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Environment Agency

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Your Ref: EN010012

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By email only

Dear Ms McKay

Planning Act 2008 – Section 88 and the Infrastructure Planning (Examination Procedure) Rules 2010 – Deadline 3: Comments on Coastal Geomorphology Reports

Application by NNB Generation Company (SZC) Limited for an Order Granting Development Consent for the Sizewell C Project

For Deadline 3 (24th June) the Examining Authority (ExA) have requested comments on additional reports submitted up to NNBGenCo (SzC) Ltd Deadline 2. We wish to provide feedback on the following reports:

- TR531 Storm Response Modelling –Preliminary evidence toward setting volumetric thresholds for SCDF recharge
- TR543 Modelling of the temporary and Permanent Beach Landing Facilities
- TR544 Preliminary design and maintenance requirements for the Sizewell C Coastal Defence Feature

The Environment Agency is one of a number of organisations that participate in the Sizewell C Marine Technical Forum (MTF) - convened to review their submissions and provide clear, comprehensive technical guidance to NNBGenCo (SzC) Ltd in response.

NNBGenCo (SzC) Ltd has not allowed sufficient time to convene an MTF ahead of their issue of the further reports expected at Deadline 3, including a revision to report TR544, on which we are only just commenting for the first time. This approach prevents our advice (and that of others) from being considered in, and applied to, any upcoming reports / further report revisions – which might perhaps otherwise allow the resolution of outstanding issues and the potential for us to arrive at common ground.

Our comments (contained in Appendix A) should be considered interim comments at this time, as we will be unable to confirm our final position until NNBGenCo (SzC) Ltd has provided their final versions of outstanding reports and there has been sufficient time for our review - independently - and more widely across Defra Group and the local Coastal Protection Authority.

Yours sincerely

[redacted]

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Appendix A: Environment Agency comments on Coastal Geomorphology Reports

TR531 Storm Response Modelling – Preliminary evidence toward setting volumetric thresholds for SCDF recharge

Reference	Comment	Suggestion / recommendation
Exec Summary, p.11	'The SCDF would be constructed and maintained between the HCDF and MHWS level'. This suggests that the SCDF itself will consist of a comparatively narrow gravel dominated upper portion of the beach. It is conceptually difficult to envisage it being feasible to maintain an SCDF covering only the upper beach for the duration of the site's operation without also managing the rest of the intertidal profile (e.g. to prevent or limit profile steepening due to recession of lower beach contours).	Provide clarity on design of the SCDF, and provide analysis of whether the SCDF alone / in combination with mitigation measures will be sufficient to maintain a functioning beach and foreshore.
Exec Summary, p.11	'The results may also prove useful in supporting and refining the design of the SCDF, although this is not the remit of Cefas.' It is a highly relevant point, but it is not clear from this report or our discussions with EDF to date how the results of this and other studies will be utilised to inform the design of the SCDF and/or HCDF.	Provide reassurance that the design can / will be refined subject to the findings of this and other relevant studies.
1.1, p. 13	'This report develops a 1D sand beach erosion model…' The fact that XBeach – a model designed to replicate sandy beach dynamics – is being used at Sizewell – a mixed sand and gravel beach – is a concern. Is there a risk that by using a sand beach model the risk of profile changes which are generally more pronounced on systems with significant gravel fractions, e.g. steepening during storms, may be underestimated? This is particularly relevant	Further discussion of the distinctions between sand and mixed sand-gravel beach dynamics, and in particular how these can / can't be accounted for by using XBeach (or indeed XBeach G) is necessary.

	given that the functioning of the SCDF will presumably depend heavily on the evolution of the rest of the foreshore (in particular the lower beach).	
2.2, p. 14-15	The description of the different XBeach modes is interesting, but there is little discussion of what the significance of this study having selected the surfbeat mode over the non-hydrostatic mode is, beyond one of reducing the computational run times. E.g. is there a risk that surfbeat may underestimate runup (compared with the non-hydrostatic mode), and therefore potentially also the risk of erosion of the upper (shingle) beach at Sizewell?	Provide commentary on the full rationale behind the choice to use the surfbeat mode, and in particular whether this brings any limitations / benefits over the non-hydrostatic mode other than those related to computational run times.
2.5, p. 17	The 'Assumptions and limitations of modelling' rightly identifies that there are issues with applying the results of XBeach modelling to a mixed sand and gravel domain, but suggests mixed sediment effects can be included 'in a somewhat heuristic manner.' However, no further details are provided to justify this statement.	Further details about the limitations and how the duneslope and sedcal parameters heuristically address these should be provided here. The report currently lacks sufficient detail to support the statements provided about the issues of applying XBeach at Sizewell.
2.5, p.17	'This results in waves always travelling perpendicular to the 1D model domain, wave refraction is ignored, and no longshore currents or transport are generated. This adds to the conservative nature of the model and is expected to result in overprediction of erosion.' It is not clear how the absence of longshore transport results in erosion being overpredicted. Clearly for some locations the input of logshore sediment will balance the outputs at a given profile, but since this is not the case everywhere it seems reasonable that excluding longshore currents may result in the model missing the possibility of longshore transport gradients occurring, which are a key driver of beach erosion.	Further clarity is required here. The report currently lacks the level of detail required to support the assertion that the model provides a conservative overestimate of erosion risk.
3.2, p. 19 – 23 (incl figs)	The two storms used for the calibration of the model appear to have created quite similar conditions (Hs between 3 – 4 m, Tp between 6 – 7 secs). Is there a risk that by using two fairly similar storms, the calibration may miss a deviation between model outputs and observed beach change which could occur under different conditions? Have sensitivity tests been carried out to consider this?	Further details needed.

3.3, p. 24	The report provides negligible detail of the sedcal parameter and how it enabled adjustments 'to parametrize the mixed sand gravel make-up of the beach face.' This is significant since it is important to understand how the model capabilities and outputs differ from the standard dynamics observed on beaches with a significant gravel component.	Further details are required regarding the sedcal parameter and how it addresses the sediment size issue with XBeach.
3.3, p. 24	It is stated that the berm slope model 'allows for improved simulation of dune behaviour due to the mixed sand gravel components of the beach at Sizewell' but no details are provided to support this assertion. As such, it is not clear how this addition improves the applicability of the model to mixed sand and gravel beaches. e.g. does the report suggest that by specifying a higher berm slope value one can account for the greater angle of repose for beaches with a significant gravel fraction? Further explanation is required.	Further details are required regarding the use of the berm slope model and how it aids the reliability of the X-Beach projections.
3.4.2, p. 27 - 30	It is significant that the model seems to be less reliable for wave events from the NNE (like the May event) than the East (like Storm Ciara), when considering that this is (presently) the dominant orientation for larger waves at Sizewell. Moreover, the differences between the model outputs and observed post-storm beach profiles for the May event are perhaps as expected when using a sand beach model on a mixed sediment system (e.g. inability to recreate berm formation, tendency to assume a gentler gradient).	Waves of different orientations should be included in the 2d modelling.
5., p. 42 onwards	The results presented appear fairly encouraging (albeit at a preliminary stage with further modelling required), but is there a risk that X-Beach – as a sandy beach model – underestimates the risk of profile steepening which can occur in beaches with a significant gravel fraction? The current model outputs broadly fit the Bruun rule style of profile flattening, with erosion of the upper beach approximately balanced by accretion lower down the profile (cut and fill), but would we expect that to be more representative of sandy beaches than mixed sediment systems like Sizewell? Moreover, the lack of reliable post-storm observed profiles for comparison with the model outputs does call into question the reliability of the BfE scenario results.	Further discussion would be helpful, or perhaps even also running scenarios using X-Beach G (designed for gravel beaches) as a form of sensitivity testing. It is not entirely clear from the content of this report how the confidence that XBeach is suitably conservative for Sizewell is justified without having undertaken comparisons with an alternative gravel beach model(s).

6.1, p. 48	Given that the lack of beach recession into the shingle barrier to the rear of the beach under the modelled scenarios is cited as a positive output, how significant is the likelihood that the surfbeat mode underestimates swash extent, considering that runup is a key control of gravel beach morphodynamics?	Further discussion should be added to provide confidence that the choice of model and calibration parameters is appropriate.
6.1, p. 48	The intention to use XBeach G in future modelling to consider coarser sediment in the SCDF is encouraging. Has the possibility of testing the baseline beach only scenario using XBeach G and comparing these results with the XBeach outputs been considered? Could this provide an indication of the sensitivity of the outputs to the choice of model? If this is considered unnecessary, further explanation should be provided to make clear why this is the case.	Either add further explanation of why it was not considered appropriate to also run the baseline scenarios using XBeach G for comparison between the two models, or consider undertaking this process to test the sensitivity of the outputs to different beach sediment compositions.
6.2, p. 49	The fact that the model used here does not consider the longshore energy component of storms is given as a reason for the results being conservative (since it effectively assumes all wave energy is expended cross shore). Is there a risk that by excluding longshore sediment transport the model may actually underestimate erosion / volume loss? We know that beach response at Sizewell is highly spatially variable, and that this is likely to be a result of similarly spatially variable wave energy creating longshore transport gradients. It will be important to consider this when running 2d models in future reports, e.g. to consider the risk that sediment moved down the profile under the 1d modelling may actually be moved out of a given profile by longshore transport, creating a more significant drawdown effect (unless balanced by inputs from updrift).	Further work is required at the 2d modelling stage to test the sensitivity of the model outputs to the addition of longshore movement as well as cross shore sediment dynamics. In particular, consideration should be given to the possibility that areas of accretion which are shown lower down the profile in the current 1d model outputs as a result of seawards sediment transport may in fact be reduced or removed entirely with the inclusion of longshore movement.

TR543 Modelling of the temporary and Permanent Beach Landing Facilities

Reference	Comment	Suggestion / recommendation
1.1, p. 23	'*Raking piles and cross braces may be required at the seaward end of the unloading platform for stability*' but that these cannot be modelled as 2d models cannot consider diagonal structures. The report states that '*the omission of these small structures will not materially affect the results of the modelling*.'	Provide some further information here. E.g. how many raking piles might reasonably be present? What could their footprint be? Were sensitivity tests carried out adding in further regular piles? The current conclusion is seemingly based on expert judgement, but without offering much insight into the rationale behind the judgement.
3.5.2, p. 34	Waves <3m Hs were excluded from the hindcast data used for the TOMOWAC modelling. It is assumed the logic of using higher waves only is for a precautionary assessment and/or because use of operational Hs limits for barge and ship result in a more representative range of Hs at the coast anyway, but further clarity would be useful. E.g. is there confidence that worst case has been considered, and scenario whereby lower waves = smaller reduction required to drop below critical threshold hasn't been underestimated.	Further comment on the rationale behind excluding waves <3m Hs, and how these waves relate to the three wave heights modelled in ARTEMIS would be helpful.
4., p. 37	'*ARTEMIS results were run for the constant water levels associated with peak flood currents and peak ebb currents, which would generate maximum combined wave-current bed shear stresses*.' This is a logical approach when considering worst case erosion scenarios, but could it be missing scenarios where a relatively small reduction during calmer conditions leads to a drop below the critical threshold, impacting sediment transport?	Provide clarity.
4.4.3, p. 65 **4.5.3, p. 73** **4.7.3, p. 87**	*'The reduction in bed shear stress is between 15 – 20 N/m2 along both the inner and outer longshore bar. The baseline bed shear stress along the outer bar is 20 – 30 N/m2…. No area is reduced below the critical threshold.'* The figures presented imply that there is the potential for shear stress to drop below the critical threshold along the outer longshore bar, contradicting the text.	Further clarity is needed, and if necessary the possibility for resulting impacts should be considered.

TR544 Preliminary design and maintenance requirements for the Sizewell C Coastal Defence Feature

Reference	Comment	Suggestion / recommendation
Exec summary, p.8	It is noted that 'The increase in SCDF crest height of 1 – 2.4 m above the present, unbreached, shingle ridge crest, is substantially greater than predicted sea level rise (SLR) in 2099 under the intermediate climate emissions scenario (RCP4.5) and is similar or greater than the very unlikely worst-case emissions scenario (RCP8.5, 95th and 50th percentiles, respectively).' Whilst this is true, it is not clear whether water level changes on top of SLR have been factored into this design, e.g. wave height, runup and setup, and the impacts these may have on performance of the current design.	Provide details of the full range of scenarios considered when determining the design of the SCDF.
Exec summary, p.8	The report considers SLR to 2099, the end of UKCP18 projections and the planned decommissioning phase of SZC assuming a 60 year operational phase. We understand that there is a distinct possibility the operational phase may be extended further into the future, and note that the Sizewell C Coastal Defences Design Report lists the design life of the structures as '110 years (up to 2140 – extended to accommodate change in spent fuel; storage strategy)'. How is this assumed extension in life of the defences being considered? Is there a risk that beyond 2099 the pressures facing the beach may be sufficient to render the SCDF unfit for purpose?	Further clarity is needed on the possibility for beach management requirements beyond 2099, and how residual uncertainty can be addressed (e.g. through formal adaptive pathway planning).
Exec summary, p. 8	Has the potential scenario in which the adaptive sea defence design is implemented been assessed? This would increase both the elevation and seaward extension of the toe of the HCDF, with potentially significant impacts on the viability of the SCDF.	Assessment of the viability of the SCDF under the adaptive defence design scenario is required.
Introduction, p.11	'A high crest' is noted as a key design feature for the SCDF. It should be noted that overly (unnaturally) elevating the crest of a managed beach can lead to	We need to see detailed designs for the beach, and assessment of how it will

	adverse effects on the performance of the beach during storms, e.g. steepening, wave reflection and net offshore movement, particularly when the effects of wave runup and setup are considered. This can be shown be examples such as Walberswick beach ridge, which was artificially maintained to have a high crest, but this made the ridge steeper and less able to respond to storm conditions and was prone to overtopping/breaching.	perform under reasonable worst case scenarios, as well as an indication of how future maintenance of the SCDF will account for changing conditions (e.g. designing beach crest suitable for sea level and storm wave regime).
Introduction, p.11	The SCDF is described here as 'embedded (primary) mitigation.' Whilst we acknowledge that its original intention was to mitigate for geomorphological impacts resulting from HCDF exposure, it now appears to be critical for the functioning of the HCDF (given that the toe depth illustrated in Figure i is above the current MLWS datum, and therefore would be undermined and at risk of collapse unless fronted by a suitable beach). Moreover, the SCDF is described as 'functionally interconnected' with the HCDF in the Sizewell C Coastal Defences Design Report. Therefore, the SCDF – in its role aiding the retention of a suitable (design) beach required for the functioning of the HCDF – is surely a key design component of the sea defences, rather than scheme mitigation. This is a significant distinction, since it increases the level of certainty required when analysing performance and impacts throughout the lifetime (both as originally designed, and accounting for any future extensions) of the development.	Provide clarity as a high priority. It may affect the way we as a regulator approach the level of residual uncertainty which remains following this work (i.e. a larger degree of uncertainty may be acceptable for environmental mitigation measures than for flood defences critical to the safety of the site).
1.1, p. 12	A high crest is described as an 'erosion resistant feature' of the design. Again, we would question whether this is accurate. Creating an unnaturally high crest on a barrier beach could be a flood protection feature of beach design (albeit an unsustainable one), but risks increasing erosion of beachface. Is there an argument that having a lower (closer to natural) crest would allow wave energy to be spread over a wider section of beach, reducing the impacts on any single area, particularly since the much higher crest of the HCDF means that the SCDF crest is not strictly required as a flood defence feature? Also, coarser sediments have higher angle of repose, therefore increasing reflectivity, contributing to increased amount of foreshore lowering. This would possibly lead to, at the very least, an	Further clarity on design rationale is needed, as well as robust assessment of the impacts of crest design on beach response to storm events in particular.

	increase in recharge activities in order to protect the integrity of both SCDF and HCDF.	
2. SCDF Design	The Sizewell C Sea Defence Design Report outlines a planned design featuring a reorientation of the SCDF inland at the SCZ – SZB interface (e.g. see Figure 3-6 in that report). It is not clear whether this design – and any resulting geomorphological implications (e.g. concerning shingle transport or wave refraction) have been considered in TR544, or whether this will be considered in TR545. Are the current defences of SZA/B of a sufficient level/height to perform the job of protecting SZC from outflanking to the south?	Analysis is required of potential geomorphological implications of the proposed design for the SCDF at the interface with Sizewell B.
2.2, p.16	'SCDF recharge would occur in areas where vegetation is naturally lost, replenishing the sediment there and facilitating potential re-colonisation of the supratidal habitat within the county wildlife site.' This is not an entirely accurate picture, since it should be remembered that naturally the coastline would be expected to rollback, meaning erosion events which result in the loss of important habitats and features would likely be followed by their return after the beach has realigned (e.g. following barrier rollback). The presence of the SZC defences (as well as remaining infrastructure at SZA and B) is what is/will prevent this natural evolution from occurring, resulting in coastal squeeze affecting the beach profile, and with it the supratidal habitat zonation.	There should be a clear distinction between what would naturally occur in the absence of SZC and what is expected to occur in light of its presence. This is relevant for assessing HRA implications.
2.3, p. 18	The SCDF sacrificial area is described as effectively a 'real-time recharge' to the beach as sediment is drawn down onto the 'active beachface.' It is not clear the extent to which we would expect shingle drawn down the beach to adequately compensate for sand lost to erosion (given that the SCDF will be comprised of much coarser sediment than the majority of material which makes up the natural beachface). In particular, is there a risk that over time this may gradually change the morphology of the foreshore from a gently sloping sand dominated system (as presently) to a steeper (and potentially more reflective), shingle dominated form?	Further clarity is needed as to the expected performance of sediment eroded from the SCDF once it enters the 'active beachface', and any potential long term geomorphological impacts that may result from this process.
2.3.1, p. 20	The preliminary modelling work reported in BEEMS TR531 is described as 'highly conservative.' As noted in EA comments on TR531, it has not been demonstrated	Further clarification on some of the parameters applied to address this issue

3, p.26	that this is a fair statement, primarily because details are lacking regarding some of the issues that may occur when applying XBeach (a sand beach model) to a mixed sand and gravel system at Sizewell.	(as briefly alluded to but not clearly explained in BEEMS TR531) is required to give confidence that the modelling is indeed suitably conservative for the purpose of this assessment.
2.3.1, p.20	We welcome the planned addition of modelling to account for more severe storms, erosion of neighbouring shoreline and higher sea levels planned for TR545. We would ideally like to see some (or preferably all) of the concerns outlined in this document and the comments on TR531 addressed in TR545 alongside these additional factors.	
2.3.2, p.21	'Overtopping per se is not of direct concern for the SCDF to achieve its purpose of avoiding disruption to longshore shingle transport due to HCDF exposure, however overwashing of quantities of sediment sufficient to alter or mobilise the crest could lead to breaching and affect integrity and maintenance frequency. The crest elevation should be high enough to avoid heavy overwashing of the crest.' Has the risk been considered that increasing the elevation of the crest may actually exacerbate erosion risk in the medium to long term by effectively changing the dominant sediment dynamic from overtopping / overwashing to one of scarping and seawards transport? We would generally advise that raising the crest substantially above SLR projections + joint probability (wave + surge) elevations is not the best way to guarantee the resilience of a barrier beach given the importance of overtopping and overwashing for natural adjustment and evolution. With SLR meaning an increase in water level, and a shifting of the tide levels landwards, plus possible increase in storm intensities, it is not confirmed that thewave conditions can be the same or less than at present. The number of storms may not be increasing, but storm intensities seem to be. Is	Further clarity is required as to how the design crest elevation was decided on, and whether lower elevations have also been considered which could potentially increase the frequency of overtopping in the medium to long term, but reduce the risk of scarping / steepening over time (and thus reduce maintenance frequency).

	Sizewell/Dunwich bank system does not move landwards and/or is not fed with sufficient sediment to keep it viable, and is effectively drowned by rapid SLR, then the banks will not provide the protection that they currently do.	
2.4, p. 23-24	Has the risk that using sediment coarser than the native size distribution may gradually alter the morphology of the system been considered? We understand the engineering benefits this may bring, and recognise that there is precedent for such an approach, but would like to see more geomorphological analysis of the potential impacts to the form – and thus functioning – of the beach in the long term. This is particularly relevant given the point made here that 'sections at Highcliffe with sand and gravel mixtures performed less well and required minor recharges.' Would the use of coarser, and therefore less mobile material, lead (eventually) to the development of a small ness feature, with the possibility of interfering with longshore transport?	Further analysis is required to add confidence in the viability of the proposed management approach.
3. (whole chapter)	The beach volume and recharge frequency calculations here are a useful first indication, but we note that these are liable to change once 2d modelling to factor in longshore sediment movement has been undertaken (as indicated in 3.1.2 & 3.1.3)	We expect the next modelling report TR545 to provide a more reliable indication of recharge volume and frequency than this one, and assume therefore that the results here are not intended as final.
3.1.1.2, p.29	'Although this estimate includes a component of SLR (that which occurred between 1991 and 2018) and several conservative factors (listed at the start of this section), it does not account for accelerating future SLR, and so may be an under-estimate.' This is a key point. In locations like Sizewell, where net shoreline trends are fairly small (due to bimodal waves), we also need to consider the possibility that climate change will alter the balance between processes, as well as their magnitude (e.g.	We understand that potential accelerated SLR rates will be factored into future assessment(s), and suggest that other relevant factors (e.g. the possibility that the wave regime may change, not just in terms of Hs / Tp but also orientation) should also be included.

	affecting the bimodality of the wave climate) as part of the process of planning for the worst case scenario.	
4., p.33	An event with 1 in 12 year return interval storm energy is listed here as severe, despite the fact that this work is assessing defences which will need to function to 2099 and beyond.	Given that the TR545 report will consider more severe scenarios, this wording ought to be adjusted to reflect the fact that events which we currently consider to be extreme are expected to be more common by the end of the century.