Office for Nuclear Regulation

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Civil Nuclear Reactor Programme

Civil Engineering workstream - nuclear site licensing of Hinkley Point C

Assessment Report: ONR-CNRP-AR-12-088
Revision 1
14 January 2013

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ASSESSMENT REPORT

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EXECUTIVE SUMMARY

Background

This report presents the findings of the Office for Nuclear Regulation's (ONR) civil engineering workstream assessment of NNB Generation Company's (NNB GenCo) application, including supporting information and arrangements, for a nuclear site licence at Hinkley Point C (HPC). This assessment supports ONR's decision whether to grant a nuclear site licence or not for NNB GenCo to install and operate two UK EPR™ units at Hinkley Point C.

The interventions described in this report have been implemented to align with ONR's overall licensing strategy (Ref. 6) and the Civil Engineering Intervention Project Record (Ref. 7). The conclusions presented in the report also inform ONR's interventions which assess NNB GenCo's safety report for HPC and NNB GenCo's organisational capability.

Assessment and inspection work carried out by ONR

ONR has engaged with NNB GenCo in the civil engineering workstream since November 2009 (outside of Generic Design Assessment) via regular Level 4 meetings and assessment of relevant documentation where available. A schedule of interventions held with NNB GenCo since the submission of a Licence Application on 29th July 2011 is provided in Annex 1. Evidence from all these interventions was used to form a judgement on recommending, or not, the granting of a nuclear site licence. Within the Civil Engineering workstream this engagement had the objective of verifying that, at this stage in the HPC Project:

- NNB GenCo is able to demonstrate an adequate intelligent customer capability.
- NNB GenCo has adequate suitably qualified and experienced personnel to control the delivery of civil engineering related safety systems, structures and components for HPC.
- There is evidence of application of NNB GenCo's hold point control process in relation to establishing adequate and suitable civil engineering related control points in the programme for delivery of HPC.
- The HPC site is suitable for the construction and operation of a twin arrangement of UK EPR™.

Matters arising from ONR's work

A number of potential areas for improvement have been identified that, for this point in the programme, are being adequately progressed by NNB GenCo. These are: improving the resilience of the civil engineering capability in Design Authority, improving the implementation of planned surveillance of the supply chain, including the Architect Engineer and giving further consideration to enhancing the document entitled 'Hinkley Point C Unit 1: Hold Point List' in order to capture suitable control of the Inner Containment and Fuel Pool construction stages.

I also observe that NNB GenCo should continue to assess site geological and hydrogeological characteristics during early earthworks and temporary dewatering activities in order to enhance the substantial body of knowledge already gathered during the site investigations.

However, no matters were identified that would detract from the overall assessment conclusion.

Conclusions

In terms of NNB GenCo's Intelligent Customer competence and capability with respect to adequacy of suitably qualified and experienced personnel in the civil engineering workstream area, no issues have been identified that preclude me recommending ONR to grant a nuclear site licence for NNB GenCo to install and operate two UK EPR™ units at Hinkley Point C. I therefore

conclude that NNB GenCo's arrangements appear adequate to manage nuclear safety for the point in time at which the nuclear site licence is to be granted.

I have obtained sufficient evidence to determine that NNB GenCo have put in place a suitable control procedure and a Hold Point List that establishes adequate (for this stage of the project) civil engineering related control points in the programme for delivery of HPC.

I have assessed a number of documents, relevant to the Civil Engineering workstream, forming part of the totality of batches provided by NNB GenCo to give a high level of confidence that the site is suitable for the construction and operation of a UK EPR™. I consider that the evidence contained in these documents is adequate in terms of scope and content for nuclear site licensing purposes. I have raised a number of comments and queries with NNB GenCo during my assessment but I am content that these have been adequately addressed for licensing. I consider that any outstanding issues can be dealt with in the interventions that may lead up to permissioning.

It is therefore concluded, based on the evidence obtained in the Civil Engineering workstream, that:

- NNB GenCo has demonstrated that there is a high level of confidence that the Hinkley Point C site can support the licensable activity.

It is noted that some of the areas of work discussed in this report are still being developed by NNB GenCo and ONR will continue to engage with NNB GenCo to monitor and encourage progress in these areas.

Recommendations

From the civil engineering perspective, I recommend that ONR should grant a Nuclear Site Licence to NNB GenCo to install and operate two UK EPR™ units at Hinkley Point C.

LIST OF ABBREVIATIONS

ALARP	As low as is reasonably practicable
BSL	Basic Safety level (in SAPs)
BSO	Basic Safety Objective (in SAPs)
BMS	(ONR) How2 Business Management System
CNRP	Civil Nuclear Reactor Programme
DR&A	Design Review and Acceptance
ETC-C	EPR Technical Code for Civil Engineering Works
FA3	Flamanville 3
GDA	Generic Design Assessment
HPC	Hinkley Point C
HPC1	Hinkley Point C Unit 1
HPC2	Hinkley Point C Unit 2
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
IPR	Intervention Project Record
LC	Licence Condition
NNB	Nuclear New Build Generation Company
ONR	Office for Nuclear Regulation (an agency of HSE)
PCER	Pre-construction Environment Report
PCSR	Pre-construction Safety Report
PCSR2	Second Pre-construction Safety Report
PID	Project Initiation Document
PSA	Probabilistic Safety Assessment
PSR	Preliminary Safety Report
RGP	Relevant Good Practice
SAP	Safety Assessment Principle(s) (HSE)
SFAIRP	So far as is reasonably practicable
SSC	System, Structure and Component
SSI	Structure Soil Interaction
SSPCSR	Site-Specific Pre-Construction Safety Report
SSSI	Structure Soil Structure Interaction
TAG	Technical Assessment Guide(s) (ONR)

LIST OF ABBREVIATIONS

TSC	Technical Support Contractor
UK EPR™	Areva Trade Mark of European pressurised water reactor, the internationalized name was Evolutionary Power Reactor, but is now simply termed EPR
WENRA	Western European Nuclear Regulators' Association

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Annex 1: Schedule of Interventions with NNB post receipt of Licence Application

1 INTRODUCTION

1.1 Background

1 NNB Generation Company (NNB GenCo) has submitted a formal application for a nuclear site licence to install and operate two UK EPR™ units at Hinkley Point C. The Office for Nuclear Regulation's (ONR) intervention strategy to inform a decision on whether, or not, a nuclear site licence should be granted to NNB in respect of Hinkley Point C is set out in Ref. 6.

2 ONR's approach to licensing is informed by interventions that consider the adequacy of NNB's -

- organisation capability;
- licence condition compliance arrangements;
- safety report and associated substantiation; and
- licensing documentation and ONR's associated legal and statutory consultation due process.

3 As part of the safety report and associated substantiation intervention ONR Pre-Construction Safety Report (PCSR) technical topic leads were required to develop and carry out an intervention focused on their topic. Civil Engineering is one such topic listed in Appendix C of ONR's Hinkley Point C licensing intervention strategy (Ref. 6). The Civil Engineering intervention developed to support licensing is summarised in the Civil Nuclear Reactor Programme (CNRP) Intervention Project Record (IPR) NNB-HPC1-IPR45 (Ref. 7).

4 This assessment report summarises the outcome of the Civil Engineering licensing intervention. The report presents the findings of the Civil Engineering topical assessment of the NNB GenCo's application as presented in the HPC PCSR2 Batch submission (Ref. 11, 12 and 13) supporting documentation provided by NNB and of interventions targeted on NNB's development and implementation of Licence Condition compliance arrangements.

1.2 Scope

5 The scope of this report covers an assessment of the civil engineering aspects of NNB's safety report and associated substantiation and of the capability of NNB with respect to civil engineering in Design Authority and in preparedness for oversight of civil engineering construction activities. The findings of the assessments that are presented in this report will inform the overall ONR 'safety report and associated substantiation' intervention, the 'organisational capability' intervention and the 'licence condition compliance arrangements' intervention as described in ONR's licensing intervention strategy (Ref. 6).

1.3 Methodology

6 The assessment was undertaken in accordance with the requirements of the ONR How2 Business Management System (BMS) procedure AST/003, Permissioning Reports (Ref. 1). The ONR Safety Assessment Principles (SAP) (Ref. 2), together with supporting Technical Assessment Guides (TAG) (Ref. 3) have been used as the basis for this assessment.

7 This assessment has focused primarily on (i) NNB GenCo's submissions of relevant sections or chapters of HPC PCSR2, provided to ONR, to support licence granting and

made as part of the Site License Application Dossier (Ref. 9) and (ii) NNB GenCo's capability as Intelligent Customer in the civil engineering technical area.

8 ONR has engaged with NNB GenCo since November 2009 in the Civil Engineering workstream, via regular Level 4 meetings and assessment of relevant documentation where available. A schedule of interventions held with NNB GenCo since the submission of their Licence Application on 29th July 2011 is provided in Annex 1.

9 A targeted inspection on NNB GenCo Design Authority with respect to compliance with their arrangements was undertaken on 27th June 2012.

2 ASSESSMENT STRATEGY

10 The intended assessment strategy for civil engineering is set out in this section. This identifies the scope of the assessment and the standards and criteria that have been applied.

2.1 Standards and Criteria

11 The relevant standards and criteria adopted within this assessment are principally the Safety Assessment Principles (SAPs) (Ref. 2), internal ONR Technical Assessment Guides (TAGs) (Ref. 3), relevant national and international standards and relevant good practice informed from existing practices adopted on UK nuclear licensed sites. The key SAPs and relevant TAGs are detailed within this section. National and international standards and guidance have been referenced where appropriate within the assessment report. Relevant good practice, where applicable, has also been cited within the body of the assessment.

2.2 Safety Assessment Principles

12 The key SAPs applied within the assessment are included within Table 1 of this report.

2.2.1 Technical Assessment Guides

13 The following Technical Assessment Guides have been used as part of this assessment (Ref. 3):

- T/AST/017 Structural Integrity: Civil Engineering Aspects

2.2.2 National and International Standards and Guidance

14 The following international standards and guidance have been used as part of this assessment (Ref. 4):

- IAEA Safety Standards: Geotechnical aspects of Site Evaluation and Foundations for Nuclear Power Plants – Safety Guide No. NS-G-3.6 (Ref. 5).

2.3 Use of Technical Support Contractors

15 A Technical Support Contractor (TSC) was employed to provide specialist advice to inform ONR's assessment of the site investigation process.

16 The TSC provided a review of technical documents related to NNB GenCo's Architect Engineer specification of the site investigations and a review of the site investigation interpretative report. The TSC made several visits to the HPC site while the site investigation was in process in order to provide advice to ONR on the management and implementation of the investigations.

17 The TSC provided comments on the scope of a second phase of site investigation and on the methodologies adopted in the investigation in comparison to relevant UK practice. The TSC also provided comments on the investigative trials that were undertaken at HPC on the potential for re-use of excavated material as fill.

18 ONR approach was to make the TSC comments and observations visible to NNB GenCo. In this way an open dialogue was established which provided a forum to achieve wider understanding of NNB GenCo's Architect Engineer intentions and to enable ONR to influence, where appropriate, in order gain assurance of the adequacy of the overall site investigation programme.

19 In summary, the TSC has been engaged in an advisory role providing specialist geotechnical and geological advice on the methodology and staged reporting of the site investigations. Regulatory judgements on the site investigation and on the overall claim that the geology of the site will provide a secure long term support to the necessary structures, systems and components are made within ONR.

2.4 Integration with other Assessment Topics

20 The Civil Engineering assessment interfaces with the External Hazards assessment in several areas. These generally associate with definition of hazards which form the design basis for safety classified civil structures. However, there are other interfaces relating to the site geology that are fully assessed as part of the External Hazards topic area and are not assessed in the Civil Engineering topic.

21 External Hazards assessment covers the potential for capable faulting at the site and covers the derivation of the HPC site specific seismic hazard ground response spectra. These topics are not assessed as part of the Civil Engineering workstream but directly relate to the site geology.

22 External Hazards assessment covers the potential for flooding of the site, whereas the Civil Engineering assessment considers NNB GenCo's approach to the hydrogeological conditions at HPC.

23 The Civil Engineering assessment of NNB GenCo's claim that there is adequate cooling capability for all normal and fault conditions relates to the adequacy of the civil structures that provide cooling capability and the potential vulnerability of those structures to hazards such as silting of intake structures. Specialist ONR assessors in other disciplines consider the adequacy of other components that comprise the overall safety system.

24 The Civil Engineering assessment of the claim by NNB GenCo that the site is of a sufficient size is limited to judgements on the suitability of the overall disposition of structures on the site and the feasibility of constructing those structures within the confines of the site so that their safety functional performance can be assured while recognising, in addition, any implications resulting from the twin UK EPR™ reactor proposition.

2.5 Out-of-scope Items

25 The following items are outside the scope of the assessment.

- Assessment of NNB GenCo's claim that the site is (or can be) connected to grid supplies was not considered to be relevant to Civil Engineering.
- Assessment of NNB GenCo's claim that the environmental conditions will not preclude the use of the site with respect to External Hazards was not considered to be relevant to Civil Engineering.

3 LICENSEE'S SAFETY CASE

26 NNB GenCo formally applied for a nuclear site licence for Hinkley Point C in letter ONR-HPC-20143R, dated 29 July 2011 (Ref. 8). This was supported by an application dossier (Ref. 9) that supports NNB GenCo's application. ONR agreed (Ref. 10) that this dossier did not need to include a Hinkley Point C site specific PCSR. For the purposes of granting a nuclear site licence ONR indicated to NNB GenCo that it would accept a document that illustrates the structure of the Hinkley Point C site specific PCSR document.

27 The ONR guidance document 'Licensing Nuclear Installations' (Ref. 14), para 61 also notes that 'A licence may be granted when ONR is satisfied that the licence applicant's safety documentation provides assurance that the site will be suitable for the proposed activities if the plant is adequately designed, constructed and operated. A full pre-construction safety case report (PCSR) is not necessary at this stage.'

28 Notwithstanding that ONR did not require a Hinkley Point C site specific PCSR as part of the application dossier, ONR expected relevant sections or chapters of the PCSR to be developed sufficiently to support licence granting, notably around confirmation that the site specific parameters are bounded by the GDA design envelope, with appropriate arrangements in place to address any discrepancies.

29 In addition, in order to provide the necessary high level of confidence that the site is suitable for the construction and operation of a UK EPR™, NNB GenCo was required to justify a number of key topics including -

- The site is of a sufficient size.
- The site is (or can be) connected to grid supplies.
- There is adequate cooling capability for all normal and fault conditions.
- The environmental conditions will not preclude the use of the site with respect to external hazards.
- The geology of the site will provide a secure long term support to the necessary structures, systems and components.
- The submission will also need to provide a schedule for submission of further PCSR updates or revisions to support subsequent construction milestones.

30 NNB GenCo supplied ONR with a number of batch submissions to cover these topics. These batches will effectively form component parts of NNB GenCo's HPC site specific PCSR2, where PCSR2 is anticipated to be the next consolidated formal issue of the PCSR which will be made to ONR in the future. Further information on the NNB GenCo proposals for developing the site specific PCSR2 are given in the ONR assessment report on the topic of Licence Condition 14. (Ref. 30) Certain topics and batches are relevant to Civil Engineering and hence were assessed to support nuclear site licensing:

- The site is of a sufficient size – Batch 3.1 – Ref. 11
- There is adequate cooling capability for all normal and fault conditions – Batch 5 – Ref. 12
- The geology of the site will provide a secure long term support to the necessary structures, systems and components – Batch 2.2 – Ref. 13.

4 ONR ASSESSMENT

31 This assessment has been carried out in accordance with ONR How2 BMS document AST/003, Permissioning Reports (Ref. 1).

4.1 Scope of Assessment Undertaken

32 The scope of the assessment is described in the following sub-sections

- Suitability of the Site (refer to Section 4.1.1)
- NNB GenCo Organisation Capability (refer to Section 4.1.2)
- Licence Condition (LC) Compliance Arrangements (refer to Section 4.1.3)

4.1.1 Suitability of the Site

33 The assessment of the suitability of the site is divided into three sub-topics. These are:

- The site is of sufficient size,
- There is adequate cooling capability for all normal and fault conditions,
- The geology of the site will provide a secure long term support to the necessary structures, systems and components.

4.1.1.1 The site is of a sufficient size

34 The ONR CNRP Intervention Project Record (IPR) (Ref. 7) was prepared with more precise definition of the evidence that ONR would expect to be provided by NNB GenCo in their justification that the site is of a sufficient size for the proposed development at Hinkley Point.

35 The sub-topics defined in the Intervention Project Record are:

- The site is of a sufficient size to allow construction
- the implications of a twin reactor site have been considered
- the effects of a twin reactor site on constructability have been considered
- issues of ageing management of shared facilities during follow-on construction have been addressed
- the civil engineering aspects of the layout are feasible and describe the design optioneering and justification employed during the development of the site layout

36 I therefore assessed NNB GenCo's Batch 3.1 submission to examine how claims, arguments and evidence are presented to enable a judgement to be made against each of the sub-topics identified in the IPR.

4.1.1.2 There is adequate cooling capability for all normal and fault conditions

37 The ONR CNRP Intervention Project Record (IPR) (Ref. 7) was prepared with more precise definition of the evidence that ONR would expect to be provided by NNB GenCo in their justification that there is adequate cooling capability under all normal and fault conditions for the proposed development at Hinkley Point C.

38 The sub-topics defined in the Intervention Project Record are:

- The concept, layout and design of the civil structures is such that adequate cooling capability is available for all normal and fault conditions

39 I therefore assessed NNB GenCo's Batch 5 submission to examine how claims, arguments and evidence are presented to enable a judgement to be made against each of the sub-topics identified in the IPR.

4.1.1.3 The geology of the site will provide a secure long term support to the necessary structures, systems and components

40 ONR CNRP Intervention Project Record (IPR) (Ref. 7) was prepared with more precise definition of the evidence that ONR would expect to be provided by NNB GenCo in their justification that the geology of the site will provide a secure long term support to the necessary structures, systems and components.

41 The sub-topics defined in the Intervention Project Record are:

- the Site Investigation and the Interpretative Site Investigation Reports are adequate and fit for purpose (i.e. at this stage adequate to support the statements that are made in the HPC PCSR)
- the implications of a twin reactor site have been considered in terms of adequacy of the site investigation, suitable assessment of the variation of geological and hydrogeological characteristics and the consequences on the preliminary design
- rock quality and characteristics at and below the foundation interface for safety related plant are adequate
- potential degradation mechanisms have been identified and that adequate protection measures are to be put in place
- there is an adequate understanding of the hydrogeology demonstrated by suitable investigation, assessment, modelling and analysis
- the impact of hydrogeology on the twin reactor site has been assessed and it is demonstrated how the characteristics can be accommodated in the design of the safety related plant
- demonstration that the geology of the site will not lead to the structures being unduly vulnerable to seismic action (e.g. capable faulting, liquefaction and seismic movements)
- having quantified the seismic hazard and the geology, explain how the structures can be designed to accommodate the envisaged forces (by analysis) and movements (by analysis and detailing)

42 I therefore assessed NNB GenCo's Batch 2.2 submission to examine how claims, arguments and evidence are presented to enable a judgement to be made against each of the sub-topics identified in the IPR.

4.1.2 NNB GenCo Organisation Capability

43 ONR look for assurance that NNB GenCo can demonstrate control of all activities that affect safety on the Hinkley Point C site, and demonstrate that it has a robust intelligent customer capability that can secure appropriate oversight of activities carried out on its behalf. The organisational capability intervention seeks to verify that NNB GenCo has developed, and satisfactorily implemented, arrangements that meet ONR's expectations. ONR planned to achieve this through Level 4 engagement with respective NNB GenCo workstream leads and by inspecting the implementation of the arrangements described in

the documents. ONR planned to focus attention on a number of key areas which are fundamental to gaining assurance that NNB GenCo has developed an organisational capability that is compatible with holding a nuclear site licence. The key areas are:

- Design Authority and Intelligent Customer arrangements
- Competency and Training (LCs 10 and 12) arrangements
- Management of Organisational Change (LC 36) arrangements
- Independent Challenge and Oversight arrangements
- Procurement arrangements

The broad assessment of NNB GenCo organisational capability is reported in a specific ONR assessment report (Ref. 32) and further details of the various components of organisational capability is described in that report.

44 ONR CNRP Intervention Project Record (IPR) (Ref. 7) established that, in the civil engineering workstream, the intervention will look for evidence to confirm that NNB GenCo can demonstrate its competence and will seek assurance that it has:

- The capability to develop a Site-Specific Pre-Construction Safety Report (SSPCSR) submission to support a request to commence the first nuclear safety related construction activity and subsequent construction and installation milestones;
- Robust arrangements for controlling development of a safety case compliant design; and,
- Robust arrangements for controlling the procurement, manufacture, construction and installation of safety related structures systems and components.

4.1.3 Licence Condition Compliance Arrangements

45 In the civil engineering workstream I have been involved in the assessment of NNB GenCo's arrangements for compliance with LC 2 – Marking of the Site Boundary and LC 16 – Site Plans, designs and specifications. Consequently, the scope of assessment includes consideration of the adequacy of NNB GenCo's arrangements for licence condition compliance on these topics.

4.2 Assessment

46 The assessment is described in the following sub-sections.

4.2.1 Assessment of Suitability of the Site

4.2.1.1 Assessment of - the site is of a sufficient size

47 The Batch 3.1 submission comprises two main documents. The main report is given in 'HPC PCSR2 Sub Chapter 2.3, Site Plot Plan Summary' (Ref. 20). This document was drafted by NNB GenCo Design Authority for the specific purpose of providing a summary of the site plot plan for the proposed Hinkley Point C Power Station, in support of PCSR2. The report is also designed to contribute to the demonstration that the site plot is of sufficient size to accommodate a twin UK EPR nuclear power station and that the layout of the buildings has been optimised to ensure that any risks which could be initiated through the layout of the site have been reduced so far as is reasonably practicable.

48 The second main document (Ref. 21) was prepared by Rolls Royce, on behalf of NNB GenCo, to provide a qualitative assessment of the hazards specifically whether the twin-

unit configuration would significantly change the risk to nuclear safety associated with the generic single unit site presented in the GDA PCSR (submitted under the ONR Generic Design Assessment (GDA) process). The document also identified and considered any potential issues, hazards and changes to GDA baseline risk associated with a twin-unit site. The potential issues, hazards and changes to risk associated with services being shared by the two HPC units were also identified and considered. Consequently the work described in this report is directed at determining if there is change in risk from the generic design, which has been assessed by ONR through the process of Generic Design Assessment, to the site specific design and in particular the twin reactor proposition.

49 References 20 and 21 were supported by submission letter ONR-HPC-20247N, Annex 2 (Ref 22) giving EDF feedback on management of the risks linked to construction neighbouring an operational plant.

50 Due account has been taken of ONR engagement with NNB GenCo since the submission of the Batch documents. The NNB GenCo responses to ONR comments are summarised in Ref. 23.

51 The following is a summary of the key justifications provided by NNB GenCo

- The site is large enough to accommodate all required buildings and services for the proposed twin UK-EPR design at HPC.
- All hazards specifically pertaining to the twin UK-EPR™ design at HPC have been identified including:
  - All hazards associated with shared services.
  - All hazards associated with the layout of the site additional to those which exist for the single UK-EPR described within the GDA.
- The risks specifically associated with the twin UK-EPR™ design at HPC have been reduced so far as is reasonably practicable, including:
  - Adequate control of the risks associated with the shared services.
  - Adequate control of the risks associated with the layout of the twin UK-EPR™ site.
- The twin UK-EPR design for HPC ensures that Hinkley Point C Unit 1 (HPC1) can be safely operated alongside the construction site for Hinkley Point C Unit 2 (HPC1).

52 The ONR assessment of the IPR sub-topics described in the following sections considers the civil engineering aspects of the Batch 3.1 submission.

4.2.1.1.1 The site is of a sufficient size to allow construction

53 I am satisfied that the investigations have followed relevant good practice and that experience from the construction of other EPR™ units worldwide has been taken into account.

54 The site plot plan summary document provides confirmation that the site is physically large enough to accommodate all the buildings and services required for the twin UK-EPR™. I note that the distance between reactor units is 230m compared to a minimum acceptable distance of 200m (Ref. 32). This has allowed the construction of the Operational Service Centre building in the centre of the site between the two UK EPR™ units.

55 I note that the complete picture with regard to constructability issues at HPC cannot be finalised until the Civil Works Contractor has been appointed and that an assumed construction sequence has been adopted at this stage. However, I am satisfied that the Early Contractor Engagement process by NNB GenCo with the Architect Engineer and the construction contractors will allow full account to be taken of updates to the construction methodology and that this will also take account of feedback from other EPR™ units being constructed worldwide.

56 I am satisfied that the investigations based on the assumed construction sequence confirm that the site is of a sufficient size to allow construction.

4.2.1.1.2 The implications of a twin reactor site have been considered

57 NNB GenCo investigations and analysis have shown that, based on the level of design currently available, it is expected that there will be no significant increase in level of risk per unit associated with the twin-unit site configuration of HPC, compared with the single unit configuration submitted under GDA.

58 NNB GenCo carried out a qualitative assessment of the changes to risk as a result of a twin-unit site configuration for each hazard identified in the GDA. Each of the hazards included in the GDA submission (both internal and external) was considered. All but one hazard (internal missiles) experienced no change in per-unit risk relative to the GDA baseline level.

59 NNB GenCo identified and assessed the potential hazards associated specifically with a twin-unit configuration, which were not included in the GDA. The assessment did not identify anything to suggest that nuclear safety would be compromised at HPC as a result of the issues unique to a twin-unit configuration. However, I note that radiological release from one unit with the potential to affect site safety is an ongoing issue that is under review by the Architect Engineer (AE) and that issues relating to the construction risks will be covered by the Early Contractor Engagement process.

60 I am satisfied that the implications of a twin reactor site have been adequately considered in the NNB GenCo Batch 3.1 submission and that the Forward Action Plan presented covers the identified outstanding issues.

4.2.1.1.3 The effects of a twin reactor site on constructability have been considered

61 I note that construction risks to the commissioning and operation of HPC1 during construction of HPC2 have been considered principally based on feedback from the Flamanville 3 (FA3) EPR™ currently under construction in France and the suggested methodology would appear to be reasonable. The complete picture with regard to constructability issues at HPC cannot be finalised until the Civil Works Contractor has been appointed and an assumed construction sequence has been adopted in the interim (Ref. 32).

62 I am satisfied that the Early Contractor Engagement process by NNB GenCo with the Architect Engineer and the construction contractors will allow full account to be taken of updates to the construction methodology and that this will also take account of feedback from other EPR units being constructed worldwide.

63 I note that ownership of the review process for the controls on construction of the site will reside with NNB GenCo as the licensee of the nuclear site and that the Design Authority will maintain control of this review process during the project to ensure that it is correctly implemented. I am, therefore satisfied that due account will be taken of constructability issues as construction proceeds.

64 In addition to the Design Authority control over the process for considering the construction methodology, I note that CDM coordinators have been appointed as part of the HPC project and will be responsible for coordinating the compliance with the CDM Regulations. (Ref. 33)

65 I note that, in support of their reviews of construction methodology, NNB GenCo intend to develop a 3D and 4D (i.e. including time) models of the whole construction site (Ref.45) to better manage the site logistics and site interfaces between contractors, in order to:

- Provide NNB GenCo and the contractors with a 4D visualisation of construction sequencing and how the project will be phased under construction;
- Link construction schedules to the 3D model to show construction sequencing for site logistics, underground works, utilisation of laydown areas, allocation of working areas, location of cranes, accesses and hoists and associated interfaces;
- Monitor the material volume forecasts in the NNB GenCo and contractors' compound/warehouses;
- Identify logistical conflicts in a virtual setting and adjusting the schedule accordingly ahead of time.
- The Site 3D model shall comprise in particular:
  - The working areas, platforms levels and compounds of the different contractors. Details shall be sufficient to monitor the material volume forecast;
  - The underground galleries;
  - All accesses to working areas and compounds, including access ramps to deep excavations;
  - The crane layout of all the different contractors;
  - The utility networks, both permanent and temporary;
  - The permanent/temporary road system around the site;
  - Above-ground structures (buildings' envelopes, temporary buildings, scaffolding, etc)

66 Following detailed discussions with NNB based on the assumed construction sequence, I am satisfied that the effects of a twin reactor site on constructability have been considered and will be adequately covered by the NNB GenCo proposals.

4.2.1.1.4 Issues of ageing management of shared facilities during follow-on construction have been addressed

67 I note that NNB GenCo have considered the prevention of latent defects, i.e. where subsequent construction activities result in unforeseen damage to structures constructed earlier in the build schedule such as subterranean structures including the technical galleries. Prevention of damage of this nature will be by means of the implementation of appropriate measures such as avoidance of placement of heavy lift equipment on ground which contains subterranean structures and, where this is not possible, reinforcement of such ground areas prior to bearing the weight of heavy lift equipment. Confirmation of the absence of latent defects will be via suitable post-construction inspection activities.

68 Plant ageing effects will be taken into account during the detailed design process and the structures will be subjected to routine maintenance, testing and inspection. With regard to identified hazards, NNB GenCo intend to apply relevant mitigation, which will be included in the construction activity (e.g. separation walls or other engineered safety systems, hold points, specific protection procedures or operational controls, adapted organisational control, load reduction, etc).

69 I am therefore satisfied that issues of ageing management of shared facilities during follow-on construction have been addressed.

4.2.1.1.5 The civil engineering aspects of the layout are feasible and describe the design optioneering

70 I have examined the NNB GenCo engineering approach to the development of the site layout. NNB GenCo have applied the 'EDF Plant Layout Guidelines' (Ref. 24) as the basic design principles used to determine the layout of HPC. The guidelines ensure suitable separation of buildings on the site (e.g. Turbine Halls) as well as the parallel positioning of the UK EPR units (to reduce the potential for turbine missile impact on a reactor building). The layout also takes into account site-specific external and natural hazards, e.g. environmental conditions, geology, seismic and flooding events. These can affect the plot plan layout (for example sea level and tidal range affect the platform level and the size of the cooling water pumphouse).

71 NNB GenCo have developed the respective positioning of units 1 and 2 based upon the rationale of simplification of the construction sequence, allowing construction of common facilities required to support both units being built with unit 1 first. NNB GenCo have adjusted the layouts to correspond with the assumed construction sequence drawings. In the second phase of the works, the construction traffic for unit 2 crossing the unit 1 site will be minimized

72 NNB GenCo have taken French and UK operational practices into account, for example in the operational administration, welfare and workshop building, as well as site-specific requirements.

73 NNB GenCo have used experience from the construction of Flamanville 3 to inform the design of HPC site layout. This has resulted in a slightly larger distance between the Turbine Hall and CW Pumphouse to allow safer and easier lifting of the turbine hall crane. The relative location of the HB building (POE) has been moved slightly to increase clearances and provide a larger gap to prevent seismic interaction issues between the HB building (POE) and the surrounding buildings. Gas storage positions such as hydrogen storage are located away from other facilities and oxidising and fuel gases are segregated.

74 As a non-standard facility, NNB GenCo have carried out detailed analysis of the location of the Interim Spent Fuel Store (ISFS – building HHK) on the site plot plan in order to determine the optimum location with regard to facility operation, safety and security. The ISFS is a facility common to both HPC1 and HPC2 for the storage of spent nuclear fuel. The design is currently at the concept stage and longevity of this building in the proposed location, including protection and mitigation measures, will be taken into account at the detailed design stage.

75 The location of the off-shore marine structures has been designed to ensure continuous availability of cooling water.(See also Section 4.2.1.2)

76 Some civil engineering structures have a projected lifespan in excess of 100 years (e.g. ISFS (HHK), ILW store (HHI), seawall). Due to the coastal location of the site, these

structures will be frequently subjected to moist salt-laden air which can be corrosive and detrimental to the structural integrity of the buildings. It is the intention of NNB GenCo that plant ageing effects will be taken into account during the detailed design process and the structures will be subjected to routine maintenance, testing and inspection throughout their life to ensure that their integrity has been maintained. The results of this testing will have to be reported on within the 10-yearly Periodic Safety Review (PSR) required under Licence Condition 15, which will confirm the adequacy, or otherwise, of the structures. I note that the designers of these concrete structures cannot guarantee a design life greater than 100 years, therefore the structures expected to be in use for more than 100 years will have to be revalidated for use after the 100 year design life. This will form part of the ageing management programme and will take account of the lifetime performance of the structures and ageing effects.

77 I am satisfied that the civil engineering aspects of the layout are feasible and the submission adequately describes the design optioneering undertaken and to be undertaken in the detailed design phase. As stated previously, the complete picture with regard to constructability issues at HPC cannot be finalised until the Civil Works Contractor has been appointed and that an assumed construction sequence has been adopted at this stage. However, I am satisfied that the NNB GenCo technical review arrangements and Early Contractor Engagement process will allow full account to be taken of constructability issues.

78 I am satisfied that the investigations have followed relevant good practice and that experience from the construction of other EPR units worldwide has been taken into account.

4.2.1.2 Assessment of - there is adequate cooling capability for all normal and fault conditions

79 The Batch 5 submission is a comprehensive document entitled ‘HPC PCSR2 Heat Sink Summary Document’ (Ref. 25) submitted under cover of letter ONR-HPC-20185N (Ref. 26). The document was drafted for the NNB GenCo Design Authority for the specific purpose of showing that the information gathered by investigations and preliminary design is sufficient to justify that there is adequate cooling capability available at the Hinkley Point site. ONR assessment of the IPR sub-topics is described in the following sections.

80 The Batch 2.1 submission is a summary document entitled ‘Site Data and Bounding Character of GDA Site Envelope’ (Ref. 27). The document was drafted by NNB GenCo Design Authority for the purpose of providing an overview of the Hinkley Point site description and data which support the Safety Case and are needed for the plant design and Safety Analyses at the Hinkley Point site. This document was used, in conjunction with the Batch 5 submission, in the ONR assessment that there is sufficient site data relevant to the heat sink and sea conditions available to support the design of the necessary civil, systems, structures and components.

81 Due account has been taken of ONR engagement with NNB GenCo since the submission of the Batch documents. The NNB GenCo responses to ONR comments are summarised in Ref. 23.

82 The ONR assessment of the IPR sub-topic described in the following section considers the civil engineering aspects of the Batch 5 submission including:

- Intake tunnels, shafts and heads
- Discharge tunnels, shafts and heads

- Forebay and Forebay link tunnels
- Pumping station
- Debris recovery building

4.2.1.2.1 The concept, layout and design of the civil structures is such that adequate cooling capability is available for all normal and fault conditions

83 NNB GenCo have defined the heat sink performance requirements as follows:

- Provision of the necessary cooling water flow rates to the required services
- Cooling water availability
- Inlet water temperature within set limits (for safety systems)
- Cooling water quality with respect to debris and marine organisms

The civil engineering structures are essential to meeting these requirements.

84 The following is a summary of the key justifications provided by NNB GenCo:

- The design of the system and pumps ensure a sufficient flow rate is maintained for each unit.
- High availability of the cooling is achieved by positioning the intake heads below water level taking into account the tidal range and the predicted effect of climate change and by introducing redundancy and diversity in many aspects of the design.
- The cleanliness of the water is ensured by both reducing the likelihood of drawing foreign material into the heat sink circuit and by using a series of filtration systems.

85 I note that EDF have engaged in significant engineering optioneering in the development of the proposals for the cooling water intake structures. NNB GenCo examined the fundamental heat sink design options applicable to the twin unit HPC site through a structured ALARP process resulting in a decision to adopt an open circuit system with two intake tunnels and two link tunnels between the forebays. The HPC heat sink design takes due account of site-specific data and environmental considerations including the very large tidal range in the Severn estuary. The location of the off-shore marine structures has been designed to ensure continuous availability of cooling water.

86 I am satisfied that the investigations have followed relevant good practice and that experience from the construction of other power plants units worldwide has been taken into account.

87 I am satisfied that there is sufficient site data relevant to the heat sink and sea conditions available to support the design of the necessary civil, systems, structures and components.

88 I have assessed the NNB GenCo justification for the siting of the heat sink civil engineering structures and consider that this is adequate. However the main threat to the provision of the necessary cooling water flow rates, cooling water availability and quality is silting of the civil engineering structures.

89 Inspection and maintenance of the heat sink civil engineering structures will be essential for the provision of the necessary cooling water flow rates, cooling water availability and quality (Ref. 28). I note that work is ongoing to refine and substantiate the design of the intake heads, forebay, pumping station and discharge pond through physical modelling and further numerical modelling of hydraulic conditions and silting effects (Ref.32).

90 In order to mitigate against silting up of the intake structures, NNB GenCo intend to analyse the hydraulics of the system in further detail in mock-up studies. This will inform the detailed design process and is likely to have a minor impact on the design of the intake structures.

91 The scope of the mock-up studies associated with the intake structures (Ref. 32) includes:

- Hydraulics of the intake heads and outfall diffusers
- Forces exerted on those structures by waves and flows
- Sedimentology studies, including
  - Sediment entrainment inside heads
  - Sediment scour around intake heads and diffusers
  - Sediment deposition in intake shafts and tunnels (numerical studies)
- Low flow conditions will be studied for sediment deposition in the intake shafts and tunnels

92 I am satisfied that the proposed additional mock-up studies will adequately underpin the detailed design work and allow silting issues to be addressed.

93 I note that work is ongoing to complete the concept design of the site-wide groundwater drainage system and the design of the heat sink structures with deep foundations (forebay, pumping station and discharge pond) against hydraulic uplift. This will be addressed in the detailed design phase.

94 I note that work is ongoing to confirm the inspection & maintenance strategy and isolation requirements for the safety related water intake structures (intake heads, tunnels, forebays and link tunnels) and that provision is being made for dewatering the forebay for inspection and maintenance.

95 I am satisfied that that the future work proposed covers the identified outstanding issues.

96 I am satisfied that, given satisfactory completion of the mock-up studies and the detailed design, the concept, layout and design of the civil structures is such that adequate cooling capability should be available for all normal and fault conditions

4.2.1.3 Assessment of - the geology of the site will provide a secure long term support to the necessary structures, systems and components

97 Batch 2.2 submission is a comprehensive document entitled ‘HPC PCSR2 Site Geology Summary Document’ (Ref. 13). The document was drafted by NNB GenCo Design Authority for the specific purpose of showing that the information gathered by site investigations and preliminary design is sufficient to justify that the geology of the site will provide a secure, long term support to the necessary structures, systems and components. ONR assessment of the IPR sub-topics is described in the following sections.

- The site investigation and interpretative site investigation reports are adequate and fit for purpose (refer to Section 4.2.1.3.1)
- The implications of a twin reactor site have been considered in terms of adequacy of the site investigation, suitable assessment of the variation of geological and hydro-geological characteristics and the consequences on the preliminary design (refer to Section 4.2.1.3.2)

- Rock quality and characteristics at and below the foundation interface for safety related plant are adequate (refer to Section 4.2.1.3.3)
- Potential degradation mechanisms have been identified and that adequate protection measures are to be put in place (refer to Section 4.2.1.3.4)
- There is an adequate understanding of the hydrogeology demonstrated by suitable investigation, assessment, modelling and analysis (refer to Section 4.2.1.3.5)
- The impact of hydrogeology on the twin reactor site has been assessed and it is demonstrated how the characteristics can be accommodated in the design of the safety related plant (refer to Section 4.2.1.3.6)
- Demonstration that the geology of the site will not lead to the structures being vulnerable to seismic action (e.g. capable faulting, liquefaction and seismic movements) and that having quantified the seismic hazard and the geology, it is explained how the structures can be designed to accommodate the envisaged forces (by analysis) and movements (by analysis and detailing) (refer to Section 4.2.1.3.7)
- Monitoring and Ongoing Investigations (refer to Section 4.2.1.3.8)

4.2.1.3.1 The Site Investigation and the Interpretative Site Investigation Reports are adequate and fit for purpose

98 The following is a summary of the key justifications provided by NNB GenCo:

- The staged process of the site investigation for the HPC site was undertaken in a progressive manner commensurate with industry guidance for site evaluation of Nuclear Power Plant in IAEA Safety Guide NS-G-3.6, Eurocode 7 and ETC-C (where ETC-C is the EPR™ Technical Code for Civil Engineering) (Refs. 5, 19 and 29). Each stage of the site investigation process informed the requirements and scope of the subsequent investigation and assessment activities - developing an increasing knowledge base of the site geology.
- The main site investigation contractor was audited by NNB GenCo (Quality) and Architect Engineer (Technical) in order to confirm capability.
- All the site investigation work was specified and controlled by EDF Architect Engineer experts in site investigation activities and geological interpretation.
- The Onshore and Offshore Step 2 Interpretive Reports were subject to NNB GenCo Design Review and Acceptance surveillance to ensure adequacy, including independent peer oversight from a UK geotechnical expert.
- The scope and outcomes from the Onshore and Offshore Site Investigation process has :

  (i) supported an assessment of the rock characterisation across the twin reactor site.

  (ii) identified the potential degradation issues relating to the underlying rock;

  (iii) provided sufficient information to enable a preliminary assessment of the bearing capacity of the supporting strata;

  (iv) provided sufficient data for preliminary estimates of anticipated settlement of the rock under applied loading;

(v) informed the heave behaviour of the rock;

(vi) informed the hydro-geological understanding of the site;

(vii) informed knowledge of the site groundwater levels and supported the development of appropriate construction control strategies;

(viii) supported an assessment to quantify the seismic hazard to the site and confirmed the low probability of vulnerable geological features (e.g. capable faults, liquefaction concerns, sink holes etc). Additionally, the small strain properties (dynamic) have been investigated to provide base data for seismic design.

99 I am satisfied that the investigations have followed relevant good practice. I have sampled the site investigation work in progress at HPC and sampled the information presented in the interpretative documentation. Previous engagement during the site investigations has supported my view that the work has been controlled by suitably qualified and experienced personnel (Ref. 16, 17 and 18). Further, NNB GenCo DA has ensured that there has been adequate independent assessment of the investigation outputs which has been targeted to aim to examine the adequacy of the interpretative document from the viewpoint of an experienced United Kingdom geotechnical expert.

100 I am satisfied that the site investigations have included sufficient desktop study incorporating appropriate use of historical data pertaining to the site and have integrated this acquired knowledge in the planning and scoping of the staged site investigations for HPC. The overall scope of investigations has followed relevant good practice and I consider that the extent of investigation has been adequate to define geology, hydrogeology and potential degradation mechanisms that may associate with the natural site materials.

101 Key observations arising from the TSC review of the first phase of site investigation were that further investigation and/or reporting of the following aspects should be included in the second phases of site investigations:

- Reporting findings of assessment of rock stiffness and anisotropy via inclined borehole dilatometer tests and seismic wave propagations
- Investigation of evaporates in the Blue Anchor formation
- Resonant column testing for small strain stiffness
- Geophysics investigation
- Extended hydrogeological studies
- Chemical test results on groundwater samples

102 I have established that the site investigation interpretative report has addressed the above points.

103 I consider that the methodology of collating interpretative data to describe the characteristics of the site is appropriate and I note that NNB GenCo's Architect Engineer is compiling Geotechnical Design Reports which are prepared to quantify important characteristics of the site, for example settlement and rock bearing capacity. In this respect NNB GenCo have used one of the Geotechnical Design Reports as a key reference thus providing suitable evidence to justify the adequacy of the site.

104 Consequently, I am satisfied that the Site Investigation and the Interpretative Site Investigation Reports are adequate and fit for purpose to support the statements that are made in the Batch 2.2.

4.2.1.3.2 The implications of a twin reactor site have been considered in terms of adequacy of the site investigation, suitable assessment of the variation of geological and hydro-geological characteristics and the consequences on the preliminary design

105 The following is a summary of the key justifications provided by NNB GenCo:

- The scope of the Site Investigation and the Interpretative reports covers the plan area of the twin reactor site and the plan area occupied by the route of the cooling water intakes and outfall.
- The site geology and hydrogeology is fully addressed in the Site Investigation Interpretive Reports.
- Detailed geological profiles have been generated for the twin reactor site that identifies the location, depth and extent of the various geological layers. In particular, the different geological conditions between Reactor Units 1 and 2 have been recognised. Unit 1 Common Raft is constructed entirely in the Blue Lias, with the south end of the Fuel Building extending mid depth into the Lilstock formation (approximate thickness of 3m for Lilstock layer). The southern end of Unit 2 Common Raft is located at the interface between the Blue Lias and the Lilstock. The Fuel Building extends through the Lilstock layer (approximately 3m) and marginally (<1m) into the Westbury layer (approximate thickness of 8m for Westbury layer).
- Mitigation for degradation of the Blue Anchor rock stratum (described in paragraph 115) will be employed during the construction phase, to ensure disturbance of the existing hydrogeological regime, and prevention of dissolution, is limited as far as reasonably practicable. Where rock quality does not conform to the designated standard during the acceptance stage prior to blinding, then this will be substituted with type B1 (mass concrete) material.

106 I observed that one important objective of the second phase of site investigation was to expand the focus of site investigation work to cover the area of the site on which Unit 2 is planned to be located.

107 The site investigation has conveniently divided the plan area of the site into zones called Structural Zones. Of relevance to safety related structures are Structural Zone 1 and Structural Zone 2. In Structural Zone 1 the geology is monoclinal. All described formations dip about 10° to the north. Some secondary faults are located or assumed in the south of this zone. Strata may be affected by some gentle E-W-trending flexures. However, in Structural Zone 2 the geology is folded and faulted. The Batch 2.2 document notes that faults strike roughly NW-SE and are assumed to dip close to the vertical. Faults seem to be constituted by several short segments bounded together by relay structures because of their relatively small slip with respect to their length.

108 Batch 2.2 describes the significance of the folded and faulted geology in Structural Zone 2. Faulting can generally create disturbed ground in which geomechanical properties are lowered and hydraulic conductivity modified. Faulting also creates a zone of disturbed ground in which permeabilities are increased, at least along the fault surface. The consequence of folding is to make formations which are lower in the stratigraphical column to subcrop: a major illustration is the E-W-trending anticline that subcrops between at the interface between structural zone 1 and 2. This anticline brings near

surface Westbury and Blue Anchor formations which are constituted respectively of weak alterable rocks and soluble rocks.

109 Following the definition of Structural Zones 1 and 2 NNB GenCo decided to locate all safety classified buildings (apart from the possible exception of the Raw Water Storage Facility) in Structural Zone 1 so that complex geological faulting and folding is avoided. Structural Zone 1 is bounded by the presence of main faults F1 (NW-SE striking) and F5 (E-W striking). Apparently, all technical galleries, including the permanent drainage galleries, are also within the boundaries of Structural Zone 1. I consider this approach to be a suitable means of locating safety related structures on the site.

110 However, I note the potential for the Raw Water Storage structure to be located in Structural Zone 2. NNB GenCo acknowledge this point in their Batch 2.2 document and recognise that the scope of Site Investigations has been focussed on developing adequate understanding and quantification of site geological characteristics in Structural Zone 1.

111 Consequently, NNB GenCo acknowledge that more localised investigative work will need to be done in the case of the Raw Water Storage structure in Structural Zone 2 to consider potential reduction in subsoil quality. For example in establishing appropriate rock mass strength in the presence of faults and folds. In addition, NNB GenCo claim that mitigation against rock degradation can be adopted during the construction works to limit dissolution of the subgrade material and that formation rock that does not meet the necessary acceptance standards prior to blinding will be removed and replaced with type B1 (mass concrete) material.

112 The nuclear safety related purpose of the Raw Water Storage structure is to retain a reserve volume of water. In the wider civil engineering industry as well as in the nuclear industry there is a large body of expertise and guidance available to inform the design and detailing of water storage structures. In addition, the loading on the formations from this type of structure would not be expected to be onerous relative to the capacity of the weaker rock strata. Consequently I am content that the investigations undertaken thus far by NNB GenCo have been adequate in identifying the challenges to be addressed in the design of the Raw Water Storage structure and that by suitable design and detailing of the structure the envisaged safety functional performance can be achieved.

113 I also note that the southern end of Unit 2 Common Raft (the common raft of the Nuclear Island primarily supports the Reactor Building, Fuel Building, together with the Safeguard Electrical and Mechanical Buildings) is located at the interface between the Blue Lias and the Lilstock bed. While the foundation for the Fuel Building extends through the Lilstock layer. This is significant because I understand that the strategy for setting the formation of the reactors was that it should be achieved in relatively high strength and stable Blue Lias rock thus leaving a depth of Lilstock and Westbury rock to provide a buffer between excavations and the underlying Blue Anchor rock and avoiding potentially weaker black fissile mudstone in the Westbury layer.

114 However, I am content that having identified the potential concerns associated with the anticipated formation materials that it will be feasible for appropriate control of the construction works to be provided to ensure an adequate formation is achieved. Such measures will require an attention to detail in the design and implementation of the construction dewatering operation in the southern end excavations and particular measures to investigate the surface and near surface of the formation rock during the process of certification of an adequate rock formation. This has been recognised by NNB

GenCo and will be incorporated into their site surveillance. As noted by NNB GenCo this may require over-excavation and replacement with suitable replacement concrete.

115 Consequently, I am satisfied that the implications of a twin reactor site have been considered in terms of adequacy of the site investigation, suitable assessment of the variation of geological and hydro-geological characteristics and the consequences on the preliminary design.

4.2.1.3.3 Rock quality and characteristics at and below the foundation interface for safety related plant are adequate

116 At this point it is of benefit to provide a summary of the strata that have been determined in the site investigation by NNB GenCo (as reported in the NNB GenCo Batch 2.2 document):

Hinkley Point site is underlain by Triassic to Lower Jurassic sedimentary rocks, having a general northward dip of 10°. They have been grouped in 7 layers and include, from surface to maximum investigated depth (140 m bgl):

- Made Grounds mainly containing clay.
- Overburden materials mainly constituted by highly to very highly plastic, stiff to very stiff silty clay with scarce tiny carbonate nodules.
- Blue Lias (Lower Jurassic) consists mainly of thin to thick beds of calcareous mudstone and fissile shale, alternating with highly fractured thin limestone beds. This layer subcrops on most of the site surface and especially in the middle and northern part of the site. Its upper limit has not been seen on site. Blue Lias vertical thickness increases northward, ranging from 3 to 72 m. Its maximum thickness measured in borehole has been encountered in the northernmost part of the site. Blue Lias intact rock is classified as weak to medium strong rock.
- Lilstock formation (Upper Triassic) includes a thick limestone bed at its top, underlain by mudstone beds. The whole layer is 1.31 to 3.18 m thick.
- Westbury formation (Upper Triassic): mainly thick weak black fissile mudstone units, alternating with very thin limestone beds. This layer is 8.75 to 10.09 m thick. Westbury intact rock is classified as weak to medium strong rock.
- Blue Anchor formation (Upper Triassic) is made of alternating grey to green siltstone and mudstone units. Gypsum and anhydrite nodules (<0.5 m thick) have been discovered in siltstone and mudstone units. They are mainly present in the uppermost 10 m, but less frequent nodules have been encountered at nearly any depth into the whole layer. Gypsum is also present as thin fracture infilling (<5 mm), as well as halite (sodium chloride) but in very small quantity. The whole layer is 31.95 to 35.10 m thick. Blue Anchor intact rock is classified as medium strong.
- Red Marls (Upper to Middle Triassic) are mainly green to red siltstones and mudstones. Gypsum and evaporite nodules have also been found in this layer but are much less abundant than in Blue Anchor formation. Its lower limit has not been reached since its maximum thickness is estimated, from bibliographical data, to be in the order of a few hundreds of metres. The maximum vertical thickness of Red Marls which has been drilled in a borehole is 73m. Red Marls matrix is classified as weak to medium strong rock.

117 The following is a summary of the key justifications provided by NNB GenCo:

- The safety related buildings are mainly founded on the limestone and calcareous mudstones of the Blue Lias (slightly weathered to fresh rock), which show sufficient strength regarding bearing capacities and sufficient stiffness regarding settlements and heave.
- The Batch 2.2 document contains a preliminary assessment of the stability (adequate bearing capacity) of key civil structures for HPC under static loading only. The assessment is undertaken by using several methods to estimate capacity. Results clearly demonstrate that bearing resistance are much higher than design vertical loads for the Serviceability Limit State (SLS) combination. This confirms that no issue of bearing capacity are expected for a large raft founded on the fresh/slightly weathered rock.
- The Batch 2.2 document contains a description of a 'preliminary' assessment of settlement and differential settlement under static loads (quasi permanent loads for the SLS). The scope of these works address settlement estimations for the entire HPC site, including those supported on the Nuclear Island (NI) Common Raft, Pumphouse, Diesel Buildings and Turbine Hall structure. Due to the relatively close proximity of buildings on the site, it was necessary to analyse the complete site in order to take account of the foundation pressure distribution (or 'pressure bulbs') in a global sense. The settlement analyses therefore made allowance for overlap of these foundation pressures and the resulting increase in local settlement where applicable. Under the Nuclear Island common raft, the total settlement has been estimated and is reported in the Batch 2.2 document to be 15 to 20mm.
- A summary of the total settlement calculations reported in the Batch 2.2 document is as follows :

  - Ground modulus increases with depth below ground level as weathering decreases along with decompression.

  - The behaviour of both units is very similar

  - The maximum settlement is obtained under the Common Raft, with a total settlement value of 15 to 20mm.

  - All the buildings surrounding the Common Raft are influenced by it and tend to tilt towards it.

  - The highest tilt takes place under the Access Towers (HW) and especially Unit 2 HW, where the tilt is about 0.5mm/m. This equates to 15mm lateral displacement of the Access Tower structure (at the elevated height of the Reactor Building at approximately +30m AOD) towards the Reactor Building. This structural tilt will be mitigated by the introduction of a 400mm clear gap between adjacent building façade.

  - The settlement under the Pumping Station (HP) is low (2 to 3mm) since the final effective stress under these buildings is low.
- The differential settlement calculated for key nuclear related civil structures, confirmed a maximum value of 15mm between the Common Raft and the Access Tower (HW), Turbine Hall (HM) or Nuclear Auxiliary Building (HN). This value is conservative as it assumes all structural loads are applied simultaneously for the buildings and makes no allowance for settlement which occurs during the construction phase.

- Larger values of differential settlement (compared to those determined in the design for FL3 which is taken as the reference design for the UK EPR™) at the junctions between the buildings will necessitate the redesign of the equipment at these junctions (larger differential displacements will result in higher stresses in pipes for example).
- The design of all plant and associated services and equipment between buildings will fully consider the settlement and tilting characteristics for HPC structures. The majority of differential settlement will occur during construction of the buildings, prior to the installation of any equipment and while the site has been de-watered (i.e. effective stress conditions). However, the movement joints and tolerances between structural elements and equipment will cater for predicted displacements during short / medium term (construction) and long term (operation) stages. Structural movement and tilting will also be accommodated by the use of adequate joints, typically 150mm clear gap as specified in the NNB GenCo Architect Engineer's EPR™ Civil Engineering Standard (Ref. zz), together with the introduction of a 400mm clear gap between adjacent building façade.
- The anticipated deep excavations at the HPC site will generally (subject to the effect of changes in groundwater level) reduce in-situ stresses in the fresh rock. The mitigation for potential heave is to re-load the formation as soon as possible. The need to ensure a minimal time lapse between placing blinding by the Earthworks Contractor and construction of the buildings by the Main Civil Works Contractor, has been assessed by the Architect Engineer. This has confirmed the duration when the excavation will be open, the consequential effects if applicable, together with the mitigating measures employed.
- Some ground movements related to a) the relaxation and stress relief of the rock mass , b) physical, chemical and biochemical weathering processes associated with the opening of joints and c) to changes in the rock mass stresses / groundwater pressures relationship can be predicted. In general, movements will be proportional to depth and the extent of excavation. Some of these movements, namely elastic rebound and stress relief, will be relatively immediate (although attenuating over a period of months).
- The preliminary heave calculations reported in the Batch 2.2 document predict an estimated value for the elastic rebound of the Blue Lias to be 2.5mm for the Nuclear Island location. This is judged to be small in terms of implications to engineering design. Other heave phenomena will be mitigated by appropriate measures (i.e. install relief wells to minimise uplift pressures, to excavate and replace with B1 mass concrete infill to protect the formation and to control potential uplift pressures.

118 I am broadly satisfied that the preliminary calculations for stability (bearing capacity) and settlement under static loading (total and differential) give an adequate indication of the factor of safety on stability and of the magnitude of settlements that might be experienced.

119 The magnitude of calculated total and differential settlements appears to be in the correct order and I note that further detailed calculations will be required to be undertaken during the detail design phase. Consequently, I am content that adequate preliminary assessment has been made to verify that the estimated settlements can be accommodated by the details embodied in the reference design.

120 I am satisfied that the indicative details provided in the Batch 2.2 document for incorporating movement joints between adjacent structures can be developed in the detail design to provide adequate inter-structure flexibility. In particular I am content that NNB

GenCo have recognised that the reduced stiffness and consequent increased settlements that may occur at the HPC site compared to the reference design at Flamanville will require re-design of components of equipment that span the movement joints. I note that the magnitude of the anticipated differential settlements appears to be such that it is credible that safety related services can be designed and detailed with sufficient flexibility to accommodate the anticipated relative movement.

121 I note that NNB GenCo have the intention of installing monitoring equipment to validate the calculation of settlement which may occur during construction and then later through operation. NNB GenCo intend that the lifetime geotechnical monitoring will be an important aspect for the forward strategy of the HPC site. The long term data will be used to support the safety case, provide confidence in the design and support future Periodic Safety Reviews. I also note that importance is attached by NNB GenCo to the specification of the monitoring system so that, when implemented, the system will provide adequate data to support the defined objectives.

122 I note that NNB GenCo have identified that mitigation measures are to be put in place to deal with the phenomena of heave of the formation rock. In this respect I consider that NNB GenCo have identified adequate means of controlling heave effects but there remains a need to provide appropriate attention to these controls during the implementation of the excavations and construction of foundations. However, I am satisfied that the rigorous approach described in the Batch 2.2 document that will be adopted for verifying the adequacy of the rock formation prior to placing blinding concrete should be an effective means of finally proving an adequate rock formation or for mitigating for potentially disturbed rock through over-excavation and replacement with concrete fill.

123 In summary I am satisfied that the rock quality and characteristics at and below the foundation interface for safety related plant are capable of being prepared and demonstrated to be adequate to receive blinding concrete.

4.2.1.3.4 Potential degradation mechanisms have been identified and that adequate protection measures are to be put in place

124 The following is a summary of the key justifications provided by NNB GenCo:

- The programme of site investigation works has identified potential rock degradation mechanisms, which primarily relate to chemical attack by dissolution of solubles in the geological strata.
- Pyrite has been confirmed across the site in the Blue Lias formation, which can oxidise to sulphate or sulphuric acid and degrade buried concrete structures.
- Oxidation of the rock formation level has been assessed regarding its potential for fragmentation and subsequent degradation of the rock strength. In particular, foundation heave due to formation of gypsum by reaction between sulphates and carbonates has been identified. Protection of the excavation during the construction phase is required to prevent oxidation occurring.
- The presence of Anhydrite and Gypsum has been confirmed in the Blue Anchor Decompression and weathering of the Blue Anchor could develop if the existing hydrogeological regime was altered and dissolution occurred.
- Highly soluble Halite minerals are present in Blue Anchor and will behave in a similar manner to the Anhydrite and Gypsum with respect to degradation.

- Somerset Halite also exists in the Mercia Mudstone group. However, due to the geological depth are not considered to be an issue for HPC.

125 I observe that NNB GenCo recognise that there is significant challenge to the long term durability of buried concrete structures at HPC. I consider that the proposed means of dealing with the aggressive ground conditions can be adequately engineered in the detail design. However, there is again a need for high standards to be achieved in concrete mix design and in the specification and installation of concrete protection measures. In particular, the additional measures proposed to protect buried concrete structures through provision of a protective membrane and exterior fin drains will require care and attention during the specification to ensure that suitable protection is provided to maintain integrity of the membrane during backfilling operations. Subsequently, appropriate supervision of works will be necessary to ensure that the installation process is controlled so that the protective components remain undamaged.

126 Measures to protect formations with respect to heave have already been discussed in Section 4.2.1.3.3.

127 I have noted the attention given in the investigation to identification of the potential for dissolution of soluble minerals in formation rocks. This phenomenon has the potential to lead to the creation of cavities in the formation rock with consequent potential for overloading of the formation and settlement. I am satisfied that the investigation has been adequate in this respect. I note that NNB GenCo have determined that suitable precautions are to be employed which will guard against possible dissolution in the Blue Anchor. These precautions relate to ensuring attention to control of groundwater flows during the temporary dewatering phase so that upward flow through the Blue Anchor is avoided. I note that these precautions will be required for the dewatering operation at the southern end of the Nuclear Island. I am content that NNB GenCo Design Authority has identified the issue and will scrutinise the design and implementation of the dewatering operation in this respect.

128 Consequently, I am satisfied that potential degradation mechanisms associated with oxidation of Pyrite, oxidation of formation rock and dissolution of minerals in Blue Anchor have been identified and that adequate protection measures are to be put in place.

4.2.1.3.5 There is an adequate understanding of the hydrogeology demonstrated by suitable investigation, assessment, modelling and analysis

129 There are two parts to the assessment of adequate understanding of hydrogeology. Firstly, with respect to implications of the hydrogeology on structures to be constructed and operated on the site. Secondly with respect to implications of managing the hydrogeology on nuclear safety related structures that are adjacent to the Hinkley Point C site. Further discussion on the second point is provided in Section 4.2.2.3.2.

130 The following is a summary of the key justifications provided by NNB GenCo:

- A network of 52 piezometers were utilised to confirm the hydrogeological characteristics across the site.
- 44 No. of these piezometers are automated (hourly measurements) and had recorded ground water level contours from December 2008 to October 2011 so that seasonal variations were captured.
- Existing groundwater levels were thus continually monitored throughout this period, which included the re-charge onto the site and that from the surrounding catchment area.

- Hydraulic conductivity of the geological layers had been confirmed by pumping tests in boreholes.
- A 3D groundwater model has been generated to investigate groundwater levels post construction (i.e. changes to site topography, changes of surface properties, presence of drainage networks, presence of buildings.
- A range of groundwater levels assessed from permanent up to accidental in order to inform the design of buried civil structures.
- The 3D model incorporates permanent drainage galleries to control groundwater levels across the site.
- It has been determined that there is very limited influence of the sea on groundwater levels on site due to limited hydraulic connection because of low vertical permeability and the dip in strata at north boundary preventing connection to the permeable layers.

131 I note that NNB GenCo have recognised the important aspects relating to ensuring adequate understanding of the site hydrogeology. For example, during construction works it will be necessary to prevent damage to the foundation rock by uncontrolled water flows or uplift pressures. During operation, many of the structures have buried foundations or basements which could potentially experience buoyancy effects when the groundwater returns to higher levels after termination of temporary dewatering during construction. Groundwater pressures will also challenge requirements for structural watertightness and will represent a loading to be accounted for in the detail design.

132 I am satisfied that the site investigation has provided adequate data to facilitate sufficient understanding of the hydrogeology at the site.

133 I note that whilst the detail hydrogeology is considered to be complex the overall interpretation of hydrogeology has been defined in a simplified yet adequate manner. Impermeable mudstone and permeable limestone layers are evident and groundwater recharge associates with the overall topology with very limited hydraulic conductivity with the sea. Site investigations have been designed to confirm the hydrogeology and to provide data to enable estimation of permeability of various strata.

134 The data obtained has provided a suitable basis for numerical modelling of groundwater control both during construction and later during operation.

135 I note that NNB GenCo have employed a specialist organisation to create a set of detailed numerical models for investigation and sizing of a permanent dewatering system. I believe that this is an appropriate approach to support the design of the safety classified dewatering structure and system components.

136 I note that NNB GenCo have undertaken analysis to investigate the effect of construction dewatering beyond the site boundary and specifically taken into consideration is the effect of drawdown of groundwater table on the stress state in the formation rocks under the Hinkley Point A and B stations. Changes in effective stress for formation rocks are of interest since there may be implications for compressibility of the rocks and therefore potential for settlement of structures.

137 NNB GenCo claim that temporary drawdown of groundwater outside the site results in only a marginal increase in effective stress which NNB GenCo consider will not threaten the safety performance of structures on the adjacent stations. NNB GenCo also note that, if necessary, a grout curtain could be designed and constructed to reduce groundwater drawdown under the adjacent stations. I have not assessed NNB GenCo's analysis in

this respect. However, I have established that NNB GenCo have put in place a procedure – 'Communicate with Adjacent Facilities' (Ref. 54) which is designed to inform the adjacent stations of construction operations on HPC that may affect HPA and/or HPB and also to form a mechanism for agreeing that such operations may be implemented. In addition, I have determined that nuclear safety issues that cross site boundaries will be covered by a formal Nuclear Safety Cooperation Agreement which is referenced in the NNB GenCo procedure (Ref. 54) and once signed by respective parties this will form the high level cooperative document.

138 I am satisfied that the investigation and assessment has been adequate in respect of hydrogeology. However, I consider that a critical aspect of the permanent dewatering system will be the design and operation of the monitoring equipment which will provide assurance of the effectiveness of the permanent dewatering structures. This aspect is discussed further in the following section, 4.2.1.3.6.

139 I am also satisfied that there will be adequate procedural control of construction operations on the HPC site via the NNB GenCo procedure and the Nuclear Safety Cooperation Agreement. In which case potential impacts of construction operations on HPC will be captured and assessed through the normal processes for securing the integrity of safety case on the HPA and HPB stations.

4.2.1.3.6 The impact of hydrogeology on the twin reactor site has been assessed and it is demonstrated how the characteristics can be accommodated in the design of the safety related plant

140 The following is a summary of the key justifications provided by NNB GenCo:

- To mitigate the high ground water levels and the potential for hydraulic uplift effects on buildings with deep foundations, a passive (gravity based) groundwater drainage system will be constructed to limit groundwater levels across the site.
- This new drainage gallery will be located along the east, south and west boundaries to capture groundwater and discharge it to sea.
- The drainage gallery ensures a controlled water table level in order to maintain stability of the buildings and prevent uplift due to buoyancy.
- A 3D hydro-geological model has been generated to calculate preliminary groundwater flows and levels, taking account of the site configuration after construction (i.e. platform construction, buried structures and drainage gallery).
- The approach adopted did not use the 3D hydro-geological model to predict the groundwater levels (due to difficulty in making an adequately reliable estimation), but to control them by introducing drainage galleries with sufficient redundancy to accommodate run-off onto the Site.
- A series of design water levels including permanent, frequent, high and accidental levels have been assessed based on the introduction of drainage galleries.
- The drainage galleries will reduce groundwater levels to between 8m and 8.5m AOD for the permanent case.
- Under accidental conditions the design ground water table is conservatively taken as +10m AOD for the Nuclear Island. Accordingly the galleries and other structures will be designed to operate for the worst case design actions from a groundwater table range between 8.0m AOD and 10m AOD.

141 The permanent drainage gallery system is clearly an important safety classified system since many other safety classified structures rely on the on-going integrity of the system for their stability and compliance with safety case. I have observed that the design of this safety classified system for permanent control of groundwater is under development. For example, it is unclear how the various derived design groundwater levels corresponding to different rainfall return periods will be used in the design load combinations and for overall structural stability design. This is however, a detail matter for consideration later in the detail design of the system.

142 The concept of a passive drainage system should provide greater assurance of reliability since it will not rely on mechanical components. The sizing of the galleries also appears to provide for capability of expansion of vertical drainage components and hence drawdown capability. In summary the concept appears to be a feasible means of managing the determined hydro-geological characteristics.

143 A critical aspect of the permanent dewatering system appears to be the responsiveness and reliability of the groundwater monitoring piezometers that are proposed to be installed to provide a means of verifying the operational effectiveness of the dewatering drainage galleries. The piezometers are instruments located in boreholes strategically drilled over the area of the site which must be capable of detecting and reporting groundwater level (or pressure) changes in relation to measured rainfall events so that the operator can make on-going judgements on the effectiveness of the vertical drains that feed the dewatering galleries. Thus, on the basis of measured performance, judgements can be made on the need to enhance vertical drainage capability for potential future rainfall events. The piezometers should be suitably reliable so that critical data is always available to support the on-going judgements on dewatering performance.

144 It is possible that vertical drains may clog or deteriorate which is a further reason for maintaining routine monitoring of system performance.

145 NNB GenCo have not provided any details of proposals for overall dewatering system architecture, for example data acquisition, monitoring and alarm levels etc. However, I anticipate that a suitable and appropriately reliable hardware and software combination can be designed for this purpose.

146 NNB GenCo have not provided details of proposals for design of the piezometers and data transmission equipment to demonstrate how the piezometer can provide the necessary reliability. Nor is information presented on how the piezometers will be arranged to measure groundwater head in the various permeable strata. However, I consider that it is feasible for the necessary plant configuration to be achieved.

147 I note that NNB GenCo have recognised that their monitoring strategy will need to address groundwater levels, chemistry and verification of assumed design parameters in order to support the safety case and ongoing periodic safety reviews.

148 However, I find that NNB GenCo have not provided evidence relating to evaluation of components of the dewatering systems that will be routinely examined and tested as part of a Plant Maintenance Schedule. (In this context a Plant Maintenance Schedule is expected to define the planned maintenance and inspection for all the safety related components of the plant.) But, I am satisfied that this depth of detail need not be evaluated at this stage in the development of the design of the dewatering system.

149 In summary, I am satisfied that NNB GenCo have demonstrated that there is a credible means of accommodating the hydrogeological characteristics in the overall design of the safety related plant.

4.2.1.3.7 Demonstration that the geology of the site will not lead to the structures being vulnerable to seismic action (e.g. capable faulting, liquefaction and seismic movements) and that having quantified the seismic hazard and the geology, it is explained how the structures can be designed to accommodate the envisaged forces (by analysis) and movements (by analysis and detailing)

150 The following is a summary of the key justifications provided by NNB GenCo:

151 Site Classification and seismic characterisation:

- Average shear wave velocity (V_{S30}) calculated for upper 30m of ground for NI and Offshore Intake locations is calculated in accordance with Eurocode 8.
- V_{S30} captures velocity in Blue Lias, Lilstock, Westbury and Blue Anchor.
- For the NI, velocity values range from 504m/s (min.) to 1178m/s (max.), with a harmonic mean value of between 730m/s to 828m/s.
- Shear Modulus (G) for HPC, based on V_{S30} values calculated, is typically 1500MPa.
- The values of V_{S30} and G for HPC are bounded by the six standard ground conditions (soft, medium and hard sites) utilised for the reference design (FL3)
- Dynamic properties of ground obtained from the Site Investigation works, including:

  (i) Seismic refraction survey

  (ii) One crosshole/downhole array of 3 boreholes (2008 campaign)

  (iii) Three crosshole/downhole arrays of 3 boreholes each (2010 campaign), one cluster near each Nuclear Island and one in vicinity of pumping house of Unit 1.

  (iv) Sonic Sonde logging of all boreholes

  (v) Strain sensitivity of modulus and damping determined from resonant column tests and published data. It is anticipated that shear strain in the rock will be low and that the effects of modulus decay will be very limited. This will be confirmed by the forthcoming Soil Structure Interaction sensitivity analyses comprising analytical studies to be undertaken in advance of the main design phase.
- The dynamic data were established via downhole tests from boreholes located at both Common Raft positions and Unit 1 Pumphouse in Structural Zone 1 only. No dynamic properties were established for Structural Zone 2 or 3 as all safety classified structures (apart from possible exception of Raw Water Storage Facility) are contained in Structural Zone 1.

152 Comparison with the Reference Design:

- A number of phenomena associated with the earthquake hazard have been considered in the overall preliminary design process in relation to the site and geotechnical design. These are :

  - Ground motions and the effects of structural response

  - Capable faulting and the potential for surface rupture

  - Liquefaction of soils

  - Slope Instability
- Batch 1.2 presents the justification of the HPC site specific Design Basis Earthquake and demonstrates that it is conservative and within the envelope assessed in GDA.

- The possibility of ground rupture on the site as a result of movement on a capable fault is addressed in Batch Submission 1.3. This justifies that the potential for ground rupture is so remote that it is not a credible hazard that needs to be addressed in the design.
- The Onshore Interpretive Report includes an assessment of materials present at the site, none of which are judged potentially subject to liquefaction which could affect safety related structures. All safety classified buildings are to be constructed on acceptable rock formation, in which liquefaction cannot develop or pose any related challenges to the structures due to its nature.
- The cohesive nature of the fill, coupled with the compaction methods adopted during the backfill process, will ensure that liquefaction will not occur during a seismic event. Testing will be undertaken to confirm the properties of the fill material, as placed, and that these conform to the design requirements.
- Other than drainage falls, there are no slopes and embankments in the vicinity of safety classified buildings. Any slope failures that may occur will therefore have no consequence on these facilities.
- For HPC the accommodation of the envisaged forces (by analysis and design) and movements (by analysis and detailing) will be addressed by multi-stage Finite Element modelling involving Soil Structure Interaction (SSI) analyses, followed by global structural and more detailed local analyses.
- In advance of the detailed design, it is proposed to undertake a set of sensitivity studies on SSI and SSSI (Structure Soil Structure Interaction) to inform, support and to provide additional validation of the SSI analyses.
- At this stage in preliminary design the dynamic analyses performed by NNB GenCo's Architect Engineer that take cognisance of the geology specific to the HPC site is confined to an examination of global acceleration values. There have been no dynamic analysis completed which address the bearing pressure demand on the foundation strata. However, the static bearing pressure assessment, which is inclusive of all load and safety factors confirms an adequate margin between demand and capacity. This is considered an adequate demonstration of the competency of the foundation strata for site licensing purposes.
- NNB GenCo's Architect Engineer has undertaken dynamic analysis of the reference design (FL3) Nuclear Island structures for a wide range of foundation strata properties.
- The subsequent analysis report defined the differential displacement values to be applied when designing equipment contained in the NI buildings founded on the common raft foundation. These include the Inner and Outer Containment Structures, Fuel Building, Safety Auxiliary Building and Safeguard Electrical buildings.
- For the purposes of site licensing the behaviour of the NI buildings is considered to provide sufficient insight relating to the demands on the geology as these buildings place a high demand on the foundation strata.
- Floor response spectra, providing input to the seismic analysis, were established for six standard ground conditions (termed: SA, MA, MB, MC, HA, HF). Ground conditions SA, MA, MB, MC and HA correspond to homogeneous ground. Ground condition HF corresponds to a stratigraphy representative of the stratigraphy of FA3. These ground conditions comfortably envelope those found at Hinkley Point.

- The results of the analyses undertaken correspond to the differential seismic displacement of the buildings with respect to the free field ground motions. A maximum differential seismic displacement value of 16mm was determined, between the Inner Containment Wall (at +30m AOD) and the Common Raft Foundation. This movement will be accommodated by the joints details between buildings and structural elements, i.e. typically 150mm clear gap between nuclear structures as noted in BTS (Book of Technical Standards) Civil Engineering Standard. (NNB GenCo Architect Engineer's EPR™ Civil Engineering Standard (Ref. 34))
- Differential seismic displacements with respect to foundation raft movements were used to dimension equipment anchored on the civil works structures and founded on the common raft. The assessed seismic movements were accommodated in the detailed design of the process pipework and associated supply services for the reference design and it is judged that movements at HPC will be within this envelope. The magnitude of seismic movement and necessary flexibility tolerances for HPC will be developed further in the detail design.

153 I note that the Stage 2 Site Investigation was scoped by NNB GenCo to obtain sufficient and appropriate quality data designed to characterise the dynamic properties of the rock strata. Equivalent work in the Stage 1 site investigation had not realised adequate data. But it is apparent that adequate dynamic data has been established and analysed following the Stage 2 investigation.

154 NNB GenCo have established that, through the process of categorising the site, the characteristic average shear stiffness of the rock fits within the envelope of 'soil' models that have been used as input to the reference design. This is important because it enables comparison with the reference design for the purposes of demonstrating non-vulnerability to seismic action.

155 I consider that NNB GenCo have demonstrated intention to follow good practice and undertake a set of sensitivity studies on Soil Structure Interaction (SSI) and Structure Soil Structure Interaction (SSSI) to provide additional validation of the detail foundation analyses. These sensitivity studies will apparently address the potential for non-linear behaviour of the rock in particular associated with seismic strains during extreme loading. I observe that the site investigation has established strain degradation curves to enable appropriate study of potential for non-linear low strain rates. I would expect these studies to reveal potential secondary effects and therefore I am content that the work is in the forward action plan.

156 I also understand that NNB GenCo intend to investigate the most appropriate method(s) of analysing the seismic response of structures with respect to dynamic soils/structure interactions taking into account the rock anisotropy. I consider this to be an important objective of the preliminary studies into seismic analysis and I expect that analytical simplifications of the geological anisotropy to be fully justified in the preliminary analysis studies.

157 NNB GenCo intend that fill material to safety classified structures may be derived from suitable excavated material. The Batch 2.2 document describes how NNB GenCo have undertaken a body of work to define fill performance requirements and to identify which natural rock material may be suitable. I consider that an appropriate amount of work has been done on this topic to establish that the selected site won material can be processed and placed as an effective side fill to safety related structures. However, I note that NNB GenCo will need to apply a degree of rigour in managing the large stockpiles of excavated

material to ensure that the necessary standards of quality are maintained in processing, segregating and protecting the selected fill that may be used for this safety related purpose. Given the large plan area of land that NNB GenCo have acquired for the purposes of managing stockpiles of excavated material I believe that it should be feasible for the necessary controls to be effective.

158 The methodology of seismic analysis undertaken for the reference design has been assessed in the scope of ONR Generic Design Assessment (GDA) (Ref. 15). There is an extant GDA Assessment Finding relating to certain aspects of the analysis, namely **AF-UKEPR-CE-08**. The resolution of this GDA Assessment Finding has not been addressed in the scope of Batch 2.2 submission. However, I consider that for the purposes of licensing, the enveloping of the HPC site by the set of soil properties used in the reference design and noting the NNB GenCo claim that the HPC design basis ground response spectra is enveloped by that used in the reference design then the adoption of the outputs of the reference design for justification at licensing of HPC appears an appropriate approach. I consider that the implications of **AF-UKEPR-CE-08** are unlikely to substantially change the order of magnitude of the values of seismic displacement referenced in the Batch 2.2 document.

159 Consequently, I believe that the magnitude of seismic displacements is in the correct order but I note that further detailed analyses are planned to be undertaken during the detail design phase. Consequently, I am content that adequate preliminary, comparative assessment has been made to verify that the estimated displacements can be accommodated by the details embodied in the reference design.

160 I note that the proposed movement joints and tolerances between structural elements and the adoption of suitable detail design provisions for equipment should accommodate the predicted seismic displacements. I consider that it should be practical for the detail design to develop adequate joints based on the typical detail which adopts a 150mm clear gap as specified in the BTS (Book of Technical Specifications) Civil Engineering Standard. (NNB GenCo Architect Engineer's EPR™ Civil Engineering Standard (Ref. 34))

161 The question of capable faulting is dealt with in ONR assessment of Batch 1.3.

162 Batch 2.2 contains an outline description of how seismic forces will be determined using multi-stage Finite Element modelling involving soil-structure interaction (SSI) analyses, followed by global structural and more detailed local analyses. I am content that NNB GenCo are applying oversight to the development of the structural analysis methodology and structural modelling targeted at realising structural design outputs for the HPC structures.

163 I am satisfied that NNB GenCo have identified, through the process of the site investigation, important characteristics that they now intend to assess through targeted soil structure interaction studies. I consider that the NNB GenCo plans to deal with particular site specific characteristics in the preliminary seismic analysis studies are evidence of application of good practice in the progression of the foundation design, broadly aligning with the IAEA Safety Guide (Ref. 5).

164 Consequently, I am satisfied that NNB GenCo have demonstrated that the geology of the site will not lead to the structures being vulnerable to seismic action and that having quantified the seismic hazard and the geology, there is evidence to show that the structures can be designed to accommodate the envisaged forces (by analysis) and movements (by analysis and detailing).

4.2.1.3.8 Monitoring and Ongoing Investigations

165 NNB GenCo have provided information in the Batch 2.2 document to explain how it is intended to continue to gather information during the early construction activities in order to enable re-validation of data determined from the site investigations.

166 NNB GenCo have also outlined a strategy for lifetime monitoring throughout the operation of the plant.

167 Therefore, I am satisfied that the proposed ongoing site assessment during construction and the early considerations for development of lifetime monitoring show adequate intent by NNB GenCo to follow good practice that correlates with the section of the IAEA Guide (Ref. 5) relating to Pre-Operational Stage Investigation and Operational Stage Monitoring as part of a Plant Maintenance Schedule.

4.2.2 Assessment of NNB GenCo Organisation Capability

4.2.2.1 Assessment of NNB GenCo capability to develop a SSPCSR submission

168 In the Civil Engineering workstream this assessment targets NNB GenCo Design Authority. ONR focus is on organisational capability and the structure of the civil engineering team within the Design Authority.

169 ONR evaluation is to consider if the NNB GenCo organisational capability is adequately developed and sufficiently robust at this stage in the project and there are adequate plans in place to match resources to meet the needs of the programme, post licensing, leading to a future request to commence the first nuclear safety related construction activity and subsequent construction and installation milestones.

170 ONR have engaged with NNB GenCo on a regular, generally, bi-monthly, basis from September 2010 up to the end of July 2011 at which time NNB GenCo submitted their Licence Application. Engagement with NNB GenCo continued after submission of the Licence Application with particular focus on matters pertaining to granting of a nuclear site licence. This regular engagement provided a means for ONR to become familiar with the development of preliminary design being undertaken by NNB GenCo's Architect Engineer and also to closely monitor the development of NNB GenCo DA capability and the development of NNB GenCo's arrangements.

171 I have observed that NNB GenCo DA capability has progressively expanded over the period since early engagement commenced in September 2010. The civil engineers in DA have been involved in oversight of preliminary design being performed by their Architect Engineer, in oversight of the progress of GDA, in procurement activities for civil engineering contracts, in development of strategy for construction oversight and in appraisals of civil engineering tenders.

172 However, to enable a judgement to be made on the adequacy of the Civil Engineering team within the Design Authority at this stage in the project, an intervention was undertaken on the 27th June 2012 with a specific objective of making this assessment.

173 The conclusion from the intervention was that NNB GenCo DA capability in Civil Engineering is fragile. I also previously found that the DA capability in Civil Engineering was stretched. The fragility arises from the inability to fill all the Nuclear Baseline roles with fully suitably qualified and experienced (SQEP) engineers and in the employment of a team which is heavily weighted with embedded contractor resources. Consequently, although I concluded that the organisational capability is currently just adequate, there is significant vulnerability to increase in workload and from unplanned loss of resource.

174 However, I was satisfied that the near-term forward recruitment plan was intended to address the apparent fragility in the organisation and this was a contributory factor in determining that the current situation is adequate.

175 In summary, although I consider that the DA capability in Civil Engineering is currently fragile, I am satisfied that it is currently adequate for managing the duties that it is required to undertake.

4.2.2.2 Assessment of NNB GenCo arrangements for controlling development of a safety case compliant design

176 In the civil engineering workstream this assessment targets NNB GenCo Design Authority (DA). In particular there is focus on DA oversight of their Architect Engineer.

177 In respect of NNB GenCo's arrangements the procedures for Design Review and Acceptance and for oversight and surveillance of their supply chain were of prime interest.

178 NNB GenCo's 'Design, Review and Acceptance' procedure (Ref. 37) identifies the means by which surveillance is planned, executed and recorded. I have determined that this procedure is now an established procedure and that the DA team are familiar its use.

179 I have determined that NNB GenCo have developed a 'Review and Acceptance Scope Specification' (Ref. 38) which represents progress in planning surveillance. However, there is limited progress in drafting and implementing Surveillance Plans which relate to specific civil engineering topics.

180 The current position on Surveillance Plans is an area that NNB GenCo recognise will require greater attention going forward as Level 2 preliminary design packages being managed by their Architect Engineer begin to reach maturity in the near future. However, to enable a judgement to be made on the current adequacy of the surveillance being undertaken by the Civil Engineering team within the Design Authority at this stage in the project, an intervention was undertaken on the 27th June 2012 with a specific objective of making this assessment.

181 In the intervention undertaken on the 27th June 2012 I was satisfied with NNB GenCo DA arrangements for surveillance of their Architect Engineer (AE) in terms of compliance with procedures and also in terms of the maturity of the interactions that are now taking place between the DA and the AE. I noted that the embedding of a highly experienced DA civil engineer into the process of the Early Contractor Involvement Contract was good evidence of targeted engagement with important development work being undertaken by the AE.

182 In addition, evidence was obtained from an intervention in which an ONR Inspector observed a Monthly Coordination Meeting held in Paris. This meeting is the routine forum for NNB GenCo DA and the Architect Engineer to review progress on preliminary design and contracts in the tender or early award status. The terms of reference for these meetings was stated by NNB GenCo to be:

- A presentation of design progress and main harmonized key performance indicators (KPIs) developed to date for Civil Works contracts
- Review of Critical Path activities per buildings before first concrete date, with focus on key issues
- Discussion of major technical issues and interfaces / related action plans (avoid detailed resolution, rather focus on the identification of potential gaps and necessary actions)

- Discussion of major interfaces with the Regulators – GDA , NSL , local consents – , PCSR expectations, and their interfaces with current Civil Works related contracts
- Design Codes status and interfaces with these contracts

183 I found that the process of the meeting provided evidence to demonstrate that NNB GenCo DA was exercising appropriate oversight over the civil engineering activities being managed by their Architect Engineer. Through observation of the meeting I considered that NNB GenCo DA were using the meeting in an effective manner in respect of their intelligent customer obligations, which are managed through an established hierarchy of meetings.

184 Therefore, overall, I am broadly satisfied that NNB GenCo are adequately controlling the development of a safety case compliant design.

4.2.2.3 Assessment of NNB GenCo arrangements for controlling the procurement, manufacture, construction and installation of safety related structures systems and components

4.2.2.3.1 NNB GenCo DA interface with procurement

185 In respect of NNB GenCo's arrangements, the procedures for 'Define, Manage and Release of Hold Points' (Ref. 35), for oversight and the procedures for interfaces between various parts of NNB GenCo (as listed in Ref. 36) were of interest. I was particularly interested in examining how the Design Authority would integrate with procurement and construction oversight activities.

186 I had attended on the 18th Jan 2012 a presentation from NNB GenCo (Ref. 36) which included a talk specifically on Procurement related to Nuclear Safety. This presentation was made by the DA representative that is nominated to integrate with the Procurement function This earlier intelligence gathered on the NNB GenCo Procurement process provided a suitable framework on which to base the inspection of the civil engineering interaction with procurement activities. I used the framework of tertiary hold points identified in the procurement process as a means of examining how the civil engineer in DA had undertaken effective interaction and contribution to clearing each tertiary hold point.

187 Following the intervention undertaken on the 27th June 2012 and following the procurement framework of activities, I was content with the interactions that are now taking place between DA and NNB GenCo Procurement in terms of compliance with procedures and also in terms of the maturity of the working processes.

4.2.2.3.2 Oversight of safety related construction activities

188 Interventions targeted at assessing NNB GenCo's intentions for management and oversight of safety related construction activities have been made partly in engagement with the Design Authority (DA) to inspect how the DA intend to apply oversight of the construction organisation and partly through ONR intervention into NNB GenCo's LC19 arrangements.

189 The routine civil engineering meetings between ONR and NNB GenCo DA have provided the forum to enable NNB GenCo DA to explain how it is currently intended to embed DA presence into the Site Engineering Team. Key objectives have been defined by NNB GenCo as:

- The DA role is beyond just safety case and design.

- DA have been interfacing with the site based team to establish arrangements for DA interactions during construction, erection and commissioning.
- DA surveillance activities will be under the 'Design Review and Acceptance' (DR&A) Procedure. (Ref. 37)
- Other interactions – such as managing non-conformances and design change are proceduralised and have appropriate links with DA.
- Site Surveillance Plans, including hold or witness points, will need to reflect DA interactions.
- DA will have a site presence.

190 On the basis of discussions held in the workstream meetings I am satisfied that the progress of integration of DA oversight into site construction procedures is progressing adequately.

191 In the LC19 workstream I note that NNB GenCo has also developed arrangements for controlling construction activities. The construction procedures recognise that the DA will retain responsibility for securing NNB GenCo's intelligent customer role and the authority to make decision and judgements affecting nuclear safety. I have also clearly established that the DA will have a permanent presence on site, and will be based with the site based team in an "integrated" group which will work in a coordinated manner to manage and control the construction process.

192 The LC19 intervention also obtained evidence explaining how the DA will apply the Design Review and Acceptance Procedure to the proposed Site Surveillance Plan and relevant site documentation. The resulting DA Surveillance Plan will be a key input to the document review matrix.

193 I note that NNB GenCo have put in place a procedure – 'Communicate with Adjacent Facilities' (Ref. 39) which is designed to inform the adjacent stations of construction operations on HPC that may affect HPA and/or HPB and also to form a mechanism for agreeing that such operations may be implemented. In addition, I have determined that nuclear safety issues that cross site boundaries will be covered by a formal Nuclear Safety Cooperation Agreement and once signed by respective parties this will form the high level cooperative document. This aspect has been discussed earlier in Section 4.2.1.3.5.

194 Consequently, I have obtained sufficient evidence to determine that NNB GenCo have developed adequate arrangements for securing NNB GenCo's intelligent customer role in the provision of oversight of nuclear safety related construction.

4.2.2.3.3 Controlling the project via Hold Point procedures

195 I have engaged with NNB GenCo on the topic of hold points in two ways: (i) on the development of NNB GenCo's company procedure for 'Define, Manage and Release Key Hold Points' (Ref. 35) and (ii) on NNB GenCo's development of their 'Hold Point List' (Ref. 41).

196 I note that the NNB GenCo procedure has now reached a stage of maturity and is widely understood and adopted in the organisation. The Hold Point is defined as a point in the sequence of work which shall not be passed without being released at the appropriate level. Primary and Secondary Hold Points relate to release of activities that could cause a serious or significant increase in risk if not appropriately controlled. Risk in this context can apply to nuclear safety risk. Secondary Hold Points relating to significant increase in

risk can be released by the Director of the responsible Head of Function. In order to define the criteria for release of the Hold Point a Management Expectation Document is prepared to capture all the enablers that are to be closed-out prior to release.

197 I had assessed and commented on a draft list of hold points (Ref. 40). Subsequently NNB GenCo DA reviewed these comments and reviewed their Hold Point List. Draft version 2.2 of the list (Ref. 41) has now included additional hold points for activities that I had considered to be important but omitted from the earlier list. These included Secondary Hold Points for Commencing Significant Preliminary Works (Earthworks), Start of safety related deep excavations, Start of Marine Works tunnelling and Commencement of prestressing of the containment building.

198 I consider that there is need for further discussion to iterate to a final suitable Hold Point List. In particular I wish to explore the potential for Secondary Hold Points associated with Reactor Containment and Fuel Pool construction stages. But I am satisfied that adequate progress has been made by NNB GenCo in establishing the procedure and the list of Hold Points in its current form.

199 I have established that NNB GenCo DA continue to review the Hold Point List and intend to open further discussion in the near future.

200 Consequently, I have obtained sufficient evidence to determine that NNB GenCo have put in place a suitable control procedure and Hold Point List that establishes adequate (for this stage of the project) civil engineering related control points in the programme for delivery of HPC.

4.2.3 Assessment of Licence Condition Compliance Arrangements

201 This assessment relates to NNB GenCo's arrangements for compliance with LC 2 – Marking of the Site Boundary and LC 16 – Site Plans, designs and specifications. Assessment relating to LC 19 – Construction or installation of new plant is discussed in Section 4.2.2.3.2

202 I have maintained a view of NNB GenCo's development of arrangements for compliance with LC 2 and LC 16 since October 2010. Early intervention was centred on providing advice on effective means of generating reference documents and on maintaining focus on the separate and specific requirements that are contained in the two licence conditions.

203 Post receipt of NNB GenCo's Licence Application I have attended two meetings in which I have observed progress in the procedural arrangements for compliance with the licence conditions and in the effectiveness of the controlling documents referenced in NNB GenCo's arrangements.

204 Further advisory comments were provided to NNB GenCo in April 2012 and NNB GenCo subsequently responded by letter (Ref. 42) in which NNB GenCo describe how their developed arrangements will address the earlier advisory comments and other actions that had been raised in the workstream meetings.

205 I am satisfied that the NNB GenCo procedure for 'Manage Site Plans, Designs and Specifications' (Ref. 43) includes a process for initially creating a lifetime record of the ordnance survey grid references of the points that define the plan area of the licensed site and then to make reference to that record in order to re-establish the boundary of the licensed site. At an appropriate time NNB GenCo will then develop a drawing using the re-established boundary of the licensed site as a basis for setting out the site boundary

markers. I note that NNB GenCo have confirmed in their letter (Ref. 42) that the data relating to ordnance survey grid references has been listed as a required lifetime record.

206 I am satisfied with the set of documents that have been developed to serve the compliance arrangements with LC 16. A single drawing is used to pictorially define the boundary of the licensed site and I accept that the LC 2 arrangements for creating a lifetime record of the ordnance survey grid coordinate references will properly define the limits of the boundary.

207 I am satisfied that a separate and unique drawing will be prepared to show every building on the site that may affect safety. I have also gained assurance that the drawing will include all safety related buildings including those that might otherwise have been associated with non-nuclear safety function. NNB GenCo have, in accordance with LC 16 (2), prepared a schedule of the identified buildings which does give a description of the building and operations associated with that building.

208 I am broadly content with NNB GenCo's proposals, (Ref. 42) for addressing my early comments/observations on the development of arrangements. I have observed how NNB GenCo have progressed and improved the site plan and schedule over the period of time since submitting the licence application. A revision of the documents has been submitted to ONR via NNB GenCo letter (Ref. 44)

209 I have reviewed the latest drawing and schedule that were included in Ref. 59 and find that these documents are adequate for compliance with LC 16. I also note that the NNB GenCo procedure for managing the site plan for LC 16 compliance links into NNB GenCo's Architect Engineer's procedures. In this way there are now arrangements in place to enable NNB GenCo to maintain overall control over modifications of the site layout so that the design is progressed within the boundary of what may become the licensed site. Furthermore I observe that NNB GenCo have a means of being able to manage changes on the licensed site with respect to buildings, plant or operations in compliance with LC 16 (3).

210 Consequently, I am satisfied that NNB GenCo have put in place adequate procedures and documentation to meet the requirements of LC 2 and LC 16 for this stage in the development of the project.

4.3 Comparison with Standards, Guidance and Relevant Good Practice

211 I note that NNB GenCo's Architect Engineer planned the site investigations on the basis of guidance provided in Eurocode 7, (EN1997-2) (Ref. 19).

212 EN 1997-2 provides rules supplementary to EN 1997-1 related to:

- planning and reporting of ground investigations;
- general requirements for a number of commonly used laboratory and field tests;
- interpretation and evaluation of test results;
- derivation of values of geotechnical parameters and coefficients.

213 Eurocode 7 is the UK implementation of EN 1997-2:2007 and consequently I consider that the guidance contained in the document represents a source of relevant good practice.

214 Guidance provided in IAEA Safety Guide NS-G-3.6 (Ref. 5) 'Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants' clearly represents relevant good

practice. Although the Site Investigation Interpretative Report does not make reference to the IAEA Safety Guide NS-G-3.6 I have noted that NNB GenCo Design Authority has recognised this guidance in their Site Geology Summary Document, Batch 2.2 (Ref. 13). NNB GenCo DA has clearly used the guide as a means of forming their own judgements on the site investigations performed by their Architect Engineer.

215 Consequently, I am satisfied that there has been good use made of appropriate standards, guidance and relevant good practice through the process of the HPC site investigations.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

216 This report presents the findings of the ONR assessment of the Civil Engineering topical assessment of NNB Generation Company's (NNB GenCo) application, including supporting information and arrangements, for a nuclear site licence at Hinkley Point C (HPC).

217 Based on the interventions carried out and assessment of the several batch PCSR2 documentation, and taking account of the point in time in the build programme, the following key conclusions are made in terms of nuclear site licensing:

- Suitability of the Site – I am satisfied that there is adequate evidence provided to demonstrate that the HPC site is suitable for the proposed twin reactors.
- However, the geology and hydrogeology at the site presents a number of challenges for ongoing analysis, design and construction of the plant. I am satisfied that NNB GenCo have identified appropriate forward action plans to address these issues. I am also satisfied that NNB GenCo intend to continue to assess site geological and hydrogeological characteristics during early earthworks and temporary dewatering activities in order to enhance the body of knowledge already gathered during the site investigations. This correlates with pre-operational stage investigation defined in the IAEA Safety Guide (Ref. 5).
- I am content that the challenges associated with geology have been adequately investigated and quantified for this stage in the project so that the preliminary design has been directed toward realising appropriate solutions and mitigations.
- I am satisfied that NNB GenCo's proposals for the development of a lifetime monitoring strategy show adequate intent by NNB GenCo to follow good practice that correlates with the IAEA Guide for Operational Stage monitoring as part of the station maintenance schedule.
- Size of site - I am satisfied that the investigations based on the assumed construction sequence confirm that the site is of a sufficient size to allow construction.
- I am satisfied that the implications of a twin reactor site have been adequately considered and that the Forward Action Plan presented covers the identified outstanding issues.
- I am satisfied that issues of ageing management of shared facilities during follow-on construction have been addressed. I am satisfied that the effects of a twin reactor site on constructability have been considered and will be adequately covered by the NNB GenCo proposals.
- I am satisfied that the civil engineering aspects of the layout are feasible and that the submission adequately describes the design optioneering undertaken and to be undertaken in the detailed design phase. The complete picture with regard to constructability issues at HPC cannot be finalised until the Civil Works Contractor has been appointed and an assumed construction sequence has been adopted in the interim. However, I am satisfied that the NNB GenCo technical review arrangements and Early Contractor Engagement process will allow full account to be taken of constructability issues.

- Cooling Capability - I am satisfied that there is sufficient site data relevant to the heat sink and sea conditions available to support the design of the necessary civil, systems, structures and components.
- I have assessed the NNB GenCo justification for the siting of the heat sink civil engineering structures and consider that this is adequate. However the main threat to the provision of the necessary cooling water flow rates, cooling water availability and quality is silting of the civil engineering structures. NNB GenCo intend to analyse the hydraulics of the system in further detail in mock-up studies. I am satisfied that the proposed additional mock-up studies will adequately underpin the detailed design work and allow silting issues to be addressed. I am satisfied that, given satisfactory completion of the mock-up studies and the detailed design, the concept, layout and design of the civil structures is such that adequate cooling capability will be available for all normal and fault conditions.
- Organisational Capability - NNB GenCo has developed its intelligent customer capability in civil engineering and this is adequate relative to the position of the project along the overall design and construction programme, and in terms of licensing.
- I consider that the NNB GenCo DA capability in Civil Engineering is fragile. However, I am satisfied that the near-term forward recruitment plan is intended to address the apparent fragility in the organisation and this is a contributory factor in determining that the current situation is adequate.
- I am broadly satisfied with NNB GenCo DA arrangements for surveillance of their Architect Engineer (AE) in terms of compliance with procedures and also in terms of the maturity of the interactions that are now taking place between the DA and the AE. A number of areas of good practice were observed in terms of oversight and surveillance during the intervention.
- I am content with the interactions that are now taking place between DA and NNB GenCo Procurement in terms of compliance with procedures and also in terms of the maturity of the working processes.
- I have obtained sufficient evidence to determine that NNB GenCo have developed adequate arrangements for securing their intelligent customer role in the provision of oversight of nuclear safety related construction relative to this point in time in the construction programme.
- I have determined that NNB GenCo have put in place a suitable control procedure and Hold Point List, to satisfy the requirements of LC 19 (4) that establishes adequate (for this stage of the project) civil engineering related control points in the programme for delivery of HPC.
- I am also satisfied that NNB GenCo have put in place adequate procedures and documentation to meet the requirements of LC 2 and LC 16 for this stage in the development of the project.
- A number of potential areas for improvement have been identified. These are: improving the resilience of the Civil Engineering capability in Design Authority, improving the implementation of planned surveillance of the supply chain, including the Architect Engineer and giving further consideration to enhancing the Hold Point List to capture suitable control of Reactor Containment and Fuel Pool construction stages. At this point in the programme these aspects are being adequately progressed by NNB GenCo.

218 To conclude, I am broadly satisfied with the claims, arguments and evidence laid down within NNB GenCo's Batch submissions. I am also satisfied that NNB GenCo has an adequate intelligent customer capability in civil engineering relative to the point in time in the design and construction programme, and in terms of licensing.

5.2 Recommendations

219 My recommendation is as follows.

- **Recommendation**: From the Civil Engineering perspective I recommend that ONR should grant a nuclear site licence to NNB GenCo to install and operate two UK EPR™ units at Hinkley Point C.

6 REFERENCES

1 *ONR How2 Business Management System. Permissioning Reports. AST/003 Issue 4. HSE. August 2011..*

2 *Safety Assessment Principles for Nuclear Facilities. 2006 Edition Revision 1. HSE. January 2008. www.hse.gov.uk/nuclear/SAP/SAP2006.pdf.*

3 *Structural Integrity Civil Engineering Aspects. T/AST/017 Issue 2. HSE. March 2005 www.hse.gov.uk/nuclear/operational/tech_asst_guides/index.htm.*

4 NOT USED *Western European Nuclear Regulators' Association. Reactor Harmonization Group. WENRA Reactor Reference Safety Levels. WENRA. January 2008. www.wenra.org.*

5 *IAEA Safety Standards: Geotechnical aspects of Site Evaluation and Foundations for Nuclear Power Plants – Safety Guide No. NS-G-3.6 IAEA 2004 www.iaea.org.*

Safety of Nuclear Power Plants: Design. Safety Requirements. International Atomic Energy Agency (IAEA). Safety Standards Series No. NS-R-1. IAEA. Vienna. 2000. www.iaea.org.

6 *NNB GenCo Ltd's Application for a Nuclear Site Licence to Install and Operate two EPR Reactor Units at Hinkley Point, ONR Intervention Strategy. ONR. February 2012. TRIM Ref. 2012/61973.*

7 *CNRP Intervention Project Record. NNB-HPC1-IPR45 NNB GenCo – Hinkley Point C – licensing: Civil Engineering and External Hazards. ONR. March 2012. TRIM 2012/348595*

8 *Application for Nuclear Site Licence for Hinkley Point. ONR-HPC-20143R. NNB GenCo. July 2011. TRIM Ref. 2011/503357.*

9 *NNB GenCo Nuclear Site Licence Application Dossier. NNB GenCo. July 2011. TRIM Ref. 2011/442090.*

10 *NNB GenCo Ltd's Application for a Nuclear Site Licence to Install and Operate two EPR Reactor Units at Hinkley Point, Specialist Assessment of Key Topics for NSL Granting. ONR. February 2012. TRIM Ref. 2012/62323.*

11 *Pre-construction Safety Report: Submission of Batch 3.1: Justification that the Hinkley Point C site is of a sufficient size. ONR-HPC-20247N. NNB GenCo. May 2012. TRIM Ref. 2012/213435.*

12 *Pre-construction Safety Report: Submission of Batch 5: Hinkley Point C (HPC) Cooling Capability. ONR-HPC-20185N. NNB GenCo. February 2012. TRIM Ref. 2012/61317.*

13 *HPC PCSR2 Site Geology Summary Document – NNB Letter Ref: HPC20274N - Updated Reference for Pre Construction Safety Report 2 (PCSR2) Batch 2.2 Submission; Hinkley Point C (HPC) Site Geology August 2012 TRIM Ref. 2012/330687*

14 *Licensing Nuclear Installations ONR Guide Document Published 2012*

15 *Generic Design Assessment – New Civil Reactor Build*
Step 4 Civil Engineering and External Hazards Assessment of the EDF and AREVA UK EPR™ Reactor ONR-GDA-AR-11-018 November 2011. TRIM Ref. 2011/

16 *HPC Geotechnical and Geological Site Investigations, ONR, 18 November 2009 CR09014 TRIM Ref. 2009/504153*

17 *On Site Inspection - HPC Site Investigations ONR, 17/18 February 2010, CR09024 TRIM Ref. 2010/106097*

18 *ONR Contact Report On site Inspection - HPC -Trials for re-use of excavated material for structural fill, 5/6 May 2010 TRIM Ref. 2013/13314*

19 *BS EN1997-2:2007 Eurocode 7 - Geotechnical design - Part 2: Ground investigation and Testing BSI (British Standards Institute)*

20 *Hinkley Point C Pre-Construction Safety Report – Sub Chapter 2.3 Site Plot Plan Summary HPC-NNBOSL-U0-ALL-RET-000001 NNB GenCo 11 May 2012 TRIM Ref. 2012/213435.*

21 *UK EPR Hinkley Point Project: Identification and Review of the Safety Implications of a Twin Reactor Design for Hinkley Point C CN376-700-00002 Issue 6 Rolls Royce 7 May 2012 TRIM Ref. 2012/213435.*

22 *Pre Construction Safety Report: Submission of Batch 3.1: Justification that the Hinkley Point C Site is of Sufficient Size NNB GenCo Letter ONR-HPC-20247N 18 May 2012 TRIM Ref. 2012/213435*

23 *Response to ONR comments on PCSR2 Early Submissions (Batch Documents) to support Nuclear Site Licence (NSL) granting for Hinkley Point C(HPC) ONR-HPC-20253N NNB GenCo 23 July 2012 TRIM Ref. 2012/296050.*

24 *EDF Plant Layout Guidelines - EDF/SEPTEN E P IE IG/01 10002 A. 24 January 2001 (In French) TRIM Ref. 2012/0342912.*

25 *Hinkley Point C Pre-Construction Safety Report – HPC PSSR2 – Heat Sink Summary Document HPC-NNBOSL-U0-000-RET-000011, NNB GenCo, 31 January 2012. TRIM Ref. 2012/613317.*

26 *Pre Construction Safety Report: Submission of Batch 5: Hinkley Point C (HPC) Cooling Capability Letter ONR-HPC-20185N, NNB GenCo, 2 February 2012. TRIM Ref. 2012/613317*

27 *Hinkley Point C Pre-Construction Safety Report – Sub Chapter 2.1* – Site Data and Bounding Character of GDA Site Envelope' *HPC-NNBOSL-U0-000-RET-000004, NNB GenCo, 12 January 2012. TRIM Ref. 2012/62447*

28 *ONR Comments on PCSR2 Early Batch Submission 5 – Heat Sink Summary Document (HSSD) Silting in water intake structures at Hinkley Point, ONR-NNB-20255N NNB GenCo, 31 May 2012. TRIM Ref. 2012/228653.*

29 *AFCEN ETC-C – 2010 Edition: ETC-C EPRTM Technical Code for Civil Works. AFCEN. 23 December 2010. TRIM Ref. 2011/403452.*

30 *NNB Genco: Hinkley Point C Licence Condition 14 Report for Licensing, ONR Report ONR-CNRP-AR-12-083 Oct 2012 TRIM 2012/412511*

31 *NNB GenCo Organisational Capability Arrangements – Workstreams 12 to 15 ONR Report ONR-CNRP-AR-12-100 Nov 2012 TRIM 2012/389494*

32 *NNB letter reference NNB-OSL-RIO-000250 dated 23rd July 2012 covering document HPC-NNBOSL-U0-000-RES-000080; NNB Generation Company Limited – Resonse to ONR Comments on PCSR2 Early submission batches to support NSL granting TRIM Ref. 2012/296050*

33 *The Construction Design and Management Regulations, currently commonly known as the CDM 2007 Regulations*

34 *EPR Civil Engineering Standard, Document Ref. ECEIG 050051*

35 *Define, Manage and Release of Hold Points NNB Procedure NNB-OSL-PRO-000012*

36 *NNB Presentation - Procurement related to Nuclear Safety TRIM 2011/600487 and TRIM 2012/276088)*

37 *Design, Review and Acceptance, NNB Procedure NNB-OSL-PRO-000035*

38 *Review and Acceptance Scope Specification, NNB-OSL-SPE-000330*

39 *Communicate with Adjacent Facilities, NNB Procedure NNB-OSL-PRO-000050*

40 *Preliminary ONR comments on a Draft Hold Point List, TRIM Ref. 2011/453075*

41 *Hold Point List,, Draft Version 2.2 NNB Document: NNB-OSL-LST-000006*

42 *NNB letter reference NNB-OSL-RIO-000183 dated 10th August 2012 TRIM Ref. 2012/328647*

43 *Manage Site Plans, Designs and Specifications, NNB Procedure NNB-OSL-PRO-000016*

44 *NNB letter reference NNB-OSL-RIO-000264 dated 15th August 2012 TRIM Ref. 2012/328755*

45 NNB Note *3D/4D Models – Construction needs*, Draft version - Rev 0.3 dated 3rd August 2012 *TRIM Ref. 2012/321126*

Table 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No.	SAP Title	Description
ECE.4	**Engineering principles: civil engineering: investigations. Natural site materials**	Investigations should be carried out to determine the suitability of the natural site materials to support the foundation loadings specified for normal operation and fault conditions.
ECE.5	**Engineering principles: civil engineering: investigations. Geotechnical investigation**	The design of foundations should utilise information derived from geotechnical site investigation
ECE.7	**Engineering principles: civil engineering: design. Foundations**	The foundations should be designed to support the structural loadings specified for normal operation and fault conditions.
ECE.9	**Engineering principles: civil engineering: design. Earthworks**	The design of embankments, natural and excavated slopes, river levees and sea defences close to a nuclear facility should be such so as to protect and not to jeopardise the safety of the facility.
ECE.10	**Engineering principles: civil engineering: design. Ground-Water**	The design should be such that the facility remains stable against possible changes in the ground-water conditions.
ECE.16	**Engineering principles: civil engineering: construction. Materials**	Civil construction materials should be compliant with the design methodologies used, and shown to be suitable for the purpose of enabling the design to be constructed, operated, inspected and maintained throughout the life of the facility.

Table 1

Relevant Safety Assessment Principles Considered During the Assessment

SAP No.	SAP Title	Description
ECE.20	**Engineering principles: civil engineering: in-service inspection and testing.**	Provision should be made for inspection during service that is capable of demonstrating that the structure can meet its safety functional requirements.
ECE.24	**Engineering principles: civil engineering: in-service inspection and testing. Settlement**	There should be arrangements to monitor foundation settlement of major facilities during and after construction, and the information should be fed back into design reviews.

…

Annex 1

Schedule of Interventions with NNB post receipt of Licence Application

Title	Date of Intervention	Report Ref	TRIM Ref
L4 Hold Point Review Meeting	14/08/2012	CR 12181	2012/332090
L4 Batch 2.2 Review Meeting	09/08/2012	IR 12162	2012/338236
L4 Batch 2.2 Review Meeting	18/07/2012	IR 12153	2012/323141
L4 Heat Sink Batch 5	17/07/2012	IR 12156	2012/296241
L4 PCSR2 Batch 3.1	29/06/2012	IR 12136	2012/279422
L4 Civil Engineering NNB Design Authority Intervention	27/06/2012	IR 12134	2012/276349
L4 Hold Points and MED for First Safety Related Concrete	18/06/2012	IR 12120	2012/319383
L4 LC19 Compliance for ONR NSL intervention purposes	22/05/2012	IR 12125	2012/289379
L4 Civil Engineering WS4 Mtg No 10	17/05/2012	IR 12096	2012/210299
L4 Civil Engineering WS4 Mtg No 9	28/02/2012	IR 12021	2012/211359
L4 Civil Engineering PCSR2 and Hold Points	31/01/2012	IR 12055	2012/235808
L4 LC16 Discussion for Licensing	26/01/2012	IR 12252	2012/205293
L4 LC19 Discussion for Licensing	24/01/2012	IR 12248	2012/100836
L4 Procurement Procedures	23/01/2012	IR 12242	2012/93920
L4 Heat Sink Design and Operation	21/12/2011	IR 11231	2012/226713
L4 Civil Engineering WS4 Mtg No 8	08/12/2011	IR 11256	2012/234060
L4 WS5 LC2 and LC16	20/10/2011	IR 11200	2011/611440
L4 LC19 Hold Points	04/10/2011	IR 11187	2011/582048
L4 Civil Engineering WS4 Mtg No 7	04/10/2011	NNB-OSL-NOT-000146	2011/582383