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CONTENTS CHAPTER 4

SUB-CHAPTER 4.1 – INTRODUCTION

Chapter 4 deals in part with the requirements 1.2, 1.4, 3.1 and 3.2 of the Environment Agency Process and Information Document [Ref-1].

Sub-chapter 4.2 describes the various activities that take place during the EPR construction phase. Sub-chapter 4.3 focuses on the aspects of the construction phase that have a bearing on the terrestrial and aquatic environments; i.e. the interface of the plant construction, erection and commissioning with the environment in terms of needs and outputs that might impact the existing environment. In particular water abstraction, discharge of contaminants and the non radioactive waste strategy are highlighted.

The data presented are those related to the EPR Flamanville 3 construction. Data concerning the site preparation works (such as volumes of soil and rocks to be excavated, volumes of soil substitution by weak concrete, water pumped from seepage, water intake and discharge structures) and data concerning the EPR buildings construction and commissioning tests are given for illustration purposes, since the figures will be site specific.

Sub-chapter 4.3 also mentions where applications for environmental permits and other consents may be necessary, under UK or local regulations.

Assessment of the impacts on the overall site environment is addressed in Chapter 12 of the PCER.

SUB-CHAPTER 4.1 – REFERENCES

External references are identified within this sub-chapter by the text [Ref-1], [Ref-2], etc at the appropriate point within the sub-chapter. These references are listed here under the heading of the section or sub-section in which they are quoted.

[Ref-1] Process and Information Document for Generic Assessment of Candidate Nuclear Power Designs. The Environment Agency. January 2007. (E)

SUB-CHAPTER 4.2 – GENERAL DESCRIPTION OF THE CONSTRUCTION PHASE

LIST OF TABLES

Construction of the EPR will be divided into three phases:

- Site preparation activities (including upgrading of existing infrastructure when necessary) and Preliminary works including the site levelling, excavation of the main deep foundations, main underground pipes (drainage collectors and seawater supply conduits) and tunnels construction;

- Construction and erection of EPR Unit main and ancillary buildings; including the seabed tunnelling operations and construction of the water abstraction and discharge structures; and

- Commissioning tests related to the EPR process until Commercial Operation.

The total duration of the construction depends on the amount and extent of work required for the site preparation and earthworks.

Eighteen months to three years may be necessary for the site preparation, while the construction of the buildings and the commissioning tests phases may take up to five years.

The different phases are described in the sections below and a typical schedule with milestones is presented in Sub-chapter 4.2 - Table 1.

1. SITE PREPARATION ACTIVITIES AND PRELIMINARY WORKS

1.1. SITE INVESTIGATIONS AND FEASIBILITY STUDIES

Feasibilities studies are carried out in order to determine the appropriate siting of the new build. These include:

- A preliminary archaeological field Investigation and Environmental Survey;

- Site investigations (onshore and offshore boreholes, trenches, onshore and offshore dynamic tests and sampling), and a topographical survey of both ground and seabed (bathymetry); and

- Environmental Surveys and collection of baseline data for the Environmental Impact Assessment of the new Power Station construction, operation and decommissioning phases.

Note: The erection of a temporary fence and creation of an access control or surveillance may be required at this stage, depending on the existing organisation at the site.

1.2. SITE PREPARATION

Prior to the start of the preliminary earthworks and construction the following items must first be implemented (the extent of these depends on the site):

- Mitigation measures (in terms of fauna, flora, air, soil, surface water and land drainage conservation or management);
- Land clearance (demolition, tree removal and vegetation clearance, rerouting of underground cables and low voltage overhead lines, rearrangement of existing roads (because of the increased traffic flows);
- Construction of internal access roads or upgrading of existing roads;
- Construction of a usable area for parking vehicles, storing equipment and providing services and facilities for the first contractors (workforce and machinery);
- Preparation of a transit area for conventional wastes during the construction work and areas with oil removers at the outlet drains; and
- Drilling of an independent well for industrial water supply if needed (site specific aspect).

1.3. PRELIMINARY WORKS TO THE UNIT CONSTRUCTION

The activities to be considered during this stage are listed below. The extent of some activities may vary in duration and volume of impact since they are site specific.

- Stripping off topsoil and transfer to a stockpile (re-use envisaged during the post-construction landscaping);
- Removal of excess spoil from the site if necessary;
- Site levelling;
- Backfilling into the sea, if the platform needs to be extended on seabed;
- Construction of the main site drainage network;
- Temporary cofferdam may be built or injections of crushed rock or existing permeable material could be made into the foreshore, in order to create a subterranean barrier to protect the excavation works against ingression of water from the sea;
- Crushing of material before re-use as fill may be required;
- Blasting and tunnelling operations may be necessary;
- Implementing provisions for dewatering the site (i.e. water to be pumped from below ground) will be installed;
- Construction of coastal protection, the underground tunnels, main water Circulation Water System (CRF) pipes, and buildings foundation excavation;

- Construction of temporary and ancillary facilities such as a concrete laboratory, permanent staff offices, water reservoir (potable water for domestic purpose or raw water for buildings construction purpose, fire-fighting reservoirs and distribution conduits), adequate security, welfare facilities, canteen and a fully equipped construction campus, possibly including temporary training facilities and medical centre (list not exhaustive);

- Construction of temporary sewage disposal facilities in order to accommodate sewage for the construction phase; and

- Construction of a temporary jetty for deliveries of material and equipment (site specific).

1.4. WATER INTAKE AND DISCHARGE STRUCTURES CONSTRUCTION

Although the final design is site dependent, water-inlet and/or water-outlet are likely to be offshore; therefore an onshore pit and tunnels shall be excavated.

Building these structures will require several specific construction facilities:

- Land based construction site: for excavating the discharge and intake tunnels and the onshore pits and also drilling or excavating the connecting structures; and

- Sea based construction site: for excavating the offshore shaft and constructing the diffusion apparatus.

Depending on the site-specific design a platform may be built over the site with a heliport, a quay and equipment storage areas, and in particular, a concrete batching plant.

2. EPR PLANT CONSTRUCTION

2.1. MAIN CONSTRUCTION WORKS

Main construction works start following the preparatory works phase for approximately three and a half years and will consist of:

- Firstly, placing reinforced steel and pouring of structural concrete for the reactor and auxiliary buildings foundations (described in Chapter 1 of the PCER); and

- Then construction of the buildings upper-structures (above platform level) and erection of the main metallic and handling structures will be performed.

Steel is used to reinforce the concrete as it is laid. The reinforcement cages will either be prepared as the concrete is laid, or made in advance in site workshops before installation.

2.2. TRADES WORK

The main construction and civil engineering work will be supplemented by activities involving trades and concerning secondary structures, various metallic carpentry, roof cladding, leak tightness, masonry and rendering, painting, and lifts and hoists. Activities are:

- The final roads and utilities include roadways, networks including rainwater drainage systems, sewage and an associated (site specific) permanent discharge outfall.
- Second stage backfilling around the main civil structures will be carried out during the main civil construction works to raise the platform up to its required final level, and allow access to the building for electromechanical contractors;
- The construction of a switching station will depend on the existing National Grid facility available at the site; it will be carried out in parallel, as this facility is required for the commissioning of the Plant and its connection to the grid; and
- The painting work mainly concerns the buildings interiors, since the external walls of the main buildings will not be painted. Various equipment and structures are painted during manufacturing before delivery on site.

2.3. MECHANICAL AND ELECTRICAL ERECTION

Mechanical and Electrical erection on site comprises:

- Mechanical assembly:
    - Large plant components (such as steam generator, reactor vessel, steam turbine and generator);
    - Smaller equipment assembly (such as tanks, pumps, exchangers, filters, overhead cranes);
    - Pipe and duct work assembly: installing supports, welding the pipe lengths, connecting to components and equipment and installing valves; and
    - Painting, insulating (protection of personnel) and tracing (protecting fluids from freezing).
- Electrical and Instrumentation and Control (I&C) systems assembly:
    - Large equipment assembly (such as transformers, generators, electrical distribution switchboards, back-up diesel generators, batteries);
    - Electrical connections: installing the cable trays, pulling the electricity cables and those for the I&C system, connecting to equipment;
    - Fitting the circuit instrumentation (such as sensors for level, temperature, pressure, analysers); and
    - Painting, insulating (protection of personnel) and tracing (protecting fluids from freezing).

Large components are generally manufactured at the supplier's factory and then delivered to the site. Their transportation may require special arrangements, especially for heavy components, which have to be inventoried, upgraded or built in advance depending on the site.

3. COMMISSIONING TESTS

3.1. GENERAL

The commissioning tests start during the construction of the EPR; and comprise:

- Testing the installed pipework for its leak tightness and its ability to withstand pressure and temperature, as appropriate;
- Checking that the completed work complies with the design; and
- Checking that the installation complies with the safety criteria.

The tests carried out are very different in nature; they include: hydraulic tests, lifting equipment tests, the Reactor Building containment pressure test, electrical insulation tests, endurance tests of equipment, no-load tests of controllers and field tests.

Tests of the water circulation systems that require water intake and generate effluent are described with more details hereafter.

3.2. WATER CIRCULATING SYSTEMS TESTS

The purpose of these tests is to flow demineralised water, with or without various conditioning products such as morpholine, phosphates, lithium hydroxide, hydrazine and boron.

The tests also enable the equipment to be thoroughly cleaned before going into service.

Testing of the water circulation systems consists of several successive stages:

- Pre-operational tests which allow the circuits to be checked and cleaned individually (these tests will be carried out using demineralised water, either pure or with added morpholine):
  - Hydraulic tests: to check the resistance to pressure (at a higher pressure than the circuits service pressure) and leak tightness;
  - By gravity and dynamic flushing: these tests both clean the circuits (removing foreign bodies and welding residue) and check that the circuits can provide circulation water at the specified quality; and
  - Use of a water lance: this operation cleans the equipment thoroughly before the overall tests; in particular it removes rust that can form on carbon steel pipework after hydraulic testing and flushing.

- Testing the entire primary side circuit: these tests allow checks on the interconnected circuits (these tests will be carried out using demineralised water, either pure or with added morpholine):
  - In-vessel flushing: the tests involve all the circuits attached to the primary circuit (Safety Injection System Operating in Residual Heat Removal Mode (RIS/RRA [SIS/RHRS]), Chemical and Volume Control (RCV [CVCS]) and Reactor Boron and Water Make-Up System (REA [RBWMS])). The circuits are filled by gravity and drained into the vessel (open). The tests include starting up the pumps in the nuclear section for the first time, flushing the equipments and checking that the circulating water has the specified characteristics;
  - Cold-testing of the nuclear steam supply system: these tests are for fine tuning the settings for pressure, flow and level settings;
  - Hydraulic testing of the nuclear steam supply system (NSSS): the tests are carried out under pressure (at a higher pressure than service pressure) once the NSSS has been cold tested, in order to verify the equipment behaviour under pressure; and
  - Hot-testing: the tests are carried out at nominal pressure and temperature. They include all trials and simulations before loading the fuel into the core and enable the checking of the leak tightness between the primary and secondary sides (boron injection).
- Testing the entire secondary side:
  - Hydraulic testing of the secondary side of the steam generators: the tests are carried out under pressure.
- Testing the tertiary system:
  - Electrochlorination testing: electrochlorination is the preparation process of chlorine from seawater; the chlorine being used in the circuits (in the Pumping Station) to reduce the growth of algae and crustaceans that could prevent proper operating of pumps or filters. The tests check the installation equipment and allow for any final adjustments;
  - CRF testing: the CRF pipework (for the condenser cooling circuit) is tested with seawater under a pressure of 5 bars to check that the pipework has been correctly assembled; and
  - Conditioning the auxiliary circuits: the tests are carried out at nominal pressures. To prevent corroding the steels in the pipework, phosphate is added to the demineralised water for these tests.

4. STAFF LIFE IN AND OUT OF SITE

During the construction phase the workforce on site will increase up to around 2400 people at the peak of activity. This means socio-economic aspects in the site area, road traffic and the need for potable water for sanitary reasons and for drinking and canteen on site.

Sub-Chapter 4.2 - Table 1: Milestones of the EPR Construction

This table shows the major stages in the construction and their place in the general schedule strategy. "D1" is the date when the first nuclear concrete for the Balance of Nuclear Island structure is poured. Months are counted negatively before D1 and positively after D1.

Major milestones of the EPR project	Timetable relative to D1
Preparatory work	
Site opening and preparation activities start	D1 - 18 to - 36
Preparatory works start	D1 - 18 to - 36
Platform levelling completed	D1 - 12 to - 30
Construction of the Nuclear Island	
Main Civil Work Contractor installation start	D1 - 6
First nuclear concrete	**D1**
Basemat of the "cross" completed	D1 + 3
Basemat of the Nuclear Auxiliary Building completed	D1 + 5
Mechanical assembly in the Safeguard Building starts	D1 + 12
Electrical assembly in the Electrical Building starts	D1 + 15
Mechanical erection in the Reactor Building starts	D1 + 18
Reactor Building Containment completed	D1 + 20
Polar crane available	D1 + 24
Reactor Vessel introduction	D1 + 25
First steam generator introduction	D1 + 26
Prestressing completed	D1 + 31
Pool tests	D1 + 33
Construction of the Conventional Island and Balance of Plant	
Concreting the base for the foundation raft starts	**D1**
Foundation raft completed	D1 + 17
Main bridge crane in the Turbine Hall erected	D1 + 18
Condenser assembly starts	D1 + 18
Turbine-generator set assembled	D1 + 21
Auxiliary transformer powered up (400 kV)	D1 + 24
Pumping Station commissioned	D1 + 33
Step-down transformers (400 kV) energised	D1 + 36
Main Components testing	
Vessel flushing starts	D1 + 37
Turning gear used to start turbine-generator set	D1 + 39
Containment testing	D1 + 41
Condenser under vacuum	D1 + 42
Start of hot testing	D1 + 43
Fuel delivered	D1 + 43
Loading starts	D1 + 47
Commercial Operation	D1 + 54

SUB-CHAPTER 4.3 – NEEDS AND OUTPUTS FOR THE EPR CONSTRUCTION PHASE

LIST OF TABLES

LIST OF FIGURES

1. NEEDS AND OUTPUTS RELATED TO THE TERRESTRIAL ENVIRONMENT

The construction site on land has the following requirements and outputs:

- the land requirements for the site facilities;
- changes to the land surfaces for construction;
- raw freshwater requirements*;
- drinking water requirements*;
- construction materials requirements;
- transport related to the construction site;
- chemicals discharged into the atmosphere and odours; and
- noise and vibration.

* Water aspects are dealt with in section 2 "Needs and outputs related to the aquatic environment".

1.1. LAND TAKE FOR THE SITE FACILITIES

One EPR unit and its ancillary facilities require around 70 hectares for construction and operation. The degree of impact on land during construction will depend on the site layout and topography.

1.2. CHANGES TO LAND SURFACES FOR CONSTRUCTION

The land upon these 70 hectares will be completely stripped of vegetation and habitat during the construction phase, as this area of land will be levelled and excavated below the final platform level (for foundations), directly impacting or displacing terrestrial flora and fauna across this area. Assessment of the impact on flora and fauna is presented in Chapter 12 of the PCER.

The construction site will mean shifting earth, building embankments and burying structures.

Construction and civil engineering works will require in-situ tower cranes and mobile cranes to move heavy loads.

In addition, there will be infrastructure requirements to service the operation, such as access roads, overhead electricity cables and pipework.

1.2.1. Earthworks

Earthworks during the construction phase of the UK EPR may include:

- Moving earth for levelling of the site to make the unit platform;
- Erecting embankments or breakwaters for flood protection or other factors by placing rocks or concrete blocks along the shore;
- Excavating rocks and/or loose material down to the depth required for buried structures, and foundations (volumes of excavated materials may amount to hundreds of thousands of m^3 depending on the site characteristics);
- Storing spoil soil at disposal; then reusing it for landscaping;
- Reusing surplus material resulting from site levelling and buildings foundations excavation as backfill around and above the buried structures once built;
- Ensuring that the work below sea level, if any, can be completed dry, by investigating the solid and drift geology of the site and by undertaking pumping trials. For example, on the reference site of Flamanville pumping takes place at different places in the work area at an estimated average flow rate of 1000 m^3 h^{-1}; the pumped water is discharged into the sea after settling (discussion and consultation with the regulatory authorities regarding dewatering of subsurface construction works will ensure that impacts such as saline intrusion into freshwater aquifers are minimised);
- Producing rock cuttings or blastings by mining with explosive, using a series of micro-charges, in areas where the land cannot be excavated using earth-moving equipment. As an illustration, the amount of explosive required to excavate the EPR Flamanville 3 platform is estimated at 70 kg per firing, with an average of 3 firings per day.
- Pouring weak concrete in various areas under the buildings foundations as soil substitution in areas such as:
    - Drainage structures below the foundations, to replace sections of the rock that may be fractured etc;
    - Backfill under the Circulation Water System (CRF) pipes, to ensure that the bed of the trench is levelled;
    - Blinding concrete between the bottom of the trench and the underside of the tunnels;
    - Infill concrete between the base rock and the foundations of structures under the gravity retaining wall for the Nuclear Island;
    - Shotcrete for the stability of the retaining walls of the trenches and banks;
    - Concrete for the gravity retaining walls under the walls of the Turbine Hall and in the Nuclear Island to provide stability for the cranes required at the civil-engineering construction stage;
    - Concrete for the heavy-duty road; and
    - Concrete for the buried service tunnels.

- Backfilling around and above buried works after construction. Using the excavated spoils supplemented with material from approved quarries (the granulometry of these materials may be very specific to the area, and backfill material under no circumstances should contain fine particles); and

- Constructing buried structures, such as service tunnels and pipework for the CRF.

For an illustration the required volume of weak concrete for the Flamanville 3 construction is estimated to 85,000 m^3.

1.2.2. Installing construction facilities on site

During construction, technical construction facilities will be required and may include:

- A crushing unit to be used during the preparatory work, for preparing the material extracted by rock blasting on the site for use as backfill or concrete aggregates (depending on the rock characteristics and suitability);

- One or several concrete batching plants at different locations for the preparatory works and the main civil construction work;

- One temporary transit area for conventional wastes and untreated waste material;

- Transformer and Generator units; and

- Temporary workshops and storage for various products such as paints and welding gases.

1.2.3. Leaks to the soil and groundwater

Several techniques may be employed in the construction and installation of infrastructure associated with the EPR. Techniques such as excavation, drilling, piling or blasting can give rise to contamination by hydrocarbons from the tools engines. This may impact soil and/or groundwater quality, depending on factor such as the site geology.

Hydrocarbons from vehicles, dust leaks and spillages of materials can also cause pollution of soils on a local scale during the construction phase, and then with a potential to cause groundwater pollution.

Dedicated measures, documented in a Construction Environmental Management Plan, for gathering and/or draining the dust and spills of pollutants and for monitoring will be put in place for the specific UK EPR site.

Where there is the potential for impact upon groundwater quality as a result of the construction and earthworks, the issue will be discussed with the Environment Agency (EA) to determine if any mitigation is required.

1.2.4. Perturbation of ecology and natural habitats

The activities linked to the construction stage of the UK EPR (such as land take, blasting, excavation, piling and drilling, mixing and blending, material delivery and storage, waste handling and surface water management), are likely to have an impact upon natural habitats and/or specific species since they have the potential to cause:

- direct loss of habitat;
- damage to foraging areas by smothering with dust or litter;
- destruction of nesting and/or burrowing sites by ground works;
- disturbance, caused by noise and/or vibration;
- changes in natural habitat as a result of nutrient enrichment caused by enriched or sediment laden surface water runoff;
- direct toxicity of particulate and gaseous emissions (direct absorption); and
- indirect toxicity of particulate and gaseous emissions (via food sources and nesting supplies).

A site specific assessment will be undertaken in order to conclude whether construction of the UK EPR will have an impact upon natural habitats and mitigation measures will be proposed whenever practicable (see Chapter 12 of the PCER).

1.3. RAW MATERIAL NEEDS

Construction of the UK EPR will require large quantities of raw material for the concrete preparation and for the metallic structures and equipment.

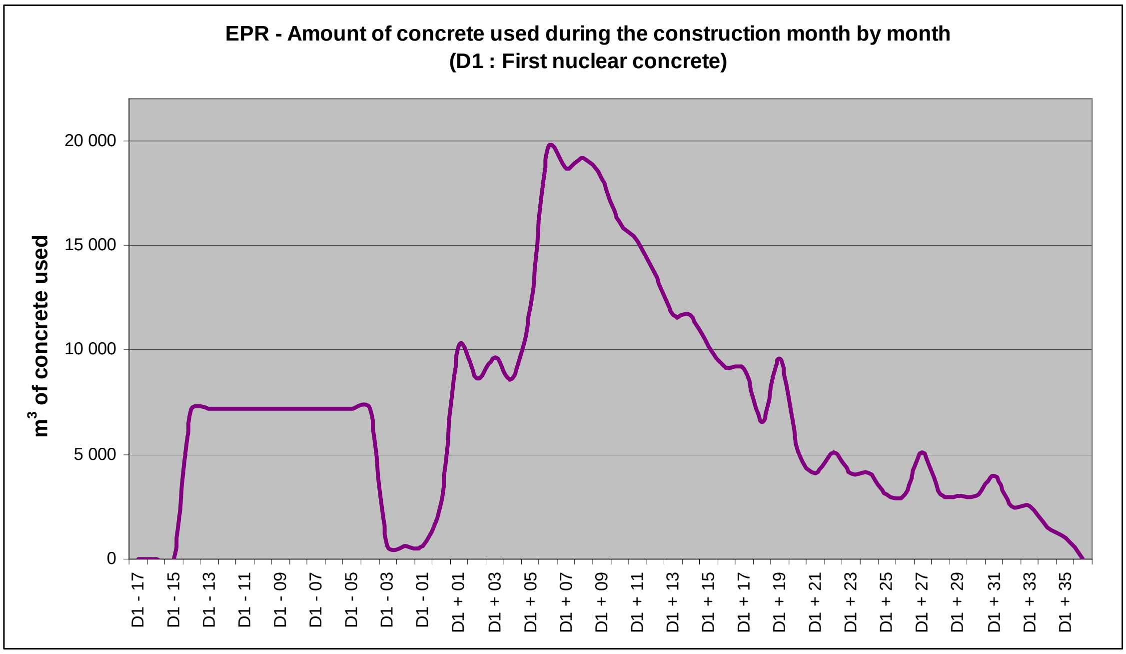
Raw materials required for construction are the following:

- Mineral supply for concrete production:

  It is anticipated that approximately 300,000 m^3 of concrete will be used during the main civil-construction stage. Concrete production will be spread over time as shown on the figure below (Sub-chapter 4.3 - Figure 1 shows how this amount is split during the construction phase taken from Flamanville EPR as an example).

  The source of supply for sand and aggregate for concrete production will be part of the site feasibility studies; i.e. consideration will be given to making use of the excavated materials or extraction from qualified quarries, since the quality of aggregates must be suitable for the different uses in the plant construction (see Sub-chapter 4.2);

Sub-chapter 4.3 - Figure 1: Amount of concrete poured during the construction phase



- The amount of steel and various metals for concrete reinforcement, girder construction, equipments (such as pipes, main components, tanks, exchangers, valves, electrical wiring) may be estimated to:
  - 46,000 tonnes of steel will be used to reinforce the concrete as it is laid (the reinforcement cages will either be prepared as the concrete is laid or made in advance in site workshops before installation);
  - 5000 tonnes of steel for the components and pipes; and
  - 330 tonnes of copper and 140 tonnes of aluminium for the electrical wiring.
- Chemicals used in the preparation of paints and surface treatment.

1.4. TRANSPORTATION RELATED TO THE CONSTRUCTION SITE

Site-related transportation is required to:

- supply the site with materials such as aggregates, steels and equipment;
- move people around the site; and
- remove waste.

Although this is a site dependant issue, lorries will probably be the main means of supplying materials and removing waste. Haulage will be reduced by recycling material excavated from the site. The number of lorries required is estimated at an average of 80 per day during the construction period.

Personnel will move around the site mainly by road using cars or a bus service according to the organisation implemented on the site management (up to 2400 persons will work on the site at the peak of activity).

Materials and personnel will be delivered to the sea platform, and extracted materials removed from it by barge where possible, or otherwise by helicopter.

1.5. SOLID WASTES

During construction a wide range of wastes will arise in addition to excavation spoil, which include:

- packaging;
- chemicals (material coating and surface treatment) and chemical containers; and
- off specification raw material (wood, plastics and metals).

Quantification of the waste arising during construction depends on parameters to be defined during the preparatory phase.

The Solid Waste Strategy will be designed to comply with the requirements of the Waste Framework Directive as implemented in the UK by domestic legislation such as the Pollution Prevention and Control (PPC) Regulations, Waste Management Licensing Regulations 1994 and subsequently the Environmental Permitting Regulations, together with the Environmental Protection (Duty of Care) Regulations 1991. By ensuring compliance with these regulations in terms of minimising waste production, storing and transferring waste responsibly, the requirements of the Waste Framework Directive will be upheld.

Obligation about limiting and managing wastes will be included within all the contracts. Use of the specific storage area created on the construction site during the preparation stage is mandatory on site.

Other waste on site will be correctly handled, stored and disposed of in accordance with the waste hierarchy: reduce, re-use, or recycle in compliance with governmental and local regulations.

The Duty of Care regulations for waste requires the UK EPR operators to ensure that waste does not escape from their control; any waste that leaves the site should do so with relevant consents and authorisation, e.g. via the appropriate discharge consent or to an authorised disposal site.

Some wastes may be classed as Hazardous, therefore the construction site will be registered with the EA as a place of Hazardous Waste Production, in accordance with the requirements of the Hazardous Waste Regulations, 2005 [Ref-1].

In addition, and in accordance with the Environmental Permitting legislation, a Site Waste Management Plan will be prepared by the construction contractors and filed with the regulatory authorities. This plan will document the measures implemented for:

- identifying the sources of waste arising at all stages of site preparation and construction;
- reducing waste arising;
- identifying and segregating waste types;
- identifying suitable recovery and/or recycling options for waste;
- containing waste to prevent its escape and contamination; and
- ensuring compliance with legislation.

In accordance with the Environmental Permitting Regulations (as they replace parts of the Environmental Protection Act 1991, Waste Management Licensing Regulations 1994 and the Pollution Prevention and Control Act 1999), if an Environmental Permit is required for the storage, treatment or deposit of waste at the site, this will be obtained at an early stage, prior to the commencement of construction. Note that, certain Environmental Permits will require appropriate planning permissions to be in place before they can be granted.

1.6. EMISSIONS TO AIR

1.6.1. Dust

Dust and/or particulates produced during construction will arise from sources that are typical of most large industrial construction site. Dust will be produced during excavations and earth moving, rock crushing, and concrete manufacturing. More specifically dust may arise from:

- Mechanical disturbance of loose particles resulting from the movement of vehicles along dry unpaved haul roads and the re-suspension of dust from the movement of vehicles along surfaced roads including the movement of internal site traffic and vehicles delivering and removing materials from site;
- Demolition of any existing site structures;
- Earthworks including excavations for foundations and service corridors;
- Material stockpiles including site excavated materials awaiting re-use and construction materials;
- Concrete mixing and/or batching operations (approximately 300,000 m^3 of concrete will be used during the main construction stage);
- Crushing of rock and existing concrete;
- Loading and unloading of materials from and onto vehicles; and
- Cutting, sawing and drilling.

Impacts associated with the generation and deposition of dust will be minimised through the implementation of measures including water spraying of roads and conveyors of crusher units. Impacts will be assessed on a site-specific basis in relation to local topography, climatic conditions and the presence of sensitive receptors in the vicinity of the site.

Some activities, such as cement batching, crushing and screening may require an Environmental Permit (Local Authority PPC permit) granted by the Local Authority. Such permits are required to principally control noise, air quality and nuisances caused by the operation of such plant. If such permits are required, these will be obtained prior to bringing them into use.

1.6.2. Vehicle and site machinery exhaust emissions

Traffic levels on roads in the vicinity of the proposed development site are likely to increase during the construction phase due to workers travelling to site, the delivery of plant equipment and materials and the removal of any excess materials. In addition to this, site machinery used on site may contribute to local emissions. The main emissions associated with vehicles and diesel run facilities are:

- Carbon monoxide: a gas which, is rapidly absorbed by the blood reducing its oxygen carrying capacity;
- Particulates: the most important of which, from the perspective of impacts upon human health are those with aerodynamic diameters of less than 10 micrometers (µm);
- Hydrocarbons: the most significant of which, from the perspective of impacts upon human health are benzene and 1,3 butadiene (both are known carcinogens, i.e. have the potential to cause cancer); and
- Oxides of Nitrogen: these contribute to photochemical smog and acid deposition.

As an illustration, the preparation of the Flamanville 3 EPR is estimated to generate an average road traffic of 80 lorries per day during the construction period.

When the UK EPR site is decided, an assessment will be carried out.

1.6.3. Chemical discharges during the commissioning phase

During the testing phase formaldehyde may be produced. Insulation surrounding the equipment and hot piping undergoes thermal decomposition during the first time that the temperature rises, and this releases formaldehyde vapour into the Reactor Building. This may result in the formation of carbon monoxide, which is discharged via the stack by operating the Reactor Building ventilation system (Containment Sweep Ventilation System (EBA [CSVS])).

The quantities of formaldehyde and carbon monoxide discharged as gases into the environment after hot tests are estimated using a worst case scenario. The maximum quantities produced in the Reactor Building are estimated to be 1230 g of formaldehyde and 1152 g of carbon monoxide. Depending on the ventilation flow rate (normal or low), the operating time required to evacuate these quantities and reduce concentrations to acceptable exposure limits, is estimated at 10 hours at normal flow and 52 hours at low flow.

1.6.4. Odour

Potential sources of odorous emissions include the exhaust gases from vehicles and site machinery such as rock crushing, concrete making facilities during construction, and formaldehyde during the testing phase.

1.7. NOISE AND VIBRATION

The primary noise and vibration sources during the construction phase of an EPR are those typical of an industrial construction site and include excavation and earth moving, crushing and the concrete batching plant.

1.7.1. Site preparation phase

Possible sources of noise and vibration during the preparatory works include:

- The use of excavator mounted and/or hand held pneumatic breaking equipment, excavators and dump trucks;
- Earth moving for site levelling, foundation excavation, etc. is likely to be undertaken by 360° excavators with spoil being removed by dump trucks;
- Blasting may be required if excavations are to be undertaken within the bedrock;
- Excavation may be required to create intake and/or discharge channels. This may take the form of dredging (ship or land based) or blasting to create the appropriate channels;
- Whenever foundations require dewatering, generators and submersible pumps may be utilised;
- Material produced during blasting or excavation may require crushing before it can be reused on the site as filling material or aggregate for concrete production. This will require crushers and/or grading plant; and
- Movements of trucks on site and in the vicinity of the site.

1.7.2. EPR structures construction phase

Possible sources of noise and vibration during the construction of buildings and services are:

- Concrete production: this may be noise from an on-site concrete production facility or transport of concrete onto the site (with possible temporary storage in silos); and
- Operation of engines associated with this stage, such as: compressors, generators, mobile and static cranes, excavators, dump trucks, asphalt laying equipment.

1.7.3. Impact of site characteristics

Site-specific characteristics, such as the local topography and presence of sensitive noise receptor sites, will be assessed when considering site design in order to mitigate against noise and/or vibration impacts.

1.8. SOCIO-ECONOMIC ASPECTS RELATED TO CONSTRUCTION

From a demographical perspective, we can distinguish the workforce employed on the site itself and the total resulting demographic impact on the region. The on-site workforce includes:

- company personnel;
- operator staff; and
- external service staff.

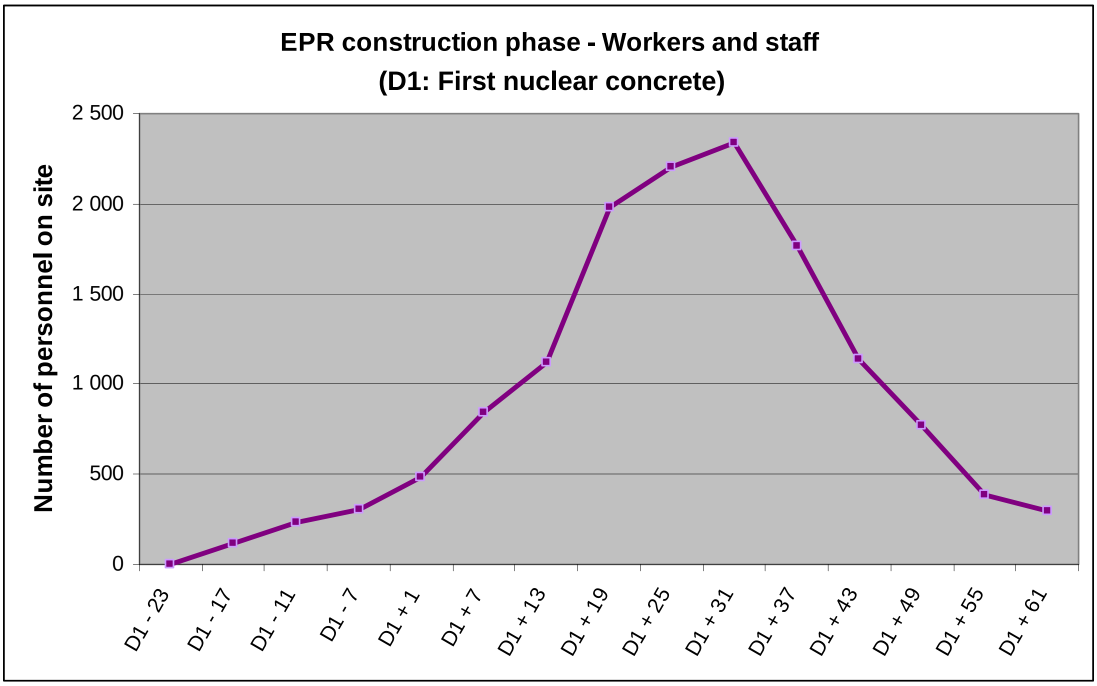
Changes in the workforce on the construction site are shown in Sub-chapter 4.3 - Figure 2. At the height of activity, 2400 workers are expected to be on the site.

- Civil-engineering personnel who prepare the site and build the structures; the main trades represented are the following, shown as average percentages:
  - o concrete casters and finishers 43%;
  - o skilled workers 30%;
  - o iron workers, concrete reinforcement 15%;
  - o team leaders 7%; and
  - o machine operators 5%.
- Staff with electromechanical expertise assigned to equipment installation; the main trades represented are the following, in approximate proportions:
  - o industrial pipe fitters 34%;
  - o welders of precious metals 15%;
  - o carbon-steel welders 11%;
  - o boilermakers 9%;
  - o maintenance engineers 9%;
  - o HVAC engineers and fitters 8.5%;
  - o electrical fitters 7%; and
  - o electrical workers 6.5%.
- External service staff: to provide site security, maintain the premises, and perform various maintenance jobs. Most of them can be recruited from the region.

Supplying of local accommodations in the vicinity for these workers and their family during the construction phase is a site-specific issue.

The assessment of the potential impacts is given in Chapter 12 of the PCER.

Sub-chapter 4.3 - Figure 2: Number of personnel on site during the construction phase



2. NEEDS AND OUTPUTS RELATED TO THE AQUATIC ENVIRONMENT

During the years of the construction phase, there will be a need for freshwater abstraction while liquid waste and suspended solids will be discharged into the sea. The shoreline and seabed will be impacted by the construction of the seawall and the water intake and discharge structures.

2.1. FRESHWATER

During the construction period, freshwater is required for the construction activities (concrete making) and filling the circuits. In addition, water will be required for sanitary and other purposes.

2.1.1. Freshwater needs for construction work

For the site preparation phase the maximum need of 600 m^3 per day estimated for the Flamanville 3 EPR construction site is kept for illustration. This water is used for concreting work, crushing unit and cleaning equipment. The actual amount is site specific.

For the remaining construction period, assumed to last for five years, freshwater will be needed for concreting work, cleaning equipment and spraying tracks.

2.1.2. Freshwater needs for demineralised water

Freshwater needs are expected to peak again during the last phase of the construction due to the requirements of demineralised water for the commissioning tests.

Testing of the primary and secondary circuits requires them to be filled and flushed several times each. The total amount of demineralised water required for the commissioning tests and start-up of the unit is estimated to 72,500 m^3 over a period of 12 to 18 months (to be evaluated at the site specific stage).

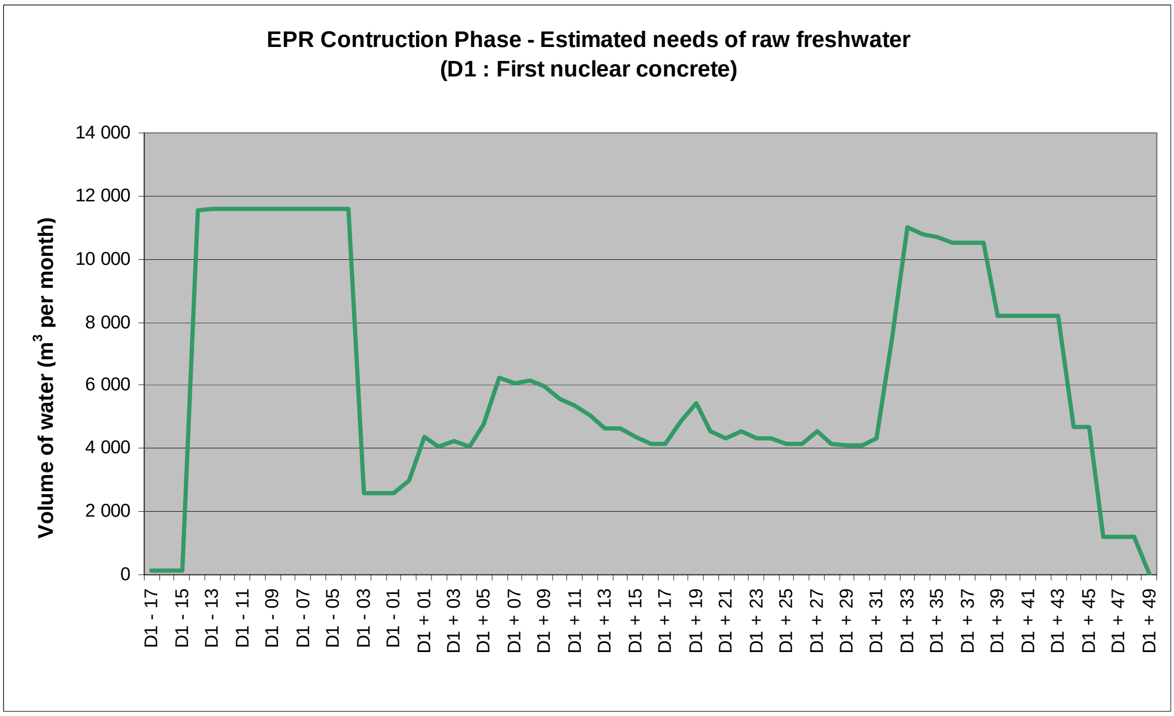
2.1.3. Summary of raw freshwater needs

Raw (untreated) freshwater needs during construction and start-up of the process are summarised in Sub-chapter 4.3 - Table 1 and in Sub-chapter 4.3 - Figure 3:

Sub-chapter 4.3 - Table 1: Raw freshwater requirements during construction

Construction Activity	Construction Phase						Freshwater Requirements
	Temporary facilities	Preparatory work	Discharge structures	Civil engineering	Erection	Testing	
Concreting work	X	X	X	X			200 l m^{-3} of concrete poured
Cleaning equipment and spraying tracks		X					5 m^3 per day
	X		X				1 m^3 per day
				X			30 m^3 per day
				X			60 m^3 per day
Crushing unit		X					500 m^3 per day
Equipment maintenance					X		60 m^3 per day
Pumping of freshwater for production of demineralised water						X	230 m^3 per day for about 12 to 14 months

Sub-chapter 4.3 - Figure 3: Pattern of the construction site raw freshwater requirements



2.1.4. Potable water requirements during construction phase

The workforce on site is estimated to be around 2400 people during the peak year of construction.

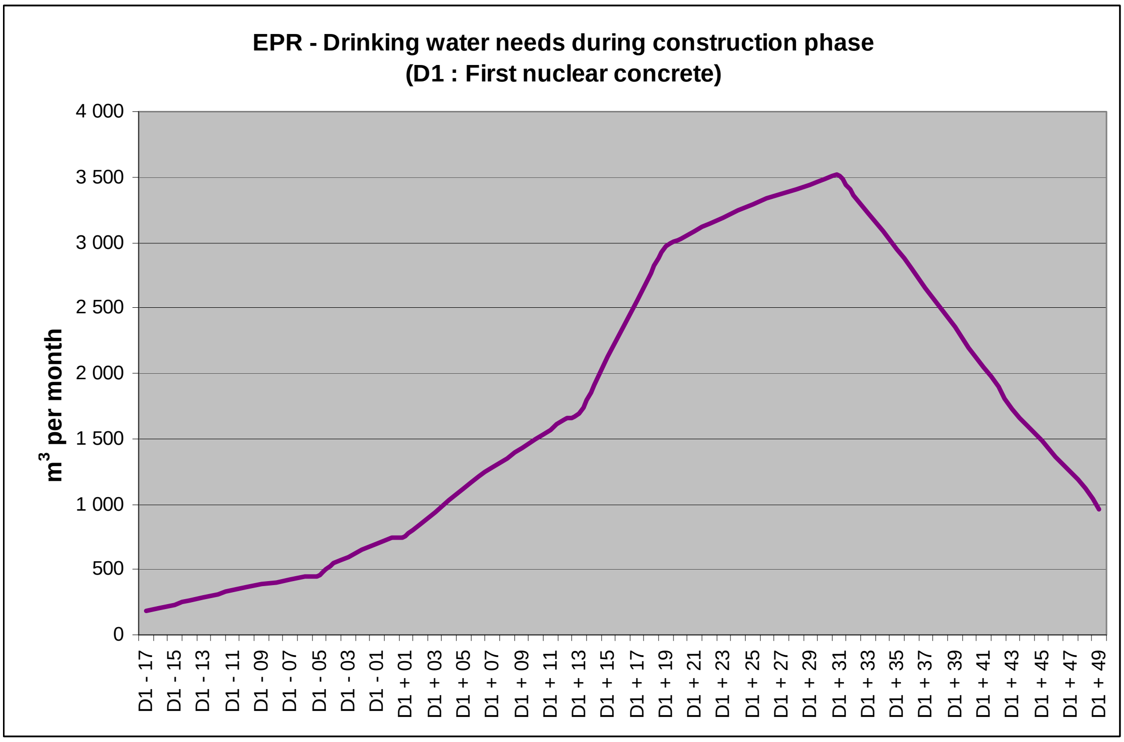
The potable water requirements during construction may be estimated in Sub-chapter 4.3 - Table 2:

Sub-chapter 4.3 - Table 2: Potable water requirements during the construction phase

Nature of use	Requirement
Showers	1 shower per person per day - 40 litres of water per shower
Lavatories	4 flushes per person per day - 6 litres of water per flush
Water for consumption	10 litres per person per day
Washing the floors	5 litres per 100 m² - 1 cleaning per day
Total	**75 litres per person per day**

The associated potable water requirements during construction are shown in the following graph, similar to the curve for workforce numbers. The graph (Sub-chapter 4.3 - Figure 4) shows that peak potable water demands are expected to occur in approximately construction years 3-5; peak demands are estimated at 2500 - 3500 m^3 per month.

Sub-chapter 4.3 - Figure 4: Potable water requirements during construction



2.1.5. Freshwater supply

Freshwater may be provided (via the necessary abstraction and treatment infrastructure) by surface water sources such as rivers or groundwaters, or from a desalination unit depending on the site characteristics. When a possible site location is confirmed an assessment of the water resource availability will be made by the Water Authorities using the EPR needs analysis results, in order to define the most sustainable means of sourcing the water both for raw (untreated) water and for drinking quality water.

If freshwater is planned to be abstracted from a surface water source, such as a river or a lake, an Abstraction Licence, granted under the Water Resource Act 1991 [Ref-1] may be required before any abstraction can take place.

If it becomes necessary to impound freshwater in a temporary or permanent reservoir, an Impoundment Licence, granted under the Water Resources Act 1991 may be required before work to construct the impoundment takes place.

2.2. SEAWATER ABSTRACTION

Seawater will be used:

- At the end of the construction phase once the pumping unit is complete, for the operation of the CRF during the testing stage, and

- Where it is necessary, due to site specific circumstances, to provide raw freshwater and demineralised water via a desalination unit rather than using rivers or groundwater.

Seawater abstraction is not a concern in terms of resource depletion; impacts associated with seawater include those associated with thermal and liquid waste discharges, which are described further in this chapter.

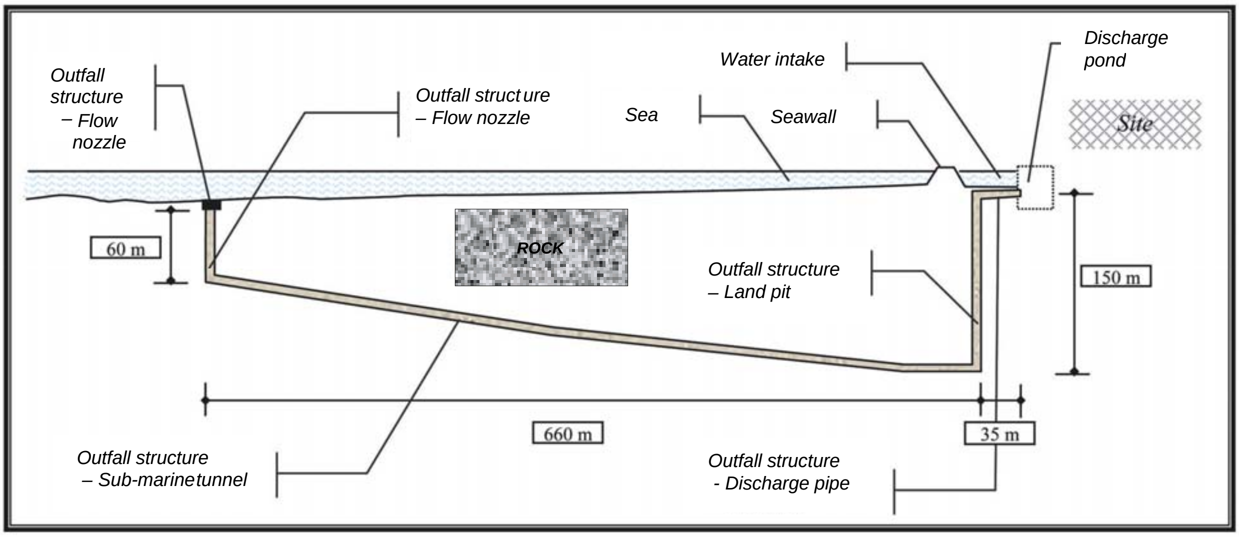
2.3. SEABED EXCAVATION

Several options will be considered for construction and installation of infrastructure associated with the cooling water intake and discharge points, which include excavation, dredging, drilling, piling, blasting and immersion of concrete blocks. Each of these activities can give rise to increased levels of suspended solids, solid waste (rock, sand, mud, etc.) and vibration, which may impact upon marine ecology, hydrology and sedimentology.

Excavation of onshore pits and tunnels may require explosives depending on local geology. As an illustration of the work that this represents, for one tunnel on the Flamanville 3 site, 2 to 3 kg of explosive were used per m^3 of rock extracted, and roughly 20,250 m^3 of rocks should be extracted for the discharge tunnel of 700 m long and approximately 5.5 m in diameter (see Sub-chapter 4.3 - Figure 5).

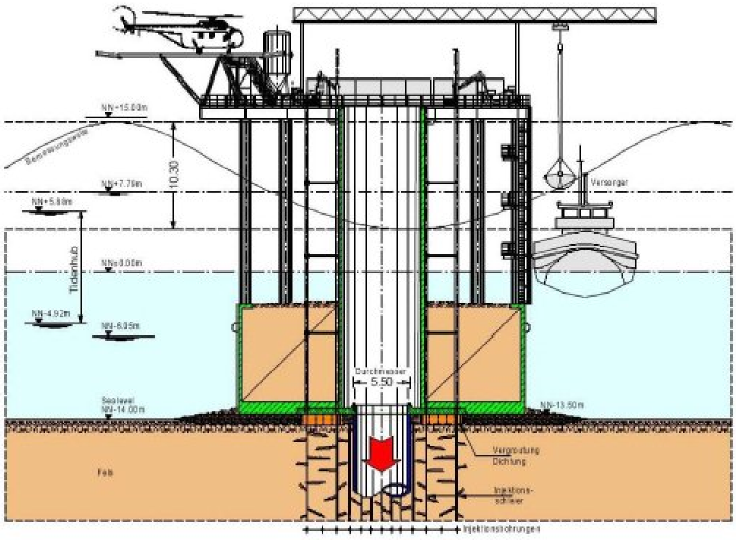
To ensure that the working conditions are optimal, water entering these subsurface workings through seepage, for example, must be continuously pumped (estimated average flow rate of 70 $m^3 h^{-1}$). The pumped water will to be discharged into the sea. Should a large volume of water enter the workings the evacuation flow rate could reach 2000 $m^3 h^{-1}$.

Sub-chapter 4.3 - Figure 5: Example of discharge structures longitudinal section



Drilling and construction techniques for the offshore pit will depend on the geology. The volume of materials excavated from drilling the offshore pit depends on the depth of the seabed. As an illustration, the construction of the offshore pit for the EPR at Flamanville 3 produced approximately 1500 m^3 of spoils (the final diameter is around 5.90 m) (see Sub-chapter 4.3 - Figure 6).

Sub-chapter 4.3 - Figure 6: Construction site at sea (example of Flamanville 3)



A diffuser made of concrete may be located at the head of the pit on the seabed to help the diffusion and dilution of the water discharged during the operation phase.

As an illustration, the amount of concrete that will be used to build the discharge structure of the EPR at Flamanville 3 is estimated to 3500 m^3.

During the site-specific assessment, the geological conditions will be determined, which will ultimately dictate the methods used for excavation.

Depending on the location of the offshore and/or onshore pits, the following permissions may be required:

- Crown Estates Consent. As the Crown Estate owns coastal land up to 12 miles out from the shore, their consent will be required if any constructions works are required on or below the surface of the seabed.

The Crown Estate will generally not provide such consent until it is satisfied that all statutory requirement have been fulfilled, including:

- Addressing the environmental impacts as part of an Environmental Impact Assessment and/or Environmental Statement; and

- Liaising with the relevant sea fisheries committee.

- Implementing a suitable disposal and/or recovery site for any waste arising.

2.4. DISCHARGES INTO THE SEA DURING THE CONSTRUCTION PHASE

2.4.1. General origin of discharges

2.4.1.1. Chemical discharges

Chemicals discharged into the sea corresponding to the various activities on the construction site fall into two categories:

- Discharge associated with the preparatory works and the main building erection and the presence of construction staff on site. This type of discharge has the potential to contain suspended solids, hydrocarbons and an increased biochemical oxygen demand for example; and
- Discharge associated with the commissioning tests, which cover conditioning of the circuits and pre-operational tests up to core loading; this discharge involves other chemicals (such as phosphates, iron, morpholine or ethanolamine, ammonia, bromoform and other oxidants).

2.4.1.2. Suspended solids

Construction activities may result in elevated levels of suspended solids in surface water runoff.

2.4.2. Effluent collected during the various construction activities other than commissioning tests

The types of effluent collected from the construction site and discharged into the sea may include:

- Rainwater collected from:
  - site drainage;
  - road drainage; and
  - the outlet for the communal parking areas.
- Grey and black wastewater collected at the outlet of the purification stations operating on the construction site, which typically contains:
  - crushing units and concrete batching plants;
  - parking areas or repair shops for construction equipment;
  - analysis and testing laboratories;
  - the transit area for waste;
  - offices and canteen; and
  - storage areas.

- Limits are set concerning the characteristics of the rainwater that is drained from the different parts of the site; as an example, the limits for the characteristics at the Flamanville EPR site are:
    - o suspended solids < 30 mg l^{-1}
    - o hydrocarbons < 5 mg l^{-1}

In addition, hydrocarbon levels are checked periodically at each outfall. Sub-chapter 4.3 - Table 3 sets out all the discharge sources with their outfalls, showing for each the concentration of chemical and the amount discharged. The figures are presented for illustration, since they will depend on the site characteristics.

Sub-chapter 4.3 - Table 3: Chemical discharge during the preparatory work and the main construction (example of Flamanville 3 EPR site)

Source of discharge	Substance discharged	Quantity	Rate
Surface water	Suspended solids	< 30 mg l^{-1} draining off the plot [1]	Depends on rainfall
	Hydrocarbons	< 5 mg l^{-1} draining off the plot[2]	
Draining the excavated areas	Suspended solids	50 mg l^{-1}	1000 m^3 h^{-1}
Digging the offshore well by rock blasting	Suspended solids	25 mg l^{-1}	70 m^3 h^{-1}
Or Digging the offshore well by drilling	Suspended solids	1 g l^{-1}	200 to 500 m^3 h^{-1}
Temporary purification stations	BOD_5	< 35 mg l^{-1} output from the station	Depends on activity

2.4.3. Liquid discharge during the commissioning tests

The commissioning tests, which will last over a two years period, use demineralised water. Two different characteristics of demineralised water are used:

- Nuclear Island Demineralised Water Distribution System (SED): demineralised water with no additives; and
- Conventional Island Demineralised Water Distribution System (SER): demineralised water with added morpholine or ethanolamine and potentially ammonia.

1 This value may rise to 650 mg l^{-1} if there is exceptionally heavy rain (10 mm of rainfall within 15 minutes) – these figures are given as examples to be adapted to the chosen site.

2 This value may rise to 7 mg l^{-1} if there is exceptionally heavy rain – these figures are given as examples to be adapted to the chosen site.

The discharge associated with commissioning tests is estimated from the volumes of SED or SER water required to carry out the different tests, the concentrations of the chemicals required to condition the various circuits (such as hydrazine, trisodium phosphate, boric acid and lithium hydroxide) and the resulting products (iron, suspended solids, bromoform and residual oxidants); and from the products resulting from the demineralised water production itself.

- Pre-operational testing:
  - Hydraulic testing: uses a volume of SED and SER water equal to the volume of the circuit. The resulting effluent contains morpholine or ethanolamine and potentially ammonia, suspended solids and iron.
  - Gravity and dynamic flushing: uses a volume of SED and SER water that varies depending on the circuit treated (1 - 6 times the capacity of the circuit, or in some cases, twice the capacity of the upline tanks). The resulting effluent contains morpholine or ethanolamine and potentially ammonia, suspended solids and iron.
  - Treatment with water lance: uses a volume of SED and SER water equal to 10% of the circuit volume. The resulting effluent contains morpholine or ethanolamine and potentially ammonia, suspended solids and iron.
- Testing the entire primary side:
  - Vessel flushing: uses a volume of SED water equal to twice the volume of the upline tanks (Fuel Pool Purification System (PTR [FFPS])). These tests are carried out after cleaning the pipework (water lance). The effluent contains no suspended solids and is purely demineralised water with no additives.
  - Cold testing and hydraulic testing of the nuclear steam supply system: uses twice the volume of the upline tanks with SED water. Half of this volume is used for testing with the vessel head open, and the other for cold and/or hydraulic testing. These tests are carried out after cleaning the pipework (water lance), so the effluent contains no suspended solids and is purely demineralised water with no additives.
  - Hot testing: uses a volume of SED and SER water, conditioned with the appropriate chemical reagents, equal to the volume of the upline tanks (PTR [FFPS]) plus the volume of the primary circuit. Depending on the conditioning selected during Hot Functional tests, the resulting effluent may contain lithium hydroxide, boric acid and ammonia.
- Testing the entire shell side:
  - Hydraulic testing of the shell side of the steam generator assembly: uses a volume of SER water equal to three times that of the shell-side of the steam generators. The resulting effluent contains morpholine or ethanolamine, hydrazine and suspended solids.
- Testing the tertiary system:
  - Conditioning the auxiliary circuits: uses SED water conditioned with phosphate. The volume is three times the volume of the relevant pipework. The resulting effluent contains phosphate and suspended solids.

- Testing related to electrochlorination: this follows the standard operational processes: normal chlorination using 0.5 mg l^{-1} of active chlorine, applied sequentially once every 30 minutes per cooling channel. This results in an average concentration in the discharge pond of 0.5 mg l^{-1} of residual oxidants and 0.02 mg l^{-1} of trihalomethanes. In addition, chlorination may, in rare occasions be carried out at 1 mg l^{-1}, for 10 days in every year, if there is excessive biological fouling.

Finally, early estimates of the volume of demineralised water needed for the EPR commissioning tests amounts to around 72,500 m^3 (to be evaluated at the site specific stage).

The demineralised water production generates iron, suspended solids, sodium and sulphates. Depending on the means of production of the demineralised water (demineralisation unit or desalination unit), the discharged effluent contains very different proportions of these chemicals.

The figures presented in Sub-chapter 4.3 - Table 4 correspond to the production of 72,500 m^3 of demineralised water (to be evaluated at the site specific stage) either by a demineralisation unit or by a desalination unit.

Sub-chapter 4.3 - Table 4: Demineralised water production

Effluent (in kg)	Method used to produce demineralised water	
	Demineralisation	Desalination
Iron	2015 kg	128 kg
Suspended solids	3850 kg	244 kg
Sodium	18,445 kg	4913 kg
Sulphate	34,300 kg	1247 kg

The quantity of effluents produced during commissioning tests, including the demineralised water production, is presented in Sub-chapter 4.3 - Table 5 below.. Table 5 presents early estimates of chemical effluents before treatment and disposal for annual flow and flow over 24 hours during the 2 years period of the commissioning tests for FA3.

The values have been calculated assuming the same balance between alternative means of producing demineralised water as expected for Flamanville 3, taking into account the specific attributes of that site. This is production via the existing demineralisation unit 40 days per year; and production via the desalination unit for the remainder of the year.

Sub-chapter 4.3 - Table 5: Early estimates of chemical effluents before treatment and disposal during electromechanical erection and start-up testing for FA3

Substances[3]	Conditioning the circuits ($kg\ y^{-1}$)*	Producing demineralised water ($kg\ y^{-1}$)	Annual quantity (kg)*	Daily*** quantity (kg)
Iron	777	314	1091	135
Suspended solids	269	600	869	82.7
Phosphates	1340	-	1340	300
Lithium hydroxide	4.1	-	4.1	4.1
Hydrazine	214	-	214	75
Boric acid/Boron**	8050/1407	-	8050/1407	4120/720
Ethanolamine Or Morpholine	125.5 Or 300	-	125.5 Or 300	21.5 Or 51.4
Sodium	960.5	6033	6033	60
Sulphates	-	4591	4591	120
Ammonia	255	-	255	94.1

* This actually represents effluents which can be produced over more than one year.

** Ratio in weight mass between boric acid and Boron is 5.72.

*** The daily quantity corresponds to the commissioning test which generates the greatest effluent.

[3] The substances listed are those that derive from the conditioning of the circuits and also the production of demineralised water necessary to fill the circuits (site specific).

The table is representative of chemical effluents produced **before treatment** during commissioning tests (conditioning of circuits, pre-operational tests up to core loading). However the figures may be site specific since:

- a number of water systems may be different (such as turbine manufacturer, length of pipes depending on site geometry),
- the means to produce demineralised water could vary (desalination, demineralisation or other);
- the sequence of mechanical erection of the circuits may have an impact on the volumes involved in the cleaning process.

At the site specific stage, Best Available Techniques (BAT) will be applied for cleaning the circuits and treating the effluents produced before discharge (in particular hydrazine, boric acid, and lithium hydroxide). The techniques to be retained will be operator and site specific.

In addition, the electrochlorination testing at 0.5 mg l^{-1} and 1 mg l^{-1} produces the same concentrations in the discharge pond than during normal operation, e.g. Sub-chapter 4.3 - Table 6 below:

Sub-chapter 4.3 - Table 6: Discharge associated with electrochlorination testing

Type of chlorination	Maximum concentration in the discharge pond (mg l^{-1})	
	Residual oxidants	Bromoform
Normal chlorination	0.5	0.02
Exceptional chlorination, at 1 mg l^{-1}	1	0.04

The assessment of the potential impacts is given in Chapter 12 of the PCER.

The discharge of effluent and runoff from the site during construction and commissioning may require a Discharge Consent from the EA, granted under the Water Resources Act 1991.

SUB-CHAPTER 4.3 – REFERENCES

External references are identified within this sub-chapter by the text [Ref-1], [Ref-2], etc at the appropriate point within the sub-chapter. These references are listed here under the heading of the section or sub-section in which they are quoted.

1. NEEDS AND OUTPUTS RELATED TO THE TERRESTRIAL ENVIRONMENT

1.5. SOLID WASTES

[Ref-1] Hazardous Waste Regulations 2005. ISBN 978-011072685-4. The Stationery Office Ltd. (E)

2. NEEDS AND OUTPUTS RELATED TO THE AQUATIC ENVIRONMENT

2.1. FRESHWATER

2.1.5. Freshwater supply

[Ref-1] Water Resources Act 1991. ISBN 978-0105457916. The Stationery Office Ltd. (E)