NNB GENERATION COMPANY (HPC) LIMITED

HINKLEY POINT C PROJECT

CASE FOR REMOVAL OF THE REQUIREMENT TO INSTALL AN ACOUSTIC FISH DETERRENT

Justification and Evidence Report to support Variation to the Water Discharge Activity Permit

APPROVAL SIGN-OFF: JUSTIFICATION AND EVIDENCE REPORT TO SUPPORT VARIATION TO THE WATER DISCHARGE ACTIVITY PERMIT

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DOCUMENT CONTROL

Version	Purpose	Amendment	By	Date
1,0	Draft Permit Variation Application	For regulatory review.	LG	01/10/18
2.0	Draft Permit Variation Application	Addressing comments on version 1.0 by the Defra family	LG	15/09/2018
3.0	Final submission	Addressing all outstanding comments and outcome of legal review.	LG	12/2/2019

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ACRONYMS

The following acronyms will be used in the report.

Acronym	Definition
AFD	Acoustic Fish Deterrent
AFD Optioneering report	Report by NNB GenCo (2019) entitled Summary of Engineering Optioneering Process followed for Hinkley Point C AFD system. NNB-301-REP-000710.
BAT	Best Available Techniques
CCGT	Combined Cycle Gas Turbines
CIMP	Comprehensive Impingement Monitoring Programme
CWGPT	Cooling Water Guidance Progress Table
CW1 report	Report by NNB GenCo (2017) entitled Hinkley Point C Cooling Water Infrastructure Fish Protection Measures: Report to Discharge DCO Requirement CW1 (Paragraph 1) and Marine Licence Condition 5.2.31 (Document ref: NNB-209-REP-0001030)
CWS	Cooling Water System
DBLS	Design Basis High Level Safety Function
Defra Family	Collective term to describe the Environment Agency, Marine Management Organisation, Natural England, Natural Resources Wales and the Devon and Severn Inshore Fisheries Conservation Agency when these bodies are providing a coordinated response following the review of technical documents.
DCO	Development Consent Order
EA	Environment Agency
EAV	Equivalent Adult Value
EIA	Environmental Impact Assessment
FRR	Fish Recovery and Return
Habitats Regulations	The Conservation of Habitats and Species Regulations 2017
Updated HRA Report	Updated Assessment to inform HRA submitted with the WDA Permit Variation Application and Proposed DCO Change Application (NNB-308-REP-000722)
HAT	Highest Astronomical Tide

Acronym	Definition
HAZID	Hazard Identification
HCB	Filtering Debris Recovery Pit
HDPE	High Density Polyethylene
HPB	Hinkley Point B
HPC	Hinkley Point C
HRA	Habitats Regulations Assessment
ICES	International Council for the Exploration of the Sea
IED	Directive 2010/75/EU of the European Parliament and the Council on industrial emissions
IMCA	International Marine Contractors Association
IPPC	Integrated Pollution Prevention and Control
LAT	Lowest Astronomical Tide
LSE	Likely Significant Effect
LVSE	Low Velocity Side Entry
MHWS	Mean High Water Spring tides
MMO	Marine Management Organisation
MSL	Mean Sea Level
NNB GenCo	NNB Generation Company (HPC) Limited
ODN	Ordnance Datum Newlyn
PINS	Planning Inspectorate
PrISM	Predictive Image Source Model
ROV	Remotely Operated Vehicle
RIMP	Routine Impingement Monitoring Programme
SAC	Special Area of Conservation
SP	Sound Projector
SPA	Special Protection Area
SPL	Sound Pressure Level

Acronym	Definition
SQEP	Suitably Qualified and Experienced Person
SSB	spawning stock biomass
TR456	Report by CEFAS entitled Revised Predictions of Impingement Effects at Hinkley Point C – 2019 HPC-DEV024-XXX-000-RET-100031 BEEMS Technical Report TR456
WDA	Water Discharge Activity
WDA Permit	The permit granted by the Environment Agency on 13 March 2013 EPR/HP/3228XT for which an application to vary has been made
WDA Permit Variation Application	The application submitted to the Environment Agency on 15 February 2019 to vary the WDA Permit to remove reference to an AFD system at HPC
WFD	Water Framework Directive
WFD Regulations	Water Environment (WFD) (England and Wales) Regulations 2017
WFD report	Report by NNB GenCo (2018) entitled Water Framework Directive Compliance Assessment (Document ref: NNB-308-REP-000725)

1 INTRODUCTION

1.1 Purpose of this report

1.1.1 This report underpins the application to vary several conditions relating to fish protection measures, specified in Environmental Permit EPR/HP3228XT. This permit was determined on 13th March 2013 and regulates the standalone Water Discharge Activity (WDA) associated with the operational phase of the Hinkley Point C (HPC) new build nuclear power station and is referred to hereafter in this report as the 'WDA Permit'. The WDA Permit was granted on the basis of the conceptual design information for the Cooling Water System (CWS) provided in the following submissions that supported the application for the Permit:

- the technical report providing design information relating to the stand-alone WDA, to comply with legal and regulatory requirements and to address the information requirements agreed with the key stakeholders; this information was submitted to the Environment Agency (EA) in September 2011; and
- further information relating to the proposed fish protection measures provided in response to question no 46 in the Schedule 5 Request, dated 13 December 2011.

1.1.2 Following the grant of the WDA Permit, NNB Generation Company (NNB GenCo) has continued to progress the design of the CWS. In relation to the fish protection measures, NNB GenCo has undertaken extensive, ecological, environmental, engineering design studies and risk analyses of health and safety aspects to:

- support the optioneering and detailed design of the fish protection measures;
- better understand the populations and behaviours of fish and other marine organisms in the Bristol Channel relevant to the fish protection system;
- refine information relating the likely effects of impingement and entrainment of fish and other marine organisms associated with the Fish Recovery and Return (FRR) system;
- confirm the baseline environmental conditions within the location of the intake heads in the Bristol Channel;
- define the constraints associated with the construction, operability and maintenance of the proposed fish protection system;
- characterise the effects of the removal from service of the Hinkley Point B (HPB) power station on the baseline environmental conditions; and
- confirm the availability of the technologies and infrastructure required to provide effective protection for fish and other marine organisms.

1.1.3 This report confirms the proposed fish protection measures to be installed at HPC and provides additional information to inform understanding of the development of the design specifications and design for these arrangements.

1.1.4 In relation to the Acoustic Fish Deterrent (AFD) system, this report provides background and context to the application to remove the requirements to install this infrastructure. It also provides a summary of the assessments and studies outlined above, that have informed this decision. Reports that consolidate these studies and assessments are specified in Section 1.3.

1.2 Scope of this report

1.2.1 The scope of this application to vary the conditions of the WDA Permit is limited to the removal and modification of certain pre-operational conditions relating to the AFD system. The AFD system is a component of the fish protection measures proposed in the original application.

1.2.2 On this basis, the scope of the report is limited to consideration of the following components of the CWS:

- AFD system;
- cooling water intake design; and
- FRR system.

1.2.3 The design of the intake tunnels, the forebay and the seawater pumping arrangements are not detailed in this application. These are not considered to constitute fish protection measures for the purpose of this application, though it is acknowledged that in accordance with the requirements of pre-operational measure PO8 of the WDA Permit, the design of these arrangements will be optimised to:

- minimise harm to fish and other marine organisms as a result of depressurisation effects, abrasion and mechanical damage; and
- optimise opportunities for fish and other marine organisms to be recovered and returned to the marine environment.

1.2.4 The report also considers the effects of seawater abstraction on fish and other marine organisms together with indirect effects on species or activities dependent on fish (such as effects on marine mammals and birds which take fish as prey and effects on commercial fisheries (in terms of fish stocks available for such fisheries)).

1.2.5 The Decision Document (Environment Agency, 2013a) that supports the WDA Permit confirms that the EA considers that fish protection measures associated with sea water abstraction are regulated by the WDA Permit on the basis that the abstraction of seawater is closely linked to the WDA, as it forms part of the overall process stream. The rationale for this position is that there is a direct relationship between the abstraction of seawater (which will be combined with storm water run-off, sewage and other process effluents) and its release to the Bristol Channel.

1.2.6 At the time the WDA Permit was determined, NNB GenCo did not object to the inclusion of conditions in the WDA Permit relating to the AFD system. Consistent with the position outlined in the Regulatory Position on Best Available Techniques for Cooling Water Systems at New Nuclear Power Stations (Environment Agency, 2018), NNB GenCo accepts that these arrangements may be more appropriately regulated by the DCO, to rationalise the conditions specified in regulatory permissions relating to the abstraction arrangements.

1.2.7 Given the limited effects associated with the proposed modification to the fish protection measures and as the flow from the FRR system is not a waste stream regulated by the WDA Permit, this report does not review the compliance status of the entire CWS or consider matters associated with discharges to the marine environment. The effects of the WDA, the primary activity authorised by the WDA Permit, were fully assessed by the EA when determining the WDA Permit application. No changes are proposed to the CWS downstream of the FRR system or to the water discharge activities regulated by the WDA Permit; therefore, these arrangements are not considered further in this report.

1.3 Supporting documentation

1.3.1 This report was prepared using a number of documents to support general understanding of the HPC Project. Project-specific documents relevant to this report have been included as part of the WDA Permit application package and are referenced throughout this report as follows:

- NNB GenCo (2018) Summary of Engineering Optioneering Process Followed for the Hinkley Point C Acoustic Fish Deterrent (AFD) System, NNB-308-REP-000710 (the 'AFD Optioneering report');
- NNB GenCo (2017) Hinkley Point C Cooling Water Infrastructure Fish Protection Measures: Report to Discharge DCO Requirement CW1 (Paragraph 1) and Marine Licence Condition 5.2.31, NNB-209-REP-0001030 (the 'CW1 report');
- Cefas (2019a) *Revised Predictions of Impingement Effects at Hinkley Point C – 2018*, HPC-DEV024-XXX-000-RET-100031 BEEMS Technical Report TR456 (the 'TR456 Report');
- Bureau Veritas (2018) Acoustic Fish Deterrent Health and Safety Review, OH2231-HPC-NNBGEN-XX-000-REP-100000 (the 'AFD Safety Report');
- NNB GenCo (2018) *Water Framework Directive Compliance Assessment*, NNB-308-REP-000725 (the 'WFD report');
- NNB GenCo (2018) *Report to Inform the Habitats Regulations Assessment*, NNB-308-REP-000722 (the 'updated HRA report').

1.3.2 The following regulatory guidance is also relevant to this report.

- Environment Agency (2010) *Cooling Water Options for the New Generation of Nuclear Power Stations in the UK*, Science Report SC070015/SR3. (Report by Turnpenny, A.W.H., Coughlan, J., Ng, B., Crews, P., Bamber, R.N., Rowles, P. for the Environment Agency, Bristol, UK.). This states that direct cooling can be BAT for estuarine and coastal sites, provided that (a) best practice in planning, design, mitigation and compensation is followed and (b) any residual impacts are not deemed to be unacceptable in respect of determining best practice.
- Environment Agency (2005) *Screening for Intakes and Outfalls: A Best Practice Guide*, Science Report SC030231. (Report by Turnpenny A.W.H. & O'Keeffe, N. for the Environment Agency, Bristol, UK).

- Environment Agency (2010) *Screening at Intakes and Outfalls: Measures to Protect Eels (The Eels Manual)*. Reference GEHO0411BTQD-E-E.
- European Commission (2001) Integrated Pollution Prevention and Control (IPPC). Reference Document on the Application of Best Available Techniques to Industrial Cooling Systems. (BAT Reference Note for Industrial Cooling.)

1.3.3 Consideration has also been given to the information provided in the Regulatory Position on Best Available Techniques (2018) provided in correspondence from the Environment Agency to NNB GenCo.

2 DESIGN CRITERIA FOR FISH PROTECTION MEASURES

2.1 Design approach

2.1.1 The initial basis of design for the CWS took into account a range of environmental criteria which were derived from the best practice requirements published by the EA (Turnpenny & O'Keeffe, 2005; Turnpenny et al, 2010, and Environment Agency, 2010 (the Eels Manual)), also making reference to the Best Available Techniques (BAT) Reference Note for Industrial Cooling published by the Integrated Pollution Prevention and Control (IPPC) Bureau of the European Commission (European Commission, 2001).

2.1.2 In relation to environmental considerations for fish protection that supported the development of the design concepts outlined in the WDA Permit, these included though were not limited to:

- legal and regulatory requirements, including consideration of the regulatory criteria for fish protection; and
- environmental setting and sensitivity.

2.1.3 It is important to note that, whilst a high priority was afforded to the environmental aspects, other considerations also had to be taken into account. These included issues such as nuclear safety, the constructability, operability and maintainability of the systems, complexity, and the health and safety of workers required to undertake construction and maintenance activities. This section considers the legal and regulatory requirements relevant to the design of these systems.

2.1.4 These aspects are considered in relation to the specific attributes of the AFD system, the seawater intake heads and the FRR system in Section 5.

2.2 Regulatory position

2.2.1 The requirements for the design of measures for protection of fish, crustaceans and other marine organisms and the technical standards for these are not expressly specified in legislation or regulations. However, criteria for environmental performance of these arrangements are specified in legal and regulatory requirements and obligations conferred by Conventions and strategic policy requirements. The concept design proposals developed at the time of submission of the regulatory approvals for HPC, were described in the applications for the WDA Permit, the Development Consent Order (the DCO) and the Marine Management Organisation (MMO) Licence (the Marine Licence).

2.2.2 On the basis of the conceptual design information submitted to support the applications for the WDA Permit, the DCO and the Marine Licence, the EA, the Secretary of State and the MMO respectively confirmed that subject to confirmation of the final design of the fish protection measures and development of management arrangements for these, the proposed arrangements complied with these legal, regulatory, convention and strategic policy requirements. On this basis, the requirement to install fish protection arrangements at HPC is regulated by the following approvals:

- the permit for a stand-alone WDA (EPR/HP3228XT), to which this application for a variation relates;
- the HPC (Nuclear Generating Station) Order 2013. (S.I. 2013 No. 648, made on 18th March 2013 (as amended)) (the DCO). The DCO authorises the development of the power station. Schedule 2 of the DCO specifies requirements relating to the AFD system; and
- the MMO Marine Licence L/2013/00178/4. This was granted on 7th June 2013. The licensed activities are specified in Section 4 of the licence. The conditions of the licence are specified in Section 5.

2.2.3 The three approvals contain similar conditions relating to the fish protection measures. The conditions included in the WDA Permit to which this application relates are summarised below at **Table 2.1**. The relevant requirements specified in the DCO and the conditions in the marine licence are included in the main application report. In parallel with this application, applications for an amendment to the DCO and to vary the conditions in the Marine Licence will be submitted to the Planning Inspectorate (PINS) and the MMO respectively.

Table 2.1 WDA Permit conditions relevant to this application

Condition No.	Condition / Requirement
Schedule 1, Table S1.2 - Operating Techniques	Requires the operation of the AFD system to be undertaken in accordance with the arrangements provided in response to Question 46 of the Schedule 5 request for further information received by the EA on 23rd March 2012
Schedule 1, Table S1.2 - Operating Techniques: Commissioning Plan for the AFD system and the fish recovery and return system	That this requirement will be discharged when the EA has confirmed that the requirements of Pre-operational measure PO8 (in Table S1.4) has been addressed.
Schedule 1, Table S1.4 – Pre-operational Measure PO2	Prior to the commencement of the Hot Functional Testing phase of commissioning the operator shall submit to the Environment Agency a report which includes a completed, as-built description of the plant and infrastructure relevant to the Water Discharge Activity. Note that the report shall take into account the cooling water system in its entirety, including the design of the AFD system and the fish recovery and return system.
Schedule 1, Table S1.4 – Pre-operational Measure PO8	Prior to the commencement of the Hot Functional Testing phase of commissioning the operator shall submit to the Environment Agency for approval a Commissioning Plan for the AFD system and the FRR system. The Plan shall include, but not be restricted to the following: A description of how the operator intends to optimise the AFD system and the FRR system to minimise impacts upon fish; Details of the monitoring proposed to facilitate optimisation and meet the above objective; Confirmation of the timetable associated with the AFD system and FRR system commissioning; Proposals for demonstrating the effectiveness of the optimisation process to the Environment Agency prior to the start of Active Commissioning of Unit 1.

2.2.4 Table S3.1a of the WDA Permit specifies the following maximum permitted discharge rates for waste stream A, associated with the release of seawater:

- 127m^3/s (tidal mean) and
- 134.6m^3/s (98 percentile).

These values were incorporated into the basis of design for the seawater cooling system and derived during the early stages of the project, pending confirmation of the flow rates for the associated systems. These systems include those associated with the Ancillary Cooling Water System, the Essential Cooling Water System, the Ultimate Cooling Water System and the Fish Recovery and Return System.

2.2.5 To ensure the technical assessments undertaken to characterise the performance of the proposed fish protection measures do not underestimate the effects on fish and other biota in the absence of the confirmed abstraction rate, a precautionary scenario of 132m3/s at mean sea level has been assumed and incorporated into the studies that underpin the Compliance Assessments undertaken in relation to the Conservation of Habitats and Species Regulations 2017 (the Habitats Regulations) and the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (the Water Framework Regulations).

2.2.6 Currently work is progressing to confirm the flow rates of these and other systems. This will enable NNB GenCo to confirm the seawater abstraction rates and to assess the resultant effects of increased dilution on the thermal and physical characteristics of the effluent streams regulated by the WDA Environmental Permit. Following confirmation these values and the preparation of a revised water balance, these values will be confirmed in the submission required to comply with Pre-operational condition P03 of the WDA Permit. This condition requires the following information to be submitted 3 months prior to the hot functional testing phase:

- A description and justification for any expected variances from the substance loadings and emissions proposed in the Permit Application and
- Any additional mitigation measures required to ensure compliance with the WDA Permit.

2.2.7 Given the conservative values assumed for these assessments, NNB GenCo considers that confirmation of these matters at this stage should not prevent or delay determination of this application.

2.2.8 To enable the EA to vary these conditions, this application is required to demonstrate that the proposed arrangements comply with a range of legal, regulatory and strategic policy commitments reviewed below, taking into account revisions to the specific regulations, with consideration also of any changes in the environmental baseline that may have occurred or are likely take place, since the original applications were submitted.

2.2.9 A summary of the legal, regulatory, convention and strategic policy requirements and criteria for environmental performance to be achieved that are relevant to fish protection measures for new build nuclear power stations is provided at **Table 2.2** below. **Table 2.2** also specifies the criteria for environmental performance associated with these requirements and provides a summary of the approach taken to demonstrate compliance.

Full details of relevant text of the primary legislation are given in **Appendix B** of the WDA Permit variation application report.

Table 2.2 Legal, regulatory and strategic policy requirements applicable to seawater abstraction and fish protection measures

No	Reference	Requirement / Criteria for environmental performance	Applicability	Approach to Demonstrating Compliance
Legal requirements				
1	Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora (the 'Habitats Directive') The Conservation of Habitats and Species Regulations 2017 (2017 No. 1012)	The requirements of the Habitats Directive are transposed in England and Wales through the *Conservation of Habitats and Species Regulations 2017*. Regulation 63 requires that (1) A competent authority, before deciding to undertake, or give any consent, permission or other authorisation for, a plan or project which— (a) is likely to have a significant effect on a European site or a European offshore marine site (either alone or in combination with other plans or projects), and (b) is not directly connected with or necessary to the management of that site, must make an appropriate assessment of the implications of the plan or project for that site in view of that site's conservation objectives. In the light of the conclusions of the assessment, he competent authority may agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the European site, unless the plan or project can be justified on the grounds of lack of alternative solutions and imperative reasons of overriding public interest. UK policy is to submit Ramsar sites to the same level of assessment. This process (known as a Habitats Regulations Assessment [HRA]) is generally considered in two parts: (i) a screening stage to identify any likely significant effect (LSE); and (ii) where a LSE is identified, an appropriate assessment of the likely effect. The WDA Permit for HPC is a relevant permission which requires the Environment Agency will need to undertake HRA. For the purposes of the application for a variation to the WDA Permit, only effects on fish and species dependent on fish have been taken into account in the information supplied by NNB GenCo to support the HRA. Details of the assessment on European and Ramsar Sites are provided in the HRA report.	Applicable	An assessment of the effectiveness of the proposed fish protection measures has been undertaken to determine whether (separately or in combination with other projects, plans and permissions) these changes may give rise to significant effects that may compromise the integrity of the conservation interest of European sites. Compliance with these criteria is demonstrated in Section 4.6 of this report.

No	Reference	Requirement / Criteria for environmental performance	Applicability	Approach to Demonstrating Compliance
2	Convention on Wetlands of International Importance especially as Waterfowl Habitat, Ramsar, 1971	UK policy is that protection of wetlands listed under the Ramsar Convention should be afforded the same level of protection as sites protected by the Habitats Regulations. See under Habitats Directive above	Applicable	See under Habitats Directive above Compliance with these criteria is demonstrated in Section 4.6 of this report.
3	Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy (The Water Framework Directive – [WFD]) The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015	The WFD requires that there is no deterioration in status of water bodies and that measures are put in place to ensure that water bodies meet good surface water status or, in the case of artificial or heavily modified water bodies, good ecological potential and good surface water chemical status. Projects (modifications) that cause deterioration or failure to meet the status objectives may only be permitted where they are of overriding public interest and/or the benefits to the environment and to society of achieving the objectives are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development, The proposed WDA Permit variation will not lead to any changes in predicted effects of the WDA on chemical or morphological water body status, therefore only biological effects arising from changes in fish populations need to be considered. Fish populations are not used in assessment of coastal water bodies. Therefore, assessment of WFD compliance for the WDA Permit variation application is only relevant to transitional water bodies and any upstream river water bodies where migratory fish populations may be affected by the proposed changes in the water abstraction arrangements. For transitional waters, effects on the Ecological Quality Ratio (EQR) calculated using the Transitional Fish Classification Index need to be assessed. For any river water bodies affected, effects on the EQR calculated using the Fisheries Classification Scheme 2 need to be assessed. Compliance criteria for the EQS values are given in *The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015*. Guidance is provided by PINS in their Advice Note 18: *The Water Framework Directive*, PINS, v1, 2017.	Applicable in relation to the Parrett Estuary water body and upstream water bodies only	An assessment of ecological status/potential has been undertaken to determine the effect of the Permit variation on compliance with the fish metric for the Parrett Estuary transitional water body, also screening for effects on upstream river water bodies where there was potential for effects on compliance with WFD fish metrics. Compliance is demonstrated in Section 4.5 of this report.

No	Reference	Requirement / Criteria for environmental performance	Applicability	Approach to Demonstrating Compliance
4	Council Regulation No 1100/2007 of 18 September 2007 Establishing Measures for the Recovery of the Stock of European Eel Eels (England and Wales) Regulations 2009 (The Eels Regulations)	The abstraction of sea water may result in impingement of eels on the band and drum screens. As these screens are not at the intake point, the Eels Regulations require provision of a by-wash allowing eels to return by as direct route as practicable to the waters from which they entered the diversion structure. Screens and by-wash system must be constructed and located, so far as reasonably practicable, so that eels are not injured or damaged. It must be demonstrated that the screening system and by-wash (in this case the FRR system) comply with the Eels Regulations. Recommendations for best practice for the design of screens and fish return are given in *Screening at intakes and outfalls: measures to protect eels (The Eels Manual)*, Environment Agency, 2010	Applicable	An assessment of the screening and FRR systems has been undertaken to demonstrate that the proposed arrangements will comply with the requirements of the Eels Regulations.
5	Environmental Permitting Regulations 2016	The application for a variation to the WDA Permit relates to an environmental permit for a stand-alone WDA. The WDA Permit was determined in accordance with the requirements of Regulation 12(i)(b) of the Environmental Permitting Regulations 2016. This provides that a person must not, except under and to the extent authorised by an environmental permit, cause or knowingly permit a WDA or groundwater activity. The legal requirement is to comply with all conditions of the WDA Permit. As determined, the WDA Permit includes conditions relating to water abstraction and the potential effects on fish and the Permit variation applied for relates solely to these conditions.	This application relates to activities associated with fish protection measures. As the flow from the FRR system is not regulated as a waste stream for the purposes of the WDA Permit, this aspect is not considered further.	The principal purpose of the WDA Permit is to regulate activities and arrangements associated with the generation and release of aqueous discharges from the cooling water system and other operational activities, to the Bristol Channel. As the flow from the FRR system is not a waste stream regulated by the WDA Permit, arrangements upstream that are related to fish protection are not considered further. Criteria for compliance with conditions relating to water abstraction and fish protection are detailed at rows 1, 2, 3, 4, 6, 7 and 8 of this table.

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No	Reference	Requirement / Criteria for environmental performance	Applicability	Approach to Demonstrating Compliance
Strategic Policies				
6	Overarching National Policy Statement for Energy (EN-1)	In relation to biodiversity and geological conservation, para. 5.3.18 requires that during construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised. Best practice is not defined in EN-1. Policy Statement EN-1 also makes it clear that the requirements of the WFD for the protection of the water environment must be met by all nationally significant infrastructure projects (see WFD row above).	Applicable in relation to all measures to protect species, therefore applicable to protection of fish.	Compliance of the proposed revised fish protection arrangements with best practice is demonstrated in this report. Guidance on best practice has been sourced from guidance referenced in EN-6 (see below) and research on use of fish protection measures at other sites.

No	Reference	Requirement / Criteria for environmental performance	Applicability	Approach to Demonstrating Compliance
9	The National Policy Statement for Nuclear Power Generation (EN-6), Vol 2	For the Bradwell site assessment, EN-6 states that "direct cooling can still be BAT for estuarine and coastal sites, provided that best practice in planning, design, mitigation and compensation are followed". Definitions for BAT and best practice are not specified in EN-6. For the purpose of this assessment, BAT and best practice have been defined with regard to the published references specified in: EN-6; the Appropriate Assessment to support determination of the Environmental Permit application for water discharge activities, combustion activities and radioactive substances (Environment Agency, 2013b); and the Decision Document that supports the Environmental Permit for the WDA (Environment Agency, 2013a). The reference sources specified in EN-6 include: *Cooling Water Options for the New Generation of Nuclear Power Stations in the UK*, (Environment Agency, 2010); *Screening for Intakes and Outfalls: A Best Practice Guide*, (Environment Agency, 2005).	Applicable	The statement made in EN-6 under the Bradwell site assessment has been assumed to be equally applicable to other coastal nuclear new build sites. The requirements of the EA references have been taken into account in the design of the following fish protection measures: - location and siting of intake heads - design of intake heads. - design of the FRR system. Compliance of the proposed revised fish protection arrangements with best practice is demonstrated in this report. These arrangements would also represent BAT, if this criterion were applicable.

2.2.10 In summary, the following approach has been taken to evaluating compliance with the environmental standards.

- The WFD Compliance Assessment and updated HRA undertaken to consider the effects of the proposed intake locations, intake head design and FRR system demonstrated that these arrangements provide the necessary protections for fish and marine organisms, to comply with these legal requirements, together with the Eels Regulations and the Ramsar Convention.
- The revised predictions of impingement effects at HPC confirm that the current detailed design of the intake heads, and the FRR system will result in the abstraction having insignificant effects on socio-economically important species, conservation species and ecologically important species.
- It is considered that the definition of BAT specified at Article 1 of the Industrial Emissions Directive is not relevant to this submission. The CWS discharge is regulated as a stand-alone WDA for the purposes of the Environmental Permitting Regulations 2016. The CWS is not an 'installation' or an activity that is directly associated with an installation for the purposes of these Regulations. It should be noted however, that the BAT Reference Note for Industrial Cooling Water Systems published by the European Commission to support interpretation and application of BAT for activities regulated by the IED contains useful factual information on cooling systems and has been used to inform the design of the CWS and in determining BAT and best practice.
- It is considered that the definition of BAT specified in Annex I in the OSPAR Convention is not relevant to this application. Article 3 requires signatories, to take "all possible steps to prevent and eliminate pollution from land-based sources" and introduces Annex I. Annex I of the Convention deals with the Prevention and Elimination of Pollution from Land-based Sources. It states that when adopting programmes and measures for the purpose of the Annex, contracting parties shall require either individually or collectively, the use of BAT for point sources and best environmental practice for point and diffuse sources. "Land based sources" are defined in Article 1(e), which refers to sources from which substances or energy reach the marine environment and includes the use of the terms "point sources" and "diffuse sources". Appendix 1 to the Convention contains the criteria for the definition of BAT and best environmental practice. This makes clear that the term BAT refers specifically to the suitability of a particular measure "for limiting discharges, emissions and wastes".
- The regulatory guidance listed in Section 1.3 has been used to determine detailed design specifications for fish protection measures and has guided the nature and scope of the extensive supporting studies to assess compliance with the criteria for environmental performance.

2.2.11 On the basis that the proposed system complies with best practice and, insofar as it is appropriate, the BAT requirements outlined in the BAT Reference Note for Industrial Cooling Water Systems, NNB GenCo considers this submission demonstrates compliance with all legal and regulatory requirements, together with the obligations outlined in the Overarching National Policy Statement for Energy (EN-1) and the National Policy Statement for Nuclear Power Generation (EN-6).

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3 ENVIRONMENTAL SETTING AND SENSITIVITY

3.1.1 The HPC power station will be situated at Bridgwater Bay in the Bristol Channel, 25 km east of Minehead and 12 km to the north-west of Bridgwater. The intake heads will be located approximately 3.3 km offshore and the intake heads for each tunnel approximately 480 m apart.

3.1.2 There are a number of international and national environmental designated sites close to Hinkley Point, some of which are relevant to this application to vary the WDA Permit. These sites either have fish as an interest feature or are designated for species that are reliant on fish as prey, specifically piscivorous birds and marine mammals. The relevant designated sites are as follows:

- Severn Estuary Special Area of Conservation (SAC)
- Severn Estuary Ramsar site
- River Wye/Afon Gwy SAC
- River Usk/Afon Wysg SAC
- Afon Tywi SAC
- Severn Estuary Special Protection Area (SPA)
- Grassholm SPA
- Skomer, Skokholm and Seas off Pembrokeshire SPA
- Aberdaron Coast and Bardsey Island SPA
- Saltee Islands SPA
- Lambay Island SPA
- Copeland Islands SPA
- Cliffs of Moher SPA
- Beara Peninsula SPA
- Kerry Head SPA
- Deenish Island and Scariff Island SPA
- Puffin Island SPA
- Iveragh Peninsula SPA
- Skelligs SPA
- Dingle Peninsula SPA
- West Donegal Coast SPA
- High Island, Inishshark and Davillaun SPA
- Tory Island SPA
- Duvillaun Islands SPA
- Clare Island SPA

- Blasket Islands SPA
- Horn Head to Fanad Head SPA
- Bristol Channel Approaches / Dynesfeydd Môr Hafren SCI
- Lundy SAC
- West Wales Marine / Gorllewin Cymru Forol SCI
- Cardigan Bay SAC
- North Anglesey Marine / Gogledd Môn Forol SCI
- Isles of Scilly Complex SAC
- Pen Llyn a’r Sarnau / Lleyn Peninsula and the Sarnau SAC
- North Channel SCI
- Rockabill to Dalkey Island SAC
- Roaring Bay and Islands SAC
- Blasket Islands SAC
- Carmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd SAC; and
- Pembrokeshire Marine/Sir Benfro Forol SAC.

3.1.3 Under the WFD Bridgwater Bay is classified as a coastal water body (GB 670807410000), with the objective to reach good overall status by 2027. The Parrett water body (GB540805210900) is classified as a heavily modified transitional water body (for reasons of coastal protection), with the objective to reach good ecological potential by 2027.

4 ENVIRONMENTAL ASSESSMENTS

4.1 Effects of sea water abstraction on fish and other species

4.1.1 The effects of seawater abstraction are the potential entrapment and impingement of organisms, mainly fish and invertebrates, on the intake screens. Marine organisms such as planktonic stages of fish and macroinvertebrates and fish small enough to pass the screens can also pass through the CWS and be subject to the effects of increased temperature and biocide dosing. The following definitions of entrainment, entrapment and impingement are commonly used (Turnpenny *et al*, 2010):

- Entrapment – inadvertent entry of aquatic organisms into the CWS caused by the ingress of water. The term implies that the organism is unable to resist capture, owing to poor or no swimming ability or failure to detect the water intake;
- Impingement – the retention of entrapped organisms on the cooling water intake screens employed to prevent debris from entering the cooling water heat exchangers. In order to be impinged, organisms must be large enough to be retained by the screen meshes. This usually includes juvenile and adult fish, macroinvertebrates, such as shrimps, crabs and large molluscs, and marine algae; and
- Entrainment – passage of entrapped organisms that penetrate the cooling water screens, typically zooplankton (including ichtyoplankton) and phytoplankton, via the pumps, heat exchangers and other components of the cooling water circuit and back to the receiving water.

4.1.2 Sea water abstraction can have a detrimental effect on fish populations, particularly in the event that:

- the CWS is not designed to minimise the effects of entrapment and entrainment of biota; and
- the CWS does not accommodate arrangements for the effective recovery of fish and marine organisms and their effective return to the water body from which they were displaced.

4.1.3 Depending on the location of the intake, the abstraction of large volumes of seawater can negatively impact the fish stock population of the area. This, in turn, can negatively affect those species that depend on fish for prey, such as certain seabirds and marine mammals. Commercial fisheries can also be adversely affected if fish stock populations start to decrease. Abstraction of diadromous fish can also interrupt the migration pattern which is crucial to their life history.

4.2 Assessment of significant effects on fish

4.2.1 Cefas was commissioned by NNB GenCo to re-assess the impacts of the HPC cooling water intake on the fish community of the Bristol Channel (TR456 Report, Cefas 2019a). Given that six years have passed since the HPC DCO examination and the advancement of science and knowledge about the Bristol Channel fish community that have occurred in this time, the TR456 report provides more context and more in-depth coverage of HPC impingement than the original assessment (which was also carried out by Cefas (Cefas, 2010)). In particular, the report:

i) explains the impingement process more fully and provides more information on the Bristol Channel fish community;
ii) reproduces the predicted effects of HPC impingement that were provided for the DCO examination;
iii) details all stages of the revised assessment process including:
    a. the selection of species included in the assessment;
    b. the scientific justification for continued use of the 1% negligible effect threshold adopted for the DCO assessment;
    c. the selection of the Equivalent Adult Values (EAVs) used to convert the number of juvenile fish impinged at Hinkley Point into equivalent adults;
    d. the selection of impingement effects indicators;
    e. a comprehensive assessment of the uncertainty of the impingement predictions by Monte Carlo analysis;
    f. an extensive analysis of the effect of interannual variability in fish numbers on the reliability of the impingement assessments;
    g. an assessment of the impact of climate change upon the predicted impingement effects.
iv) provides updated impingement predictions that include an assessment of the impact of the HPC intake head design upon impingement numbers; and
v) provides impingement effect predictions for species that could not be assessed in TR148 (Cefas, 2010) (salmon and sea trout) or for which the assessment was unrealistically precautionary (marine lamprey).

4.2.2 In considering the effects of not fitting an AFD system, the TR456 report draws together and presents all of the changes that are relevant to the impingement predictions in order to enable both a like-for-like comparison with the original assessment and a full re-assessment based on all of the new information obtained since the original application was submitted.

4.2.3 To investigate the effects of the CWS at HPC, Cefas carried out a revised impingement assessment for the following scenarios:

i) HPC with no impingement mitigation; and
ii) HPC fitted with the planned LVSE intake heads and FRR system.

4.2.4 This revised impingement assessment uses the latest impingement data available and a more robust assessment method than that carried out previously during the EIA. **Table 4.1** provides a description of the changes that have taken place in the HPC fish entrainment/impingement assessment since the DCO submission. As in the original assessment, a significance threshold of 1% was used.

Table 4.1 Changes to HPC impingement assessment since the DCO submission

Description of change	Impact on assessment compared with the DCO assessment
Revised impingement indicators based upon the latest scientific advice (Adult population sizes, international catch and HPB RIMP impingement time series extended to 2017)	Uses the most up to date scientific evidence. For some species the adult population sizes have increased, whilst others have decreased.
Use of site specific Equivalent Adult Value (EAVs) derived from measurements made at Hinkley Point during the CIMP survey programme in 2009/10.	Uses the most biologically relevant data rather than non-site specific data from different years of uncertain accuracy. Causes the predicted impingement impact to increase for some species, and to decrease for others.
Incorporates the detailed design for the HPC cooling water system. HPC CW flow rate is now confirmed to be 131.86 cumecs (at Mean Sea Level) with a worst case of 9% water flow through the band screens. Band screens to be fitted with an FRR system and HPC forebay to be fitted with trash racks of 50mm vertical bar spacing fitted with fish friendly buckets for fish recovery.	More accurate impingement assessment. Results in increases in predicted impingement impact.
Added assessments for six additional species not included at the time of DCO (bass, thornback ray, flounder, thin lipped grey mullet, five bearded rockling and sand goby).	Provides confidence that the assessment is fully representative of the effects of HPC impingement on the fish assemblage
Quantitative analysis of the expected impact of the HPC LVSE intake heads on impingement. This was not addressed in the original HRA.	By not taking account of the design of the HPC intake heads the previous impingement estimates were unrealistically conservative. The revised estimates are considered more reliable but still conservative as they do not take into account the full impact of the HPC intake design and location.
Revised impingement numbers from the CIMP programme and use of a statistically more robust bootstrapping procedure to calculate the mean and confidence limits on the impingement estimates. A comprehensive uncertainty analysis using Monte Carlo simulation process has been undertaken. A significantly expanded analysis on the effects of interannual variability in impingement numbers has been included. A more robust statistical analysis of trends has been undertaken on the RIMP data. The CIMP data have been subject to enhanced quality assurance which has resulted in increased numbers for 16 fish species in the raw CIMP impingement dataset.	Provides substantially more confidence in the reliability of the impingement predictions.
Revised mean weights used to convert the number of equivalent adult fish into impingement weight.	More reliable impingement predictions. Results in increases in predicted impingement impacts for some species
Provision of assessments for species that were not detected during the CIMP survey (Salmon and sea trout) using the RIMP dataset.	Substantially increased confidence in the DCO assessment that the impingement effect on these designated species is negligible.

4.3 Revised HPC impingement assessment with no mitigation measures

4.3.1 Full methods are given in the TR456 report (Cefas, 2019a) which uses three impingement effects indicators, as listed below, to compare the predictions against an objective measure of the status of each population.

- comparison with the adult spawning-stock biomass SSB in the assessment year as published by the International Council for Exploration of the Sea (ICES);
- comparison with the international landings (or catch when discards are significant) of a fish stock in the assessment year (ICES); and
- analysis of the 37-year impingement trend data to draw conclusions about the local population and the impact of the station (from the HPB RIMP programme).

4.3.2 The stock units that have been used in the Cefas 2019 TR456 assessment are the ICES 2017 definitions which are the outcome of the best available international science. ICES provide unbiased scientific advice to the governments of 20 member nations and to international regulatory commissions in support of the management and conservation of coastal and ocean resources and ecosystems. Advice on the management of 135 separate finfish and shellfish stocks is provided to the North-East Atlantic Fisheries Commission, North Atlantic Salmon Conservation Organization and the European Commission.

4.3.3 For most species the predicted unmitigated HPC impingement as a percentage of SSB or the fishery landings/catch is less than the 1% negligible effects threshold, however a number of species did exceed this value.

4.4 Revised HPC impingement assessment with FRR system and LVSE intake head as mitigation

4.4.1 The revised assessment carried out by Cefas concluded that HPC with LVSE intakes and an FRR system fitted and operational would have negligible effect on the species assessed, which are considered representative of the fish assemblage of the Severn Estuary, and no significant adverse effect on any of the fish species that are interest features of designated European sites or listed Ramsar sites. **Table 4.2** contains a summary of the predicted HPC impingement with a LVSE intakes and FRR system installed as mitigation but no AFD system installed. For all species in **Table 4.2** the predicted mitigated HPC impingement as a percentage of SSB or the fishery landings/catch is less than the 1% negligible effects threshold. These values also take account of the interannual and uncertainty analysis reported in TR456 (Cefas, 2019a).

4.4.2 It is concluded in the TR456 report (Cefas, 2019a) that HPC with LVSE intakes and FRR systems fitted would have negligible impingement effect on the species assessed which are considered representative of the fish assemblage, the local WFD transitional water body and include all the HRA designated conservation species.

4.4.3 Without an AFD system HPC is expected to impinge more fish than expected in the HPC DCO application. Sprat are the dominant fish species at Hinkley Point and comprised approximately 50% of all of the fish impinged in the 1-year CIMP programme. Sprat arrive in large shoals at Hinkley Point in the period November to January of every year (99% of their abundance) but are only present in very low numbers for the rest of the year (1% of their abundance). Sprat are predicted to have a 100% mortality in the HPC FRR system. At DCO 406,000 dead sprat were expected to be discharged at the HPC FRR system outfall. The revised figure in BEEMS Technical Report TR456 is 932,000 sprat i.e. an increase of 526,000 fish. The Environment Agency have asked NNB Genco whether the dead sprat will create a nuisance on the beaches in Bridgwater Bay.

4.4.4 A particle tracking study was conducted by Cefas using the validated 3D GETM hydrodynamic model of Hinkley Point (25 m resolution) to investigate the dispersion of impinged sprat released from the HPC FRR outfall. The model treated the dead sprats as passive particles and included the effects of predation by marine birds (herring gull and black headed gull are the dominant species in winter) and measured dead sprat sinking rates.

4.4.5 Population densities, distributions and sizes of foraging seabirds in the vicinity of the HPC FRR were obtained from British Trust for Ornithology (BTO) wetland bird surveys (WeBS). Based on these numbers and published energy requirements, foraging rates were calculated to parameterise predation in the model.

4.4.6 To assess the buoyancy of impinged sprat, and parametrise the behavior in the model, sprat were collected during routine impingement sampling at the Sizewell B station by Cefas staff. Over several campaigns from summer and winter 2018, a total of 1,366 dead sprat were collected, of which 88.3 % sank immediately, with the rest sinking over 24 hours. Based on the observed buoyancy data of sprat, particle sinking behaviour was parameterised whereby 88.3% of particles sink immediately. A 24-hour linear decay rate was then applied to the remaining particles and after 24 hours, any remaining particles were classified as sunk. Once the particles reached the seabed in the model they were removed from the simulation. This sinking model is considered highly conservative as the fish holding tanks were not agitated. In practice, passage through the FRR system would be expected to remove the air bubbles which were present in the mouths of dead fish leading to more rapid sinking rates.

4.4.7 A total of 168,743 particles were released over a spring neap cycle in the model, with each particle representing 2 sprat.

4.4.8 The study showed that only a very small proportion of sprat reached the beach along the surrounding coastline, with an average daily beaching rate of up to approximately 50 sprat per 24 hours. The sprat that sink to the seabed will quickly be scavenged by benthic animals and would not present a pollution risk at the seabed. The beached sprat were spread over 11km of coastline from 3.6 km west of the FRR to 7.3 km east (west of Lilstock to east of Stolford). To put this in context, a single herring gull needs to eat 52 sprat for its daily energy consumption. The model did not take account of all of the seabirds present in the Hinkley Point vicinity and therefore the very few beached sprat are expected to be quickly scavenged and not present any nuisance to the public.

Table 4.2 Predicted HPC Impingement Effects with LVSE intake heads and FRR system fitted as mitigation

Common Name	Species	Mean effect	Upper 95%ile effect	Impingement indicator
Sprat	*Sprattus sprattus*	0.016% (from RIMP data)	0.043%	PELTIC SSB for 2013- 2016
Whiting[4]	*Merlangius merlangus*	0.038%	0.072%	SSB for 2009
Sole, Dover[4]	*Solea solea*	0.069%	0.140%	SSB for 2009
Cod[4]	*Gadus morhua*	0.054%	0.119%	SSB for 2009
Mullet, thin lipped grey	*Liza ramada*	Population trend increasing. Negligible effect predicted.		RIMP trend analysis
Flounder	*Platichthys flesus*	Population trend increasing. Negligible effect predicted		RIMP trend analysis
Five-bearded rockling	*Ciliata mustela*	Population trend increasing. Negligible effect predicted.		RIMP trend analysis
Herring[4]	*Clupea harengus*	0.050%	0.081%	International catch for 2009
Sand Goby	*Pomatoschistus minutus*	Population trend increasing. Negligible effect predicted.		RIMP trend analysis
Bass	*Dicentrarchus labrax*	0.011%	0.013%	SSB for 2009
Plaice	*Pleuronectes platessa*	0.002%	0.005%	SSB for 2009
Ray, Thornback	*Raja clavata*	0.118%	0.194%	International catch for 2009 + Cefas discard estimate.
Whiting, Blue	*Micromesistius poutassou*	0.000%	0.000%	SSB for 2009
Eel	*Anguilla*	0.043%	0.084%	Independent stock estimate[1]
Shad, Twaite	*Alosa fallax*	0.0026% (from RIMP data)[3]	0.0043%	Independent stock estimate[1]
Shad, Allis	*Alosa alosa*	0.017%	0.053%	Independent stock estimate[2]
Lamprey, Marine	*Petromyzon marinus*	0.078%	0.166%	Independent stock estimate[1]
Lamprey, River	*Lampetra fluviatalis*	0.008%	0.021%	Independent stock estimate[1]
Salmon	*Salmo salar*	Less than 0.0086%. From RIMP data.	Less than 0.020%	EA/NRW estimates
Sea trout	*Salmo trutta*	Less than 0.0054%. From RIMP data.	Less than 0.04%	Extrapolated from rod catch for 2012-2016
Brown shrimp	*Crangon crangon*	Population trend increasing. Negligible effect predicted.		RIMP trend analysis

Notes:

1. Appendix G (TR456 Cefas, 2019a).
2. BEEMS SPP071 edition 3 (Cefas, 2019b).
3. 50th percentile impingement effect from SPP071 edition 3 (Cefas, 2019b).
4. Corrected by results of interannual variability analyses

4.5 Water Framework Directive (WFD) Compliance

4.5.1 Specific assessment of effects in relation to the fish elements of supporting water bodies is considered in the separate WFD Compliance Assessment report. The conclusion of the report is that the proposed changes to the CWS, i.e. with no AFD system as mitigation, will have no effect on compliance with the WFD.

4.6 Habitats Regulations Assessment (HRA)

4.6.1 The updated HRA report affirms the conclusion of the HRA Stage 2: Appropriate Assessment of the proposed material change of the HPC development, i.e. a CWS with an FRR system and LSVE intake head but no AFD system installed, will not adversely affect the integrity of the designated sites in question in view of their conservation objectives, either alone or in-combination with other permissions, plans or projects.

5 FISH PROTECTION MEASURES AT HPC

5.1 Initial proposals for fish protection

5.1.1 The initial proposals for fish protection were outlined in the application for the WDA Permit (NNB GenCo, 2011). Subsequent information was provided in response to requests for further information issued pursuant to Schedule 5 of the Environmental Permitting Regulations 2010. The information was consistent with the information provided in the application for the DCO and the Marine Licence.

5.1.2 As part of the design of the fish protection measures, a FRR system was also proposed, to return entrapped and impinged fish and other marine organisms to the Severn Estuary, via a single tunnel extending approximately 600 m under the foreshore.

5.1.3 The WDA Permit application provided descriptions of the fish protection measures to be installed to mitigate the effects to fish and marine organisms as outlined above. In summary, the fish protection measures initially proposed included the following components:

- an AFD system (subject to securing arrangements for an electricity supply and maintenance);
- intake heads designed to minimise entrapment of fish through careful siting of the intake heads and design of the heads themselves; and
- an FRR system.

5.1.4 This Section summarises the information provided in the WDA Permit application submitted in 2011 relating to fish protection measures and the approach taken to evaluating options for the AFD system. It should be noted that, at the time of the application, the design of the intake and fish protection arrangements was at a relatively early stage in development. The updated proposals for these arrangements are also outlined in this section.

Acoustic Fish Deterrent (AFD) system

5.1.5 Section 2.5.2 of the application for the WDA Permit provided a description of the design concept for the AFD system. The information provided reflected the limited site specific information available at the time the application was submitted. The basis of the design for the system was based on criteria outlined in the guidance provided in the EA's Science Report (Turnpenny *et al*, 2010). The application proposed that, subject to securing power supplies for the system and confirming that maintenance arrangements were viable, an AFD system would be installed.

5.1.6 AFD systems rely on the repulsion of certain species of fish that are sensitive to sound via amplified sound signals. This minimises the potential for fish sensitive to the sound frequencies emitted to be entrained or entrapped in the CWS, on the basis that they will navigate away from the intake heads. Although AFD systems are less effective for sinuous fish such as lampreys and eels, studies suggest that the application of these systems in estuarial and inland waters is effective in diverting salmon, trout, cyprinid and percid species from cooling water intakes.

5.1.7 AFD systems comprise the following four principal components:

Signal generators

5.1.8 The signal generators provide a suite of signals selected according to species of interest. The application did not provide details of the technology considered to generate the signal, given the early stage in the design of the system.

Sound projectors (SPs)

5.1.9 The SPs generate the sound waves at the required frequency range to deter the fish from entering the intake heads. The resilience and reliability of the SPs at HPC would be critical, given the limited opportunities available for access to the system, due to the harsh environmental conditions and the tidal range of the Bristol Channel.

5.1.10 At the time of the submission of the application, the technology to be used for sound projection had not been confirmed, though underwater acoustic numerical modelling had demonstrated that the projector array envisaged (outlined below) would be capable of providing a sound field of 160dB re 1µPa along almost the entire length of the intake head, which was considered to be sufficient to ensure effective fish deterrence.

Sound projection mounting structures

5.1.11 As outlined in published guidance on best practice for fish deterrent systems (Turnpenny *et al*, 2010), SPs are required to be mounted in banks or arrays on mounting structures. The size, shape and positioning of the mounting arrangements determine the size of the sound field produced and the acoustic gradient.

5.1.12 As the mounting structures are required to be located proximate to the intake heads which are nuclear safety classified structures, it is important that these do not impact on the operation of the intake heads, particularly during maintenance activities.

5.1.13 The application confirmed that the design concept for the sound projection mounting structures would require each intake head to be provided with two arrays, each of which would incorporate 20 SP units (speakers).

Power and communications supplies

5.1.14 The AFD system would require a continuous and reliable electrical supply, together with communications and diagnostic links. The design concept acknowledged the requirement that the AFD system modules would be streamlined and proposed that the design would incorporate cowled tidal turbines to provide power for the SPs.

5.1.15 Consistent with the published best practice requirements (Turnpenny *et al*, 2010), the design acknowledged that the system would be designed to enable servicing and maintenance in accordance with manufacturer's requirements. On this basis, NNB GenCo proposed that the system would be designed to enable underwater servicing of the equipment installed. NNB GenCo also confirmed that diagnostic equipment would be installed to enable the performance of the system to be monitored.

5.1.16 Following submission of the WDA Permit application, the design of the AFD system was progressed from concept through to detailed design, taking into account the improved characterisation of the environmental constraints associated with the marine environment in the Severn Estuary and risk analyses of the health and safety aspects associated with the construction and maintenance of the system. More detailed information relating to the proposed cooling water abstraction system is provided in this section of this report together with justification for not incorporating the AFD system into the design of the intake arrangements.

Cooling water intake structures

5.1.17 For each seawater intake, the cooling water structures will comprise two intake heads for each of the two intake tunnels. Four intake heads will be installed in total. A forebay to receive seawater pending transfer to the filtration (screening) and pumping arrangements will also be installed, though the design of the intake tunnels, the forebay and the pumping arrangements are not considered within the scope of this report, as these matters are not directly associated with fish protection. In relation to fish protection associated with abstraction of seawater into the subsea tunnels, two key matters associated with the intake infrastructure require consideration:

- location and siting of the intake heads; and
- design of the intake heads.

5.1.18 These matters are considered below.

Location and siting of the intake heads

5.1.19 Section 2.5.1 and Table 3.1.1 of the original WDA Permit application (NNB GenCo, 2011) summarised the aspects taken into account to determine the locations and siting of the intakes.

5.1.20 In accordance with the best practice recommendations published by the EA (Turnpenny *et al*, 2010), the following geographical, operational, safety and security considerations were taken into account:

- the location is required to provide a sufficient depth of water at the intake heads to protect against low water conditions, which will also protect against the entrapment, impingement and entrainment of pelagic fish;
- the distance of the intake heads from shallow water where young fish and shellfish are most concentrated;
- proximity of the intakes to areas of the seabed having loose sediment which could be shifted by tidal currents or drawn into the intakes;
- proximity to the outfall heads and the depth of water to ensure the thermal load of the outfall is not recycled into the intake system;
- separation between the intake heads on one tunnel and intake heads on the other to protect against external hazards; the distance proposed in the application was 480 m to mitigate against aircraft impact and to provide to provide a significant degree of segregation against ship impact and blocking hazards; and

- the presence of suitable and stable ground conditions.

5.1.21 Although the grid references for the intake heads were not specified in the application, the conceptual locations were identified in Figure 1.4.2 in Annex A of the application.

Design of the intake heads

5.1.22 Section 2.5.1 and Table 3.1.1 of the original application (NNB GenCo, 2011) also summarised the specified design criteria for the design of the intake heads. The design criteria took into account the best practice requirements published by the EA (Turnpenny & O'Keeffe, 2005 and Turnpenny *et al*, 2010).

5.1.23 The application confirmed that each of the two intake heads installed on each intake tunnel will be located approximately 200 m apart, elevated above the sea bed. They will be designed so that they do not create a vortex and so that the local velocity field generated by the intake would be reduced to 0.3 m/s to minimise the potential for entrapment of fish and marine organisms.

Fish Recovery and Return (FRR) system

5.1.24 Sections 2.5.2 and 3.1.3 of the original WDA application (NNB GenCo, 2011) summarised the design concept for the FRR system. The description of the FRR system provided took into account the best practice recommendations published by the EA (Turnpenny & O'Keeffe, 2005 and Turnpenny *et al*, 2010). The following design criteria were specified:

- the drum screens will be installed with smooth mesh (5mm);
- the drum screens will rotate continuously;
- the screens will be designed to enable fish to be washed into the buckets;
- the buckets will be designed to retain water and prevent the fish from falling into the drum chamber (including design to deter sinuous fish such as eels from escaping from the buckets and being recaptured repeatedly);
- the contents of the buckets will then be transferred via a wash water gully to the sea under gravity;
- the geometry of the collection hoppers will be designed to minimise the return of fish into the screen well;
- very low-pressure water sprays (1 bar) will be used to remove fish from the screens;
- gullies will be covered;
- swept bends of radius >3 m will be constructed;
- a dedicated fish return tunnel (separate from the CWS outfall tunnel) will be installed for the transfer of fish and other marine organisms to the Severn Estuary; and
- a wash water supply will be provided to ensure fish are immersed whilst in transit along the fish return system.

5.1.25 A schematic illustrating the conceptual layout of the intake arrangements together with the FRR system was provided in Appendix A of the application.

5.2 Combined effectiveness of the AFD system, intake head design and the FRR system for fish protection

5.2.1 An assessment of the effects of the abstraction of seawater (125 m^3/s) on estuarine fish populations was undertaken to support the original WDA application. The assessment was based on the Comprehensive Impingement Monitoring Programme (CIMP) surveys undertaken in 2009-2010 and analyses of raw impingement catch data. The objective of the assessment was to determine the total annual impingement of fish based on:

- no mitigation being provided; and
- installation of Low Velocity Side Entry (LVSE) intakes, FRR and AFD systems.

5.2.2 The findings of the assessment were summarised in Tables 5.10.9 and 5.10.10 respectively of the original application (NNB GenCo, 2011).

5.2.3 It should be reflected that the most accurate and reliable information available to the HPC Project at the time was used to inform the documents submitted with the original application. Notwithstanding the above, given the limited environmental baseline data available and understanding of fish behaviours within the Severn Estuary, conservative assumptions were used to inform the assessments, reflecting the maturity of the design information available.

5.2.4 The Decision Document that supported the WDA Environmental Permit (Environment Agency, 2013a) confirmed that the fish protection measures comprising the FRR system and an AFD system in the design led the EA to conclude there would be no adverse effect on fish with the site operating alone with these systems in place. The EA also stated that given the complex nature of the estuary and the dependence on the mitigation measures detailed above, it was appropriate that the final designs were tested at the commissioning stage, well in advance of the full operation of HPC, to allow optimisation of performance prior to starting the full operation. Condition PO8 of the Permit was included to address this requirement.

5.2.5 Following the issue of the WDA Permit, the design of these arrangements has progressed to the detailed design stage. NNB GenCo has liaised with the Defra Family to progress studies and assessments to develop the designs to ensure that these preventative measures provide appropriate protection to minimise the impingement and entrapment of fish and marine organisms in the CWS, to reduce the potential for harm to fish and to optimise the return of live fish to the marine environment. The latest designs of the CWS were detailed in the CW1 report. The CW1 report provides a summary of the proposed fish protection measures which comply with best practice and are currently agreed by the Defra Family but includes no design details for the AFD system.

5.2.6 It is noted that the CW1 report relates specifically to discharge of DCO requirement CW1 (paragraph 1 only) and marine licence condition 5.2.31 and has been approved by the MMO in consultation with the EA. Other DCO requirements and licence conditions remain to be discharged. The CW1 report does refer to the requirement for an AFD system set out in DCO requirement CW1 (paragraphs 2 and 3) and in separate marine licence conditions but states that the report only deals with Paragraph 1 of CW1 and does not cover the design of the AFD system. Where necessary, however, the AFD is referred to in respect of its potential anticipated mitigating effects where these would complement the FRR system and, thus, contribute to the overall fish protection measures of HPC.

5.3 Proposed fish protection measures

5.3.1 This Section provides information to confirm that the CWS arrangements proposed in this report comply with the legal and regulatory criteria for fish protection. To enable an informed understanding of the justification for this position, the following information is provided:

- a review of the design of the intake heads and FRR system to confirm the high priority afforded to fish protection and to demonstrate that these arrangements comply with the regulatory criteria for fish protection. The assessment of the regulatory criteria for design of fish protection measures is provided in this Section. The assessments that justify these arrangements are provided in Section 4;
- a review of behavioural fish deterrent systems available and their suitability for HPC;
- a description of the proposed AFD system to inform understanding of the complexity of the construction and maintenance requirements;
- a summary of the constraints associated with the proposed AFD system; and
- a review of the suitability of AFD systems for application at HPC with reference to experience operating these types of systems at other sites.

5.3.2 To support discharge of the conditions associated with condition CW1(1) of the DCO and condition 5.2.31 of the Marine Licence, NNB GenCo and the Defra Family have taken a collective approach to identify and address the best practice requirements for fish protection measures with regards to the design of the CWS (as described in the CW1 report).

5.3.3 The following sections focus on the fish protection measures incorporated into the design of the cooling water intake heads and the FRR system. This is followed by a review of current behavioural deterrent systems with a particular focus on AFD systems.

5.4 Cooling Water Intakes

Location of intake heads

5.4.1 The overarching priority for the location of seawater intakes is to ensure a consistent and continuous supply of water to meet the cooling requirements of the power station. Notwithstanding the above, the locations of the seawater intakes were also determined using site-specific criteria, taking into account the best practice requirements published by the EA (Turnpenny & O'Keeffe, 2005; Turnpenny *et al*, 2010 and Environment Agency, 2010).

5.4.2 Extensive hydrodynamic modelling was undertaken to confirm the location of the intake and the outfalls to ensure the location of the intake did not enable the thermal loads discharged to the Severn Estuary to be recirculated into the CWS.

5.4.3 The seawater intakes will be located approximately 3.3 km north-west of the HPC power station at the grid references provided in Table 3 and shown in Figure 4 of the CW1 report (Section 4.2).

5.4.4 Details of the best practice requirements and the approach taken to demonstrate compliance with these are provided in the 'regulatory criteria for fish protection for intake arrangements' matrix in the CW1 Report. In accordance with the requirements of the best practice guidance, the intake heads are located in open water and not proximate to any fish spawning or nursery grounds. The following criteria are also met for the location of the intake heads:

- the intakes will not distort the ambient flow regime significantly;
- seawater will not be abstracted from intertidal areas; as the intakes are located over 3 km offshore, the risk of drawing in juvenile and intertidal fish is minimised;
- no known fish spawning or nursery areas are located with the vicinity of the intake heads; risk of entrainment of ichthyoplankton and juvenile fish is not considered significant at population level for potentially affected SACs or local WFD water bodies; and
- the offshore location of the intakes will mitigate against seaweed inundation.

5.4.5 As confirmed in the regulatory criteria for fish protection matrix in the CW1 Report, the Defra Family has confirmed that the location of the intake heads complies with best practice. This was agreed prior to the DCO decision in 2013, with the DCO process validating the decision made regarding the location.

5.4.6 As confirmed in Section 4.6, the removal of the AFD system will not give rise to significant effects on the fish population of the Severn Estuary and will not give rise to the deterioration of the conservation interest of any European or Ramsar sites. On this basis, the modification of the fish protection measures proposed at HPC will not give rise to reconsideration of the location of the seawater intakes.

Intake head design

5.4.7 The detailed design of the seawater intake heads has progressed significantly since the application for the WDA Permit was submitted. Comprehensive optioneering assessments have been undertaken to optimise the intake design, to ensure a consistent and continuous supply of water to the power station, whilst also minimising entrapment and entrainment of fish and marine organisms and minimising abrasion and mechanical damage caused to them. Full details of the intake head design can be found in Section 4.3 of the CW1 report.

5.4.8 Similar to the approach taken to identify and confirm compliance with the best practice requirements for the location of the seawater intakes, a collective approach has been taken to identify and confirm the compliance status of the design proposals for the seawater intakes. Details of the best practice requirements and the approach taken to demonstrate compliance with these requirements are provided in the 'regulatory criteria for fish protection' matrix provided in the .CW1 Report. These aspects of the design have been agreed with the Defra Family for the purposes of compliance with condition CW1 Paragraph 1 of the DCO and condition 5.2.31 of the Marine Licence.

5.4.9 A brief outline of the proposed intake design agreed during the discharge of condition CW1(1) of the DCO is provided below, together with a summary of arrangements implemented to comply with the best practice requirements.

5.4.10 Each intake head is a significant structure, capable of abstracting 33 m^3/s. The combined (mean) abstraction rate of the 4 intakes will be approximately 132 m^3/s (depending on tidal state). Each intake head will be nuclear safety classified and of a consistent design. The design will comprise a rectangular structure with a total size of 43.90 m x 10.00 m x 2.80 m. The structure has an isometric wedge-shaped 'nose' structure at each end and the distribution chamber (the intake section) is 35.50 m long (**Figure 4.1**).

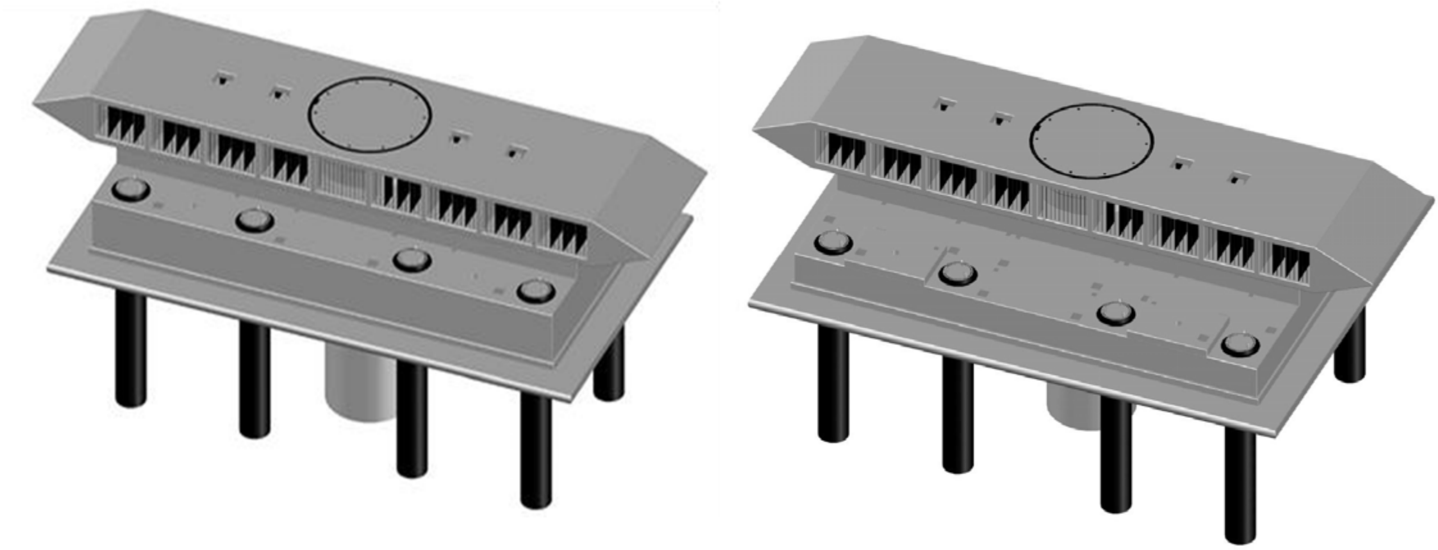

Figure 5.1 3-dimensional views of the intake heads

(Type 1 on the left and Type 2 on the right; only the foundations are different; hydraulic performance is the same for both types)

5.4.11 Each unit will be installed with LVSE intakes. The LVSE design is based on three key principles that are consistent with best practice requirements to allow fish in the vicinity the maximum opportunity to escape being drawn in with the water as follows:

- intake flow rates should be slow (i.e. slower than the 'burst' swimming speed of fish), so that they can swim away from the intake, provided they are able to detect it and choose to do so;
- the apertures to the intake head should be perpendicular to the main natural current flow, so that intake velocities are not added to by current/tidal flow; and
- the intake should draw in water sideways, because fish are more able to escape from a horizontal current than they are from a vertical current.

5.4.12 The HPC LVSE intake head design achieves all three of these objectives (further information on LVSE effectiveness is given in TR465, Cefas, 2019a). **Figure 4.2** and **Figure 4.3** provide a side view a plan view of an intake head.

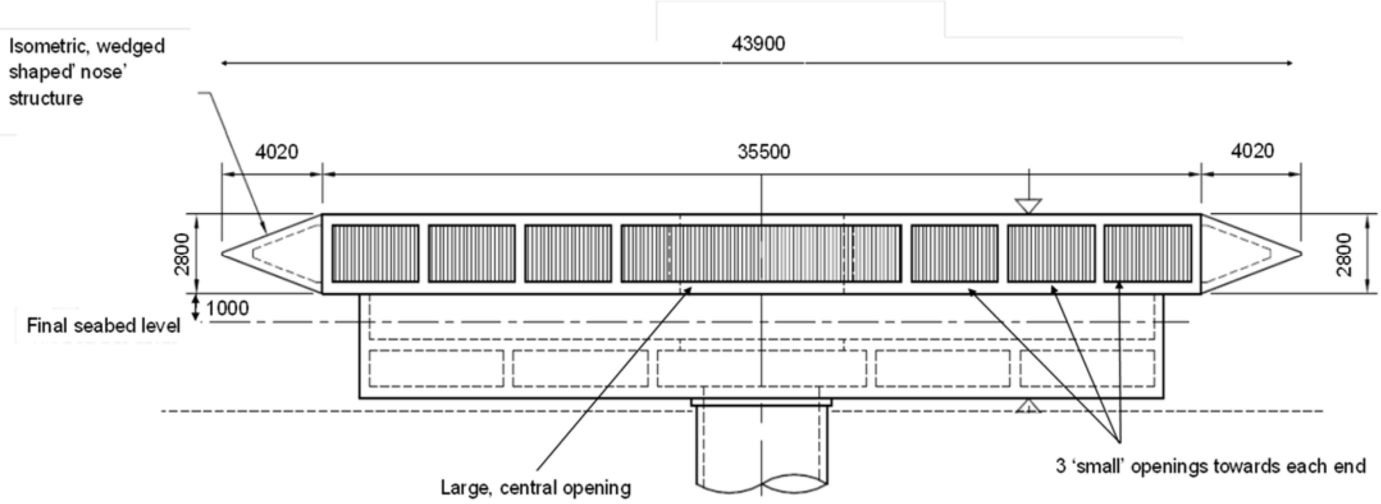

Figure 5.2 Side view LVSE intake head

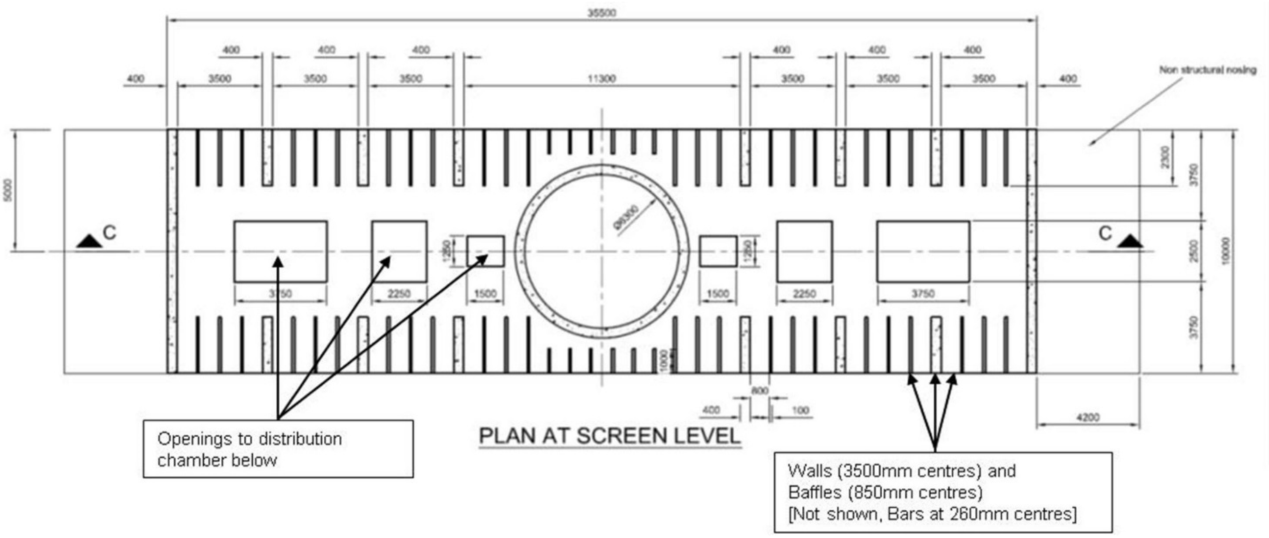

Figure 5.3 Plan view of LVSE intake head

5.4.13 The EA's best practice requirements specify that velocities at the intake entrance (often known as "approach velocities") are low enough for fish to avoid. For most power plant intake purposes a design fish-escape velocity of 0.3 m/s is considered sufficient for fish escape purposes and to meet best practice requirements. The CW1 report confirms the aim of the current LVSE intake design was to comply with this approach velocity along the whole length of the intake, 100% of the time. As described in the CW1 report, numerical modelling demonstrates that the final design will achieve the recommended 0.3 m/s for approximately two thirds of the time and that approach velocities will vary along the length of the intake head. NNB GenCo considers that this is the best that can be achieved for a system this large when all constraints are considered.

5.4.14 There are two factors that affect the intake velocities:

- the rate of abstraction - this is fixed and is constrained by the cooling requirements of the nuclear power station; and
- the size of abstraction (intake head) aperture - this could be increased in one of two ways, namely make the four intake heads larger or have more intake heads.

5.4.15 The reasons that HPC cannot have larger or more intake heads are detailed in the CW1 report.

5.4.16 Consistent with best practice, the intake heads incorporate the following design features:

- the intake heads will be will elevated 1 m from the seabed to minimise the potential for the entrapment of demersal and benthic species; and
- the intake heads will be installed with three types of vertical structures: walls at 3.5 m centres (to provide structural integrity), 'baffles' at 0.85 m centres (to help standardise intake flows) and bars at 0.26 m centres to prevent large fish, marine mammals and larger items of debris from entering the intake.

5.5 Fish Recovery and Return (FRR) System

5.5.1 The FRR system will be provided as a component of the open circuit cooling water infrastructure to recover and return certain fish and crustaceans impinged on the screens by the cooling water flow.

5.5.2 The criteria specified within the EA's report (Turnpenny & O'Keeffe, 2005) can be summarised as follows:

- the design and performance of any forebay raking system is compatible with FRR requirements;
- any entrained fish must be able to survive any raking system and be returned to sea;
- any moving screens should rotate continuously and at a constant speed, so fish are not impinged against screens for long periods of time;
- any materials used should be smooth and fish-friendly;
- backwash sprays should be low pressure (≤1 bar);
- geometry of collection hoppers should be designed so fish cannot fall back into the screen well;
- flow velocities onto the fine filtration screens should be sufficiently high to ensure that fish are impinged effectively and do not take up residence in the forebay; and

- fish collection and transit gutters should be of a certain specification, e.g. smooth, minimum diameter, specific bend size(s), appropriate gradient and debris removal and fish recovery should not be combined.

5.5.3 Similar to the intake arrangements, the FRR system has been subject to significant development since the WDA Permit application was submitted. Comprehensive optioneering assessments have been undertaken to ensure the FRR system design is optimised to ensure a consistent and continuous supply of water to the power station, whilst also optimising:

- capture of fish impinged on the fine screens;
- the condition of the fish recovered to the fish return system; and
- the proportion of fish returned alive to the Severn Estuary.

5.5.4 Similar to the approach taken to identify and confirm compliance with the best practice requirements for the location of the seawater intakes, a collective approach has been taken to identify and confirm the compliance status of the design proposals for the FRR system. Details of the best practice requirements and the approach taken to demonstrate compliance with these are provided in the 'regulatory criteria for fish protection' matrix provided in the CW1 Report.

5.5.5 The measures incorporated into the design to address these requirements are confirmed in the CW1 report. These aspects of the design have been agreed with the Defra Family for the purposes of compliance with condition CW1 Paragraph 1 of the DCO and condition 5.2.31 of the Marine Licence. Notwithstanding the above, there are several best practice requirements that require further consideration by NNB GenCo.

5.5.6 An outline of the proposed FRR system intake design is provided below, together with a summary of arrangements implemented to comply with the best practice requirements. Further details of the FRR system are provided in the CW1 report.

5.5.7 The CWS comprises the following principal components relevant to fish protection that are collectively known as the FRR system.

- **Debris (trash) racks and rakes:** the debris racks and rakes filter large fish and debris from the cooling water that could otherwise potentially damage the fine mesh of the drum and band screens. There will be a separate rack and raking system on each band screen train and four rack and raking systems on each drum screen train, giving 10 systems in total per Unit. The racks and rakes are also referred to as 'coarse filtration'.
- **Fine filtration screens:** HPC will have two types of 'fine filtration'; band screens and drum screens. These are located in the cooling water pump house.
    - The band screens filter water that serves the service and safety CWS (the auxiliary cooling water, essential service water and ultimate CWS). The band screens are nuclear safety classified.
    - The drum screens filter water that mostly supplies the main CWS, the essential service water and ultimate CWS.

- **Debris recovery pit and the debris racks:** fish and debris are transported from the debris racks, the band screens and the drum screens by gutters to the filtering debris recovery pit.
- **The fish return system:** This system comprises the gutter running from the filtering debris recovery pit, the tunnel that transfers the water and fish from HPC to below a point on the shore that lies below low water on the very lowest tide (Lowest Astronomical Tide, LAT), together with the associated headworks.

5.5.8 An overview of the FRR system is provided in **Figure 4.4**

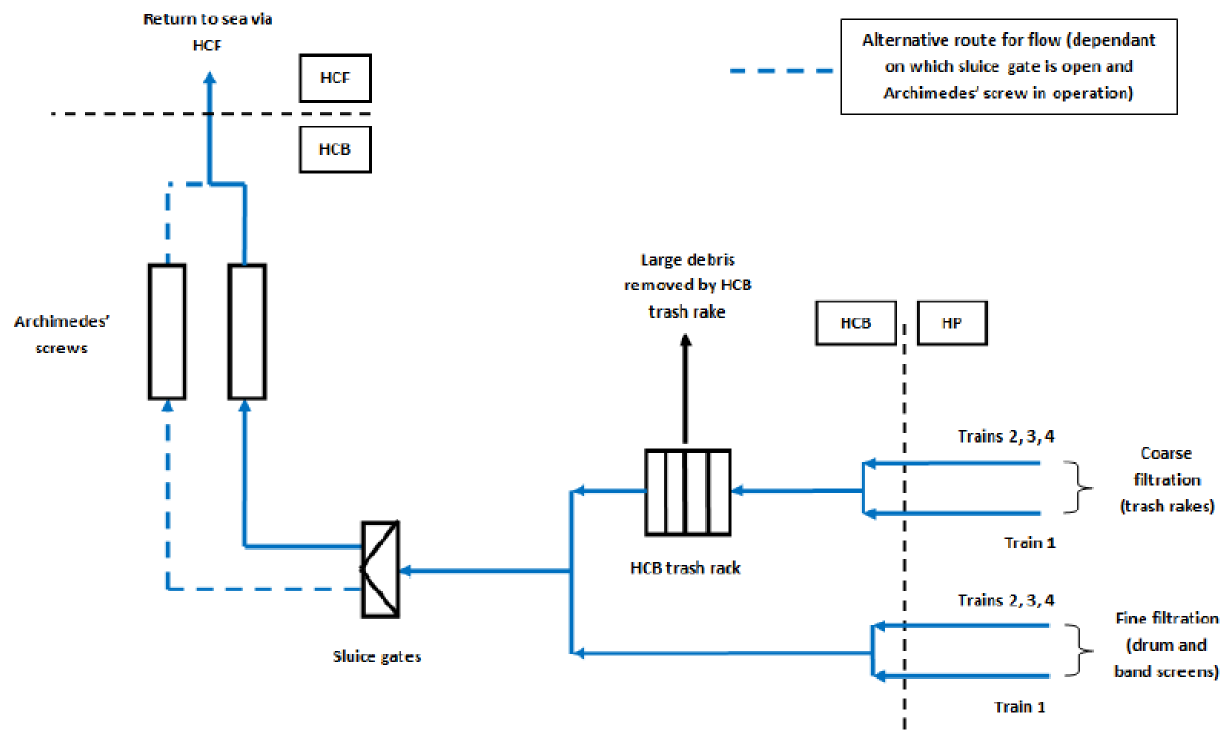

Figure 5.4 FRR system

Debris (trash) racks and rakes (coarse filtration)

5.5.9 Water entering the cooling water pump house from the forebay will be diverted through ten water channels for onward transfer to band screens and the two drum screens. Before the water enters these screens, it passes through a debris (trash) rack which filters out large fish and pieces of debris from the seawater that could otherwise potentially damage the fine mesh of the drum and band screens.

5.5.10 The flow rate through the band screen channel trash rack under normal operating conditions will be 0.23 m/s with the tide at Mean Sea Level (MSL), though this may vary between 0.2 and 0.3 m/s with the tide. Velocity through the drum screen channel trash rack under normal operating conditions is 0.36 m/s at MSL. It can vary between 0.3 and 0.4 m/s with the tide. These flow rates are appropriate to minimise the potential for abrasion and mechanical damage to fish and other marine organisms according the best practice guidance.

5.5.11 The rake itself consists of a ‘skip’ (or bucket) which passes from the bottom to the top of the rack, by means of a hoist system with hydraulic power pack, collecting material impinged on the rack as it does. The skips will be sized according to the fine filtration unit they protect. The skips are trough-shaped so that they collect and retain enough water for fish protection, along with the debris.

5.5.12 When the rake reaches the top of the rack, the skip is tipped to allow water, debris and any impinged fish to discharge into the collection gutter, before a scraper scrapes out any trapped debris. The skip discharges directly into a collection gutter which runs parallel to the raking system for transfer of the debris and fish to the filtering debris recovery pit.

Fine filtration screens

5.5.13 HPC will have two types of ‘fine filtration’; band screens and drum screens. These are located in the cooling water pump house. Full details of the screens are provided in the CW1 report.

5.5.14 Band screens

5.5.15 The band screens filter water that serves the service CWS and safety CWS (the auxiliary cooling water, essential service water and ultimate CWS).

5.5.16 The band screen comprises a continuous ‘band’ of fine filtration mesh which travels in a conveyor-like motion around a spindle at the top and bottom of the band. During the CW1 report review, the EA had expressed concern relating to the duration (up to 46 mins) that fish will be retained in buckets on the band screens at certain tide states. Though the pumphouse is shaded and cool, NNB GenCo is reviewing opportunities to increase of screen speed to respond to operational conditions.

5.5.17 Consistent with the best practice requirements published by the EA (Turnpenny & O’Keeffe, 2005 and Turnpenny *et al*, 2010), the mesh will be smooth and made from stainless steel and will have a mesh size of 5 mm × 5 mm. Although the mesh size will be oversized in terms of specific best practice for young eel stages, the EA has confirmed that, given nuclear safety considerations and combination of mitigations to minimise the velocities in the intake system, the specified mesh size is acceptable in relation to the Eels Regulations.

5.5.18 The CW1 report confirms that low-pressure backwash spray ≤1 bar will be used to flush the fish, with higher-pressure jets ≥ 3 bar to remove debris at a point later in the cycle.

5.5.19 The band screens will operate continuously (so fish are not impinged against the screen for long periods before removal) and are designed to rotate at three different speeds; high speed, low speed and also a very low (continuous ‘creep’) speed:

- high and low speeds are 10 m/min and 2.5 m/min, respectively; and

- the very low speed has been specifically incorporated to enable fish protection, with a speed of 0.5 m/min. The screens will travel at this speed continuously so that impinged fish are continuously recovered from the screen (instead of being impinged until the next rotation is triggered). This slow continuous rotational is not standard operation for band screens but has been incorporated to enable the screen to be operated continuously to enable fish recovery. It is acknowledged that continuous operation at low speed would cause excessive wear of the screen's motor chains

5.5.20 The band screens will be fitted with buckets for the safe recovery of fish from the screens. These will be fitted at approximately 600 mm intervals. The design of the buckets has not yet been confirmed though the type of bucket envisaged is illustrated in **Figure 4.5**.

Figure 5.5 Anticipated fish recovery bucket design

5.5.21 Each bucket will retain approximately 40 l of water, which equates to an approximate depth of 90 mm, once the bucket emerges from the water on its ascent towards the top of the screen, though it is acknowledged that water will drain from the buckets as the bucket inclines. This may adversely affect the fish depending on the rotation speed of the screens pending transfer into the gutter system.

5.5.22 The geometry of the buckets proposed includes an inward curved lip to prevent more active fish species, lamprey and fibrous fish such as eels from flipping out of the bucket and falling back into the screen well. This basic design is considered best practice for the safe retention of most/all fish species likely to be encountered at HPC.

5.5.23 Drum screens

5.5.24 Each of the two cooling water pump houses will have a rotating drum screen to remove finer debris at a flow velocity of 0.5 m/s under normal conditions, which will consist of a large rotating cylindrical structure with mesh filtration panels attached to the periphery. The mesh panels are the same specification as these on the band screens: mesh size = 5 mm × 5 mm and made of smooth, stainless steel, consistent with the best practice requirements. The drum screens will be also able to rotate at three different speeds, depending on the degree of head loss (indicative of debris loading). The CW1 report has full details on the design of the drum screens (Section 6.3 of the CW1 report).

5.5.25 To improve fish protection, the drum screen will accommodate one collection bucket mounted at the junction of every radial spoke of the screen, which equates to a total of 56 pairs of collection buckets on each drum screen.

5.5.26 Similar to the design of the band screens, as the water level in the cooling water pump house varies according to tidal level, the volume of water retained in the buckets will vary. The retained volume may be as low as 14% of the bucket volume. This matter is currently being considered by NNB GenCo to optimise the survivability of fish during low tide, low rotation events.

Debris recovery pit and the debris racks

5.5.27 Material from the coarse and fine filtration schemes exit the cooling water pump house and flow into the filtering debris recovery pit. A route back to sea for the fish recovered from the filtration systems is achieved through the use of an Archimedes screw which lifts fine debris and fish to an elevation that is high enough to allow return to sea under gravity. Other material recovered from the recovery pit and raking system is disposed of to a licenced waste disposal facility. The rack spacing is sized as large as possible to allow large fish to pass through but small enough to adequately protect the Archimedes screw and fish return system from obstruction.

5.5.28 This design is considered best practice for the safe recovery of most fish species likely to be entrained within the CWS of HPC.

Fish return outfall system

5.5.29 The fish return outfall system comprises the gutter running from the filtering debris recovery pit, the tunnel that transfers the water, debris and fish from the HPC site to a point on the shore that lies below low water at LAT and the concrete outfall head structure. The fish return system unifies the water, debris and fish from the two units at a junction immediately prior to the fish return tunnel. The routing of the fish return system is shown in **Figure 4.6** and full details are provided in the CW1 report.

5.5.30 The return tunnel will be approximately 658 m long, 0.938 m in diameter and will be lined with High Density Polyethylene (HDPE), or a similar material, to ensure a smooth surface to minimise abrasion and physical damage to fish transiting in the tunnel. The fish return system tunnel will start at 11.51 m ODN, at which point it has a gradient of 13.7%. The gradient of the fish return system tunnel varies due to its vertically curved path; the average slope is 10.9 %. The fish return system outfall structure will be a pre-fabricated concrete structure located at a point whereby the fish will be returned to the subtidal zone at all tidal states.

5.5.31 The fish return system also incorporates a means to sample the fish, so that assessments can be made in respect of numbers and types of fish caught as well as fish survivorship through the system. This design is considered to be best practice and adheres to the guidance provided by the EA (Turnpenny & O'Keeffe, 2005 and Turnpenny *et al*, 2010) and is optimised to ensure maximum return of live fish from the HPC CWS into the Severn Estuary.

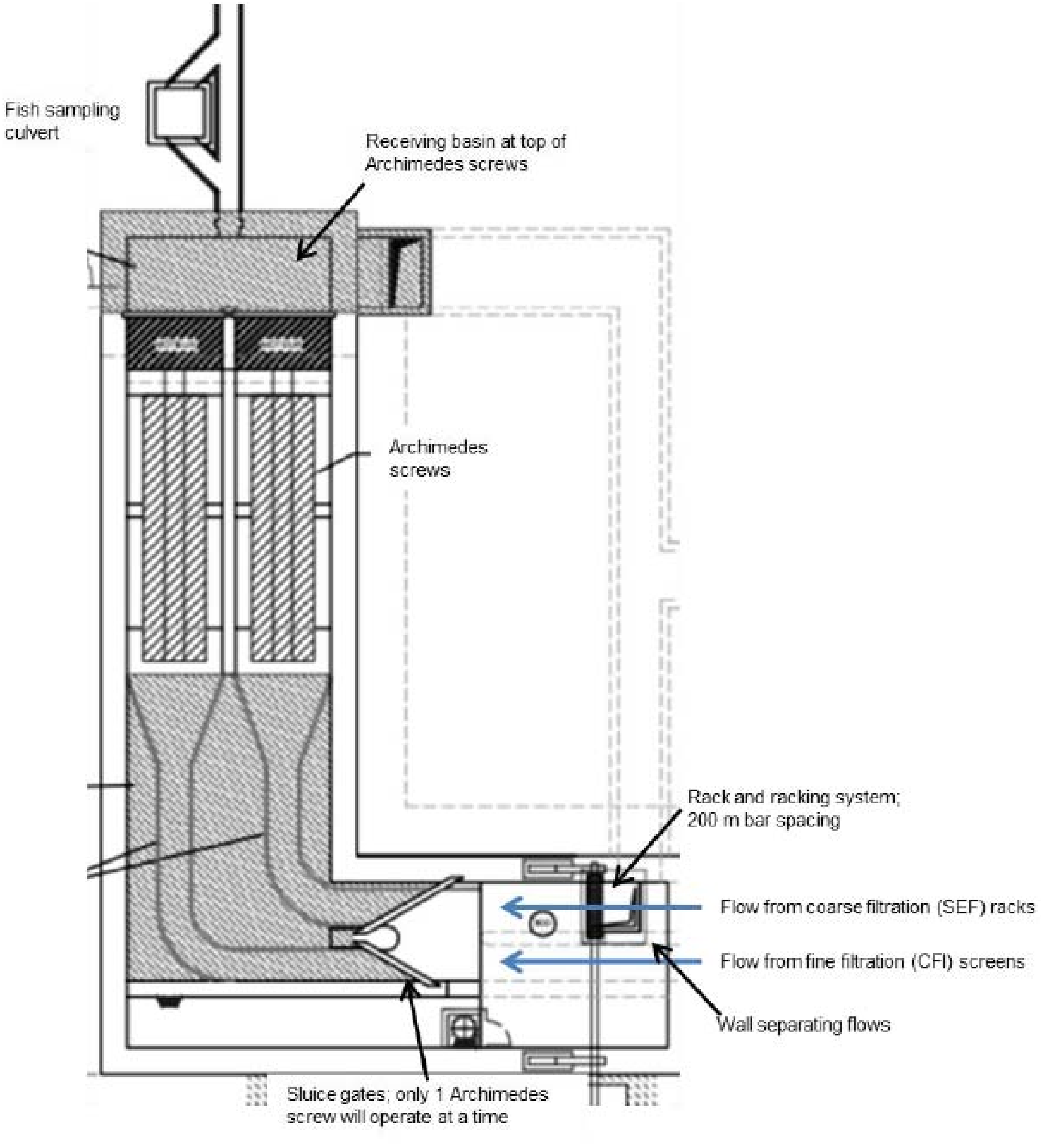

Figure 5.6 Plan view of filtering debris recovery pit leading to Archimedes screws

5.6 Behavioural deterrents

5.6.1 Consistent with the best practice requirements for behavioural deterrents provided in guidance by the EA (Turnpenny & O'Keeffe, 2005 and Turnpenny *et al*, 2010), NNB GenCo has considered a range of fish deterrent options. These included bubble curtains, strobe lighting, electric barriers and AFD systems. A summary of the technologies and the considerations that influenced selection are outlined below.

Bubble curtains

5.6.2 Air bubble curtains are formed by compressed air-fed porous or perforated pipes fixed to the sea or river bed. The rising curtain of bubbles deflects certain organisms from entering the area protected by the curtain. By laying the curtain diagonally with respect to tidal flow, organisms are deflected to one side and away from the intake. Fish deflection performance resulting from bubble curtains is generally significantly lower than for other deterrents such AFD systems and fish habituation limits their value for resident fish species (non-migratory).

5.6.3 Bubble curtains are known to suffer from poor reliability at sea, owing to fragile structures on the seabed, blockage risk and disruption by vessel activity and dredging. They are typically at high risk of storm damage owing to the exposed position of infrastructure on the seabed. Although used at a number of sheltered intake locations (e.g. Heysham), bubble curtains are not considered sufficiently robust for operating in the open and exposed marine environment at HPC. EA best practice guidance states that bubble screens may be used as a low-cost behavioural barrier in low-flowing water situations where high performance is not demanded. Fast-flowing or deep water may lead to an unacceptable breakup of the curtain's integrity, reducing effectiveness. Given the fragile nature of the structures, the requirement for effective performance and the challenging environment at HPC (elevated concentrations of suspended sediment, wave action, high tidal flows and tidal ranges), this option was not pursued further.

Light-based fish deterrent

5.6.4 Strobe light based systems can be used to minimise entrapment of fish by illuminating any physical or behavioural deterrents (e.g. bubble curtains), making them more visible to fish and allowing them to orientate themselves in relation to flow (optomotor response); and secondly, to provide an artificial stimulus to deter fish (Turnpenny & O'Keeffe, 2005).

5.6.5 Light-based fish deterrent systems are most effective against eels and have minimal effect against other types of fish. However, due to the highly turbid conditions at HPC resulting in very little or no visibility, the effectiveness of this type of deterrent is severely reduced and it is not considered to be a viable behavioural deterrent at HPC. Therefore, with regard to the HPC intake, this technology was not pursued any further.

Electric fish barrier

5.6.6 An electric fish barrier is a non-physical barrier that prevents fish passage from one location to another or induces fish movement from one area to another within a body of water using an electric current. Electric barriers use the same principle as an impressed current cathodic protection system by passing an electrical current through a conductive liquid, i.e. water, thus creating an electric field. The electric current causes a physiological reaction in fish; as fish enter the electric field they become part of the electrical circuit and experience electric current flowing through their body. As the fish approaches the anode, the electric field intensifies, which causes the fish to generally turn around and swim away from the electric barrier.

5.6.7 The set-up of an electric barrier requires a series of electrodes, alternating anodes and cathodes to span across a body of water. As the intake at HPC is situated offshore in open sea water and electric barriers are affected by water conductivity and are unsuitable for marine or brackish water environments (Environment Agency, 2010), the use of an electric fish barrier is considered not to be feasible.

Acoustic Fish Deterrent (AFD) System

5.6.8 This Section outlines the extensive work undertaken by NNB GenCo to optioneer and attempt to develop a suitable design for an AFD system at HPC. It was recognised in the application documents that provision of an AFD system would be subject to securing a supply of electricity and maintenance arrangements. The challenges associated with the design of such a system are outlined here, together with a description of the constraints that have resulted in NNB GenCo concluding that the operation and maintenance of an AFD system at the site is not viable.

5.6.9 To develop the design of the AFD system, NNB GenCo committed to an extensive programme of optioneering and design over a two-year period to develop a system that was optimised to provide a sufficiently robust technology to operate in the challenging environmental conditions at HPC. Full details of each stage of the AFD system optioneering process can be found in the AFD Optioneering report.

5.6.10 Given the complexities of developing an AFD system for application in demanding offshore environments and the challenges associated with the constructing, operating and managing this system, a multi-disciplinary team was pulled together to support the HPC Project, including specialists with experience in remotely operated vehicles (ROV) and divers. All specialists were confirmed as a Suitably Qualified and Experienced Person (SQEP) and were selected for their expertise in the given subject.

Environment and best practice requirements of an AFD system at HPC

5.6.11 AFD systems have become commonplace in recent years at large inland water abstractions where the physical screening of fish is problematic. The effectiveness of AFD systems is dependent upon the hearing ability of the fish species concerned; for example, the effectiveness of AFD systems for the deflection of salmonids is typically in the order of 50-70% whilst deflection efficiencies for low sensitivity species such as European eel and sea lamprey are significantly lower. In theory installing a greater number of SPs and increasing sound levels would increase effectiveness for all species; however, the law of diminishing returns applies.

5.6.12 During the consultation process of the CW1 report, the following key features for an AFD system were recommended by the Defra Family:

- the sound signal should be within the frequency spectrum 10 Hz – 3 kHz;

- the nature of the signal should be repellent to fish, not pure tones but either a blend of different frequencies applied as a pulse or crescendo, or a 'chirp' comprising sweep across a frequency band;
- the sound level received by the fish at the required point of deflection should be sufficiently above ambient noise level (typically at least ten times or >20 dB); and
- SPs need to be pre-pressurised or have pressure-compensation, the latter being more suitable for fixed positions in tidal waters.

5.6.13 For best results, the SPs should be located close to the intake opening, so as to yield high signal particle velocities in the paths of incoming fish (Turnpenny & O'Keeffe, 2005). The optimum number and positioning of SPs can be determined using an acoustic model such as Predictive Image Source Model (PrISM). The ideal sound field should form a steep acoustic gradient approaching the entrance, free from acoustic nulls, so fish are guided away from, and not into, the intake.

5.6.14 It was recommended that after commissioning, measurements should be taken to confirm the field characteristics and to ensure that there was no risk of deterring fish over too large an area. In addition, the signal generated may need regular (e.g. daily) changes to avoid habituation.

5.6.15 It was acknowledged by the Defra Family that it would be essential that a mechanism could be provided for bringing the SPs to the surface for maintenance without need to use divers.

5.6.16 In response to these requirements, NNB GenCo determined the key requirements for the design and installation of an AFD system at HPC would be the following features:

- the sound envelope must maintain a strong acoustic gradient with sound pressure levels (SPLs) reducing with distance from the intake screens;
- SPL generated has to be >160 dB Re 1 μPa across the whole surface of the intake screens (at the entrance to the intake heads) with minimal interference and acoustic nulls;
- SPL has to be maintained for all states of tide, demonstrated by use of an appropriate acoustic model;
- the sound signal should be within the frequency range of 30 – 600 Hz, with the capability of operating up to 2000 Hz;
- the AFD system's control system needs to be programmable, so that it can emit different sound patterns (chirp, sweep, etc.);
- to ensure the AFD system meets operational needs the AFD system design should be based on proven technologies;
- the entire AFD system (including SPs must be designed to withstand fluctuating water depths between 0 – 25 m (tide + wave height) and current speeds between 0 - 1.8 m/s;
- the entire AFD system should be powered from onshore via submarine cable(s);

- to ensure the AFD system acts as a deterrent, as planned, the entire AFD system must meet a minimum availability of 90%, including downtime for both planned and unplanned maintenance;
- the system needs to be designed to ensure operability on an 18-month replacement cycle for SPs; and
- maintenance activities of the AFD systems and associated mechanical and electrical power supply infrastructure should not interfere with, or risk damage to, the cooling water intake structures.

5.7 Engineering Optioneering Process

5.7.1 In order to examine the influence of SP location in relation to the intake head on the acoustic field generated, sound modelling was performed using PrISM software. The different SP locations and configurations modelled were to test the feasibility of two different deflection principles, which are further defined in the AFD Optioneering report.

- Deflection Principle 1: the SPs are mounted at the ends of the intake heads. This arrangement comprises mounting SPs in clusters upstream and downstream of the intakes, with the clusters either operating at both ends simultaneously or only at the upstream end.
- Deflection Principle 2: the SPs are mounted along the sides of the intakes. In this scenario, unless the SPs are mounted directly on, or very close to the intake heads, some degree of upstream deflection may be required to ensure that fish remain on the correct side of the SPs and the sound pressure gradient when they are carried towards the intake heads at higher tidal velocities.

5.7.2 The two deflection principles were modelled using PRiSM modelling software. Two different base cases were modelled, with each case subsequently being modelled in a variety of configurations in an attempt to optimise the SP layout and generate the most robust sound field.

5.7.3 The conclusion of the initial sound modelling was that Deflection Principle 2 should be taken forward, with a focus on trying to reduce the offset between the SPs and the intake head as far as possible to improve the sound field around the intakes and to maximise the probable effectiveness of the AFD system.

5.7.4 As outlined in the AFD Optioneering report, this decision was taken for the following reasons.

- Deflection Principle 1 differs from EA best practice (EA, 2005), which recommends SPs are located closed to the intake opening, forming a steep acoustic gradient, free from acoustic nulls
- All the SP configurations associated with Deflection Principle 1 performed poorly in sound modelling and did not provide an adequate sound field compared with the SP configurations associated with Deflection Principle 2, which performed well in sound modelling and provide a good sound field (on the proviso that the offset distance between the SPs and the intakes is kept as low as possible).

- The performance of Deflection Principle 1 is based on fish reacting to sound and swimming laterally to a distance great enough to avoid being able to drift back towards the intake. Given the high and fluctuating current speeds at the HPC intake location, not only does this lead to a very large sound field envelope requirement (long at high current speeds to provide sufficient upstream deflection and wide at low current speeds to provide sufficient lateral deflection), but it is also reliant on being able to accurately predict both the fishes' swimming direction and speed in response to the sound and there is no available evidence that this technique would be effective.
- There are currently no operational AFD systems based on Deflection Principle 1. In addition, the AFD at Doel initially had the SP arrays mounted away from the intake heads and proved ineffective, with the current performance levels only being attained once the SPs were relocated on to the intake heads.

5.7.5 Following conformation of the deflection requirements, the optioneering process was progressed focussing on key areas identified at **Table 5.1** below.

Table 5.1 NNB GenCo Criteria for viability of engineering options against NNB requirements for an AFD system at HPC

Criterion	Comment
Location of the SPs for acoustic field generation	
Two different sound projector locations and configurations were modelled using PRiSM software to test the feasibility of mounting sound projectors.	The selected deflection principle (2) (see the AFD Optioneering report) accommodated the SPs being arranged in a single row parallel to the intake screens. Two offset distances were selected to evaluate the general sound field generated by the SPs: • a close proximity scenario where the projectors are mounted 2.5 m from the intake head foundation chamber; • an offset proximity scenario where the SPs are mounted 8 m from the intake head. Sound modelling of various offset configurations confirmed that both offset distances generated strong sound fields over the intake screens; however, the offset proximity resulted in decreasing sound pressure gradient between the SPs and the intake heads. Mitigation would require additional SPs to deflect fish onto the correct side of the sound field to avoid fish being 'funnelled' towards the intake. The preferred configuration from the Deflection Principle 2 scenario was therefore the 2.5 m offset. Further work was subsequently undertaken to confirm opportunities to mount the SPs nearer to the intake heads

Criterion	Comment
AFD system sound projector mounting structures	
To determine the most appropriate option that will: 1 Minimise the impact on the intake head structures, as these are nuclear safety classified, therefore the AFD system must not in any way impact on the intake heads' capacity to draw the safety critical flow rate.	In relation to criteria 1 and 2: 12 structural options were examined, with 5 options progressed to detailed optioneering stage for more detailed review of viability against the considerations noted opposite. Subsea discrete lightweight structures supported by posts cast into the intake heads was considered the most viable option and the best solution overall. The key advantages of this option are: • lowest footprint and impact on intake hydraulics of all the solutions with greatest potential for mounting the structures close to the intake screens to achieve an effective sound field; • small size and low mass mean that the structures do not require seismic qualification; and • similar to structures used extensively in the oil and gas industry, meaning less technological risk as the technology is already proven in another industry and is not the first of a kind. Acknowledging that the maintenance challenges would need to be addressed, this option was the only design that allowed the SPs to be mounted close enough to the intake heads to provide effective fish deterrence and the most acceptable from a nuclear safety perspective with regard to the impact of having large, heavy structures around the intake heads. Further design development was recommended in relation to analysing the interface between the AFD system SP structures and the intake heads in greater detail to enable the integration of the AFD system with the intake head structures and ensure that the AFD system SP structures did not hinder access for maintenance of the intake heads. It was also recommended that opportunities were taken to site the SPs as close to the intake screens and with as regular a spacing as possible (i.e. fewer discrete clusters) to generate the best possible sound field.
2. Minimise the impact on intake head hydraulics, to ensure that the smooth, low turbulence, low velocity intake profile as close to 0.3 m/s as possible is not disrupted. The solution should therefore avoid restricting the inlet screens and disrupting streamlines or creating turbulence as far as possible.	The CW1 report confirms the intake heads will achieve an approach velocity of 0.3 m/s along the whole length of the intake most of the time. Further design development was recommended in relation to minimising the impact of the AFD system SP structures on intake hydraulics.
3 Maximise the performance of the AFD system in deterring fish, to provide a higher level of performance than the target levels in order to avoid the risk of the system falling short of requirements.	A large number of AFD system SP configurations were assessed and modelled to determine effectiveness. This demonstrated that optimal performance is achieved through placing the SPs close to, and in front of, the open faces of the intake heads rather than placing them upstream to achieve a deflection-based deterrent.

Criterion	Comment
4 Facilitate maintenance. As the AFD system is situated offshore in an area with high tidal ranges and currents, access for maintenance is challenging and requires the use of marine vessels. This exposes personnel to a hazardous environment. In addition, the minimum required availability for the AFD system is 90% and although specific reliability data for the system components is not available, the operating experience from sites with significantly less challenging environmental constraints suggests that frequent maintenance will be required. Therefore, a system which facilitates easy and safe access to the AFD system is deemed highly advantageous.	The further review of the challenges associated with maintenance of the selected option is provided later in this section. Further work was recommended to minimise the number of SP clusters to facilitate maintenance of the AFD system.
5 Maximise availability. This criterion is strongly linked to maintenance as a system which is designed for maximum reliability not only increases availability (which is set at ≥90% for HPC), but also reduces the need for maintenance operations.	Operational feedback from AFD system SP market leaders and current operators suggests a maintenance frequency (every 6 – 12 months) that is suboptimal and could not be safely achieved in the HPC context. It is critically important that any design achieves a maximal availability of SPs and length of time between maintenance tasks, in order to reduce risks posed to workers carrying out the maintenance activities in this harsh offshore environment.
6 Good track record/minimal risk. There are currently a limited number of AFD systems that have been installed, and as far as known none in a configuration similar to HPC where the majority of the components are located offshore. The proposed equipment available will require to be modified to suit this application. A solution which minimises any modification may be considered as involving less risk	A summary of operational experience associated with AFD systems is provided at Table 5.3.

Criterion	Comment
7 Maximise expandability /future proofing. The AFD system is to be designed to operate for 70 years. It is, therefore, likely that the system may be subject to alterations sometime in the future for a variety of reasons, including: • improvements in technology, • component obsolescence; and • suppliers exiting/entering the market. Additionally, the system may require to be expanded if the installed number of sound projectors does not achieve performance targets.	Consideration of the availability of AFD system technology suitable for application in the marine environmental is provided at section 0 *et seq*.
8 Minimise Capital Expenditure (CAPEX), subject to satisfying the above criteria.	Given the limitations of the selected option, this matter is not subjected to further consideration.
Electrical power supply/distribution and communications	
A constant and reliable power supply is required, which may include onshore and offshore options.	A range of options was considered, including: • shore derived power supply with either subsea or platform mounted electrical equipment (transformers, etc.); • offshore platform mounted diesel generators; • marine turbine, wind turbine and photo-voltaic (solar) with offshore battery and distribution platform; and • autonomous buoys with photo voltaic panels and wind generators. A shore derived power supply was judged to be the only proven, low maintenance technology that could reliably provide the large amounts of power required (of the order of 250 kW total). The most viable power supply network consists of a shore-based power source linked to a monopile central hub by submarine cable capable of carrying a 10 kV 3 phase high voltage power supply. However, given the size and scale of the AFD system at HPC and the large number of SPs, routing and managing all the cables required for power and communications from the monopile to each intake head and then down to the individual SP clusters and then each discrete SP represents a real challenge, especially in terms of reliability, to which solutions would need to be found.

Criterion	Comment
Shore crossing (the connection between the power supply on land and the submarine cable feeding the AFD)	
Determine the position of the electricity supply network that connects the power supply on land and the submarine cable connecting the AFD system and technique for installing the cables.	The optioneering completed identified that the most viable method for installing the section of the AFD system power supply that crosses the shore is horizontal directional drilling, due to the reduced environmental impact compared with the alternative approach, conventional trench excavation and backfilling.

5.7.6 One of the key areas of interest for this assessment was the mounting structures. As outlined in the AFD Optioneering report, twelve options were considered in Phase 1 of the Optioneering Process. Five options were progressed to Phase 2 of the process. **Table 5.2** summarises the options considered and the basis for not pursuing these options further.

Table 5.2 NNB GenCo Criteria for viability of engineering options against NNB requirements for an AFD system at HPC

Option No	Mounting Structure Option	Justification for not Pursuing Further
Options rejected during Phase 1 of the Optioneering Process		
1	SPs suspended from subsea buoy and weighted by clump weight on sea bed	In order to maintain line tension between the buoy and the clump weight to minimise the effect of the tidal current on the SPs the buoy must remain at least partially submerged at all times. As the SPs have to be suspended approximately two metres above the seabed no advantages can be seen for this option over mounting them on a rigid structure.
2	SPs suspended from surface buoy	As the tidal range at the HPC intake location is over 13 m, the buoy will move markedly with the tide. To design the buoy system and mooring so that the buoy would not affect the inlet head under extreme conditions would present design challenges and offered no advantages over mounting them on a rigid structure

Option No	Mounting Structure Option	Justification for not Pursuing Further
3	SPs on articulated arms	This option would enable the sound projectors to be lifted out of the water for maintenance. However, the system has numerous drawbacks: - this is a complex subsea pivot structure; - the structure would be susceptible to marine growth jamming the mechanism; - the large structure could impact intake hydraulics; and - structural collapse could impact on the intake heads.
4	SPs mounted on tie-bars cast into intake head, installed with quick release fittings]	This option would require subsea diver or ROV intervention for maintenance. Access to the sound projectors and associated cabling would be restrictive. Any damage to the intake head concrete (safety classified) would be difficult to repair and expanding the system or repairing/replacing damaged or corroded tie-bars would be extremely challenging. Diver or ROV intervention to a vessel for maintenance.
5	SPs mounted on the underside of shallow bottomed barge	The barge would be held in position by a mooring system utilising mooring chains, with one barge per intake head. However, this system has numerous drawbacks including: - only 2.7 m clearance with the top of the intake head at LAT. Even for a shallow bottomed barge if LAT coincided. On this basis, with anything but very small waves, the barge would impact the head; - the sound field over the heads would also vary greatly with the tidal fluctuations.
6	Modify intake head nose to incorporate AFD	A maintenance access hatch would be provided to improve the streamlining of the head and minimise the impact on the intake velocity. As this configuration aligns with Deflection Principle 1, the AFD system in this location would be unable to generate an effective sound field and intake head design would require major modification.
7	Sound projectors mounted on top of the intake head	Due to the location of the sound projectors, the generated sound field is unlikely to be sufficient. This will be particularly relevant during particularly at low water, due to the proximity of the sea surface not allowing the sound field to establish.

Option No	Mounting Structure Option	Justification for not Pursuing Further
Options rejected during Phase 2 of the Optioneering Process		
8	Subsea gravity base mounting structures, sound projectors being held down by own weight	Gravity bases cannot be mounted on the intake head foundation chamber, resulting in a sub-optimal sound field. The area immediately around the foundation chamber is back-filled with suitable material such as rock, which would create potential stability issues for the gravity base. Moving the gravity bases out of the back-filled area would further reduce their proximity to the head and the effectiveness of the sound field. The sound projector units would be retrieved with diver or ROV intervention to a vessel for maintenance.
9	Subsea beam structure anchored to intake head foundation chamber	The piles of this additional structure would transmit very high loads to the intake head foundation chambers, impacting the seismic response and integrity of the intake heads. The sound projector units would be retrieved with diver or ROV intervention.
10	Subsea discrete lightweight structures	This option was deemed viable and to be the best solution overall for the reasons outlined in the AFD Optioneering report.
11	Subsea piled beam structure	The large footprint and the need to seismically qualify the beam structure (given its size, mass and location). The structure also has a greater impact on intake hydraulics and therefore reduces the potential for mounting the SPs close enough to the intake screens to achieve an effective sound field. The SP units would be retrieved from the beam with diver or ROV intervention to a vessel for maintenance.
12	Non-subsea piled structure	This option would enable the sound projectors to be lifted out of the water for maintenance. However, the system has numerous drawbacks: - potential for disruption in the event of jamming or malfunctioning of the buoyant structure; - the concept design would be challenging to install given the size of the structures - the concept design has a very large footprint which would have a high impact on intake hydraulics and greatly reduce the potential for mounting the SPs close enough to the intake screens to achieve an effective sound field - the structures would need to be seismically qualified due to their size and proximity to the intake heads This system can only be installed if it can be prevented from collapsing and damaging the intake heads.

5.7.7 The AFD Optioneering report details the most viable AFD system configuration for HPC. In summary, the proposed AFD system would be made up of six SP clusters per side with six SP on each cluster equating to 12 SP clusters per intake head and 48 SP clusters in total for the four intake heads. This is a total of 288 individual SPs. The SPs clusters would be arranged in a single row parallel to the intake screens mounted below the intake screens. In order to allow the SPs to be mounted close enough to the intake heads to provide effective fish deterrence whilst maintaining nuclear safety (with regards to the impact of having large, heavy structures around the intake heads), a system of subsea discrete lightweight structures supporting the SP clusters would be mounted below the intake screens at an offset distance of 0.5 m (**Figure 5.7**).

5.7.8 This configuration of SP clusters was obtained through a detailed review and modelling of species' reaction levels with audiograms for the hearing sensitivity thresholds determining the sound levels necessary to achieve the required efficiencies. The AFD system proposed, therefore, targets an SPL of 160 dB across the intake head to increase the likelihood of the AFD achieving its required efficiency target for the percentage of fish deflected.

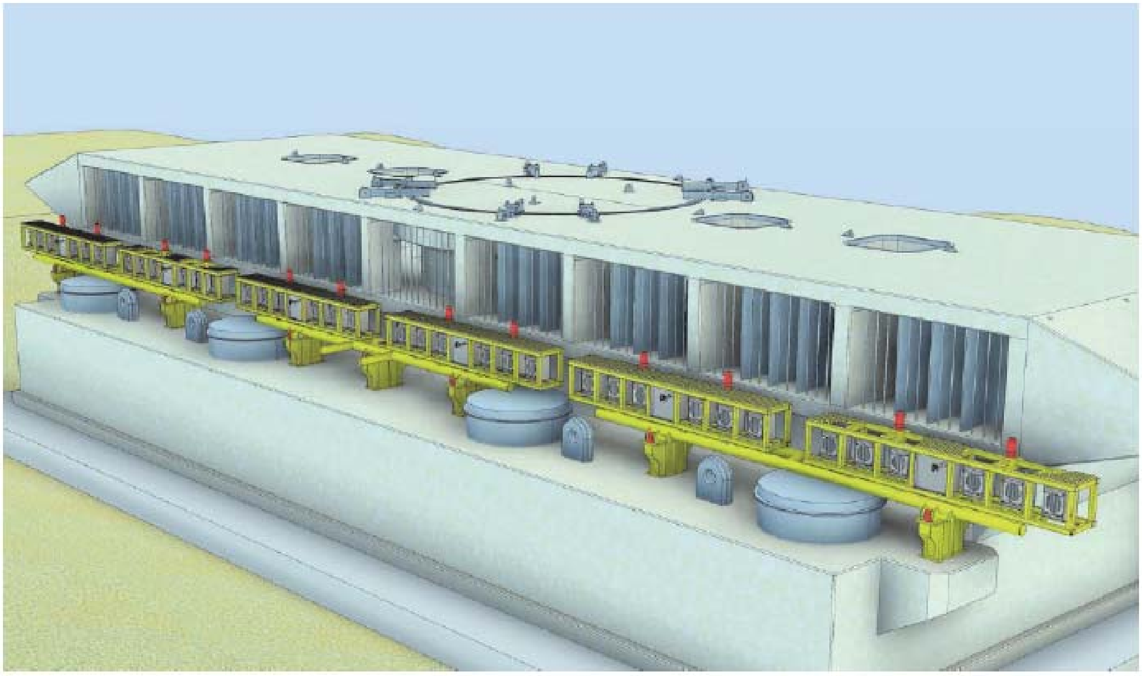

Figure 5.7 Plan and profile view showing siting of SP clusters next to intake structure

5.7.9 The optioneering process identified that the most viable AFD system power supply network would consist of a shore based power source linked to a monopile central hub by submarine cable capable of carrying a 10 kV 3 phase high voltage power supply. Given the size and scale of the AFD system at HPC and the large number of SPs, routing and managing all the cables required for power and communications from the monopile to each intake head and then down to the individual SP clusters and then each discrete SP represents a real challenge, especially in terms of reliability, to which solutions would need to be found.

5.7.10 As outlined at **Table 5.3**, a number of conclusions were reached that required further consideration to confirm that the operation of an AFD system would be feasible at HPC.

5.7.11 These included the following.

- **Availability of an effective AFD system for HPC** - there is only one SP supplier on the market with commercial scale installations that have proven efficiency in deterring fish. The technologies have not been used for offshore marine cooling water intakes with challenging environmental conditions similar to those experienced in the Severn Estuary.
- **Maintenance requirements** – the AFD systems reviewed at Doel nuclear power station and Pembroke Combined Cycle Gas Turbine (CCGT) power station require frequent cleaning and replacement in environmental conditions that are far more benign than those encountered at HPC. Although these SP systems are less extensive than the proposed arrangements at HPC, the maintenance requirements are nevertheless extensive. Ease of access to the SPs is also easily provided. The SP technology will require significant design development and improvement both to render it suitable for the conditions at HPC and also to extend the service life to an interval which is compatible with the scale of the plant and the limited access. However, even if this were achieved, it would still mean exposing personnel to frequent maintenance operations in hazardous conditions.
- **Accessibility of the AFD system for maintenance** - During the pre-optioneering and optioneering phases, different AFD system structure types were analysed with both surface and subsea ROV or diver retrieval of SP clusters. However, none of the surface retrieval structural options was found to be feasible for implementation at HPC, from both a technical and acoustic field perspective. Although the retained concept (subsea discrete lightweight structures) presents a greater challenge in terms of maintenance due to the requirement for diver or ROV intervention, it was the only solution allowing the SPs to be mounted close enough to the intake heads to ensure effective fish deterrence, while presenting an acceptable nuclear safety impact with regard to having large, heavy structures around the intake heads.

5.7.12 These aspects are considered in further detail below.

Use of AFD system for water abstraction intakes

5.7.13 A detailed literature review to confirm the nature and extent of the use of AFD systems at other water abstraction intakes was undertaken, with a summary provided in **Table 5.3**.

5.7.14 During the optioneering process NNB GenCo conducted extensive research and analysis of potential AFD system suppliers. The conclusions of the supplier research and analysis exercise was that the number of viable suppliers is extremely limited. Given the scale and complexity of the Project and the severe environmental conditions encountered in the estuary, it became absolutely clear that no supplier (even those with previous experience) is currently able to meet all of the minimum criteria.

Table 5.3 Water intakes employing AFD systems and comparison with HPC conditions

Development	Abstraction rate	Intake type	Intake location	Water body	Comments
HPC (proposed)	**130 m^3/s**	**Offshore seabed**	**Open estuary**	**Severn Estuary, UK**	**Intake approximately 3 km offshore, 2 m above seabed and in an area of high water velocity and extremely turbid conditions. 288 SPs are proposed to be located within 0.5 m of intake screens.**
Other power stations					
Doel Nuclear Power Station (3 & 4)	25.1 m^3/s	Estuary bed	Estuary / tidal river	Scheldt Estuary, Doel, Antwerpen, BE	Intake in 5 m of water with intake apertures 2 m above the sea bed. Intake located at 200 m (maximum) from the shore (note HPC proposed cooling water intakes are over 3 km offshore). 20 SPs installed on a rail system for above-water recovery for maintenance.
Hartlepool Nuclear Power Station	34 m^3/s	Bankside	Estuary	Seaton Channel, inside Tees Estuary system, Teesside, UK	Onshore intake, short dredged channel opens into Seaton Channel. Total of eight SPs deployed approximately 40 m upstream from intake.
Oldbury Nuclear Power Station (closed)	25.5 m^3/s	Bankside	Tidal reservoir	Severn Estuary, UK	Trial period of 14 days only. Sub-standard system used with limited results.
Great Yarmouth CCGT Power Station	9.3 m^3/s	Bankside	Estuary	River Yare, Great Yarmouth, UK	8 SPs in total
Marchwood CCGT Power Station	15 m^3/s	Bankside	Estuary	River Test, Marchwood, UK	Onshore intake on the estuarine part of a river, width of river approximately 0.7 km across. A total of eight SPs arranged in four columns are deployed.
Pembroke CCGT Power Station	40 m^3/s	Bankside	Estuary	Channel off Pembroke River, inside Milford Haven, Wales, UK	72 SPs are mounted on buttresses that separate inlet gates. The SPs are mounted on sliders and vertical rails for easy access for maintenance from the shore.
Shoreham CCGT Power Station	5.6 m^3/s	Bankside	Estuary	Harbour off River Adur, Shoreham, UK	Intake inside enclosed harbour. 6 SPs in total.
Staythorpe CCGT Power Station	1.3 m^3/s	Bankside	Non-tidal river	River Trent, near Newark, UK	River width approximately 100 m

Development	Abstraction rate	Intake type	Intake location	Water body	Comments
Lambton Power Station coal (closed)	150 m^3/s	Bankside	Non-tidal river	St Clair River, Ontario, Canada	Intake channel off inland river approximately 500 m wide.
Plant Barry (Units 4 & 5) coal and gas generating plant	30 m^3/s	Bankside	Tidal river	Canal off Mobile River, Bucks, Alabama, USA	Trial deployment only at intake on 100m wide canal off major inland river.
Fawley Power Station (oil) (closed)	31 m^3/s	Bankside	Estuary	Channel off Southampton Water, UK	Channel off Southampton Water, which is approximately 3 km wide at this point
Flood Pumping Stations					
Foss Flood Barrier Pumping Station	32 m^3/s	Bankside	Non-tidal River	River Foss, York, UK	Bankside intake on river channel 16-28 m wide at the intake location, six SPs in total.
Hydro-electric plants					
Backbarrow Hydro-electric Plant	10 m^3/s	Bankside	Non-tidal river	River Leven, Cumbria, UK	Bio-acoustic fish fence (a combination of a bubble curtain and sound projectors) used in headrace channel in spring to deflect salmon smolts into a by-wash.
Beeston Hydro-electric plant	60 m^3/s	On weir	Non-tidal river	River Trent, Nottingham, UK	River a maximum of 80 m wide above weir. Bio-acoustic fish fence (a combination of a bubble curtain and sound projectors) used above intake to deflect fish into a by-wash.
Blantyre Hydro-electric Plant	20 m^3/s	On weir	Non-tidal river	River Clyde, Hamilton, Scotland, UK	River a maximum of 100 m wide above weir. AFD system used to deflect fish towards the fish ladder.
Tummel Bridge Hydro-electric Plant	>100 m^3/s	Bankside	At reservoir dam	Dunalistair water, Perth and Kinross, Scotland, UK	Reservoir approximately 80 m wide at dam. AFD system used to deflect fish towards the fish smolt return by-wash.
Annapolis Royal Generating Station	400 m^3/s	Barrage	Estuary	Annapolis, Bay of Fundy, Nova Scotia, Canada	Trial deployment only
Potable water abstraction locations					
Barcombe potable water intake	0.845 m^3/s	Bankside	Non-tidal river	River Ouse, near Lewes, Sussex, UK	Inland bankside intakes on tidal rivers less than 100 m wide, with sheltered conditions and easy access to AFD system.
Canaston potable water intake	0.7 m^3/s	Bankside	Non-tidal river	Eastern Cleddau, Narberth, Wales, UK	

NOT PROTECTIVELY MARKED

Development	Abstraction rate	Intake type	Intake location	Water body	Comments
Farmoor Reservoir potable water intake	2.7 m^3/s	Bankside	Non-tidal river	River Thames, near Oxford, UK	Inland bankside intakes on non-tidal rivers less than 100 m wide, with sheltered conditions and easy access to AFD system.
Datchet potable water intake	24 m^3/s	Bankside	Non-tidal river	River Thames, Datchet, UK	
Hythe End potable water intake	3.2 m^3/s	Bankside	Non-tidal river	River Thames, Staines, UK	
Laleham potable water intake	12 m^3/s	Bankside	Non-tidal river	River Thames, Laleham, UK	
Walton potable water intake	14 m^3/s	Bankside	Non-tidal river	River Thames, Walton-on-Thames, UK	
Hampton potable water intake	5.8 m^3/s	Bankside	Non-tidal river	River Thames, Hampton, UK	
Surbiton potable water intake	2.7 m^3/s	Bankside	Non-tidal river	River Thames, Surbiton, UK	
Kilgram Bridge potable water intake	0.54 m^3/s	Bankside	Non-tidal river	River Ure, Masham, Yorkshire, UK	

5.7.15 As can be seen from **Table 5.3**, no other development that has used an AFD system has the same environmental conditions faced by HPC. All developments that have employed an AFD system have used a bankside or onshore intake, except for Doel Nuclear Power Station. The number of SPs required for a bankside intake is significantly fewer than the number proposed for HPC, with Pembroke CCGT power station having the most SPs (72 in total). Installing an AFD system at a bankside intake poses far fewer issues than for an offshore intake. Fewer SPs are required and, given the proximity of the intake to the shore, most SPs can be installed on rails for ease of removal and maintenance conducted on land.

5.7.16 As part of the optioneering process, a review of the AFD systems installed at Doel nuclear power station and Pembroke CCGT power station was undertaken to examine reliability, redundancy and maintenance requirements and to understand lessons learned from the operation of the system. These sites were selected as they are the only known power station sites in Europe with operational AFD systems on a commercial scale on cooling water abstractions. Additionally, out of all the power stations that have AFD systems installed, Doel is the one that is the closest in design to HPC with regard to the location of intakes (albeit the station does not use once-through cooling like HPC, therefore abstraction is on a much smaller scale than proposed at HPC).

5.7.17 The findings of the assessment are provided at **Table 5.4** below.

Table 5.4 Comparison of HPC AFD system with Doel nuclear power station and Pembroke CCGT power station

Consideration	HPC	Doel nuclear power station	Pembroke CCGT power station
Location and intake distance from shoreline	Severn Estuary, 3 km from the shoreline	Scheldt Estuary, 50-200 m from the shore depending on tide	Milford Haven. Bankside intake on inlet off Pembroke River is accessible on foot
Sound projector systems	288	20	72
SP retrieval	Subsea by diver or ROV	Surface: manual winch, carriage rail system	Surface: motorised rail-mounted gantry crane
Maintenance schedule	18 months	6 monthly cleaning schedule to remove biofouling	9 monthly cleaning
Refurbishment frequency	18 months (target)	12 months	15 months
Maintenance duration		2-3 days every 6 months	
Redundancy	>16% though further sound modelling is required more accurately to define redundancy	No redundancy though the system is oversized. Fish are deterred even when some projectors are not working depending on location of failed SPs	25%

Lessons learnt	Effective deflection is associated with proximity of the SPs to the intake structure Effective cleaning schedule / special measures are required to control biofouling. For an AFD system, the SPs represent the majority of the maintenance burden and are generally replaced around once every 12 months. However, even at this replacement rate, unexpected failures still occur. This may be a more significant issue at HPC given the environmental conditions. Unexpected failure occurs associated with the cable connectors to the SPs and the SP's internal pressure compensation bladder. Maintenance of the AFD system is a very significant undertaking. Given the larger scale of the AFD system which would be required at HPC, the need to operate in harsher environmental conditions and the restriction of accessibility arising from the offshore location, the maintenance burden of the HPC AFD system is anticipated to be significantly greater than at any other site.

5.7.18 In conclusion, it has been determined that there are no AFD systems installed at seawater intake heads under the same, or even similar, conditions to those prevailing at HPC.

Maintenance Requirements

5.7.19 Details of the AFD system maintenance required is described Section 7 of the AFD Optioneering report. Below is a summary of the maintenance requirements and challenges posed.

5.7.20 As outlined above, the engineering optioneering phase sought to ensure that the selected AFD system accommodated SP mounting structures and retrieval modes that were considered viable in engineering terms at HPC. Following confirmation of the preferred design the detailed maintenance requirements of this system were considered to enable an effective maintenance schedule to be determined.

5.7.21 The exact requirement for the maintenance of the AFD system is dependent on the type of equipment supplied, once all design and testing has been finalised. However, it is envisaged that the following will be the main inspection and maintenance activities regardless of the type of equipment being used:

- maintenance and testing of the offshore monopole central hub and equipment; and
- SP maintenance and replacement.

5.7.22 In addition, maintenance of the supporting elements of the AFD system will also be required, such as the repair and replacement of the following elements:

- the structural frame that supports the SP clusters;
- electrical equipment and cabling; and
- submarine cabling, either from the hub to the intake head locations, or from the shore-based power supply to the distribution hub.

5.7.23 The maintenance schedule for all the various systems comprising the AFD system varies, ranging from every six months to every 10 years. In general, the maintenance and replacement of an individual SP unit (based on trials carried out at other power stations that operate an AFD system) is once every 12 months. However, the harsher conditions at HPC would put a greater strain on the equipment, requiring more frequent maintenance and replacement to avoid failure. This would require an existing SP design currently available on the market to be redesigned to raise the reliability of the SP units sufficiently to increase maintenance frequency up to 18 months (there is no guarantee that the maintenance frequency could be increased to every 24 months).

5.7.24 Discussions with the suppliers has determined that there is currently no SP on the market that can withstand a maintenance schedule of every 18 months and withstand the environmental conditions found at Hinkley Point.

5.7.25 **Table 5.5** summarises the anticipated maintenance requirements of the AFD system at HPC.

Table 5.5 Summary of inspection and maintenance requirements

Activity	Frequency	Accessibility	Comments
Offshore monopile central hub and equipment			
Visual inspection and testing of offshore monopile central hub and equipment	Every 6 months	Mobilisation of a vessel and crew. Divers would be mobilised depending on the results of surveys.	Visual inspection would be carried out by a remotely operated vehicle (ROV), with maintenance, testing, and replacement of parts carried out using divers, ROVs, and suitable vessels for lifting out of system parts.
Maintenance and testing of the offshore monopile central hub and equipment	Every 12 months	Mobilisation of a vessel and crew. The vessel mobilised would be larger than that needed for the six-monthly maintenance activities due to the need to transport parts and lifting equipment to the monopile location.	Visual inspection would be carried out by a remotely operated vehicle (ROV), with maintenance, testing, and replacement of parts carried out using divers, ROVs, and suitable vessels for lifting out of system parts.
Major maintenance of offshore monopile central hub and equipment	Every 10 years	An underwater survey would be carried out by ROV. Repair or replacement of underwater elements may be required depending upon the survey results. For the underwater work a dive vessel, a support vessel and a transfer vessel would be required.	Visual inspection would be carried out by a remotely operated vehicle (ROV), with maintenance, testing, and replacement of parts carried out using divers, ROVs, and suitable vessels for lifting out of system parts.
SP replacement			
SP replacement	12 - 18 months	Mobilisation of a vessel, crew and diving team or ROV.	Replacement frequency is dependent on findings of the sound projection development and testing reqime that would confirm maintenance requirement. NNB GenCo would use a vessel to deploy divers or ROV. The diver or ROV would locate the SP cluster of six SPs, attach the necessary lifting gear and then the lifting gear aboard the vessel would raise the SP cluster on to the vessel deck. Given the EPR outage strategy, this activity would be likely to be required to take place when the plant was operational.

Activity	Frequency	Accessibility	Comments
AFD system component repair - examples			
Structural frame that supports the SPs	Not possible to anticipate	Mobilisation of a vessel, crew and potentially diving team and/or ROV	The repair and replace operations would require substantial mechanical intervention
Submarine cabling	Not possible to anticipate	Mobilisation of a vessel, crew and potentially diving team and/or ROV	
Electrical equipment and cabling	Not possible to anticipate	Mobilisation of a vessel, crew and potentially diving team and/or ROV	

Challenges to AFD system maintenance at HPC

5.7.26 The AFD Optioneering report, considered the challenges associated with the maintenance of the AFD system, given the offshore environment at HPC. Offshore lifting operations, diving or ROV use require specific weather conditions and sea state to be conducted safely. This prevents any maintenance being carried out during the winter months due to the predominant adverse weather conditions found during this period and potential for lengthy downtime in between occasional good weather conditions. As outlined in the guidelines provided by the International Marine Contractors Association (IMCA), the allowable limit for divers performing light work is 0.5 m/s of water velocity. ROVs are capable of working in greater water velocities up to 1.3 m/s, with several manufacturers developing ROVs capable of working in water velocities of 1.5 to 2.0 m/s. However, these are not yet commercially available. It is important to note that water velocity at HPC can reach up to 1.5 m/s.

5.7.27 This results in a seasonal constraint that will restrict opportunities for the maintenance and repair of components of the AFD system. Options to refine the SP replacement strategy were investigated, though with other safety considerations in place, it was confirmed that only one SP cluster could be replaced per day. This would require 72 days to undertake one round of SP maintenance. This timescale does not take into account any downtime due to the weather.

5.7.28 The maintenance requirements for the AFD system present significant challenges. The AFD Optioneering report provides full details of all the options for maintenance. These are summarised below.

- Current market-available SPs require a maintenance window of 12 months, with research and development (R&D) required to develop a SP that requires maintenance every 18 months or longer.
- SP maintenance relies on using divers and, if possible, ROVs. The conditions found at HPC present a great risk for divers – the zero-visibility environment increases the risk of diver/ROV umbilical entanglement causing potential harm to the divers or damage to the ROV/intake structures.
- The tidal window for using divers for maintenance is approximately one hour per tidal cycle, which does not provide adequate time to replace one SP.
- The visibility conditions at HPC will severely limit the effectiveness of standard ROV cameras and, therefore, a high reliance on sonar systems will be required.

There is no existing ROV currently on the market that operates with the addition of sonar. The ability of the manipulation tasks to be carried out by the ROV using sonar in the conditions at HPC would require extensive testing; the use of ROVs in zero visibility environments results in a high risk of entanglement between the ROV, its tether and the structure. Should entanglement or entrapment of the ROV occur, its recovery would be restricted by the tidal velocities and visibility conditions. This also poses a risk to the intake heads.

- It has been calculated that in total 72 days are required to undertake a single round of maintenance; however, this does not take into account any adverse weather conditions and, therefore, given the predominant weather conditions for the Bristol Channel, it is highly likely that there will not be 72 days in the year suitable for SP maintenance; and
- Use of a maintenance vessel poses a risk to the safety classified intake head structures and to date no solution has been found to mitigate the risk of vessel mooring lines affecting or interacting with the intake heads.

5.7.29 As explained above (and within the AFD Optioneering report), it is not possible to pre-empt the future development of ROV technology capable of performing the necessary tasks during SP maintenance at HPC. Even if ROV technologies became available there would still be occasions where use of ROVs would not be practicable and diving operations would be required. On this basis, NNB GenCo undertook a feasibility review of the diving operations that would be required at HPC, which were heavily based on lessons learned from the 2017 unexploded ordnance (UXO) survey, undertaken within the area of the proposed intake locations. Key considerations and constraints that have informed the feasibility assessment for diving operations are outlined below.

- Diving operations for maintenance activities associated with the SP clusters would involve a diver being deployed from the dive vessel. The diver would be connected to the dive vessel via an umbilical cord which carries communications and air supply.
- A second diver would remain onboard the dive vessel, in a basket, to be deployed in the case of emergency. Divers would be fitted with sonar equipment. Images would be relayed to the operator on board the dive vessel who would guide the diver.
- The dive vessel would be supplied with a decompression chamber as evacuation from this location to a shore-based decompression chamber would take longer than the two hours limit.

5.7.30 Diving in zero visibility conditions presents major difficulties. As outlined in the AFD Optioneering report, the diver would need to be equipped with sonar equipment due to the reduced underwater visibility experienced at Hinkley Point. The quality of the images provided by acoustic cameras are fairly accurate, though these do not give any perspective and are difficult to interpret with relation to the distance. When the diver is in position, the task can only be performed by touch.

5.7.31 The risk of entanglement described for ROVs described above is also relevant to diving operations. As the diver will be working in close proximity to the active intake head, there is a significant risk of entanglement with the AFD system structure or intake head, or entrapment on the intake heads itself. This risk is heightened due to the low visibility conditions.

AFD system safety review

5.7.32 NNB GenCo has undertaken assessments to assess the safety risks associated with the installation, operation and maintenance of the potential AFD system throughout its design lifecycle. To this end, NNB GenCo appointed Bureau Veritas to undertake an independent review of the AFD system optioneering work and associated safety documentation. The purpose of the review was to:

- appraise the safety risks associated with the installation, operation and maintenance of the preferred AFD system design, considering the hazards associated with working in the marine environment of the Severn Estuary;
- provide an independent view as to the relative suitability of the selected design, in terms of safety risks, when compared to the other options considered during the optioneering phase; and
- quantify the safety risks of the selected design and assess these in comparison with industry standard tolerability thresholds.

5.7.33 The scope of the reviews undertaken included the risks associated with the construction, operation and maintenance of the selected AFD system option. Full details of the outcome of the review process can be found in the AFD Safety report.

5.7.34 The findings of the assessment confirm that:

- for the preferred AFD option, divers are within the most at-risk worker category;
- risk during AFD system installation and maintenance is the major contributor to overall fatality risks in all activities that involve at least some diving;
- the fatality risks associated with the maintenance of the AFD system lie marginally below the unacceptable threshold for the individual risk of workers;
- for the preferred AFD system option, all offshore workers will be subjected to individual risks of fatality per annum of less than 10^{-3}, with divers subjected to 9.2×10^{-4}; and
- over the course of a 70-year plant lifetime it is estimated that NNB GenCo could expect 0.39 fatal injuries associated with AFD system installation, maintenance and operation.

5.7.35 It should be noted that as an Employer for the purposes of the Health and Safety at Work Act 1974, NNB owes a duty to employees (this definition also includes contractors) to reduce risks to as low as reasonably practicable. NNB GenCo considers that installing ad AFDS system that has not significant benefit, the maintenance of which will inevitably expose divers to risk, is not compatible with this duty.

6 CONCLUSIONS

6.1.1 The scope of this report was to demonstrate that a CWS at HPC designed with a LVSE intake and a FRR system, but no AFD system, is considered to be best practice with regards to fish protection; therefore, justifying the need to vary the conditions of the WDA permit to remove the requirement to install, operate and maintain an AFD system.

6.1.2 The extensive impingement studies carried out by Cefas and (and reported in the associated statutory assessments) have shown that the environmental benefits realised by installing an AFD system at HPC are negligible and as a consequence the installation of an AFD system is not justified.

6.1.3 Furthermore, the challenges and risks associated with installation, operation and maintenance of the system add further weight to that conclusion. Between 2015 and 2017, an extensive engineering optioneering exercise was carried out to develop the design of the CWS from a fish protection perspective. This process did not include the design of the AFD. The result of this optioneering exercise is captured in the CW1 (Part 1) discharge report. The report details the design of the CWS and how it has been adapted and optimised to maximise fish survivability within the constraints imposed by nuclear and industrial safety and constructability. The fish protection measures incorporated into the CWS design were accepted (following consultation with the EA, NE, NRW and the Devon & Severn IFCA) by the MMO on 28 September 2017. These measures have been extracted from the CW1 (Part 1) discharge report and are discussed within Section 5 against the information provided in the Environment Agency's various guidance and evidence reports on this matter.

6.1.4 In order to ascertain whether a CWS with an FRR system and LVSE intake but no AFD system caused adverse significant effects on fish, and other species dependent on fish, a revised and updated HPC fish impingement analysis was carried out by Cefas (TR456 report). Table 4.1 details the changes made to the impingement assessment since the original assessment. The two key changes were the use of updated datasets and using the latest scientific advice. The revised assessment showed that a CWS with an FRR system and LVSE intake but no AFD system would have negligible effects on the fish species analysed. This outcome was supported by the WFD compliance assessment and the updated HRA (information to inform the regulators appropriate assessment under the Habitats Regulations).

6.1.5 A separate, equally extensive optioneering exercise was also carried out for designing, installing, operating and maintaining an AFD system. The conclusion of the optioneering exercise was that although a system design could, theoretically, be implemented, actually installing and maintaining an AFD system at HPC presented unique engineering, operational and safety challenges.

6.1.6 On the basis of all the above criteria investigated, NNB GenCo considers that the safety risks associated with the construction and maintenance of the AFD system are unacceptable. This is particularly relevant when this is considered alongside the assessment that that the removal of the AFD system as a fish protection measure would not cause significant impact upon fish and other organisms reliant on fish as prey, nor would it adversely affect the integrity of European designated sites in view of their conservation objectives, either alone or in combination with any other plans or projects.

NOT PROTECTIVELY MARKED

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