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UK ABWR

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## UK ABWR Generic Design Assessment

# Other Environmental Regulations


Hitachi-GE Nuclear Energy, Ltd.

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# 1. Acronyms

| | |
|---|---|
| AA | Annual Average |
| ABWR | Advanced Boiling Water Reactor |
| AURN | Automatic Urban and Rural Network |
| BAA | British Airport Authority |
| BAT | Best Available Technique |
| CA | Competent Authority |
| CAD | Controlled Area Drain |
| CAS | Chemical Abstracts Service |
| CCGT | Combined Cycle Gas Turbine |
| CCW | Condenser Circulating Water |
| CHP | Combined Heat and Power Plant |
| CO | Carbon Monoxide |
| $CO_2$ | Carbon Dioxide |
| COD | Chemical Oxygen Demand |
| COMAH | Control of Major Accident Hazards |
| CSG | Combustion Sector Guidance Note |
| CST | Condensate Storage Tank |
| CUW | Reactor Water Clean-up System |
| CW | Circulating Water System |
| D/W | Dry Well |
| DECC | Department of Energy and Climate Change |
| DEFRA | Department for Environment, Food and Rural Affairs |
| DHN | District Heating Networks |
| DTA | Direct Toxicity Assessment |
| EC | European Commission |
| EPR/EPR10 | Environmental Permitting (England and Wales) Regulations 2010 |
| EQS | Environment Quality Standards |
| ETS | Emissions Trading Scheme |
| EU | European Union |
| GDA | Generic Design Assessment |
| GEP | Generic Environmental Permit |
| H1 | Environment Agency’s Horizontal Guidance Note H1 Environmental Risk Assessment and its annexes |

| | |
|---|---|
| H2 | Environment Agency's Horizontal Guidance Note IPPC H2 Energy Efficiency |
| HCEP | How to comply with your environmental permit |
| HCW | High Conductivity Waste |
| HMIP | Her Majesty's Inspectorate of Pollution |
| HNCW | HVAC Normal Cooling Water System |
| HSA | Hazardous Substances Authority |
| HSD | Hot Shower Drain |
| HSE | Health and Safety Executive (UK) |
| HVAC | Heating Ventilation and Air Conditioning System |
| IA | Instrument Air System |
| IED | Industrial Emissions Directive |
| IHT | Inter-seasonal Heat Transfer |
| IPPC | Integrated Pollution Prevention and Control |
| LCW | Low Conductivity Waste |
| LD | Laundry Drain System |
| LLE | Liquid-liquid Extraction |
| LT | Lower Tier |
| LWMS | Liquid Waste Management System |
| MAC | Maximum Allowable Concentration |
| MAPP | Major Accident Prevention Policy |
| MMR | Monitoring and Reporting Regulation |
| MUWP | Makeup Water Purified System |
| NO | Nitric Oxide |
| $NO_2$ | Nitrogen Dioxide |
| NOx | Oxides of Nitrogen (NO and $NO_2$) |
| $N_2O$ | Nitrous Oxide |
| NPP | Nuclear Power Plant |
| NRW | Natural Resources Wales |
| NSD | Non-radioactive Storm Drain |
| OCGT | Open Cycle Gas Turbine |
| P&D | Plumbing and Drainage System |
| P&ID | Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Design |
| PC | Process Contribution |
| ppb | parts per billion |
| PPG | Pollution Prevention Guide |
| RAS | Recirculation Aquaculture Systems |

| | |
|---|---|
| R/B | Reactor Building |
| RCW | Reactor Building Cooling Water System |
| RHR | Residual Heat Removal System |
| RSR | Radioactive Substances Regulation |
| RSW | Reactor Building Service Water System |
| RW/B | Radwaste Building |
| S/B | Service Building |
| SA | Station Service Air System |
| SLC | Standby Liquid Control System |
| SLD | Standby Liquid Drain |
| $SO_2$ | Sulphur Dioxide |
| Sv | Sievert |
| SWSD | Surface Water Storm Drain |
| T/B | Turbine Building |
| TBD | to be determined |
| TCW | Turbine Building Cooling Water System |
| TRL | Transport Research Laboratory |
| TSW | Turbine Building Service Water System |
| TT | Top Tier |
| UK | United Kingdom |
| ULSD | Ultra Low Sulphur Diesel |
| UNECE | United Nations Economic Commission for Europe |
| US | United States |
| USA | United States of America |
| VOC | Volatile Organic Compounds |
| WFD | Water Framework Directive |
| WHEP | Waste Heat Energy Parks |

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# 3. Introduction

The Environment Agency has identified the information it requires to assess the environmental impacts of the UK Advanced Boiling Water Reactor (ABWR) at a generic site in the Process and Information Document for the Generic Assessment of Candidate nuclear power plant Designs (P&ID) [Ref-1].

Table 1, part 8 of the P&ID details the information Hitachi-GE is required to provide regarding the applicability and impact of other environmental regulations on the design and the generic site. The areas in question relate to the non-radioactive regulations, specifically:

- Water use and abstraction.
- Discharges to surface waters.
- Discharges to groundwater.
- Operation of installations (combustion plant and incinerators).
- Substances subject to the Control of Major Accident Hazards (COMAH) Regulations.

Hitachi-GE's Step 1b Other Environmental submission summarised the applicability of these five areas to the UK ABWR, and set the scope of the information to be provided by Hitachi-GE as part of the Generic Design Assessment (GDA) process.

This Step 2 report supports the next stage of the GDA process and presents the further information now available. This Step 2 Report has been prepared in line with the scope of work described in the Step 1b submission and has been sub-divided into five sections, each addressing one of the five areas detailed in the P&ID requirements.

- Water use and abstraction (Section 4).
- Discharges to surface waters (Section 5).
- Discharges to groundwater (Section 6).
- Operation of installations (combustion plant and incinerators) (Section 7).
- Substances subject to the Control of Major Accident Hazards (Section 8).

The conclusions from the five sections are summarised in a separate section (Section 9) at the end of the report.

# 4. Water Use and Abstraction

The purpose of this section of the report is to address the Environment Agency's P&ID requirements [Ref-1] with regard to water use and abstraction requirements.

Some of the P&ID requirements for water use and abstraction will be addressed at site-specific stage as they are dependent on aspects specific to the characteristics of the chosen site.

## 4.1 P&ID Requirements

The Environment Agency has identified the information it requires to carry out the GDA in the P&ID [Ref-1]. The P&ID requirements relating to water use and abstraction are reproduced in the following bullet points:

1. *Provide details and estimates of fresh water requirements for the design.*
2. *Provide details and estimates of cooling water requirements for the design relevant to the generic site. Include consideration of:*

- *seawater or river water abstraction;*
- *use of conventional cooling towers or hybrid cooling towers;*
- *abstraction inlet fish deterrent schemes; and*
- *fish return systems.*

The information to address these P&ID requirements is presented in three sections.

- **Freshwater requirements** (Section 4.3) - describes the fresh water requirements for the UK ABWR generic design at the generic site.
- **Cooling water system requirements** (Section 4.4) - describes the cooling water requirements for the UK ABWR generic design at the generic site.
- **Fish deterrent and fish return systems** (Section 4.5) - describes the fish deterrent and return systems that could be used for the UK ABWR.

## 4.2 Regulatory Context

There are two main areas of legislative requirements relevant to this section of the P&ID:

- Water abstraction – regulated under the Water Resources Act 1991 (as amended) [Ref-2];
- The Eels (England and Wales) Regulations 2009 [Ref-3].

Water abstraction from controlled waters is regulated under the Water Resources Act 1991 (as amended) [Ref-2], Part II, Chapter II, and the Water Resources (Abstraction & Impounding) Regulations 2006 [Ref-4]. A licence is required from the Environment Agency or Natural Resources Wales (NRW) in Wales to impound water or to abstract over $20m^3$/day water from a river or stream, reservoir, lake or pond, canal, spring, underground source or estuary, bay or arm of the sea. Abstraction licensing is a site-specific issue.

The Eels (England and Wales) Regulations 2009 implement EC Council Regulation (1100/2007) (the EC Eel Regulation) (Eels Regulations) [Ref-5]. This regulation requires the operator of an abstraction or water diversion of more than $20m^3$/day, or any discharge to a channel, bed or sea (out to 6 nautical miles) to screen it to prevent the entrainment of eels. After 1 January 2015, it will become an offence not to have a screen on any such intake or outfall, unless the Environment Agency/NRW has specifically issued notice to exempt the requirement.

In addition the Environment Agency/NRW can require the provision of fish passes and screens for the protection of salmon and migratory trout (sea trout or sewin) under the Salmon and Freshwater Fisheries Act 1975 [Ref-6].

## 4.3 Fresh Water Requirements

The GDA is based on the assumption that all fresh water requirements will be supplied by the local water company and that fresh water abstraction, and an abstraction license, will not be required. This does not preclude the consideration of other fresh water supply options for specific sites (depending on the availability of local sources of fresh water).

Fresh water will be used for drinking,  washing and showering by personnel, and within the process as part of the Domestic Water System. Fresh water may also be used for fire fighting purposes.

Fresh water will be de-ionised for various uses as part of the Makeup Water Purified System (MUWP). De-ionised water will be stored in the Purified WaterStorage Tank. The MUWP pump transports the de-ionised water to the Condensate Storage Tank (CST), or for use elsewhere within the UK ABWR [Ref-7]. De-ionised water usages include the following processes:

- De-ionisation plant re-generation.
- Reactor water (refill of primary circuit water loss, clean-up).

- Auxiliary boiler water.
- Boronated water in the Standby Liquid Control System (SLC).

Typically, total fresh water usage is estimated at 900 $m^3$/day, with 450 $m^3$/day of this being used to make de-ionised water [Ref-7].

Fresh water and de-ionised usage rates will vary for the different operating regimes (commissioning/start-up / routine operation / shutdown /outage).

Fresh water use for sanitation and drinking, showers and laundry will depend on a number of factors, such as the number of staff and the number and nature of operations support buildings.

Fresh water usage within the process includes:

- Concentration Tank for Drained Water Treatment - (Normal / Shutdown / Outage): 24 $m^3$/day (continuous); Emergency condition: 0 $m^3$/day.
- Hydrochloric Acid Scrubber for Water Purifying Equipment - (Normal / Shutdown / Outage): 24 $m^3$/day (continuous); Emergency condition: 0 $m^3$/day.
- Sludge Pump - (Normal / Shutdown / Outage): 4 $m^3$/day (continuous); Emergency condition: 0 $m^3$/day.
- Washing Machine - (Normal / Shutdown / Outage): 40 $m^3$/day (continuous); Emergency condition: 0 $m^3$/day.
- Circulation Pump for Condenser Ball Cleaning Device - (Normal / Shutdown): 7.2 $m^3$/day (continuous); Outage / Emergency condition: 0 $m^3$/day.
- Insulator Washing Tank - (Normal / Shutdown / Outage): 720 $m^3$/day (intermittent); Emergency condition: 0 $m^3$/day.
- Condenser - Normal operation / Emergency condition: 0 $m^3$/day; Shutdown / Outage: 160 $m^3$/day.
- Reactor Building Cooling Water System (RCW) Heat Exchanger - Normal / Shutdown / Emergency condition: 0 $m^3$/day; Outage: 79 $m^3$/day.
- Turbine Building Cooling Water System (TCW) Heat Exchanger - Normal / Shutdown / Emergency condition: 0 $m^3$/day; Outage: 32 $m^3$/day.

The use of fresh water for fire-fighting will be confirmed at Step 3.

Further details of the types of fresh and de-ionised water uses and estimates of the quantities of water to be used will be provided at Step 3.

## 4.4 Cooling Water System Requirements

### 4.4.1 Selection of Cooling Water System

The GDA is based on the assumptions that the site is coastal [Ref-8] and that a once-through seawater cooling system will be used. In general, the use of once through cooling systems is considered BAT for a coastal location [Ref-9].

This does not preclude the consideration of other cooling water system options and the exact details of the cooling system will be defined at the site-specific permitting stage. Potential cooling options that could be considered as the alternative to the once-through seawater cooling identified for the generic site, include:

- Once-through cooling using sea, estuary, river, or lake as the heat sink.
- Once-through cooling using cooling towers to cool water before discharge to sea, estuary, river, or lake.

- Recirculation system using natural draft cooling towers.
- Recirculation system using mechanical draft cooling towers.
- Closed-circuit dry air cooled systems.
- Closed-circuit wet cooling.
- Hybrid wet/dry cooling systems (closed or open circuit).

These options are not considered further within the GDA submission.

### 4.4.2 Description of Cooling Water Systems and Water Use

The UK ABWR will use seawater for once-through cooling in the main steam condenser and for cooling of other reactor and turbine components. The cooling water flow rate is based on a 12°C temperature increase.

The seawater cooling systems of the ABWR can be broken down into five systems, namely the Circulating Water (CW) system, the Turbine Building Service Water System (TSW), TCW, Reactor Building Service Water System (RSW) and RCW.

The TCW and RCW systems are both closed loop systems [Ref-11], and their only interaction with the TSW and RSW systems is the transfer of heat via heat exchangers. There is no mixing of the water between the two systems. No other materials or contaminants are transferred between the cooling water and service water systems.

The design of the CW, TSW and RSW systems will include control measures to prevent fouling (physical, chemical, biological and mechanical). The control measures selected will depend in part on the characteristics of the receiving marine environment and will therefore be finalised at site-specific stage. The three once-through systems are described further in the following bullet points:

- CW - this system supplies service water into the condenser tube as cooling water [Ref-12]. The system runs continuously during the generation of power, including during start-up and shutdown. Under normal operation the intake rate to the CW system is 184,800 $m^3$/h. Under outage conditions the rate of intake will be between 0 and 184, 800 $m^3$/h.
- TSW - the purpose of this system is to cool and remove heat from the TCW, through the TCW heat exchanger [Ref-13]. The TCW system supplies cooling water to the equipment that contains non-radioactive fluid in the turbine building [Ref-13]. Under normal operation the water intake rate to the TSW system is 7,500 $m^3$/h. Under outage conditions the intake rate will be between 3,750 and 7,500 $m^3$/h.
- RSW - the purpose of this system is to cool and remove heat from the RCW, through the RCW heat exchanger [Ref-13]. The RCW system supplies cooling water to the equipment in the reactor and radioactive waste treatment buildings, and the equipment that contains radioactive fluid in the turbine building [Ref-13]. Under normal operation the rate of water intake to the RSW system is 5,400 $m^3$/h (1,800 $m^3$/h per unit). In shutdown operation and under abnormal/emergency conditions the intake rate will be 10,800 $m^3$/h.

Both the TSW and RSW systems are dosed with ferric iron at a concentration of 0.03ppm over three months from the installation of new tubing. The iron dosing is undertaken to prevent corrosion within the tubes of the TCW and RCW heat exchangers [Ref-13]. Following dosing, an iron oxide layer is formed on the inner surface of the tubing. This reduces the ferric iron concentration in the TSW and RSW water to 0.01ppm. There is no dosing of the CW system [Ref-13].

### 4.4.3 Seawater Intake (and Outfall)

The seawater inlet and outlet structures for the system will need to be sited and designed to reduce the potential for sediment mobilisation and scour on the sea bed, and to be sited to minimise impact on surrounding habitats and species. These factors are site-specific and will be addressed at the site-specific permitting stage.

Regardless of location certain measures will be considered with the site specific design, for example the seawater intake will be screened to remove debris.

The seawater outfall and cooling water discharge are considered further in Section 5.

## 4.5 Fish Deterrent and Fish Return Systems

Large water intakes can entrain fish and other marine organisms. These may be killed, or suffer physical damage, as they pass through the system before the cooling water is discharged. Inlet structures are usually protected with grills or screens to prevent the entrainment of material into the cooling systems where it could cause mechanical damage and block condenser tubes. However, fish may become pressed against screens and killed or damaged (an effect that is known as impingement). Evidence suggests that fish entrainment and impingement particularly affects fish larvae and young fish.

Fish entrainment and impingement is a highly complex matter [Ref-9] that varies with locality, and depends on the interplay of numerous factors, including the chemical and physical nature of the water body, the intake requirements of the facility, climatic conditions, and biology of the area [Ref-14]. A number of techniques have been developed and applied by industry to prevent or reduce the entrainment and impingement of fish in large cooling water inlets, and reduce their mortality. The BREF document [Ref-9] notes that the optimum solution must be evaluated on a site-specific basis, and further states that no particular techniques to deter and/or protect fish can yet be identified as BAT. The US Environmental Protection Agency (EPA) guidance document [Ref-14] echoes this assessment, and goes on to state that one or more fish deterrent technologies can be used to provide significant impingement and entrainment protection at most sites.

As the design of any fish deterrent/protection scheme will depend on site-specific factors, it is not possible to define a scheme design at this stage and full design of the system will be considered at site-specific permitting. At this stage however, a number of options can be considered and taken forward to the full site-specific options assessment and selection. Measures that may be adopted as part of the system to reduce fish impingement and entrainment include:

- Design of the inlet structure to minimise intake velocities.
- Location of the inlet structure.
- Use of screens and fish return systems.
- Physical barriers.
- Behavioural barriers.

These measures are briefly described below. Any approach to the water inlet system and to reduce fish entrainment and impingement undertaken will be compliant with the requirements of the Eels Regulations [Ref-3] as appropriate.

### 4.5.1 Design of the Inlet Structure to Minimise Intake Velocities

Limiting the speed of water inflow through careful design can allow fish to escape and prevent entrainment and impingement. However, there is some evidence to suggest that limiting intake velocity may have a limited efficacy as some entrained fish allow themselves to drift even when they are able to swim fast enough to escape the inlet [Ref-9].

### 4.5.2 Location of the Inlet Structure

Consideration should be given to avoidance of critical areas, for example spawning grounds, fish nurseries and migration routes.

### 4.5.3 Use of Screens and Fish Return Systems

Physical screens are used to prevent the intake of materials and debris, including fish, in the cooling water, but have the effect of causing fish impingement. Various types of screen are available, such as drum screens, travelling band screens, and bar screens (for upstream coarse screening). Each screen type is used in conjunction with other techniques to limit damage to the fish:

- Drum screens – when used to screen debris from the water intake, high pressure sprays are used to remove the debris from the screens. However, this is particularly damaging to fish [Ref-14]. Implementing a low pressure spray in advance of the high pressure spray may wash the fish off the screen in a less damaging way.
- Travelling band screens - can be modified so that impinged fish are collected from the screen surface in fish buckets or baskets, and transported to a fish return system. A variation on modified travelling screens is to use fine mesh screens, which have mesh sizes below 5 mm.
- Bar screens - the intake velocity should be limited in front of the bar to prevent impingement.

The selection of appropriate screens will be considered at the site-specific design stage.

### 4.5.4 Physical Barriers (other than screens)

Physical fish barriers can be used in front of, or around, cooling water inlets. They can take the form of fish nets, microfiltration barriers, or porous dikes.

Barrier fish nets form a physical barrier to prevent fish becoming entrained in cooling water inlets; they have to be sized to minimise fish becoming stuck in the meshes [Ref-14]. They are most commonly used seasonally, to provide barriers to migratory fish.

Microfilter barriers are fine barriers that are designed to filter out organisms. In order to ensure a reasonable through-flow they are placed at a distance from the inlet to ensure a large surface area.

Porous dikes (also termed leaky dams) are structures resembling breakwaters that surround a cooling water inlet. The dike is constructed from cobbles or gravel that permits the through-flow of water, but acts as a physical and behavioural barrier to aquatic organisms.

### 4.5.5 Behavioural Barriers

There are a variety of behavioural barriers that can be used to divert fish away from inlets and screens. The main types of behavioural barriers that could be considered for fish deterrent schemes are light and sound barriers. The use of both measures may supplement the effect of the other.

# 5. Water Discharge

The purpose of this section of the report is to address the Environment Agency's P&ID requirements [Ref-1] with regard to discharges from the UK ABWR to surface waters. In summary, this section describes the aqueous waste streams that arise, where they will be discharged to, and how they will be managed in order to minimise the environmental impact posed.

Some of the P&ID requirements for discharges to surface waters will be addressed at site-specific stage as they are dependent on aspects specific to the environment and topography of the chosen site.

## 5.1 P&ID Requirements

The Environment Agency has identified the information it requires to carry out the GDA in the P&ID [Ref-1]. The P&ID requirements relating to discharges to surface waters are reproduced below:

1. *Provide a description of how aqueous waste streams will arise, be managed and be disposed of throughout the facility's lifecycle. Including:*
    - *Sources and quantities of contaminants (including disinfectant and biocides), highlighting any priority substances (as specified in the 'Priority Substances' Directive (EU, 2008)).*

- *Identification of the effluent and surface water run-off streams contributing to the overall discharge and how they are controlled.*
- *Potential options and associated environmental impact for disposal of each individual effluent stream.*
- *The means of control in the event of detection of unplanned radioactive or other contamination of the discharge.*
- *Options for beneficial use of the waste heat produced.*
- *Environmental impact of thermal discharges.*

The information to address these P&ID requirements is presented below in three sections.

- **Effluent characterisation** (Section 5.3) **-** describes the key aqueous effluent streams generated from the UK ABWR Nuclear Power Plant (NPP) at the generic site, and the information available on the potential non-radioactive contaminants present.
- **Effluent treatment and assessment of the impacts of discharged effluents** (Section 5.4) **-** describes the planned management or treatment options for each of the effluent waste streams to mitigate environmental impacts that may occur. This includes the design of the effluent treatment system to manage unplanned releases.
- **Identification of options for the beneficial use of the waste heat produced** (Section 5.5) **-** reviews the potential options for the beneficial use of power cycle waste heat. The option chosen will be determined (in part) on issues specific to the selected site. Therefore, no final selection of the option to be used has been made at this GDA stage.

### 5.1.1 Thermal Discharges

In order to assess the environmental impact of the thermal plume generated by the cooling water discharge, accurate information is required on the behaviour of the receiving surface water and how this interacts with the various substances discharged. This can only be achieved using computational modelling supported by localised monitoring data from the specific site.

It is therefore proposed that no thermal dispersion modelling is undertaken at the GDA stage, on the basis that the assessment of the impact of thermal dispersion is site-specific and, as a consequence, the thermal impact of discharges will be assessed in detail at the site-specific permitting stage using site-specific dispersion modelling.

Information to input into the thermal dispersion modelling, such as the temperature uplift of the cooling water is presented at GDA stage and has been included as part of the review of the aqueous effluent streams in Section 5.3.1.

## 5.2 Regulatory Context

Discharges of trade effluent (which encompasses all non-radioactive effluents generated at the generic site) to controlled waters (which include coastal waters out to the territorial limit) require a permit under the Environmental Permitting (England and Wales) Regulations 2010 (SI 2010 No.675), as amended [Ref-15].

The nuclear power plant operator will have to apply for an Environmental Permit at the site-specific permit application stage. The permit application will include information on the source of the effluent, identify the flow rate and contaminants in the effluent (including heat) and assess the impact of the releases on the receiving environment, including specific assessment of the impact on EU Habitats sites and nationally designated sites and species.

At the GDA stage, the P&ID requires the requesting party to provide information on proposed discharges to surface water in order to demonstrate that the UK ABWR can operate within the requirements of the UK regulatory requirements. The approach undertaken by Hitachi-GE draws upon the relevant parts of the Environment Agency's guidance [Ref-16].

## 5.3 Effluent Characterisation

Aqueous waste streams that could be generated at the UK ABWR licensed site are divided into four main categories, namely the discharges from the cooling water systems, the drainage networks from non-radioactive and radioactive areas, special liquid wastes, and run-off from rainfall onto the buildings and ground within the nuclear licensed site. These are described in more detail in the following paragraphs.

### 5.3.1 Cooling Water Systems

The cooling water systems for the UK ABWR are described in Section 4.4.2.; three of these, the CW, RSW and TSW are once-through systems and discharge seawater back to the sea. The TCW and RCW systems are both closed loop systems [Ref-11], and their only interaction with the TSW and RSW systems is the transfer of heat across the relevant heat exchangers. No other materials or contaminants are transferred between the cooling water and service water systems.

- CW - discharge of seawater from the CW system is 184,800 $m^3$/h under normal operation. Under outage conditions the discharge rate will be between 0 and 184, 800 $m^3$/h. The CW system is also designed to remove scales in each cooling tube of the condenser through physical processes (ball cleaning and backwashing during operation of the plant). These washings are discharged to sea within the CW system discharge. There is no chemical dosing into the CW system identified at this stage [Ref-13]. Chemical dosing to manage bio-fouling within the CW discharge system will be addressed at site-specific stage as it requires consideration of the characteristics of the receiving environment for the discharge.
- TSW - under normal operation the discharge rate from the TSW system is 7,500 $m^3$/h. Under outage conditions the discharge rate will be between 3,750 and 7,500 $m^3$/h, and under abnormal/emergency conditions the discharge rate will be 11,250 $m^3$/h.
- RSW - under normal operation the discharge rate from the RSW system is 5,400 $m^3$/h. In shutdown operation and under abnormal/emergency conditions the discharge rate will be 10,800 $m^3$/h.

The TSW and RSW systems are dosed with ferric iron at a concentration of 0.03 ppm over three months from the installation of new tubing in order to deposit an iron oxide layer on the tubing internals.

The discharges from these three systems are mixed in the Seal Pit before discharge to the sea.

#### 5.3.1.1 Potential Contaminants Present (Cooling Water Systems)

The function of the three systems is purely a cooling one, with seawater taken in, passed through a heat exchanger and discharged. None of systems receive drainage from other areas within the ABWR facility. Consequently, the cooling water systems should not have any radioactive or non-radioactive systems present, apart from those added specifically (see the chemical dosing strategy and the bullet points below). The need for chemical dosing of the cooling water discharge lines to manage bio-fouling within the pipework will be addressed at site-specific stage, and has therefore not been addressed further at this Step 2 stage.

The cooling function of all three systems means that the seawater discharged from these systems will be warmer than the intake, and consequently warmer than the water in the receiving environment around the discharge point.

- CW system - no chemicals are added to the CW system. Scale washings from the condenser cooling tubes may be present. The thermal uplift of the seawater discharged is expected to be 12°C (at point of discharge). Discharge should therefore comprise seawater (at higher temperature than receiving water) and scale washings. The discharge stream is sampled at a seal pit before final discharge to confirm that water quality meets the criteria for release (Table 5.3.2.1-1).

- TSW system - ferric iron is added to this system. No other chemicals are added. The thermal uplift of the seawater discharged is expected to be 5.1°C (at point of discharge). The discharge stream is sampled at the seal pit before final discharge to confirm that water quality meets the criteria for release (Table 5.3.2.1-1).
- RSW system - ferric iron is added to this system. No other chemicals are added. The thermal uplift of the seawater discharged is expected to be 5.4°C (at point of discharge). The discharge stream is sampled at the seal pit before final discharge to confirm that water quality meets the criteria for release (Table 5.3.2.1-1).

### 5.3.2 Drainage Networks

The drainage networks within the UK ABWR facility are categorised according to:

- Where the waste water is generated (from controlled or non-controlled areas).
- The presence (and level) of radioactivity, seawater, detergents, chemical impurities, and suspended solids.
- The conductivity of the aqueous waste present.

The flow diagram in Figure 5.3.2-1 presents the categorisation methodology applied by Hitachi-GE for the aqueous waste streams.

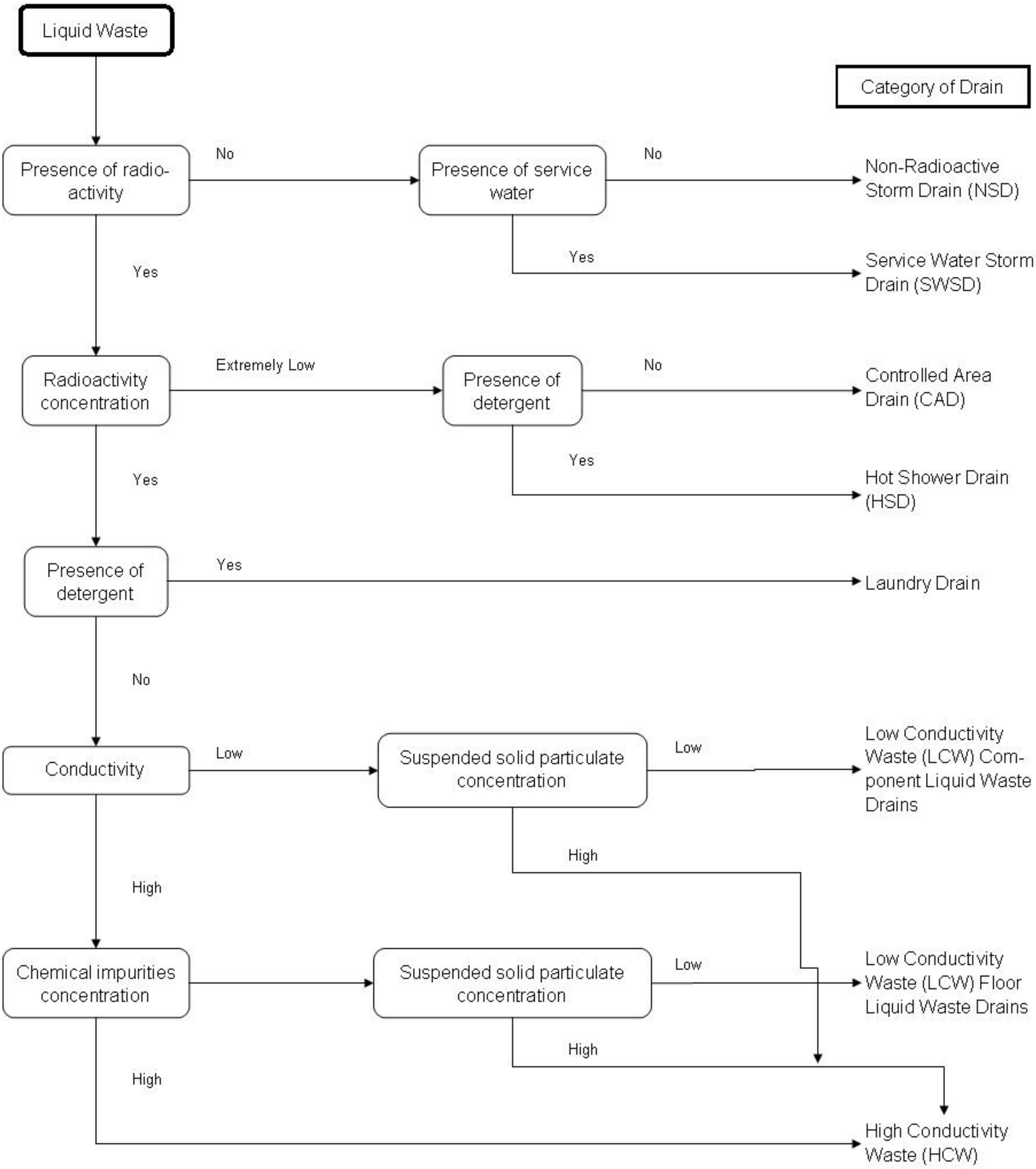


**Figure 5.3.2-1: General Methodology for the Classification of Aqueous Waste**

The drainage from the ABWR facility consists of six effluent streams:

- Service water storm drain (SWSD).
- Non-radioactive storm drain (NSD).
- Controlled area drain (CAD).
- High conductivity waste (HCW).

- Laundry drain (LD) and hot shower drain (HSD).
- Low conductivity waste (LCW) - Component liquid waste drain and the floor liquid drain.

The NSD and SWSD stream capture liquid effluent from non-controlled areas of the site, and should therefore have zero or very low radioactive contamination.

The other four drainage streams arise from controlled areas of the site and may therefore have radioactive contaminants present. These four drainage streams make up the ABWR's liquid radioactive waste management system (LWMS) [Ref-17]. Further information on these is provided in section 5.3.3.

Figure 5.3.3-1 provides an overview of management and ultimate disposal routes for these six effluent streams. Further detail on the LWMS systems is presented in Figure 5.3.3-2.

#### 5.3.2.1 Service Water Storm Drain

The SWSD receives water discharged from the RSW and TSW pumps and piping during maintenance. The RSW and TSW pumps circulate the seawater in the RSW and TSW cooling systems through the RCW and TCW heat exchangers (Section 5.3.1).

The SWSD drains to the SWSD sump and is then pumped directly to the sea by the SWSD pump. The discharge is monitored by grab sampling and a conductivity detector prior to release to ensure that discharge criteria are met (Table 5.3.2.1-1).

The discharge rate from the SWSD drain is determined by the capability of the SWSD pump. The normal discharge rate is estimated (on this basis) as 24 $m^3$/day, with a maximum of 240 $m^3$/day.

**Table 5.3.2.1-1: Discharge Criteria for Liquid Waste to the Environment (criteria apply to all liquid discharges (from SWSD, NSD, and LWMS)**

| Item | Criteria | |
|---|---|---|
| pH | 5.8 - 8.6 | |
| chemical oxygen demand (COD) | <30 mg/l | Daily maximum |
| | <20 mg/l | Daily average |
| Suspended solids | <20 mg/l | Daily maximum |
| | <15 mg/l | Daily average |
| Concentration of normal-hexane extract | <3 mg/l | Daily maximum |

Note: These are the criteria for a Japanese ABWR and are presented here to demonstrate the level of discharge control in place for the ABWR NPP.

##### 5.3.2.1.1 Potential Contaminants Present (SWSD)

Potential contaminants within the SWSD system should be minimal. As the system drains from non-controlled areas of the site, radioactive contaminants should be negligible.

#### 5.3.2.2 Non-radioactive Storm Drain

The NSD receives arisings from non-radioactive drains in non-controlled areas. The NSD drainage stream differs from the SWSD stream described above in that the liquid is de-ionised water rather than seawater (service water) (Figure 5.3.2-1).

The NSD receives liquid waste from the following systems:

- RCW.
- TCW.
- MUWP - supplies the cooling water expansion tank of the diesel cooling water system.
- Station service air system (SA).
- Instrument air system (IA).
- Heating ventilation and conditioning (HVAC).
- HVAC normal cooling water (HNCW) - used as a cooling resource within the HVAC system.

The NSD system drains to the NSD sump and is then pumped directly to the sea by the NSD pump . A radiation monitor in the discharge line monitors for the presence of radioactive material in the discharge. Monitoring is also undertaken for the presence of corrosion inhibitors (rust preventing agents) in the waste stream. The capability exists to divert the NSD waste stream to the CAD collection tank for treatment in this system. If corrosion inhibitors are drained to the NSD sump then the effluent is diverted to the CAD collection tank. No corrosion inhibitors are discharged to sea therefore through the NSD discharge route.

The discharge rate from the NSD drain is determined by the capability of the NSD pump. Normal discharge rate is estimated (on this basis) as 24 $m^3$/day, with a maximum of 240 $m^3$/day.

If the NSD sumps, which collect the aqueous wastes, receive radioactive material or waste containing corrosion inhibitors, then the discharges from the sumps are switched to the CAD collection tank. The aqueous waste is discharged to sea after ensuring it meets the discharge criteria. Alternatively the discharge may be routed to the HCW system [Ref-12].

#### 5.3.2.2.1 Potential Contaminants Present (NSD)

The NSD system should have no radioactive contaminants present, as a consequence of it draining from non-radioactive rains in non-controlled areas.

Information available at Step 2 stage indicates that non-radioactive contaminants present in the NSD discharge stream will include a corrosion inhibitor (such as Kurilex L-111). The corrosion inhibitor is present following dosing into the auxiliary equipment cooling systems (TCW, RCW, HNCW, and HECW for example) to prevent rusting within the piping and heat exchanger tubes.

### 5.3.3 Drainage Networks - Liquid Waste Management System

The LWMS system comprises the CAD, HCW, LCW and LD drainage systems, and has the following overarching strategies [Ref-18]:

- To contain any water leaks and any water drained from the closed loop systems of the Primary Circuit and/or the Fuel Pool [Ref-17].
- To control, collect, process, handle, store and dispose of liquid wastes generated as the result of normal operations.
- To enable the re-use (recycling) of treated liquids where possible, so that liquid discharges (including radioactive contaminants) are minimised as far as practical.
- To have sufficient capacity so as to be able to deal adequately with anticipated cases in which the maximum amounts of waste liquids are generated.
- To have systems in place to prevent leakage of liquid radioactive substances, and uncontrolled discharge outside of the ABWR site.
- To collect all potentially radioactive liquid wastes in dedicated systems (sumps or drain tanks) [Ref-19].

An overview and ultimate disposal routes of the four effluent streams within the LWMS is presented in Figure 5.3.3-1. Further detail on the LWMS is presented in Figure 5.3.3-2.

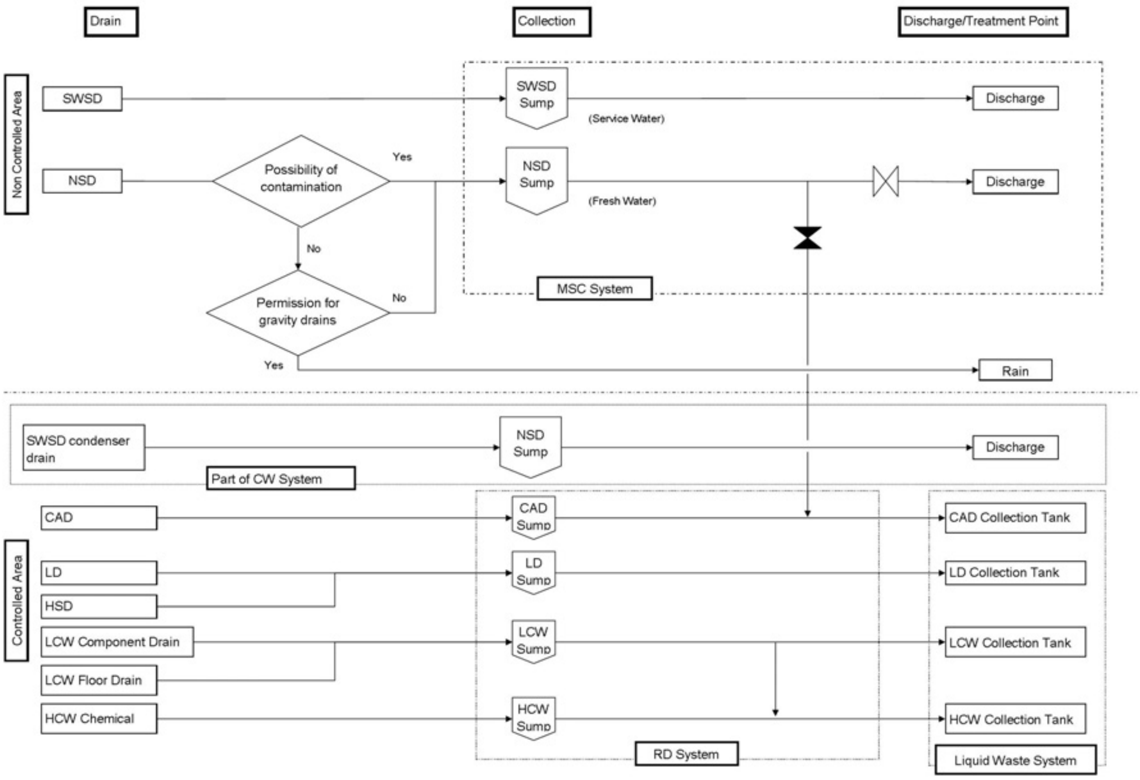


**Figure 5.3.3-1: Overview of Liquid Waste Treatment Flows**

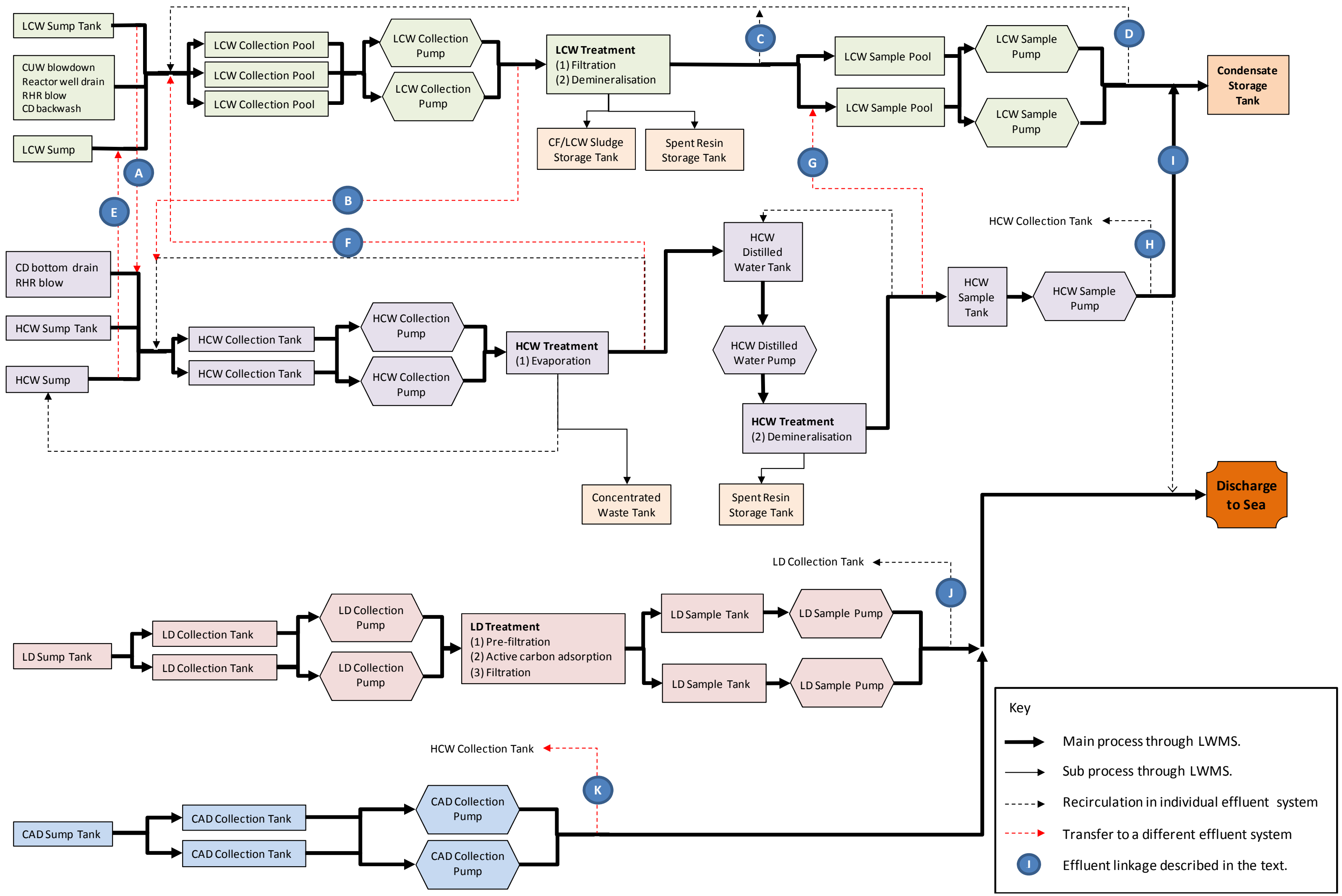


**Figure 5.3.3-2: Outline of Liquid Waste Management System (LWMS) - Highlighting Linkages between the Effluent Treatment Systems**

As shown in Figure 5.3.3-2 (references A-K) there are linkages between and within the LCW, HCW, LD and CAD systems:

- Linkages between the systems allow for the transfer of effluent according to the level of contamination present. This improves the efficiency and efficacy of the LWMS and prevents the overloading of a system should it receive waste that it is not capable of treating effectively, for example during an unplanned release.
- Linkages within each system to allow for the re-circulation of effluent through a system multiple times to enable the required level of treatment to be achieved.

The linkages between and within the systems are shown on Figure 5.3.3-2, references A-K.

**Table 5.3.3-1: Transfer Linkages for Effluent Between and Within LWMS**

| **Linkage reference** | **Transfer from** | **Transfer to** |
|---|---|---|
| B | Downstream of the LCW collection pump | HCW collection tank |
| C | Downstream of LCW demineraliser | LCW collection pool |
| D | Downstream of LCW sample pump | LCW collection pool |
| G | Downstream of HCW demineraliser | LCW sample pool |
| H, J, K | H - Downstream of HCW sample pump<br>J - Downstream of LD sample pump<br>K - Downstream of CAD collection pump | H - HCW collection tank<br>J - LD collection tank<br>K - HCW collection tank |
| I | Downstream of HCW sample pump | CST |

Note - Discharge criteria for UK ABWR will be determined at Step 3 stage.

#### 5.3.3.1 Controlled Area Drain

The CAD system collects drain and sampling water from non-radioactive equipment systems in the controlled areas of the reactor building (R/B) and turbine building (T/B) [Ref-17]. The CAD system therefore receives liquid arisings from the:

- CAD sump tank in the R/B.
- CAD sump tank in the T/B.
- Controlled area drain in the radwaste building (RW/B).

The liquid waste streams collected from the locations described drain to two CAD collection tanks, and are then pumped to the discharge point to sea. Liquid is sampled from the CAD collection tanks and analysed for chemical and radioactive contaminants. Although this effluent stream drains from a controlled area it is expected to be essentially free from radioactive contamination [Ref-17]. If the liquid meets the required criteria it is discharged to the sea (Table 5.3.2.1-1). If the discharge criteria are not met then the effluent is transferred to the HCW collection tank for treatment within the HCW system (line K in Figure 5.3.3-2).

There is no mechanism to transfer effluent from the CAD system into the CST, as is the case for the HCW and LCW systems.

Normal discharge rate from the CAD system is 3 $m^3$/day, with a maximum of 34 $m^3$/day. Note these figures (and subsequent discharge figures given for the other drainage systems) are for a Japanese ABWR and are provided for information only at this stage. The information will be updated at Step 3.

##### 5.3.3.1.1 Potential Contaminants Present (CAD)

The CAD system should be essentially free of radioactive contaminants [Ref-19].

Effluent from the CAD system can be diverted to the HCW collection tank if any unacceptable chemical contamination (or significant radiological contamination) is detected which will minimise the levels of contaminants discharged to sea from this system.

#### 5.3.3.2 High Conductivity Waste

HCW system is located within the RW/B and is designed to treat radioactively contaminated or potentially radioactively contaminated water with higher levels of impurities than that managed through the LCW system [Ref-19].

The inputs to the HCW system arise from the:

- HCW sump tank in the RW/B.
- Dry well (D/W) HCW sump - effluent collected here may also be transferred to the LCW system if the receiving criteria for the LCW system are met.
- LCW sump tanks in the R/B, T/B and RW/B (line A in Figure 5.3.3-2).
- Chemical drains bottom drain - receives chemical waste generated at the laboratory in the Service Building (S/B) and high conductivity water.
- LCW system downstream of the LCW collection pools (line B in Figure 5.3.3-2).
- CAD system downstream of the CAD collection tanks (line K in Figure 5.3.3-2).

The liquid waste streams discharged into the HCW system are collected in two HCW collection tanks. Effluent is then pumped from these through the treatment process (see section 5.4) to the HCW sample tank. During the treatment process some of the treated effluent is re-circulated back to HCW collection tanks. Radioactive materials removed during treatment are collected and contained in the form of wet sludges and used ion exchange resins. These wet-solid wastes are stored in the concentrated waste tank and spent resin storage pool, before transfer to the solid radioactive waste treatment facility for processing into a passively safe state [Ref-19]. Treated effluent is transferred to LCW sample pool (line G in Figure 5.3.3-2) or HCW sample tank. Line F is also utilised if the HCW demineraliser is not available, with the LCW demineraliser used instead.

The water quality of the treated effluent is analysed in the HCW sample tank. As far as possible treated effluent in the HCW sample tank is re-used within the ABWR facility. Effluent suitable for re-use is transferred to the condensate storage tank (CST) (line I in Figure 5.3.3-2). Effluent not suitable for re-use (and transfer to the CST system) is transferred back to the HCW collection tank (line H in Figure 5.3.3-2) for re-circulation through the HCW system. If the CST cannot receive the liquid due to the constraints of water balance within the power plant then liquid may be stored temporarily in the HCW sample tank to avoid discharge to sea as much as possible. Discharge to sea from the HCW sample tank only occurs if water quality criteria are met (Table 5.3.2.1-1). Effluent that does not meet discharge criteria will be re-circulated back through the HCW system (line H in Figure 5.3.3-2), as described above.

The normal discharge rate from the HCW discharge route will be shown at Step 3

#### 5.3.3.2.1 Potential Contaminants Present (HCW)

The function of the HCW system as the recipient for the more contaminated liquid effluents generated within the UK ABWR, means that the HCW system will contain various non-radioactive and radioactive contaminants. Non-radioactive contaminants may include sodium hydroxide and sodium dihydrogen phosphate. Information on other specific contaminants present is not available at this Step 2 stage, and will be addressed further in Step 3. However, the HCW system is designed so that the contaminants present are removed from the effluent stream into spent resins and the concentrated waste tank during the effluent treatment process. The discharge limits described at Step 2 stage are detailed in Table 5.3.2.1-1; these will be reviewed and potentially amended at Step 3.

### 5.3.3.3 Low Conductivity Waste (LCW)

The low conductivity waste system is located within the RW/B building and is designed to treat relatively large volumes of radioactively or potentially radioactivity contaminated waste water [Ref-19]. The LCW system receives liquid arisings from the:

- LCW sump tank in the R/B, T/B and RW/B. This collects waste water spillages in each separate area of the R/B, T/B and RW/B.
- Drywell LCW sump. Effluent may also be received from the drywell HCW sump.
- Reactor water clean-up system (CUW) blowdown.
- Reactor well drain.
- RHR blow.
- HCW system downstream of the HCW evaporator (line F in Figure 5.3.3-2).
- HCW system downstream of the HCW demineraliser (line G in Figure 5.3.3-2).

This liquid effluent route is differentiated from the HCW discharge stream by a lower level of radioactive contamination, low conductivity, low suspended solids, and low chemical impurities.

If effluent collected in the locations described above does not meet the acceptance criteria for the LCW system then it is transferred to the HCW collection tank (line A in Figure 5.3.3-2). There is sufficient capacity within the LCW sumps (and associated pumps) to handle any liquid spillages within the R/B, T/B and RW/B that may occur during normal operations, start-up, shut-down and outages [Ref-17].

The liquid waste streams discharged into the LCW system are collected in the LCW collection pool. Effluent is then pumped from these through the treatment process (see section 5.4) to two LCW sample pools. If the effluent collected is not suitable for processing by the LCW, then it is transferred from the LCW collection pool to the HCW collection tanks (line B in Figure 5.3.3-2) (Table 5.3.3-1).

During the treatment process some effluent is removed to the sludge and spent resin storage tanks. Following treatment, effluent may also be re-circulated back to the LCW collection pool (line C in Figure 5.3.3-2) for retreatment through the system.

The treated effluent is analysed in the LCW sample pools. All treated effluent in the LCW sample pool is reused within the ABWR facility. If the effluent is suitable for re-use it is transferred to the CST. If it is not suitable for re-use it is re-circulated back to the LCW collection pool (line D in Figure 5.3.3-2). There is no discharge to sea from the LCW system.

##### 5.3.3.3.1 Potential Contaminants Present (LCW)

As with the HCW system, the purpose of the LCW system as a recipient system for contaminated liquid effluents generated within the UK ABWR, means that the LCW system will contain various non-radioactive and radioactive contaminants. Information on other specific contaminants present and levels will be addressed further in Step 3.

The LCW system is designed so that the contaminants present are removed from the effluent stream into wet sludges and spent resins during the effluent treatment process. Also there is no discharge from the LCW system to the sea, with the liquid effluent from the end of the LCW system either discharged to the CST or re-circulated back to the LCW collection pool.

#### 5.3.3.4 Laundry Drain

The laundry drain receives liquid effluent from the LD and the HSD. The waste stream will therefore include arisings from hand washing and the washing of protective clothing. The water to form these arisings is either de-ionised water or the fresh water supply. These liquid waste streams drain via the LD sump tanks in the S/B buildings to two LD collection tanks. The effluent is then pumped through the treatment process (see section 5.4) to two LD sample tanks where the water quality is analysed for chemical and radioactive contaminants. If the effluent meets the discharge criteria it is then discharged to the sea (Table 5.3.2.1-1).

The HSD discharge should have negligible levels of radioactive contaminants, whereas the LD discharge may contain some radioactive contaminants [Ref-17][Ref-19].

The presence of detergent in both the LD and HSD liquid effluent streams means that the combined (LD(HSD)) waste stream is not suitable for recycling and re-use within the ABWR site.

If on analysis in the LD sample tank the effluent does not meet the criteria for discharge to sea (Table 5.3.2.1-1) then the liquid is transferred back to the LD collection tank (line J in Figure 5.3.3-2) for re-circulation through the LD(HSD) system. Re-circulation (and therefore re-treatment) can be repeated multiple times if required. There is no mechanism to transfer effluent from the LD(HSD) system to the CST.

The quantity of liquid discharged through this route is dependent on the number of people using the controlled area. The quantity of liquid will be provided at Step 3.

##### 5.3.3.4.1 Potential Contaminants Present (LD)

The potential contaminants present in the LD discharge system are detergents, suspended solids and organic materials, and possibly low levels of radioactive material.

Treatment of the effluent captured by the LD system will remove some of the contaminants to filters and activated charcoal units. The discharge limits described at Step 2 stage are detailed in Table 5.3.2.1-1; these will be reviewed and potentially amended at Step 3. If the discharge does not meet the criteria set then it is not discharged to sea and is re-routed back to the LD collection tank for re-treatment through the process.

### 5.3.4 Discharge Criteria to Sea

Whilst the objective of the LWMS is to re-use liquid effluent within the ABWR, the system does provide a pathway for the discharge of treated effluent from the LWMS to the sea. The criteria for the liquid discharge to the sea are described in Table 5.3.2.1-1. These are the criteria for a Japanese ABWR and are presented here to demonstrate the level of discharge control in place for the ABWR NPP. These criteria will be amended at Step 3 or 4 in the GDA process. It is also noted that the discharge criteria could have a site-specific component, as a consequence of the sensitivity of the receiving water environment. The discharge criteria (to sea) may therefore also be reviewed and amended at site-specific stage.

Discharges to sea will occur from the SWSD, NSD, HCW, LD(HSD) and CAD drainage routes. The criteria shown in Table 5.3.2.1-1 apply to these systems.

The discharge criteria to the sea that are established at Step 3 (or Step 4) stage for the UK ABWR will need to meet the environmental quality standards (EQSs) (where available) for the contaminants present, so that the EQS thresholds are not exceeded in the receiving water (the sea). The most up to date EQS values for England and Wales are given in The River Basin Districts Typology, Standards and Groundwater Threshold Values (Water Framework Directive) (England and Wales) Direction 2010 [Ref-20]. The EQS for any dangerous substance not identified under the Water Framework Directive (WFD) will continue to apply until the Dangerous Substances Directive is repealed. If no EQS is available, the process contribution (PC) should be compared to natural background concentrations and/or ecotoxicity data. At the site-specific stage, the comparison will take into account any sensitive local species and the results of habitat surveys.

At GDA stage, the EQS used should be relevant to discharge into the marine environment. At site-specific stage the EQS should also take account of the natural chemistry of the receiving seawater.

#### 5.3.4.1 Assessment of Impact to the Receiving Environment

Information on the non-radioactive discharges from the UK ABWR's LWMS is not complete at Step 2, and an assessment of the impact to the receiving water environment has not been undertaken therefore.

For the purposes of this Step 2 assessment, information is presented on the methodology that will be applied to determine the impact(s) of non-radioactive discharges to the receiving environment. The methodology applied will follow the approach set out in the Environment Agency's Horizontal Guidance Note H1 ('H1 assessment'). The type of assessment to be undertaken is determined by whether the discharge is defined as 'simple' or 'complex' [Ref-21]:

- Simple discharges - defined as continuous discharges over time, where all the components have been identified, the toxicity and environmental effects of individual chemicals is documented and the combined effects can be estimated by simple addition. The concentration of individual contaminants is determined both at end of pipe (i.e. in the final discharge), and also in the receiving environment following dilution, to give a process contribution (PC) (µg/l) to the receiving water. The PC values are then compared to the relevant EQS. If the PC is <4% of the EQS maximum allowable concentration (MAC) or the EQS annual average (AA), then the contaminant is screened out of further consideration.

- Complex discharges - defined as discharges where there is no available information on the safe levels or aquatic toxicology of the likely combination of chemicals in the discharge, even if there is information on the individual chemicals. The complex discharge approach is also applied if the receiving water is especially sensitive or if the simple approach has not allowed a discharge to be 'screened out' on the basis of negligible impacts. Sensitivity of the receiving water would be identified at site-specific stage. As with the simple discharge approach, the concentration of individual contaminants is determined both at end of pipe and in the receiving environment following dilution, to give a PC (µg/l) to the receiving water. The PC values are compared with relevant EQS (or other environmental quality criteria if EQS is not available). The methodology may also require an assessment to be made on whether the discharge causes >10% deterioration in background concentrations already present. It may also require a direct toxicity assessment (DTA) to be made.

The assessments of both simple and complex discharges have a site-specific component, and can therefore only be completed at site-specific stage. In the GDA therefore, it will only be possible to undertake the simple and complex discharge assessments up to the determination of the concentration of contaminants at end of pipe (i.e. in the final discharge).

### 5.3.5 Special Liquid Waste

The special liquid waste stream is the arisings from the standby liquid drain (SLD) and the decontamination drain. Drained boric-acid solution from the SLD is separated completely from other waste and collected in containers. Collected liquid waste will be treated adequately. Liquid waste from the decontamination drain is collected through the Plumbing and Drainage (P&D) System piping.

### 5.3.6 Rainwater Run-off

Rainwater run-off from the UK ABWR site is managed according to whether the precipitation occurs inside or outside of the inner fence. Precipitation onto areas within the inner fence flows to the Seal Pit where it is mixed with the discharges from the cooling water systems (CW, TSW and RSW). After sampling, water in the seal pit is discharged to the sea.

Precipitation onto areas within the wider site boundary, but outside the inner fence, is collected separately.

### 5.3.7 Details to be Addressed at Step 3 - Effluent Characterisation

Full details of the liquid effluent streams within the UK ABWR have not been determined completely at the Step 2 stage to enable all of the Environment Agency’s P&ID requirements to be addressed. It is proposed that the gaps in the information will be addressed at Step 3 stage. In summary these gaps are:

- Levels of corrosion inhibitor in the NSD drainage system.
- Discharge criteria for the UK ABWR - the discharge criteria provided at Step 2 (Table 5.3.2.1-1) are those for Japanese ABWR.

## 5.4 Effluent Treatment and Assessment of Impacts

Each of the liquid discharge streams described in the previous section (apart from the SWSD system) are subject to some form of treatment or monitoring to ensure that potential impacts to the environment from the discharges can be identified and mitigated where necessary. The information presented in the following sections describes the level of detail that is available at Step 2. It is expected that further information will be provided at Step 3 as the discharge criteria are reviewed.

### 5.4.1 Treatment of Cooling Water Systems (CW, TSW and RSW)

There is no treatment of the discharges from the three cooling water systems (CW, TSW and RSW) prior to their discharge to the sea. However, the discharges from all three systems are monitored to confirm (before release) that discharge criteria are met.

The function and design of the three cooling systems means that the seawater discharged should be free of contamination. Consequently treatment should not be required.

### 5.4.2 Treatment of Drainage Networks (SWSD and NSD)

There is monitoring of the discharge from the SWSD and NSD systems (see Table 5.3.2.1-1 for discharge criteria), but no treatment processes are proposed within either system. Whilst the NSD system does not contain any treatment processes, if contaminants are identified the effluent is diverted to the CAD collection tank, before any liquid is discharged. The linkage between the CAD and HCW systems means that effluent from the NSD system can be transferred via the CAD system to the HCW system for treatment. There is no mechanism to divert discharges from the SWSD system. However, the nature of the SWSD discharge means that the potential for contaminants to be present is extremely low.

### 5.4.3 Treatment of Drainage Networks (LWMS)

The drainage networks within the LWMS are the CAD, HCW, LCW and LD drainage systems. The purpose of the LWMS is to control, collect, process, handle and store liquid radioactive waste generated as a result of normal operation, including anticipated operational occurrences. The LWMS has the following general design features which will ensure effective containment of the effluent through the treatment process [Ref-17]:

- Tanks, pipes, pumps etc. in the LWMS use appropriate materials, are designed against appropriate design temperatures and pressures and are manufactured and tested in accordance with appropriate engineering standards. Except where break-in requirements for maintenance or recovery from breakdowns, the LWMS are fully welded systems.
- Measures will be taken, so far as is reasonably practicable, to minimise leakages from pipework transferring radioactive effluents that are embedded in floors or walls.
- The LWMS control system includes monitoring of all the main process parameters (pressure, flow, temperature, tank levels, etc.) with appropriate alarms provided to the operators in the event of abnormal conditions.
- The LWMS control system includes level control for all tanks including appropriate interlocks to prevent tank overflows. All LWMS tanks have engineered overflow routes to alarmed sumps where appropriate.
- All floor drains and bund sumps have leak detectors/alarms and pumps to recover spilled liquids into the LWMS.
- Bunding will be provided in line with UK regulatory requirements and industry best practice, including all tanks and where appropriate any other piece of equipment containing liquids. Bunding is provided at all external doors to LWMS buildings to prevent the spread of any spilt liquids to the outside of the buildings.

All potentially radioactive liquid wastes are collected in sumps or drain tanks at various locations in the ABWR and transferred to collection tanks in the RW/B [Ref-12]. The LWMS operates normally on a batch basis. Treatment of the liquid wastes is undertaken according to the type of impurity and chemical content in each waste stream, so as to provide the most efficient and economical process. With the exception of the LD aqueous waste stream, the waste streams within the LWMS are treated to enable as much of the liquid waste to be recycled within the ABWR [Ref-19]. The LD waste stream is likely to contain detergent impurities making it unsuitable for re-use, although effluent can be re-circulated multiple times through the LD system [Ref-19].

Separate liquid effluent treatment systems exist for the HCW, LCW and LD discharge routes. There is no treatment of effluent directly within the CAD drainage system, although contaminated effluent can be diverted to the treatment system in the HCW system.

Information on the treatment for each system is provided in [Ref-17].

### 5.4.4 Treatment of Rainwater

Precipitation falling within the UK ABWR site is treated according to whether it falls inside or outside the inner fence. Precipitation falling within the inner fence drains to the seal pit where water quality is manually sampled regularly.

Precipitation falling in between the inner and outer fence, and around the perimeters of buildings and structures is treated to remove suspended solids (turbidity removal) and hydrocarbons (oil separation), before discharge to sea.

### 5.4.5 Details to be Addressed at Step 3 - Effluent Treatment and Discharge

The details of the treatment of the liquid effluent streams within the UK ABWR, and the identification of potential impacts to the surrounding environment have not yet been developed to the level that allows the Environment Agency’s P&ID requirements to be fully addressed. It is proposed that the gaps in the information will be addressed in Step 3. In summary these gaps are:

- Review of the treatment system or each of the liquid effluent waste streams.

## 5.5 Identification of Options for Beneficial Use of Waste Heat

### 5.5.1 Introduction

For the purposes of the GDA it is assumed that the site location is coastal and that the design will use a once-through seawater cooling system. This is regarded as the Best Available Technique (BAT) in the BREF Report [Ref-22].

There are three circuits using seawater to remove heat from various auxiliary plant and equipment returning it to the marine environment via a common cooling water outfall. The three circuits are described in Section 4.4.2 and include:-

- CW - Circulating Water; removing heat from the main power cycle via the main condenser.
- RSW - Reactor System Water; removing heat from various auxiliary heat exchangers and equipment within the Reactor Building.
- TSW - Turbine Building Service Water; removing heat from various auxiliary heat exchangers and equipment within the Turbine Building via the TCW heat exchangers.

Seawater will be abstracted via a common inlet structure and passed through the three cooling circuits. The returning water from the three circuits enters a common seal pit prior to discharging back to sea.

Table 5.5.1-1 summarises the data in relation to the design of the ABWR cooling water system.

**Table 5.5.1-1: Summary of the ABWR Data - Cooling Water Design Parameters**

| Circuit | Flow Rate - $m^3$/hr ($m^3$/sec) | Temperature Uplift under normal operation (°C) | Calculated Energy Transfer (MW) |
|---|---|---|---|
| CW | 184,800 (51.3) | 12 | 2,483 |
| RSW | 5,400 (1.5) | 5.4 | 33 |
| TSW | 7,500 (2.1) | 5.1 | 43 |
| Total | 197,700 (54.9) | - | 2,559 |

### 5.5.2 Options for Waste Heat Utilisation

Condenser circulating water (CCW) is used to condense the low-pressure steam, thus removing the "waste heat" from coal-fired, oil-fired, combined cycle gas-fired, and nuclear plants that operate on the Rankine cycle. The CCW is heated while passing through the plant's condenser and discharged into the environment. In open systems, the heat in the CCW is discharged to lakes, rivers, or oceans, and in closed systems, it is discharged directly into the atmosphere, typically through cooling towers.

A consequence of the second law of thermodynamics is that any electric power plant that is operating on the Rankine cycle must reject approximately 60% to 70% of the heat that is added to the cycle through the condenser to the ambient environment in order to complete the cycle. The temperature of the waste heat exiting power plants, while too low for electric power generation, may be suitable for other purposes such as heating greenhouses and aquaculture (fish farming) facilities, particularly those power plants that reject this waste heat directly to the atmosphere via cooling towers due to the marginally higher rejection temperatures. If heat was intended to be a bi-product of a Rankine cycle plant, as in a Combined Heat and Power Plant (CHP), then the temperature of the waste heat can be raised to higher levels, although this reduces the electrical output and efficiency of the power plant [Ref-38][Ref-39][Ref-40][Ref-41].

It has been determined that around 2,595 MW of waste heat will be generated in the form of low grade heat with a mean temperature of 23°C. At this temperature, the heat is regarded as very low grade, limiting its recovery and application.

However, to put this quantity of energy into perspective, the heat output during a 6 month heating season[1] would be in the region of 22,700 GWh/yr (assuming 2,595 MW is produced continuously over the year). In very approximate terms, this is equivalent to the thermal energy (GWh) required to heat around 750,000 homes during the UK heating season leaving a similar amount of energy available for other uses during the non-heating season. Between 2008-2012, the normalised average natural gas consumption per household was ~15,200 kWh/yr [Ref-23]. When put in this context, the challenge of distributing and utilising this amount of heat can be appreciated.

If the waste heat can be recovered and used to offset conventional heat generation from fossil fuels it will produce a favourable carbon benefit and potential financial savings to the end user whilst also reducing the environmental impact of the power plant. Utilisation of this waste heat could also offset the requirement for more power generation required for decarbonising the UK's heating demands.

Heat can be either used directly, or converted into electricity. As this heat is already the bi-product of electricity generation this report has not considered in any depth, the potential for further generation because it is assumed that the ABWR has been designed to maximise the production of electricity resulting in the production of low temperature waste heat thereby maximising electrical generation efficiency.

Since the temperature of the waste heat has already been reduced to the lowest possible level, the task of utilising the waste heat is quite challenging. In addition, space heating for personal comfort is only required during the cooler months (or heating season), which further limits the economic case for heat recovery for comfort heating. As illustrated above, the sheer quantity of heat is also a factor, in that whilst there are potential opportunities to utilise the heat e.g. aquaculture (fish farming), the demand from this activity (in the context of the UK) would be relatively small and may not be economically justifiable to develop a heat recovery infrastructure for this purpose alone. In addition, if users are reliant on heat distributed from power plant, consideration has to be given to installing back-up heating systems should the heat from the power station be unavailable for any reason, further increasing the required infrastructure and overall project costs.

By increasing the temperature of the available waste heat in order to increase the quality of the thermal energy, the power production in the power station would be reduced, therefore creating a tradeoff between reduced electricity generation versus availability of higher grade heat which has greater economic potential to be usefully recovered than the low grade heat described above.

Consideration of the use of this heat should therefore consider:

- The recovery of the low temperature heat.
- Increasing the temperature of the cooling water with subsequent cascading of its utilisation as the quality degrades.
- Raising the temperature of the media through the application of heat pump technology and integration of heat networks / energy parks (See Section 0 for further information).

#### 5.5.2.1 Crop Growing (Glasshouses)

There are increasing pressures on the horticultural industry, not least population growth. But further pressures are being faced bringing big challenges. Competition from imports (Holland, Spain, Canaries etc), and pressure from customers including the major supermarkets is driving the need to improve yield and quality, as well as an increasing drive for locally sourced fresh food and for lowering household grocery costs.

The area cultivated in the UK for glasshouse crops has reduced as a result of these commercial pressures [Ref-24]. Older, less efficient glasshouse businesses are going out of production and being replaced by modern ones. Despite this, some crops, such as tomatoes are increasing in total UK yield. The value of cucumber and lettuce has fallen dramatically and the strength of Sterling (£) has helped support imports

[1] The heating season refers to the cooler months of the year during which a typical household would use heating.

[Ref-24]. Some of these crops are being replaced with growing bedding plants and sweet peppers [Ref-24]. However UK producers offer some advantages compared to their European competitors including labour relations, pest and disease control, and water supply.

Protected horticulture in the UK is a complex and diverse industry with many types of crop being produced in a wide range of facilities.

Heating is often used in large commercial glasshouses to enhance plant growth. Typically hot water is piped throughout the glasshouse in un-insulated metal pipes that radiate the heat. A water temperature of 60 to 90°C is generally utilised and the return temperature will depend on the amount of heat removed from the circuit. A typical glasshouse will have an annual heat demand of between 175 and 675 kWh/$m^2$ (subject to intensity of cultivation and crop type) [Ref-25].

- Energy intensive edible crop production - for example, tomatoes, cucumbers and peppers require ambient temperatures above 18°C together with humidity and $CO_2$ control.
- Energy intensive ornamental crop production - for example, chrysanthemum, begonia and poinsettia require ambient temperatures above 18°C together with humidity control, $CO_2$ enrichment and supplementary lighting.
- Energy low-intensive edible crop production - for example, lettuce production require lower growing temperatures and less complex environmental controls.
- Energy extensive ornamental crop production - including crops that are grown at low temperatures (<150°C heating temperature) such as bedding plants etc.

**Table 5.5.2.1-1: Energy Use Benchmarks - kWh/$m^2$**

| | **Edible Crops** | | **Ornamental Crops** | |
|---|---|---|---|---|
| | Intensive | Extensive | Intensive | Extensive |
| Typical | 675 | 250 | 450 | 175 |

Extremely large glasshouse complexes are required to utilise the significant amount of waste thermal energy that is generated from a typical power station. Such complexes would need to be justifiable primarily on market value of the products, which would dictate the types of crops / plants grown. To put this in perspective, on the basis of utilising 2,595 MW continuously throughout the year, the total area of glasshouses required would range between 3,363 hectares (Ha) and 12,971 Ha (subject to intensity of cultivation and crop type). At the higher of these figures, this equates to an area of 130 $km^2$ (greater than the area of Bristol). Clearly sinking heat into glasshouses alone would require a significant development to even use a small proportion of the heat available.

Direct contact, under soil/floor and forced air (dry) heat exchangers have demonstrated some capability for maintaining the temperature above 14°C [Ref-26]. High humidity associated with direct contact heat exchange may create problems and necessitate disease control.

Soil or floor heating systems are only considered viable in moderate climates for production of cool season crops and in colder climates only as a secondary heat source in glasshouses, although cheaper energy may turn this viewpoint around. In respect to field crops and use of under soil heating pipes, outcomes include quicker emergence and faster early growth of field and vegetable crops. Although if the process brings the crop on too early, this may subject the crop to frost damage and/or can reduce hardiness. Therefore careful selection of crops is essential [Ref-26].

An alternative method of heating glasshouses commonly used in Europe takes heat from gas fired CHP, with the $CO_2$ in the exhaust gases used to enhance crop growth as the plants absorb $CO_2$ to grow [Ref-26]. This benefit would not be available from heat associated with a nuclear plant so growers may still chose to burn fossil fuel to generate the required $CO_2$. This could form the primary heat source with waste heat from the power plant acting as the secondary under soil/floor heating.

Consideration may also be given to maintaining environmental conditions for livestock. Whilst there is little useful benefit for beef and dairy cattle, rearing pigs and poultry broiler production may offer a heat sink as these can demand air temperatures of 10 to 24°C [Ref-26].

#### 5.5.2.2 Aquaculture (Fish Farming)

Fish are an important source of food for people around the world. Fish can be either caught wild or farmed, known as aquaculture.

As wild fishing stocks collapse through over-fishing, fish farming is growing rapidly as an industry. In 1970 only around 5% of the fish eaten came from farms [Ref-27]. Today half of the fish eaten is farmed. Some scientists have predicted that by 2048, stocks of all species of sea fish will have collapsed, forcing almost exclusive use of farmed fish. The species raised in fish farms include salmon, trout, cod, carp, catfish, sea bass, tilapia, and others. Today the vast majority of Atlantic salmon and rainbow trout are farmed intensively in fish farms [Ref-27].

Most of the existing UK finfish aquaculture industry is based upon open, flow-through systems where natural water bodies provide a clean water supply, and remove and assimilate wastes. Such culture systems have been criticised as they are dependent upon this natural supply, which if intensive, can incur an environmental cost on the supplying / receiving environment [Ref-28].

An alternative model for intensive finfish production is closed Recirculation Aquaculture Systems (RAS). In RAS, water is recirculated and technology is used to remove wastes and maintain oxygen levels. RAS are often perceived as having strong ‘green credentials and RAS products are promoted as sustainable by environmental organisations such as Seafood Watch and Greenpeace because, as closed systems, they abstract little, if any, water from natural water bodies (once operational), produce minimal effluent, with readily managed waste streams and they reduce the potential environmental impacts from escapees and pathogen release [Ref-28].

RAS also offers many potential benefits to the producer and supply chain:

- Control of the fishes’ environment allows consistent and predictable production, essential for modern food production.
- Removal of the dependence on a natural, clean, flowing water supply eliminates the potential effects of seasonal variations (e.g. floods, droughts), widens the potential locations, and enables farms to be located closer to markets.
- Improved bio-security in closed systems reduces the risk of pathogen ingress and disease outbreaks.
- Closed systems eliminate losses due to predators.
- Containment within buildings aids temperature control, allowing all year round production.
- Heating allows alternative tropical fast growing species to be farmed.

Despite these apparent benefits, RAS may still attract criticism due to high energy usage and its associated carbon impacts and for ethical reasons. There is increasing recognition that most fish have highly developed senses and are said to be capable of feeling pain, fear and stress and through scientific discovery have been found to have long-term memories and social structures [Ref-27]. RAS are typically intensive systems, which may be viewed as “factory farms”. Fish in fish farms are reared in large numbers in densely stocked tanks or enclosures in rivers, lakes or at sea in sea-cages. Many farmed fish are fed largely on wild fish - this is regarded as unsustainable and adds to the welfare concerns about how wild fish are caught and killed [Ref-28].

Over the last 10 years there has been a notable increase in both the number and size of land-based, warm-water RAS farms in England and Wales. In 2000 there were a couple of small scale farms, but a decade later this is approaching twenty farms which vary in scale from the production of 10 to 1000 t/yr. [Ref-28]. These new farms represent a diversification in the UK aquaculture industry, and thereby help strengthen the UK's seafood security. However, despite the optimism surrounding RAS, a notable proportion have gone into administration. Various potential factors have been suggested anecdotally as contributing to the recurrent failure of commercial RAS in the UK, including high running costs, of which the cost of heating will be a factor [Ref-28].

Heating can obviously be delivered in numerous ways; space heaters are used by the majority of sites as it is generally considered more economical to heat the entire unit rather than just the water. This assumes that the building is well insulated. The space to heat is therefore a factor to consider in the initial design: there should not be an excessive space (air volume) to heat, although there should be sufficient exchange to prevent $CO_2$ build-up [Ref-28].

#### 5.5.2.3 Heating of Road / De-icing Airport Runway Surfaces

It may be possible to use the low grade heat directly with the current low temperature cooling water to prevent ice and frost on road or airport runway/aircraft parking stand surfaces.

##### 5.5.2.3.1 Under- Road Heating

This would require an extensive under surface heating network and there may be limitations for this application in relation to the distance between the road(s) and the ABWR. As a minimum, the waste heat could be used to heat the access roads around and into the NPP. The benefits of under-road heating include:

- Providing ice and snow free roads - safer roads and reducing accidents.
- Reduce reliance on expensive gritting machinery and salt.
- Reducing salt pollution to the water table.
- Reduce winter journey times.
- Reduce freeze-thaw damage of road surfaces, minimising potholes and increasing the life of the surface - thereby reducing maintenance costs.

The Transport Research Laboratory (TRL) completed a 2 year trial in 2007, on a section of the M1 motorway using a patented technology, called Inter-seasonal Heat Transfer (IHT) [Ref-29]. This process utilises the fact that black asphalt can reach temperatures 15°C higher than ambient in the summer through solar gain. In IHT a series of water filled pipes are laid beneath the surface of the road to capture the solar heat in summer, storing this heat in thermal banks (at ~7 m below ground the temperature is stable all year round at around 10°C and IHT can raise this to 25°C in summer months). In winter this heat is then used to keep the road surface temperature above freezing. Whilst utilising waste heat from the ABWR would not require the collection of heat and its storage, the application of under-road heating has shown some potential. In addition, the temperature uplift potential of the cooling water in warmer months may offer additional benefits such as increasing the output temperature from heat pumps.

Whilst the application of this approach is limited, a small town in Michigan (USA) in 1988 [Ref-30], installed an extensive network of pipes through which warm water (waste heat) from a nearby coal fired power station was pumped, maintaining snow and ice free streets and pavements in the downtown area during the winter.

##### 5.5.2.3.2 De-icing at Airports

Heathrow operates up to 98% of capacity. Therefore any delays create knock-on effects and cancellations. BAA put its snow and ice disruption cost at £25million in December 2010 [Ref-31], and British Airways lost £50million. The key problem is not just snow, which can be cleared by snow ploughs, but ice. Ice bonds to the ground surface, compromising the braking ability of aircraft and damaging the surface through freeze-thaw expansion and contraction.

Often expensive and hazardous chemicals are used (grit and salt cannot be used as they can cause damage to engines) [Ref-31], and if these fail more powerful de-icing treatments are required. Ice problems are significant on aircraft parking stands where it is more difficult to clear the snow and ice where aircraft are already parked. Introducing under runway heating for a busy airport may be expensive in terms of lost business, but its application may be more feasible for parking stand areas.

However, it is unlikely that the ABWR will be located within in any reasonable proximity to an airport as a result of safety issues.

#### 5.5.2.4 Heat for Algae Bio Diesel Growth

Algae are simple aquatic plants that range from single-celled microalgae to large seaweeds. Algae can harvest the power of the sun absorbing carbon dioxide through photosynthesis and convert this into biomass, including oil. Many species are fast growing and more productive than land plants per unit area. This makes them an important part of the carbon cycle and they are able to produce complex molecules, such as hydrocarbons and carbohydrates [Ref-33].

Research is being undertaken to uncover novel microalgal compounds that could provide alternatives to those obtained from petrochemical sources. There are a wide range of bioenergy products that can be obtained from culturing algae including biomass for combustion to produce heat and electricity, fermentation to produce bioethanol, biobutanol or biogas, oil for conversion to biodiesel or even possibly algal synthesised biodiesel. Some microalgae have unique abilities such as being able to produce hydrogen gas which can be used in fuel cells to produce electricity. Others, such as cyanobacteria, have been suggested may be used in solar panels to generate electricity directly [Ref-33].

Algae require very nutrient rich environments, often toxic to other plants, so they could be used for treating ‘waste waters’, from a range of industrial and agricultural sources [Ref-32]. At a small scale, recycling nutrients from waste water could potentially provide some of the nutrients required by the algae, and there may be some scope to combine fuel production and waste water remediation.

Microalgae can be grown in large bioreactors or open raceways and continually harvested, unlike crops. One of the benefits of algae production is that it could use marginal land or sea, thereby minimising competition with food production. Algae can be grown using water resources such as brackish-, sea-, and wastewater unsuitable for cultivating agricultural crops [Ref-32].

Algae production requires a number of energy demanding processes which include the energy required for drying and de-watering the produced biomass. Using waste heat to dry the biomass is one strategy that might improve the overall carbon balance of the process [Ref-32].

Solar radiation is one of the most important factors influencing algal growth and to achieve high levels of production throughout the year, the culture of algae on a large commercial scale has so far been restricted to sunny climates, where there is little seasonal variation. For this reason the application in the UK maybe somewhat limited with the current strains of algae that are available, although waste heat from industrial processes could be used to warm ponds and increase growth rates [Ref-33].

#### 5.5.2.5 Desalination

Although water covers 75% of the earth’s surface, only 3% of it is potable. Increasing population raises the pressure on limited water sources and increases the demand for technologies that can provide potable water. More than 7,500 desalination plants operate worldwide, with two-thirds of them in the Middle East, where there often is no other alternative for fresh water. The technology is less common in North America, where residents get less than 1 percent of their water from desalination plants, however, as the populations increase in cities and towns, desalination has been proposed as one solution to meet the demand for fresh water [Ref-34].

Here in the UK, whilst water is not a scarce commodity, there are increasing stresses on water treatment companies and the requirements to supply large volumes of potable water to cities and large conurbations.

Most commercial desalination plants now use either distillation or reverse osmosis. Distillation involves boiling and evaporating salt water and then condensing the vapour to produce freshwater. In reverse osmosis, high-pressure pumps force salt water through fine filters that trap and remove waterborne salts and minerals [Ref-34][Ref-36].

Boiling the vast amounts of water needed for the distillation process requires large amounts of energy. Using low grade waste heat would not only reduce the operating costs but would also be more sustainable. Reverse osmosis uses less energy but has other problems, including mineral build-up clogging the filters, and causing plants to shut down, plus and the cost of replacing membranes is high.

The first large-scale desalination plant in the UK opened in 2010 in Beckton on the River Thames in London - demonstrating the water stress in one of the UK's most populated region. This area is said to receive less rainfall per person than Istanbul, Dallas or Sydney. Thames Water spent £250million building the plant and pipes, and said they intend operating the plant at times of drought, when it can supply up to 1 million people. Opponents have claimed that the plant will use too much energy and the company should be doing more to stop leaking pipes and reduce the average water use of customers by installing more water meters and better promotions. Thames Water has suggested that they are considering alternative ‘green’ fuels to supply the energy required. Some have speculated that Thames Water could connect the desalination plant directly to the next-door Beckton sewage treatment plant, to produce recycled water. The recycling process uses similar technology and is usually cheaper than desalting water, but has so far been too unpopular to be accepted by homes anywhere in the world except the Namibian capital Windhoek [Ref-35].

Alternative options are mainly experimental with no commercial operations in existence. Much research is focused on membrane technology having low thermal demands.

Liquid-liquid extraction (LLE) is currently used in various industrial applications. The main solvents used are amines and polymers but no solvent extraction desalination plants are currently commercially available. Amines have been rejected as potential solvents due to their presence in the final product. However, the ‘Puraq’ method is an LLE process that uses a specially tailored liquid polymer to extract salt out of seawater at temperatures around 29°C. This is in the experimental stage and no commercial applications are known to exist [Ref-36].

Another experimental technology relies on a mass diffusion to evaporate salt water utilising waste heat [Ref-34]. Pumps spray salt water warmed as a by-product of power plant cooling processes into the top of a tower packed with a polyethylene matrix that creates a large surface area for the water to flow across as it falls. Other pumps at the bottom of the tower blow warm, dry air up the column. As the trickling salt water meets the warm dry air, it evaporates. Blowers push the now-saturated air into a condenser, the first stage in a process that forces the moisture to condense as freshwater. A small experimental prototype has been developed producing about 500 gallons of freshwater daily. Calculations made by others are said to show that a larger version, tapping the waste coolant water from a typically sized 100 MW power plant, has the potential to produce 1.5 million US gallons daily. The cost is projected at $2.50 per 1,000 US gallons, compared with $10 per thousand US gallons for conventional distillation and $3 per thousand US gallons for reverse osmosis.

To be cost effective, that the desalination equipment would have to extract as much heat as possible from the coolant water, so it would need to be incorporated into the NPP’s design and would require a large area of land.

#### 5.5.2.6 District Heating

District heating can be used to supply heating and hot water to a number of dwellings from a central heat source. This would require flow and return pipe work to be distributed to every dwelling to connect to a hydraulic heating interface unit typically requiring a flow temperature of 80 to 90°C at the point of use. Electrical energy will be required for circulation pumps to pump the water through the pipework. District heating permits the use of renewable heat technologies on a scale that would not be viable or practical on an individual scale.

The typical cost for installing a district heating scheme to serve 1,000 dwellings would be in the range of £4k to £8.5k per household [Ref-37]. The costs vary significantly depending on the ground conditions for installing the pipe work, the distances and number of bends involved between the individual dwellings.

Larger schemes would benefit from further economies of scale resulting in lower maintenance costs and lower safety check costs when compared to the costs of installing and maintaining gas-fired central heating boilers to the individual dwellings. The whole life costs need to be lower than individual heating options for this to be financially attractive to residents.

To achieve the required water temperature at the point of use by raising the temperature of the CCW would have the impact of lowering electrical generation efficiency and reducing electrical output.

There is a body of thought in the UK [Ref-38][Ref-39][Ref-40] that is supportive of an alternative approach and on a larger scale than installing end of the pipe systems such as some of those discussed above. This concept is that of developing a heat network, taking waste heat from power stations such as coal fired, nuclear, energy from waste, Combined Cycle Gas Turbine (CCGT) and biomass power etc. and distributing it over large distances to energy hubs in cities and towns incorporating district heating networks (DHN). The temperature of the media from the power plants would be raised at the sacrifice of power generation but is returned at the same low temperature as if the heat was rejected without recovery. The concept of this process has been proven in Denmark [Ref-29][Ref-41].

A similar school of thought in the USA centres around the concept of ‘Waste Heat Energy Parks’(WHEP).

The idea of co-locating a business near a power plant to use its waste heat or water is not new, but building dedicated systems to deliver hot water can be prohibitive with a single user. The concept of a WHEP is to combine multiple users who have different needs. Some would "consume" the waste heat, whilst others would use the water after it is cooled - such as under floor greenhouse heating in winter with evaporative cooling in summer and passed through a spray aeration system (oriented spray cooling) oxygenating and cooling the water to a temperature suitable for its next use at an aquaculture facility.

Other businesses could be added to maximise the heat used and minimise the power plant's cost. There needs to be a synergy among the users to gain the maximum benefit from the capital costs of the distribution system.

# 6. Groundwater

## 6.1 P&ID Requirements

The P&ID requirement relating to discharges to groundwater is:

1. *If there will be discharges to groundwater, describe the nature and quantity of those discharges and provide an assessment of the impact on groundwater.*

## 6.2 Regulatory context

Discharges to groundwater are controlled by the Environmental Permitting Regulations (England and Wales) Regulations 2010 (SI 2010 No.675) (EPR 2010) [Ref-15], which make it an offence to cause or knowingly allow a groundwater activity to take place without an environmental permit or an exemption. Groundwater activities include the discharge of a pollutant which results in the direct or indirect input of the pollutant to groundwater.

### 6.3 UK ABWR Discharge to Groundwater

The UK ABWR generic design does not include any requirement for routine discharges to groundwater. There will not be any intentional discharges to groundwater at the generic UK ABWR site.

As a preventative measure, each building that contains radiation controlled areas has a roof drainage system. Rainwater is guided by the drainage system to a seal pit and then discharged to the environment with cooling water. Therefore no rainwater is discharged directly to groundwater.

The UK ABWR design will utilise BAT to prevent accidental leaks and spills of non-radioactive pollutants, which could give rise to accidental pollution of land and groundwater [Ref-18]). These will include physical measures such as:

- Tank bunding and secondary containment of potentially polluting substances.
- Hard surfacing areas of potential spills risk (e.g. loading areas).
- Use of oil interceptors on drainage systems.
- Provision of spill kits.
- A P&D to collect and segregate potential leaked water (e.g. firewater water run-off).

In addition, occurrence of such events will be minimised through various measures such as:

- Staff training in spills prevention and emergency response.
- Emergency response exercises.
- Vehicle routing.
- Delivery and off-loading operational instructions.
- Inspection and preventative maintenance programmes for structures providing pollution prevention functions.

## 7. Operation of Installations (Combustion Plant and Incinerators)

### 7.1 Introduction

The purpose of this section of the report is to address the Environment Agency’s P&ID requirements [Ref-1] with regard to the operation of combustion installations at the UK ABWR generic design. The information presented summarises the design information that is currently available. As the design details are not complete and will be developed further, then the information presented in this section will be reviewed and updated at Step 3.

### 7.2 P&ID Requirements

The Environment Agency has identified the information it requires to carry out the GDA in the P&ID [Ref-1]. The P&ID [Ref-1] requirement relating to operation of installations including combustion and incineration is reproduced in the following bullet points:

1. *Identify what combustion plant (for example, for standby generation or auxiliary boilers) will be provided:*
    - *If the aggregate rated thermal input of all combustion plant is greater than 50 MW, provide a comparison of the proposed technology against our sector guidance; and*
    - *If the aggregate rated thermal input of all combustion plant is greater than 20 MW, describe how greenhouse gas emissions will be monitored.*

2. *If the design includes an on-site incinerator with a capacity or 1 tonne or more per hour, provide a comparison of the proposed technology against our sector guidance.*

The information to address these P&ID requirements is presented in six sections.

- **Regulatory context** (Section 7.3) - summarises the regulations relevant to combustion activities.
- **UK ABWR assumptions** (Section 7.4) - summarises the assumptions made in order to provide the basis for the development of the Step 2 GDA requirements.
- **UK ABWR combustion plant installation** (Section 7.5) - describes the combustion plant within the UK ABWR generic site as per the design at this Step 2 stage.
- **Comparison with sector guidance** (Section 7.6) - describes combustion plant present as part of the UK ABWR generic design, and identifies the Environment Agency's sector guidance that it should be assessed against. This is required as the combustion plant for the generic site exceeds 50 MWth.
- **Impact assessment** (Section 7.7) - describes the methodology for the assessments to be undertaken at Step 3, to identify the minimum recommended stack height to ensure adequate dispersion of emissions (D1 assessment), and to determine conservative ground level concentrations of the main combustion products (H1 assessment).
- **Greenhouse gas emissions monitoring** (Section 7.8) - describes the monitoring approach proposed to meet the requirements on greenhouse gas emissions monitoring. This is required as the aggregate rated thermal input of the combustion plant proposed for the generic site exceeds 20 MWth.

The proposed ABWR design does not include any requirement for on-site incineration (of either general waste (hazardous or non-hazardous) or radioactive waste) and it is assumed for the purposes of the GDA process that there will be no waste incineration activities at the generic UK ABWR site. The P&ID requirement to provide an assessment of proposed incineration technology against the Environment Agency's sector guidance is therefore not appropriate and waste incineration is not considered any further in this document.

This does not preclude a future UK ABWR operator from seeking to operate a waste incinerator at a UK ABWR site. However, compliance with the requirements of any relevant legislation in force at the time of application and operation of the incinerator would be required.

## 7.3 Regulatory context - Combustion Activities

Combustion activities are controlled under the Environmental Permitting (England and Wales) Regulations 2010 (SI 2010 No. 675) (EPR 2010) [Ref-15], as amended by the Environmental Permitting (England and Wales) (Amendment) Regulations 2013 (SI 2013 No. 390) (EPR 2013) [Ref-48]. EPR 2013 came into force on 6th April 2013 and transposes Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) (the Industrial Emissions Directive, IED) [Ref-49].

Schedule 1, Part 2, Chapter 1, Section 1.1 of EPR 2010 (as amended by EPR 2013) identifies those combustion activities which come under the Regulations. This listing includes the following relevant activity:

*1.1 Part A (1) (a) Burning any fuel in an appliance with a rated thermal input of 50 or more megawatts.*

The interpretation provided in EPR 2010 (section 1.1) in the following paragraph states:

*For the purpose of Part A (1) (a) of this Section, where 2 or more appliances with an aggregate rated thermal input of 50 megawatts or more are operated on the same site by the same operator those appliances must be treated as a single appliance with a rated thermal input of 50 megawatts or more.*

It will therefore be necessary for the site operator to apply for an Environmental Permit for the operation of the combustion activity at the site-specific permit application stage, since the aggregate rated thermal input of the auxiliary boilers and emergency diesel generators is greater than 50 MWth. The permit for the combustion activity may be combined with the water discharge Environmental Permit.

## 7.4 UK ABWR Assumptions

The following assumptions have been made in order to provide the basis for the development of Hitachi-GE's approach to addressing the GDA requirements relating to the operation of combustion installations (covered by non-RSR environmental regulations) within the nuclear site:

- The ABWR design does not include any requirement for on-site incineration of either general waste (hazardous or non-hazardous) or radioactive waste. Hitachi-GE has therefore assumed that there will be no waste incineration installation at the generic UK ABWR site.
- Combustion plant at the generic site consists of the following main plant items:
  - three (3) standby emergency diesel generators, each with a rated thermal input of 14.6 MWth, located in the reactor building;
  - two (2) back-up emergency diesel generators, their drive system is under design and is assumed to be a diesel generator in this assessment as a likely system, each with a rated thermal input of 14.6 MWth, located in the back-up building; and
  - two (2) auxiliary diesel-fired boilers, each with a rated thermal input of 13.1 MWth, located in the boiler house building.

  Aggregate combustion capacity is therefore 99.2 MWth rated thermal input.
- All principal combustion plant as described above will be fired on diesel (standard UK specification ultra low sulphur diesel (ULSD)).
- Each standby emergency diesel generator will exhaust to air via an appropriate silencer and individual stack which will exit the building through the roof with the final emission point orientated vertically.
- The auxiliary boilers will exhaust to air via a twin-flue combined stack which will exit the building through the roof with the final emission point orientated vertically.
- Emergency diesel firewater pumps and other minor local combustion plant (e.g., isolated space-heating boilers) are likely to have individual rated thermal inputs of less than 3 MWth and may be considered as trivial. They may therefore be excluded from permitting by agreement with the Environment Agency. Such units are not considered further in this GDA.
- The GDA submission will not require a Site Condition Report, since this is a site-specific document. Such a report will be prepared in conjunction with the application for permitting of the combustion installation prior to commencement of operations.

## 7.5 UK ABWR Combustion Plant Installation

The scope of the combustion installation within the generic UK ABWR site will be defined as follows in order to facilitate delivery of the following requirements of the GDA process:

- Definition of the boundary of the permitted installation.
- Assessment of likely stack heights for effective dispersion and dispersion of combustion gases.
- Screening level dispersion modelling of combustion gases (using the Environment Agency's H1 Environmental Risk Assessment Screening Tool) in order to assess the potential for environmental impact.

The UK ABWR combustion installation for the generic site will include the following plant:

- Three (3) standby emergency diesel generators, each with a rated thermal input of 14.6 MWth, located in the reactor building; each unit will exhaust combustion gases to air via its own silencer and individual stack which will exit the building through the roof with the final emission point orientated vertically.
- Two (2) back-up emergency diesel generators, each with a rated thermal input of 14.6 MWth, located in the back-up building; each unit will exhaust combustion gases to air via its own silencer and individual stack which will exit the building through the roof with the final emission point orientated vertically.
- Suitable industry standard electrical switchgear and transmission systems for the injection of generated power into the wider UK ABWR site electrical system.
- Two (2) auxiliary diesel-fired boilers, each with a rated thermal input of 13.1 MWth, located in the boiler house building; the auxiliary boilers will exhaust combustion gases to air via a twin-flue combined stack which will exit the building through the roof with the final emission point orientated vertically.
- The diesel generator systems will include appropriate frost protection systems, where necessary.
- There will be bulk tank storage for lube oil equipped with appropriate pollution prevention measures together with suitable facilities for diesel generator lube oil changes.
- The auxiliary boilers will be equipped with the following:
    - Appropriate boiler feed-water system with de-ionised water for maintenance of boiler water quality;
    - Suitable steam condensate recovery systems in order to minimise de-ionised water usage, with condensate returned to the boiler feed water tank; and
- The combustion installation will be provided with bulk diesel storage tanks equipped with appropriate containment systems and pollution prevention measures; each combustion unit will have a suitable day tank which will be supplied from bulk storage via dedicated pipework systems.
- The combustion installation will include appropriate facilities for the storage of other raw materials (for example lube oil, glycol, maintenance sundries, etc.).
- The combustion installation will include appropriate facilities for the storage of generated wastes, including storage for spent fuel oil and waste lube oil.
- Abatement systems for combustion gases will be considered where appropriate, subject to technical and economic feasibility, and in accordance with the demonstration of BAT.

The final selection of appropriate plant for the UK ABWR combustion installation will be based on a review of suitable combustion plant and associated equipment available in Europe, with each selection determined in accordance with an assessment of BAT.

## 7.6 Comparison with Sector Guidance Note

Having established that the combustion plant to be provided at the generic UK ABWR consists of emergency standby diesel generation units and auxiliary diesel-fired boilers with an aggregate rated thermal input greater than 50 MWth, the Environment Agency's P&ID [Ref-1] for the GDA requires a comparison of the proposed technology against relevant guidance.

In this instance, the appropriate guidance has been identified as follows:

- General guidance for industrial activities provided in How to comply with your environmental permit (HCEP) [Ref-42].
- The Combustion Sector Guidance Note (CSG) [Ref-43].

- For the purposes of a screening level impact assessment of emissions arising from operation of the generic UK ABWR site, the Environment Agency's Horizontal Guidance Note H1 Environmental Risk Assessment and its annexes (e.g., Annex F Emissions to Air) have been referenced (H1) [Ref-44][Ref-45][Ref-46].
- For the consideration of energy efficiency, the Environment Agency's Horizontal Guidance Note IPPC H2 Energy Efficiency has been referenced (H2) [Ref-47].

For the purposes of the comparison with Environment Agency guidance, the installation has been assumed to be as defined above in Section 7.5.

At Step 3 the combustion plant proposed for the generic UK ABWR will be compared against guidance under the following headings:.

- Appropriate measures.Permitted activities.
- Energy efficiency.
- Efficient use of raw materials and water.
- Avoidance, handling, recovery or disposal of wastes.
- Point-source emissions to water – including controls on fuel and raw material storage, and handling and treatment of process effluents including de-ionization effluent, boiler water blow-down and cleaning water.
- Point-source emissions to air – including emission control in design (primary control measures) in-process controls and consideration of abatement technologies for $NO_x$, $SO_x$, CO, VOCs and particulate control. HCEP requires operators to assess the dispersion capability of their vent and chimney heights and make an assessment of the fate of the substances emitted to the environment – this will be discussed in the impact assessment section (Section 7.7).
- Fugitive emissions – control of fugitive emissions to air, water, groundwater and ground.
- Monitoring – this includes monitoring requirements and a requirement to meet the indicative benchmark standards for emissions except in justifiable circumstances.
- General management, including having a written management system, responsible persons, training and records.
- Site security.
- Control of odour, noise and vibration.
- Emission benchmarks.
- Industrial emission directive

## 7.7 Impact Assessment

### 7.7.1 Introduction

This section identifies data inputs and further work which will be carried out at Step 3 to identify appropriate stack heights for the UK ABWR combustion plant, and then to use the Environment Agency's H1 impact screening tool to identify areas where further site-specific assessment of ground level concentrations of emitted combustion products will be required.

The section will identify the inputs required for the calculation to determine minimum appropriate stack heights for the combustion equipment, based on GDA design information, using the Her Majesty's Inspectorate of Pollution (HMIP) D1 stack height calculation method [Ref-55]. This method takes account of the physical flue gas characteristics, pollutant emission rates, the dimensions of associated structures and the local ambient background pollutant concentrations.

The following items of equipment are considered:

- 3 × standby emergency diesel generators, located in the reactor building.
- 2 × back-up emergency diesel generators, located in the back-up building.
- 2 × auxiliary boilers, located in the house boiler building.

A screening assessment, for the main pollutants likely to be emitted to atmosphere from the diesel fired generators and boilers, will be undertaken using the Environment Agency H1 guidance [Ref-56]. The main process emissions associated with combustion of liquid fuel in engines and boilers are $NO_x$, CO, particulate matter and relatively minor amounts of $SO_2$. These emissions may be released either continuously or intermittently from point sources, according to the mode of operation.

The D1 and H1 calculations will be undertaken at Step 3 stage after the design of generators and boilers are fixed.

### 7.7.2 Methodology

The stack height and impacts screening assessments entail:

- Data gathering to identify stack discharge characteristics for each source, building layouts and ambient background concentrations (Section 7.7.3).
- D1 stack height calculations for each engine and boiler location for full load operation. This will identify a minimum stack height recommendation (to be addressed at Step 3).
- H1 screening assessment to determine conservative ground level concentrations of the main combustion products (to be addressed at Step 3).

It should be noted that short-term ground level concentrations may be mitigated by an adequate stack height, whilst annual average concentrations are relatively insensitive to changes in stack height.

### 7.7.3 Data Gathering

The first step in the assessment process is to establish the conditions under which the pollutants would be emitted from the diesel generator and boiler exhaust stacks. The following data are required for this, which allows for the estimation of parameters:

- Thermal input, MWth.
- Power output, MWe.
- Overall thermal efficiency, %.
- Fuel consumption, kg/hr
- Internal stack diameter, m.
- Flue gas temperature, °C.
- Flue gas flow rate, $m^3/s$.
- Pollutant emission concentration, $mg/Nm^3$.
- Pollutant emission rate, g/s.

An indicative layout and dimensions of the main facility structures, based on the generic site, will be used.

Background concentrations of air pollutants (NO and $NO_2$) for inclusion in the D1 and H1 calculations are downloaded from the DEFRA air quality archive [Ref-57] for a recent year, for a suitable continuous monitoring station representative of a rural location in England and Wales.

### 7.7.4 D1 Stack Height Determination

#### 7.7.4.1 Stack Parameters

The input parameter used in the D1 stack height calculations are presented in Table 7.7.4.1-1. This information will be available at Step 3, and the D1 calculation made.

**Table 7.7.4.1-1: Plant Design and Stack Emissions Characteristics**

| | **Engine** | | **Boiler** | |
|---|---|---|---|---|
| **Parameter** | **Value** | **Source / Comment** | **Value** | **Source / Comment** |
| Rated thermal input, MWth | TBD | TBD | TBD | TBD |
| Electrical output, MWe | TBD | TBD | TBD | TBD |
| Steam production rate, t/h | TBD | TBD | TBD | TBD |
| Efficiency, %<br>[electrical for generator; thermal for boiler] | TBD | TBD | TBD | TBD |
| Fuel molecular weight, g/mol | TBD | TBD | TBD | TBD |
| Fuel mass flow rate, kg/h | TBD | TBD | TBD | TBD |
| Flue gas discharge temperature, °C | TBD | TBD | TBD | TBD |
| Stack diameter, m | TBD | TBD | TBD | TBD |
| Discharge velocity, m/s | TBD | TBD | TBD | TBD |
| Oxygen content of flue gas, % vol (dry basis) | TBD | TBD | TBD | TBD |
| Operational excess air, % | TBD | TBD | TBD | TBD |
| Actual discharge flow rate, $am^3/s$ | TBD | TBD | TBD | TBD |
| Normalised* flow rate, $Nm^3/s$ | TBD | TBD | TBD | TBD |
| Oxides of nitrogen (as NO2) conc., $mg/Nm^3$ | TBD | TBD | TBD | TBD |
| Sulphur dioxide conc., $mg/Nm^3$ | TBD | TBD | TBD | TBD |
| Carbon monoxide conc., $mg/Nm^3$ | TBD | TBD | TBD | TBD |
| Particulate matter conc., $mg/Nm^3$ | TBD | TBD | TBD | TBD |
| Oxides of nitrogen (as $NO_2$) emission rate, g/s | TBD | TBD | TBD | TBD |
| Sulphur dioxide emission rate, g/s | TBD | TBD | TBD | TBD |
| Carbon monoxide emission rate, g/s | TBD | TBD | TBD | TBD |
| Particulate matter emission rate, g/s | TBD | TBD | TBD | TBD |

#### 7.7.4.2 Building Dimensions

The precise layout and orientation of buildings is not critical to the D1 stack height calculation but it is important that the dimensions of the largest, nearby structures are included. The assessment made at Step 3 stage will be undertaken on the basis of the details for building layout and sizing.

The D1 calculation uses the nominal heights of the reactor building, control building, heat exchanger building, turbine building, radioactive waste building, backup building and service building. Certain structures were found to be outside the specified distance for each of the stack calculations and hence are not relevant to the assessment. The dominant structures are shown in Table 7.7.4.2-1.

## Table 7.7.4.2-1: Dominant Plant Structures

| Structure | Height (m) | Dimensions (m) |
|---|---|---|
| Reactor building | 42.3 | 59 x 61 |
| Control building | 15.7 | 31 x 58 |
| Turbine building | 33.9 | 69 x 110 |
| Radwaste building | 21.5 | 31 x 52 |
| Backup building | 23.2 | 44 x 44 |
| Service building | 16.0 | 61 x 36 |
| Boiler house building* | 20 (estimated value) | 100 x 30 (estimated value) |

* Boiler house building design is purely nominal at this stage. Layout is not within GDA Step 2 scope. The dimensions for this building are therefore estimated at this stage, for the purposes of the D1 assessment. The dimensions will be reviewed at Step 3 stage when further information on the buildings is available.

### 7.7.4.3 Background Concentrations

The D1 calculation uses background concentrations for the pollutants of interest; these are specified as the 98th percentile of hourly concentrations over a year. As this assessment is for a generic design, values are determined for a relevant site that forms part of the DEFRA Automatic Urban and Rural Network of stations (AURN). The selected station is Harwell, in a rural location in the south of England[2].

The 98th percentile results for this site for the year 2012 are shown in Table 7.7.4.3-1 for the measured pollutants. Carbon monoxide is not measured therefore a conservative value from D1 of 500 µg/m$^3$, is applied.

The H1 screening assessment uses annual mean concentrations. These results for the year 2012 are also shown in Table 7.7.4.3-1. A mapped value from DEFRA [Ref-58] of 220 µg/m$^3$ is used for CO in the absence of measurement data.

## Table 7.7.4.3-1: Background Pollutant Concentrations in 2012, µg/m$^3$

| Pollutant | 98th Percentile | Annual mean |
|---|---|---|
| Oxides of nitrogen | Not used | 12.5 |
| Nitrogen dioxide | 44 | 10.1 |
| Nitric oxide | 15 | Not used |
| Sulphur dioxide | 9.3 | 2.7 |
| Particulate matter | 49 | 16.6 |

### 7.7.4.4 D1 and H1 Results

The results of the D1 stack height and H1 impact screening assessments will be provided in Step 3.

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[2] A comparison of annual mean data for this site with other rural (including coastal) locations in England and Wales showed that concentrations were similar to or higher than other remote locations, including at Narberth, Lullington Heath, Yarner and High Muffles. Furthermore, all required pollutants are measured at Harwell including particulates and $SO_2$.

### 7.8 Greenhouse Gas Emissions Monitoring

The proposed approach to monitoring greenhouse gas emissions will meet the requirements contained in Guidance Document (MRR No 1): The Monitoring and Reporting Regulation - General guidance for installations, which provides guidance on the implementation of Commission Regulation (EU) No. 601/2012. It is not proposed however, that a detailed Monitoring Plan will be developed for GDA, as this is more appropriately developed by the operators of UK ABWRs.

The purpose of the Monitoring Plan is to ensure that systems are in place that allow the UK ABWR operator to comply with their obligations under the European Union Emissions Trading Scheme (EU ETS) as described in the EU Emissions Trading Directive 2003/87/EC and Commission Regulation (EU) No. 601/2012. The Monitoring Plan should enable data on the annual emissions from the UK ABWR site to be presented to an external verifier in a way that is clear and transparent. The monitoring methodology used should therefore be as simple as possible, drawing on reliable data sources, robust metering instruments, short data flows and effective control procedures.

#### 7.8.1 Monitoring Approaches

The Guidance Document (MRR No 1) states that there are numerous monitoring methodologies available for the UK ABWR that can be put together using a building block type approach to form an overall monitoring system. There is an onus on the operator to demonstrate that these blocks have been put together in such a way that there are no gaps in the monitoring or any double counting of emissions. The approved monitoring methodologies are as follows:

- Calculation based approaches:
    - Standard methodology; and
    - Mass balance.
- Measurement based approaches;
- Methodology not based on tiers (“fall-back approach”);
- Combinations of approaches.

Calculation based approaches require a level of measurement to inform the calculations, typically in the form of fuel consumption quantity measurement. Measurement based approaches are based around direct measurement of the greenhouse gases themselves.

For the UK ABWR it is proposed at this stage that an approach incorporating the ‘Standard Methodology’ is used as the primary monitoring approach (it is noted that the approach may change later in the design process). The basis of the “Standard Methodology” is that the greenhouse gas emissions are calculated by measuring both the input fuels and process inputs, and then applying appropriate emission, process and oxidation factors to give the final total emissions.

The monitoring approach described will allow the UK AWBR to meet its requirements under the EU ETS, and for simple, clear and transparent data on the greenhouse gas emissions to be provided to the external verifier.

## 8. COMAH

### 8.1 Introduction

The purpose of this section, as determined at Step 1b stage is to address the applicability of the Control of Major Accident Hazards (COMAH) regulations to the UK ABWR generic design, and to confirm whether or not the UK ABWR is likely to require regulation under the COMAH Regulations.

The Step 1b submission described this process as being undertaken through two stages:

- Collection of data on materials stored at the UK AWBR site.
- Comparison of the quantities of COMAH-listed substances to be stored on a UK ABWR site with applicable COMAH qualifying thresholds (for named substances and generic risk-phrase groups and in aggregation).

To comply with the COMAH Regulations the comparison of the on-site inventory against the COMAH-listed thresholds should be made on the basis of the maximum possible inventories of materials on the generic site. This will decide if the site will be designated as a COMAH Top Tier (TT), Lower Tier (LT) or non COMAH site.

In addition to the above, if the site is to be designated as COMAH TT or LT site then a Hazardous Substances Consent will be required.

The notification requirements to the regulators for COMAH TT and LT sites are summarised within this section.

## 8.2 P&ID Requirements

The Environment Agency has identified the information they require to carry out the GDA in the P&ID [Ref-1]. The P&ID [Ref-1] requirement relating to COMAH legislation is reproduced in the following bullet points:

1. *Identify any need for on-site storage of substances above the qualifying thresholds in COMAH; and*
2. *If a threshold is exceeded, describe the measures taken in the design to prevent a major accident to the environment".*

Information on the on-site chemical inventory for the ABWR at GDA stage is not sufficiently complete to undertake the COMAH assessment described at Step 1b stage. Consequently it is not possible to address the Environment Agency's P&ID requirements detailed above at this time. Key information on quantities of chemicals stored is not available.

As a consequence of this, a partial assessment has been undertaken, on the basis of the information that is available. A more complete assessment will be made at Step 3, when full details of the chemical inventory and quantities stored on site will be available.

The assessment that has been undertaken is presented in four sections.

- **Introduction to COMAH** (Section 8.4) **-** presents an overview of the COMAH assessment process, and describes the approach taken at this Step 2 stage as a consequence of the current information available for the UK ABWR generic design.
- **Chemical inventory** ([Ref-63]) **-** summarises the chemical inventory likely to be held onsite, as of May 2014. This information is presented in [Ref-63].
- **Findings - Step 2 COMAH assessment** (Section 8.5) **-** presents the results of the assessment undertaken at Step 2 stage, and comment on the significance of the chemicals likely to be present in relation to the COMAH assessment.
- **COMAH regulation requirements (Se**ction 8.7) **-** provides information on the further actions that would be required if the UK ABWR generic design was subject to the COMAH regulations as a LT or TT site.

## 8.3 Regulatory context

The COMAH Regulations 2005 [Ref-61][Ref-62] (the COMAH Regulations) apply to establishments which keep (or transport) listed substances in quantities exceeding identified thresholds. The COMAH Regulations specify two threshold quantities for each listed substance or risk category of substance: the lower quantities are the threshold for lower tier COMAH sites, the higher quantity is the threshold for top tier COMAH sites. The COMAH Regulations do not cover radioactive materials.

Operators of establishments covered by the COMAH Regulations have a general duty to take all necessary measures to prevent major accidents and to limit their consequences, and report any major accidents to the competent authority. They must prepare a "Major Accident Prevention Policy" which should demonstrate that an adequate safety management system is in place to prevent major accidents. The enforcing authority should be sent details ("notification") of the name and address of the operator, the address of the site, identify who is in charge, and details and amounts of dangerous substances held at the site. Any changes in these details should be notified to the authority. If the site is a top tier site additional requirements apply.

## 8.4 Background to COMAH

The COMAH regulations relate to the prevention control and mitigation of the effects of accidents involving dangerous substances.

Schedule 1 of the regulations provides details of dangerous substances to which the regulations apply. Schedule 1 (PART 2) provides a list of named substances which are known to be particularly harmful to the environment and/or human health. Schedule 1 (PART 3) provides a list of categories of substances of similar hazardous properties which are not specifically named under Part 2. These categories are provided in Table 8.4-1.

**Table 8.4-1: Schedule 1 PART 3 Categories of Substances and Preparations not specifically Named in PART 2**

| | **(Column 1)** | **(Column 2)** Lower Tier Threshold | **(Column 3)** Top Tier Threshold |
|---|---|---|---|
| | **Categories of Dangerous Substances** | **Quantity in tonnes** | |
| 1 | VERY TOXIC | 5 | 20 |
| 2 | TOXIC | 50 | 200 |
| 3 | OXIDISING | 50 | 200 |
| 4 | EXPLOSIVE | 50 | 200 |
| 5 | EXPLOSIVE | 10 | 50 |
| 6 | FLAMMABLE | 5,000 | 50,000 |
| 7a | HIGHLY FLAMMABLE | 50 | 200 |
| 7b | HIGHLY FLAMMABLE | 5,000 | 50,000 |
| 8 | EXTREMELY FLAMMABLE | 10 | 50 |
| 9 | DANGEROUS FOR THE ENVIRONMENT | | |
| 9a | R50/53 Very toxic to aquatic organisms | 100 | 200 |
| 9b | R51/53 Toxic to aquatic organisms: may cause long terms adverse effected in the aquatic environment | 200 | 500 |
| 10 | ANY CLASSIFICATION (not covered above in combination with the following) | | |
| 10a | R14 Reacts violently with water | 100 | 500 |

| | | | |
|---|---|---|---|
| 10b | R29 In contact with water, liberates toxic gas | 50 | 200 |

The COMAH Regulations include specified quantitative thresholds of dangerous substances which are used to determine whether an establishment falls within LT (Column 2 in Table 8.4-1) or TT (Column 3) thresholds. These thresholds vary for different substances.

- If the site stores, uses or can produce more than the lower threshold for a dangerous substance but less than the TT threshold the site is classed as a LT site.
- If the site stores, uses or can produce more than the higher threshold the site is a TT site.

### 8.4.1 Standard COMAH Assessment Process

The standard process used to determine whether a site is subject to the COMAH regulations and classed as either TT or LT is as follows:

The process follows COMAH guidance document L111.

- Collate an inventory of chemicals and investigate total amounts of dangerous substances onsite. List each dangerous substance and its total amount in tonnes.
- Compare the amount of a dangerous substance with the total amounts against the LT and TT thresholds defined within Schedule 1 (Part 2) and Schedule 1 (Part 3) of the COMAH regulations. Dangerous substances are assigned to the COMAH categories according to their Risk Phrase.
- The threshold amount in tonnes reflects the total amount that the operator is allowed before the relevant COMAH tier is applied.
- If the quantity of dangerous substance onsite does not meet the lower threshold the site is not classed as a COMAH site.
- If the site uses, stores or can produce more than the LT threshold, the site is classed as a LT COMAH site.
- If the site uses stores or can produce more than the TT threshold, the site is classed as a TT COMAH site.

If the total amount of a named substance (Schedule 1 Part 2) or a category of substances (Schedule 1 Part 3) does not meet the threshold for LT, an aggregation is applied to all substances labelled with the same category. A second stage of aggregation is then applied to some categories (where several categories are added together), which then provides a quantity that can then be compared to the thresholds. This is expanded upon in section 8.6.1.

### 8.4.2 Step 2 COMAH Assessment

Due to the detailed information not having been developed at this stage (in terms of storage capacities), a full COMAH assessment cannot as yet be completed. Therefore, the following tasks have been undertaken for the COMAH assessment at Step 2:

- A chemical inventory has been collated (from best available information at point of this Step 2 submission) [Ref-63].
- The inventory list has been compared to the COMAH regulations to identify COMAH category, risk phrases and LT/TT thresholds.
- The inventory is presented as a spreadsheet which lists all of the likely chemicals to be held onsite, their Chemical Abstracts Service (CAS) number, COMAH Category, risk phrases and relevant thresholds.
- The chemicals with the lowest threshold or likely highest storage amounts are highlighted in section 8.5 as substances which may result in the site being subject to the COMAH regulations.

- This report states which of the chemicals will need to be aggregated, in accordance with the regulations.
- The requirements for TT and LT sites under the COMAH regulations have been stated in order to plan for Step 3 tasks.
- Recommendations for the process to be undertaken at Step 3 in order to finalise the COMAH assessment and ensure compliance with the regulations are provided.

The flow diagram (Figure 8.4.2-1) describes the activities undertaken in relation to the COMAH Regulations at Step 2 stage, and those proposed to be undertaken at Step 3.

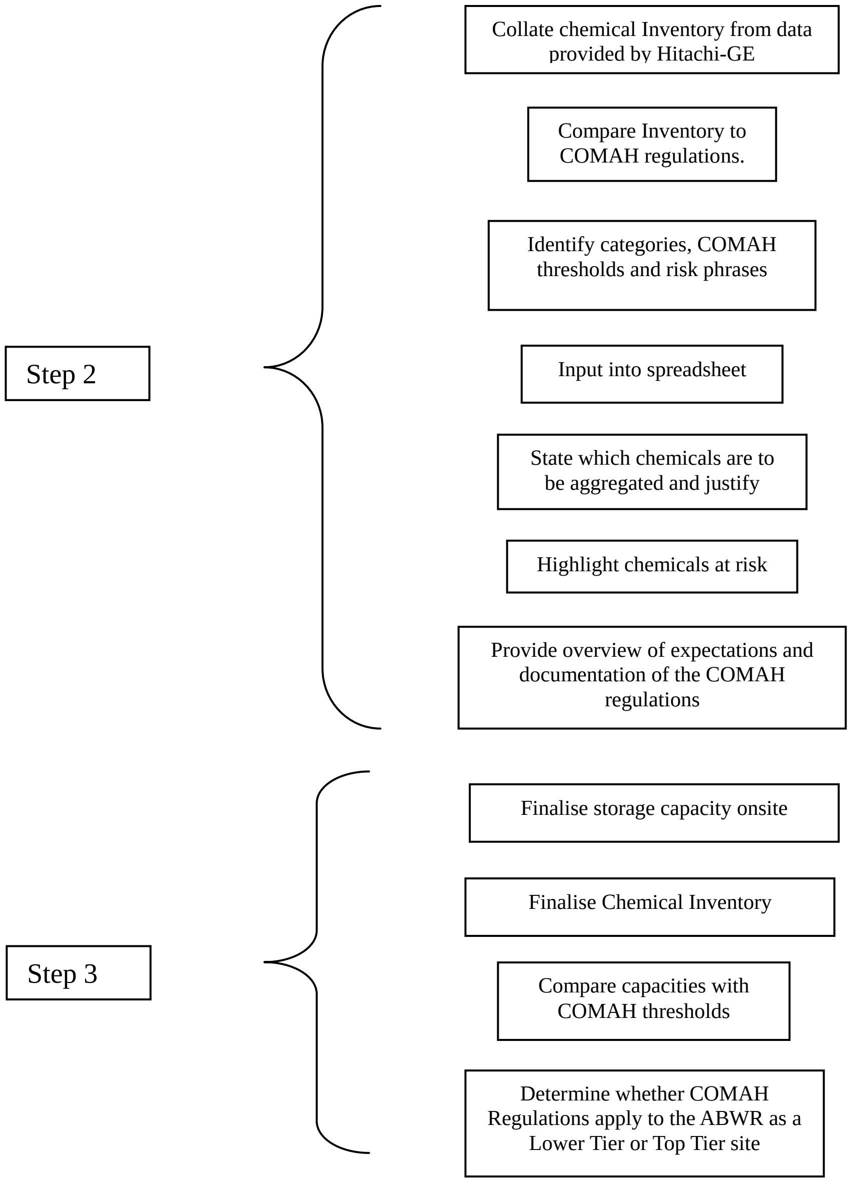


**Figure 8.4.2-1: Flow Diagram of the Activities to be Undertaken in Relation to the COMAH Regulations for Step 2 and Proposed Tasks to be Undertaken at Step 3**

## 8.5 Chemical Inventory

Information on the chemical inventory is provided in separate document [Ref-63]. This details the general purpose and use of each chemical and the associated risk phrases associated. The relevant COMAH category is provided and whether or not the chemical is a named substance under the COMAH regulations.

## 8.6 Findings: Step 2 COMAH Assessment

Due the fact that a full COMAH assessment cannot be carried out at this time, as storage capacities and a complete chemical inventory have not yet been finalised, this report highlights specific substances which have the potential to result in the site being classed as a COMAH site.

The most significant dangerous substance which may subject the site to the COMAH regulations is hydrazine (60%). However, the implications of this can only be confirmed at Step 3, when storage capacity and usage is finalised.

At present hydrazine (60%) with a total estimated quantity of 3,400 kg (3.4tonnes) exceeds the COMAH TT threshold. Hydrazine (5%) has a LT threshold of 0.5 tonnes and a TT threshold of 2 tonnes. This chemical is a named substance under the COMAH regulations and is classed as a CARCINOGEN at concentrations above 5% by weight. This chemical can also be categorised as FLAMMABLE, TOXIC and DANGEROUS FOR THE ENVIRONMENT (very toxic to aquatic organisms R50/53).

From the information gathered for Step 2, the other named dangerous substances (defined in Schedule 1, Part 2) do not appear to likely exceed the LT or TT thresholds. However, the COMAH regulations also require that an aggregation assessment is carried out for dangerous substances with similar hazard potential. In order to progress this assessment during Step 3, information will be required about the specific quantities of dangerous substances that may be used, stored, or produced on site.

### 8.6.1 Aggregation Process

The aggregation process is required for both TT and LT thresholds for dangerous substances which have similar hazardous properties. The approach is summarised in the following paragraphs:

Dangerous substances and applicable categories are as follows:

- Extremely Flammable:
  - hydrogen; and
  - acetylene.
- Explosives:
  - explosive substances (when substance confirmed).
- Flammable:
  - hydrazine; and
  - diesel ( defined as a Petroleum Product in Part2).
- Toxic
  - hydrazine (defined as a Carcinogen in Schedule 1, Part 2);
  - Kurilex L-111 (sodium nitrite);
  - (potentially once further information provided) ethylene glycol; and
  - detergents (unspecified at Step 2).
- Dangerous for the Environment:
  - hydrazine;

- o Kurilex L-111 (sodium nitrite);
- o sodium hypochlorate; and
- o detergents (once substances confirmed).

The aggregation rule must be applied separately for:

- Toxic and very toxic substance.
- Oxidising, explosive, flammable, highly flammable and extremely flammable substances.
- Substances dangerous for the environment.

#### 8.6.1.1 Toxic and Very Toxic Substances

Named substances in Part 2 (classed as toxic and very toxic) together with substances and preparations classed as very toxic and toxic in Part 3:

- (Named substance) hydrazine.
- (Toxic) Kurilex L-111.
- (Toxic) ethylene glycol.
- (Toxic) detergents (unspecified at Step 2).

#### 8.6.1.2 Oxidising, Explosive, Flammable, Highly Flammable and Extremely Flammable Substances

Addition of named substances (within Part 2) classified as oxidising, explosive, flammable, highly flammable or extremely flammable, together with substances falling into the categories of oxidising, explosive, flammable, highly flammable or extremely flammable (within Part 3).

- (Flammable) hydrazine.
- (Oxidising) Kurilex - L111.
- (Flammable) diesel.
- (Extremely flammable) hydrogen.
- (Extremely flammable) acetylene.
- (Explosives) explosive substances.

#### 8.6.1.3 Substances Dangerous for the Environment

Addition of substances named in Part 2 and classified as Dangerous for the environment (R50 (including R50/53) or R51/53), together with substances and preparations falling into categories 9a and 9b (very toxic to aquatic organisms (R50) and Toxic to aquatic organisms: may cause long terms adverse effects in the aquatic environment).

- (Named substance R50/53) hydrazine.
- (Very toxic to aquatic ecosystems R50) Kurilex L-111 (sodium nitrite).
- (Very toxic to aquatic ecosystems R50) sodium hypochlorate.
- (Dangerous for the environment) detergents (once substances confirmed).

#### 8.6.1.4 Aggregation

Qualifying quantities are used from Schedule 1, Part 2 if the substance is named, or from Schedule 1, Part 3 if it is not.

The aggregation rule must be applied for comparison with both the LT and TT thresholds.

The aggregation calculation requires that partial fractions are determined for each qualifying substance. These are totalled together to provide an aggregated figure for each category. If the total derived is greater than or equal to 1 the Regulations will apply at the appropriate tier.

Where a named substance has more than one classification, the qualifying quantities in Schedule 1, Part 2 should still be used when applying the aggregation rule for each relevant classification. However, when substances not specifically named have more than one classification and the aggregation rule has to be applied, and the qualifying quantities in Schedule 1, Part 3 for each of the relevant classifications should be used.

The regulations apply if any of the calculations from the second stage of aggregation results in a value greater than or equal to 1.

The aggregation process should be carried out as soon as possible once the chemical capacities are confirmed to ensure Hitachi-GE will be fully compliant with the COMAH regulations.

## 8.7 COMAH Regulation Requirements

### 8.7.1 Lower Tier

If, following the review of COMAH requirements at Step 3, the site is deemed to be a LT COMAH site, the following measures will be required by the regulations:

- The operator must notify the Competent Authority (CA) by providing the details listed in the following bullet points:
    - name and address of the operator;
    - address of the establishment concerned;
    - name or position of the person in charge of the establishment;
    - information sufficient to identify the dangerous substances or category of dangerous substances present;
    - the quantity and physical form of the dangerous substances present (or likely to be present);
    - a (brief) description of the activity or proposed activity of the installation concerned; and
    - details of the immediate environment liable to cause a major accident or to aggravate the consequences thereof.

The joint CA is, in this case, the HSE and the Environment Agency[3].

- LT operators must prepare a Major Accident Prevention Policy (MAPP). This duty reflects the role of management systems in accident prevention. The essential elements of a Safety Management System (SMS) which must be addressed by the MAPP are:
    - company policy on major accidents;
    - organisation and personnel (including training);
    - identification and evaluation of major hazards;
    - operational control;
    - planning for emergencies; and
    - monitoring compliance, audit and review.

[3] SEPA or Natural Resources Wales replace the Environment in Scotland and Wales respectively.

### 8.7.2 Top Tier

If following Step 3 COMAH assessment the site is deemed to be a TT COMAH site, the following must be carried out in accordance with the regulations:

- Operators must notify the competent authority by providing the details listed in the following bullet points:
  - name and address of the operator;
  - address of the establishment concerned;
  - name or position of the person in charge of the establishment;
  - information sufficient to identify the dangerous substances or category of dangerous substances present;
  - the quantity and physical form of the dangerous substances present (or likely to be present);
  - a (brief) description of the activity or proposed activity of the installation concerned; and
  - details of the immediate environment liable to cause a major accident or to aggravate the consequences thereof.
- Operators planning to build new TT establishments must submit information before construction. This is usually in the form of:
  - Pre-Construction Safety Report; and
  - Pre-Operations Safety Report.
- TT operators do not have to prepare a separate MAPP document (like the LT sites) but a full MAPP must be included within the COMAH Safety Report (the production and submission of which is a requirement for TT sites). Pre-Construction and Pre-operations reports should be submitted to the CA in a reasonable timeframe before construction or on site operations commences. This is normally six months to one year before construction for the pre-construction report and a similar timeframe for the pre-operations report. It is normally the case that the CA will assess the report and feedback to the operator before the operator begins to build safety-critical parts of the establishment. This is to ensure that safety is considered fully at the design stage. It may be possible to combine the Pre-Construction and Pre-Operations SR into one report; however, this must be discussed and agreed with the CA.
- Emergency Plans (onsite/offsite) must be prepared and discussed with CA before construction begins on site.
- Once the plant is fully operational the operator must submit a full COMAH safety report.

## 8.8 Requirements for Step 3

Hitachi-GE has collated a chemical inventory based on the best available information to date in order to begin the COMAH assessment process. Hitachi-GE will seek to develop this inventory further at Step 3 stage as the relevant (and finalised) information becomes available. Hitachi-GE will complete the COMAH assessment at Step 3 to ensure the COMAH regulation implications are fully assessed by this stage.

Once all chemical data has been confirmed, the final inventories can be used to establish whether any named dangerous substance(s) or aggregated amounts will exceed the LT or TT thresholds. If either threshold is met or exceeded, the site will be subject to the relevant level of the regulations and plans will be developed in order to provide the necessary documentation (as detailed above) to the CA. The chemical inventory will be updated on a regular basis to ensure that the requirements of the COMAH regulations are met.

### 8.9 Additional Note: Hazardous Substances Consent

If the COMAH regulations apply and the site identified as a LT or TT site, then the site operator is also required to submit a COMAH Hazardous Substances Consent. The consent is a planning control that enables a Hazardous Substances Authority (HSA) to consider whether the presence of a significant quantity of a hazardous substance is appropriate having regard to the risk to the community[4].

This is required before site operations commence and although it is a separate regulatory process from COMAH, it is best undertaken in parallel to COMAH preparatory work. Following the review of the COMAH Regulations at Step3, Hitachi-GE will review whether the Hazardous Substances Consent requirement applies.

## 9. Conclusion

Conclusions are presented for each of the five sections addressed in this report.

It is important to note that much of the conventional environmental impact assessment work is heavily reliant on site-specific data and so will necessarily fall out of the scope of the GDA assessment. Hitachi-GE is, however, committed to addressing as many requirements as possible in the design stage to mitigate effects where feasible. The assessments that are suitable for completion within GDA have been (and will be) undertaken at the appropriate stage. The results from these stages will be fed back into both the BAT assessments and the design process itself where appropriate, in order to ensure the design is fully optimised

As described in this document, the assessments for all of the 'Other Environmental' requirements have been started. The information available at Step 2 stage means that some requirements have been:

- Completed (for example groundwater and the greenhouse gas emissions monitoring) and may not need to be addressed further in the GDA process.
- Completed as a first draft and will need to be reviewed and revised at Step 3 when further design information is available.
- Provided in outline but have not been addressed further at Stage 2 of the GDA as they are dependent on site-specific parameters and will therefore need to be addressed at site-permitting stage (for example the fish deterrent and return systems).

### 9.1 Conclusions - Water Use and Abstraction

The GDA is based on the assumption that the site is coastal with a once-through seawater cooling system. Information has been provided on the expected usage of seawater for this system. Alternative cooling water systems may be considered at a site-specific stage.

The GDA is based on the assumption that all fresh water requirements will be supplied by the local water company and that fresh water abstraction, and an abstraction license, will not be required. Alternative water supplies may be considered at a site-specific stage.

The selection and design of fish deterrent and / or return systems is dependent on a number of site-specific factors and will therefore be addressed at the site-specific stage.

### 9.2 Conclusions - Water Discharge

Discharge of water from the UK ABWR will occur from the cooling water systems (via the Seal Pit), the storm drain systems (SWSD and NSD) and from the LWMS. Releases will only occur if the discharge criteria are met. Draft criteria have been presented at this Step 2 stage, and these will be reviewed at Step 3.

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4 Further information on this process is available at www.planningportal.gov.uk/permission/responsibilities/beforeyoustart/otherpermissions/hazsubs (England), http://wales.gov.uk/topics/planning/policy/dear-cpo-letters/hazsubletter/ (Wales), and www.scotland.gov.uk/Topics/Built-Environment/planning/publications/legislation (Scotland).

Discharges from the Seal Pit will be seawater with relatively low levels of contaminants and elevated levels of heat. The need for biocides and water treatment chemicals to control biofouling within the cooling water systems will be determined at site-specific stage and has therefore not been addressed as part of Step 2.

Drainage from the storm drain systems and the LWMS have been characterised on the basis of the contaminants present, with the lowest levels and different categories of contaminants present in the SWSD drainage, and the highest in the HCW. Discharges from the LWMS are minimised through the overarching strategy of recirculating effluent through the treatment process to remove contaminants, and then re-using the treated effluent within the UK ABWR.

Information on the presence and levels of particular contaminants is not available at the Step 2 stage, and will either be addressed at GDA Step 3 or at the site-specific stage.

### 9.2.1 Conclusions - Options for the Beneficial Use of Waste Heat

Options for the use of the waste heat available from the ABWR have been reviewed. All of options reviewed have advantages and disadvantages, which result in some not being appropriate for use alongside the ABWR generic design. A key issue common to all options is the requirement for the user of the waste heat to be in close proximity to the ABWR. Health and safety issues may therefore be a limiting factor for all options. Options considered include:

- Crop growing - a possible option, although has a land take requirement adjacent to the ABWR.
- Aquaculture - a possible option, although the heat requirement would be small compared to that available from the power station.
- Under road heating - a possible option, although requires considerable infrastructure (piping) to be implemented, especially if retrofitted to existing roads. There also needs to be road network close to the ABWR requiring heating.
- De-icing at airports - not considered a possible option on safety grounds given the requirement for the ABWR and airport to be located close to each other.
- Algal growth - limited potential in the UK because of lower solar radiation levels in this country. Not considered a possible option therefore.
- Desalination - not considered a possible option as the temperature of the waste heat from the ABWR is not high enough. Also has land take requirement close to the ABWR and the sea. Not really in demand in the UK for water supply.
- District heating - the waste heat from the ABWR is not of sufficient temperature for this system to be viable on its own. However, it may be a possible option using the WHEP approach, where the waste heat from the ABWR is used in conjunction with other systems to boost the temperature to a level sufficient for district heating use.

The ABWR is able to operate irrespective of any of the type of waste heat utilisation systems described in the bullet points above. However, the implementation of such a system would provide a sustainability benefit for the ABWR facility, as the waste heat generated is being put to further use rather than being disposed of.

Any option to use the waste heat depends on site-specific issues, such as land availability or building and infrastructure requiring heating. Further consideration of this will not be made until site-specific stage.

## 9.3 Conclusions - Groundwater

The UK ABWR generic design does not include any intentional discharge to groundwater. Therefore the P&ID requirement for this aspect is considered complete and will not be addressed further in the GDA process.

### 9.4 Conclusions - Operation of Installation (Combustion Plant)

The following conclusions are summarised from the review of the combustion installation as described at this Step 2 stage for the UK ABWR generic design.

- The UK ABWR generic design does not include incineration activities. Therefore regulatory requirements relating to incineration will not need to be addressed further in the GDA process.
- Aggregate rated thermal input for the site exceeds 50 MWth.
- An Environmental Permit will be required at site permitting stage.
- A number of assumptions have been made for the combustion equipment and buildings in which they are located. These assumptions will need to be reviewed at Step 3 stage and amended as required.
- The actual plant to be used has not been determined at this Step 2 stage. Further assessment will be required when the plant to be used has been identified. This will include consideration of energy efficiency, and materials and water use.
- The fuel to be used in the combustion installation is assumed to be ULSD.

#### 9.4.1 Conclusions - Impact Assessment

Input parameters to the HMIP D1 procedure have been clarified to calculate the minimum stack heights for each of the standby emergency diesel generators, back-up emergency generators and auxiliary boilers. The calculation will be made at step 3.

#### 9.4.2 Conclusions - Greenhouse Gas Emissions Monitoring

The proposed approach to Greenhouse Gas Emissions Monitoring will be identified at Step 3.

### 9.5 Conclusions - COMAH

Insufficient information is available at Step 2 of the GDA process to enable an assessment of the UK ABWR’s chemical inventory against the COMAH thresholds. It is expected that this information will be available at GDA Step 3 and that the assessment will be undertaken then.

Information on the chemical inventory that is available indicates that chemicals will be present on the UK ABWR site that fall under the COMAH regulations as a consequence of their flammability, explosive, toxic and / or dangerous to the environment categorisation. The most significant of these substances is the hydrazine. At present, hydrazine is predicted to have an inventory of 3.4 tonnes, which exceeds the Top Tier toxic threshold of 2 tonnes.