Year 2200 sea level rise 2.55m to 5.0m

'*BECC Scoping Paper: How to Define Credible Maximum Sea Level Change Scenarios for the UK Coast. January 2014*'. Page 35. This document was obtained under FoI and is not in the public domain.

If we take the '*BECC Upper'* in EDF's Table 4.2 for 2200 as 5.0m, the 1000-year event is 3.44m making 8.44m—1.14m above the main nuclear platform level which seems to conform to EDF's figures.

If we consider a 'Structured Expert Judgement' there is a 5% probability of a 7.5m polar ice sheet sea level contribution by 2200 in a 5° scenario; a 1,000-year event 3.44m still water level flood level will then be 10.94m in 2200. This would be 3.64m above the main nuclear platform level.

The following table summarises the findings for the 1:1,000 return period:

Summary of the Assessed flood depth on the main platform for 1,000-year event at 2190/2200 with extreme still water level above platform height comparing EDF and Independent figures.

Return Period	Source of data	Epoch	Climate Change	Sea Level rise	Extreme sea level (1953)	Overall still water sea level	Main Platform Level	Flood Depth on the main platform
1,000-year	EDF- Reasonably Foreseeable .	2190	RCP8.5 95 pc	2.9m	3.44	6.34		0
1,000-year	EDF High Level	2190	BECC Upper	5.0m	3.44	8.44	7.3m	1.14
1,000-year	Independent High level 5° 5% prob.	2190	Structured Expert Judgement	7.5m ice sheet contribution	3.44	10.94		3.64

Notes:

- EDF's level of 8.84m appears to be a misprint and perhaps should be 8.44m.
- Sea level rise for EDF High level is 5m.
- Sea level rise ice sheet contribution for SEJ High level is 7.5m.
  This is a 5°C temperature rise scenario showing a 5% probability of a 7.5m sea level rise contribution by 2200 from the polar ice sheets GrIS, WAIS and EAIS.

  For the 5° scenario and longer timescales the Probability Distribution Functions are 'long tailed' which means that an 83rd percentile can be 2.51m and the 95th percentile 7.5m. It is therefore important to consider the 95th percentile. This level is ice sheet data only and for 2200 thermal expansion should be added (~50cm and glaciers ~40 cms).

- 1,000-year 'extreme' still water level applied is 3.44m—the 1953 flood level. The IPCC, UKCP18 and the Environment Agency suggest that 'event frequency' will significantly increase in the coming years—particularly beyond 2100. This appears to suggest that a 1000-year event could be a more 'regular' occurrence during the lifetime of Sizewell C. This is explained in Section 4 above.

- The figures quoted above are still-water levels. According to Pye and Blott the 100-year significant wave heights from the North/ North-East would be 7.3m-7.8m. For later epoch high water levels, the Sizewell-Dunwich banks would no longer be effective in dissipating wave energy so it must be expected that these wave heights could have less restricted access to the Sizewell/Minsmere coastline. (Note: a 7.5m wave does not add 7.5m height to still water levels). See section 6.

- This suggests the need to consider increased still water volumes created by waves breaking onto the wetlands/marshlands surrounding the landward side of the main nuclear platform.
- Actually it means that wave breaking (due to increased water depths from still water level increases is less competent and therefore hold onto their energy muck longer, breaking much closer to the shore with greater height. Effectively this amounts to the Banks' levels lowering.

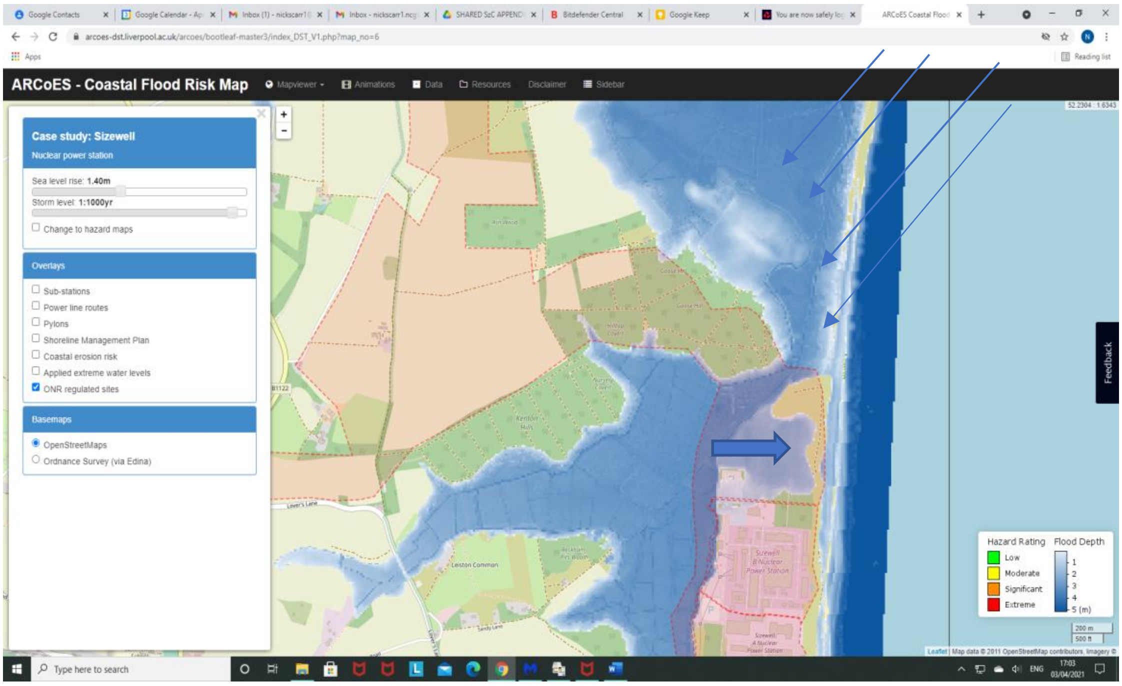
- 2190 represents the theoretical maximum site lifetime according to EDF. The 'Interim' spent fuel store is 'assumed' to be decommissioned by 2150 but this is not independently verified and may be 2180-2230 if NDA data are considered.

- *"For any given future climate scenario, the ice sheets constitute the component with the largest uncertainties by a substantial margin, especially beyond 2050"*. Structured Expert Judgment op cit., p 1.

The table indicates that there is a requirement for Independent, authoritative bodies to agree on high-end climate change recommendations for nuclear planners to 2200. It is not clear that EDF's 'reasonably foreseeable' parameters fully acknowledge the flood risk. See section 7.3.6.

Appendix to Section 4: Flood map illustrating EDF's statement that the 'the primary mechanism for flooding was identified as water ingress onto the platform from the land side'.

The chart below, illustrates inundation from the landward side with an example of a 1.4m climate level sea level rise by 2100 (0.5m lower than the H++ level of 1.9m) with a 1953 flood level. The heavy blue arrow shows the proposed location for Sizewell C, light blue arrows show significant wave directions – see map in section 6.



Projection for still water sea level rise of 1.4m in 2100 (0.5m less than the UKCP18 recommended H++ 2100 level of 1.9m and 1.1m less than the *US National Oceanic and Atmospheric Administration level of 2.5m at 2100)* combined with still water 1:1,000 (1953) year flood event

Technical note: Explanation and data used. Blue arrow is proposed site for Sizewell C.

Source: ARCoES, https://arcoes-dst.liverpool.ac.uk/. Select 'Map Viewer', 'Sizewell'.
The nearest Environment Agency chainage point at Sizewell is 4192. (Newlyn is chainage point zero).

The applied extreme water level data at 4192, which do not incorporate any sea-level rise, are:

1:1	2.21m			
1:200	3.13m			
1:500	3.36m			
1:1,000	3.55m	(The 1953 level was 3.44m/3.5m)		
1:10,000	4.21m	1:10,000	5.73m	$\pm$ 0.29m

Note: *"Statistical estimates of the 1 in 10,000-year high water level for present conditions range from 3.61 m OD (Joint Probabilities Method) to 5.05 m OD (Generalised Pareto Distribution Method). A 1 in 10,000-year value of 4.26 m OD was obtained using the method of Dixon & Tawn (1997) and a 1 in 1 year level for Sizewell of 2.21 m OD"* BEEMS TR139 Op cit., Page 3

5. EDF's Expert Geomorphological Assessment (EGA) - a response to DCO studies.

EDF informs us in the documentation, that it commissioned seven expert geomorphologists to examine the shoreline change processes associated with Sizewell C:

> *"Seven Expert Geomorphologists, internal and external to Cefas, were convened to assess the physical and scientific evidence for shoreline change processes and to derive a plausible future shoreline baseline using the EGA [Expert Geomorphological Assessment] approach. "*

DCO: 6.3 Revision: 1.0 Applicable Regulation: Regulation 5(2)(a) PINS Reference Number: EN010012 Volume 2 Main Development Site Chapter 20 Coastal Geomorphology and Hydrodynamics Appendix 20A Coastal Geomorphology and Hydrodynamics: Synthesis for Environmental Impact Assessment TR311 Sizewell MSR1 (Ed 4) Paragraph 7.2.1.

The EGA is based on the work of Cefas in Beems document TR311 and TR403 *'Expert Geomorphological Assessment of Sizewell's Future Shoreline Position' 21/3/19 rev. 21/4/20'*.

There are fundamental limitations to the study:

- The EGA limits its timescale to 2070. End of plant life, however is 2190. Energy Policy statement, EN-1 (July 2011, 4.8.6) states that *"..applicants for new energy infrastructure have taken into account the potential impacts of climate change.. [for] the estimated lifetime of the new infrastructure."*

- The EGA limits its study to 3 Km of coastline when coastal processes affected by Sizewell C's defences will affect a far greater spatial scale.

The study then adds a further set of assumptions and limitations, listed as follows:

1. To adopt a future projection based on "reasonably foreseeable" conditions.
2. Sea level rise in the year 2070 would be 0.52 m relative to 1990 levels
3. The offshore wave climate remains unchanged
4. The inshore wave climate remains unchanged
   Coastal Geomorphology and hydrodynamics, Appendix 20A, op.cit., Page 134

These assumptions and limitations are each discussed below:

1) The Expert Geomorphological Assessment limited its study to 'reasonably foreseeable conditions' a phrase that does not appear to be completely clear in this context. EDF claims that, 'no assessment can be made of extreme events', and the drivers of change are 'moderate' events:

> *"A projection based on the 'reasonably foreseeable' conditions was considered the most appropriate method of reaching consensus as **'extreme events' that could occur have a low (or poorly-determined) chance of occurrence** and geomorphic systems tend to be shaped by more frequent moderate events (Wolman and Miller, 1960), with the exception of cataclysmic change".* Coastal Geomorphology and hydrodynamics, Appendix 20A, op.cit., Page 134 and BEEMS TR403, p.33.

The explicit exclusion of extreme events—is *an unsupportable premise.* The shoreline at Sizewell is dominated by frequent small low-energy events, so it is shaped by these most of the time, and then a storm (particularly Easterly) does much damage through erosion and flooding. Storm frequency and intensity—and consequently overall energy supply to the coastline—will be much increased in the coming epochs. To suggest that '*extreme events*' will have a '*low chance of occurrence*' is in direct contradiction with authoritative advice from climate science. See section 2 and 4.
Agreed. See supporting refs in our report

2) The 'panel of seven' stipulated a limited 0.52m sea-level rise at 2070 – a mid-category Representative Concentration Pathway (RCP 4.5).

> *"…future shoreline change affecting the Sizewell C development was assessed based on SLR in 2070 of 0.54m (the 95th percentile under the UKCP18 mid-range scenario)."*
> DCO: Coastal Geomorphology and hydrodynamics, Appendix 20A, op.cit., *Paragraph 2.4.1 Page 48*

This does not appear to be consistent with advice from UKCP18 which advises that planners use H++ values, or at least RCP8.5, 95th percentile. See section 4.

If the assessment considered, as it should in my opinion, an end-of-life timescale of 2190 RCP 8.5 sea-level rise will be between 1.3 and 2.9m—**a median level of 1.8m.** agreed

3) The panel limited the offshore wave climate to 'unchanged'. UKCP18 does not stress major increase in offshore wave climate, nevertheless, EDF notes in the Main Development Site Flood Risk Assessment:

> *"4.2.16 The Environment Agency guidance (Ref 1.7) suggests assuming a precautionary increase in wave height of 5% up to 2055 and then 10% from 2055 to 2115."*
> DCO: Main Development Site Flood Risk Assessment, op.cit., Page 54.

They may argue there will be spatial (regional) differences

Also, UKCP18 suggests 'inherent uncertainty' as regards 'Significant Wave Height' predictions as they represent an area of low predictive accuracy:

> *"Given the inherent uncertainty in projections of storm track changes and the limited sample size available, the wave projections presented here should be viewed as indicative of the potential changes with* ***low confidence****."* UKCP18, Ibid., Page 28.

It continues that wave patterns are defined by local activity, which, for Sizewell C will be from a North/North/East fetch across the large expanse of the North Sea. The 1:100 return period (an 81.9% chance of occurring between now and 2190) wave height being 7.3m-7.8m.

4) For the 'inshore wave climate to remain unchanged' is in my view to **explicitly state that the panel's review of Sizewell C placed full reliance and dependency on the Sizewell-Dunwich offshore bank feature remaining in its current form.** This bank network, as previously stated, attenuates and dissipates offshore waves reducing and controlling the inshore wave climate.
(Tucker, Carr et al.) (BEEMS TR311).

In my opinion, and that of leading authorities such as Mott Macdonald, the respected global engineering consultancy which undertook an extensive study of the area in 2014 considers that:

> ***"…at a local scale the SDBC [Sizewell-Dunwich Bank Complex] has the potential to change over time-scales shorter than a few decades."*** Mott Mac., op. cit., page 57.

Cefas also acknowledges uncertainty:

> ***"…our understanding of bank dynamics is poor"***
> BEEMS Technical Report Series 2009 no. 058, Sizewell: Morphology of coastal sandbanks and impact to adjacent shorelines. Page 47.

However, despite these considerations, EDF's Expert Geomorphological Assessment tells us in the DCO:

> *"The principal receptors (beach, bars, bank and crag) of the future baseline can be expected to resemble the present (i.e. no regime shift) over much or all of the station life."* Chapter 20 DCO: Coastal Geomorphology and Hydrodynamics. Paragraph 20.4.78.

The statement above outlining the approach of its geomorphological experts is in open contradiction to the following acknowledgement:

> *"It is important to note that changes to the broad coastal regime and coastal processes may occur within the station life."*
> The Sizewell C Project 6.14 Environmental Statement Addendum, Volume 3: Environmental Statement Addendum Appendices Chapter 2 Main Development Site, Appendix 2.15.A Coastal Geomorphology and Hydrodynamics. Para 6.5

agreed

EDF also acknowledges:

> *"20.14.1 The …Expert Geomorphological Assessment shows that, without secondary mitigation, shoreline recession (a shifting future baseline) is very likely to expose the HCDF within the operational life of the Sizewell C station. An exposed HCDF could disrupt, and eventually block, shingle transport, leading to potential event-based and net downdrift erosion. A plausible time window for such exposure of 2053 – 2087 is identified."* Chapter 20 DCO: Coastal Geomorphology and Hydrodynamics.

I have already established in this paper that this scenario of future offshore geomorphology 'resembling the present' would, in my opinion and seemingly EDF's opinion, be an unsupported and unsupportable premise. This is discussed further in the following section 6.

In a recent 'East Anglian Daily Times' article, a senior coastal scientist at Cefas, and one of the seven expert geomorphologists responsible for the study is reported as saying:

> *"… that while Cefas does look far ahead into the future, it is generally only possible to predict detailed changes to the coastline over the next 10 years."* He continues, *"We can try and predict as much as we like, but almost every prediction in the very long-term has no certainty around it." 'Flooding and 'extreme' storms won't put Sizewell C in danger, experts say'* by Andrew Papworth, East Anglian Daily Times, 06 August 2020', https://www.eadt.co.uk/news/cefas-sizewell-c-coastal-erosion-2684774

This is a different perspective from that of EDF which suggests in its public information newsletter, '*Doing the power of good to Britain'*, and quoted in the introduction, that the Expert Geomorphological Assessment forecasts the 'very best assessment of long-term coastal change' and therefore shows Sizewell C to be 'future-proofed'.

In my view, the opportunity and capacity within which the review has taken place, combined with one of the geomorphologist's view that forecasts cannot extend reliably beyond 10 years, compromises its value. *Historical precedent shows the extreme erosion that can occur on this particular Sizewell shoreline* (see Section 2), a consideration seemingly completely overlooked by EDF/Cefas's Expert Geomorphological Assessment. The approach also does not appear to be consistent with DCO 'Rochdale Envelope' requirements. In my opinion an independent review is required such that the merits and deficiencies of the Expert Geomorphological Assessment's may be fully understood.
Caution here as equally so any predicted/modelled storm extreme can fall under the same statement including any modelling of the changes in the Sizewell-Dunwich Bank morphology. **It seems strange that extreme predictions of future sea level are not used, especially given the nature of the infrastructure at risk.**

6. The Sizewell-Dunwich banks.

6.1 The Sizewell-Dunwich banks—wave attenuation and shoreline protection.

The offshore Sizewell-Dunwich complex—referred to in previous sections and in its current form—mitigates the effects of storm surges onto the Sizewell foreshore by wave refraction and attenuation. The work of Tucker and Carr using Waverider buoys installed in the 1970s (and later work by BEEMS, and EDF, including modelling) shows that any incident wave approaching the Sizewell-Dunwich banks from offshore, if higher than a critical value, is forced to break on the offshore banks thereby reducing its height to that value before it hits the Sizewell coastline. This critical value of wave height is 2.12m to 2.52m depending on tidal depth. This feature of the Sizewell-Dunwich bank complex is of primary importance to the inshore wave climate and protection of the Sizewell foreshore. This is acknowledged in the DCO: Coastal Geomorphology and Hydrodynamics, Appendix 20A. op cit., Page 27. Tucker and Carr's work is also acknowledged in BEEMS TR319, page 27.

Cefas's BEEMS technical report TR500 states that, should Dunwich bank remain the same, then it:

> *"…would therefore be expected to continue to provide protection from high-energy storm waves across the majority of the GSB." [GSB = Greater Sizewell Bay]*
> BEEMS Technical Report TR500 Sizewell-Dunwich Bank Morphology and Variability, Page 11

Therefore, it must be accepted that if the Sizewell-Dunwich banks are compromised by the formation of a major gap, loss of height or change of orientation then incident waves—such as one of 4.71m N/NNE as recorded off the banks by Waverider buoys in 2008-2011, or the forecast 1:100 N/NNE wave height of 7.3-7.8m, as examples—will have less restricted access to the Sizewell foreshore. (see Technical note below). Mott Macdonald confirms that:

> *".. a reduction in the size of this feature…[would reduce its effect in attenuating waves thereby increasing] the magnitude of extreme events on the shoreline and increase the risk of erosion".* Mott Mac., op. cit., page 57.

The converse is of course possible in that the banks could build-up or remain the same, but Sizewell C needs unqualified site security until at least 2150, a timeframe that I believe will cover at least one 'episodic' change, which could be a serious threat to the Sizewell-Dunwich banks and hence the stability and protection of the Sizewell foreshore.

> Technical note: **Offshore Wave heights.**
> The largest waves recorded by a Waverider buoy deployed offshore from the Sizewell-Dunwich Bank complex (SDBC) in 18m of water from 11 February 2008 to 24 February 2011 had a significant wave height of 4.71m (15.45 ft). The highest waves are predicted to approach the coast from the north and northeast. According to Mott MacDonald "the Halcrow (2001a) wave hindcast study estimated a maximum 1 in 100-year offshore Hm0 (significant wave height) value of **7.8m** for waves from the N –NNE sector". According to Pye and Blott the 1:100 would be **7.3- 7.8m**. These predictions predate IPCC climate change scenarios. (It is important to note that wave height is the difference between the crest and the trough, however this is complicated by the wave being a transient phenomenon. Flood risk assessments are likely to have a still water level to which overtopping volumes due to the waves are added. The calculation of this overtopping volume will include wave setup and wave runup.) Initial section from: 'Thorpeness Coastal Erosion Appraisal Final Report December 2014', Mott Macdonald, Page 15. See 'Figure 58' below for a diagram of wave structure.

The following schematic illustrates wave setup and run up:

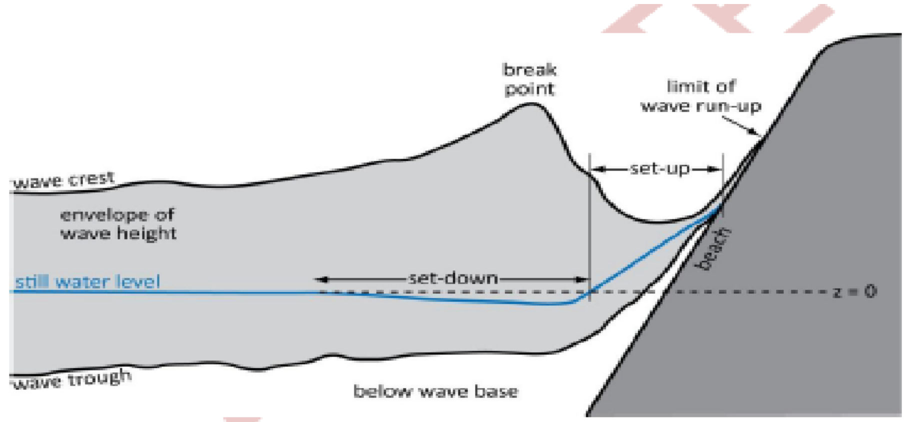


Figure 58 Schematic diagram showing variations in mean still water level due to wave set-up and set-down, and the limit of wave run-up. Modified after Dean and Walton (1983)

BEEMS TR139, Edition 2: A Consideration of "Extreme Events" at Sizewell, Suffolk, With Particular Reference to Coastal Morphological Change and Extreme Water Levels. Page 140.

BEEMS report TR058, confirms that sea level rise will also compromises the wave attenuation properties of the banks:

"In a scenario of rising sea level combined with a reducing volume and/or sediment supply at the bank, the resultant increase in water depth over the bank crest (i.e., sea level rising and/or bank elevation lowering) will have a more significant effect on inshore wave climate and shoreline response."
BEEMS Technical Report Series 2009 no. 058, Sizewell: *Morphology of coastal sandbanks and impact to adjacent shorelines*. Page 46.

The loss or part-loss of the Sizewell-Dunwich banks could be critical to foreshore stability and, as mean sea-levels rise, water over the banks will be deeper which will reduce the attenuating effect of the banks on larger waves. (Tucker and Carr's study suggests waves will break over the banks when their height is half the water depth). Depends also on the tide elevation at the time plus any positive surge both of which ultimately dictate local water levels the waves are operating in.

6.2 Instabilities in the Sizewell-Dunwich banks and the effects on coastal processes.

As stated in Section 2, evidence from core samples and seabed grab samples do **not** suggest the existence of erosion-resistant Coralline Crag in the Sizewell-Dunwich banks offshore and northwards of the proposed location for Sizewell C and is confirmed in the DCO:

"…the Dunwich Bank has no inherited stabilising hard geology (i.e., no headland or underpinning crag). [The Sizewell bank has a headland but also limited crag]. DCO: Geomorphology Appendix 20A, op cit., Page 135 of 167

EDF is aware of significant instability of the northern part of the Sizewell-Dunwich bank, confirmed by the following:

"Bathymetric surveys undertaken between 2007 and 2017 showed that Sizewell Bank has remained in a relatively stable position… ***In comparison, the Dunwich Bank has … showed greater variability over the same period [a decade]:*** *migration landward of the landward flank of the bank by 50 m and by 200 – 400 m on the seaward flank, whilst substantial lowering (1-2 m) occurred across approximately 10% of its area. "*
DCO: Geomorphology Appendix 20A, op cit., Page 135 of 167

EDF continues:

"Records over the last decade show…Dunwich Bank exhibited greater variability in both its morphology and position with:

- ***erosion north of 267000N, resulting in bank lowering of -0.5 – -1.5 m,***
- ***a decrease in its northern extent of approximately 250 m,***
- ***landward movement (200 – 475 m) of the northernmost 2.75 km of its seaward flank,***
- *accretion/migration on its landward flank adjacent to its peak and most landward position (between approximately 267000N – 267600N), and*
- *ongoing migration of the landward flank for the -6 to -10 m (ODN) contours (approximately -6 m/yr)"* DCO: Geomorphology Appendix 20A, op cit., Page 21. (BEEMS Technical Report TR500).

This erosion of the Dunwich bank is confirmed by Cefas in BEEMS TR500:

> *"In contrast to Sizewell Bank, **Dunwich Bank exhibited large-scale erosion** across its northern third."* BEEMS Cefas Technical Report TR500, ibid., Page 32.

As discussed below there has been a paucity of bathymetric surveys of the Dunwich bank which compromises detailed analysis, however, Cefas's BEEMS technical report TR500, obtained under FOI, tells us that:

> ***"If the lowering and reduction in Dunwich Banks northern extent continued, the extent of shoreline exposed to higher wave energy from the northeast sector would be expected to expand to the south accordingly." [i.e. affect Sizewell C].*** BEEMS, Cefas Technical Report TR500 Sizewell-Dunwich Bank Morphology and Variability, Page 59.

As noted by Cefas, the predominant driver of significant wave heights is from the North to North-East—a direction which will expose both the erodible shoreline of Sizewell C, if the Dunwich bank were lost, as well as the northern parts of the Sizewell bank. EDF effectively acknowledges this driver in the following statement:

- *"The largest fetch is towards the north (up to 3,000 km) and correspondingly **the largest and longest waves arrive from the N-NE sector. [1:100 wave heights 7.3m-7.8m]**. Waves with periods greater than 8 seconds approach exclusively from the NE – ENE sector."* DCO: Geomorphology Appendix 20A. op.cit., Paragraph 2.3.2.2.2

An independent, 2020 perspective concerning the importance and fragility of the Sizewell-Dunwich banks can be established from Scottish Power Renewables' research and reports. Scottish Power Renewables is intending to land offshore windfarm cables in the Sizewell area and therefore has a requirement to cross the Sizewell-Dunwich banks. Scottish Power's independent studies have some consonance with this paper and reveal that any 'disturbance' of the Sizewell-Dunwich banks could have geomorphological implications to the banks themselves and the stability of the Sizewell shoreline. Scottish Power also notes:

> *"EDF Energy has stated it will object to any damage to the crag [The Sizewell-Dunwich bank] on a precautionary basis."* This is explained fully in the document below.
>
> East Anglia 2 Offshore Windfarm Appendix 4.6, Coastal Processes Applicant: East Anglia TWO Limited, Document Reference: 6.3.4.6, SPR Reference: EA2-DWF-ENV-REP-IBR-000896_006 Rev 01 Pursuant to APFP Regulation: 5(2)(a). The Sizewell-Dunwich banks are analysed at length in the paper, see page 54 for the quotation used.

EDF states that by 2053-2087 the Hard-Coastal Defence feature could be exposed and therefore voided of its vegetated shingle.

> *"An exposed HCDF could disrupt, and eventually block, shingle transport, leading to potential event-based and net downdrift erosion. A plausible time window for such exposure of 2053 – 2087 is identified."* Chapter 20 DCO: Coastal Geomorphology and Hydrodynamics.

6.3 EDF's downgrade of the importance of the Sizewell Dunwich banks in the DCO.

In EDF's Newsletter for the public, *SIZEWELL C LATEST NEWS, Doing the power of good for Britain*, released after the DCO was accepted, informs us that:

> *"Sizewell is located within a stable part of the Suffolk coastline, between two hard points and the offshore bank of sediment known as the 'Dunwich-Sizewell Bank'."* Page 13

EDF itself is fully aware of the importance of the Sizewell-Dunwich Bank complex as can be confirmed from its pre-DCO Scoping document:

> *"7.13.7 Approximately 1.5km offshore from the coast is the Sizewell-Dunwich Bank. The bank represents a natural wave break preventing larger waves from propagating inshore and thus, reducing erosion rates along this shoreline.* ***As a result, the Bank forms an integral component of the shore defence and provides stability for the Sizewell coastal system.****"*
> Sizewell C EIA Scoping Report, April 2014, Planning Inspectorate Ref: EN010012

However, in the DCO there is a significant modification:

> *"The waves acting on the shingle beach face and, during elevated water levels on its landward barrier, are substantially lowered before arriving at the shore due to dissipation across the GSB's [Greater Sizewell Bay's]* ***three positive relief features****; the Sizewell – Dunwich Bank and the two longshore bars. Coastal sandbanks and longshore bars dissipate wave energy through bottom friction in shallow water (e.g., over the 1-km-wide [Sizewell-Dunwich] sand bank) and wave breaking, when the water depth is less than about 1.3 times the wave height (i.e., waves larger than about 3-4 m approaching the Greater Sizewell Bay). As waves shoal across these morphologies, they are also refracted toward a more shore-normal direction of travel, which reduce longshore transport potential."*
> DCO: Coastal Geomorphology and Hydrodynamics Appendix 20A: 2.3.2.2.3.

EDF has added two additional 'positive relief features': the two nearshore, longshore bars. This idea is found in the BEEMS Technical Report TR 058:

> *"The Sizewell bars and bank can be considered as a three tiered system of coastal defence, where the inner bar, outer bar and bank dissipate respectively dissipate energy associated with small, moderate and large storm waves."*
> TR 058 British Energy Estuarine & Marine Studies Technical Report Sizewell: Morphology of coastal sandbanks and impact to adjacent shorelines. Page 49.

The paragraph is stating that two nearshore, longshore bars dissipate small and moderate waves whereas the 'bank'—a reference to the Sizewell-Dunwich bank—reduces large storm waves to moderate inshore waves.

I consider the nearshore longshore bars to be geomorphologically insignificant minor shoreline features that lack the qualities for serious consideration as receptors providing long term stability and wave attenuation to the Sizewell coastline. I am supported in this by the following statement from EDF itself, as stated earlier: ***"The inner and outer longshore bars are smaller and shallower and are consequently relatively mobile features that would change their positions relatively quickly…"***
DCO: Coastal Geomorphology and Hydrodynamics Appendix 20A. op. cit., P.135

> **Disagree with this as depending on the tidal stage (height) nearshore bars are significant in dissipating and wave energy through wave breaking.

It is also my view that it would not be plausible to consider the loss of the Dunwich bank as compatible with the retention of the nearshore, longshore bars. See Figure 2 in this section.
Not really true, the nearshore bars can exist without offshore banks such as Dunwich – many examples elsewhere. See my comments page 48 below

EDF also introduces 'the shingle beach' in the DCO and suggests it to be an important wave receptor (Haskoning says the shingle is not considered in MDS FRA part 1 of 14 page 48 of 57 Haskoning section) and 'relief feature' in its flood risk modelling assessment; this will be discussed in section 7. The use of the 'shingle beach' appears to be first mentioned in the 2019 Scoping report:

> *"The potential receptors have been adjusted compared to those described [previously, and are now] the:*
> *- shingle beach and its shoreline position;*
> *- two sandy, shore-parallel longshore bars;*
> *- Sizewell–Dunwich Bank; and*
> *- erosion-resistant Coralline Crag ridges that extends to the north-east from Thorpeness."*
> EDF 2019 Scoping Report op.cit., Paragraph 6.14.25.

This is extended in the DCO to become:

> *"…there is a substantial shingle beach and vegetated sand dunes at all of the potential flood routes involving wave overtopping at Sizewell C. It is important that those features are considered in the wave overtopping analysis as they may have a significant impact on wave propagation and run-up before waves reach the formal new engineered sea defences".* Main DCO: Development Site Flood Risk Assessment Appendices 1-7 Part 1 of 14. Appendix 1 Coastal Modelling report. (Containing APPENDIX A: 'Sizewell C Flood Risk Assessment Modelling overtopping of sea defences' Technical Note Royal Haskoning DHV, February 2017) Paragraph 1.2.9.

However, Sizewell C will also be built further to seaward than Sizewell A and B thereby reducing its foreshore:

> *"The Sizewell C platform is estimated to extend ~40m tbc further seaward than the `building line' established by Sizewell A and continued by Sizewell B."*
> East Suffolk Council, Extraordinary Meeting of the Full Council, to be held on Thursday 3 September 2020 at 6.30pm. Page 68. See section 10 for seawall design.

6.4 EDF's bathymetric surveys of the Sizewell-Dunwich banks

A seeming disparity exists between pre-DCO statements and the DCO regarding the frequency of bathymetric survey of the Sizewell-Dunwich banks. The pre-DCO Scoping Report states that EDF has undertaken:

> ***"…high resolution bathymetric surveys of Sizewell-Dunwich Bank (2008/9) with further surveys in 2010, 2011 and 2012 to provide additional coverage, particularly in the nearshore zone…and a full survey of Sizewell-Dunwich Bank in 2017".***
> Sizewell C EIA Scoping Report May 2019 Ref: EN010012. Paragraph 7.13.2, page 149 and Paragraph 6.14.5, page 174.

However, the DCO states that: ***"due to its large size…the bank is not regularly surveyed.***"
DCO: Geomorphology, Appendix 20A, op.cit., Page 21
They probably mean "in its entirety".

2008/9 Swathe Services made a partial survey of the Sizewell-Dunwich banks and in 2017 Titan Services and the Maritime and Coastguard Agency made a full survey. Radar transects were taken with 1km spacing in 2014-16 which provide peripheral detail but the surveys of 2010, 2011 and 2012 do not appear to relate to the Sizewell-Dunwich banks. See: BEEMS Technical Report TR500 'Sizewell-Dunwich Bank Morphology and Variability'. Page 22.

Date	Extent	Source
15/08/2017	Full Bank	Titan Surveys
15/03/2017	Full Bank	Maritime and Coastguard Agency
29/07/2016	Radar Transects[1]	Titan Surveys
29/07/2015	Radar Transects[1]	Ocean Ecology
16/06/2014	Radar Transects[1]	Ocean Ecology
10/01/2009	Partial Bank[2]	Swathe Services
22/09/2008	Partial Bank[2]	Swathe Services
22/03/2007	Partial Bank[2]	Gardline Environmental

BEEMS Technical Report TR500 'Sizewell-Dunwich Bank Morphology and Variability'. Page 22.

There is however extensive recent, but not historic, detailed bathymetry of the geomorphologically insignificant nearshore, longshore bars which, as noted earlier, now seem to be regarded as primary relief features. (Extensive nearshore/longshore bar bathymetry and analysis is in Coastal Geomorphology and hydrodynamics, Appendix 20A, op.cit., Paragraph 7.2.1 Page 45/46)
These bars are not 'insignificant'.

My comments (Nick Scarr) on this- I agree that the nearshore/longshore bars are wave relief features *as long as the Sizewell shoreline remains as it is, and the bars do not erode or shift.* The problem as I see it is:

1) the nearshore bars are constituent parts of a recently accreted shoreline and therefore 'soft and erodible',
2) they have no hard geology that I am aware of,
3) EDF did not mention the nearshore bars in its 2012 assessment of wave relief features for Sizewell B,
4) EDF states clearly that they '*could change their positions quickly*', (see Page 46)

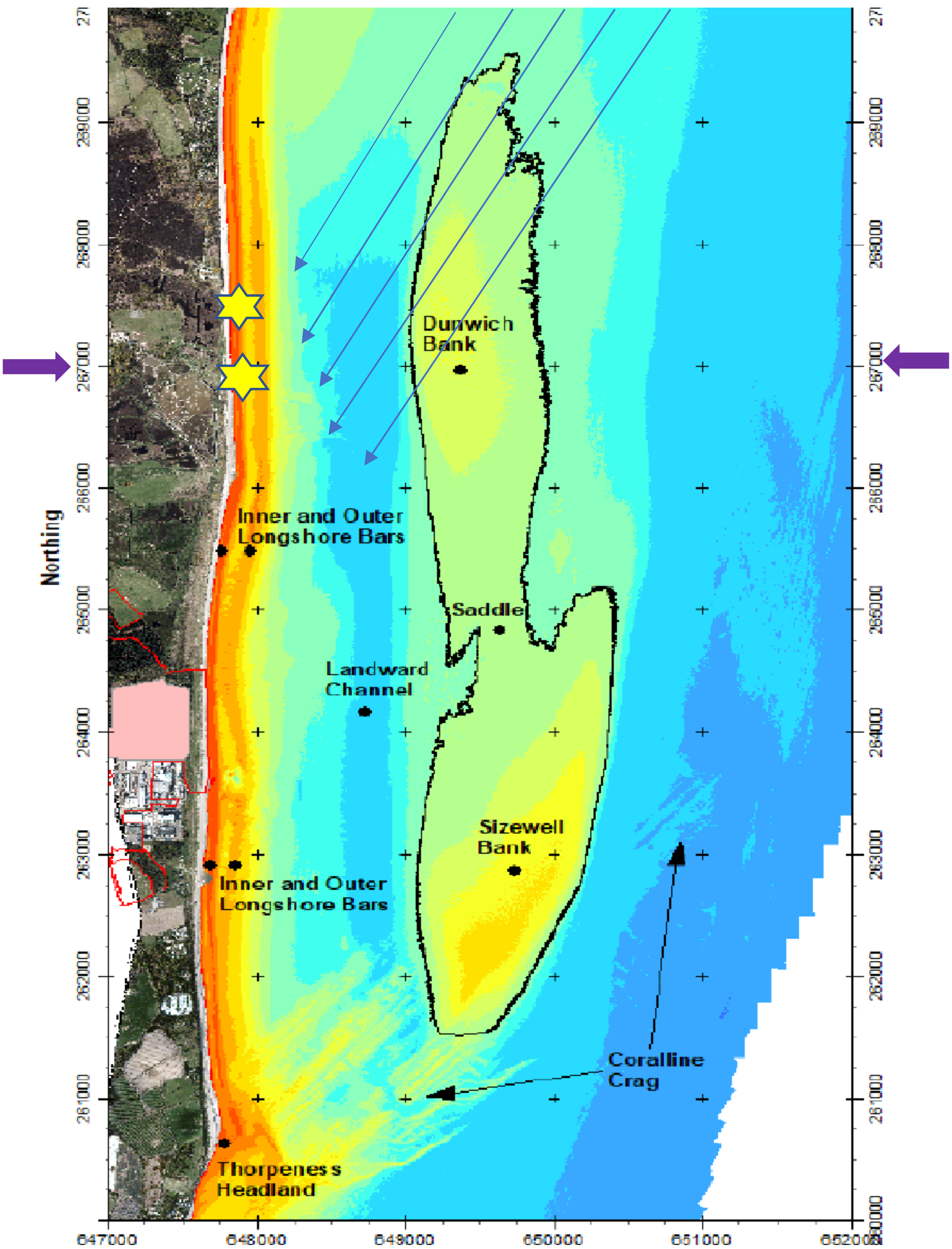
In my opinion their resilience is in question and hence my claim that they should not be relied upon to the extent they appear to have been in the FRA. (It appears that these bars are part of 'present bathymetry' and so relied upon as immutable features in the FRA for Sizewell C station life. In my view this cannot be considered a reasonable assumption). Nick Scarr

It appears, then that the Sizewell-Dunwich banks have not been extensively bathymetrically surveyed by EDF which, in my opinion, represents a deficit in EDF's geomorphological obligations.
Not a strong point to use

My comments (Nick Scarr) on this – the coastal sandbanks of Shingle Street and the Deben entrance are fully bathymetrically surveyed every year for sailing purposes. I obtained a quotation of £1800 to bathymetrically survey the Northern half (the eroding section) of the Dunwich bank. It remains difficult for me to understand why EDF has not assiduously and regularly bathymetrically studied the Dunwich bank over the last decade. In the CPMMP doc (Examination reference, REP5-059), released recently by EDF at Deadline 5, EDF makes clear that its intention is to survey the banks once every 5 years in the future. In my view this is not sufficient. Nick Scarr

The following chart shows the relative scales of the Sizewell-Dunwich banks and the newly introduced wave energy relief features:

6.5 The chart below illustrates the Sizewell Dunwich banks and the longshore bars offering a comparative scale of the wave energy relief features:



<u>The Sizewell-Dunwich Banks. The purple arrows mark 26700N— to the north of which the crest height of Dunwich bank is lowering.</u> Chart from BEEMS Technical Report TR500 'Sizewell-Dunwich Bank Morphology and Variability'. Page 14.

- The 'three positive relief features' as suggested by EDF in the DCO. The orange and red lines show the 'inner and outer' nearshore, longshore bars, now regarded in the DCO as significant relief features. The DCO provided detailed bathymetry of the inner and outer Longshore bars and not the Sizewell-Dunwich banks.

- The pink square shows the proposed location of Sizewell C.

- ***"Records over the last decade show…Dunwich Bank exhibited greater variability in both its morphology and position with erosion north of 267000N,*** [shown by the purple arrows] ***resulting in bank lowering of -0.5 to -1.5 m"*** DCO: Geomorphology Appendix 20A, op cit., Page 21. BEEMS Technical Report TR500).

- The four blue, fine arrows show the direction of the most significant storm waves from the North/North East— ***the largest and longest waves arrive from the N-NE sector. [1:100 wave heights 7.3m-7.8m***]. The loss of the northern section of the bank could allow unbroken storm waves to break on the foreshore and increase water volumes in the South Minsmere levels in flood conditions. See map in section 4.3. DCO: Geomorphology Appendix 20A. op.cit., Paragraph 2.3.2.2.2

  Haskoning's modelling assumes 'shore-normal' angles (all waves will strike the shore at 90 degrees). In the complex bathymetry offshore from Sizewell plus significant wave directions stated above do not support this assumption. See section 7. Note that very shallow nearshore (even before the nearshore bar locations) wave refraction locally will redirect waves and cause them to line up parallel to local bathymetric contours.

- There has been net erosion of the foreshore in the area of the proposed Sizewell C since 1993 according to BEEMS Table 2. This may be an indication of compromise to the Dunwich bank. See BEEMS TR223 op cit., Page 119 and Table 12 on page 115.

- The two yellow stars show the locations of breaches - 267400 15/12/03 and 14/2/05 and 266900 14/2/05. *"This 200 m section is the most vulnerable stretch of coastline between Dunwich and Sizewell, and represents the most likely location of a major breach occurring during a future storm surge."* Pye and Blott 2005, Coastal evolution RSPB op. cit., page 154 of 160. Page 28/160

7. The Sizewell-Dunwich banks: a permanent feature in EDF's FRA overtopping datasets.

I understand the Planning Inspectorate requires DCO applicants to consider the 'Rochdale Envelope Approach' in their applications, which obliges them to describe 'cautious, worst case conditions:

> *"It is important that these [descriptions] should be adequate to deal with the worst case, in order to optimise the effects of the development on the environment"*. The Planning Inspectorate, *Using the Rochdale Envelope*. July 2018

In view of this, EDF's modelling study is required to consider and publish worst-case conditions in its Flood Risk Assessment. EDF/Haskoning/Cefas's worst-case wave modelling is, in my opinion, puzzling as shown below.

7.1 Finding the Sizewell-Dunwich banks in the FRA.

Considering EDF's previously held importance of the Sizewell-Dunwich banks for both Sizewell B and C, I had expected that they would merit much mention and discussion in both the main DCO Flood Risk Assessment (FRA) and the FRA Addendum documents and worst-case conditions would consider the banks' compromise or loss.

In the twenty-two DCO main Flood Risk Assessment and fourteen FRA Addendum documents the Sizewell-Dunwich banks are not explicitly named; EDF's FRA Addendum states that modelling methodology remains the same as the original FRA. See MDS FRA Addendum Part 10 of 10, para 3.1.5. The modelling methodology 'which remains the same' is defined in MDS FRA Part 1 of 14.

The FRA document: '5.2 Revision: 1.0 Applicable Regulation: Regulation 5(2)(e) PINS Reference Number: EN010012 Main Development Site Flood Risk Assessment', gives greater attention to the nearshore, longshore bars and not the Sizewell-Dunwich banks:

> *"5.3.5 The sub-tidal part of the beach along the existing power station complex frontage is sand-dominated with inner and outer longshore bars that run parallel to the shore. The longshore bars are a conduit for longshore sand transport and act to dissipate some wave energy by causing waves to break which reduces the remaining wave energy at the shoreline."*

EDF in 5.3.5 above is clearly referring to the nearshore, longshore bars, not the Sizewell-Dunwich banks.

> *"5.3.16 As discussed in section 5.3.5 of this report, the presence of the sub-tidal longshore sand bars may contribute to dissipation of some of the wave energy nearshore. There is concern that the sand bars might erode in the future. That would most likely represent greater flood risk as it would result in the greater wave energy nearshore."*

Again, EDF in 5.3.16 above is referring to the nearshore, longshore bars.

Now we arrive at what can only be a reference to the Sizewell Dunwich banks but using the same term 'sand bar' as the immediate, preceding paragraph:

> *"5.3.17 An additional series of lowered sand bar scenarios were analysed in the wave transformation model by the lowering of the sand bank by 5m with assumption the sediment is lost from the system entirely. This was to test the effect of the sand bank on nearshore wave conditions. The derived nearshore wave conditions for the baseline (with sand bar) and lowered sand bar scenarios were compared showing that the baseline scenario predicted higher nearshore waves than the lowered bar scenario. Therefore, the baseline scenario was taken forward for wave overtopping assessment for the Sizewell C FRA, as it is more* ***conservative.****"*

Despite oblique language, a cross-reference with BEEMS TR319, shows that EDF, in 5.3.17 above must now be referring to the Sizewell-Dunwich banks - variously called 'sand bank' and 'sand bar' in the first sentence. *EDF is stating that the derived nearshore wave conditions are higher with the Sizewell-Dunwich banks present.* As a generalised statement this is counter to geomorphic principle and established orthodoxy which has been confirmed by EDF, Mott Macdonald and many academic studies and discussed in section 6. The following section examines how EDF/Haskoning's FRA uses this 'new approach' to inshore waves:

7.2 Inshore wave heights and EDF/Haskoning/Cefas's FRA modelling.

In further examining the modelling I expected the industry standard overtopping modelling package EurOtop to have been used. EDF decided not to use this package for the following stated reason:

> *"1.2.7. EurOtop methods are regarded as the UK industry standard for predicting wave overtopping, particularly for 'standard' defence profiles, which have been well tested and are incorporated into the EurOtop database. The primary issue with using EurOtop at Sizewell C is that the defence profiles at SIZEWELL C are not 'standard', as they comprise of shingle beach and vegetated sand dunes."*
> DCO: 5.2 Revision: 1.0 Applicable Regulation: Regulation 5(2)(e) PINS Reference Number: EN010012 Main Development Site Flood Risk Assessment Appendices 1-7 Part 1 of 14

According to Haskoning, however, the '*shingle layer is not to be considered'* which is confusing as it appears to be the purpose of the choice. See 'Table 19' below.

EDF then continues with details of the package it did use:

> *"1.2.9. Plate 1.2 to Plate 1.4 demonstrate that there is a substantial shingle beach and vegetated sand dunes at all of the potential flood routes involving wave overtopping at Sizewell C. It is important that those features are considered in the wave overtopping analysis as they may have a significant impact on wave propagation and run-up before waves reach the formal new engineered sea defences, referred to as 'Hard Coastal Defence Feature (HCDF). These defence shapes cannot be properly represented by the EurOtop methods, and therefore AMAZON software was recommended and used for predicting wave overtopping for the Sizewell C coastal flood risk assessment."*
> DCO: Main Development Site Flood Risk Assessment Appendices 1-7 Part 1 of 14, op cit.

Input wave data to the Amazon modelling were provided by Cefas:

> *"1.2.11. The TOMOWAC wave model has been developed by Cefas for investigating wave propagation from offshore to nearshore areas."*
> DCO: Main Development Site Flood Risk Assessment Appendices 1-7 Part 1 of 14. Op cit.

> *"1.3.11 To determine whether the disappearance of the offshore sand banks could have a significant impact on wave overtopping, the TOMOWAC wave transformation model was tested for three scenarios. These are the baseline, 'Low 5' with the offshore sand banks lowered by 5m and 'ST1' with a shallow south trough."*
> DCO: Main Development Site Flood Risk Assessment Appendices 1-7 Part 1 of 14. Op cit.

The use of opaque language is again found in an associated document– the *'sand banks'*, being offshore and capable of a 5m reduction refers to the Sizewell-Dunwich banks:

> *"Overall, the 'baseline' scenario predicted slightly higher nearshore waves than the other scenarios and was therefore taken forward for assessment for the FRA overtopping model runs."*
> DCO: Main Development Site Flood Risk Assessment Appendices 1-7 Part 1 of 14. Op cit. Section 1.3.13.

EDF in this statement (and the paragraph 5.3.17 in the FRA quoted earlier) is seemingly explaining that the output data from the TOMOWAC modelling provided by Cefas (which feeds the AMAZON modelling) claim that the Sizewell-Dunwich offshore banks produce higher 'nearshore waves' and were therefore 'taken forward' (and retained, presumably, in their present form) for the FRA modelling runs as it would be the more 'conservative approach'.

My comments (Nick Scarr) – initially Profs A and B disagreed with this statement but then sent the following email:

[redacted]

Mon, 12 Jul, 13:40 (11 days ago)

Hi Nick,

Yes, I see what you mean in terms of the muddled language they use, and it resulted in misunderstanding on our behalf. I had another read through and yes, the Baseline they are taking is that the Banks retain their place and size (incl. depth). They are saying that waves modelled over that configuration compared to other scenarios e.g. lowering banks by 5m, resulted in higher nearshore waves **(impossible to believe)** - so I agree with you completely - **this should not be, as a lowering of the offshore bank by 5m should increase nearshore waves compared to the baseline of retaining the offshore banks. So, ignore our comment and you can be assured we concur with your thinking.**

[redacted]

I recommend that the Examiners consider how the geomorphologically unorthodox premise that the Sizewell-Dunwich banks do not reduce the inshore wave climate is explained:

EDF/Haskoning refers to the authority of BEEMS TR319, authored by Cefas, for explanation. Close analysis of this document, obtained under FoI, reveals that the FRA wave modelling is seemingly based on Cefas's perplexing suggestion that it would be '*logical*' to use *'present bathymetry'* for subsequent modelling work because it has been '*accurately surveyed*':

> *"The simulations of the geomorphic scenarios show that it is only the lowered bank scenario that results in near shore wave increases in the vicinity of the SZC proposed site. Simulations run at low return periods (2 to 100 years) do show near shore (1000m) increase in wave energy in the lowered bank simulations and by inference the importance of the present bank, although very near shore (<200m) there is little difference. However, for extreme waves (1:1000 returns), when sea levels are also raised there is little difference in the near shore between the geoscenarios and the present bathymetry. Geoscenarios are necessarily artificial (albeit developed from the existing bathymetry),* ***whereas present bathymetry has been accurately surveyed, it would therefore seem logical to focus the majority of subsequent work (e.g. wave run up studies) on the present bathymetry cases."***
> Cefas BEEMS TR319 ed. 2. 'Sizewell – Derivation of extreme wave and surge events at Sizewell with results of the coastal wave modelling, climate change and geomorphic scenario runs.' Page 55.

Cefas's concluding paragraph from BEEMS TR319 reproduced above, in my opinion, appears to be informing the modelling exercise with a false premise for three reasons as follows:

1. That *'present bathymetry has accurately been surveyed'* has no relevance or validity for defining a remit for subsequent work; work that should instead be based on recognition and understanding of the changing offshore geomorphology.

2. Surveys of the Sizewell-Dunwich banks show them to be predominantly in a state of flux such that bathymetric data are ephemeral. '*Present bathymetry*' has no meaning unless defined with both a date and time and the offshore area deemed to be its constituent parts.

3. Cefas states clearly in the first two sentences that a lowered Sizewell-Dunwich bank results in higher inshore wave climate and therefore recognises 'the importance of the Sizewell-Dunwich banks'. This has agreement with orthodoxy. Cefas notes that the Sizewell-Dunwich banks will have little effect on inshore wave climate in late epoch, extreme raised water level scenarios due to the depth of water over the banks. This again, has agreement with orthodoxy.

    - However, Cefas has seemingly accepted this particular, late epoch, high water, geo-scenario and suggested it is generally applicable for the purposes of wave overtopping modelling studies. In my opinion, this is not a valid, generalised premise.

I suggest therefore that it is not '*logical to focus' on present bathymetry*.

This 'Present bathymetry' (the Sizewell-Dunwich banks in situ) is accepted by EDF/Haskoning and becomes their 'baseline scenario'.

- Cefas supplies Tomowac wave data to Haskoning which makes the claim that *"…The 'baseline' scenario predicted higher nearshore waves than the 'Low 5' [The Sizewell Dunwich banks reduced by 5m] scenario. It is therefore recommended that the 'baseline' scenario is taken forward for assessment in the FRA model runs."*
  Pages 23- 29 of the Haskoning section of Main Development Site Flood Risk, Assessment Appendices 1-7 Part 1 of 14'

In summary we now have:

- Cefas's *'present bathymetry'* becomes EDF/Haskonings '*baseline scenario'* which, when incorporated as a parameter into EDF/Haskoning/Cefas modelling runs, becomes equivalent to *'the Sizewell-Dunwich banks and other offshore features will seemingly remain an unchanging geomorphic fixture for station life for modelling purposes'*.

In the following 'table 19,' authored by Haskoning in the 'Main Development Site Flood Risk Assessment' we see that the last item lists the 'Baseline geo-scenario' to be used for modelling because it is '*more conservative'*. There does not appear to be a mention of any other geoscenario.

Table 19: Key uncertainties in the proposed wave overtopping modelling processes

Key Uncertainties	Mitigation	Conservativeness
Inshore wave height	The uncertainty in modelled inshore wave heights is to be addressed by adding 10% wave height. The comparison between modelled and measured wave heights at a near-shore wave buoy by Cefas showed model errors below 10%	Reasonably conservative
Inshore wave period	Use offshore wave period and JONSWAP spectrum. This approach is to address two-peaked wave spectrum inshore	Reasonably conservative
Inshore wave angle	Assume shore-normal wave approach angle	The modelled inshore wave data show that most extreme waves are almost in shore-normal angles. Slightly conservative
Beach profile	Beach profiles were taken from the lowest levels from the last 5 years' survey data	Slightly conservative to neutral
Sacrificial berm	Sacrificial berm is to be removed in overtopping models	Sensitivity tests described in Section 5 show that "no berm" gave the worst overtopping. Reasonably conservative
Shingle layer	Shingle layer is not to be considered	Sensitivity tests described in Section 5 show that a shingle layer has very limited effect in overtopping for extreme events. Slightly conservative
Offshore sandbanks	Use Baseline geo-scenario	Cefas' study shows that the Baseline geo-scenario produced slightly higher inshore wave. Slightly conservative.

Main Development Site Flood Risk, Assessment Appendices 1-7 Part 1 of 14. Page 48 of 57 of the Haskoning section.

EDF/Cefas/Haskoning's modelling appears then, to be structured so that it is taking a best-case geomorphological scenario (the Sizewell-Dunwich banks in situ) while claiming this modelling geo-scenario to be reflecting a safety-case of 'conservative,' 'worst-case' conditions.

This is shown in the table above marked with blue arrow.
The grey arrow suggests that the shingle is not considered after all.

BEEMS TR319 data on inshore wave heights (i.e., that they are greater with the banks in situ) agreed appears to me to be ambiguous and the converse of accepted geomorphological understanding. The following points in Cefas's methodology might be considered:

- Haskoning refers the reader to BEEMS TR319 for explanation but suggests Cefas's results are caused by a '*change in wave shoaling effect*'. **It is not clear why this has not been noticed by previous, authoritative academic studies.** Main Development Site Flood Risk, Assessment Appendices 1-7 Part 1 of 14. Page 24 of 57 of the Haskoning section.

- The yellow arrow notes where Haskoning assumes that wave approach will be 'shore-normal', that is, 90 degrees to the shore. In the complex bathymetry offshore from Sizewell this is hardly a reasonable assumption.

- EDF/Cefas and Haskoning are also measuring (or rather, sampling Tomowac output with embedded bathymetry of the Sizewell-Dunwich banks) the inshore wave heights 'one wavelength from the water's edge':
  - ***"The wave height at a distance of one wavelength from the waters' edge is used as the input condition for the AMAZON modelling, and this is therefore the location where wave height sensitivity to offshore sand bank depletion was measured."*** DCO: Main development Site Appendices 1-7 Part 1 of 14. Op. cit., Page 23.

  - **'One wavelength from the water's edge' would be inshore of the longshore bars and inshore of the vegetated shingle and sand dunes** ('present bathymetry' is geographically undefined but may include these features).

  - Measuring inshore wave heights 'one wavelength' from the water's edge is not consistent with general practice such as Carr Tucker et al., Mott Macdonald and BEEMS studies other than TR319 that measure inshore wave heights **one kilometre** from the foreshore or in the lee of the Sizewell-Dunwich bank.
  - agreed

  - TR319 notes that if wave heights are measured 1Km they do indeed show conformity to geomorphic principal: ***"Simulations run at low return periods (2 to 100 years) do show a near shore (at 1000m) increase in wave energy in the lowered bank simulations and by inference the importance of the present bank [The Sizewell Dunwich Bank]."*** Cefas BEEMS TR319 ed. 2. 'Sizewell – Derivation of extreme wave and surge events at Sizewell with results of the coastal wave modelling, climate change and geomorphic scenario runs.' Page 11

This position taken by Cefas/Haskoning/EDF, in my view, extrapolates '*present bathymetry'* to become '*worst-case'* modelling and in the process confounds geomorphological orthodoxy and both academic and empirical research.

I can only find one other study that attempts to suggest the lack of importance of the Sizewell-Dunwich banks to inshore wave energy:

- Pye and Blotts's 2006 paper discusses a wave modelling exercise by Halcrow Maritime which apparently makes the premise that '*the banks are **not** very important in terms of energy that reaches the coastline under **moderate** wave conditions'*. Pye and Blott acknowledge, however," *…this study only considered one set of wave conditions with a fixed (shore normal) angle of approach and [mild] weather".* They continue*," …the banks may be far more important in sheltering the coast from storms when waves approach from other directions."* Considering the acknowledgement that the banks protect in storms (as authoritative, orthodox study confirms—the banks reduce large wave heights to 2.2-2.5m) then they are de facto important in terms of the overall energy that reaches the coastline. Coastal Processes and Morphological Change in the Dunwich-Sizewell Area, Pye. Blott. Op.cit., page 456.

In my opinion EDF/Cefas's approach can only result in compromised modelling (which must reasonably acknowledge offshore and nearshore geomorphological change), and there is therefore a need to qualify the methodology and data found in Cefas' BEEMS TR319 report and Cefas's and Haskoning's understanding and use of wave data.

See DCO: Appendix 1-7, Part 1 of 14, Haskoning Page 23-29 of 57.

7.3 Overtopping levels—overtopping of the main defence crest by wave action and the consequent flooding of the main nuclear platform.

Example of wave overtopping taken in the Netherlands. Eurotop manual, 2018. Page 52.

The volume of water that 'overtops' a sea defence is measured in litres per second over a one metre length of sea wall (hence the unit l/s/m).

7.3.1 EDF's Hard Coastal Defence Feature (HCDF) crest height.

EDF has submitted an extensive redesign of the permanent sea defence crest height (Hard Coastal Defence Feature -HCDF) from the originally planned 10.2m AOD:

1. According to the original FRA:
   EDF's original FRA submitted in June 2020 that heights would be **10.2m** AOD with potential adaptive change to **14.2m** AOD at some future point:

   "7.2.18 As mentioned in ***section 7.1b*** *of this* ***report****, the defence design assumes a crest level of 10.2m AOD with potential to raise it in the future up to 14.2m AOD.* ***As the timing of adapting the defence is not yet confirmed****, the impact of breach of sea defence on the main platform flood risk was assessed for both heights of the defence."* Main Dev Site Flood Risk Assessment 7.2.18 May 2020

2. According to the Project Consultation Document released by EDF informing details of the intended FRA Addendum:
   In its *'Sizewell C Project Consultation Document on Proposed Changes Nov-Dec 2020'* EDF proposed it would become **14m** AOD, with adaptive change to **15m** AOD. (Paras 4.8.8, 4.8.12).

3. According to the FRA Addendum itself:
   The FRA Addendum of January 2021, in order to achieve a more *"conservative tolerable overtopping rate"* changed this to became **12.6m** AOD (with landscaping to **14.6m** AOD) and adaptive change to **16.4m** AOD (with landscaping to **18m** AOD)**.** (Main FRA Addendum Page 1,2 and Para 4.2.14).
   EDF also states in *FRA Addendum Jan 2021* that the raised crest height of 14.2m of the original FRA would have been required by 2046 – little more than a decade after plant completion. EDF claims that it was aware of this requirement at the time:

   "In the original Application… our assessments at that time showed that the raised HCDF of 14.2m AOD (maximum crest height presented in the Application) ***would need to be established by 2046,*** *a relatively short period"* Main Dev Site FRA Addendum Jan 21. Page 1.

These somewhat precipitate changes are concerning in their contradiction and uncertainty. It is also the case that the hard Coastal defence feature reduces to 10m as it meets the adjoining defences for Sizewell B. See section 10.

The changes in sea defence crest heights alters the overtopping rates for given conditions and these are discussed as follows.

7.3.2 EDF's 'tolerable' wave overtopping levels of the HCDF.

EDF's statement of 'tolerable' wave overtopping levels in the original FRA are not encouraging:

> *"5.4.7. For the end of theoretical maximum site lifetime at 2190, the results suggest that with the design defence crest at 10.2m AOD the overtopping rates might be dangerous to people and vehicles for the in 1 in 1,000 and 1in 10,000-year events,* [Note that the 1:10,000 event is only 0.71m above the 1953 historical flood level] *however with adaptive defence* [i.e. rebuilding the defence crest from 10.2m to 14.2m] *the risk would be mitigated to* ***a tolerable overtopping rate of 5 l/s/m****."*
> Main Development Site Flood Risk Assessment Appendices 1-7 Part 1 of 14. Op. cit., Page 36.

The following paragraphs are EDF's justification in the original FRA that 5 l/s/m is a 'tolerable level':

> *"7.1.34 …Available guidance on tolerable overtopping rates does not provide specific thresholds for people behind the defences, especially considering that the main platform would be set back from the new hard coastal defence.* ***Therefore, the referenced threshold of 5 l/s/m should be considered very conservative [i.e. very safe]*** *as it does not account for energy dissipation between overtopping of the defence and water reaching the main platform area."*
> DCO: Main Development Site Flood Risk Assessment Appendices 1-7 Part 1 of 14. Op. cit., Page 107

In the FRA Addendum EDF, however, EDF modifies its sea defence crest height design to accommodate its 'new', 'tolerable overtopping' rate of **2** l/s/m:

> *"Functional Requirements for the HCDF as part of the ongoing design process. These include a more conservative tolerable overtopping rate (design basis limit) of 2 l/s/m based on guidance provided in the CIRIA 'Rock Manual' (Ref. 1.2) to limit the potential for flooding on the platform by increasing safety margin throughout the operation and decommissioning phases of the project."*
> The Sizewell C Project5.2 Revision: 1.0 Applicable Regulation: Regulation 5(2)(e)
> PINS Reference Number: EN010012 Main Development Site Flood Risk Assessment Addendum Page 2.

EDF is taking this 'tolerable rate' from its following statement:

> *"5.1.2 For the design basis, a tolerable overtopping rate (design basis limit) was adopted as 2 l/s/m to ensure that the defence would withstand such events without failure. That threshold is based on guidance provided in the CIRIA 'Rock Manual' (Ref. 1). The EurOtop Manual on wave overtopping (Table 3.1 in Ref. 2) suggests limit for wave overtopping for structural design of rubble mound breakwaters, seawalls, dikes and dams with reinforced [see Note below] rear side between 5-10 l/s/m. Therefore, the adopted overtopping limit of 2 l/s/m for the design basis is considered to be conservative."*
>
> FRA ADDENDUM: The Sizewell C Project 5.2 Revision: 1.0 Applicable Regulation: Regulation 5(2)(e) PINS Reference Number: EN010012 Main Development Site Flood Risk Assessment Addendum Appendices A-F Part 10 of 10

Table 3.1 in the Eurotop manual 2018, referred to above, however, is a table specifying the structural design overtopping limits for seawalls, it is not a recommendation for wave overtopping limits for the damage to property behind the defence. This is covered by Table 3.2 of the same manual which specifies that overtopping rates must be equal to or less than 1 l/s/m to prevent overtopping flood damage occurring to equipment set back 5-10m from the seawall. See http://www.overtopping-manual.com/eurotop/downloads/

Note: EDF has not stated anywhere that I am aware of that the rear of the sea defence bank will be reinforced, certainly not on its new cross section details.

7.3.3 Independent guidance for tolerable overtopping levels

EDF has adopted the 'design basis' overtopping 'tolerable level' as its 'adopted threshold'.

The overtopping rates are below EDF's 'adopted threshold overtopping level' of 2 l/s/m however, this level is not justified by any guidance that I am aware of and is inconsistent with the advice from world-leading coastal consultant, HR Wallingford:

> ***"…overtopping rates became a danger to vehicles when the mean discharge exceeded 0.2 l/s/m."***
>
> Wave Overtopping of Seawalls Design and Assessment Manual HR Wallingford Ltd February 1999 R&D Technical Report W178

EDF's staff, however, will have no difficulty with over three times this level as EDF states that an overtopping rate of 0.64 l/s/m is considered insignificant for people at the platform behind the defence. "*Such overtopping rate is considered not significant for people at the platform behind the northern mound defence and would be easily manageable by trained staff*". Main Dev. Site, FRA, May 2020. op cit., Para 7.1.28,

Other professional bodies concur with HR Wallingford, not EDF:

The *Institute for Water Education, Unesco-IHE EurOtop* document for example:

> *"…aware pedestrian, clear view of the sea, not easily upset or frightened, able to tolerate getting wet, wider walkway would represent 0.1 l/s/m" and "damage to equipment set back 5-10m would occur at 0.4 l/s/m."*
>
> *Admissible overtopping Linked movies on overtopping behaviour, Unesco-IHE, Chapter 3 in EurOtop. Wave Overtopping of Seawalls Design and Assessment Manual.*

Allsop et al. in '*Direct Hazards from Wave overtopping*':

> *"A precautionary limit of q = 0.03 l/s/m might apply for conditions where pedestrians have no clear view of incoming waves; may be easily upset or frightened; are not dressed to get wet; may be on a narrow walkway; or are in close proximity to a trip or fall hazard. Research studies have however shown that this limit is only applicable for the conditions identified and should NOT be used as the general limit for which q [mean overtopping discharge] = 0.1 l/s/m in Table 1 is appropriate."*
>
> DIRECT HAZARDS FROM WAVE OVERTOPPING – THE FORGOTTEN ASPECT OF COASTAL FLOOD RISK ASSESSMENT? WILLIAM ALLSOP et al. Page 7

EDF itself appears to acknowledge that overtopping levels should be 'equal to or less than' 1 l/s/m:

> *"Building structure elements; Hm0 (significant wave height) = 1-3m =< 1 l/s/m*
> *Damage to equipment set back 5-10m =< 1 l/s/m"*
> DCO: Main Development Site Flood Risk Assessment Appendices 1-7 Part 1 of 14. Op. cit., Tables 5.4 and 5.5, Page 33.

Nevertheless, EDF accepts 2 l/s/m as a safe, tolerable overtopping level for the main platform. This is a level of overtopping that would introduce 96,000 litres of water onto the main platform **in one minute** of continued flow over an 800-metre seaward, seawall stretch.

> Technical note:
> Flood water flow is most likely to be significantly deeper and rapidly varied over a short distance from the point of overtopping, then gradually varied for the rest of the floodplain.

It appears that EDF is 'accepting as tolerable' overtopping rates that are greater than national and international guidance.

7.3.4 Overtopping rates: EDF's initial design of HCDF—10.2m crest height with 'adaptation' to 14.2m

- EDF's modelled overtopping levels for its initial design of a 10.2m defence crest before 2190 are as follows:

  1:200 (RCP 8.5) in 2140 is 0.3 l/s/m (litres per second per metre)
  1:1000 (RCP 8.5) in 2140 is 3.79 l/s/m
  1:10,000 (RCP8.5) in 2090 is 5.8 l/s/m
  1:10,000 (RCP8.5) in 2140 is 36.42 l/s/m.
  Main Development Site Flood Risk Assessment Appendices 1-7 Part 1 of 14. Op. cit., Table 5.6. Page 35/36 of 262.

- EDF's modelled overtopping levels for a 14.2m defence crest height are still showing overtopping:

  Modelled flood overtopping levels for a 14.2m sea defence crest height:

  1:1000 (RCP8.5) in 2190 is 0.02 l/s/m.
  1:10,000 (RCP8.5) in 2140 is 0.29 l/s/m.
  1:10,000(RCP8.5) in 2190 is 4.41 l/s/m.
  Main Development Site Flood Risk Assessment Appendices 1-7 Part 1 of 14. Op. cit., Table 5.6. Page 35/36 of 262

7.3.5 Overtopping rates: EDF's later design of HCDF submitted in the DCO Addendum

EDF's latest modelled overtopping levels according to the FRA Addendum for a 12.6m AOD defence crest height are stated as:

1:200 (RCP8.5)	in 2140 is 0.0 l/s/m based on wave height 3.72m
1:200 (BECC Upper)	in 2140 is 5.2 l/s/m based on wave height 4.48m
1:1000 (RCP8.5)	in 2190 is 1.9 l/s/m based on wave height 4.42m
1:10,000 (RCP8.5)	in 2140 is 2.4 l/s/m based on wave height 4.42m

FRA ADDENDUM: EN010012 Main Development Site Flood Risk Assessment Addendum Table 4.1.

These figures are modelled with inshore wave heights of 3.73m-4.48m as stated. There is no indication whether EDF has modelled variance into the Sizewell-Dunwich banks nor where inshore wave height is being recorded.

The 1:100-year offshore Hm0 (significant wave height) value is **7.8m** for waves from the N – NNE sector. According to Pye and Blott the 1:100 would be **7.3- 7.8m**. These predictions predate IPCC climate change scenarios. Thorpeness Coastal Erosion Appraisal Final Report December 2014', Mott Macdonald, Page 15. See 'Figure 58' below for a diagram of wave structure.

Technical note: A 1:200 return period means that there is a 57.3% probability of the event occurring between now and 2190, and a 15.6% probability of a 1:1000 event. See https://www.weather.gov/epz/wxcalc_floodperiod

7.3.6 EDF's assessment of still water and wave overtopping of the main nuclear platform.

Wave action and overtopping of sea defences may occur at the same time as extreme still water levels:

"2.1.5 Table 2.1 [reproduced below] presents a list of overtopping scenarios for the reasonably foreseeable (RCP8.5 95 percentile) and credible maximum (H++ or BECC Upper) climate change allowances and respective extreme still water levels, highlighting in red bold those scenarios with extreme sea level above platform height that were not undertaken in this assessment"

FRA ADDENDUM: op cit., Main Development Site Flood Risk Assessment Addendum Appendices A-F Part 10 of 10

Table 2.1: Summary of wave overtopping scenarios

Return period	2090 epoch		2140 epoch		2190 epoch	
	RCP8.5	H++	RCP8.5	BECC	RCP8.5	BECC
200-year	4.58	5.19	5.48	7.58	6.31	**8.48**
1,000-year	5.12	5.73	6.02	**8.12**	6.85	**9.02**
10,000-year	5.98	6.59	6.88	**8.98**	7.71	**9.88**

FRA ADDENDUM: op cit., Main Development Site Flood Risk Assessment Addendum Appendices A-F Part 10 of 10

EDF's table above includes wave action. The table below is a comparison excluding wave action and only considering the return period sea level rise and climate change sea level rise:

Return	2100 epoch		2140 Epoch		2200 Epoch	
Period	**RCP8.5**	**H++**	**RCP8.5**	**BECC**	**RCP8.5**	**BECC**
200-year	**4.25**	**5.03**	**4.93**	**no data**	**6.03**	**8.13**/8.00
1,000-year	**4.67**	**5.45**	**5.35**	7.94	**6.45**	**8.55**/8.84
10,000-year	**5.33**	**6.11**	**6.01**	8.85	**7.11**/7.58	**9.21**/9.75

Figures shown are in height of water AOD. Any figure greater than 7.3m AOD (main nuclear platform height) represents a flood level.

Data used: See section 7 (7.1.4). The 1953 flood level is approximately 1:1000. Figures in blue are EDF's figures from its table 4.2 in section 4.

Data used: 1:200 3.13m; 1:1000 3.55m; 1:10,000 4.21m
RCP8.5 2100 1.12m; RCP8.5 2140 1.8m; RCP8.5 2200 2.9m; BECC 2200 5.00m

Comparing the two tables it can be seen the contribution of wave action to sea level allocated by EDF for each return period and epoch – approximately 0.16 to 0.6m.

However, the significant 1:100 (100-year) offshore wave heights are **7.3- 7.8m** from the N –NNE sector. Should the Dunwich bank be lost or compromised—an orthodox worst-case scenario—then storm waves would break over the flooded South Minsmere levels, immediately to the North of Sizewell C. In flood conditions these waves would add to the water volumes in the contiguous marshes of South Minsmere and Sizewell and therefore suggests the possibility of a greater contribution to sea level around the main nuclear platform than 0.1-0.6m. See sections 6 and 7.

In my view, the suitability of a 'reasonably foreseeable' (RCP8.5) climate change scenario and a 1953 flood level (1:1000) as the defining design parameters for nuclear platform flood risk, does not provide reassurance.

8 EDF's assessment of breach flooding

EDF's states that the main nuclear platform will be flooded by a 1:200-year event if the defence is breached, a scenario that must be considered for all events:

> *"7.1.6. For the scenario with breach of the main sea defence (HCDF), the main platform would get flooded to a depth of approximately 0.2-0.4m (for the 1 in 200-year event) and 0.3-0.7m (for the 1 in 1,000-year event). This breach scenario was assessed for the credible maximum climate change (very conservative but plausible) scenario."*
> Main Development Site FRA Appendix 1-7, Part 7 of 14, op.cit., Page 91. **Epoch not stated—see 5.4.13 below which states 2030.**

This is confirmed in the main FRA document for the start of **operation** period:

> *"5.4.12 The most significant area of risk in both events is to the north-west of the existing Sizewell Drain in the area of the main platform which is at 'danger for most' in the 1 in 200-year event and rises to 'danger to all' for the 1 in 1,000-year event. However, for the platform area to the south-east of the Sizewell Drain, the hazard rating is 'low hazard' in the 1 in 200-year event and rises to 'danger for most' for the 1 in 1,000-year event."*
>
> *"5.4.13 The analysis for the Sizewell C Project shows the main platform area is at risk of flooding due to breach of coastal defences at both 1 in 200-year and 1 in 1,000-year events **in 2030** (Figure 25 and Figure 26) with water levels at 1.83m AOD and 2.05m AOD respectively."*
> DCO: Main Development Site Flood Risk Assessment, op cit., Page 77 For Figure 25 and 26 see: DCO: Development Site Flood Risk Assessment Figures 21- 30.

There does not appear to be a statement in the DCO documentation as to how the spent fuel, all stored onsite (until at least 2150 and possibly 2230), is to be safely managed during flooding events or how the reactor can be managed when flood water will, in my view, preclude safe pedestrian or vehicular access to buildings from off the site.

9. Sizewell as a potentially suitable site – Nuclear Energy policy statement EN-6 and concerns expressed by other professional bodies.

9.1 The Department of Energy and Climate Change in its 'National Policy Statement for Nuclear Power Generation (EN-6) July 2011', considered Sizewell to be a '*potentially* suitable site'. This judgment is derived from the following guidelines: "Nuclear power stations need access to cooling water…therefore…nuclear power stations in the UK are most likely to be developed on coastal or estuarine sites… at greater risk of flooding." However, the document continues:

> ***"In light of the findings of the Nuclear AoS, (Appraisal of Sustainability) applicants should assess the site's geology [and] geomorphological processes in order to understand the ongoing…coastal and geomorphic processes. This will include identifying impacts on coastal processes."*** The National Policy Statement for Nuclear Power Generation (EN-6) Vol 1 of 11. July 2011: Paras. 2.10.2, 3.6.6, 3.8.3

EDF's infrequent full bathymetric surveys of the Sizewell-Dunwich banks combined with their retention in unchanging form in its FRA modelling appears to be in contradiction to the requirements of the AoS.

The EN-6 National Policy Statement quoted (under review and paused by government) pre-dates fresh evidence on coastal stability presented in the two authoritative reports discussed earlier – the 2019 IPCC report (IPCC The Ocean and Cryosphere in a changing climate 24 September 2019) and UKCP18, published in November 2018.
In my opinion, the National Policy Statement (NPS) that declared Sizewell to be a 'potentially suitable site' for newbuild reactors eleven years ago is adversely impacted by UKCP18 and IPCC reports that it was unable to consider. I consider the claim to current stability of this coast in EDF's FRA and EGA is flawed and has an unreasonable dependency on the offshore Sizewell-Dunwich banks. EDF's reliance upon a best-case, no regime shift, geomorphological scenario—rather than considering variance in offshore geomorphology—suggests it fails to meet the current requirements of EN-6's Appraisal of Sustainability as defined in this section.

9.2 The Office for Nuclear Regulation's (ONR) 'Nuclear Safety Case', which is not fully public, is aimed at enforcing a 1:10,000 flood event risk as a basis for design which would, I believe, must be considered alongside high-end climate change scenarios:

> *"The FRA assesses the risk from all sources of flooding up to the 1 in 1,000-year return period event. More extreme events, such as the 1 in 10,000-year and 1 in 100,000-year events are considered in the safety case assessment as set out by the Office for Nuclear Regulation (ONR) and are not considered in detail in this FRA."*
> DCO: Main Development Site Flood Risk Assessment, op cit., Executive Summary

This advice note is taken from ONR's Safety Assessment Principles as follows:

> *"261. Facilities should be protected against a design basis flood by adopting a layout based on maintaining the 'dry site concept'. In the dry site concept, all vulnerable structures, systems and components should be located above the level of the design basis flood"*

The ONR continues:

> *"239. For external hazards, the design basis event should be derived conservatively to take account of data and model uncertainties. The thresholds set in FA.5 for design basis events are 1 in 10 000 years for external hazards and 1 in 100 000 years for internal hazards".*
>
> SAFETY ASSESSMENT PRINCIPLES FOR NUCLEAR FACILITIES 2014 EDITION, REVISION 1 (JANUARY 2020) Paragraphs 261 and 239.

However,

1. For a 1:10,000 event, with the 'new' FRA Addendum crest height of 12.6M AOD height the overtopping levels still represent a *'danger to vehicles'* in 2140 of 2.4 l/s/m as discussed in the previous section 7.3.

2. The overtopping level of 2.4 l/s/m is calculated for 1:10,000 using an emissions scenario of RCP8.5 95 percentile. There are no H++ data. The ONR must state whether this is regarded as adequate to the safety case.

   - As far as I am aware there is no consideration to wave overtopping volumes adding to still water levels in the Minsmere/Sizewell marshland that could affect the unprotected landward main nuclear platform at a level of 7.3m.

3. **BEEMS TR322 still water data, published by EDF in the DCO, of a 1:10,000 level of 5.73m ± 0.29m represents a still water flooding of the main platform in 2100 using H++ of 1.9m. (An overall level of 7.63m and a platform flood level). See section 4.**
   The 1:10,000 level of 5.73m is found in the DCO document: The Sizewell C Project 6.12 Revision: 1.0 PINS Reference Number: EN010012, *Reports Referenced in the Environmental Statement*. Page 72 of 389. This is a PDF page number as the pages are unnumbered. See section 3 of this paper.

4. The 'adaptive approach', although validated by the Environment Agency and the ONR, is not capable of restructuring the development of a breach in the offshore Sizewell-Dunwich bank complex any more than it can modify sea level rise over the banks. An 'adaptive approach' cannot deal with sudden increased flood risk or surge, unknown rates of change to the Sizewell foreshore in event of compromise to the Sizewell-Dunwich banks or a breach of the proposed defences.

It is not clear to me how the Sizewell C design is regarded as meeting ONR flood risk requirements.

9.3 The Environment Agency:

"Much of the Sizewell C Main Development Site and associated development sites are in Flood Zone 3—a high probability of flooding".
Environment Agency Relevant Representation on Sizewell C DCO Sept 2020. Page 6.

The Environment Agency goes on to say that it is therefore essential that the DCO is supported by an adequate Flood Risk Assessment. Sizewell C needs unqualified protection from flooding of the main platform to at least 2150.

9.4 The Institution of Mechanical Engineers, referring specifically to Sizewell B, state:

"…in the UK, nuclear sites such as Sizewell, which is based on the coastline, may need considerable investment to protect it against rising sea levels, or even abandonment/relocation".
IME (Institution of Mechanical Engineers) (2009): Climate Change: Adapting to the inevitable, Institution of Mechanical Engineers, Westminster, London.

9.5 DEFRA produced an unpublished government analysis (now partly obtained under FOI) in 2011 which shows that Sizewell is considered a high flood risk up to and including 2080 with no forecast beyond. The Guardian journalist continues:

"Experts suggested that the main worry was that inundation would cause nuclear waste to leak. 'Sea level rise, especially in the south east of England, will mean that some of these sites will be under water within 100 years,' said David Crichton, a flood specialist and an honorary professor at the Hazard Research Centre in University College London."

"This will make decommissioning expensive and difficult, not to mention the recovery and movement of nuclear waste to higher ground."
Guardian, 8 March 2012, Rob Edwards, *'Most nuclear sites at risk of flooding and coastal erosion, says government study.' https://www.robedwards.com/2012/03/most-nuclear-sites-at-risk-of-flooding-and-coastal-erosion-says-government-study.html*

9.6 Sizewell A is controlled by Magnox under the auspices of the Nuclear Decommissioning Authority. Magnox's solicitors have offered the following Representation:

4.4 At this stage, and on the basis of the Applicant's current [DCO] proposals, the NDA and Magnox are not yet satisfied that the Sizewell C Nuclear Generating Station can be constructed and operated in accordance with the Applicant's application proposals in a manner which adequately ensures the safe, secure and environmentally sound decommissioning of the Sizewell A Nuclear Site.
JOINT RELEVANT REPRESENTATION OF THE **NUCLEAR DECOMMISSIONING AUTHORITY** AND MAGNOX LIMITED submitted to the Planning Inspectorate 30 September 2020 From Pinsent Masons LLP.

NDA/Magnox Joint Relevant Representation link:
https://infrastructure.planninginspectorate.gov.uk/projects/eastern/the-sizewell-c-project/?ipcsection=relreps&relrep=41888

9.7 There is a possibility of competing and conflicting land demands for the Sizewell foreshore from windfarm and offshore grid cable landfall.

Parts of the Sizewell foreshore may have to accommodate—and the Sizewell-Dunwich banks be crossed by—the cable landfalls of EA1N and EA2 wind farms, Nautilus and Eurolink interconnectors and National Grid offshore grid-to-grid links SCD1 and SCD2. There is also the likelihood of a Sizewell cabling landfall for the Galloper and Greater Gabbard extensions and the four new wind auctions under proposal. Details are not yet available.

10. Sizewell **B** versus Sizewell **C** sea defence design.

10.1 Sizewell **B**

"4.77 The [Sizewell B] site is currently protected from seaward flooding by a northward extension of the flood defences associated with the existing Sizewell B power station, comprising a sand and shingle vegetated embankment with a crest height of +10m OD. This bank lies landward of a further landscaped structure with a crest height of approximately +4m OD, the purpose of which is to absorb the impact of storm waves." DECC Appraisal of Sustainability Report 2010 EN-6: Revised Draft National Policy Statement for Nuclear Power Generation, Oct 2010

Sizewell B

1. The picture shows the gully between the sea defences and the main nuclear platform of Sizewell B.

2. The concrete and steel wall topped with barbed wire offers security from trespass.

3. Sizewell B has a **10m** AOD sea defence crest height.

4. Sizewell **B**'s operational life is under review and will probably be extended to 2055 with spent fuel remaining onsite for a considerable time thereafter. Sizewell B spent fuel 'Interim storage' dates vary depending upon fuel use such as REPU, burn rate and operational extension. According to the NDA these dates are between 2097 and 2270.
   NDA Radioactive Waste Management Directorate Packaging of Sizewell B Spent Fuel (Pre-Conceptual stage) Summary of Assessment Report Issue date of Assessment Report: 23 December 2011. Page 7. REPU is Reprocessed uranium.

5. Sizewell B and C are adjoining sites and **EDF has stated that a 14.2m crest height will be required for Sizewell C by 2046.** Main Dev Site FRA Addendum Jan 21. Page 1.

- However, the adjoining Sizewell **B** which has a 10m AOD sea defence crest height. The proposed sea defence designed for Sizewell **C** (14.6m - 16.4m AOD) does not appear to cover the frontage of Sizewell B (see Plate 5.3 below**). I have not seen an explanation for this. Sizewell B will not respond to correspondence asking whether they will increase sea defence height. In its present form, according to EDF in its statement above, Sizewell B's defences must represent a danger to itself and Sizewell C by 2046.**

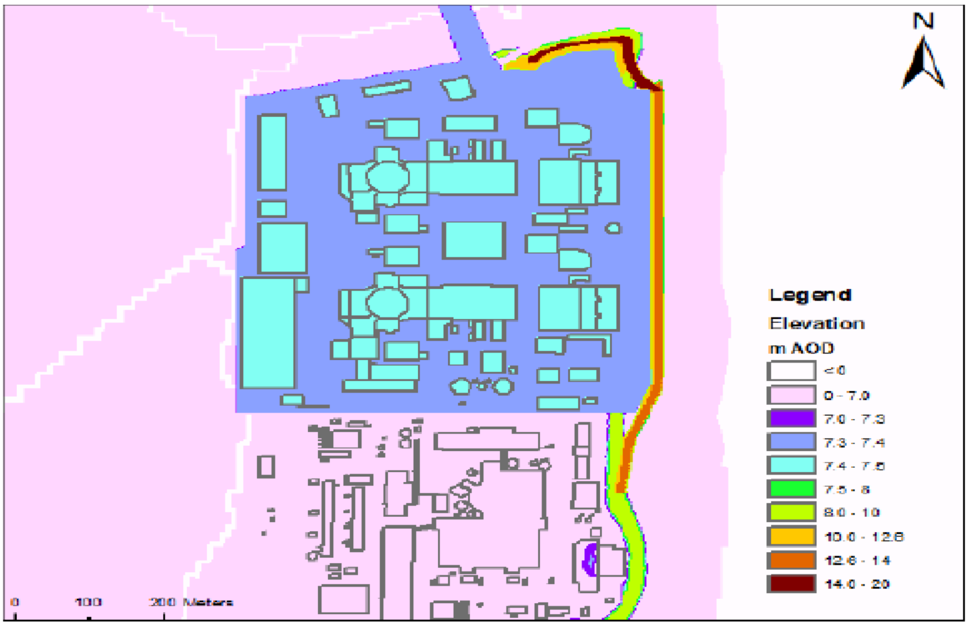
- The Sizewell C Project 8.13 Revision: 1.0 Applicable Regulation: Regulation 5(2)(q) PINS Reference Number: EN010012 Sustainability Statement states:

> *"3.2.21 . As Sizewell C has a boundary with Sizewell B to the south and both platforms are at differing ground levels, a retaining wall would be constructed to prevent surface water discharging from Sizewell C to Sizewell B. "*

This does not appear to resolve the questions raised above relating to sea defence height disparity.

10.2 Sizewell **C**

Plate 5.3: Representation of the main platform and HCDF in the inundation model



SIZEWELL C

EDF Addendum: Main Development Site Flood Risk Assessment Addendum Appendices A-F Part 10 of 10. Note in Plate 5.3 that the 12.6m-14.6m sea defence contour of Sizewell C merges into the mainly unchanged 8-10m Sizewell B defences

Plate 4.3: Proposed Permanent HCDF cross-sectional profile (extract from EDF Energy drawing no. SZC-EW0601-XX-000-DRW-400025 rev. 01, 27/11/20)

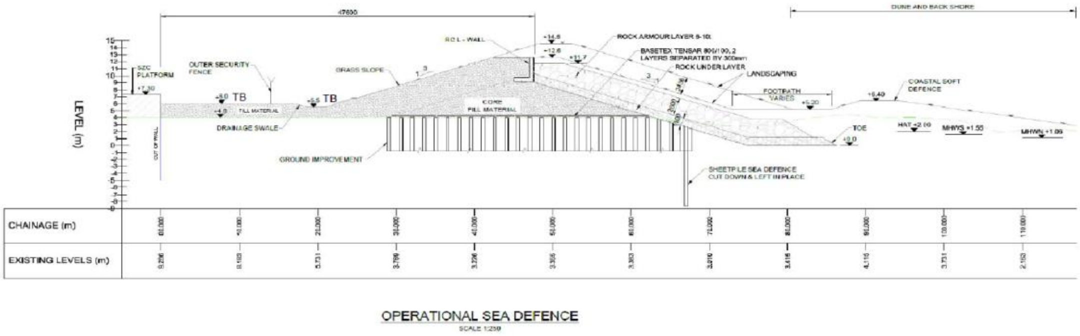
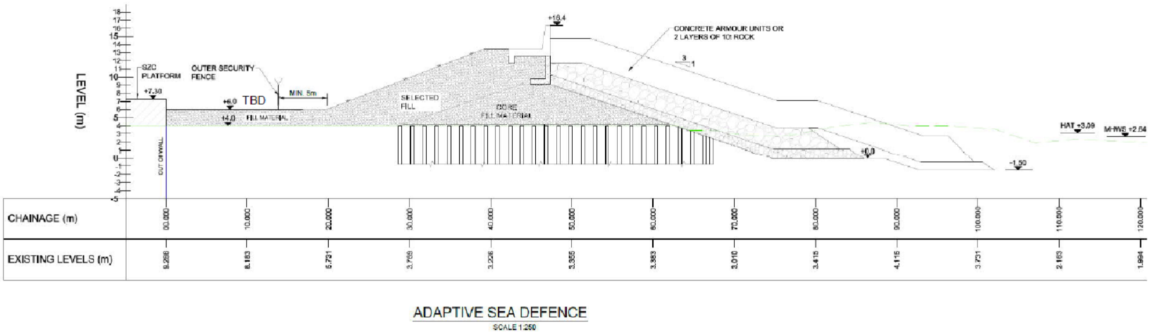


Plate 4.4: Proposed Adaptive Sea Defence (HCDF) cross-sectional profile (extract from EDF Energy drawing no. SZC-EW0601-XX-000-DRW-400025 rev. 01, 27/11/20)



1. EDF's image quality is poor but a swale is shown on the lower crest height. There appears to be a flat area which may offer flood storage capacity.

2. There is no indication of a concrete and steel wall topped with barbed wire for security from trespass.

3. Sizewell C defence crest height is much greater at **14.6m** AOD with adaptive change to **16.4m** AOD (with landscaping to **18m** AOD).

4. The Sizewell C finished site will be 35 hectares. See MDS FRA Addendum Part 10 of 10, op. cit., 2.3.4. (The building site will be 371.7 hectares)

5. Sizewell C will be built approximately 40m further to seaward than Sizewell B according to the East Suffolk Councils. East Suffolk Council, Extraordinary Meeting, Thursday 3 September 2020 at 6.30pm. Page 68.

11. Spent Fuel cooling period and Fuel Store decommissioning date.

Sizewell C's minimum requirement for unqualified security from flood and coastal processes is necessary until the spent fuel store is decommissioned. It is not clear when this will be.

EDF states, somewhat disconcertingly that:

> *"26.5.11 Project lifetime is considered to include the construction stage of 12 years and the proposed operational stage of 60 years."* Doc 6.3 Vol 2 Main Dev Site Chapter 26 Climate Change.

This manifestly appears to be ignoring what I consider to be the single most important factor in environmental risk for Sizewell C: the cooling and storage of spent fuel in the face of risk from climate change sea level rise, storm events and the loss or compromise of the Sizewell-Dunwich banks.

EDF's decommissioning of the Intermediate Spent Fuel Store:

In the original FRA, EDF states:

- *2022: start of construction.*
- *2034: end of construction and start of operation (sometimes quoted as 2030).*
- *2090: end of operation.*
- *2140: interim spent fuel store decommissioned.*
- *2190: theoretical maximum site lifetime.*

DCO: Main Development Site Flood Risk Assessment. Op cit., section 1.2.16. Page 18.

In the FRA Addendum EDF states:

- *2022 – Start of construction;*
- *2034 – End of construction (2030 used);*
- *2090 – End of operation;*
- *2140 – Interim spent fuel store decommissioning; and*
- *2190 – Theoretical maximum site lifetime,*

FRA Addendum: Main Development Site Flood Risk Assessment Addendum Appendices A-F Part 10 of 10.

The word 'decommission' has changed tense; perhaps EDF considers 2040 to represent the start of decommissioning but this is not explicitly stated.

EDF suggests that, '*It has been assumed that the decommissioning of the ISFS would take 5 years and would be completed within 60 years from End of Generation*'. EDF's assumption is seemingly that the Intermediate Spent Fuel Store will be decommissioned by 2150. Volume 2 Main Development Site Chapter 5 Description of decommissioning. Para 5.1.5.

- This date does not appear to be endorsed by the Nuclear Decommissioning Authority (NDA) which suggests the date to be 2180 or 2230:

  "Current RWMD generic disposal studies for spent fuel define a temperature criterion for the acceptable heat output from a disposal canister. In order to ensure that the performance of the bentonite buffer material to be placed around the canister in the disposal environment is not damaged by excessive temperatures, a temperature limit of 100°C is applied to the inner bentonite buffer surface. ***Based on a canister containing four EPR fuel assemblies, each***

***with the maximum burn-up of 65 GWd/tU and adopting the canister spacing used in existing concept designs, it would require of order of 140 years for the activity, and hence heat output, of the EPR fuel to decay sufficiently to meet this temperature criterion**."*

*"**It is acknowledged that the cooling period specified above is greater than would be required for existing PWR fuel to meet the same criterion*** **[due to its higher levels of radioactivity and high decay heat radioisotopes]** *and RWMD proposes to explore how this period can be reduced. This may be achieved for instance through refinement of the assessment inventory (for example by considering a more realistic distribution of burn-up), by reducing the fuel loading in a canister* **[which will increase the geological disposal footprint]** *or by consideration of alternative disposal concepts. The sensitivity of the cooling period to fuel burn-up has been investigated by consideration of an alternative fuel inventory based on an assembly irradiation of 50 GWd/tU. For this alternative scenario it is estimated that the cooling time required will reduce to the order of **90 years** to meet the same temperature criterion."*

NDA 'Geological Disposal Generic Design Assessment: Summary of Disposability Assessment for Wastes and Spent Fuel arising from Operation of the UK EPR' Jan 2014 section 6, page 6.